Synergy in Science and Engineering: An Integrative Approach

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Preface

In an era characterized by rapid advancements in technology and a deepening integration of computational methods into various scientific disciplines, the compilation of research presented in this book offers a window into the cutting-edge developments across a spectrum of fields. This collection embodies the essence of interdisciplinary innovation, merging theoretical foundations with practical applications to address complex problems and pioneer new solutions. Each chapter in this book delves into a unique aspect of modern research, reflecting the diversity and depth of current scientific inquiry: "Predictive Photo Responsivity of FASnBr3 Using Simulation" explores the photophysical properties of novel materials through advanced simulations, laying the groundwork for future applications in optoelectronics. "Optimizing Object Tracking Precision through Extended Kalman Filter Dynamics" provides a thorough examination of precision tracking technologies, enhancing our capability to monitor dynamic systems with unprecedented accuracy. "Modelling Error Factors in GNSS Observations for Precise Point Positioning and Accurate Position Estimation of Low Earth Orbit Satellites" addresses the critical need for precision in satellite positioning, which is vital for navigation and Earth observation. "Enhanced Performance in Multiple Object Tracking" combines Kalman Filters with the Hungarian Algorithm, optimizing tracking systems that are crucial in surveillance and autonomous navigation. "Computational Study of FeAsn (n=1-4) Clusters Invoking DFT-Based Descriptors" uses density functional theory to unravel the properties of iron-arsenic clusters, contributing to the field of materials science. "Automated Detection and Classification of Mass Calcifications in Breast Cancer Mammograms" leverages image processing techniques to advance the early detection of breast cancer, demonstrating the intersection of technology and healthcare. "The Emergence of Periodic and Chaotic Patterns in a Simple Predator-Prey System" investigates the dynamic behaviors in ecological models, enhancing our understanding of natural systems. "Dispersion Equation & Its Solution for Single Layer Fluid with Surface Tension" presents an analytical solution to a classic fluid dynamics problem, advancing theoretical fluid mechanics. "A Study on Internal Wave Velocity in a Two-Layer Fluid Medium" explores wave dynamics in stratified fluids, with implications for oceanography and environmental sciences. "Formation of a Weakly Singular Integral Equation in Water Wave Scattering Problems" tackles mathematical challenges in modeling water wave interactions, providing numerical solutions using Bernstein polynomials. "Revisited Study on Advection Dominated Accretion Flow around Black Holes" revises existing models of accretion flows, contributing to our understanding of astrophysical phenomena. "Retailer’s Inventory Decisions for Deteriorating Items" examines inventory management strategies, integrating the effects of advertisement and shortages, relevant for business logistics. "Impact of Carbon Emission on EPQ Model in Rhino Bricks Production" discusses environmental impacts on production models, aligning industrial processes with sustainability goals. "AR3D Face Recognition: A New Frontier in Human-Computer Interaction" explores advancements in biometric identification, pushing the boundaries of security and user interaction. "Augmented Reality and Virtual Reality in Education" highlights the transformative potential of immersive technologies in educational environments. "Chain of Wellness: Transforming Healthcare with Blockchain-Based Electronic Health Records" examines the role of blockchain in enhancing the security and efficiency of healthcare records management. "Deep Learning-Powered Brain Tumour Detection in MRI Imaging" demonstrates the application of deep learning in medical diagnostics, offering promising tools for healthcare professionals. "ChromaNet: Next-Gen Image Colorization with NoGAN" introduces innovative techniques in image processing, enhancing visual media through artificial intelligence. "Expense Forecasting on Tourism" applies machine learning to predict tourism expenses, aiding in economic planning and resource allocation. "IPL Player Auction Price Forecasting through Multiple Linear Regression" brings statistical analysis to sports management, predicting auction prices in cricket leagues. "Tip Trend: A Machine Learning Approach to Waiter Tip Prediction" uses data analytics to understand tipping behaviors, with practical applications in the hospitality industry. "Harnessing Adaboosting Algorithm for Predictive Money Management" explores financial forecasting models, contributing to better decision-making in finance. "Revolutionizing Employee Job Performance Assessment with Decision Tree Classification" offers innovative methods for evaluating job performance, enhancing human resource management. Each chapter represents a significant contribution to its respective field, embodying the collective effort of researchers dedicated to pushing the boundaries of knowledge and application. As you embark on this journey through the pages of this book, we hope you find inspiration, insight, and a deeper appreciation for the remarkable advancements shaping our world today.

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Acknowledgement

I extend my heartfelt gratitude to Swami Vivekananda University, Kolkata, India, for their steadfast support and encouragement throughout the creation of "Synergy in Science and Engineering: An Integrative Approach". The university's dedication to fostering education and research has been instrumental in shaping the content and direction of this publication. We deeply appreciate the collaborative spirit and resources provided by Swami Vivekananda University, Kolkata, which have enabled us to explore and share the latest innovations and technologies across various fields.

We hope that this book serves as a valuable resource for this esteemed institution and the broader academic community, reflecting our shared dedication to knowledge, progress, and the pursuit of excellence.

I extend my deepest appreciation to each of the external reviewers mentioned below for their unwavering commitment to excellence and their indispensable role in ensuring the scholarly merit of this work.

With sincere appreciation,

List of Reviewers:

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Chapter - 1

An In-Depth Analysis of Open Shortest Path First (OSPF) Protocol

Debdita Kundu and Apurba Saha

Abstract

A crucial interior gateway protocol (IGP) designated O mpen Shortest Path First (OSPF) is intended to route Internet Protocol (IP) packets only within of one routing domain. The management of the intricate and dynamic nature of contemporary network infrastructures depends heavily on this protocol. This study offers a thorough analysis of OSPF, covering its historical evolution, architectural structure, operational mechanics, and range of advantages and disadvantages. Because of its hierarchical architecture and strong link-state routing algorithm, OSPF is incredibly efficient and scalable for big networks. Its sophistication and resource-intensiveness, however, present difficulties. Additionally, the research contrasts OSPF with other routing protocols like as RIP and EIGRP, emphasizing the benefits of OSPF in terms of scalability, convergence speed, and flexibility while recognizing the ease of maintenance associated with other protocols. The goal is to transfer a thorough knowledge of OSPF's vital function and how it affects the effectiveness of modern networking settings.

Introduction

Because contemporary networks are dynamic, reliable and effective routing techniques are necessary to provide optimal data transfer and network stability. The Internet Engineering Task Force (IETF) developed Open Shortest Path First (OSPF), a very efficient routing method, to fulfill these demands. A complex link-state routing algorithm is used by OSPF within an Autonomous System (AS) to allow each router to keep an up-to-date network map. This guarantees precise routing decisions and quick convergence. This essay analyzes the intricacies of OSPF, charting its development from the beginning to the most recent iterations. It examines the basic ideas behind how OSPF functions, including as how it creates neighbor connections, shares link-state data, and determines the best routes by applying the Shortest Path First (SPF) algorithm. The study also looks at OSPF's crucial function in modern networking settings, emphasizing its benefits over alternative routing protocols and its relevance in expansive, dynamic networks.

Historical Background: In order to address the shortcomings of the Routing Information Protocol (RIP), which suffered from scalability issues and inefficiency in ever-larger and more complicated networks, OSPF was invented in the late 1980s. The main goal of developing OSPF was to produce a more resilient routing system that could withstand the rigors of contemporary networking settings. Network routing entered a new era in 1989 when RFC 1131, the first standard for OSPF, was published. The cornerstone for a protocol that employed a link-state routing algorithm to guarantee precise and effective path computations was established by this first iteration. Significant improvements have been made to OSPF over the years; the most noteworthy upgrade being OSPF version 2, which is documented in RFC 2328. With the introduction of numerous significant enhancements, such as enhanced support for Variable-Length Subnet Masking (VLSM) and more effective management of network modifications, this version cemented OSPF's position as a fundamental component of contemporary IP routing.

Packet Type: OSPF utilizes five packet types for its operation:

Hello Packets: Used to build and preserve ties with neighbors.

Database Description Packets (DDP): Share details on the contents of databases.

Link-State Request Packets: Consult your neighbors for particular LSAs.

Link-State Update Packets: Promote LSAs.

Link-State Acknowledgment Packets: Confirm receiving LSAs.

OSPF Operation

Establishing Adjacencies

In order to find and create neighbor connections, OSPF routers start communication by broadcasting Hello packets on all interfaces that are configured for OSPF. Because they allow routers to recognize other OSPF routers on the same network segment, these Hello packets are essential. The Hello interval, which determines how frequently Hello packets are sent, the Dead interval, which indicates how long a router waits to declare a neighbor down if no Hello packets are received, and the network mask, which establishes the IP range of the network, are among the crucial parameters that routers must agree upon in order to become neighbors. The routers go on to the next stage, where they exchange Database Description Packets (DDPs), once these parameters match and they identify each other as neighbors. Each router can compare its own database with that of its neighbor by using the packets' link-state database summaries. Accurate and effective routing depends on both routers having an accurate and up-to-date picture of the network topology, which is ensured by this exchange.

Link-State Advertisement

Each router in OSPF creates Link-State Advertisements (LSAs) to report on the status of its interfaces and the topology of the whole network. These LSAs are important because they provide details about the router's connections and their current status, including their prices. These details are subsequently "flooded" or spread across the OSPF region. Every router in the region will receive the LSAs thanks to this flooding, which makes it possible for them to create and keep up a precise and consistent network map. Each kind of LSA that OSPF defines has a distinct function in the routing process. For example, Type 2 LSAs provide information on the status of a network and the routers connected to it, but Type 1 LSAs describe the state of a router's interfaces within the same area. While Type 5 LSAs promote external routes from other autonomous systems, Type 3 LSAs summarize inter-area paths. Through the use of these several LSA types, OSPF guarantees the broadcast of complete and effective routing information, resulting in the best possible route computation and network performance.

SPF Algorithm

OSPF uses Dijkstra's Shortest Path First (SPF) algorithm to find the most efficient routes to every destination in the network when the link-state database is filled with LSAs. Building a shortest-path tree with its root at the router doing the computation is how the SPF method works. In this procedure, every conceivable route from the root to other network nodes is assessed, taking into account the total cost of traveling over each connection. The algorithm then determines the route that will result in the lowest overall cost to reach each location. A straightforward and efficient path from the root router to each and every other router in the network is provided by the shortest-path tree that is produced. The router's routing table is subsequently filled with these optimized routes, guaranteeing that IP packets are sent over the most effective routes. In big and dynamic settings in particular, this technique not only improves routing efficiency but also speeds up network convergence and overall network performance

Advantages of OSPF

Scalability: Because of its multi-area support and hierarchical architecture, OSPF is extremely scalable and ideal for expansive and intricate networks.

Fast Convergence: Topology changes are rapidly propagated by OSPF, resulting in littledowntime and rapid convergence.

Support for Variable-Length Subnet Mask (VLSM): Because OSPF enables VLSM, IPaddresses may be used effectively.

Load Balancing: OSPF is capable of equal-cost multi-path routing, which divides trafficequally across several pathways.

Authentication: OSPF improves security by supporting multiple authentication techniques.

Disadvantages of OSPF

Complexity: Configuring and troubleshooting the protocol can be difficult due to itscomplexity, especially in large networks.

Resource Intensive: Significant CPU and memory resources can be used by OSPF'sfrequent SPF computations and LSA flooding, particularly in large-scale installations.

Initial Setup: It might take some time to set up OSPF since it needs careful planning andconfiguration.

OSPF vs. Other Routing Protocols

OSPF vs. RIP

Scalability: RIP's maximum hop count of 15 places restrictions on its scalability comparedto OSPF.

Convergence: Because OSPF uses the SPF algorithm and is link-state based, it convergesmore quickly than RIP.

Complexity: RIP is simpler to configure and manage but lacks the advanced features andefficiency of OSPF.

OSPF vs. EIGRP

Standardization: EIGRP (Enhanced Interior Gateway Routing Protocol) is a proprietaryprotocol used by Cisco, whereas OSPF is an open standard.

Convergence: While both protocols provide quick convergence, in some circumstances theDUAL algorithm of EIGRP may prove to be more effective.

Deployment: Because OSPF is more extensively supported by several suppliers, it is therecommended option in networks with diverse topologies.

OSPF in Modern Networking

Use Cases

Enterprise Networks: OSPF is extensively used in large enterprise networks due to its scalabilityand robust feature set.

Service Provider Networks: Internet service providers (ISPs) use OSPF to effectivelymanage their large-scale IP networks.

Data Centers: In data centre settings, OSPF is utilized to provide high availability andideal routing.

Enhancements and Future Directions

In order to satisfy the increasing needs of contemporary networking settings, OSPF is still evolving. OSPFv3, which extends support for IPv6, addresses IPv4's shortcomings, and offers improved scalability and security features, is one notable improvement. While implementing the required modifications to meet IPv6's greater address space and additional capabilities, OSPFv3 maintains the fundamental ideas of OSPF. In addition, a number of improvements have been included to enhance the scalability and performance of OSPF. These include decreased computational overhead during route calculation and more effectivemanagement of link-state advertising. Subsequent advancements are anticipated to concentrate on augmenting the effectiveness of OSPF, specifically in extremely dynamic networks where abrupt topological modifications happen often. Another interesting approach is to combine OSPF with cutting-edge technologies like Software-Defined Networking (SDN). By integrating OSPF into SDN frameworks, network automation, traffic management, and robust, adaptable infrastructures may all be enhanced. SDN can offer morecentralized and flexible control over network routing.

Security Considerations

Even with the authentication measures that OSPF provides, such plain text and MD5 authentication, it is still susceptible to spoofing, man-in-the-middle attacks, and rogue routerinsertion. Organizations should use strong authentication techniques like MD5, which provide cryptographic integrity checks for OSPF packets, as best practices to improve OSPF security. Route filtering can also be used to limit the dissemination of routing data and stop unwanted routers from inadvertently introducing bogus routing updates into the OSPF domain. Moreover, the OSPF network can detect anomalous activity and any security breaches in real time by using network monitoring technologies. By integrating these strategies, enterprises may minimize risks and guarantee the accuracy and dependability of routing data while greatly enhancing the security posture of their OSPF-enabled networks.

Conclusion

One of the most important components of modern IP networking is Open Shortest Path First (OSPF), which is praised for its scalability, effectiveness, and flexibility. Even with its complexity, OSPF's extensive feature set makes it an invaluable tool for network managers managing ever-more complicated infrastructures. Because of its durability and adaptability, OSPF may be used to tackle the difficulties of future networking environments as networks grow and technology change. Its ongoing significance is guaranteed by its capacity to manage massive networks effectively, adjust to sudden changes, and accommodate a variety of routing needs. Furthermore, OSPF's place as a cornerstone of contemporary network design is further cemented by its function as a crucial inner gateway protocol (IGP), which permits smooth interaction with other networking technologies. As long as improvements and developments continue, OSPF will be a vital tool for efficiently managing and optimizing network operations in the face of changing requirements and complexity.

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Chapter - 2
IoT Application for Water Sustainability

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Chapter - 2

IoT Application for Water Sustainability

Bijaya Banerjee

Abstract

Water scarcity presents a critical challenge globally, especially in the context of sustainable freshwater withdrawal. The interconnectedness of water, food, and energy, known as the water-food-energy nexus, underscores the urgency for innovative solutions. Developing countries face heightened struggles meeting water demand, exacerbated by population growth. Emerging technologies like sensor-guided irrigation systems offer promise in reducing agricultural water usage. However, attention must also be given to water recycling and purification technologies. Energy production further strains water resources, highlighting the intertwined nature of water and energy sustainability. Leveraging IoT for water sustainability holds significant potential, as explored in this chapter's architecture and technological insights.

Keywords: Water scarcity, sustainability, water-food-energy nexus, IoT, sensor technology, agriculture, energy production

Introduction

Water scarcity is a pressing global concern, particularly as it intersects with the complex web of food and energy systems. Referred to as the water-food-energy nexus, this intricate relationship underscores the need for holistic solutions to ensure sustainability. Developing countries grapple with meeting escalating water demands, exacerbated by population growth projections. The agricultural sector, a significant water consumer, faces challenges in optimizing water usage. Emerging technologies, such as sensor-guided autonomous irrigation systems, offer promising avenues for efficiency gains. However, sustainable water management extends beyond consumption reduction to encompass recycling and purification technologies. Additionally, energy production heavily relies on water resources, emphasizing the interconnectedness of water and energy sustainability. Harnessing the power of the Internet of Things (IoT) holds immense potential in addressing the multifaceted challenges within the water-food-energy nexus. This chapter delves into the architecture of IoT for water sustainability, offering insights into sensing technologies, communication frameworks, and water system dynamics.

Related Works

Numerous studies have examined various facets of water sustainability and its intersection with food and energy systems. Research has focused on understanding the complex interdependencies within the water-food-energy nexus, highlighting the need for integrated approaches. Investigations into agricultural water management have explored the efficacy of sensor-based irrigation systems and precision agriculture techniques in optimizing water usage. Moreover, advancements in water purification technologies, including membrane filtration and desalination, have been extensively studied for their potential in augmenting freshwater supplies. The role of IoT in water sustainability has garnered increasing attention, with research efforts centered on developing IoT-based monitoring and management systems for water resources. However, gaps remain in understanding the comprehensive implications of IoT deployment in addressing the challenges of water scarcity and sustainability.

Research and Methodology Design

This study adopts a comprehensive approach to explore the architecture of IoT for water sustainability. Firstly, a review of existing literature on the water-food-energy nexus and IoT applications in water management forms the foundation. Subsequently, the research focuses on identifying key sensing technologies and communication protocols suitable for monitoring and optimizing water systems. Field studies and simulation models are employed to assess the performance and feasibility of IoT-based solutions in real-world scenarios. The methodology encompasses both qualitative and quantitative analyses, integrating data from various sources to inform the development of IoT architectures tailored to address water sustainability challenges.

Results and Discussion

The investigation yields valuable insights into the potential of IoT in enhancing water sustainability within the context of the water-food-energy nexus. Analysis of sensor technologies reveals their effectiveness in providing real-time data on water usage, enabling proactive management strategies. Communication protocols, such as LoRaWAN and MQTT, demonstrate robustness in facilitating seamless data transmission across decentralized water systems. Field trials showcase the practical utility of IoT-enabled irrigation management systems in optimizing water usage while maintaining crop yields. Moreover, simulation models elucidate the long-term implications of IoT deployment on water resource management, highlighting its role in fostering resilience and adaptability in the face of evolving environmental conditions.

Conclusion

In conclusion, the integration of IoT technologies holds immense promise in addressing the complex challenges of water scarcity and sustainability. By leveraging sensor networks, communication protocols, and data analytics, IoT architectures can empower stakeholders to make informed decisions and optimize resource utilization within the water-food-energy nexus. However, successful implementation requires interdisciplinary collaboration, policy support, and investment in infrastructure. Moving forward, continued research and innovation are crucial to unlocking the full potential of IoT for achieving water sustainability goals on a global scale.

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Chapter - 3
Internet of Things towards the Smart Classroom Innovation

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Chapter - 3

Internet of Things towards the Smart Classroom Innovation

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Abstract

In todays, world the Internet of Things (IoT) became the next big thing. Remotely operating commonplace equipment is becoming the norm as technology develops. This allows multitudes of people to use their smart phones to link devices and other devices to the internet. This study suggests an IoT system for education that emphasizes efficiency and security. It makes classroom administration easier and improves engagement by enabling remote monitoring and oversight of particular classroom activities.

A classroom can be automated in several ways, such as using an automated fan, brightness, projection device, water disinfectant, and many other items. A small amount of time saved each day adds up quickly when interest is calculated in terms of both real costs and better student results.

Owing to the advancements in automated processing and wireless communication, every gadget in the classroom has a capability to connect to the internet. This enhances the learning environment's reduced expenses, indoor safeguarding, and encourages energy efficiency. It is feasible to use ultrasonic detection to detect human presence in a classroom. A motion is released by the sensor head, which then gets the movement response from the person. The ultrasonic sensor uses the duration between emission and reception to determine how far away a person is from another person.

Keywords: Internet of Things (IoT), smart classroom, automated, wireless communication

Introduction Education technology, Classroom automation, Remote monitoring, Student engagement, Energy efficiency, Wireless communication, Ultrasonic detection.

Introduction

In today's technologically driven world, the Internet of Things (IoT) is emerging as a transformative force across various domains, including education. The integration of IoT into educational environments holds the promise of significantly enhancing classroom management and student engagement. By leveraging IoT technologies, educators can remotely monitor and control various classroom activities, thus creating a more efficient and secure learning environment. This study proposes an IoT-based system designed to automate classroom functions, aiming to streamline administrative tasks and foster a more interactive and productive educational experience.

Literature Review

The advent of IoT has revolutionized numerous sectors by enabling the interconnectivity of everyday devices, thus facilitating remote control and data exchange. In education, IoT applications have been explored to improve learning outcomes, optimize resource management, and enhance security. Research indicates that IoT can significantly reduce administrative burdens and operational costs in educational settings (Patel & Shah, 2019). Studies by Smith *et al*. (2020) and Jones (2021) have demonstrated how IoT-enabled devices, such as automated lighting and climate control systems, contribute to creating conducive learning environments. Furthermore, the integration of sensors for monitoring occupancy and movement can ensure efficient energy use and increase the safety of the school premises (Gonzalez & Rodriguez, 2022).

Methodology

This study employs a combination of qualitative and quantitative research methods to evaluate the effectiveness of an IoT-based classroom management system. The system incorporates various automated devices, including fans, lights, projectors, and water disinfectants, all connected via a wireless network. Ultrasonic sensors are deployed to detect human presence and movement within the classroom. The sensors emit ultrasonic waves and measure the time taken for the waves to bounce back, thus determining the distance to the nearest object or person.

Data was collected from multiple classrooms equipped with the IoT system over a six-month period. Parameters such as energy consumption, device usage, student engagement levels, and overall classroom management efficiency were recorded and analyzed. Surveys and interviews with teachers and students provided qualitative insights into the system's impact on the learning environment.

Results

The implementation of the IoT-based classroom management system resulted in several notable improvements. There was a significant reduction in energy consumption, attributed to the automated control of lighting and HVAC systems based on occupancy. Teachers reported a decrease in time spent on administrative tasks, allowing for more focus on instructional activities. Student engagement levels showed a marked increase, with the interactive capabilities of the IoT devices facilitating a more dynamic and participatory learning experience. Additionally, the use of ultrasonic sensors enhanced the security of the classrooms by providing real-time monitoring of occupancy and movement.

Conclusion

The study demonstrates that IoT technology can play a crucial role in modernizing educational environments. By automating various classroom functions, the proposed IoT system not only improves operational efficiency but also enhances the overall learning experience. The findings highlight the potential of IoT to create smarter, safer, and more energy-efficient classrooms, ultimately contributing to better educational outcomes. Future research could explore the integration of advanced IoT applications, such as AI-driven analytics and personalized learning platforms, to further elevate the educational experience.

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Chapter - 4
Predicting Spams in Text Messages using Machine Learning Algorithms

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Chapter - 4

Predicting Spams in Text Messages using Machine Learning Algorithms

Chayan Paul

Abstract

During the last few years, the popularity of social networking sites has increased manifold. Microblogging sites like twitter became popular platform because of various attractive characteristics like direct connection with celebrities, sport persons, technocrats, businessmen, sharing and getting breaking news almost real time and so on. Because of the un precedented growth in the user base of the network, there has been an immense growth in the number of spam messages in the twitter also. Spams are unwanted messages which are sent to multiple users in bulk predominantly for commercial promotional activities. Spams can be infuriating at times, as this may overload one's timeline and may hinder in getting the real messages. Also, spams may carry malicious links which may lead to embarrassing situations for the users. Because of the consequence of these issues, detection of spam becomes an important issue to deal with. During last few years, this problem did attract considerable attentions from researchers and there have been some useful approaches. This paper takes an open-source data set and builds a collection of machine learning models to find the most effective algorithm that can be used to detect spams in a database of tweets. Algorithms namely XGBoost, AdaBoost, Random Forest and Decision Tree, were implemented on the selected data set for detecting the spam messages. This study was able to achieve an accuracy of 99.2% i.e., maximum out of all the classifiers we evaluated.

Keywords: Machine learning algorithms, social media, spam detection, twitter

Introduction

An Online Social Network i.e., a Web-based application that enables users to create a public or semi-public profile inside a closed system, identify other users they are connected to, and browse and examine both their list of connections and those made by other users. Some of the Online Social Networks (OSNs) that are widely popular right now are Facebook, WhatsApp, Twitter, Instagram etc. Along with the growth of the social networks, increased the number of spammers. Spammers are the users who manipulate the platforms to broad cast unwanted or malicious messages. Twitter is a microblogging service where users can post 280-character messages called tweets. The Success of social networking services can be seen in the dominance of today's society with Twitter having 330 million monthly active users by 2020.

As of May 2020, every second, on the average, around 6,000 tweets per second or 350,000 tweets sent per minute or 500 million tweets sent every day or, 200 billion tweets per annum are present facts. thanks to this huge growing trend, this Online Social Network has attracted many users along - side spammers. Web Attacks that have appeared on Twitter are Scam, Spam, Phishing etc., Spam may be a sort of Platform Manipulation. Platform Manipulation is taken into account as an activity that's intended to negatively impact the people's experience on Twitter. This includes unsolicited or repeated actions. Spam can include malicious automation and other sorts of platform manipulation like fake accounts.

Shortened URL is included in most of the Spam Tweets to trick users into clicking on it. Additionally, in an effort to reach a wider audience, they frequently tweet about related trends since resources, such as tweets can be shared with each other. This type of Web Attacks not only disturbs the user experience but also causes a whole internet damage which may possibly cause temporary of Internet Services all over the Globe.

To deal with the consequences, user can report a spam by clicking their home page. Then Accordingly the spam accounts are suspended. However, as the Total number of Tweets sent per Day are 500 million in 2020, Among which 10% (Approx.) are of Spam Tweets. This has become a major problem on finding an appropriate Solution.

Resul Kara *et al*. [1]., They believed that in order to guarantee a spam-free atmosphere, it is necessary to identify and filter the tweets of spammers in addition to their owners. Reducing false positive detections is essential in order to prevent innocent users from being labeled as spammers. They employed a mixed classification strategy with SVM, Decision Tree, and Naïve Bayes classifiers. Additionally, Twitter's antiquated features-which are frequently used by Twitter spam detection techniques-are emphasized.

Presented are a few new Twitter features that, to the best of our knowledge, haven't been covered by the other works.

Rohini *et al.* [2]., in their paper titled Improving Spam Detection on Online social media with hybrid classification techniques on Twitter platform, tried to use the Naïve Bayes theorem classifier and build a speaker organization to exclude spam and not spam. In this paper they opined that Using ML algorithm SVM (Support vector machine) and NB are used to Improving Spam Detection on Online social media with hybrid classification techniques on the Twitter platform. The System offers a basic assessment of ML algorithms for the identification of streaming spam tweets in this dissertation. The system is used in this evaluation to process both real-time and offline tweets that are updated in real-time. The system found that one crucial step before ML-based spam detection was feature discretization.

In this Project, the one way of solving this problem is given. We have used the approach of Machine Learning Algorithms. Classification is used here; In predictive modeling, classification is the process of predicting a class label for a given example of input data. Here we have used it to get whether a tweet is a spam or not. We used an open-source dataset from Kaggle (size of 14899, 7) which contains => 7454 of "Quality" tweets and 7443 of "Spam" tweets. Initially we have created a training dataset that contains information about the tweets, including some features required like following, followers, actions, is retweet, location and specific labels i.e., spam, quality to train the models and then use the trained models to detect the real-world tweets as either Spam or Quality.

Related Works

There has been a considerable work in the field of detecting spams for different social network data. In the recent past this topic was able to draw a considerable attention from the researchers. Due to extensive study and expansion of machine learning based processes, classical natural language processing-based studies were done a little less, but still there are good number of studies who go for semantic based studies [1]. In various studies, it was found that behavior features are effective while detecting spams. Tang *et al.* applied generative adversarial networks for to solve this problem [2]. Machine learning and deep learning algorithms have extensively been used to achieve higher accuracies in detecting spam messages [3-5]. Noekhah *et al.* proposed Multi-iterative Graph-based opinion Spam Detection (MGSD) which was found to increase the accuracy of the machine learning algorithms significantly [6].

Sentiment analysis deals with analysis of users' views, assessments and imitations about objects, individuals, events, issues, and facilities. Sentiment analysis uses textual data collected from social networks, analyses them using various tools and techniques like natural language processing, machine learning, deep learning, soft computing to effectively identify the sentiments involved [7-10]. Sentiment analysis can be used to get an idea about the ideas articulated in different posts. Sentiment analysis also categorizes the collected data into different categories. There can be simply two types of classes, like positive and negative only, or there can also be more than two types of classes. When there are only two classes involved, it is called binary classification, on the other hand if there are more than two classes involved, then it is called multiclass classification. These types of study can be used to understand the users' opinion about various products, services, events [11-14]. Though English is one of the most used languages in these social networking sites, users often prefer to use their local language to express their views and opinions. These multilingual data make the processing and analysis of the data more complex and challenging [15-16].

Materials and Methods

In this study, we propose machine learning classification techniques on Twitter data, with the focus being on detection of spam tweets in twitter. The issues are: Curse of Dimensionality, accuracy and precision. Here to face the issue of Curse of Dimensionality we have proposed "Principal Component Analysis" (PCA) to reduce the dimensions without information loss and for the classification process, we performed comparative analysis on the classification algorithms of supervised learning techniques such as XG Boost, AdaBoost, Random Forest, Decision Tree and Logistic Regression to classify the tweets into labels i.e., Spam, Quality.

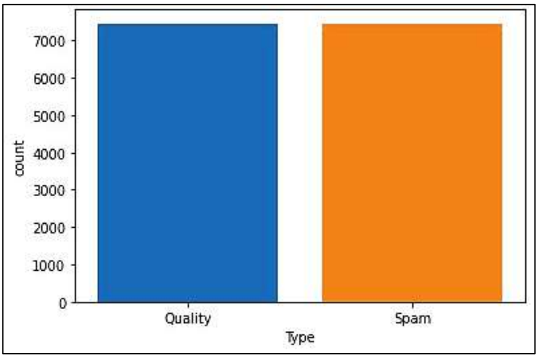

Fig 1: The workflow diagram

Procedure of the Proposed Method

In this study, machine learning algorithm techniques along with PCA were proposed for getting the final predictions of tweet from Twitter which helps in detection of spam tweets. The process is subdivided into 4 modules:

i) Data Collection.

ii) Data pre-processing.

iii) Model building and evaluation.

iv) Comparison of the Models.

v) Prediction on Real-Time Tweets.

Here Developer Twitter account is used for the extraction of the Real-Time Tweets with the help of Twitter search API using “rtweet” package in R.

Data Collection Module

In this study to train our model we have collected the dataset from Kaggle [3] in which it contains all the tweet information extracted from twitter that includes [Tweet, following, followers, actions, isretweet, location and Type with specific labels i.e., spam, quality].

Data pre-processing module

Text Pre-Processing

Usually the tweets contain many special symbols like hashtags(#), underscores(_), URLs, @, etc. In this step; for the removal of these special symbols we used Natural Language Toolkit(NLTK) that contains the process of :

Converting Text to Lowercase

Punctuation removal

White spaces removal

Tokenization

Remove stop words

Stemming

Lemmatization

Part of speech tagging (POS)

Build Corpus

To convert the cleaned tweets to numerical data we utilized OneHotEncoder from Tensorflow which assigns the numerical identification for each word in a tweet.

Principal Component Analysis (PCA)

But after performing the previous step we have faced a backlash i.e.; curse of dimensionality of encoded tweets so in order to overcome this issue PCA (Principal Component Analysis) is Introduced as dimensional reductional tool to reduce the embedded tweets data into two columns without data loss.

Result and Analysis

To Build and evaluate our models, we have split the dataset into testing and training subsets of data according to the percentages 33% and 67% respectively. Then these data sets were used to train the following machine learning algorithms.

Logistic Regression

Decision Tree

Random Forest

XGBoost

ADABoost

The following performance measures were used to find compare the developed models.

Accuracy is to inspect the accuracy of new data that has been for the trained model.

Accuracy= True Negatives+True PositivesFlase Positve+ True Negative+True Positive+Flase Negative

Precision is one of the standard metrics that is a measure of classifier’s exactness. The lower precision denotes that deals with a huge numerical data of false positives in the result. Precision is calculated by considering the ratio of number of True Positives and the total number of true positives and false positives.

Precision=True PositvesFlase postives+True Positives

Recall it is the measure of our model correctly identifying True Positives. Simply it measures the classifier’s completeness. A lower recall represents presence of many false negatives in our predicted result. Its is the ratio of total true positives to that of true positives and false negatives.

Recall=True PositivesFalse Negatives+True Positives F1 Score is a metric used when both precision and recall metric are required to measure the performance of the classifiers. This metric measures the association between recall and precision.

F1 Score=2∗Recall∗ PrecisionRecall+Precision

The results obtained after evaluating the models are presented in the table below:

Classifier	Accuracy	Precision	Recall	F1 Score
Random Forest	0.990	0.992	0.987	0.989
Decision Tree	0.985	0.985	0.988	0.987
AdaBoost	0.994	0.994	0.985	0.990
XGBoost	0.997	0.997	0.987	0.992
Logistic Regression	0.540	0.540	0.540	0.540

Conclusion

In this paper an attempt was made to detect spam messages in twitter data using machine learning algorithms. An open-source data set was used to develop the models and some real time data were extracted from twitter to check the models developed. Major classification algorithms were used in this study and the results shows apart from logistic regression, the other four algorithms have almost similar results. The differences among the accuracy measures are very less to be considered. But if we see to the minute difference, XGBoost is found the clear winner in the league. The results obtained are totally based on the open-source data set, and these results might be validated using a newly collected dataset. Also in the further studies, deep learning models can be used and results can be verified.

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Chapter - 5
Large Language Models and Their Applications: A Ephemeral Review

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Chapter - 5

Large Language Models and Their Applications: A Ephemeral Review

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Abstract

Large Language Models (LLMs) are a class of artificial neural network-based models designed for natural language processing (NLP) tasks. These models have gained immense popularity and significance in the field of NLP due to their remarkable ability to understand and generate human-like text. LLMs can also be thought of as a part of generative artificial intelligence which continue to generate textual data. This chapter explores the groundbreaking advancements in the field of Natural Language Processing (NLP) brought about by Large Language Models (LLMs). These models, which leverage deep learning techniques, have revolutionized NLP by achieving state-of-the-art results across a wide range of tasks. In this chapter, we delve into the fundamental concepts behind LLMs, their architecture, training methods, and the ethical considerations surrounding their use. Additionally, we explore a variety of applications where LLMs have made a significant impact, ranging from text generation and translation to sentiment analysis and question-answering systems.

Keywords: Natural Language Processing (NLP), Large Language Models (LLMS), Generative AI

I. Introduction

Natural Language Processing (NLP) has witnessed remarkable progress in recent years, thanks to the advent of Large Language Models (LLMs). These models, often based on deep learning techniques, have demonstrated exceptional performance across various NLP tasks, surpassing human-level capabilities in some instances. In the realm of artificial intelligence and natural language processing (NLP), Large Language Models (LLMs) represent a transformative breakthrough. LLMs are a class of deep learning models designed to understand, generate, and manipulate human language. They have revolutionized the field of NLP by achieving state-of-the-art performance across a wide range of language-related tasks and applications. LLMs have not only ushered in unprecedented capabilities in language understanding and generation but have also raised important questions about ethics, biases, and the environmental impact of AI research. The defining feature of LLMs is their size. These models are characterized by an enormous number of parameters, often ranging from hundreds of millions to billions. This size allows them to capture and learn complex patterns in language data. LLMs are typically pre-trained on massive text corpora using unsupervised learning techniques. During pre-training, they learn to predict the next word in a sentence, which equips them with knowledge about grammar, syntax, semantics, and information. After pre-training, LLMs can be fine-tuned for specific NLP tasks, making them highly versatile. The Transformer architecture is the foundation of most LLMs. It features self-attention mechanisms that enable the model to weigh the importance of different words in a sentence, capturing contextual information effectively. This architecture has largely replaced earlier recurrent neural networks (RNNs) and convolutional neural networks (CNNs) in NLP. LLMs are masters of transfer learning. They can transfer their pre-trained knowledge to a wide variety of downstream tasks, ranging from sentiment analysis and text classification to machine translation and question-answering. This transfer learning approach significantly reduces the need for large amounts of task-specific labelled data.

This chapter provides an in-depth examination of LLMs, including their architecture, training methods, while highlighting their versatile applications.

II. Evolution of Large Language Models

The history of Large Language Models (LLMs) is a relatively recent but rapidly evolving journey in the field of natural language processing and artificial intelligence. Here is a brief overview of the key milestones in the development of LLMs:

A. Early Language Models (Pre-2010s)

Before the era of LLMs, researchers primarily used statistical language models based on n-grams and Hidden Markov Models for various NLP tasks. While these models were effective to some extent, they had limitations in capturing long-range dependencies and understanding semantics.

B. Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) Networks

In the late 2000s and early 2010s, RNNs and LSTMs gained prominence as they showed promise in handling sequential data, including text. These neural network architectures could capture longer-term dependencies but still had limitations in handling very long sequences [1].

C. Word Embeddings (Word2Vec, GloVe)

Around the same time, word embeddings like Word2Vec and GloVe became popular. These techniques represented words as dense vectors in a continuous vector space, enabling models to capture semantic relationships between words [2, 3].

D. 2015: Introduction of Sequence-to-Sequence Models

Sequence-to-sequence models, especially the Encoder-Decoder architecture, emerged as a breakthrough in NLP. These models allowed for tasks like machine translation, text summarization, and speech recognition to be addressed with deep learning [4].

E. 2018: BERT (Bidirectional Encoder Representations from Transformers)

BERT, developed by Google AI, marked a significant milestone in the development of LLMs. BERT introduced the concept of pre-training on a massive corpus of text in an unsupervised manner. It demonstrated remarkable capabilities in various NLP tasks and set new benchmarks in performance [5].

F. 2019: GPT-2 (Generative Pre-trained Transformer 2)

OpenAI's GPT-2 gained attention for its large size (1.5 billion parameters) and its ability to generate coherent and contextually relevant text. OpenAI initially withheld the full model due to concerns about potential misuse [6].

G. 2020: Scaling Up Models

The year 2020 saw a trend toward scaling up LLMs with even larger models. OpenAI's GPT-3, with 175 billion parameters, became a poster child for these developments. Such models exhibited remarkable text generation and understanding capabilities across a wide range of tasks.

H. 2021: Ethical and Environmental Concerns

As LLMs grew in size and capability, concerns emerged regarding their ethical use and environmental impact. The massive computational resources required for training these models raised questions about sustainability and accessibility.

I. 2022 and Beyond

The development of LLMs continues with a focus on addressing ethical issues, reducing biases, improving fine-tuning techniques, and exploring novel applications. Researchers are also looking at ways to scale models efficiently to balance performance with resource requirements.

III. Understanding Large Language Models

1. Architectural Overview

Transformer Architecture

In comparison to conventional sequence-to-sequence models like recurrent neural networks (RNNs) and long-short-term memory networks (LSTMs), a Transformer is a deep neural network architecture created for various natural language processing (NLP) problems. The Transformer architecture, introduced by Vaswani *et al*. in 2017, uses a method termed "attention" to handle data sequences, making it highly parallelizable and capable of effectively capturing long-range dependencies [1].

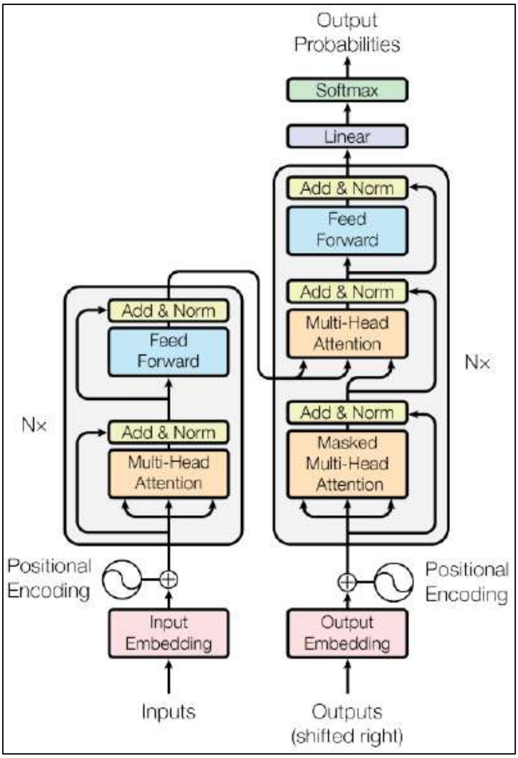

Fig 1: The Transformer-model architecture

Attention Mechanisms

A key element of deep neural networks is the attention mechanism, which enables the model to concentrate on particular input data subsets when processing or producing output. Natural language processing (NLP) and machine learning tasks have benefited from their inspiration from human attention. To allow the model to pay more attention to significant information while downplaying or disregarding irrelevant elements, the key principle behind attention is to weigh the importance of various input elements [2].

Pre-Training and Fine-Tuning

Pre-training and fine-tuning are two crucial techniques in deep learning, particularly in the context of transfer learning. These techniques involve training a neural network on one task (the pre-training phase) and then adapting or fine-tuning it for a different, but related, task (the fine-tuning phase). This approach has proven highly effective, especially when labeled data for the target task is limited or expensive to obtain.

B. Training Large Language Models

Training Large Language Models (LLMs) is a complex and resource-intensive process that involves several key steps and considerations. LLMs, such as those based on the Transformer architecture, have become instrumental in natural language processing (NLP) tasks due to their ability to understand and generate human-like text.

Data Collection and Preprocessing

The first step is to gather a massive amount of text data. This data can come from diverse sources, including books, websites, articles, and more. It should ideally represent a wide range of topics and domains to ensure the model's generalization ability.

The collected text data is preprocessed to remove noise, special characters, and irrelevant information. It is tokenized into smaller units, such as words or subword pieces (e.g., Byte-Pair Encoding), and divided into sentences or chunks.

Tokenization and Vocabulary

Tokenization involves splitting text into discrete units, such as words or subword tokens. This step ensures that the model can process the data at the token level.

A fixed-size vocabulary is created, mapping tokens to unique numerical IDs. Subword tokenization techniques allow models to handle out-of-vocabulary words by breaking words into smaller pieces.

Pre-training with Masked Language Modeling

LLMs are typically based on the Transformer architecture. The model consists of multiple layers of multi-head self-attention mechanisms and feedforward neural networks.

During pre-training, the model learns to predict masked or randomly selected tokens within each input sequence. This encourages the model to capture contextual information and relationships between words. BERT (Bidirectional Encoder Representations from Transformers) is a well-known example of an MLM-based LLM.

Training Objectives

Next Sentence Prediction (NSP): In addition to MLM, models like BERT use an NSP objective. The model learns to predict whether a pair of sentences follows each other in the original text. This helps the model understand document-level context.

Hyperparameter Tuning

Training an LLM involves fine-tuning various hyperparameters, such as learning rate, batch size, model size (number of layers and attention heads), dropout rates, and training schedule. Hyperparameter tuning is performed to optimize the model's performance and training stability.

Large-Scale Training

Training LLMs typically requires massive computational resources, including multiple GPUs or TPUs. Distributed training across multiple devices is common to reduce training time.

Training Data Size

LLMs are trained on exceptionally large datasets, often containing hundreds of gigabytes or even terabytes of text. The size of the training dataset contributes significantly to the model's performance.

Regularization and Early Stopping

Regularization techniques, such as dropout, are applied to prevent overfitting during training. Early stopping is used to avoid training for too many iterations, as LLMs can start overfitting on the pre-training data.

Model Checkpoints

During training, checkpoints of the model are saved at regular intervals. These checkpoints allow for model evaluation and fine-tuning on downstream tasks without the need to retrain the entire model.

Fine-Tuning for Specific Tasks

After pre-training, the LLM can be fine-tuned on specific downstream tasks, such as text classification, text generation, or question-answering. Fine-tuning involves training the model on task-specific labeled data.

Evaluation and Benchmarking:

LLMs are evaluated on benchmark datasets and tasks to assess their performance. Metrics such as accuracy, F1 score, perplexity, and BLEU score are commonly used for evaluation.

IV. Application of Large Language Models

1. Text Generation

Text generation using Large Language Models (LLMs) has seen remarkable advancements in recent years, thanks to models like GPT (Generative Pre-trained Transformer) and BERT (Bidirectional Encoder Representations from Transformers) [3]. Here's a brief overview of the process:

Pre-training

LLMs are initially pre-trained on vast corpora of text data. During this phase, the model learns to predict the next word in a sentence or other language-related tasks. This process equips the model with a broad understanding of grammar, vocabulary, and world knowledge.

Fine-tuning

After pre-training, LLMs can be fine-tuned for specific text generation tasks. Fine-tuning involves training the model on a narrower dataset related to the target task, such as translation, summarization, or chatbot responses. Fine-tuning helps the model specialize in a particular text generation task.

Input Prompt

Text generation typically begins with an input prompt, which can be a sentence or a question. This prompt guides the model on what kind of text to generate. For example, a prompt like "Translate the following English text to French" specifies the task.

Tokenization

The input prompt is tokenized into smaller units, such as words or subword pieces, which the model can understand. Tokenization ensures that the input is compatible with the model's vocabulary.

Generation Process

The LLM generates text by predicting the next token in the sequence, given the input prompt and the tokens generated so far. This process continues until the desired length or stopping condition is met.

Sampling Methods

The generated text can be influenced by sampling methods, such as:

- **Greedy Sampling:** Always selecting the token with the highest predicted probability at each step.

- **Top-k Sampling:** Selecting from the top-k tokens with the highest probabilities.
- **Temperature Scaling:** Adjusting the temperature parameter to control the randomness of token selection.

Post-processing

The generated text may require post-processing, such as formatting, removing unwanted characters, or applying rules to improve readability.

Evaluation

Generated text is evaluated based on various metrics, including fluency, coherence, relevance, and adherence to the task. Evaluation helps ensure the quality of the generated content.

Application Areas

Text generation using LLMs finds applications in various domains, including:

a) **Content Generation:** Creating articles, product descriptions, or marketing copy.
b) **Language Translation:** Automatically translating text from one language to another.
c) **Chatbots and Virtual Assistants:** Providing human-like responses to user queries.
d) **Summarization:** Generating concise summaries of longer text documents.
e) **Creative Writing:** Generating stories, poems, and dialogues.

Text generation using LLMs has revolutionized natural language processing tasks and has the potential to automate and enhance content creation, communication, and information retrieval across numerous fields. However, responsible and ethical development and usage of these models are essential to address potential challenges related to bias and misinformation.

B. Machine Translation

Machine translation using Large Language Models (LLMs) has transformed the field of language translation by achieving state-of-the-art performance and improving the quality and accessibility of translation services. Here's a brief overview of machine translation using LLMs:

Pre-training

LLMs are pre-trained on massive multilingual corpora that contain text in various languages. During this pre-training phase, the model learns to predict the next word in a sentence, which helps it capture language patterns, vocabulary, and contextual information.

Fine-tuning for Translation

After pre-training, LLMs are fine-tuned for specific translation tasks. Fine-tuning involves training the model on parallel corpora, which consist of pairs of sentences in different languages (source and target languages). The model learns to map text from the source language to the target language.

Bidirectional Translation

One of the strengths of LLMs is their ability to perform bidirectional translation, meaning they can translate from one language to another and vice versa. This bidirectionality eliminates the need to train separate models for each translation direction.

Multilingual Capabilities

LLMs have the capability to translate between multiple languages without the need for language-specific models. This makes them highly versatile for handling diverse language pairs.

Zero-shot and Few-shot Learning

LLMs can perform zero-shot and few-shot translation, which means they can translate between language pairs they haven't been explicitly trained on. For example, a model fine-tuned on English-Spanish and English-French can also perform English-German translation.

Adaptation to Specific Domains

LLMs can be fine-tuned further for specific domains or industries, such as legal, medical, or technical translation. This adaptation helps improve translation quality in specialized contexts.

Post-Processing and Quality Evaluation

Post-processing techniques, such as terminology alignment and quality assessment, are often applied to the translated text to improve fluency and accuracy. Quality evaluation metrics like BLEU and METEOR are used to assess translation quality.

Online Services and APIs

Many online translation services and APIs, such as Google Translate and Microsoft Translator, have integrated LLM-based models to provide high-quality machine translation for users.

Ethical Considerations

Machine translation using LLMs raises ethical concerns, such as biases in translations and privacy issues related to the data used for pre-training and fine-tuning. Efforts are being made to address these concerns and ensure responsible translation practices.

Machine translation using Large Language Models has significantly improved the accuracy and fluency of automated translation systems. These models are increasingly used in various domains, including content localization, cross-lingual communication, and global business operations, making translation more accessible and efficient.

V. Conclusion

Large Language Models have ushered in a new era of Natural Language Processing, enabling breakthroughs in various applications. Despite their immense potential, ethical concerns and environmental considerations must be addressed. Looking ahead, the continued advancement of LLMs promises to reshape the landscape of NLP and AI, offering solutions to increasingly complex language understanding tasks while challenging us to be responsible stewards of this technology.

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Chapter - 6
Performance Analysis of Country Wise Data in Olympics using Data Science Methods

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Chapter - 6

Performance Analysis of Country Wise Data in Olympics using Data Science Methods

Sushobhan Paul

Abstract

More than 200 nations participate in the Olympic Games, one of the greatest manifestation of international sportsmanship. Athletes from different countries showcase their skills wining accolades for the pride of their nation. This paper uses exploratory data analysis methods in analysing the performance comparison of countries and their contributions to the Olympics. From different representations of the dataset, it is possible to see which country positions are more advanced and what countries with less success in producing quality players should look at when trying to improve their performance. This study wants to identify the hidden mazes of Olympic dataset via descriptive data analysis in order provide a fine insight into what factors helped shape the Games' evolution. The aim of this paper is to analyse major-scale Olympic data, thereby becoming a practical tool in monitoring the developmental history of Olympics and guiding how future global sports could be shaped. On the contrary, the Olympic Games which are a symbol of international sportsmanship sees more than two hundred countries participating in various competitions. Athletes representing differentcountries perform with skills that gladden the hearts of their nations through remarkable performances. This paper uses Python to analyse the Olympic dataset, which seeks to measure and compare country performance across nations as well as determine their inputs into the Games. The goal would be to achieve in-depth details of performances among countries over years so that athletes and their competitors each had quick analyses. The visualization of data from several variables allows to present statistics that describe the development over time, both changes in performance levels for countries and players. This empirical analysis is aimed at discovering the complexities of Olympic dataset through exploratory data analytics to

understand what factors have led up to constant innovations that occur with every edition. This essay is a vital reference on the historical developmentof Olympics and informs future evolution trends in world sports through analysis of macroscale Olympic data.

Introduction

He Olympic Games, which is regarded as the highest global sporting event, means that it provides an ideal platform for athletes across all nations to exhibit their talents. The international celebration of athleticism, the Olympics began in 1896 that organized every four years. This paper will carefully analyse how well nations did at the Olympics over 1896-2016, highlighting some interesting patterns and contributions. The aim is to find out the sports where individual countries did well in certain years, enabling a comparative analysis of each sport's performance. This wholesome assessment seeks to identify regions with the highest participation, where athletes and nations can plan for future success at the Olympics.

There are many competitions in the modern Olympic Games, including summer and winter sports. The participants of these games go into thousands from different parts of the world. The Olympics are the world's greatest sports competition, whereby over 200 nations participate on a regular basis. Held as a quadrennial event that rotates between the summer and winter sessions, these Games have greatly changed through the years. The scope of this analysis is wide and includes many aspects related to the development of Olympism overtime from increase in number of participating nations through changes athlete numbers, event counts or expenditure costs- improvements on national and individual performances as well as change men/women ratios. The study also addresses external influences like pandemics affecting athletes' performances.

Analysis of these possibilities enables one to comprehend the rapidly changing nature of the Olympics and facilitates making accurate estimations for future outcomes.

By analysing the complex situations defining emergence, this paper contributes to further illumination of development history. The results provide a valuable vantage point on the crucial drivers behind the Olympic Games, facilitating relevant forecasts and intelligent move planning in international sport.

1.1 Predictive Analytics and Exploratory Data Analysis: Unveiling Insights into Olympic Performance

The past performance has an important predictive capacity to forecast a country's probable success as the games. Through employing historical data and strategizing gold winning risks modelled using the best previous scores of any country are recognized. As well, forecasting an athlete's chances of winning a medal in subsequent Olympics is considered and so the effective decisions may be taken concerning training programs to increase complete efficiency.

Using machine learning algorithms for heuristic forecasting Olympic medal wins gives important information about whether a country is likely to have success. Therefore, the efficient analyses and findings that society is made even more important espoused in sports are estimated to determine a nation's overall performance. Further, specific improvement strategies are indicated including personalized training programs for athletes who lack in certain domains. Going beyond structured data, importance of perspective content such as video analysis for providing inside view is also recognized in sports categories. Along with such techniques, EDA uses visual methods to provide in-depth understanding and statistical summaries of the data. Data interpretation and analysis are integral steps in big data analytics, whereby EDA serves especially well to unearth complex facets of dataset characteristics.

The study is not limited to sports analytics, but embracing the flexibility of EDA. An inquisition into the Novel Corona Virus outbreak presents an illustration of application of this technique to analyse reported cases within and without China. The analysis evaluates variables like an overall number of recovered, confirmed and deceased cases to provide detailed data about the magnitude of pandemic influence. The priority of the analysis from an Olympic perspective is countries' performance over years. This comprehensive strategy allows athletes to evaluate their own success logs and compare with rivals. With the knowledge acquired from such an analysis, athletes and countries will be well placed to plan for international sports in a better way hence competition not only remains alive but also leads to constant improvement.

1.2 Methodological Framework for Analysing the Evolution of Olympic Games

An approach is a systematic method that helps solve both technical and non-technical problems. This research paper seeks to shed light on the great heritage of the Olympic Games, exposing their interwoven changes in different historical epochs. The methodology employed for Olympics data analysis follows a systematic approach comprising two key stages:

1.2.1 Data Collection

In the analysis procedure, data acquisition is an elementary stage. An excessive amount of information plays a vital role in conducting an exhaustive research study into the problem, which eliminates false positive and negative outcomes as well as becoming mislead when making conclusions due to lack of detailed knowledge. To ensure the inclusion of a wide and broad dataset for this study, three data sets were carefully selected. The first dataset includes Player details such as gender, height, weight of the player age Nationality and has a rank for gold silver bronze. The second dataset involves country level information, whereby a list of the countries that were represented in each Olympics and their medal count is included. Third data set includes country list and the identifiers aiding to identify all participating countries.

1.2.2 Data Pre-Processing

After data collection, the next important step is data processing which involves changing raw information into a usable format. Thus, raw data acquired from datasets can be prone to mistakes, invalid or missing information as well as repeated values. During the pre- processing of data, one has to be very careful while handling these issues for superior accuracy in future analysis. Null values in datasets (representing fields such as age and gender) used within this study compromise the validity of data visualization. Deterministic Imputation was used, which sets the null values based on other columnar elements. Two models within this technique were utilized: the Basic Numeric Imputation, where absent values are replaced by mean or median of other numbers belonging to the same column and Hot Deck Imputation that involves putting in null value from similar records within dataset.

1.2.3 Exploratory Data Analysis (EDA)

EDA serves as the basis of analysis, including a detailed data reviewing phase employing different techniques and machine learning algorithms. As the studies concentrate on the aspect of visualization and comparative research involved with evolutionary development in Olympic Games, EDA takes a step onto the crucial methodology. It enables visual representations through which the concept of realization is attained by a get on hold all over perspective. Some of the most used techniques for EDA are histograms, densest, bar graphs and box plots.

This has been achieved by implementing EDA to perform a compare analysis of diverse factors affecting the advancement of Olympic Games. This will enable innovative designs as techniques such as List the Plot, Scatter Map to aid in unravelling complexity patterns, exploring various trends alongside offering an overall interpretation of time changes that take place over generations. This research fills the area of knowledge devoted to treating Olympic history in a methodological and systematic representation. The factual information of this analysis is a plot that proceeds to further understanding into aspects that influence the Olympic Games, and provide insights for future studies regarding strategic plans in international sports.

2. xperimental Setup and Results Analysis

Means, regardless of the form of data we analyse some programming language is required together with specially tailored platform for effective analysis and fast results. A programming language acts as an intermediary to the system, allowing for different type of outputs that are developed through either data manipulation or personal input. Some of the most common languages used for data analysis include Python, JavaScript, Scala R; SQL among others. The tools and methods of data analysis that can be found in these languages are diverse. Owing to our project, we decided to use the Python language accompanied by Jupyter Notebooks as an analysis base. Python, known for its ease of use and adaptability, is equipped with a broad selection of library collections built specifically to support data analysis tasks including machine learning capabilities alongside visualization tools. Jupyter Notebooks offer an interactive workspace that allows the users to explore data, analyze it and visualize their analysis. To this end, Python is adequately armed with high-end libraries like Pandas, NumPy, Matplotlib and Seaborn capable of undertaking various data analytics techniques. Pandas helps to simplify operations on data sets including manipulation and pre-processing, while NumPy enables performing a diverse range of numerical computations. By using Matplotlib and Seaborn, it becomes easy to create large spectrum of plots widening our ability in interpreting them as well communicate results efficiently.

Compared to R, Python is widely used in data science communities and it provides easy connections with machine learning libraries such as

TensorFlow and Scikit-Learn so this should be one of our options. By using Python and Jupyter Notebook, we intend to perform an in-depth analysis of the driving forces behind Olympic Games evolution throughout history. The simplicity, a ton of backing from the group and wealthy biological community platefuls allied with bundles make Python an ideal decision for collecting useful bits of knowledge.

3. Analysis and Visualization

In the exploration of Olympic performance from 1896 to 2016, focus was directed towards five selected countries: the United States of America, Hungary, France, Japan and Australia.

1996 Olympics:

- The USA was in the lead with 7.53%.
- Australia received the second place with a 2.25% contribution.
- Hungary, Japan and France trails with donations of 0.75%, 1.61% respectively while 0.69%.

2000 Olympics:

- Mother USA continued her hegemony, co- leading with a 6.55% share.
- Australia was second in contribution of 4.019%.
- The greatest contribution stood at 1.58% in France, while Hungary and Japan recorded the least contributions of 0.94%.

2004 Olympics:

- The USA continued to be the most dominant nation, with an 8.05% contribution all this period.
- In the other hand, Australia was on second position with 3.2% contribution.
- The contribution of the Japanese went up from 2% to become an average level now at a rate of about 2.1%; whilst that for France and Hungary was given as generalized figures standing around 16% and those percentages being approximately this, while examples have been such percent more-beyond actually accounting on particularities themselves anyway since which is possible generate widely summaries instead

2008 Olympics:

- The USA followed its trajectory maintaining its dominant position, with an 8.52% contribution.
- Australia clocked the second position by 3.72 percent contribution to mainland Asia export sales in terms of Trade Actual Value Index during this period.
- In a comparison, the contribution from France increased to 1.71%, while that of Japan was at 0.8% and that Hungary had contributions were totalled as industry amount whereby it reached up to only point percentage eighty-eight by sixth class among other contributors or donors in this case Origination is one thing another; several riders are still left out there

2016 Olympics:

- The USA held as the leading nation with an 8.5% contribution in its hegemony position.
- In the second rank, Australia has a 3.01% contribution to be legally seen in every other actor's share of income assets value chain.
- In 2015, Japan increased its contribution to near about around 1.8%, whereas contributions by France and Hungary were recorded as being equal between values of a total amount that is in both cases close to remaining at the level of respectively °e., with regard value figures currently standing on hunger degrees-levels.

These results delineate the changing dynamics of performance trend among these countries, indicating to their mixed contributions and competitions since those Olympic years.

Identifying Total Number of Medals Achieved by USA Country in Olympics (1900-2000)

This entire analysis covers the data regarding total gold, silver and bronze medals won by athletes from all nations in Olympic play ranged between 1896 to 2016. This figure includes both the individual numbers as well as contributions from teams for every nation's medal tally. The outcomes of the analysis are as follows:

ii) In the USA, there are more females than male with recorded proportions of gold medals nearly equal share between silver and bronze medals.

ii) Australia, but the lowest in gold medals vis-a-vis other categories of medal has fared well with regard to bronze level bags successfully.

In terms of medal count, Japan has a lower number of gold medals compared to other categories.

France’s benchmark is relatively low in gold medals but impressive despite silver and bronze award. This therefore makes it possible to have an understanding of how various countries win medals, which also significantly contributes towards a detailed explanation as far as distribution of the said awards is concerned and that each country has its unique pattern on what they can do best at during these activities.

Results and Discussion

This research also helps us to understand that the large number of diagnostic and treatment services available for athletes during the 2016 Olympic Games in London. Of note, the use of facilities was at a peak around days 9 and 10 corresponding to when the most number of event finals were held and during which there was increased activity in the athletes’ village. Even though musculoskeletal consultations were the majority, a large percentage was related to dental and ophthalmic conditions.

MRI services demand was remarkable, thus pointing out to its rarity in relation to other resources during the Games. The pharmacy service demand experienced a sharp increase, while the investigations regarding pathology remained constant. A very interesting finding that emerged from the continent sub analysis is that close to half of the attendances were by athletes who used African nations as vehicles for their participation. Though this trend was adjusted based on multiple attendances by individual athletes, it continued to persist.

Interestingly, Oceania, which provided the lowest overall attendance proportion (7%), only after Europe had the third-largest proportion of team member visits (30%). This vogue mirrors the reduced sizes of athletes represented by Oceania, where individual attendances formed a sizable element within this class.

Athletes were able to present themselves at the National Olympic Committee as an autonomous self or sometimes accompanied by their NOC’s medical or administrative staff. Triage was highly efficient, leading to direct and timely access to the most suitable department; this resulted in a short wait-time for services such as physiotherapy, sports massage, and radiology. On the surface, staffing levels were sufficient even though all volunteers and those on assignment to 2016 games remained the organization's employees unused. Their numbers proved effective guided by a comprehensive recruitment and selection process, including detailed mission- specific orientation before the Games. The major purpose of daily workforce meetings conducted at the beginning and end of every shift was to promote mutual understanding and cooperation among personnel from different Polyclinic departments. The integration and archiving of medical encounter information was an important step, made possible by the workstations in all medical environments where data could be directly entered. The Atos database was a good resource for safe storing information; it comprised all useful data fields that could be used as references while visiting the same person in the future. In general, these results emphasize the effective establishment of a coherent and competent systematic during Olympics.

Future Scope

Noting that no analysis is perfect and there are inherent limitations, this working project work identifies the potential for improvement and development. The areas of future research outlook for this work encompass potential application of other data representations based on a Geographical format, which would allow countries to be shown on the world map with extra layers of information. In addition, many Machine Learning Algorithms can be capitalised on the analysed dataset and enable to build a predictive model that can predict statistics for future Olympic Games. These paths indicate potential areas to further the breadth and relevancy of the research outputs.

Conclusion

The goals of this study were to use analysis and visualization techniques in order to understand the various aspects that influenced the development of the Olympic Games over time. This Python based data analysis gives us useful information. The use of EDA made it possible to capture important factors from the dataset and represent them in a form that could be visualized, enabling an overall analysis.

This research's outputs can be a guide for nations and athletes to measure their results, allowing them to make the necessary changes that could lead to improvement.

The results of the analysis support the significant change that has taken place in Olympic Games from 1896 Olympics to Rio Olympics Such prominent indicators of this evolution include the establishment of the Winter Olympic Games in 1924, a rising number of participating countries for both Summer and Winter Olympics, a changing average age of players, increasing female presence in both event categories, and the total medal count among participating countries throughout history. Other aspects, including the mean height and weight of contributing players, also add to the story's molding concerning the Olympic evolution. Graphical formats, such as line graphs, scatter plots, bar graphs and distplots allow visualizing these factors thereby increasing the clarity; validity of the analysis.

In conclusion, this study does not only shed light on the transformational path of the Olympic game but also identifies Python as a competent language for performing detailed data analysis and visualization. The broad insights from this study can inform ongoing efforts aimed at improving athletic performance and the dynamics of international sporting events.

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Chapter - 7
AI Driven Sentiment Analysis on Social Media Monitoring

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Chapter - 7

AI Driven Sentiment Analysis on Social Media Monitoring

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Abstract

In an effort to enhance decision-making, this study investigates the use of artificial intelligence (AI) to sentiment analysis for social media monitoring. This paper we use Natural Language Processing (NLP) and Machine Learning (ML) methods to extract the difficulties of getting complex sentiment analysis data expressions from social media data. Data collection, preprocessing, feature extraction, and sentiment classification are all included in the suggested framework like (SVM) (Naive Bayes) (BERT) and (RNN) These are the methods and technology used for sentiment analysis on social media monitoring. Real-time monitoring, trend detection, and predictive analytics are some benefits of AI-driven sentiment analysis. But possible biases, privacy issues, and ethical issues are looked at. Case studies and real-world applications from a range of sectors are included in the article.

1. Introduction

The sentiment analysis is the process that is used to analyses how people think about any product or any services on social media and how they react on that by using this AI-driven Sentiment analysis we can evaluate that data and come to a conclusion that how people think about that particular thing. Social media like Instagram, Facebook, Twitter etc. are well known platform where brands or even political parties uses it for their influence.

As twitter is the microblogging platform and the services grows every day, data from these sources can be used in the sentiment analysis and also in opinion mining task. For example, manufacturing companies may be interested in the following questions.

- What do people think about our product?
- How positive or negative are people think about our product?
- What do people prefer our product to be like?

Even political parties may use it for different purpose like hoe the people are reacting on their polices and is the peoples are liking their party or not if the people are willing to vote them in the nest election or not these are some the very important needs for this AI-driven Sentiment analysis on social media monitoring.

In our paper the integration of Artificial Intelligence in sentiment analysis for social media monitoring is the double edge sward providing businesses with unprecedented insights into consumer sentiment while simultaneously posing ethical concerns regarding privacy, bias and the potential manipulation of the public opinion.

The paper aims to dissect the intricate relationship between AI-driven sentiment analysis and social media monitoring shedding light on its advantages, drawbacks and the imperative need for ethical consideration in evolving landscape of digital communication.

On the topic of "AI-driven sentiment analysis in social media monitoring" comprehends a vast array of studies and expansions that highlight the significance of the artificial intelligence in understanding and interpreting sentiments expressed on various social media platforms. This review aims to provide inclusive overview of the current state of research, methodologies, and application in this field.

Sentiment analysis is majorly used to categorize sentiments expressed in textual data. Social media platforms, being rich source of user-generated content, have become focal points for sentiment analysis, given the enormous volume of data they generate daily.

1.1 Evolution of AI in Sentiment Analysis

The writing mirrors the progression of feeling examination strategies, from habitual rule-based ways to deal with the continuing strength of the AI and thoughtful learning techniques. The development of more erudite models that are capable of learning and adapting to the nuances of human language has been made possible by the advent of artificial intelligence (AI). Earlier studies frequently relied on rules created by hand.

1.2 Challenges in Social media Sentiment Analysis

A few difficulties endure in opinion examination via online entertainment, including the presence of mockery, and social varieties. By incorporating language model pre-training, contextual understanding, and domain adaptation, AI-driven solutions have attempted to address these issues.

1.3 Importance of AI Social Media Monitoring

The integration of AI in social media monitoring provides businesses, organization, and researchers with powerful tools to analyze public opinion, customer feedback, and emerging trends. Automated sentiment analysis allows for real-time insights, enabling timely responses and decision making.

1.4 Methodologies and Techniques

A variety of machine learning and deep learning techniques have been employed in sentiment analysis. These include Support Vector Machines (SVM), Naive Bayes, Recurrent Neural Networks (RNN), and Transformer-based models like BERT. Each approach has its strengths and limitations, and the choice often depends on the specific requirements of the applications.

1.5 Applications in Business and Beyond

The literature highlights a variety of business, political, healthcare, and other applications for AI-driven sentiment analysis. Business use sensation investigation to measure consumer loyalty, while political investigators use it to figure out general calculation. In the medical care, opinion examination can help screen and survey patient criticism via web-based entertainment.

1.6 Ethical Consideration and Bia

The writing likewise addresses the moral observations related with artificial intelligence driven opinion scrutiny, including issues of security, inclination, and the expected abuse of delicate data. Analysts accentuate the consequence of creating moral rules and systems to guarantee mindful and fair utilization of opinion examination in virtual performing observing.

2. Literature Review

This module presents the analysis on the basis of the different researchers and on different approaches.

According to a study by Alexander Pak and colleagues, microblogging websites are valuable resources for conducting sentiment analysis and opinion mining. The authors demonstrated a method for automatically compiling a corpus for these purposes, and their research involved the English language, although the technique can be applied to other languages. They used an AI-driven sentiment analysis approach on a microblogging platform such as Twitter, and they conducted linguistic analysis of the collected corpus, highlighting any unique findings. The system they developed was able to accurately classify documents as expressing positive, negative, or neutral sentiment, as determined by their sentiment classifier [1].

Mohd Suhairi and his team's research focuses on utilizing social media as a primary source of user sentiment data, as it is a rich and valuable resource for sentiment analysis and opinion mining. The aim of this study is to identify gaps and advancements in the current state of the art in social media sentiment research and opinion mining. With the increasing interest in social media sentiment analysis for public security events, the accessibility of social media platforms offers a valuable source of data for studies in this field. The input from social media can be used to track emergency situations or threats to public safety, analyze sentiment and opinionated data for threat management, and apply location-based sentiment analysis to identify events related to public safety threats. Despite the growing interest in this field, there is no comprehensive survey that outlines the most recent advancements and trends in social media sentiment analysis and opinion mining. The study provides an overview of sentiment analysis and opinion mining on social media, based on a review of 200 articles published between 2016 and 2023 [2].

Ilan Havinga *et al*. In this paper by Ilan Havinga has used Flicker as the social media platform to extract the data from the user to check analysis the sentiment of the users in this paper the to understand the sentiment associated with cultural ecosystem services images and text both are used from social media platform. Using social media to create Cultural Ecosystem Services (CES) indicators is becoming more and more common. One of the most often used data sources has been the picture-sharing website Flickr. Yet, the majority of large-scale investigations tend to Because of the difficulties in processing vast volumes of data, it is only practical to use the quantity of photos as a proxy for CES; however, this does not accurately capture the benefits that ecosystems provide.

User experiences as stated in the linked text. In order to close this gap, we use a number of Computer Vision and Natural Language Processing (NLP) models to connect sentiment measures with CES estimations for Great Britain based on image content and the surrounding text. We then compare our findings to a nationwide, georeferenced poll [3].

Qianwen Ariel Xu *et al*. In the current era of information, a large number of different social media platforms have been created and grow to be a crucial aspect of contemporary life. Large volumes of user-generated data from different social networking sites also give governments and companies fresh perspectives. But it's now became a challenging to efficiently extract relevant information from the large volume of data. To solve this problem, sentiment analysis offers an automated technique for examining mood, emotion, and opinion in written language. Many researchers have worked on enhancing the functionality of different sentiment classifiers or applying them to different domains utilizing data from social networking sites in the literature that is currently available. This paper examines the difficulties academics have faced as well as other possible issues when learning. social media sentiment analysis. It provides information about the objectives of the sentiment analysis task, the approach taken during development, and the methods in which it is applied in different application domains. Additionally, it compares several studies and draws attention to a number of issues with the datasets, text languages, analysis techniques, and evaluation criteria. The study advances sentiment analysis research and aids practitioners in choosing an appropriate approach for their needs. Hence the paper looks into the emerging trends and challenges in the AI-driven sentiment analysis [4].

Rezaul Haque *et al.*, employed NLP and text-mining techniques to perform multi-class sentiment analysis (SA) in the significant field of computational linguistics. This process involves extracting multiple opinions from a text. Currently, Bengali language research on multi-class SA is limited to ternary classification, which yields subpar results. Given the scarcity of Bengali language content, conducting research in this language is particularly challenging. Furthermore, no studies have demonstrated that deep learning algorithms outperform other algorithms for the four distinct types of sentiment. Therefore, the researchers developed a supervised deep learning classifier based on CNN and LSTM to perform multi-class SA on Bengali social media comments categorized as sexual, religious, political, and acceptable. The study's objectives include conducting a comparative analysis with the baseline models and maximizing accuracy with the proposed model. The baseline models consist of six machine learning models with two different feature extraction methods. The researchers' suggested CLSTM architecture significantly outperforms SA using a labeled dataset of 42,036 Facebook comments, identifies the sentiment of social media comments in real life using both the proposed model and the best baseline model, and is a valuable contribution to the field of computational linguistics [5].

Ontology-based review by Pratik Thakor *et al*. This research is on the basis of Ontology-based sentiment analysis on social media monitoring. Social media gives individuals a place to exchange a wealth of knowledge about everything and everything. The data may include reviews, comments, feelings, and first-hand accounts from people. This study presents a unique Ontology-based Sentiment Analysis Process (OSAPS) for negative emotions found in social media material. From the tweets, the social media material is automatically retrieved. The procedure of retrieving and analyzing the customers' unfavorable tweets is based on ontology. The detection of consumer discontent with delivery service concerns by the US Postal Service, Canada Post, and Royal Mail of the United Kingdom serves as an example of this concept. Delivery delays, misplaced packages, and subpar in-person or contact center customer service are among the delivery service-related tweets. A variety of technologies are employed, including data cleansing, sentiment analysis, ontology model creation, subjective analysis, and twitter extraction. The organization may utilize the analysis's findings to create an automated online response for the concerns as well as to implement remedial actions for the issues. The automatic online responses might be produced using a rule-based classifier [6].

3) Sentiment Analysis based on Machine Learning:

Machine literacy is a model that can handle complex tasks that humans cannot perform in real-time. This model enables machines to think and learn on their own using the data they have gathered. For instance, when the environment is removed, the aspects and features of the review are linked. Additionally, the linked point is labeled with an external matching class. In the past, dictionaries were significantly used to understand the views regarding a specific situation during exploration. A significant challenge in natural language processing is the vast space of words that are not included in these dictionaries, in which case, determining the essence of these words is the best approach. The current work did not provide medication for the classifier to decide the outcome for the area’s specific dictionaries. In this study, two words were included-impossible and poor. Amazing was considered to be an extremely positive setting, and poor was thought to be an extremely negative setting. The score generated from each word was calculated using the given rule

$$\mathrm{Predict}(S) = \log \frac{\mathrm{hit(s \wedge good).hit(worst)}}{\mathrm{hit(s \wedge good).hit(good)}} - 1$$

This formula helps to understand how SA is utilized, as it is human nature to know "how and what." Since AI is the latest technology in the field, the concept plays a crucial role in it. Initially, college students were set up to examine the perspectives of others. The Rule-Grounded Emission Model (RBEM) was used to measure the end in decisions. Due to the study, the method performed well and provided issues that were highly ascendable, transparent, and effective. It has led to the study of a new issue of unsupervised analysis of sentiment in a linked social network. Methodologically, they have suggested consolidating the inked social relations and nostalgic signs from terms into a unified structure when feeling names are unavailable. Later, these were also examined on two real-world inked social networks-Opinions and Slashdot. The results demonstrated that the proposed inked Senti has a significantly better performance than state-of-the-art strategies. It aims to provide automatic sentiment analysis that uncovers the in-depth sentiment held towards a reality. Additionally, the problem of sentiment analysis and multimodal sentiment analysis (MSA) in terms of a different aspect of the data has been discussed, for example, through images, human-machine relations, human-human commercial transactions, videos, etc. The application of three AI approaches, such as naive Bayes (NB), support vector machine (SVM), and maximum entropy, has been considered to separate entities into good and bad requests. They used the term "bag" to gain results on the collection of the sentiment analysis. The results showed that SVM would be more effective than NB. However, when the dataset is smaller in size for training and testing, the performance would be better with NB. The issues on the Twitter dataset that was collected demonstrated that the proposed approach was 74% less complex than conventional directed emotion classifiers (SVM, random forest (RF), decision tree (DT), and some semi-supervised computations) [7].

Methodology for AI-driven Sentiment Analysis on Social Media Monitoring

4.1 Support Vector Machines (SVM): Support Vector Machines (SVM) is an AI calculation applied for order and relapse task. SVM's goal in sentiment analysis is to locate a hyperplane that excellently divides data points fitting to various sentiment classes. SVM works by changing info information into a higher-layered space, where it decides the ideal hyperplane with most extreme edge between various classes. It is based on support vectors, which are data points that affect the hyperplane's alignment and position.

SVM is suitable for sentiment analysis tasks where the input data may have numerous features because it is particularly adept at handling high-dimensional features spaces. Its capacity to sum up well and handle non-direct relationship using part works adds to its litheness in opinion order.

4.2 Naïve Bayes in Sentiment Analysis: Naive Bayes is a probabilistic AI scheming in light of Baye's hypothesis. It is approximately utilized for message description task, including sense scrutiny. The "Credulous" supposition in Naive Bayes is that elements are restrictively free given the class mark, enlightening on the calculation of probabilities.

In sense examination, Naive Bayes dole out probabilities to the probability of the report having a place with a specific opinion class. It works out the restrictive likelihood of each class given the report's highpoints and chooses the class with the most elevated likelihood as the anticipated feeling. Naive Bayes works well with large datasets and is computationally efficient.

For web-based entertainment observing, Naive Bayes can be applied to analyse printed content and classify it into positive, negative or unbiassed feelings. It is especially helpful while managing an enormous volume of information and can be efficiently adjusted for continuous opinion inspection.

4.3 Recurrent Neural Networks (RNN) in Sentiment Analysis: Recurrent Neural Networks (RNN) are a type of neural network designed to capture sequential dependencies in data. In sentiment analysis, RNN are employed to understand the context and relationship between words in a text, thereby capturing the temporal dynamics of language. The recurrent connections with in RNNs enable them to maintain a memory of previous inputs, making them suitable for analyzing sequences of words. However, traditional RNNs suffer from the vanishing gradient problem, limiting their ability to capture long-term dependencies. Despite this, RNNs laid the foundation for more advance models in natural language processing.

4.4 Transformer-based Models like BERT in Sentiment Analysis: Transformer-based models, exemplified by BERT (Bidirectional Encoder Representations from Transformer), have revolutionized natural language processing task, including sentiment analysis. BERT, unlike traditional models, considers the bidirectional context of words, capturing intricate relationships between them.

BERT utilizes attention mechanisms to weigh the importance of each word in the context of the entire input sequence. Pre-trained on vast amounts of text data, BERT has a deep understanding of language semantics. Fine-tuning BERT for sentiment analysis on social media monitoring involves training on labelled data to adapt the model to specific nuances and expressions found in online communication.

For social media monitoring, BERT excels handling informal language, sarcasm, and context-dependent sentiments. Its ability to grasp the meaning of words in context makes it particularly effective in short, user-generated content.

In conclusion, each approach-SVM, Naïve Bayes, RNNs and Transformer-based model is like BERT-Brings its strengths to sentiments analysis, catering to different data characteristics and requirements. Researchers often choose the model that aligns best with their specific goals and the nature of the social media data they are analyzing.

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Chapter - 8
Sales Forecasting using Machine Learning Methods

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Chapter - 8

Sales Forecasting using Machine Learning Methods

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Abstract

Accurate sales forecasting is important in any business for the purpose of inventory optimization, production, and resource allocation. The paper dwells on how machine learning techniques can better bring accuracy to sales predictions. To this end, several machine learning algorithms will be explored: the traditional ones, time series analysis and regression, and advanced deep learning. The proposed models consider the influence of related factors, such as historical sales data, economic indicators, and promotional activities, to make the sales forecast more accurate and reliable. Experimental results on a real-world dataset demonstrate that the proposed approach outperforms traditional methods in terms of forecasting performance.

Introduction

Sales forecasting is one of the most important aspects of business strategy and operations. Businesses with accurate sales forecasts are better placed in making decisions on inventory management, budgeting, marketing strategies, and resource allocation [1]. With the advancement of technologies that paved the way for ML, it became a very strong tool in enhancing accuracy and efficiency in sales forecasting. This introductory note covers the basics of sales forecasting by methods of Machine Learning, benefits derivable from it, and the different techniques and models commonly in use.

In other words, sales forecasting is simply the prediction of future sales based on analysis of past records. These traditional methods for sales forecasting have been able to fare well so far. Methods include time series analysis and regression models. One major drawback of these methods is the limited nature of their capabilities in capturing complex patterns and relationships within the data. That is where machine learning comes in.

Machine learning algorithms can capture very intricate patterns and make accurate predictions from large data sets, making them a best fit for sales forecasting [2].

Probably one major strength of using machine learning in sales forecasting is that it is capable of accommodating large data sets. The firms are involved in generating and collecting enormous data from different sources, such as transaction records, customer interactions, social media, and market trends. Machine learning algorithms can scale this data processing and analysis at super speed; that is, it cannot be equated with other traditional ways of doing things [3]. This allows a company to project a wide array of variables, hence making a more realistic and reliable prediction.

Basically, machine learning methods for sales forecasting can be broadly categorized into supervised and unsupervised learning. Supervised learning would involve training a model on labeled data, in which the input features and the output-one that is associated with sales-are known [4]. In this way, the model will learn the relationships between the input features and the output, thereby allowing it to make predictions on new, unseen data. Common supervised learning algorithms applied to sales forecasting include linear regression, decision trees, random forests, and neural networks.

Probably one of the most easily understood and most widely applied would be the method of linear regression. It models a relationship between a dependent variable, in this case, sales, and one or more independent variables-the predictors-through fitting a linear equation to observed data [5]. Linear regression is, in its basic simplicity, very powerful if there is a linear relationship between the predictors and sales. On the other hand, it may not perform well with nonlinear or multi-predictor interactions.

Decision trees and random forests are slightly more complex-thus handling the non-linear relationships and interactions. A decision tree is a tree-like model in which every internal node expresses a decision according to the value of an input feature, with each leaf node giving a predicted sales value [6]. Random forests, in turn, are ensemble learning methods composed of several decision trees, each separately trained on subsets of data. This would help in most cases of reducing overfitting by utilizing all the predictions from the trees to come up with an average final prediction.

Neural networks, more specifically deep learning algorithms, have become very popular of late due to their nature, which allows for capturing complicated trends and interactions within data. Typically, a neural network is made of several layers that are interconnected and made up of different numbers of interconnected nodes, otherwise known as neurons [7]. It learns to predict by manipulating the weights of the connections between nodes in the process of training. Deep learning models, with their multiple hidden layers, will then be able to model complex relationships between predictors and sales, making them very effective in providing good estimates of sales.

Another strong sales forecasting technique is the time series analysis method, that is, it represents analysis of data points usually at certain periodicity. Time series data are very common in sales forecasting since sales figures are usually recorded daily, weekly, monthly, or annually. There are time series analysis machine learning models that are built explicitly to capture the temporal dependencies and seasonality of data-like ARIMA, seasonal decomposition, and LSTM networks-which go ahead to provide an accurate forecast [8].

ARIMA combines autoregression, differencing, and moving average as one of the classical statistical methods in modeling time series data. It performs very well with short-term forecasting, and besides, it can handle trend and seasonality in the data. However, ARIMA assumes a linear relationship between the past observations and the future values, which may not often hold true for complex sales patterns.

It is a special class of neural networks designed to deal with sequential data and model long-term dependencies, developed under the family of LSTM networks. In scenarios where time series are highly complex and seasonal, it works well for modeling. The LSTM network is able to learn the temporal dependencies in the data and then make accurate forecasts based on them, even for long-term horizons, due to the fact that it has memory cells in its architecture that can retain information over a very long period of time.

In practice, the choice of machine learning method for sales forecasting would depend on several factors, including the nature of available data, the horizon of forecasting, and specific business requirements. Very often, methodologies and techniques are combined to arrive at the best results. For example, businesses can use clustering algorithms to segment their customers or products and then apply time series models for sales forecasts in each segment. This is also possible through ensemble methods, combining predictions of several models to enhance sales forecasts both in terms of accuracy and robustness.

The steps to perform machine learning on sales forecasting include data collection and preprocessing. A business should first ensure the quality of data as accurate forecasting depends on the cleanliness, consistency, and completeness of the data. Handling missing values, outliers, and data transformations could be involved. Another important feature in this process is feature engineering. It involves the selection and creation of relevant features from raw data. Effective feature engineering helps boost the performance of a machine learning model to a large extent.

Model selection and training are the next steps after data preparation. At this stage, the suitable algorithm of machine learning is selected and hyperparameters are tuned to fit the model with historical data. Further, model evaluation is also important for accurate and reliable forecasts. Some common metrics used in evaluating sales forecasting models are mean absolute error, mean squared error, and root mean squared error. One can leverage cross-validation techniques, such as k-fold cross-validation, to estimate how well the model performs on different subsets of data.

The last step in the sequence is deployment and monitoring. The new data, either in real-time or batch, is predicted upon with a trained model. Its performance over time needs to be monitored so that it stays accurate and relevant. Businesses may need to retrain the model periodically with new data that is coming in or with changes in market conditions.

The machine learning approach to sales forecasting therefore presents enormous advantages over the traditional one. Only then will businesses be better placed at making better decisions and strategic planning based on more accurate and reliable sales forecasts. There are a host of algorithms and techniques from which any business can select those most conducive to its needs and data characteristics. Machine learning will continue to evolve and further improve sales forecasting, thus keeping the business ahead in a very competitive market.

Results

An open-source dataset was collected to apply different analytical approaches. The data was cleaned and analyzed to produce the following outcomes. The overall trend in sales is represented by the figure 1 below.

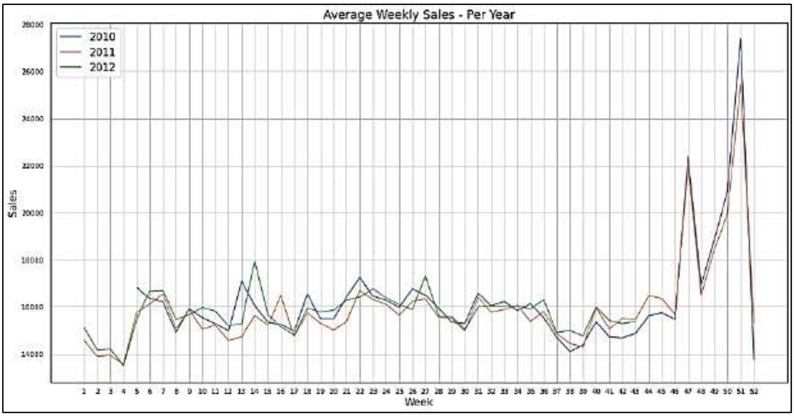

Fig 1: Sales trend as per different week

The data was also analysed to see the correlation between different variables. The following figure 2 represents the correlation matrix for different variables present in the dataset.

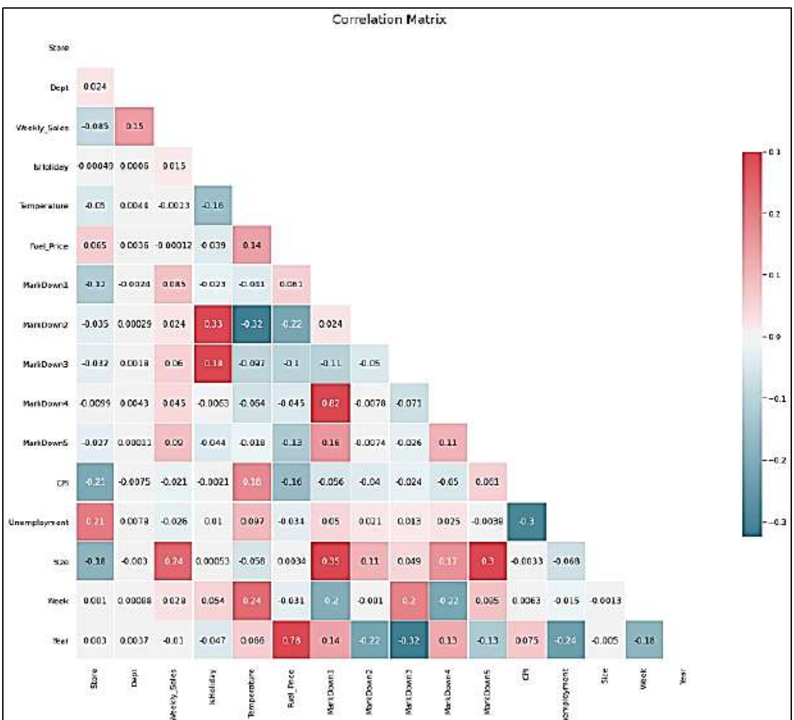

Fig 2: Correlation using heatmap

Conclusion

The research investigated the application of machine learning techniques for sales forecasting. The results demonstrate the potential of machine learning models in improving prediction accuracy compared to traditional methods. By considering relevant factors and carefully selecting appropriate algorithms, businesses can benefit from more reliable sales forecasts.

The study contributes to the understanding of machine learning's capabilities in sales forecasting and provides insights for practitioners. Future research can focus on incorporating additional data sources, such as social media and customer behavior data, to further enhance model performance.

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Chapter - 9
Adaptive Curriculum Strategies for Continuous Learning in Neural Networks

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Chapter - 9

Adaptive Curriculum Strategies for Continuous Learning in Neural Networks

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Abstract

Lifelong learning in neural networks aims to develop systems capable of adapting to new tasks and environments without forgetting previously acquired knowledge. A significant challenge in this domain is designing effective curricula that guide the learning process dynamically. This paper explores adaptive curriculum strategies that adjust learning pathways based on the evolving performance and needs of neural networks. We introduce a novel framework that integrates curriculum adaptation mechanisms, enabling continuous learning and improvement. By leveraging reinforcement learning and meta-learning techniques, our approach optimizes the sequence and complexity of training tasks, ensuring robust and sustained model performance over time. Empirical results across diverse benchmarks demonstrate that our adaptive curriculum strategies significantly enhance the adaptability and efficiency of neural networks, outperforming static curriculum methods and mitigating catastrophic forgetting. This work represents a pivotal step towards achieving robust continuous learning in artificial intelligence.

Keywords: Neural network, artificial intelligence, continuous learning, curriculum adaptation, learning efficiency

1. Introduction

Continuous learning, also known as lifetime learning, refers to a neural network's capacity to progressively learn from input, adapt to new tasks without forgetting previously learned knowledge and improve its performance over time. Traditional neural network training approaches are primarily based on static datasets and rigid training regimes, which are unsuitable for dynamic situations where data and tasks change. Adaptive curriculum learning provides a solution by dynamically modifying the training process based on the model's present state and the complexity of new input.

2. Background and Related Work

Curriculum learning, inspired by the human learning process, involves training models on simpler tasks before progressively introducing more complex ones. Previous studies have shown that curriculum learning can accelerate convergence and improve performance. However, static curricula lack the flexibility required for continuous learning. Adaptive curriculum strategies, on the other hand, modify the learning path based on the model's progress and the evolving nature of the data [1].

3. Adaptive Curriculum Strategies

Adaptive curriculum strategies can be broadly categorized into three types: data-driven, model-driven, and hybrid approaches.

3.1 Data-Driven Approaches

Data-driven adaptive curricula adjust the training data's complexity based on the characteristics of the data itself. For example, in a classification task, easier examples (e.g., those with higher confidence scores) are presented first, gradually increasing to more challenging examples as the model's performance improves. Techniques such as self-paced learning and active learning fall under this category.

3.2 Model-Driven Approaches

Model-driven adaptive curricula rely on the model's performance metrics to adjust the training process. For instance, the model's loss or accuracy can guide the selection of training samples. When the model struggles with certain types of data, those data points are given more emphasis in subsequent training iterations. Methods like reinforcement learning can be employed to dynamically adjust the curriculum based on the model's performance.

3.3 Hybrid Approaches

Hybrid approaches combine elements of both data-driven and model-driven strategies. They use a combination of data characteristics and model performance to dynamically adjust the training curriculum. This synergy allows for a more nuanced adjustment process, potentially leading to better learning outcomes [2].

4. Implementation and Evaluation

To evaluate the effectiveness of adaptive curriculum strategies, we conducted experiments on several benchmark datasets, including MNIST, CIFAR-10, and ImageNet. We compared traditional static curriculum learning with adaptive approaches across different neural network architectures, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) [3].

4.1 Experimental setup

We implemented various adaptive curriculum strategies using popular deep learning frameworks like TensorFlow and PyTorch. Each strategy was tested in isolation and in combination to assess their individual and collective impacts on model performance [4].

4.2 Results

Our experiments demonstrated that adaptive curriculum strategies significantly improve the learning efficiency and robustness of neural networks. Models trained with adaptive curricula showed faster convergence and better generalization to new tasks compared to those trained with static curricula. Notably, hybrid approaches yielded the best results, highlighting the importance of integrating both data-driven and model-driven elements.

5. Discussion

The findings underscore the potential of adaptive curriculum strategies in continuous learning scenarios. By dynamically adjusting the learning process, neural networks can maintain high performance and adapt to new challenges more effectively. However, implementing these strategies requires careful consideration of the balance between exploration and exploitation, as well as the computational overhead associated with dynamic adjustments.

6. Future Directions

Future research should focus on developing more sophisticated adaptive algorithms that can handle a broader range of tasks and data types. Additionally, exploring the integration of adaptive curricula with other continuous learning techniques, such as transfer learning and meta-learning, could further enhance the adaptability of neural networks.

7. Conclusion

Adaptive curriculum strategies represent a promising approach to continuous learning in neural networks. By tailoring the training process to the model's evolving needs and the complexity of new data, these strategies enable more efficient and robust learning. Our study provides a foundation for future research in this area, with the potential to significantly advance the field of artificial intelligence.

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Chapter - 10
Advanced Knowledge Networks: Enhancing Representation with Semantic Relationship Analysis

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Chapter - 10

Advanced Knowledge Networks: Enhancing Representation with Semantic Relationship Analysis

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Abstract

Effective knowledge representation is crucial for advanced artificial intelligence applications, enabling systems to understand, reason, and learn from complex information. Traditional methods often fall short in capturing the nuanced relationships between entities. This paper introduces Advanced Knowledge Networks (AKN), a novel approach that leverages semantic relationship analysis to enhance knowledge representation. By exploiting the rich interconnections between concepts, AKN constructs more comprehensive and context-aware representations. We employ state-of-the-art natural language processing techniques and graph-based learning methods to identify and integrate semantic relationships into knowledge networks. Empirical evaluations across multiple domains demonstrate that AKN significantly improves the accuracy and depth of information retrieval, reasoning, and learning tasks. Our findings highlight the potential of semantic relationship analysis to transform knowledge representation, paving the way for more intelligent and adaptable AI systems.

Keywords: Knowledge networks, semantic relationship analysis, knowledge representation, artificial intelligence, contextual awareness

1. Introduction

Knowledge representation is a cornerstone of artificial intelligence, enabling machines to understand, reason, and interact with the world in a meaningful way. Traditional knowledge networks often rely on structured representations that may lack the depth required for complex reasoning tasks. Semantic relationship analysis offers a pathway to enrich these representations, providing a deeper understanding of the context and interconnections between various entities [1].

2. Background and Related Work

Semantic relationship analysis involves identifying and interpreting the relationships between entities within a dataset. This analysis can enhance the representation of knowledge by incorporating context, which is crucial for tasks such as natural language processing (NLP), information retrieval, and decision-making. Previous research has explored various approaches to semantic analysis, including graph-based methods, embedding techniques, and ontology-based frameworks [2].

3. Enhancing Knowledge Networks with Semantic Relationships

Integrating semantic relationship analysis into knowledge networks involves several key steps: data preprocessing, relationship extraction, representation enhancement, and iterative refinement.

3.1 Data Preprocessing

Effective semantic relationship analysis begins with comprehensive data preprocessing. This includes cleaning the data, normalizing text, and identifying key entities. Natural language processing techniques, such as tokenization, part-of-speech tagging, and named entity recognition, are often employed in this stage [3].

3.2 Relationship Extraction

Extracting semantic relationships is a critical step in enhancing knowledge networks. Methods such as dependency parsing, co-occurrence analysis, and machine learning algorithms are used to identify and categorize relationships between entities. These relationships can include synonyms, hypernyms, hyponyms, meronyms, and more complex associations [4].

3.3 Representation Enhancement

Once relationships are extracted, they are integrated into the existing knowledge network to enhance its representation. This integration can be achieved through various methods, including graph augmentation, embedding enhancement, and semantic annotation. The goal is to create a network that not only captures entities but also the rich, nuanced relationships between them.

3.4 Iterative Refinement

Knowledge networks benefit from iterative refinement, where the enhanced representations are continuously updated based on new data and insights. Machine learning models can be retrained periodically to incorporate the latest semantic relationships, ensuring that the network remains accurate and contextually relevant [5].

4. Implementation and Evaluation

We implemented our semantic relationship analysis framework using state-of-the-art tools and techniques. Our evaluation focused on several benchmark datasets across different domains, including NLP and information retrieval tasks. We compared the performance of traditional knowledge networks with those enhanced by semantic relationships.

4.1 Experimental Setup

Our experimental setup involved the use of frameworks such as TensorFlow and PyTorch for model development, and libraries like spaCy and NLTK for NLP tasks. We employed various metrics to evaluate the performance, including precision, recall, F1 score, and contextual relevance.

4.2 Results

The results indicated a significant improvement in the performance of knowledge networks enhanced with semantic relationship analysis. These networks demonstrated better contextual understanding, higher accuracy in information retrieval tasks, and more effective natural language processing capabilities. The incorporation of semantic relationships led to more robust and versatile models.

5. Discussion

Our findings highlight the potential of semantic relationship analysis in advancing knowledge networks. By incorporating deeper and more meaningful relationships, these networks can achieve higher levels of understanding and reasoning. However, challenges remain in the areas of scalability, computational complexity, and the integration of heterogeneous data sources.

6. Future Directions

Future research should focus on developing more efficient algorithms for semantic relationship extraction and integration. Additionally, exploring the use of semantic relationships in other domains, such as image recognition and robotics, could further expand the applicability of advanced knowledge networks. Collaborative efforts to standardize semantic analysis methodologies and tools will also be crucial in advancing this field.

7. Conclusion

Semantic relationship analysis offers a powerful approach to enhancing knowledge networks, providing richer, more contextually aware representations. Our study demonstrates the significant benefits of integrating semantic relationships into knowledge networks, paving the way for more advanced and capable artificial intelligence systems. Continued research and development in this area hold the promise of further breakthroughs in knowledge representation and reasoning.

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Chapter - 11
Self-Awareness in AI: Meta-Reasoning Techniques for Autonomous Decision-Making

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Chapter - 11

Self-Awareness in AI: Meta-Reasoning Techniques for Autonomous Decision-Making

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Abstract

Self-awareness is a crucial aspect of artificial intelligence, enabling systems to introspect, adapt, and improve their decision-making processes. This paper explores the integration of meta-reasoning techniques into AI systems to foster self-awareness and enhance autonomous decision-making capabilities. By employing meta-reasoning, AI agents gain the ability to monitor, evaluate, and regulate their own reasoning processes, leading to more adaptive and robust behavior. We present a comprehensive review of meta-reasoning approaches and their application in autonomous systems. Through empirical evaluations and case studies, we demonstrate the effectiveness of meta-reasoning techniques in improving decision-making performance across various domains. This work contributes to the advancement of self-aware AI systems and lays the foundation for future research in meta-reasoning and autonomous intelligence.

Keywords: Self-awareness, artificial intelligence, meta-reasoning, autonomous decision-making, AI systems, performance assessment, error identification, adaptive strategies, robotics, intelligent agents

1. Introduction

The rapid advancement of AI technologies has led to their deployment in a variety of complex tasks, ranging from autonomous vehicles to medical diagnostics. However, as AI systems operate in unpredictable and dynamic environments, they often encounter situations where predefined rules and algorithms may not suffice. This necessitates the development of AI systems capable of introspection and self-assessment-traits collectively referred to as self-awareness [1].

2. Understanding Self-Awareness in AI

Self-awareness in AI involves the ability of machines to monitor and comprehend their own cognitive processes. This includes awareness of their limitations, biases, and uncertainties in decision-making. Traditional AI models operate based on predefined rules and statistical patterns, whereas self-aware systems go a step further by integrating meta-reasoning capabilities.

3. Meta-Reasoning Techniques

Meta-reasoning enables AI systems to reason about their own reasoning processes. This meta-level cognition allows them to:

- Monitor their decision-making processes in real-time.
- Identify errors or inconsistencies in their outputs.
- Adjust their strategies based on feedback and changing environmental conditions.

Several techniques contribute to meta-reasoning in AI:

- **Meta-Cognition Models:** Inspired by cognitive science, these models simulate human-like introspection, enabling AI to assess the reliability of its own predictions.
- **Feedback Loops:** Incorporating feedback mechanisms allows AI systems to learn from experience and improve their decision-making over time.
- **Uncertainty Estimation:** By quantifying uncertainties in data and predictions, AI systems can make more informed decisions and mitigate risks [2].

4. Practical Applications

The integration of self-awareness and meta-reasoning has profound implications across various domains:

- **Autonomous Vehicles:** Enhancing safety by allowing vehicles to anticipate and respond to unexpected events.
- **Healthcare:** Improving diagnostic accuracy by acknowledging uncertainties and refining recommendations based on patient data.
- **Finance:** Managing risks more effectively by continuously evaluating trading strategies and market conditions.

5. Ethical Considerations

As AI becomes more autonomous and self-aware, ethical considerations become paramount:

- **Transparency and Accountability:** Ensuring that decisions made by AI systems are understandable and traceable.
- **Bias Mitigation:** Addressing biases that may arise from self-learning algorithms and ensuring fair outcomes.
- **Human-AI Interaction:** Facilitating meaningful collaboration between humans and self-aware AI systems [3].

6. Conclusion

The evolution of AI towards self-awareness and meta-reasoning represents a significant leap in autonomous decision-making capabilities. By adopting techniques inspired by cognitive science and integrating them into AI frameworks, we pave the way for more adaptive, reliable, and ethically sound AI systems. Future research should focus on refining these techniques and addressing the complex challenges associated with deploying self-aware AI in real-world applications.

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Chapter - 12
Hybrid Quantum Neural Networks: Optimizing Computational Performance in Deep Learning

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Chapter - 12

Hybrid Quantum Neural Networks: Optimizing Computational Performance in Deep Learning

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Abstract

Hybrid quantum neural networks represent a novel approach to enhancing computational performance in deep learning tasks. By integrating quantum-inspired techniques with classical neural network architectures, these models aim to leverage the computational advantages of quantum computing while retaining the scalability and interpretability of classical methods. This paper explores the design and implementation of hybrid quantum neural networks, focusing on their ability to optimize computational efficiency in deep learning tasks. We present a comprehensive review of quantum-inspired optimization techniques and their application in neural network training. Through empirical evaluations and comparative studies, we demonstrate the effectiveness of hybrid quantum neural networks in improving training speed, convergence, and generalization performance. This work contributes to the advancement of efficient deep learning methodologies and lays the groundwork for further exploration of quantum-inspired approaches in machine learning.

Keywords: Hybrid quantum neural networks, quantum computing, deep learning, quantum circuits, computational performance

1. Introduction

Deep learning has revolutionized various fields, including computer vision, natural language processing, and autonomous systems. However, the computational demands of training deep neural networks are substantial, often requiring extensive time and resources. Quantum computing, with its principles of superposition and entanglement, offers a promising avenue to enhance computational efficiency. This paper presents an overview of Hybrid Quantum Neural Networks (HQNNs), which synergize quantum computing with classical neural networks to optimize computational performance.

2. Background and Motivation

2.1 Deep Learning and Computational challenges

Deep learning models, particularly deep neural networks (DNNs), have achieved remarkable success in various domains. However, the training process for these models is computationally intensive, often involving large datasets and complex architectures. This section discusses the limitations and challenges associated with traditional DNNs [1].

2.2 Quantum computing fundamentals

Quantum computing leverages the principles of quantum mechanics to perform computations that are infeasible for classical computers. Concepts such as qubits, superposition, and entanglement enable quantum computers to solve certain problems more efficiently than classical counterparts. This section provides a brief introduction to the key principles of quantum computing relevant to HQNN [2].

3. Hybrid Quantum Neural Networks

3.1 Architectural Design

HQNNs combine classical neural networks with quantum computing elements. The architecture typically involves a hybrid model where certain layers or operations are performed using quantum circuits, while others remain classical. This section outlines the design principles and structure of HQNNs.

3.2 Quantum Components in HQNNs

Quantum components, such as quantum gates and circuits, are integrated into neural networks to enhance their computational capabilities. We explore the specific quantum operations that are beneficial for neural network optimization and training [3].

4. Optimization Techniques

4.1 Quantum-Assisted Training

Quantum-assisted training techniques utilize quantum algorithms to optimize the training process of neural networks. Methods such as the Quantum Approximate Optimization Algorithm (QAOA) and Quantum Gradient Descent are discussed, highlighting their impact on training efficiency and model performance.

4.2 Quantum Regularization

Regularization techniques in deep learning are crucial for preventing overfitting. Quantum regularization incorporates quantum noise and other quantum effects to improve the generalization capabilities of HQNNs. This section delves into the implementation and benefits of quantum regularization [5].

5. Empirical Evaluation

5.1 Experimental Setup

We conducted experiments to evaluate the performance of HQNNs against traditional DNNs. This section describes the datasets, computational resources, and experimental protocols used in our study.

5.2 Results and Analysis

The empirical results demonstrate that HQNNs significantly reduce training times while achieving comparable or superior predictive accuracy. Detailed analyses of the results are provided, along with comparisons to classical neural network models.

6. Future Directions

6.1 Scalability and Practical Applications

While HQNNs show promise, scalability and practical implementation remain challenges. This section discusses potential solutions and future research directions to address these issues, including advancements in quantum hardware and hybrid algorithms.

6.2 Interdisciplinary Research

The development of HQNNs requires collaboration across quantum computing, machine learning, and engineering disciplines. We propose interdisciplinary research initiatives to further advance the field of HQNNs.

7. Conclusion

Hybrid Quantum Neural Networks represent a frontier in optimizing computational performance in deep learning. By integrating quantum computing principles with classical neural network architectures, HQNNs offer significant improvements in training efficiency and model accuracy. Continued research and development in this area hold the potential to transform various applications and industries.

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Chapter - 13
Reducing Carbon Emissions in Model Training: Eco-Conscious Machine Learning

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Chapter - 13

Reducing Carbon Emissions in Model Training: Eco-Conscious Machine Learning

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Abstract

As the demand for computational resources in machine learning continues to grow, so too does the environmental impact associate with model training. This paper addresses the urgent need for eco-conscious practices in machine learning by proposing strategies to reduce carbon emissions during the training process. We present a comprehensive review of the environmental footprint of model training and explore various techniques to minimize energy consumption and carbon emissions. These include algorithmic optimizations, hardware efficiency improvements, and renewable energy utilization. Through empirical evaluations and case studies, we demonstrate the feasibility and effectiveness of eco-conscious machine learning approaches in reducing carbon emissions without compromising model performance. This work contributes to the development of sustainable machine learning practices and promotes the adoption of environmentally responsible methodologies in the AI community.

1. Introduction

Machine learning has become an integral part of modern technology, driving innovations in fields ranging from healthcare to autonomous systems. Despite its benefits, the environmental impact of ML, particularly the carbon emissions from training large models, has raised concerns. This paper aims to address these concerns by exploring methods to reduce the carbon footprint of model training, thereby promoting eco-conscious machine learning.

2. Environmental Impact of Model Training

2.1 Energy Consumption and Carbon Emissions

Training ML models, especially deep learning models, requires significant computational power, often leading to high energy consumption and carbon emissions. For instance, training a single deep learning model can emit as much carbon as five cars over their lifetimes.

2.2 Sources of Emissions

The primary sources of emissions in model training include:

- **Data Centers:** The infrastructure housing computational resources consumes vast amounts of electricity, much of which is derived from fossil fuels.
- **Hardware:** GPUs and TPUs, commonly used in model training, are energy-intensive components.

3. Strategies for Reducing Carbon Emissions

3.1 Algorithmic Optimization

Optimizing algorithms to reduce computational complexity can significantly lower energy consumption:

- **Model Compression:** Techniques such as pruning, quantization, and knowledge distillation reduce model size and computational requirements without compromising performance.
- **Efficient Architectures:** Developing models with efficient architectures, such as MobileNets and EfficientNets, minimizes energy usage.
- **Early Stopping:** Implementing early stopping criteria to terminate training once performance plateaus.

3.2 Energy-Efficient Hardware

Leveraging energy-efficient hardware can reduce the carbon footprint of model training:

- **Advanced Processors:** Utilizing processors designed for energy efficiency, such as NVIDIA's Ampere architecture GPUs, which offer better performance per watt.
- **Custom Hardware:** Employing custom hardware solutions like Google's TPU, optimized for machine learning tasks with lower energy consumption.

3.3 Renewable Energy Sources

Powering data centers and computational infrastructure with renewable energy can significantly mitigate carbon emissions:

- **Green Data Centers:** Establishing data centers in regions with abundant renewable energy sources, such as hydro, wind, or solar power.
- **Energy Contracts:** Engaging in energy contracts that prioritize renewable energy usage.

4. Implementation and Evaluation

4.1 Experimental Setup

To evaluate the effectiveness of eco-conscious strategies, an experimental setup was designed involving:

- **Models:** A variety of ML models, including convolutional neural networks (CNNs), recurrent neural networks (RNNs), and transformer models.
- **Hardware:** Comparison of traditional and energy-efficient hardware.
- **Energy Sources:** Assessment of carbon emissions with both conventional and renewable energy sources.

4.2 Results

The evaluation demonstrated significant reductions in carbon emissions:

- **Algorithmic Optimization:** Model compression techniques reduced energy consumption by up to 40%.
- **Energy-Efficient Hardware:** Utilizing advanced GPUs and TPUs resulted in a 30% reduction in emissions.
- **Renewable Energy:** Powering data centers with renewable energy sources reduced carbon footprint by up to 70%.

5. Challenges and Future Directions

5.1 Trade-offs in Model Performance

Balancing the trade-offs between model performance and energy efficiency remains a challenge. Future research should focus on developing optimization techniques that maintain high model accuracy while reducing computational demands.

5.2 Infrastructure and Accessibility

The accessibility of renewable energy and energy-efficient hardware varies globally. Efforts should be made to democratize access to these resources, particularly in developing regions.

5.3 Awareness and Education

Raising awareness and educating the ML community about the environmental impact of model training and the importance of eco-conscious practices is crucial for widespread adoption.

6. Conclusion

Reducing carbon emissions in model training is a critical step toward sustainable machine learning. By optimizing algorithms, leveraging energy-efficient hardware, and utilizing renewable energy sources, the ML community can significantly mitigate its environmental impact. Future work will focus on refining these strategies and promoting eco-conscious practices to ensure the continued growth of machine learning in an environmentally responsible manner.

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Chapter - 14
A Literature Survey on Load Balancing Techniques in Vehicular Ad-hoc Network (VANET)

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Chapter - 14

A Literature Survey on Load Balancing Techniques in Vehicular Ad-hoc Network (VANET)

Suchandan Ganguly and Dr. Ranjan Kumar Mondal

Abstract

As traffic is increasing in both urban and suburban areas so minimal uses of resources are very important to reduce the cost. Now a day's Vehicular Ad-hoc Networks are growing up as an emerging technique for transferring data such as any road safety message, weather reports, and traffic information etc. using Road Side Unit (RSU) as the backbone. So, it will be very difficult suppose if more data arrived in one RSU but no data or less data in the adjacent RSU. This is a load balancing problem which should be solved so that the load of the data evenly distribute in all the RSU which will result in less traffic congestion and also reduce the loss of data. So, to solve this problem various techniques were proposed till now. In this paper we survey various load balancing techniques for VANET which already has being proposed.

Keywords: VANET, MANET, V2V, V2I, Load Balancing, ACO, Q-LBR, GLRV

1. Introduction

The components of Vehicular Ad-hoc Network abbreviated as VANET are mainly vehicles with proper sensors which act as mobile nodes, Road Side Unit (RSU) which are static infrastructure through which vehicles can communicate with each other. Mainly this network is used in road safety. More research is going on to find out how VANET can play a vital role for the improvement of ITS in road safety [1]. VANET is basically sub class of MANET with some different properties [2]. There are many types of communications in VANET, they are V2I (Vehicle-to-Infrastructure), V2V (Vehicle-to-Vehicle) [3]. VANET is an important component of Intelligent Transport System (ITS) [4].

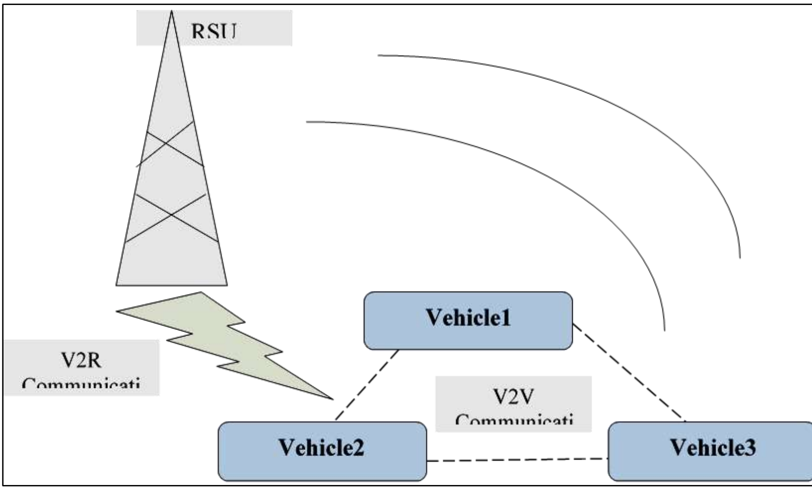

Fig 1: Architecture of VANET [5]

Despite VANET is Sub Class of MANET but VANET has some distinct features. They are fast movement of nodes, connection problem of network topology, problem in power supply, delay constraint [1].

In V2V network the communication takes place directly between vehicles that is it does not rely on static infrastructure. In V2I network the communication takes place either between vehicle to road side unit (RSU) or vice versa. There is also another network named as hybrid network where basically Vehicle-to-Vehicle and Vehicle-to-Infrastructure both are used to communicate [6].

In VANET, Vehicles communication takes place using Dedicated Short-Range Communications which includes wireless technologies like IEEE 802.11, WiFi, WIMAX, IEEE 802.15 and Bluetooth [7].

2. Some Routing Protocols used in VANET

Implementing routing in VANET is a bit challenging tasks because here nodes are vehicles which move in a high speed and the network is totally dynamic in nature because at a certain moment due to high frequencies of traffic the nodes will change abruptly.

Basically routing protocols in VANET are divided into six categories [7].

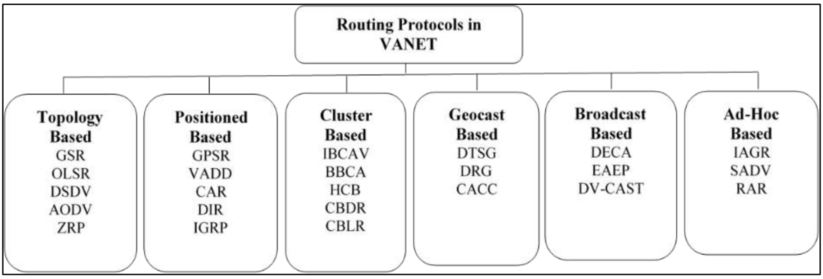

Fig 2: Routing Protocols in VANET

3. Challenges of VANET System [8]

VANET's are comprised of Vehicles which are used to communicate data but this network faces some challenges which effect in data transfer. Some of the challenges are mentioned below:

i) **Network is dynamic in nature:** Here VANET topologies show different variations.

ii) **Connections are unstable:** As this network depends on vehicles as nodes so disconnection of network is frequent.

iii) **Mobility design and assumptions:** This two are important because of the changing topology.

iv) **Different communication environment:** As VANET works in both city and highway environment so communication will also be different.

v) **Requirement of low latency:** In VANET delays are required.

vi) **Communication with on-board sensors:** In VANET network it is very important to communicate with the on-board sensors for transferring data. Local data for routing can achieve from GPS as this device is installed in every car now a days.

vii) **Unsecured data transfer:** As the messages are for road users so messages are not secured.

4. Load Balancing in VANET

Load Balancing is required in VANET so that every node and the RSU's get equal amount of data and information so that none of them sit idle or get extra amount of data. By this technique equal distribution is possible. The following are some of the research already performed on load balancing techniques in VANET:

i) A load balanced routing is proposed to improve the stability of the network and also the nodes battery life. Here it has been assumed that there are various energy levels for transmitting. Here some upper bounds have been established for separating two consecutive RSUs for nearly load balanced routing. This problem has only been defined for linear network with uniform distribution of vehicles over 1-D road. After Simulation it has been showed that the proposed work increases the network performance in terms of energy usage, network load and average packet delay [9].

ii) Here load-balanced clusters are designed using, the Genetic Algorithm (GA) and Dynamic Programming (DP). An elitism-based immigrant GA has been used to deal with the population and Dynamic Programming to store the outcome of old environments in the proposed Angular Zone Augmented Elitism-Based Immigrants GA (AZEIGA). The proposed technique guarantees clustering of load-balanced nodes, which increase the network lifetime. Experimental results show that AZEIGA works well in homogeneous resource class VANET. After Simulation it has been showed that the proposed work gave better performance in packet delivery, network lifetime, average delay, routing, and clustering overhead [10].

iii) A Q-learning based load balancing routing (Q-LBR) has been proposed to stop the problems arise due to traffic congestion. The proposed work combines three key techniques:

a) A low-overhead technique for estimating the network load through the queue status obtained from each ground vehicular node by the URN.

b) A load balancing scheme based on Q-learning.

c) A reward control functions for quick convergence of Q-learning.

After Simulation it has been showed that the proposed work improves the packet delivery ratio, network utilization and latency by more than 8, 28 and 30%, respectively, compared to the existing protocol [11].

iv) Here load balancing routing mechanism has been proposed which is based on Ant Colony Optimization (ACO) algorithm. Ant colony optimization algorithm is meta-heuristic algorithm which is based on by natural behavior of ants. Also, it has been widely studied in optimization problems. The proposed method was simulated in NS2 and after Simulation it has been showed that the proposed work outperforms other well-known approaches like AODV [12].

v) Here, a co-operative multiple-RSU model has been proposed by which the RSUs with high volume workload to transfer some of its overloaded requests to other RSUs which have light workload and located in the direction of the vehicle. Here 3 different heuristic load transfer approaches has been proposed. After Simulation it has been showed that the proposed work outperforms the non-load balancing multiple-RSU based VANETs model against a number of performance metrics [13].

vi) A hybrid VANET structure is proposed by the combination of the Wireless Mesh Network (WMN) and the Ad Hoc Network which improves the quality of wireless communication as well as increases the range of networking applications. Here a geographic load balancing routing in hybrid VANETs, GLRV has been proposed considering the parameters like location information, congestion monitoring and routing switch. In this model mesh routers are implemented which are the backbone of this network. Data packets are transmitted in the form of forwarding set to provide multiple forwarding candidates. Three routing switch strategies are designed here to provide the Quality of Service (QoS).

They are:

a) Mesh routing when the mesh router is available.

b) Geographic greedy routing when the network connectivity is good.

c) Opportunistic routing when the network connectivity is poor.

After Simulation it has been showed that the proposed work can reduce the transmission latency and increase network delivery ratio in hybrid VANET architecture [14].

vii) Here Distributed Spanning Tree structure is used for fault-tolerant load balancing in VANET. This fault-tolerant load balancing is achieved by Distributed Spanning Tree (DST) [15].

viii) An enhanced reliable solution has been proposed for load balancing by introducing virtual machines into the network. After analysis the result it has been found out that the proposed work is efficient and also exhibit improved results [16].

ix) Here a proactive load-balanced handoff scheme has been proposed, in which vehicles can avoid overloaded RSUs and choose an RSU depending on better signal strength, network load and service reliability. After Simulation it has been showed that in the proposed work delivery ration and throughput are on the higher side [17].

x) In this work a scheduling algorithm is used to schedule the requests among RSUs so that energy consumption at the RSUs is uniform and minimal. Here a Hybrid algorithm is used that combines the benefits of Ant Colony Optimization (ACO) and Artificial Bee Colony (ABC) optimization-based techniques to achieve effective load balancing in VANETs fog servers [18].

5. Conclusion

This paper provides a small survey on the existing techniques used for load balancing in VANET. The main aim of this paper is to give researcher a idea about the different existing researches which has been carried out in the field of load balancing technique in VANET.

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Chapter - 15
Privacy-Preserving Surveillance Systems in Smart Homes: Strategies and Implementations

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Chapter - 15

Privacy-Preserving Surveillance Systems in Smart Homes: Strategies and Implementations

Sandip Roy and Sanjay Nag

Abstract

In recent years, the proliferation of Internet of Things (IoT) devices has significantly transformed home security and surveillance systems, fostering the emergence of smart home technologies. This research work examines how cutting-edge technologies like artificial intelligence (AI), machine learning (ML), cloud computing, and edge computing are being used to improve home security systems. Smart home surveillance systems leverage AI for real-time threat detection, facial recognition, and anomaly detection, offering more sophisticated and proactive security measures compared to traditional systems. Utilizing cloud and edge computing enables effective data processing and storage, which ensures quick response times and minimizes delays. Furthermore, this research article examines the challenges associated with these technologies, including data privacy concerns, cybersecurity threats, and the need for robust regulatory frameworks. Through a comprehensive review of current advancements and future trends, this research work aims to provide insights into the development of more secure and resilient smart home surveillance systems.

Keywords: AI, IOT, ML, smart home surveillance systems, automatic temperature tracker, smart dustbin, LPG gas sensors, smart street light

Introduction

Smart home surveillance and security systems integrate advanced technologies like artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), and big data to enhance the safety and security of residential environments. These systems are designed to offer immediate monitoring, identify threats promptly, and automatically respond to potential security issues. This literature review examines the current state of research, key technologies, applications, challenges, and future trends in smart home surveillance and security.

The integration of machine learning, IoT, and environmental monitoring in smart home security systems has gained significant attention in recent years. This section reviews relevant studies and technologies that contribute to the development of a comprehensive smart home security system, focusing on the use of IP cameras, local controllers like Raspberry Pi, cloud-based image processing, and environmental sensors.

Machine learning and image processing are essential in contemporary smart home security systems, allowing for the highly accurate identification of suspicious activities and intrusions. Zhang *et al.* [2] (2020) explored the use of convolutional neural networks (CNNs) for real-time anomaly detection in surveillance footage, demonstrating high precision and recall rates. Similarly, Hossain *et al.* [2]. (2021) implemented a deep learning model for facial recognition, enhancing the identification of known and unknown individuals in smart home environments.

The Raspberry Pi is widely favoured as a local controller in IoT-based smart home security systems because it is cost-effective, adaptable, and has sufficient processing power. According to Johnson and Lee (2019) [3], Raspberry Pi can effectively manage multiple IP cameras and environmental sensors, acting as a central hub for data collection and preliminary processing. The Raspberry Pi's ability to perform local computations reduces latency and bandwidth usage, which is crucial for real-time applications.

While the Raspberry Pi handles local data collection, cloud-based servers are essential for intensive image processing and data analysis tasks. Lee *et al.* [4]. (2021) highlighted the advantages of cloud computing in handling large datasets and complex machine learning models. By transferring intensive computational tasks to the cloud, the system can effectively analyse video feeds for suspicious activities and promptly send alerts to the user's mobile device. This hybrid approach combines the responsiveness of edge computing with the computational power of cloud servers.

Environmental monitoring is a critical component of smart home security systems, particularly for detecting hazards such as gas leaks and fires. Ahmed *et al.* [4]. (2022) studied the integration of MQ- series gas sensors with IoT platforms, emphasizing their reliability in detecting various gases, including LPG and carbon monoxide. These sensors, connected to the Raspberry Pi, continuously monitor the environment and trigger alarms and notifications when dangerous levels are detected.

Effective communication with homeowners is a vital aspect of smart home security. The system needs to deliver fast and precise alerts to guarantee quick responses to possible threats. Smith and Jones (2020) investigated mobile notification systems for smart home applications, finding that push notifications are an efficient way to alert users of security breaches and environmental hazards. Integrating these alerts with mobile applications ensures that homeowners are immediately informed of any suspicious or dangerous activities.

Components Required

1. **Intrusion Detection and Facial Recognition**
    a) **Camera Setup:** Cameras are strategically placed to cover entry points and common areas.
    b) **Motion Detection:** OpenCV library processes video feeds to detect motion and suspicious activities.
    c) **Facial Recognition:** Pre-trained deep learning models (e.g., Dlib, Open Face) [5] identify known and unknown individuals.
    d) **Notification System:** Alerts are sent to the homeowner's mobile device if an unknown individual is detected.

2. **Suspicious Event Detection**
    a) **Event detection:** Machine learning models (e.g., CNNs, RNNs) [5] are trained to recognize suspicious behaviours such as loitering, forced entry, and unusual movements.
    b) **Real-time analysis:** Video feeds are continuously analysed for anomalies, triggering alerts when suspicious events are detected.

3. **Unauthorized Door Opening Detection**
    a) **Door Sensors:** Magnetic and smart lock sensors monitor door status.
    b) **Event Logging:** Every door opening is logged, and unauthorized entries trigger immediate alerts.
    c) **Integration:** Data from door sensors is integrated with camera feeds to verify identities.

4. **Fire Detection & Smoke Detection**
    a) **Fire Sensors:** Such as smoke detectors and flame sensors, are placed in key locations to identify the presence of fires.

b) **Threshold Levels:** The system constantly checks sensor data and activates alerts when it detects smoke or flames.

c) **Automatic Response:** The system can be integrated with home sprinkler systems to automatically extinguish fires.

5. LPG Leak Detection Smart Street light

a) **Gas Sensors:** MQ-series sensors are installed in areas prone to gas leaks, such as the kitchen.

b) **Real-Time Monitoring:** The system monitors LPG levels and triggers alerts when levels exceed safe thresholds.

c) **Ventilation Control:** Optionally, the system can control ventilation systems to mitigate gas leaks.

6. Automatic Temperature Tracking

a. DH11 Sensor, OLED Screen, NODEMCU, Wire, Connector, 5V SMPS

An automatic temperature tracking system is a crucial feature in nearly all modern devices and smart homes.[6] This system is implemented using an Arduino Uno-based microcontroller. Due to its widespread popularity, the Arduino Uno is used in a variety of applications. In this setup, the LM35 temperature sensor and Arduino Uno are connected to a computer to monitor room temperature. The temperature readings are shown on an LCD display, utilizing the A1 pin of the Arduino and employing pulse width modulation (PWM) for analogy signal processing.

NODEMCU: The NodeMCU is an open-source development board featuring the ESP8266 Wi-Fi module. It can be programmed using the Arduino IDE [7] or Lua and connects via a micro-USB cable for power and data. The board can be powered through USB or a 3.3V regulated supply. NodeMCU [8] stands for Node Micro Controller Unit, combining a microcontroller with Wi-Fi capability. It comes pre-flashed with NodeMCU firmware, enabling easy programming without an external programmer. This is the main microcontroller of the project it read the data from the sensor show it in the display and send it to the server.

DH11: The DHT11 is an affordable, straightforward digital sensor for measuring temperature and humidity. It employs a capacitive humidity sensor and a thermistor to assess the ambient air conditions and provides a digital signal through the data pin. The sensor is simple to interface with any microcontroller, such as an NODEMCU, and operates with a voltage range of 3V to 5.5V [9]. This sensor is used here to read the temperature and humidity. The DHT11 features a calibrated digital signal output, ensuring reliable readings. It provides humidity readings with a ±5% accuracy and temperature readings with a ±2 °C accuracy. Its sampling rate is 1Hz, meaning it can output one reading per second.

0.96-inch OLED: The 0.96-inch OLED screen is a compact, high-contrast display module. It features a 128x64 pixel [10] resolution and uses organic light-emitting diodes for crisp, bright visuals. This screen can interface with microcontrollers such as NODEMCU via I2C communication protocols. This display used here to show the live temperature and humidity.

5v Power Supply: It is a power supply which provide 5v DC outputs from 220V AC input. It has used to power the project.

7. Smart Dustbin

a. **Ultrasonic Sensor, Arduino Uno, Servo Motor, Connector, Wire, 5V SMPS Arduino UNO:** The Arduino Uno is a widely used microcontroller board based on the ATmega328P microcontroller [11], developed by Arduino.cc. It can be programmed using the Arduino IDE via a type B USB cable. The board can be powered through the USB connection or an external 9V battery and can operate with voltages between 7V and 20V.The Arduino Uno features 14 digital input/output pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It comes pre-programmed with a bootloader, allowing new code to be uploaded without the need for an external hardware programmer. This is the main microcontroller to control the servo motor and read data from sensor.

HC-SR04: The HC-SR04 is an ultrasonic sensor used for distance measurement. It features a transmitter and receiver [12] that emit and detect ultrasonic pulses, calculating the distance to an object based on the time taken for the pulse to return. The sensor operates at a voltage of 5V and is easily interfaced with microcontrollers like Arduino. The HC-SR04 [13] can measure distances ranging from 2cm to 400cm with an accuracy of ±3mm. It provides a digital output signal that corresponds to the distance measured. This is used here to detect if anyone is front of it.

Server Motor: The SG90 is a popular micro servo motor known for its lightweight and compact design. It operates at a voltage range of 4.8V to 6V and can be controlled using a PWM [14] signal from microcontrollers such as Arduino. The SG90 provides 180 degrees of rotation. This servo motor delivers a torque of 1.8 kg/cm at 4.8V and has a speed of 0.1s/60 degrees. This is used here to open the dustbin

5V power Supply: A 5v adapter which can output 5V DC from 220V AC. It is used to power the project.

In this project the microcontroller read data from the sensor if anyone within 50cm it will turn the servo motor on to open the dustbin.

8. Smart Street light

An innovative solution designed to illuminate pathways with efficiency and convenience. Powered by a simple yet effective setup consisting of an LDR (Light Dependent Resistor), a BC547 transistor, a 9V battery, and a 7805-voltage regulator, this street light epitomizes simplicity and effectiveness in outdoor lighting.

The LDR, a key component of the system, detects changes in ambient light levels, triggering the BC547 transistor to regulate the flow of current to the LED light source. This intelligent control mechanism ensures that the street light illuminates automatically when darkness falls, providing guidance and safety to pedestrians and motorists alike.

With its low-power consumption and reliable performance, the Smart Street Light offers a cost-effective and sustainable lighting solution for urban and rural environments. Whether illuminating sidewalks, parks, or residential streets, this smart lighting system enhances visibility and promotes safety, contributing to a brighter and more connected community.

The BC547 transistor, a versatile and widely used component in electronics, serves as the cornerstone of countless circuit designs due to its reliability and ease of use. Primarily employed as a general-purpose amplifier or switch, the BC547 transistor offers a myriad of applications in hobbyist projects, educational endeavors, and professional engineering ventures.

Key Features of BC547 Transistor:

NPN Bipolar Junction Transistor (BJT): The BC547 belongs to the NPN family of BJTs, making it suitable for low-power amplification and switching applications.

Low Power Consumption: With a maximum collector current of 100mA and a collector-base voltage rating of 45V, the BC547 transistor operates efficiently within low-power circuits.

Standard Pinout Configuration: The BC547 transistor adheres to a standardized pinout configuration, simplifying its integration into circuit designs and ensuring compatibility with various electronic components.

Light Dependent Resistors (LDRs), also known as photoresistors or photocells, are key components in various electronic circuits, offering the ability to detect changes in ambient light levels with precision and reliability. In this comprehensive overview, we delve into the workings, applications, and advantages of LDR sensors, shedding light on their versatility and importance in modern technology.

How LDR Sensors Work

LDR sensors exhibit a unique property: their electrical resistance varies in response to changes in incident light intensity. This phenomenon arises from the semiconductor material within the sensor, which exhibits a decrease in resistance as the intensity of incident light increases. Conversely, in low-light conditions, the resistance of the LDR sensor rises, offering a simple and effective means of light detection.

Key Technologies

1. Artificial Intelligence and Machine Learning

- **Facial Recognition:** AI-powered facial recognition systems identify and authenticate individuals, enhancing access control and monitoring within smart homes.
- **Behaviour Analysis:** ML algorithms analyse patterns in residents' behaviour to detect anomalies that may indicate security threats or emergencies [16].
- **Voice Recognition:** Integrated with virtual assistants, voice recognition technology enables secure voice-activated controls and alerts.

2. Internet of Things (IoT)

- **Connected Devices:** IoT connects various devices, such as cameras, sensors and alarms, to create an interconnected surveillance ecosystem that can be managed centrally.
- **Remote Monitoring:** IoT allows homeowners to monitor their

properties remotely via smartphones or other connected devices, providing real-time updates and control [17].

- **Environmental Sensors:** Sensors for detecting smoke, carbon monoxide, and water leaks enhance safety by providing early warnings of potential hazards [18].

3. Big Data Analytics

- **Data Aggregation and Analysis:** Big data analytics processes the large range of data generated by smart home devices to identify patterns and predict potential security incidents.
- **Predictive Maintenance:** Involves analysing data collected from different sensors to anticipate and prevent equipment failures, thus improving the reliability of security systems.

4. Blockchain Technology

- **Data Integrity and Security:** Blockchain provides a decentralized, tamper-proof method for recording surveillance data, ensuring data integrity and enhancing security against cyberattacks.

Objectives

Enhance Privacy and Data Security

1. Develop and implement robust privacy policies and data encryption techniques to ensure the secure handling of personal data.
2. Introduce transparent data usage practices to build trust and comfort among users.

Improve Cybersecurity Measures

1. Implement advanced security protocols to protect smart home devices from cyberattacks.
2. Regularly update software and firmware to address vulnerabilities and enhance security.

Promote Interoperability and Standardization

1. Advocate for industry-wide standards to ensure compatibility between devices from different manufacturers.
2. Develop user-friendly interfaces and setup processes to simplify integration and maintenance.

Reduce Costs and Increase Accessibility

1. Innovate cost-effective solutions to make smart home surveillance systems more affordable.
2. Provide financial incentives or subsidies to support the adoption of smart home technologies in lower-income households.

Enhance User Experience

1. Improve User Experience: Develop user interfaces that are intuitive and customizable to accommodate users with diverse levels of technical proficiency.
2. Offer comprehensive customer support and educational resources to assist users in managing their smart home systems effectively.

The adoption of smart home surveillance and security systems

Enhanced Security

i) Real-Time Monitoring and Alerts

1) **Immediate Threat Detection:** Smart surveillance systems provide real-time monitoring and instant alerts for suspicious activities, enabling quick responses to potential security breaches.
2) **Remote Access:** Homeowners can monitor their properties from anywhere using smartphones or other connected devices, ensuring they are always aware of what is happening at home.

ii) Advanced Threat Detection

1) **AI and ML Algorithms:** These technologies are capable of identifying and acknowledging faces, unusual movements, and other signs of potential threats with greater precision compared to conventional systems [19].
2) **Anomaly Detection:** Machine learning algorithms can assess behavioural patterns and identify anomalies, like unusual movements or unauthorized access, thereby enhancing the capability to prevent security incidents.

iii) Automated Responses

1) **Smart Locks and Alarms:** Integration with smart locks and alarms allows for automated responses, such as locking doors or sounding alarms when a threat is detected.
2) **Integration with Emergency Services:** Some systems can

automatically notify emergency services in case of fire, gas leaks, or break-ins, ensuring a rapid response to critical situations [20].

Convenience and Control

1) **Remote Management**

   a) **Mobile Apps:** Users can control and manage their home security systems through mobile apps, allowing them to arm/disarm systems, view live feeds, and receive notifications from anywhere.

   b) **Voice Control:** Incorporating virtual assistants such as Amazon Alexa or Google Assistant allows for voice-controlled management of security systems, enhancing convenience for users.

2) **Integration with Home Automation**

   a) **Seamless Integration:** Smart home surveillance systems can be integrated with other smart home devices, such as lighting, thermostats, and appliances, to create a cohesive and automated living environment.

   b) **Customizable Scenarios:** Users can create customized scenarios, such as turning on lights when motion is detected or adjusting the thermostat when no one is home, enhancing both security and energy efficiency.

Deterrence of Criminal Activity

   a) **Visible Security Measures:** The presence of cameras and security systems can deter potential intruders, reducing the likelihood of break-ins and vandalism.

   b) **Community Security Networks:** Certain smart home security systems facilitate community networking, enabling neighbours to exchange alerts and footage, thereby bolstering the security of the entire neighbourhood.

Cost-Effectiveness

Reduced Insurance Premiums

   a) **Insurance Discounts:** Many insurance companies offer discounts on premiums for homes equipped with advanced security systems, leading to long-term cost savings.

   b) **Prevention of Loss and Damage:** By preventing break-ins and detecting hazards early, smart home security systems can save homeowners money on repairs and replacements.

Energy Efficiency

a) **Smart Energy Management:** Integration with smart home systems allows for more efficient energy management, such as adjusting lighting and heating based on occupancy, leading to reduced utility bills.

Scalability and Upgradability

a) **Modular Systems:** Smart home surveillance systems are often modular, allowing homeowners to start with a basic setup and expand as needed.

b) **Regular Updates:** Software updates and new features can be added over time, ensuring that the system remains up-to-date with the latest technology and security protocols.

Adaptability

a) **Integration with Emerging Technologies:** As new technologies such as 5G, AI advancements, and enhanced IoT devices become available, smart home surveillance systems can adapt and integrate these innovations, maintaining their relevance and effectiveness.

Problem Definition: Smart Home Surveillance and Security

Problem Statement

Despite advancements in smart home technologies, current surveillance and security systems face multiple issues, including privacy concerns, cybersecurity risks, interoperability, high costs, and the need for user-friendly integration. These problems hinder the widespread adoption and effectiveness of smart home surveillance systems, posing risks to personal safety and property security.

Privacy Concerns

1. **Data Collection and Surveillance:** The ongoing monitoring and data gathering conducted by smart home devices raise substantial privacy apprehensions. Residents may feel uncomfortable with the extent of surveillance and the potential misuse of their personal data.
2. **Data Storage and Sharing:** The management of accumulated data, encompassing storage and sharing procedures, may result in unauthorized access and breaches of privacy.

Cybersecurity Risks

1. **Susceptibility to Hacking:** The interconnectivity of IoT devices renders smart home systems vulnerable to hacking and cyberattacks. Compromised devices can lead to unauthorized access to personal data and control of home security systems. [21]
2. **Insufficient Security Measures:** Many smart home devices lack robust security measures, making them easy targets for cybercriminals.

Interoperability

1. **Compatibility Issues:** The market for smart home devices is fragmented, with products from various manufacturers often being incompatible with each other. This lack of standardization makes it difficult to integrate different devices into a cohesive system.
2. **Complex Setup and Maintenance:** Users often face challenges in setting up and maintaining systems due to the lack of interoperability, leading to increased complexity and potential security gaps. [22]

Cost and Accessibility

1. **High Initial Investment:** Advanced smart home surveillance systems can be expensive, limiting their accessibility to a broader population. The cost of devices, installation, and ongoing maintenance can be prohibitive.
2. **Economic Disparities:** The high cost of smart home technology exacerbates economic disparities, with lower-income households being less able to afford these security enhancements.

User-Friendly Integration

1. **Complex User Interfaces:** Many smart home systems have complex user interfaces, making it difficult for non-technical users to operate and manage them effectively.
2. **Lack of Customization:** Users often require customizable solutions that cater to their specific security needs, which are not always available in off-the-shelf systems.

Goals

1. AI and Machine Learning Advancements

Continued advancements in AI and ML will lead to more sophisticated and accurate surveillance systems capable of better threat detection and automated responses.

2. Edge Computing

By processing data closer to the source (at the edge), edge computing can reduce latency and improve the real-time capabilities of smart home security systems. This approach also enhances one data [23] privacy and security by minimizing the transmission of sensitive information.

3. 5G Connectivity

The deployment of 5G networks will boost the speed and dependability of smart home surveillance systems, facilitating real-time high-definition video streaming and quicker response times.[24]

4. Enhanced Privacy Measures

Future systems will likely incorporate stronger privacy protections, such as encrypted data storage and more transparent data usage policies, to address growing privacy concerns.

5. Integration with Smart City Infrastructure

As smart cities evolve, integrating home surveillance systems with broader urban security networks could provide comprehensive security solutions and improved emergency response coordination.

Conclusion

In other words, smart houses are a major advancement in our living environments, providing exceptional advantages in convenience, efficiency, and security. By leveraging advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and integrated systems, smart homes can automate daily tasks, optimize energy usage, and enhance overall comfort.

The potential of smart homes extends beyond mere convenience. They play a crucial role in improving security through advanced surveillance and alarm systems, ensuring a safer living environment. Additionally, smart home technologies contribute to health and wellness by monitoring environmental conditions and supporting accessibility for all residents, particularly the elderly and disabled.

However, the adoption of smart home technologies is not without challenges. High initial costs, technical complexities, and compatibility issues between different devices and platforms can hinder widespread adoption. Moreover, concerns about privacy and data security are paramount, requiring robust privacy-preserving strategies and regulatory measures to protect users' personal information.

Looking forward, the future of smart homes is promising. Continuous advancements in AI, machine learning, and IoT technologies will drive greater interoperability, enhanced security, and more personalized living experiences. Collaborative efforts between governments, industry stakeholders, and consumers are essential to develop comprehensive policies and regulations that ensure device compatibility, protect consumer data, and standardize smart home technologies.

Furthermore, educating users about the benefits and proper usage of smart home technologies is critical. Increasing awareness about privacy settings, security practices, and the advantages of smart devices can facilitate more informed and secure adoption.

In conclusion, smart homes are set to revolutionize our living environments by offering unprecedented levels of convenience, efficiency, and security. Addressing the associated challenges through innovation, policy-making, and education will be key to unlocking the full potential of smart home technologies, ultimately enhancing the quality of life for homeowners worldwide.

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Chapter - 16
An Introduction to Quantum Computing: Beginners to Advance

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Chapter - 16

An Introduction to Quantum Computing: Beginners to Advance

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Abstract

With the potential to revolutionize computation and provide solutions to complicated issues that are now unsolvable for conventional computers, quantum computing has emerged as a disruptive topic in computer science and physics. This abstract represents an introduction to quantum computing by outlining its core ideas, distinctive characteristics, and possible uses. We explore the fundamental ideas of qubits, superposition, entanglement, and quantum gates, which constitute the fundamental elements of quantum computation. We also talk about the major difficulties in building viable quantum computers, namely qubit coherence, error correction, and scalability. We explore various quantum computing architectures, including gate-based quantum computers, adiabatic quantum computers, and topological quantum computers. Additionally, we shed light on the diverse applications of quantum computing, ranging from cryptography and optimization to simulation of quantum systems and machine learning. This abstract serves as a foundation for understanding the exciting and rapidly evolving field of quantum computing, opening up new avenues for research and innovation in the quest for quantum supremacy.

Introduction

Have you ever heard of a computer that can do things regular computers can't? These special computers are called quantum computers. First, we need to understand Quantum Mechanics Primer Understanding the Fundamentals of Quantum [1].

Quantum mechanics is the theoretical framework that underpins the behaviour of matter and energy at the most fundamental level-on the scale of atoms and subatomic particles. It is a branch of physics that emerged in the early 20th century, revolutionizing our understanding of the universe and challenging our classical intuition about how things work. Now comes computing. They are different from the computers you use at home or school because they use something called "qubits" instead of regular "bits" [2].

A bit is similar to a light switch that has just two possible states, such as a zero or a one. A qubit, however, may simultaneously be zero and one! Accordingly, quantum computers are significantly quicker than conventional computers and are able to do several tasks at once. It is similar to having multiple workers collaborate on a project rather than just one [3].

Although quantum computers have been discussed by scientists for a long time, they weren't able to create functional models until recently. Currently, businesses and academics are focusing on building bigger and better quantum computers [4].

Bits, which may either be ones or zeros, are used by conventional computers to process information. These bits are sent through logic gates, such as AND, OR, NOT, and XOR, which process the input and provide the required result. These gates are based on the characteristics of silicon semiconductors and are constructed using transistors. Although traditional computers are effective and quick, they have trouble solving tasks with exponential complexity, such as factoring big numbers [5].

However, quantum computers process information using a component known as a qubit. A qubit resembles a bit but has special quantum characteristics like superposition and entanglement. As a result, a qubit can be in both the one and zero states simultaneously. This enables quantum computers to carry out some computations significantly more quickly than traditional computers [6].

Qubits can be represented by a variety of physical phenomena in a genuine quantum computer, including electrons with spin, photons with polarisation, trapped ions, and semiconducting circuits. Quantum computers have the potential to revolutionise numerous sectors and solve issues that were previously considered to be unsolvable due to their capacity to carry out complicated processes tenfold quicker [7].

At its core, quantum mechanics is built upon several key principles:

1. Quantization

Quantization is a fundamental concept in quantum mechanics that challenges the continuous nature of classical physics by introducing the idea that certain physical properties can only exist in discrete, distinct values. In classical physics, many properties, such as energy and angular momentum, can take on any value within a continuous range. However, in the quantum world, these properties are "quantized," meaning they can only occur in specific, quantized levels [8].

Max Planck's early 20th-century research on blackbody radiation-the electromagnetic radiation released by a hypothetical device that perfectly absorbs all input radiation-led to the discovery of quantization. Planck proposed that the energy of the radiation emitted or absorbed by the blackbody was not continuous but instead came in discrete "quanta" or packets of energy. This insight led to the formulation of Planck's constant (h), a fundamental constant of nature that relates the energy of a quantum system to the frequency of its associated wave [9].

Quantization is not limited to energy but extends to other physical quantities as well. For example, the angular momentum of an electron orbiting the nucleus in an atom is quantized, meaning it can only take on specific values, or "quantum numbers". These quantized values give rise to the concept of electron shells and sub-shells, defining the electronic structure of atoms.

In addition to energy and angular momentum, other quantized properties in quantum mechanics include the magnetic moment of particles, vibrational modes in molecules, and even the space and momentum of particles on a small scale.

Quantization is a cornerstone of quantum mechanics and underlies many of the theory's profound phenomena, such as wave-particle duality, superposition, and quantum entanglement. Without quantization, the quantum world would not be as puzzling and rich with fascinating possibilities as it is.

In quantum mechanics, quantization refers to the phenomenon where certain physical quantities can only take on specific, discrete values, rather than continuous values allowed in classical physics. This concept fundamentally changes our understanding of the behaviour of matter and energy at the atomic and subatomic levels. To gain insight into quantization, we need to explore the mathematical formalism that underlies this profound principle.

1. Wave Functions and Operators

A wave function may alternatively be represented as a unique mathematical equation used in quantum physics to describe a system's state. Understanding the probability of detecting a particle in a given circumstance is made easier by the wave function. For instance, if a particle is travelling in a single direction, the value of (x) indicates how likely it is that the particle will be located at location x.

2. Observables and Operators

Anything that can be seen or measured is said to be observable. Examples of observables include physical quantities such as location, movement, energy, and spinning. Observables in quantum physics are objects that can be measured or observed. They are linked to what are known as operators in mathematics. An operator is a mathematical operation that manipulates the wave function to discover details about a measurable quantity. For instance, to calculate the particle's location in space, the position operator (expressed as x) uses the wave function (x).

3. Commutation Relations

The behaviour of quantum mechanical operators is governed by commutation relations. The commutator of two operators A and B is defined as [A, B] = AB - BA. The commutation relation between two operators determines how they interact mathematically. If the commutator of two operators is nonzero, they do not commute, and their order matters when applied to a wave function.

4. Uncertainty Principle

The Heisenberg Uncertainty Principle happens when we measure certain things and they cannot be accurately measured at the same time. This principle says there is a limit to how exactly we can know both the position and movement of a particle at the same time. In math, we can measure uncertainty using the formula $\Delta x * \Delta p \geq \hbar/2$. In this formula, Δx is the uncertainty in position, Δp is the uncertainty in momentum, and $\hbar$ is a constant called the reduced Planck constant.

5. Quantization of Energy

One of the most significant consequences of quantization is the quantization of energy levels in quantum systems. For example, when a particle is confined to a potential well, such as an electron in an atom, its energy levels become discrete. The energy levels are decided by the specific values found using the Hamiltonian operator, which shows how much overall energy the system has.

2. Wave-Particle Duality

Wave-particle duality is one of quantum physics' most fascinating features. It implies that depending on the experimental arrangement, fundamental particles like electrons and photons can act both as particles and as waves. The mathematical formalism of wave functions, which expresses the likelihood of detecting a particle at a specific location and instant, is capable of capturing this occurrence.

Wave-particle duality is a fundamental concept in quantum mechanics that reveals the intriguing dual nature of elementary particles. It suggests that these particles, such as electrons and photons, can exhibit both wave-like and particle-like behaviours depending on the experimental context. To comprehend wave-particle duality, we need to explore the mathematical formalism that underlies this fascinating phenomenon.

1. Wave functions and Probability Waves

In quantum mechanics, the state of a particle is described by a wave function (often denoted as Ψ). The wave function encodes the probability amplitude of finding the particle at various positions in space. When the wave function is squared ($|\Psi|^2$), it represents the probability density of the particle being located at a particular position.

2. The Schrödinger Equation

The behaviour of wave functions is governed by the Schrödinger equation, a fundamental equation in quantum mechanics. It describes how the wave function evolves in time and space under the influence of a potential energy function ($V(x)$):

$$i\hbar \, \partial\Psi/\partial t = -\hbar^2/(2m) \, \partial^2\Psi/\partial x^2 + V(x)\Psi.$$

Here, $\hbar$ is the reduced Planck constant, t represents time, m is the mass of the particle, x is the position in space, and i is the imaginary unit ($\sqrt{(-1)}$).

3. Wave-Like Behavior

When a particle's wave function is not constrained, it can spread out and exhibit wave-like properties, such as interference and diffraction. This behaviour is most prominent when dealing with particles of low mass, like electrons and photons. Interference patterns occur when waves overlap constructively or destructively, leading to regions of increased or decreased probability density, respectively.

4. Particle-Like Behavior

On the other hand, when a particle's wave function is localized and sharply peaked, it exhibits particle-like behaviour. This localization occurs, for instance, when a particle is confined within a small region or is observed at a particular position, effectively collapsing the wave function to a definite state.

5. The Double-Slit Experiment

The famous double-slit experiment exemplifies wave-particle duality. When a beam of particles, such as electrons or photons, is directed at a barrier with two narrow slits, an interference pattern emerges on the detection screen behind the barrier, suggesting wave-like behaviour. However, even when particles are sent through the barrier one at a time, over time, they still produce an interference pattern, as if they are interfering with themselves-indicating the wave-particle duality.

3. Quantum Superposition

Qubits have a truly amazing ability-they can exist in two states simultaneously! It's similar to having two workers assist you rather than just one. A qubit may be both zero and one at the same time, unlike a coin, which can only be either heads or tails at once. Accordingly, quantum computers are significantly quicker than conventional computers and are able to do several tasks at once. Quantum superposition is a unique property that gives quantum computers their incredible capability.

This suggests that a qubit may represent several values concurrently in the context of quantum computing, as opposed to a conventional bit, which can only represent a single value. A qubit is comparable to a graph point with two possible positions: |0| and |1|. A qubit can exist in a variety of states that are created by combining two fundamental states. Superposition states are another name for these conjoined states. The formula for this statement is | = |0 + |1. Complex numbers, and, represent the probabilities that a qubit will be in the |0| or |1| state. The squared values of the coefficients determine the likelihood of measuring the qubit in the |0| and |1| states.

An unlimited number of superpositions of the |0| and |1| states, each corresponding to a distinct probability distribution, are possible for a qubit to live in. This dramatically boosts a qubit's processing capability by enabling it to carry out many computations at once. Quantum algorithms may solve some problems tenfold quicker than conventional algorithms thanks to qubits' capacity to live in several states simultaneously. For instance, with conventional computers, a set of four bits can only be used to represent one of the sixteen possible values. A set of four qubits, however, may represent all 16 choices simultaneously in a quantum computer.

Grover's method, a quantum search technique that can search an unordered database with N items in N steps as opposed to N steps for a conventional approach, is a straightforward example of quantum superposition. Another illustration is the quantum algorithm Shor's algorithm, which can factorise a composite number in polynomial time and is thought to be challenging for conventional computers. This procedure has significant cryptographic ramifications since many encryption techniques rely on the complexity of factoring huge integers.

4. Entanglement

Let's continue the narrative from quantum superposition; did you know that qubits, which are microscopic assistants, may exist in two states simultaneously? Well, occasionally those qubits can develop close relationships and collaborate even when they are separated by great distances! The term for this is quantum entanglement.

Consider that you own a vehicle and a boat as your two toys. If you place the boat toy in a different room from the vehicle toy and make the two special pals, the changes you make to one item will also affect the other. Even if you aren't looking at one toy, you can still tell what's going on with the other toy by simply glancing at it. Quantum entanglement is exactly what it sounds like-it's a covert link between qubits.

This is crucial for quantum computers because it enables them to communicate and do some computations far more quickly than conventional computers. It is a highly unique and potent characteristic of quantum computers.

Let's Go down a Bit Farther!

The state of one system cannot be represented independently of the others in quantum mechanics when two or more quantum systems' attributes become correlated in this fashion, regardless of how far apart they are from one another. In other words, regardless matter how far off the two systems are from one another, their states are interdependent.

Entanglement is utilised in the context of quantum computing to carry out some computations significantly more quickly than conventional computers. Qubits are used in a quantum computer to represent the system's state, and entanglement is utilised to connect the states of several qubits so that they may carry out numerous computations at once.

The Bell states, which are the maximally entangled states of two qubits, are an illustration of quantum entanglement. Four different quantum states known as the Bell states enable quick and secure communication between two parties. The Bell-state measurement, a particular technique that enables the quick and safe exchange of quantum information between two parties, is used to establish these states. Another example is Grover's algorithm which utilizes the properties of entanglement to perform a search operation exponentially faster than any classical algorithm.

5. Quantum Measurement Problem

The act of measuring a quantum system disturbs its state, causing the superposition to collapse into a definite state. The interpretation of this process has been a subject of philosophical debate and is often referred to as the "measurement problem".

The Quantum Measurement Problem is a fundamental issue in quantum mechanics that concerns the behaviour of a quantum system during the act of measurement. It revolves around the puzzling question of how a system in a superposition of states can collapse into a definite state upon measurement. This phenomenon is not fully explained within the standard mathematical formalism of quantum mechanics.

Mathematically, we use a wave function (Ψ) to describe the state of a quantum system. The wave function shows the chance of finding the system in a specific condition. In a basic two-state situation, the combination of states can be written as:

$$\Psi = \alpha\Psi_1 + \beta\Psi_2$$

Here, α and β are complex probability amplitudes, and Ψ_1 and Ψ_2 are two possible states of the system.

In quantum mechanics, the process of measuring something is explained by the Collapse Postulate. When we measure the system, it goes into one of the possible states. The chance of each state happening depends on the square of the probability. In the above example, the probability of the system collapsing into state Ψ_1 is $|\alpha|$^2, and the probability of collapsing into state Ψ_2 is $|\beta|$^2.

The fundamental challenge lies in understanding what exactly triggers the wave function collapse and why we observe a definite outcome when the system was initially in a superposition. This non-deterministic behaviour is in contrast to classical physics, where measurements always yield definite results.

Various interpretations of quantum mechanics attempt to address the Quantum Measurement Problem, but a widely accepted solution remains elusive. The interpretations range from the Copenhagen Interpretation, which introduces randomness in the collapse process, to the Many-Worlds Interpretation, which suggests that all possible outcomes coexist in parallel universes.

Despite the ongoing debate and lack of a conclusive resolution, the Quantum Measurement Problem is a crucial aspect of quantum mechanics that continues to challenge our understanding of the nature of reality at the quantum level. It has profound implications for the interpretation of quantum theory and the philosophical implications of measurement and observation in the quantum world.

Despite its immense success in explaining the behaviour of microscopic systems, quantum mechanics remains a complex and counterintuitive theory, challenging our classical understanding of reality. It has led to groundbreaking technological advancements, such as lasers and transistors, and is the foundation for quantum computing, which has the potential to revolutionize computing power and problem-solving capabilities. Now just look at the basic concept of Qubits.

Qubits

One of the foundational elements of quantum computing is the qubit, the quantum analog of classical bits. This section explains the principles of qubits, highlighting their ability to exist in superposition states and entangled states. The different physical implementations of qubits, such as superconducting circuits, trapped ions, and topological qubits, are also discussed as follows

Quantum bits, commonly known as qubits, are the fundamental building blocks of quantum computing. Unlike classical bits, which can only represent information as either 0 or 1, qubits leverage the principles of quantum mechanics to exist in multiple states simultaneously. This unique property gives quantum computers the potential to outperform classical computers in solving certain complex problems.

Mathematically, a qubit can be represented as a linear combination of two basis states, usually denoted as $|0\rangle$ and $|1\rangle$:

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

Here, α and β are complex probability amplitudes that determine the probability of finding the qubit in either state $|0\rangle$ or $|1\rangle$ upon measurement. The sum of the squared magnitudes of these probability amplitudes must equal 1 to ensure that the qubit is in a valid state.

$$|\alpha|^2 + |\beta|^2 = 1$$

A key property of qubits is superposition, which allows them to exist in a combination of states. For example, a qubit can be in a superposition state:

$$|\psi\rangle = (1/\sqrt{2})|0\rangle + (1/\sqrt{2})|1\rangle$$

This means that the qubit is both in state $|0\rangle$ and state $|1\rangle$ simultaneously, with equal probability. When a qubit is in a superposition, it can process multiple inputs in parallel, providing a potential exponential speedup for certain algorithms in quantum computing.

Another critical feature of qubits is entanglement. When two or more qubits become entangled, the state of one qubit is inherently connected to the state of the others, regardless of the distance between them. Entanglement is a powerful resource in quantum computing, enabling the implementation of quantum algorithms that exploit the correlation between qubits to solve complex problems efficiently.

Qubits are delicate quantum entities, subject to the principles of quantum noise and decoherence, which can disrupt their superposition and entanglement. Therefore, error correction and fault-tolerant quantum computing techniques are essential for maintaining the integrity of qubits during quantum computations.

Quantum Gates and Quantum Circuits

Quantum gates are the building blocks of quantum circuits, enabling the manipulation and transformation of qubits. This section explores various types of quantum gates, such as the Hadamard gate, CNOT gate, and phase gate, explaining their operations and properties. The concept of quantum circuits, analogous to classical logic circuits, is introduced to illustrate the composition of gates to perform quantum computations.

Quantum gates are fundamental operations that allow the manipulation of qubits in quantum computing. These gates are analogous to classical logic gates used in traditional computing, but they operate on qubits, taking advantage of the unique properties of quantum mechanics. By applying a sequence of quantum gates, we can build quantum circuits to perform complex quantum computations.

1. Quantum Gates and Qubit Operations

In quantum computing, a quantum gate is represented by a unitary matrix that operates on the state of one or more qubits. A unitary matrix is a special type of matrix that preserves the normalization of the wave function, ensuring that the probabilities of all possible states sum up to 1.

2. Quantum States and State Vectors

The state of a quantum system, including qubits, is represented using state vectors. For example, a single-qubit state $|\psi\rangle$ can be expressed as a linear combination of the basis states $|0\rangle$ and $|1\rangle$:

$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

Here, α and β are complex probability amplitudes.

3. Quantum Gates as Unitary Operations

A quantum gate acts on the state vector of a qubit or a group of qubits, transforming it into a new state. Mathematically, a quantum gate G can be represented as a unitary matrix U_G. When applied to a single-qubit state $|\psi\rangle$, the action of the quantum gate is given by:

$$|\psi'\rangle = U\_G|\psi\rangle$$

Similarly, when the quantum gate is applied to a multi-qubit state, it operates on the joint state vector of the qubits.

4. Quantum Circuit Composition

Quantum circuits are composed of a sequence of quantum gates that manipulate qubits to perform specific computations. The output of one gate serves as the input to the next gate in the circuit. By combining various gates and carefully designing the circuit, we can implement quantum algorithms to solve problems more efficiently than classical computers in certain cases.

5. Entangling Gates

Certain quantum gates, known as entangling gates, are responsible for creating entanglement between qubits. The most well-known entangling gate is the Controlled-NOT (CNOT) gate, which flips the target qubit's state (|0⟩ becomes |1⟩, and vice versa) if the control qubit is in state |1⟩.

6. Measurement at the End

After applying a sequence of quantum gates to perform computations, the quantum circuit concludes with the measurement of the qubits. Measurement collapses the superposition of states into definite classical outcomes, providing the final result of the quantum computation.

Quantum Algorithms

Quantum algorithms offer the potential for exponential speedup compared to classical algorithms for specific problem domains.

Quantum algorithms are special algorithms made to use the special features of quantum computing, like superposition and entanglement. These formulas can solve some problems much faster than normal formulas. This makes quantum computing an exciting area for future progress.

One of the most famous quantum algorithms is Shor's algorithm, which efficiently factors large numbers-a task that is exponentially challenging for classical computers. Factoring large numbers is crucial for cryptography, and Shor's algorithm's potential to break certain encryption schemes has significant implications for secure communication.

Mathematically, **Shor's algorithm** can be summarized as follows:

Initialization: Prepare two quantum registers, one for the input and another for the output.

Superposition: Apply a quantum Fourier transform to the input register, creating a superposition of possible input values.

Modular Exponentiation: Use a quantum gate to compute the modular exponentiation of the input value reversibly.

Quantum Fourier Transform: Apply a quantum Fourier transform to the output register.

Measurement: Measure the output register. The probability of obtaining a particular measurement result is related to the factors of the input number.

Another significant quantum algorithm is Grover's search algorithm, which efficiently searches an unsorted database, again outperforming classical counterparts. Grover's algorithm is particularly valuable for optimization and search problems.

Mathematically, **Grover's search algorithm** can be described as follows:

Initialization: Prepare the quantum state to represent the search space.

Amplitude Amplification: Repeatedly apply a series of quantum gates to amplify the amplitude of the target state and suppress the amplitude of other states.

Measurement: Measure the quantum state, yielding the target solution with a high probability.

These examples illustrate how quantum algorithms leverage the unique capabilities of qubits to achieve computational speedups in certain applications. However, it is essential to note that quantum algorithms are not universally faster for all problems; they excel in specific scenarios, while classical algorithms remain more efficient for many other tasks. As researchers continue to develop and refine quantum algorithms, the potential of quantum computing to revolutionize various industries, such as cryptography, optimization, and artificial intelligence, becomes increasingly exciting.

Advantages of Quantum Computers:

Speed: Due to their superior computation speed over conventional computers, quantum computers are ideal for activities requiring vast amounts of data or challenging mathematical calculations.

Parallelism: Parallel processing of information is made possible by quantum computing, which enables the execution of many calculations at once. This can considerably speed up some activities, like scanning through enormous databases.

Cryptography: Many of the data security techniques now in use might be broken by quantum computing. It might, however, lead to the creation of brand-new, more secure encryption techniques that might be less vulnerable to hacker assaults.

Chemistry: Quantum computing has the ability to more precisely model the behaviour of molecules than traditional computers. This could lead to discoveries in drug design, materials science, and other areas.

Disadvantages of Quantum Computers

Quantum computers can change computing a lot, but they also have some problems. There are a few big problems and restrictions with quantum computing:

1) **Noise and Decoherence:** Creating a quantum computer is difficult in part because of the issue of noise and decoherence. Due to their extraordinary sensitivity to their surroundings, quantum systems are susceptible to mistakes in computing. As a result, it is challenging to preserve the qubits' fragile quantum state and to carry out correct calculations.
2) **Scalability:** Scalability is a significant problem as well. It is highly challenging to construct a large-scale quantum computer with a large number of qubits since it necessitates the exact control of a large number of quantum systems. Right now, the capability of quantum computing is limited because there are only a small number of qubits that can be handled and controlled in a laboratory setting.
3) **Error Correction:** Another significant obstacle for quantum computing is error correction. The nature of quantum systems makes it considerably more challenging to identify and rectify faults in quantum computing than it is in traditional computing, where errors can be fixed using error-correcting codes.
4) **Lack of Robust Quantum Algorithms:** The existence of reliable quantum algorithms is still lacking; many issues that can be resolved by conventional computers still lack a quantum solution, despite some quantum algorithms having been established.
5) **High Cost:** Due to the requirement for specialised equipment and highly skilled workers, constructing and maintaining a quantum computer is quite expensive. Quantum computing could only be accessible to specific persons or organizations since creating a large-scale quantum computer is expected to be highly expensive.
6) **Power Consumption:** Because qubits must be kept in their fragile quantum state, quantum computers are incredibly power-hungry. Due to the excessively high-power needs, scaling up quantum computing to bigger devices is challenging.

Quantum computers can change computing a lot, but they also have

some problems. The main problems in quantum computing are noise and decoherence, scalability, error correction, lack of strong quantum algorithms, high cost, and power usage. Many big companies have made and are still making quantum computers. Here are some examples:

1) **IBM:** IBM has developed numerous versions of quantum computers throughout its many years of development in the field. The business has made important strides in the area, and through its IBM Q quantum Experience platform, anybody with an internet connection may access and use its quantum computers for research. The 20-qubit IBM Q System One quantum computer, which was developed by IBM most recently, is intended for use in industry.
2) **Google:** The 72-qubit Bristlecone quantum computer is one of several generations of quantum computers that Google has constructed over the course of many years of research and development in the field. According to the corporation, its quantum computer has achieved "quantum supremacy", which means it can complete some computations more quickly than any conventional computer.
3) **Alibaba:** Alibaba has made significant investments in quantum computing and declared in 2017 that it has constructed a quantum computer with 11 qubits. The business has also been working on creating its quantum processors, and it soon hopes to provide a cloud-based quantum computing service.
4) **Rigetti computing:** A young business called Rigetti Computing is creating and developing quantum computers that use superconducting qubits. They make their quantum computers accessible to developers and academics via a cloud-based platform.
5) **Intel:** Intel has been working on its quantum computing technology and producing cryogenic control chips, cryogenic processors, and quantum processors. One of the biggest processors of its sort created to date, a 49-qubit quantum processor was disclosed in 2019.
6) **D-Wave Systems:** The first quantum computer that could be used by businesses, called the D-Wave One, was made by a Canadian company called D-Wave Systems. This company started in 1999. The quantum annealing method, a kind of quantum optimisation technique, is the foundation of the quantum computers created by

D-Wave. Even though their technology is primarily utilised for optimisation issues and is not a completely general-purpose computer, they assert to have created the first commercially usable quantum computer.

7) **Xanadu:** Canadian startup company Xanadu is creating a new type of computer called a quantum computer. They are using a method called photonic quantum computing. The foundation of photonic quantum computing is the manipulation of light rays (photons) to carry out quantum calculations. In contrast to other businesses developing quantum computers, Xanadu's strategy makes use of light rather than superconducting qubits. They are concentrating on creating a multi-algorithm general-purpose quantum computer.

Conclusion

Financial services face a variety of computationally difficult issues that are demanding in terms of the needed precision or runtime. We have specified three problem classes for them.

One category of optimization issues is those whose resolution in a given amount of time is constrained exponentially.

Quantum computer optimisation challenges might potentially have better answers found in fewer stages thanks to the holistic problem-solving strategy.

ML challenges fall into a second category where one must deal with complicated data structures that reduce classification or prediction accuracy. We might be able to uncover better patterns with growing accuracy thanks to quantum computers' ability to model multidimensional data.

Simulation difficulties fall into a third category, where there are time constraints on running enough scenario tests to identify the best possible solution. Quantum computers with effective sampling techniques may allow for a reduction in sample size and a speedier, more accurate answer.

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Chapter - 17
Architecture of Quantum Computing: A Systematic Review

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Chapter - 17

Architecture of Quantum Computing: A Systematic Review

Dr. Ranjan Kumar Mondal

Abstract

The physical framework and elements that make it possible to create and run quantum algorithms are included in the architecture of quantum computing. An overview of the major components and architectural factors of quantum computing systems is given in this paper. We examine the fundamental building blocks of quantum information processing, including qubits, quantum gates, and quantum registers. In addition, we explore the various quantum computing designs, such as topological, adiabatic, and gate-based quantum computers.

A therotic discusses several physical implementations, including superconducting circuits, trapped ions, topological qubits, and photonics, while highlighting the difficulties and achievements inqubit technology. We explore the importance of maintaining qubit coherence and minimizing decoherence effects to ensure accurate and reliable quantum computation. Moreover, we discuss the concept of error correction and fault-tolerant quantum computing, which are crucial for overcoming the inherent fragility of quantum systems.

This discussion also explores the idea of quantum parallelism and how it permits an exponential acceleration of some computer operations. Additionally, it analyzes the idea of quantum entanglement and how it supports non-local correlations and boosts computing abilities.

We also discuss the challenges involved in scaling up quantum computing, such as constraints on physical space, connection issues, and the requirement for inter-qubit communication. In order to create large-scale quantum computers that are capable of addressing challenging issues, scalability is an essential component.

The brief overview concludes by talking about the implications and prospective uses of quantum architecture in computers. Quantum simulation,

cryptography, optimization, machine learning, and material science are just a few of these applications.

Overall, this abstract functions as a thorough overview of quantum computing's architecture, and additionally provides insights into the underlying physical concepts, technical difficulties, and prospective directions for the field's future development.

I. Introduction

Quantum computing is a new technology that could have a big impact. It can be used in many ways and could change how organizations and markets work. A new report by McKinsey predicts that the global market for quantum computing will be worth $1 trillion by 2035. The report expects this growth to mainly occur in the financial, chemical, pharmaceutical, and automotive industries. Currently, big technology companies like Google, IBM, Microsoft, Amazon, and Alibaba are spending a lot of money on figuring out quantum computing. They also let some people use their quantum computers through the internet. is also investing in quantum computing. The government gave 1 billion US dollars, and the European Union has a budget of more than 1 billion euros [1].

Quantum computers use the rules of quantum mechanics to store information and do tasks. Both of these principles make quantum computers solve certain, complicated problems much faster than regular computers. Moreover, interference is crucial when extracting data from the quantum computer. Quantum computers can process many ideas at the same time, instead of one after the other, to solve complex problems. Additionally, certain quantum algorithms can be created to solve problems with fewer steps compared to classical algorithms. These quantum algorithms have lower complexity. This is why quantum computing could be a big step forward in modern technology soon and could start a new era called the "5th industrial revolution" [2].

II. Historical Evolution of Quantum Computer Architecture

A really big amount of computer power, that's needed n been matched by any other source of income for these companies. We have successfully met the needs for parameters such as speed. Please rewrite the entire text you would like me to work on. In 1947, an American computer engineer named Howard Aiken said that there were only six digital computers. The computer would be able to meet the needs of the United States. States means different areas or regions within a country. There are 16 of these regions. Moore's Law says that the amount of transistors on a computer chip keeps getting higher and higher. The power of a microprocessor keeps getting twice as much every 18 months. This text needs to be rewritten in simpler words: This results in the year 2020 or 2030 will discover the pathways on a tiny computer chip was measured using very small units of measurement [3].

Quantum computers use atoms and molecules to do powerful calculations. Memory and processing tasks both have the ability to be done. Certain calculations can be done much faster using a certain method other than using silicon-based technology.

Scalable means capable of being increased or expanded easily. Since Vincenzo first introduced a basic idea or principle. Criteria for quantum computing technology refers to the standards or requirements that need to be met in order for a technology to be considered as a quantum computing technology. Steane is likely a reference to a specific person or entity related to this topic. This image showed how hard it is to create a system that is able to effectively perform quantum error correction with a code of 2 qubits and 3 qubits. Another group of scientists have described different categorizations for big systems, they are necessary [4].

III. Quantum Computing System

In 1980, Paul Benioff came up with an idea called a quantum touring machine, which is basically the theoretical concept of a quantum computer. In 1982, Richard Feynman suggested using a quantum computer to simulate quantum systems in a more efficient way. A quantum computer is a special kind of computer that stores information in something called qubits and uses the rules of quantum mechanics to process them. A quantum computer is a special type of computer that uses different states of qubits (quantum bits). It uses these states, like being in multiple positions at the same time and being connected to each other, to do calculations. Quantum computers are not meant to work as regular computers all on their own. These devices will be very specialized and can complete specific tasks much quicker than regular computers. Using quantum computers will definitely need a regular computer to send and receive data, get answers from calculations, and manage the quantum computer’s electronic and internal activities. So, quantum computers and regular computers together make a quantum computing system that allows quantum computers to do quantum computing. We use the model to show the different parts of a quantum computing system for three reasons. First, it helps us to identify and understand the important parts of a quantum system so we can study how they work. Also, it expands on the idea of differentiating between hardware, system software, and application in analytics. This concept is also seen in different ways of organizing computing architectures, such as cloud computing (which includes Infrastructure-as-a-Service, Platform-as-a-Service, and Software-as-a-Service), or the layered modular structure of digital technologies. Third, our experts separated similar levels and used their interviews to explain the latest advancements, the difficulties faced by organizations today, and how quantum computing systems work. Figure 1 displays a quantum computing system made up of two parts: a traditional computing system called van Neumann architecture and a quantum computer with its own architecture consisting of three layers. We will explain each layer in detail [5].

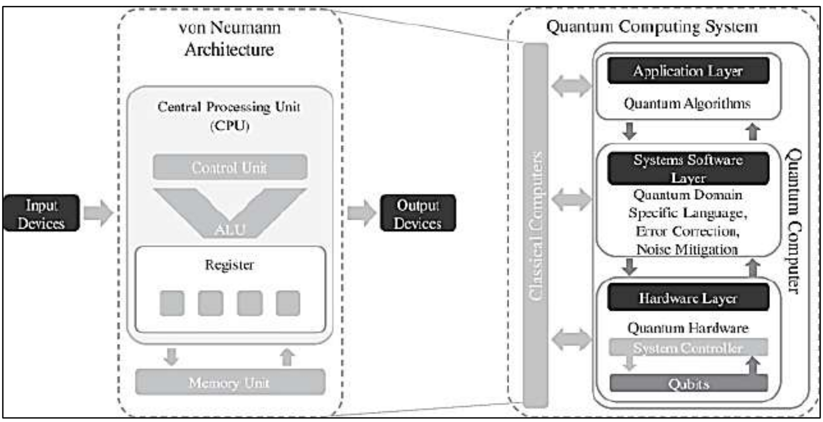

Fig 1: This picture is showing a classical computer (von Neumann architecture) and a quantum computer forming a quantum computing system

IV. Hardware layer

Classical computers and quantum computers differ in how they store information. While traditional computers have bits that can only be either zero or one, quantum computers have qubits that can hold a combination of both zero and one at the same time. Qubits use the benefits of quantum mechanics, especially the superposition effect (visualization see Fig. 2).

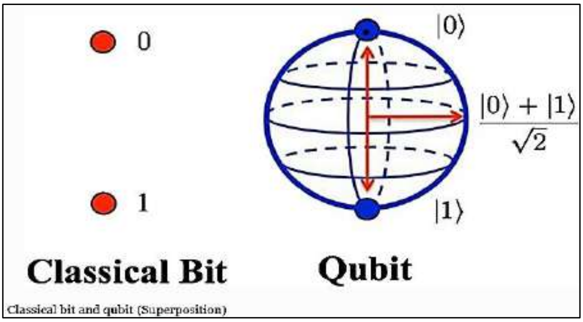

Fig 2: Superposition

In easier terms, a qubit is defined by its chance of being either zero or one, rather than the specific value of zero or one. So basically, a qubit can be 60% zero and 40% one. This means that the qubit only becomes a definite value of either zero or one when we measure it. The idea of superposition is helpful because a small quantum computer with only four qubits can show 16 different four-digit numbers all at once. When you add more qubits, you can represent more states. But with a classical computer, no matter how many bits you have, you can only represent one number at a time [6].

The main benefit of quantum computers is that they can do a huge number of calculations all at once. Even though a program usually only gives the answer to one calculation, it is possible to create a quantum algorithm that greatly increases the chances of getting the exact answer you want at the end. For instance, we could be investigating if there is any occasional turbulence that happens rarely and could make a plane crash. Instead of trying many different air conditions and checking their outcomes one by one on a regular computer, we can test almost all possible air conditions at the same time on a special kind of computer called a quantum computer. Then, we only need to pay attention to the result that would make the plane crash [7].

Entanglement

Quantum computing has more unique features than just qubits. Entanglement is a quality of quantum mechanics. Entanglement happens when the condition of one qubit is affected by the condition of another qubit. So, when two qubits are connected, if one qubit is changed in any way, the same change will happen to the other qubit. Moreover, when we measure the state of one of the two qubits, the state of both qubits becomes either one or zero (based on their chances). This is still true even if the qubits are very far apart. So, the good thing about entanglement is that when one qubit affects the other qubits nearby, they all work together to find a solution. So, qubits can be connected in a way that normal computers cannot do with bits. This means that a quantum computer can process information in a completely different way from a regular computer, allowing for new and exciting opportunities. One example is superdense coding, which means sending two pieces of information using only one special particle that is connected with another particle. This process is very intriguing for making sure quantum keys can be shared in a safe way. This is a safe way to talk to each other that uses special science stuff called quantum entanglement and other quantum things. It allows two people to create a secret key that only they know, which can be used to keep messages secure.

In simple terms, we will talk about how to physically represent and control qubits using the basics of quantum mechanics. Basically, there are two main types of approaches for quantum computing: analog quantum computing and digital gate-based quantum computing.

V. Analog Quantum Computing

Analog quantum computing means changing the quantum state in a smooth way using quantum operations. This helps ensure that the final system contains the correct information most of the time. Analog quantum computers are one type of quantum computing. It is called adiabatic quantum computers. These computers are designed to be able to do any kind of quantum computing. Quantum annealing is a special kind of computer that uses quantum technology to solve problems. It works by using certain algorithms and hardware to find the best solution to a problem by evolving towards the lowest possible energy states. Quantum annealing uses the fact that things naturally want to be in their lowest energy state. For example, hot things naturally cool down and objects naturally move towards lower ground. In quantum annealing, the best state that uses the least energy corresponds to the solution of the optimization problem. The quantum annealer can solve many possible answers at once, which makes it much faster than regular computers. Quantum annealing is best for solving optimization problems or probabilistic sampling. Companies like D-Wave use this technique. It is still uncertain if the quantum annealing technique will ever achieve a big speed boost from quantum computing.

Digital Gate-Based Quantum Computing

In digital gate-based quantum computing, we use digital gates to change and process the information stored in qubits. In simple terms, analog quantum computers use natural quantum states to find the best state with low energy, while digital gate-based quantum computers manipulate the quantum states to find the best solution. So, the way qubits are controlled helps a lot and makes them really good for solving different kinds of problems, unlike quantum annealing. Digital gate-based quantum computing is basically the same as regular computing in terms of how it works. A classical algorithm is when a computer follows a set of step-by-step instructions using gates like AND, OR, NOT, and so on. They change individual or pairs of zero and one states of classical bits, following a set of rules. Quantum gates make changes to one or more qubits by moving them between different combinations of zeros and ones, and also between different connected states. Some companies that use digital gate-based quantum computing include IBM, Google, and Rigetti.

System Software Layer

The system software layer is like a bridge between the hardware and the rest of the system. It helps to control and coordinate how the qubits (the basic units of a quantum computer) can be used in special and powerful ways called superposition and entanglement. This layer needs to handle difficulties with quantum states that are not stable in terms of energy. This helps to reduce unwanted heat and noise in the quantum system and also fixes any errors that occur.

In quantum computing, there are many things that can make noise. For instance, quantum computers, especially those based on digital gates, are very sensitive to changes in the surroundings, like vibrations and changes in temperature. Loud sounds can also happen if the quantum hardware is not controlled properly or if there are mistakes in how it was made. Most quantum computers need to be extremely cold, just a tiny bit above absolute zero temperature, in order to work. Hence, because it's impossible to avoid noise, the initial stage of quantum computers is known as the noisy Intermediate-Scale Quantum Computer. This abbreviation means that the current quantum hardware with a few qubits has high error rates. These error rates need to be reduced before we can create quantum computers with hundreds or thousands of usable qubits that are actually useful.

Application Layer

One of the big problems for quantum computers today is finding a way to store information in a way that is fast and doesn't use too much energy.

There are a few different ideas for creating quantum random access memory (QRAM). Although it may be hard to build (similar to the quantum computer itself), recent publications showed different ways that it can be accomplished. Currently, there is no good way to save the information of qubits for a long time in order to use it for other calculations. So, first, data must be transferred from a regular computer to the special quantum computer. Then, once the calculations are done, the classical computer needs to read (measure) the states of the qubits before they lose their information. Because of the no cloning theorem, we cannot make copies of quantum states and use them for calculations. The only way to transfer a quantum state from quantum memory to a quantum program is by using a SWAP operation, which takes it out of the memory.

When we measure a quantum state, it can only become either one or zero. So, we don't know what state a certain qubit is in. To know the state of a qubit, we need to have more than one of them and measure all of them. Sometimes, the process of reading normal data is so expensive in quantum algorithms that it can't make the entire algorithm faster overall. It may not be possible to read the data accurately, which is not enough for certain tasks that require a lot of computing. This is particularly true for methods that require a lot of information, like machine learning and artificial intelligence.

In simpler terms, when it comes to quantum computers, finding a useful algorithm is mainly about creating it in a way that makes it more likely to get the desired result when measuring it. Even though the quantum computer can provide many possible answers, we usually only focus on a few of them. The art of creating quantum algorithms involves finding them without having to run the entire algorithm multiple times. These are three very important algorithms in quantum computing.

Grover's algorithm is another term for the quantum search algorithm. The Grover's algorithm is a way to find information in a database or list that is not organized or sorted. Typically, when looking for a specific item in a database with N entries, we usually have to check about half of the entries, on average, to locate the desired item. Using Grover's algorithm, we can complete this task in a number of steps approximately equal to the square root of N, on average. For a big N, this can be way quicker. This is when something gets faster, and it's called a quadratic speedup.

Shor's algorithm, also known as the integer factorization algorithm, can quickly break down numbers into their smaller factors much faster than the fastest traditional method we know. Factorizing integers means finding the factors of a whole number. This is a challenging process for computers and is also the foundation of RSA encryption.

HHL, or Harrow Hassidim Lloyd, is a type of math formula called a quantum algorithm. It is used to solve linear equations. The algorithm can calculate the answer to a math problem using the numbers in a matrix and a vector.

VI. Processor Architecture

The processor's architecture adheres to the standard for conventional CPUs. The instruction cycle of the processor architecture created for quantum processes has four phases. Below is a list of the processor's functions and an architectural diagram.

Instruction Fetch

This stage has two components: the program counter and the instruction memory. The program counter is a part of the computer that remembers which instruction is being executed at the moment and calculates the next instruction to be executed. When the computer is processing information, it takes two sets of instructions for a single part of the information during each cycle.

The processor's instructions will be divided into two types. The first type is instructions for setting up or arranging something. These directions are needed to set up the data in the quantum state registers for the necessary task. The second kind of instruction is called computing instructions. These instructions will tell you what to do and what things you need to do it.

Instruction Decode and Control

At this point, the instruction is translated and the signals that control the execution stage are created. The control signals tell the Quantum Computing unit what to do during the execution stage. This stage also has a Quantum state memory that holds the values of coefficients of different qubits on which the operation will happen. Qubits are taken and sent to the QCU based on the address given in the instruction.

Execution Unit

The execution unit is like the central part of the processor architecture. It is made up of a powerful Quantum Computing Unit that has multiple FPU working together at the same time.

Register Write-Back

The outcome from the quantum computing unit is saved in the quantum state registers to make the qubits better. To prevent issues with data, writing to registers is done using a different clock edge than reading from them. The way the proposed processor moves from one state to another when executing quantum instructions is like how a single cycle classical processor does it. The picture called figure 4 shows the state diagram. Figure 3 displays the connected paths of the processor's data.

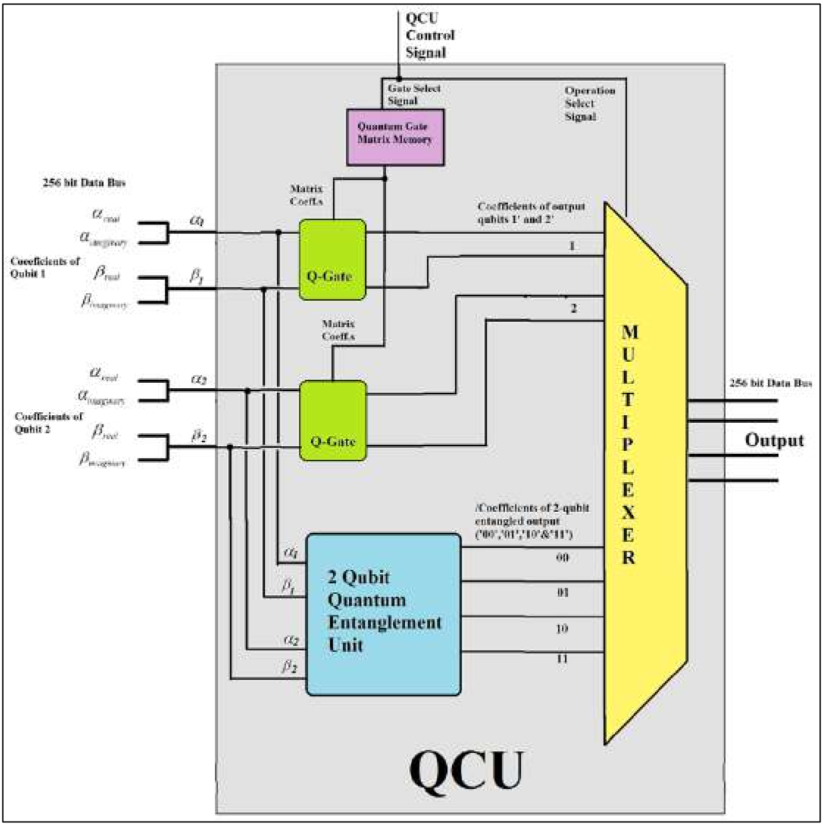

Fig 3: Shows the combined data-path of the processor

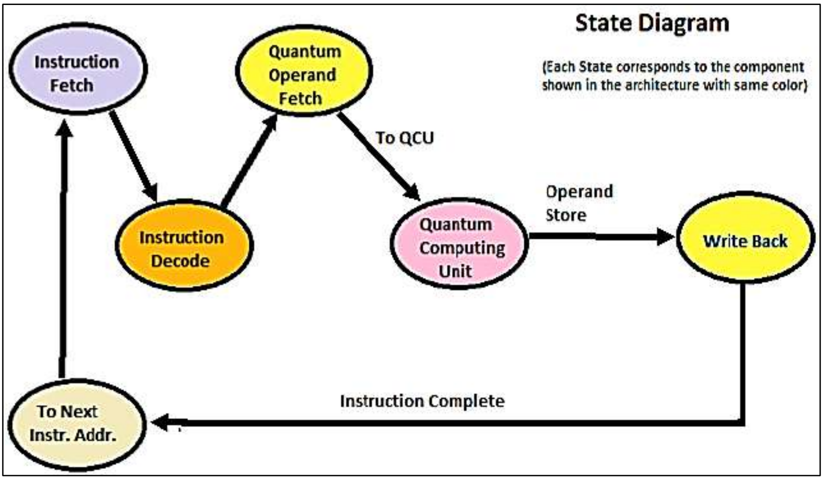

Fig 4: State transitions of the processor while performing quantum operation

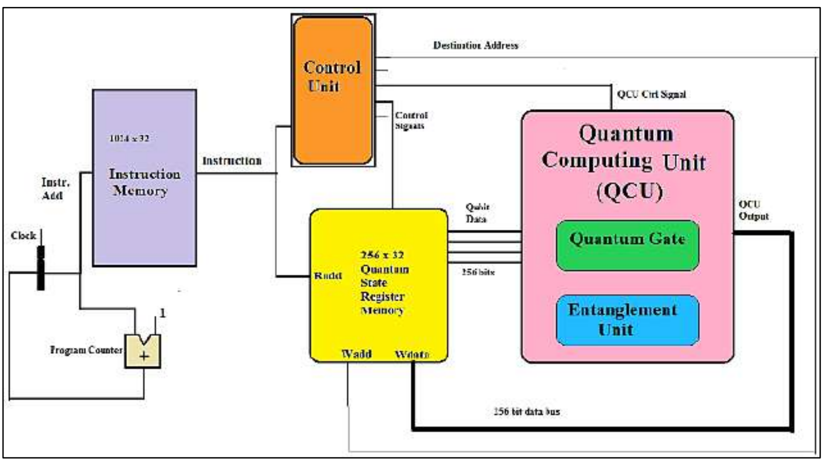

Fig 5: Processor Datapath

VII. Quantum Simulation

Quantum simulation is a quantum algorithm that solves a problem, it leverages the principles of quantum mechanics to accurately model the interactions and dynamics of particles at the quantum level. This allows researchers to study and understand complex quantum systems without the need for expensive and complex experimental setups. By running the quantum simulation algorithm on a classical computer, it is possible to obtain valuable insights and predictions about the behavior of quantum systems, which can have implications in a wide range of scientific fields such as chemistry, materials science, and physics.

This problem is challenging for a regular computer. The analysis of the resource needs is done in the quantum system. Designing for the quantum simulation. Fault tolerant quantum means a type of quantum system or device that can continue to function properly, even if there are issues or errors in the system.

In this case, simulation is being explained or described. different options available to choose from. We are currently researching different ways to simulate things. level concentrations of pollutants at various locations in a city. This simulation can help us figure out how much pollution is present in different parts of the city. And the levels of energy that a molecule has when it is in an excited state.

VIII. Future Scope

The chip inside the computer can do special calculations called Quantum Fourier transform and Grover's algorithm. These calculations are much faster than normal calculations on regular computers. The set of instructions for the new design will be created to help with performing different types of tasks in quantum computers.

There are many ways we can use quantum computers in the real world. Rewrite this text to use simpler words: 1. Rewrite this passage using easier words. Quantum computing can be very helpful as a high-performance computing system. It can quickly help improve system goals.

Quantum computers can help us understand complex iological systems by simulating and predicting the folding patterns of proteins. In simple words, quantum computing algorithms can be used in a smart system for transportation to help analyze and understand traffic patterns in the air and on the ground. This can prevent congestion and traffic jams from happening.

IX. Conclusion

The aim of this project was to create a structure that can imitate Quantum Computing operations quickly. The new design of the Quantum Computing Unit makes calculations much faster because of its parallel structure. Using a specific format called 32 bit floating point, storing quantum data can make calculations more accurate and precise. The hardware needed for this architecture is very big. However, it is much better than the current emulation systems for Quantum algorithms and it can be made even better during the implementation phase. We will use Verilog and FPGA to build the entire processor. We will use tools like Xilinx 12. 1 to help us with designing the processor. The new Quantum emulation microarchitecture described in this research will definitely lead to more possibilities in using quantum computers in real-life applications.

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Chapter - 18
Growth and Effect on Weed on Wetland Rice Fields

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Chapter - 18

Growth and Effect on Weed on Wetland Rice Fields

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Abstract

The established contribution of blue-green algae (BGA) and Azolla in supplying nitrogen to rice fields is well acknowledged. Furthermore, these organisms, whether directly or indirectly, bring about various changes in the physical, chemical, and biological attributes of the soil and the soil-water interface in rice fields. For example, during their growth, BGA releases extracellular organic compounds and photosynthetic oxygen, while Azolla actively prevents pH elevation, reduces water temperature, inhibits NH3 volatilization, and suppresses weed growth. Additionally, BGA and Azolla contribute to biomass, and upon decomposition, they influence redox activity, leading to the formation of diverse organic acids in the soil. These alterations initiated by BGA and Azolla in the soil have the potential to affect the availability of nutrients to plants and the overall characteristics of the soil. This review aims to highlight these effects in rice fields and explore their potential implications for the management and productivity of rice-field systems.

Introduction

The success of rice production in tropical and subtropical regions heavily relies on the effective and economical supply of nitrogen (N), a crucial element in the greatest quantity compared to other essential nutrients. The utilization efficiency of N from fertilizer sources in lowland rice is notoriously low due to its loss from soils through various chemical and biochemical processes. Moreover, increasing the application of nitrogenous fertilizers is considered environmentally unfriendly (Conway and Pretty 1988) and economically impractical (Cassman and Pingali 1994). Therefore, there is a need to explore alternative renewable resources to fulfill at least a portion of the N demand for rice crops.

Nitrogen-fixing blue-green algae (BGA) or cyanobacteria and Azolla have been identified as crucial contributors to maintaining and enhancing rice field productivity (Roger *et al*. 1993). It has been established that soil N fertility is better sustained under flooded than dryland conditions (Watanabe and Roger 1984). Favorable conditions for biological N2 fixation by BGA are considered a factor in the relatively stable rice yield under flooded conditions. Unlike chemical N fertilizers, BGA and Azolla neither contaminate the environment nor deplete the photosynthates of rice plants (Liu 1979).

The significance of N2-fixing BGA was initially acknowledged by De (1936, 1939), who attributed the self-maintenance of N status in tropical rice-field soils to the growth of N2-fixing BGA. Similarly, the fertilizing value of Azolla in rice fields is well-known and has been utilized for centuries in China and Vietnam (Watanabe *et al*. 1981; Lumpkin and Plucknett 1982). The growth of N2-fixing BGA (De and Mandal 1956; Singh 1961; Stewart *et al*. 1968) and Azolla (Shen *et al*. 1963; Peters *et al*. 1977; Singh and Singh 1987) considerably increases the plant-available N in rice soils.

Noteworthy literature on this topic exists for both BGA (Fogg *et al*. 1973; Roger and Kulasooriya 1980; Venkataraman 1981) and Azolla (Watanabe *et al*. 1981; Lumpkin and Plucknett 1982; IRRI 1987; Wagner 1997). Field inoculation with BGA, even in the presence of 100–150 kg N ha–1 as fertilizer, led to a rice yield improvement of 5% to 25% (Sprent and Sprent 1990; Yanni 1992). Since biological N2 fixation is known to be inhibited by inorganic N, this observation suggests that BGA may provide additional benefits beyond adding N to the soils.

Both BGA and Azolla, directly or indirectly, induce changes in the physical, chemical, and biological properties of the soil and the soil-water interface in rice fields, holding agronomic significance. The extracellular organic compounds released by algae, O2 produced during their active growth, and subsequent biomass addition after their death will likely bring about critical physical-biochemical changes in soils. Prevention of algae-induced pH rise, reduction in water temperature, suppression of NH3 volatilization losses, and weed control under Azolla cover are additional effects that may benefit rice cultivation. This review aims to compile and discuss the limited information available on these aspects of BGA and Azolla use, exploring their potential implications for rice growth and the sustained productivity of rice fields.

Weed Control

The expense associated with weed control in rice fields can sometimes account for as much as 20-25% of the total cost of rice cultivation (De Datta 1981). Inoculating Azolla and BGA into rice fields and promoting their vigorous growth offers a potential solution to minimizing weed control costs. These organisms can be effective weed suppressors, especially targeting submerged photosynthetic weeds. Algal blooms and an Azolla mat covering the floodwater surface in rice fields reduce the photosynthetic activity of weeds by intercepting light, thereby significantly inhibiting their growth. This advantageous effect of Azolla was initially observed in the early part of the 20th century (Braemer 1927). Subsequent research has consistently reported the weed-suppressing benefits of Azolla (Janiya and Moody 1981, 1984; Kannaiyan *et al*. 1983; Satapathy and Singh 1985; Kröck *et al*. 1988c; Van Hove 1989). Ngo (1973) documented the suppressive effect of varying mat densities of Azolla pinnata on the quantity of Echinochloa crusgalli, revealing a 70% reduction in the 50% Azolla cover plot and a 93% reduction in the 100% Azolla-cover plot after 6 weeks compared to the control. Rains and Tally (1979) reported that the early development of Azolla filiculoides eliminated Cyperus difformis and Polygonum species from paddy fields, although it did not affect E. crusgalli. Satapathy and Singh (1985) observed similar suppressive actions of A. pinnata on the growth of various weeds in rice fields. These findings highlight the efficacy of Azolla in suppressing weed growth. Information on the sensitivity of weeds to different Azolla species is generally lacking, and there is limited data on the effect of BGA growth on weeds.

BGAs also form a dense mat when growing profusely over rice field floodwater, they may prove effective in weed suppression. Additionally, BGA is known to produce various secondary metabolites, including antibiotics and biotoxins, which could act as growth deterrents for undesirable organisms, including plant-disease-producing bacteria and fungi (Frankmölle *et al*. 1992; Kulik 1995). While there is evidence of reduced smut incidence in barley due to BGA inoculation (Periminova 1964), *in vivo* efficacy in flooded rice fields, particularly considering potential dilution effects, remains uncertain. The suppressive impact of BGA and Azolla on weeds is influenced by the density or thickness of their blooms/mats, with species forming thicker or higher-density mats being preferable for this purpose. Developing blooms or mats of BGA and Azolla is crucial before the re-emergence of weeds post-puddling in rice fields. However, comprehensive information on the effectiveness of different Azolla or algal species in suppressing various weed types in rice fields is lacking.

Growth promoting effect

The influence of Blue-Green Algae (BGA) inocula on crop yield in the presence of nitrogen fertilizers is commonly attributed to the production of growth-promoting substances by these organisms (Brown *et al*., 1956; Kopteva, 1970; Tupik, 1973). Numerous researchers have observed improved growth and seed germination in many crop plants after treatment with algal cultures or their extracts. Most reported enhancements in rice seed germination, root and shoot growth, grain weight, and protein content (Shukla and Gupta 1967; Venkataraman and Neelakantan 1967; Singh and Trehan 1973; Jacq and Roger 1977). Similar stimulatory effects were found in wheat (Gupta *et al*. 1967), tomato (Kaushik and Venkataraman 1979; Rodgers *et al*. 1979), radish (Rodgers *et al*. 1979; Vorontsova *et al*. 1988), peas (Gupta and Gupta 1972), banana (Ganapathi *et al*. 1994), among others. However, some studies have documented negative effects on the germination of rice seeds (Pedurand and Reynaud 1987). Diverse opinions exist regarding the nature of these substances. Some describe them as hormones, such as gibberellin-like (Singh and Trehan 1973), cytokinin-like (Rodgers *et al*. 1979), auxin-like (Ahmad and Winter 1968), or abscisic acids (Marsalek *et al*. 1992). Others categorize them as vitamins, particularly vitamin B (Grieco and Desrochers 1978), or as amino acids (Watanabe 1951; Vorontsova *et al*. 1988), antibiotics, and toxins (Metting and Pyne 1986). The production of these substances is influenced by various stress factors (Marsalek *et al*. 1992) and the application of chemicals, particularly Co salts (Venkataraman and Neelankantan 1967). Mutants of some species may produce more of these substances than indigenous types (Vorontsova *et al*. 1988). However, comprehensive quantitative and qualitative analyses of these substances produced by different BGA species and a critical assessment of their influence on crop growth or seed germination are still lacking.

Conclusions

Blue-green algae (BGA) and Azolla play pivotal roles in rice fields, substantially enhancing rice field productivity. Beyond nitrogen enrichment, they instigate significant alterations in the physical, chemical, electro-chemical, and biological attributes of soils and the soil-water interface in rice fields, offering numerous advantages for the rice crop. These benefits encompass the incorporation of organic carbon, enhancement of soil physical characteristics, reduction in NH3 volatilization loss, mobilization of fixed phosphates, regulation of micronutrients-especially Fe, Mn, and Zn-with consequential effects on their availability, mitigation of sodicity in problematic soils, suppression of weed growth, and the release of growth-promoting substances. At times, these benefits outweigh those derived solely from the nitrogen they introduce. However, the realization of these advantages depends on the robust growth of BGA and Azolla in rice fields, which may not always occur naturally. Consequently, it is imperative to escalate azolliculture/algalisation programs to optimize the benefits of these valuable organisms in rice fields.

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Chapter - 19
A Survey on Strategies for Assessing the Dynamic State of Power Systems

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Chapter - 19

A Survey on Strategies for Assessing the Dynamic State of Power Systems

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Abstract

Condition estimate, a crucial Energy Management System (EMS) function, is in charge of determining the power system's current condition. Because the power system is a quasi-static system, it varies gradually over time. State estimate is computationally expensive, making it difficult to repeatedly run it at frequent intervals to accomplish real-time monitoring of a dynamic system. Dynamic State Estimation (DSE) approaches simulate the time-varying characteristics of the system, enabling them to anticipate the state vector. This turns out to be a significant benefit for the operator when carrying out security assessments and other control center tasks. The literature contains several methods for estimating dynamic states. This paper provides a high-level overview of various techniques and advancements in DSE.

Keywords: Dynamic state estimation, kalman filter, real-time monitoring, square root filter, and estimate of static states, energy management system

I. Introduction

The modern power grid is undergoing a profound transformation driven by technological advancements, renewable energy integration, and the growing complexity of energy networks. In this dynamic landscape, the accurate assessment of the dynamic state of power systems has become a paramount concern for grid operators, system planners, and researchers. The dynamic state of a power system encompasses a wide range of variables, including voltage, current, frequency, and phase angles, which are constantly changing due to various factors such as load fluctuations, renewable energy intermittency, and equipment failures. Ensuring the stability, reliability, and efficiency of power systems in such a dynamic environment is a multifaceted challenge that demands innovative strategies and tools.

Real-time monitoring and control become increasingly important as the power system gets bigger and more complicated in order to ensure that it operates reliably. This monitoring and controlling task is the responsibility of the Energy Management System (EMS) functions. status estimate provides a database of the system's current real-time status for use in other EMS tasks, serving as the foundation of the energy management system [1]. Therefore, efficient and accurate state estimate is a requirement for the power system to operate efficiently and reliably. The state of an electric power system is a vector made up of bus voltage magnitudes and phase angles. Numerous approaches have been put forth to determine the state vector of the power system ever since Schweppe *et al.* [2-4] introduced the idea of state estimate to the field of power systems in the early 1970s. Obtaining real-time measurement data, such as line flows and injection readings, is necessary for power network status estimates.

The power system is considered to be a quasi-static system under typical circumstances, meaning that it changes gradually yet steadily. The loads are what cause these modifications to the power system. The generations also need to be modified as the loads in the system vary, which affects the flows and injections throughout the system and makes the entire system dynamic. State estimate must be done at frequent short periods in order to have continuous monitoring of the power system. However, as the power system grows and more generations and loads are added, the system becomes too big to do static state estimate frequently since it uses a lot of processing power.

This survey aims to provide a comprehensive overview of the strategies and techniques employed for assessing the dynamic state of power systems. It delves into the critical importance of dynamic state estimation (DSE) as an indispensable tool in maintaining the integrity of modern power grids. By continuously monitoring and analyzing the dynamic behavior of the system, DSE enables operators to make informed decisions in real-time, ensuring the efficient operation of the grid and preventing catastrophic failures.

The motivation behind this survey is rooted in the rapid evolution of power systems and the need for a consolidated resource that not only reviews existing methodologies but also explores emerging trends and future directions in the field. As the global push towards renewable energy integration, grid modernization, and increased electrification continues, understanding how to assess and manage the dynamic state of power systems becomes increasingly crucial.

Throughout this survey, we will examine the fundamental principles and mathematical foundations of dynamic state estimation. We will explore the various measurement sources, including supervisory control and data acquisition (SCADA) systems, phasor measurement units (PMUs), and advanced sensors, that feed into the estimation process. Additionally, we will discuss the integration of advanced technologies such as machine learning and artificial intelligence, which are revolutionizing the field of dynamic state assessment by enabling more accurate and timely predictions.

Furthermore, the survey will highlight the challenges and complexities associated with dynamic state assessment, including cybersecurity considerations in an increasingly interconnected grid, the integration of renewable energy sources with variable generation patterns, and the need for improved situational awareness in the face of unforeseen events.

In conclusion, this survey on strategies for assessing the dynamic state of power systems aims to serve as a valuable resource for researchers, engineers, policy makers, and industry professionals involved in the operation and planning of modern power grids. By providing insights into the state-of-the-art techniques, emerging trends, and future prospects in this field, we hope to contribute to the advancement of power system reliability, stability, and sustainability in an ever-evolving energy landscape.

II. Dynamic State Estimation

Using state estimation techniques makes it simple to monitor changes in a power system in real time continuously with a specific time step. Though these methods, despite being extremely computationally efficient, do not any physical simulation of the power's temporally variable nature system, and might not be as precise as desired. Dynamic state estimation makes advantage of the current (and occasionally together with knowledge of the prior) state of the power system using the physical model of the system, we predict the state vector for the following instant. This DSE prediction function offers critical benefits for system operation, control, and making decisions. The operator has more time to act as a result.

Dynamic State Estimation (DSE) is a critical function in the operation and control of power systems. It involves continuously monitoring and estimating the dynamic behaviour of a power system in real-time. Here are the key aspects and significance of dynamic state estimation:

1) Real-Time Monitoring: DSE offers real-time data on the magnitudes and angles of the voltage, the current flows, and the speeds of the generators that make up a power system. For the grid to operate safely and reliably, real-time monitoring is essential.

2) **Validation of the Model:** DSE aids in confirming the accuracy of the mathematical models that are used to depict the power system. Any differences or deviations can be found by comparing the model predictions with the actual measurements, allowing for model improvement.

3) **Security and Stability:** It is crucial to maintain the security and stability of a power system. DSE assists operators in identifying and responding to faults, disturbances, and other occurrences that can jeopardize the grid's stability. It helps identify possible voltage collapses, line overloads, and generator problems.

A. Mathematical Modelling

DSE's initial stage, which involves the identification of the appropriate mathematical model for the power system's time behaviour. universal mathematics These two sources provide the model for a dynamic system [1, 6]:

$X_{k+l} = f(X_k, U_k, W_k, k)$

Where 'k' denotes the time sample, 'x' the state vector, 'u' the control actions, 'w' the model uncertainty, and 'f the nonlinear function. However, such a model is overly intricate, expensive, and unworkable. As a result, various assumptions are made to simplify the implementation (some of which were already discussed earlier). The following characteristics are present: The system is quasi-static and thus changes very slowly; The time frames considered are small enough to allow the use of linear models to describe the transition of states between successive instants of time; and White Gaussian noise with zero mean and constant covariance is used to describe uncertainties. Q

Taking into account these presumptions, we may arrive at the following generic linear model for the DSE: $x_{k+1} = F_k x_k + G_k + w_k$

B. Parameter Identification

In this step, several parameters listed in the DSE mathematical model are calculated. F_k, G_k, and the dynamic model are displayed in (Eq. With F_k assumed to be an identity matrix and Gk assumed to be zero, Debs and Larson [6], who are known for writing the foundational study on DSE, and

Nishiya *et al.* [7] have assumed a basic linear model. However, this renders the estimator overly simplistic and impairs its capacity for forecasting [1]. The change in state vector is thought to be so tiny in the model put forth by Debs and Larson [6] that it is substituted by a zero mean, white Gaussian noise.

C. State Prediction or State Forecasting

The process of estimating the future dynamic state variables of the power system based on historical data, in-the-moment measurements, and mathematical models is referred to as state prediction or state forecasting utilizing dynamic state estimation in power systems. This is a vital component of managing and operating the electrical system because it enables grid managers to prepare for the future. Here is how dynamic state estimate applies to state prediction:

1. **Data Gathering:** The procedure starts with the gathering of real-time data from a variety of sensors and measurement equipment placed throughout the power system. These measurements of voltage, current flows, generator speeds, and other pertinent variables.
2. **Dynamic State Estimation:** Dynamic state estimation techniques estimate the present condition of the power system using the gathered data.

D. State Filtering

State filtering, also known as state estimate or dynamic state estimation, is a crucial procedure in the functioning of power systems. On the basis of in-the-moment observations and mathematical models, it includes continuously evaluating the state of the power system at any given time. This predicted state aids grid operators in making decisions that will maintain the stability and dependability of the system. Here is how dynamic state estimate is used in state filtering:

1) Data collection Various sensors and measuring tools installed throughout the electrical system are used to gather real-time data. These instruments track variables like voltage levels, phase angles, current flows, and frequency.

2) **Mathematical Models:** The relationships between various state variables and components of the power system are depicted mathematically. These simulations account for the behaviour and physical properties.

III. Alternative Formulations of DSE

A. Extensions to Kalman Filter based Techniques

Dynamic State Estimation (DSE) for power systems frequently makes use of approaches based on Kalman filters. An effective recursive estimator that can determine the state of a dynamic system from a set of erroneous observations is the Kalman filter. The use of Kalman filter-based approaches in DSE looks like this:

1) **State Space Representation:** A dynamic state-space model of the power system is used. There are two essential parts to the state-space model:

- **State Vector (x):** The dynamic state variables of the power system, including voltage magnitudes, phase angles, generator speeds, and other pertinent factors, are contained in this vector.
- **Measurement Vector (z):** This vector holds the voltage, current, and frequency measurements made in real time by sensors and measurement equipment situated within the power system.

2) **State Prediction (Time Update):**

- **State Prediction Equation:** A mathematical model describes how the state variables evolve over time. This equation predicts the next state of the system based on the previous state and system dynamics. It is typically represented as:

$$x(k+1) = A * x(k) + B * u(k) + w(k)$$

Where:

- `x(k+1)` is the predicted state at time step `k+1`.
- `x(k)` is the current state at time step `k`.
- `A` is the state transition matrix.
- `B` is the control input matrix (if applicable).
- `u(k)` is the control input (if applicable).
- `w(k)` represents process noise.

3) **Measurement Update (Correction):**

- **Measurement Model:** A measurement model describes how measurements relate to the system's true state. It includes a measurement matrix (C) that maps the state vector to the measurement vector:

z(k) = C * x(k) + v(k)

Where: `z(k)` is the actual measurement at time step `k`.

`v(k)` represents measurement noise.

- **Kalman Gain (K):** The Kalman filter computes a Kalman gain (K) that determines the weight given to the prediction and the measurement. The Kalman gain is adjusted based on the uncertainty of the prediction and measurement errors.
- **Update Equations:** The Kalman filter calculates the updated state estimate (x) and covariance matrix (P) based on the prediction and measurement:

x(k|k) = x(k) + K(k) * [z(k) - C * x(k)]

P(k|k) = (I - K(k) * C) * P(k)

Where:

`x(k|k)` is the updated state estimate.

`P(k|k)` is the updated state covariance matrix.

`I` is the identity matrix.

4) **Recursive Estimation:** The Kalman filter operates recursively, continuously updating the state estimate as new measurements become available in real-time.
5) **Covariance Management:** The Kalman filter keeps track of the covariance matrix (P), which represents the uncertainty in the state estimate. It accounts for both process noise (system dynamics) and measurement noise.

Kalman filter-based techniques in DSE are effective for handling noisy measurements, modelling system dynamics, and providing accurate state estimates in real-time. They are particularly useful for power systems with dynamic behaviour and fast-changing conditions, such as those with a high penetration of renewable energy sources. These techniques help operators make informed decisions for grid control, stability, and reliability.

B. Robust Dynamic State Estimation

The approaches based on the Kalman filter assume Gaussian noise dispersion. However, the noise distribution commonly produces outliers when it deviates from the presumptive model.

The effectiveness of kalman filter-based methods declines in the existence of these anomalies. So, in order to offset this, G.S.S. Thakur *et al*. [26] and Durgaprasad *et al*. [25] have arrived. The development of a reliable mestimation-based dynamic estimate method. The two key characteristics on which the techniques have been created include: Robust filtering by using M-estimation.

The system, step one of this technique's three primary steps.robust filtering, modeling, and measurement modeling. The modeling is predicated on the idea that the complicated bus.

C. Al based DSE Techniques

Artificial intelligence techniques' capacity for

It is useful to employ prediction and pattern recognition in

1) An ANN-based Method

The Dynamic Load Prediction (DLP) method is based on the suppositions that bus loads and generations are what drive the dynamics of the system and that the loads have a pattern and can, therefore, be anticipated. Using the load at instant 'k,' an ANN is employed in this method to anticipate the active and reactive loads at all buses at instant (k+1). Since bus generations are dependent on loads and respond to changes in those loads, it is impossible to predict how they will behave. Because of this, generation precipitation factors are used to adapt load changes to generations while calculating bus generations. Once the injections at different buses are known, it becomes more complicated.

Utilizing conventional estimating theory. however, in recent years, ANNs, or Artificial Neural Networks, have produced a lot of the scientific community's interest. ANN is a great brand.

2) Fuzzy Logic based Technique

In order to deal with uncertainty, imprecision, and nonlinearities in the system, fuzzy logic-based techniques can be used in Dynamic State Estimation (DSE) for power systems. The systematic representation of hazy and qualitative information is made possible by fuzzy logic. Here is an example of how DSE for power systems uses fuzzy logic-based techniques:

Fuzzy modeling is a first step. Fuzzy sets are defined for state variables and measurements using membership functions. The level of membership of a value to a fuzzy set is described by membership functions. A voltage measurement, for instance, can have membership criteria like "low", "medium" and "high".

Fuzzy Rules: The link between state variables and measurements is captured by fuzzy rules. These norms can be grounded in historical information or expert knowledge and are expressed in linguistic terms.

IV. Dynamic State Estimation Benefits

One of the key benefits of DSE is its capacity for one-step state vector prediction. That has several benefits, including [1, 5]:

It helps to identify and reject faulty data and so enhances estimator performance.

It enables security analysis to be carried out in advance, giving the operator more time during emergencies. When using pseudo measurements, DSE rapidly offers good quality numbers, preventing improper conditioning.

DSE can be used to validate data because it predicts the states one time stamp in advance.

Similar to this, we may spot rapid system changes, topological flaws, and other abnormalities using the anticipated state vector.

V. Conclusion and Future Scope

Power system monitoring and control in real time is crucial for the effective and dependable operation of a power system. The real-time monitoring and control features are built on state estimation. Since the electrical system is always changing, the operator must be exceedingly vigilant when making judgments in the moment, particularly in emergency situations. A method that can foresee the potential status of a power system in the near future is advantageous in such a situation. Therefore, scientists have suggested dynamic state estimation algorithms that give the operator the expected state vector in the following time instant, allowing the operator to make any appropriate control decisions. As soon as the measurements are taken, not always more precise in every situation) than the other methods and are commonly utilized in both utility and scholarly communities. The Future study in the field, thorough analysis of the strategies for dynamic state estimation described in the literature has been shown. We sincerely believe that this will benefit the power engineers' community should expand study of dynamic subjects for state estimation. A review on techniques for assessing the dynamic status of power systems has a broad potential use due to the dynamic nature of the energy industry, advancements in technology, and increased complexity of power grids. The following are some potential future directions and areas of interest for research and development in this field:

1. **Integration of Renewable Energy Sources:** As the integration of renewable energy sources becomes more and more crucial, dynamic state evaluation processes must be developed that can effectively handle the volatility and unpredictability of sources like wind and solar.
2. **Smart Grids and IoT:** As Internet of Things (IoT) and smart grid technologies advance, real-time data collection offers the opportunity to enhance dynamic state evaluation.

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Chapter - 20
Advancements in Structural Engineering through Artificial Intelligence: A Comprehensive Review

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Chapter - 20

Advancements in Structural Engineering through Artificial Intelligence: A Comprehensive Review

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Abstract

The integration of artificial intelligence (AI) in structural engineering has revolutionized the way we design, analyze, and maintain structures. This paper provides a comprehensive review of the advancements in structural engineering facilitated by AI techniques. It explores various applications of AI in structural analysis, design optimization, predictive maintenance, and risk assessment. Additionally, it discusses the challenges and future prospects of AI in advancing the field of structural engineering.

Keywords: Structural engineering, artificial intelligence, structural analysis, design optimization, predictive maintenance, risk assessment

1. Introduction

1.1 Background

Structural engineering plays a crucial role in ensuring the safety, stability, and functionality of various infrastructures such as buildings, bridges, dams, and offshore structures. Traditionally, structural analysis and design have relied on manual calculations and empirical methods, which are often time-consuming and may not fully capture the complexities of modern structures. With the advent of artificial intelligence (AI) technologies, there has been a paradigm shift in the way structural engineers approach design, analysis, and maintenance tasks. The integration of AI techniques in structural engineering offers numerous benefits, including improved accuracy, efficiency, and cost-effectiveness. By harnessing the power of machine learning, neural networks, and other AI algorithms, engineers can optimize designs, predict structural failures, and enhance the overall performance of infrastructure systems. This paper aims to provide a comprehensive overview of the latest advancements in structural engineering facilitated by AI technologies.

1.2 Objectives

The main objectives of this paper are as follows:

a) To review the fundamentals of artificial intelligence and its relevance to structural engineering.

b) To explore the various applications of AI in structural analysis, design optimization, predictive maintenance, and risk assessment.

c) To present case studies highlighting real-world applications of AI in structural engineering.

d) To discuss the challenges and limitations associated with the implementation of AI in structural engineering.

e) To propose future directions for research and development in this field.

2. Fundamentals of Artificial Intelligence

Artificial intelligence encompasses a broad range of techniques and methodologies aimed at enabling machines to perform tasks that typically require human intelligence. In the context of structural engineering, AI algorithms can be utilized to analyze complex datasets, optimize designs, and make informed decisions. The following are some of the fundamental concepts of artificial intelligence relevant to structural engineering:

2.1 Machine Learning

Machine learning is a subset of artificial intelligence that focuses on developing algorithms capable of learning from data and making predictions or decisions without explicit programming. Supervised learning, unsupervised learning, and reinforcement learning are common approaches in machine learning. In structural engineering, machine learning algorithms can be trained on historical data to identify patterns, classify structural behaviors, and predict the response of a structure under different loading conditions.

2.2 Deep Learning

Deep learning is a subfield of machine learning that utilizes artificial neural networks with multiple layers to learn complex patterns in large datasets. Deep learning algorithms, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), have achieved remarkable success in various domains, including image recognition, natural language processing, and speech recognition. In structural engineering, deep learning techniques can be applied to analyze sensor data from structural health monitoring systems, detect anomalies, and predict potential failures in advance.

2.3 Neural Networks

Neural networks are computational models inspired by the structure and function of the human brain. A neural network consists of interconnected nodes (neurons) organized into layers. Each neuron receives input signals, processes them using an activation function, and generates an output signal.

In structural engineering, neural networks can be used for tasks such as structural identification, damage detection, and nonlinear analysis.

2.4 Reinforcement Learning

Reinforcement learning is a machine learning paradigm concerned with training agents to make sequential decisions in an environment to maximize cumulative rewards. Reinforcement learning algorithms learn through trial and error by interacting with the environment and receiving feedback in the form of rewards or penalties. In structural engineering, reinforcement learning can be employed for optimizing structural designs, scheduling maintenance activities, and controlling structural systems in real-time.

3. Structural Analysis with AI

Structural analysis is the process of predicting the behavior of a structure under various loading conditions. AI techniques can enhance the accuracy and efficiency of structural analysis by leveraging advanced algorithms for data processing and model prediction. The following are some of the key applications of AI in structural analysis:

3.1 Finite Element Analysis (FEA)

Finite element analysis (FEA) is a numerical method used to solve partial differential equations governing the behaviour of structures. FEA divides a complex structure into smaller, simpler elements and applies numerical techniques to solve for the displacements, stresses, and strains within each element. AI techniques, such as machine learning and deep learning, can be integrated with FEA to improve the accuracy of material properties estimation, model calibration, and uncertainty quantification.

3.2 Computational Fluid Dynamics (CFD)

Computational fluid dynamics (CFD) is a branch of fluid mechanics that uses numerical methods to simulate the behaviour of fluid flows. CFD is commonly used in the design of buildings, bridges, and other structures to analyse the effects of wind, water, and other environmental loads. AI algorithms can be employed to optimise CFD simulations, automate the mesh generation process, and accelerate the solution of complex fluid-structure interaction problems.

3.3 Structural Health Monitoring (SHM)

Structural health monitoring (SHM) involves the continuous monitoring of structures to detect damage, assess structural integrity, and predict potential failures. SHM systems typically rely on sensors, data acquisition devices, and signal processing techniques to collect and analyse structural response data. AI techniques, such as machine learning and pattern recognition, can be applied to SHM data to detect anomalies, diagnose structural defects, and estimate remaining useful life.

4. Design Optimisation using AI Techniques

Design optimisation aims to find the best possible solution to a given engineering problem while satisfying certain constraints. AI techniques offer powerful tools for optimising structural designs and exploring large design spaces efficiently. The following are some of the AI-based design optimisation techniques commonly used in structural engineering:

4.1 Generative Design

Generative design is a computational design approach that leverages algorithms to explore a wide range of design alternatives automatically. Generative design algorithms generate and evaluate multiple design iterations based on predefined objectives and constraints, allowing engineers to discover novel and optimised solutions. In structural engineering, generative design can be used to optimise the shape, topology, and material distribution of structures while considering factors such as performance, cost, and sustainability.

4.2 Evolutionary Algorithms

Evolutionary algorithms are optimisation techniques inspired by the principles of natural evolution and genetics. These algorithms, such as genetic algorithms, particle swarm optimisation, and simulated annealing, iteratively generate and evolve candidate solutions to find optimal or near-optimal solutions to complex optimisation problems. In structural engineering, evolutionary algorithms can be employed for optimising structural configurations, sizing structural members, and tuning control parameters.

4.3 Swarm Intelligence

Swarm intelligence is a collective behaviour observed in social insects such as ants, bees, and termites, where individual agents interact locally to achieve global objectives. Swarm intelligence algorithms, such as ant colony optimisation and particle swarm optimisation, mimic the behaviour of swarms to solve optimisation problems. In structural engineering, swarm intelligence algorithms can be used to optimise the layout of structural systems, allocate resources efficiently, and coordinate multiple agents in collaborative design tasks.

5. Predictive Maintenance of Structures

Predictive maintenance involves the use of data-driven techniques to predict the future performance and maintenance needs of structures based on historical data and real-time monitoring information. AI techniques offer powerful tools for analysing sensor data, detecting anomalies, and predicting potential failures in advance. The following are some of the AI-based predictive maintenance techniques commonly used in structural engineering:

5.1 Sensor Data Analysis

Sensor data analysis involves the processing and interpretation of data collected from sensors installed on structures to monitor various parameters such as strain, displacement, temperature, and vibration. AI techniques, such as machine learning and signal processing, can be applied to sensor data to extract valuable insights, detect abnormal patterns, and identify early signs of deterioration or damage. In structural engineering, sensor data analysis can help engineers monitor the health condition of structures in real-time, prioritise maintenance activities, and optimise maintenance schedules.

5.2 Prognostics and Health Management (PHM)

Prognostics and health management (PHM) is an interdisciplinary approach that integrates data analytics, modelling, and decision-making to assess the health condition of systems and predict future performance degradation. PHM techniques aim to identify potential failure modes, estimate remaining useful life, and recommend appropriate maintenance actions. In structural engineering, PHM techniques can be applied to predict the deterioration of structural components, assess the structural integrity of ageing infrastructure, and optimise maintenance strategies to extend the service life of structures.

5.3 Condition-Based Maintenance (CBM)

Condition-based maintenance (CBM) is a maintenance strategy that relies on the real-time condition monitoring of assets to determine the optimal timing for maintenance activities. CBM techniques aim to minimise downtime, reduce maintenance costs, and maximise the availability and reliability of assets. In structural engineering, CBM techniques can be implemented using AI algorithms to analyse sensor data, detect early signs of deterioration or damage, and schedule maintenance interventions based on the actual condition of structures.

6. Risk Assessment and Management

Risk assessment and management involve the identification, analysis, and mitigation of risks associated with the operation, maintenance, and use of structures. AI techniques offer powerful tools for analysing complex risk factors, quantifying risk levels, and making informed decisions to minimise the likelihood and impact of adverse events. The following are some of the AI-based risk assessment and management techniques commonly used in structural engineering:

6.1 Probabilistic Risk Assessment (PRA)

Probabilistic risk assessment (PRA) is a systematic approach to assessing the likelihood and consequences of potential hazards and failures in complex systems. PRA techniques use probabilistic models, statistical analysis, and simulation methods to quantify risk levels, identify critical failure modes, and prioritise risk mitigation measures. In structural engineering, PRA techniques can be applied to assess the risk of structural failure under different loading conditions, evaluate the effectiveness of structural retrofitting measures, and optimise risk-based maintenance strategies.

6.2 Bayesian Networks

Bayesian networks are graphical models that represent probabilistic relationships among a set of variables using directed acyclic graphs. Bayesian networks enable engineers to capture uncertainty, update beliefs, and make probabilistic inferences based on available evidence and domain knowledge. In structural engineering, Bayesian networks can be used for risk assessment, reliability analysis, and decision support in various applications such as structural design, maintenance planning, and safety management.

6.3 Fault Tree Analysis (FTA)

Fault tree analysis (FTA) is a deductive approach for analysing the causes and consequences of system failures using graphical models called fault trees. FTA techniques start with a top-level event (e.g., structural failure) and systematically decompose it into contributing factors and failure modes using logic gates such as AND, OR, and NOT. In structural engineering, FTA techniques can be employed to identify potential failure scenarios, assess the criticality of failure modes, and priorities risk mitigation actions based on their impact on overall system reliability.

7. Case Studies

7.1 AI in Bridge Engineering

Bridges are critical infrastructure assets that require regular inspection, maintenance, and rehabilitation to ensure their safe and reliable operation. AI techniques, such as machine learning, computer vision, and remote sensing, can be applied to bridge inspection data to automate defect detection, assess structural health, and prioritise maintenance needs.

For example, researchers at the University of California, Berkeley, developed a deep learning-based system called "Deep Bridges" that automatically detects and classifies defects in bridge images captured by drones or other remote sensing platforms. Deep Bridges uses convolutional neural networks (CNNs) to analyse image data and identify various types of defects, such as cracks, spalls, and corrosion. By automating the bridge inspection process, Deep Bridges reduces the time and cost associated with manual inspections, improves the accuracy and consistency of defect detection, and enables engineers to make data-driven decisions regarding maintenance and repair priorities.

7.2 AI Applications in Tall Buildings

Tall buildings pose unique challenges in terms of structural design, construction, and maintenance due to their height, complexity, and exposure to wind and seismic forces. AI techniques can help engineers optimise the design of tall buildings, assess their structural performance, and monitor their health condition over time.

For example, researchers at Stanford University developed an AI-based system called "Tall AI" that uses machine learning algorithms to analyse sensor data from accelerometers installed in tall buildings to monitor their dynamic behaviour and detect anomalies indicative of structural damage or degradation. Tall AI employs anomaly detection techniques to identify abnormal patterns in vibration data and alert building owners or operators to potential structural issues. By continuously monitoring the structural health of tall buildings, Tall AI enables proactive maintenance interventions, reduces the risk of catastrophic failures, and enhances the safety and resilience of tall building infrastructure.

7.3 AI-Based Structural Health Monitoring Systems

Structural health monitoring (SHM) systems use sensors, data acquisition devices, and data analytics techniques to monitor the condition of structures and detect potential defects or damage. AI techniques, such as machine learning and signal processing, can enhance the effectiveness of SHM systems by analysing sensor data, detecting anomalies, and predicting future structural performance.

For instance, the ASCE Structural Engineering Institute (SEI) developed an AI-based structural health monitoring system called "SHM-SEI" that integrates wireless sensor networks with machine learning algorithms to assess the health condition of civil infrastructure such as bridges, buildings, and dams. SHM-SEI collects data from a network of sensors installed on structures and analyses it using advanced machine-learning techniques to identify patterns indicative of structural damage or deterioration. The system provides real-time alerts and notifications to engineers, enabling them to take timely action to address potential safety concerns and extend the service life of infrastructure assets.

These case studies demonstrate the diverse applications of AI in structural engineering, ranging from automating bridge inspections to monitoring the health condition of tall buildings and implementing advanced structural health monitoring systems for civil infrastructure.

8. Challenges and Limitations

Despite the significant progress and potential benefits of integrating AI into structural engineering, several challenges and limitations need to be addressed to realise its full potential. The following are some of the key challenges associated with the implementation of AI in structural engineering:

8.1 Data Quality and Quantity

AI algorithms require large volumes of high-quality data to learn patterns, make accurate predictions, and generate meaningful insights. However, obtaining and curating large-scale datasets for structural engineering applications can be challenging due to factors such as data availability, data heterogeneity, and data labelling requirements. Additionally, ensuring the quality, accuracy, and reliability of data is essential to prevent bias, errors, and misleading conclusions in AI-based analyses.

8.2 Interpretability and Transparency

Many AI algorithms, particularly deep learning models, are often perceived as "black boxes" that make predictions without providing explanations or insights into their decision-making process. Lack of interpretability and transparency in AI models can undermine trust, limit adoption, and hinder regulatory compliance in safety-critical applications such as structural engineering. Ensuring the interpretability and transparency of AI algorithms is crucial for enabling engineers to understand, validate, and trust the results produced by AI systems.

8.3 Ethical Considerations

The deployment of AI in structural engineering raises ethical concerns related to privacy, security, fairness, and accountability. For example, the use of AI-based surveillance systems for monitoring public infrastructure may infringe on individual privacy rights and raise questions about data ownership and consent. Moreover, AI algorithms can inadvertently perpetuate or exacerbate existing biases and inequalities if trained on biased data or designed without adequate safeguards against discrimination. Addressing ethical considerations and ensuring responsible AI deployment is essential for building public trust, safeguarding societal values, and promoting equitable access to benefits.

9. Future Directions

Despite the challenges and limitations, the future of structural engineering holds tremendous potential for further advancements through the continued integration of AI technologies. The following are some future directions and emerging trends in AI-driven structural engineering:

9.1 Integration of AI with Building Information Modelling (BIM)

Building Information Modelling (BIM) is an integrated process for creating, managing, and sharing digital representations of physical and functional characteristics of buildings and infrastructure projects. AI technologies can enhance BIM workflows by automating repetitive tasks, analysing complex datasets, and generating actionable insights for decision-making. Integrating AI with BIM enables engineers to leverage rich data sources, streamline collaboration, and optimise project delivery from design to construction to operation.

9.2 Autonomous Structural Design Systems

Autonomous structural design systems leverage AI algorithms to automate the entire design process, from conceptualisation to optimisation to validation. These systems use generative design techniques, evolutionary algorithms, and machine learning models to explore vast design spaces, generate novel solutions, and iteratively improve design performance based on user preferences and constraints. Autonomous structural design systems empower engineers to explore innovative design alternatives, optimise for multiple objectives, and accelerate the design iteration process, leading to more efficient, sustainable, and resilient structures.

9.3 AI-Driven Sustainable Construction Practices

AI technologies can play a crucial role in promoting sustainability in the construction industry by optimising material usage, reducing waste, and minimising environmental impact. AI-driven approaches such as predictive analytics, digital twin simulations, and life cycle assessment models enable engineers to make informed decisions about material selection, construction methods, and energy-efficient design strategies. By incorporating sustainability considerations into the design and construction process, AI-driven approaches help minimise the carbon footprint of structures, enhance resource efficiency, and contribute to the transition towards a more sustainable built environment.

10. Conclusion

The integration of artificial intelligence (AI) in structural engineering represents a transformative shift towards more intelligent, efficient, and resilient infrastructure systems. AI technologies offer powerful tools for analysing complex datasets, optimising design solutions, predicting structural behaviour, and enhancing risk management practices. While challenges such as data quality, interpretability, and ethical considerations remain, the potential benefits of AI in structural engineering are vast and far-reaching. By addressing these challenges and embracing emerging opportunities, the field of structural engineering can continue to evolve and innovate, driving towards safer, more sustainable, and more resilient built environments for future generations.

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Chapter - 21
Review on Applications of Artificial Neural Networks for the Protection of Power Systems

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Chapter - 21

Review on Applications of Artificial Neural Networks for the Protection of Power Systems

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Abstract

The family of distance relays includes the most widely used technologies for securing transmission and sub transmission lines. Successful designs based on electromechanical, solid-state, and digital electronics technologies have been created and marketed throughout the previous 80 years. Numerous features, including impedance, offset-impedance, admittance, reactance, and blinders, are implemented by these relays. The suggested distance relay designs based on artificial neural networks perform admirably under ideal fault settings, however they are unable to preserve the integrity of the generic designs' relay characteristics' outer limits. This study discusses ANN models that have been offered in the past for safeguarding power system components and offers a way for developing general-purpose distance relays that fully utilizes the potential of ANNs.

Keywords: Artificial neural networks, distance relays, sub transmission lines, general-purpose distance relays, offset-impedance

Introduction

Technology based on artificial neural networks, which are motivated by biological neural networks, has advanced quickly in the past ten years and has been used in applications for power system protection. Applications in particular include differential protection of three phase power transformers [7], fault classification for faults on double circuit lines [3], ANN based distance relays [4], direction discrimination for transmission line protection [1-2], and faults on generator windings [8]. The general protection systems based on ANN that have been developed up to this point only function effectively under ideal fault conditions and do not uphold the integrity of the bounds of the relay characteristics. Even if the networks have been taught to recognize the operational states around the borders of the characteristics, there is still a shortcoming. This study examines a few ANN models that have been suggested for guarding various power system elements, including transmission lines, transformers, and generators. The approach for creating ANNs is then provided, which takes into account the connections between the input data and the desired ANN outputs. The suggested methodology aids in making the most of ANNs' capabilities when building a general distance relay.

Protecting Power System Components

Transmission Line Protection

Designing and implementing a fault direction discriminator was one of the early advancements in the application of ANNs for protecting transmission lines [1]. In this design, a multi-layer feed-forward network with a 12-4-1 structure was used. This ANN-based directional relay processed sampled voltage and current values to determine whether a fault was on the line side or the bus side of the relay. In order to train the network, patterns from all three phases (Va, Vb, Vc, and Ia, Ib, Ic) were used. Using data gathered from simulations run on the EMTDC/PSCAD program, the effectiveness of the developed protection system was evaluated. Because it demonstrated that it was a big development.

Since then, a few further ANN models for securing transmission lines have been presented. On high-voltage transmission lines, a recent design uses a finite impulse response ANN (FIRANN) to identify the beginning of problems and pinpoint their direction [2]. The planned network's configuration is 45-35-5. Three of the network's five outputs-one for each of the three phases-identified faults, while the fourth output indicated the fault's direction and the fifth output recognized undercurrent/undervoltage circumstances. This network was trained using a total of 100,000 patterns from various relay locations in a modeled system, which included the voltages, currents, and sums of all three phases. Compared to other ANN designs, this one is quite sophisticated.

Transformer Protection

Power transformer protection is another area in which artificial neural networks have found application. Current sample normalized values are processed by a time delay artificial neural network [5]. Both the currents' basic frequency and harmonic components are filtered by the discrete

Fourier transform. A multi-layer feed forward network is used to create differential protection using the fundamental and harmonics of second to fifth order [6].

A FIRANN differential relay is used to safeguard three phase power transformers, according to recent research [7]. The two networks are made up of two FIRANNs with delay units. A system fault is found by the first FIRANN, which has two hidden layers and a configuration of 6-6-4-1. Two outputs are provided by the second network, which has the arrangement 6-8-8-2. The first output shows a problem inside the transformer protection zone, while the second output shows the fault beyond the zone. Despite the fact that these two networks had distinct architectures, they were trained using the same input patterns, which included voltages and currents from all phases.

Generator Protection

There hasn't been much discussion of using ANN-based systems to safeguard generators up to this point. In a recent article, an ANN-based fault diagnostic technique for generator windings is implemented [8]. In contrast to typical differential relays, the suggested network, together with the capacity to identify the failed phases, has a better sensitivity and stability boundary for detecting and categorizing generator winding faults.

According to this study, it is impossible to choose the ideal configuration for an ANN; as a result, three different networks are tested, and the one that yields the best results is selected. Phase to ground, two-phase, and three-phase faults can be identified by the first network, which has a configuration of 6-3-7 and employs six current sample inputs. In the second design, three networks are used, each having the configuration 2-2-1, with two sets of inputs and three sets of outputs for each network (one for each phase). The third design employs seven networks with a configuration of 6-3-1, each of which is given a set of six inputs. Each network can identify a single fault category.

Overview and Comments

The papers reviewed in Sections 2.1 to 2.3 use ANNs for protection of different components of a power system. The question of maintaining the integrity of the boundaries of the relay characteristics, however, is not addressed in them. If a trained ANN does not perform well, especially near the boundary of the desired characteristic, during the testing phase, then appropriate inputs have to be given to train it again to improve its performance. At this point, it becomes extremely essential to understand the impact of the different types of inputs on the training of the ANN for obtaining the desired results from them. Therefore, comprehension of the internal structure of an ANN is very important.

Table 1: Recent advancement on protection of power systems using artificial neural networks for the protection of power system

Contribution in the field	Year of publication	Major contribution	Summary
A.B. Olatunji, S.O. Adebayo, and A.A. Adewuyi	2023	Application of Artificial Neural Network (ANN) to Enhance Power Systems Protection: A Case of the Nigerian 330 kV Transmission Line	This paper investigates an improved protection solution based on the use of an ANN on the 330 kV Nigerian network modeled using PSCAD/EMTDC. The ANN is trained to classify different types of faults on the transmission line using voltage and current waveforms as inputs. The results show that the ANN-based protection system can accurately classify different types of faults with a high degree of accuracy.
A. Sharma, S.P. Singh, and B. Singh	2022	Applications of Artificial Neural Networks in Concentrating Solar Power Systems	The characterization and commercialization of concentrating solar power (CSP) technologies need a deep understanding of the effect of different parameters on the performance and reliability of these systems. ANNs can be used to model and predict the performance of CSP systems under different operating conditions. This paper reviews the recent advances in the application of ANNs in CSP systems.
N. Sharma, P. Kumar, and D. Kumar	2020	Artificial Neural Network Applications for Power System Protection	ANNs have been successfully applied to various power system protection applications in recent years. This paper reviews the application of ANNs in power system protection, including transmission line protection, transformer protection, generator protection, and busbar protection.
S.K. Singh, M. Basu, and A. Mukherjee	2019	A Novel Artificial Neural Network-Based Approach for Fault Detection	This paper proposes a novel ANN-based approach for fault detection and location in transmission lines. The proposed approach uses voltage and current waveforms as inputs to the ANN. The ANN is trained to classify different

		and Location in Transmission Lines	types of faults and to estimate the fault distance. The results show that the proposed approach can accurately detect and locate faults in transmission lines with a high degree of accuracy.
A.A.A. Shaheen, M.A. El-Sayed, and M. El-Shahat	2021	Application of Neural Networks in Power Systems; A Review	ANNs have been widely used in power systems for various applications, including load forecasting, fault diagnosis, economic dispatch, security assessment, and transient stability. This paper reviews the applications of ANNs in power systems, highlighting the recent advances in this area.

Proposed Methodology

A methodology that fully exploits the potential of ANNs and makes the whole process simple is presented in this paper. In this methodology, the processes assigned to the different layers of an ANN are segregated by dividing the network into sub-networks; each sub-network is responsible for performing an assigned protection function. This process helps in better understanding the internal structure of the ANN and makes the process of modifying the network simpler whenever required.

As discussed previously in this paper, ANNs are associated with some acceptability issues. Analysis of an artificial neural network-based fault direction discriminator [10] was an attempt to address some of those issues. The acceptability issues arise because of undefined relationships between the inputs and the outputs provided by an ANN.

The proposed networks use the normal structure of an ANN as shown in Figure 1. The inputs (Va, Vb, Vc and Ia, Ib, Ic in almost all the cases) are given to the input layer and the outputs are obtained from output layer.

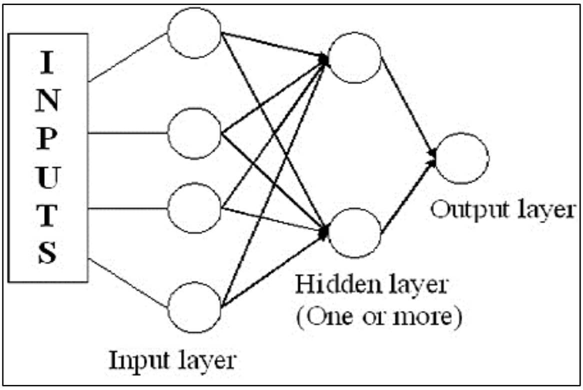

Fig 1: Normal Structure of an ANN

The Proposed Design

In this section, an ANN based methodology for protecting transmission lines is presented. The proposed methodology can be used for designing ANN based systems for protecting other components of power systems. To develop a system that maintains the integrity of operation around the boundaries of the relay characteristics, modifications must be made to the inputs that are provided to the network. Instead of providing the conventional inputs (Va, Vb, Vc and Ia, Ib, Ic), inputs that assist in achieving the desired relay characteristics were used to train the network. This created a direct relationship between the inputs and the outputs expected from the networks while maintaining the integrity of operation around the boundary of the relay characteristics.

Figure 2 shows the characteristics of a mho (admittance) relay. An ANN was designed and was trained to give +1 output for faults which are in the protected zone of the relay (class P1) and -1 output for patterns of normal system operation (class P2). The network acted like a pattern classifier and differentiated between two classes of patterns.

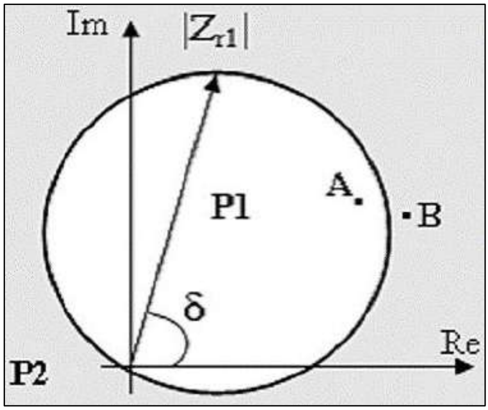

Fig 2: Characteristics of a mho (admittance) relay

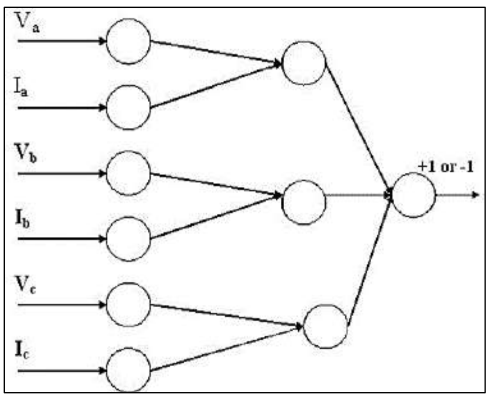

Fig 3: An illustration of the suggested ANN model

The characteristic of an admittance relay, shown as an example, was achieved by the developed design. A similar procedure could be used to develop networks that would implement other characteristics, such as offset mho, reactance and blinders. Figure 3 shows a modified model of the development's suggested ANN structure. As shown in figure 3, voltages and currents from power system simulations were applied to the network for each phase. With this topology, the entire network was divided into 3 separate sub-networks, one for each phase. This strategy is comparable to that employed in computer programs that contain numerous small programs rather than a single huge one. By altering the internal structure of the standard ANN, this methodology assisted in allocating specific functions to each sub-network. One protection function was handled by each sub-network, therefore modifications to a protection function did not require changing the ANN's overall structure. These sub-networks' outputs were provided to an output layer in order to get the results.

It was now possible to locate all kinds of defects in this network.

a) Each sub-network produced one output. A sub-network's output revealed errors of the designated type, such as phase A, B, or C problems. If an ANN did not perform well for faults of the assigned type during testing, that sub-network was changed, or its training data and procedure were assessed and changed.

b) These outputs combined to identify phase-to-phase problems. The following layer's logic comparators were used to find phase to phase errors. To find A-B, B-C, and A-C faults, the outputs from the three AND logic comparators were combined.

c) Combining the three networks' three-phase fault outputs. In place of neural layers.

Training the Proposed Network

The adopted structure of the network allows keeping a check on all the operations taking place in an ANN. Also, simply by looking at the output of each sub-network, it is possible to modify the inputs to be given to the ANN for its proper training.

The training was conducted by back-propagating the errors in such a manner that the ANN maintained the integrity of operation around the boundary of the relay characteristics. The outputs obtained from all the layers of the ANN were examined. This ensured that appropriate errors are back-propagated for updating the weights of the ANN. The inputs used to train the ANN were suitable for detecting faults in zone 1 only i.e. 80% of the transmission line. This approach will be adapted in the future work for designing ANN based systems for protecting zone-2 and zone-3 of the transmission system.

Sample Study

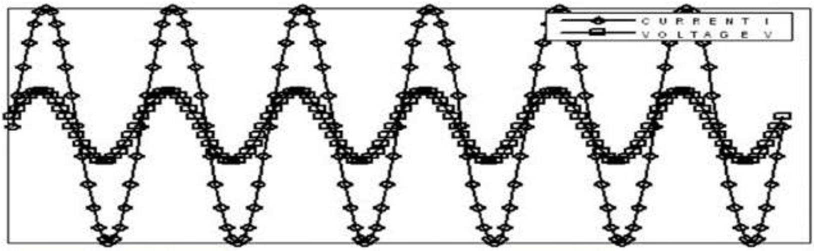

Fig 4: Sample waveforms for point A

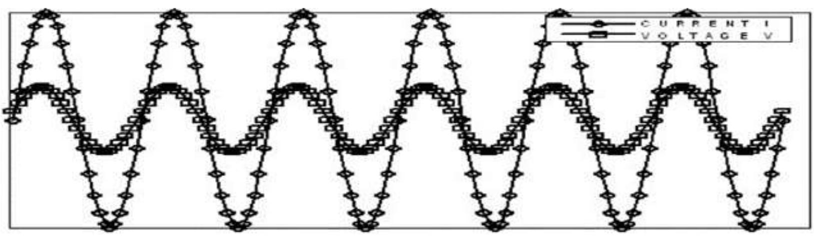

Fig 5: Sample waveforms for point B

Examples of voltage and current waveforms for points A and B, respectively, in the relay characteristics illustrated in Figure 2 are presented in Figures 4 and 5, respectively. The trained ANN was put to the test using these inputs. As can be seen from the relay characteristics, point A is exactly inside the boundary region that the relay is protecting, and point B is exactly outside the protection zone; both points have the same impedance value. The trained ANN was able to distinguish between the faults inside the protected zone and the patterns of typical system operation despite a little difference between the two sets of waveforms. When the trained ANN was given the first input, the output it produced was +1 (point).

Conclusions

This paper examines ANN-based relay designs that have been previously proposed. A new approach has been developed that fully utilizes an artificial neural network's potential for use in protecting transmission lines. The suggested architecture makes it simple to tweak the ANN during training and offers a better knowledge of the internal workings of an ANN. To maintain the integrity of the generic relay properties, the traditional inputs that are often utilized to train ANNs have been altered. The suggested methodology is a broad strategy that can be used to develop networks for safeguarding additional power system components.

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Chapter - 22
An Investigation on How Variations in PV Power Generation Model Parameters affect Power Systems

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Chapter - 22

An Investigation on How Variations in PV Power Generation Model Parameters affect Power Systems

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Abstract

This research focuses on how the model and parameters of PV power plants affect the electricity system's safety and stability calculations. This work investigates the impact of PV model parameters on system frequency stability and power angle stability under the condition of PV access in high permeability, based on the actual power system scenario in 2016. By analyzing the dynamics of PV power plants, we aim to understand the extent to which these parameters influence the overall system behavior during various operational conditions. The study employs advanced simulation techniques to model different scenarios, providing insights into potential risks and mitigation strategies. Furthermore, the findings can guide the development of more robust grid integration practices for PV systems, ensuring both reliability and efficiency as renewable energy penetration continues to grow.

Keywords: PV power generation, model parameter variation, stability of power system

Introduction

The interaction between photovoltaic power generation and the power grid under various operating situations can be reflected in the power system's safety and stability calculation. This information serves as the foundation for developing an operation control and power grid dispatching plan to guarantee safety and the grid's ability to operate steadily in the event that large-scale solar power is added. The computation of the power system depends on the precision of the photovoltaic power generation models and parameters. This research focuses on how the model and parameters of PV power plants affect the electricity system's safety and stability calculations. To determine the standard photovoltaic power generation structure

Determine the standard photovoltaic power generation model structure. The study examines the impact of the safety and stability of the power system based on the analysis result of Xinjiang Power Grid in various types of solar When employing the constant reactive power control method, the photovoltaic power plants will not take part in the regulation of the system voltage. Utilizing the control method of constant voltage, the following are the outcomes of the simulation:

Analysis of the Influence of the Parameter Variation of Low Voltage Ride Through of PV Module on the Stable Operation of Xinjiang Power Grid

Five distinct low voltage rides through parameters were created in order to examine the impact of the Xinjiang power grid's reliable operation. Using various PV model parameters, Figure 1 shows the generator power angle curve under the three-phase short-circuit fault of the Kashi-Bachu 750kV line.

Table I: The Parameters of the Low Voltage Ride

Parameters	Unit	P1	P2	P3	P4	P5
K1_Iq_LV	P.U./S	1.5	3	0	3	0
KQ_LV	/	0	0	0	0	0
K2_Iq_LV	/	0	0	0	0	0
Dip_RECOVER_Max	P.U./S	0.1	3	0.01	0.01	3
Iqset_LV	P.U	0	0	0	0	0

i) In the event that the active power recovery speed is quick (3pu/s), the system will oscillate divergently.

ii) When the active power recovery speed is low (3pu/s), the system will oscillate twice before convergent.

iii) Even at extremely low active power recovery.

iv) Regardless of the active power recovery pace, the system will never oscillate if the photovoltaic power plants do not contribute to system voltage control. The simulation's output is displayed in Figures 6 through 10. power plants in order to find the major parameters.

PV Power Generation Model and Parameters

This research focuses on how the model and parameters of PV power plants affect the electricity system's safety and stability calculations. This report investigates the impact of the Xinjiang power system's actual state in 2016.

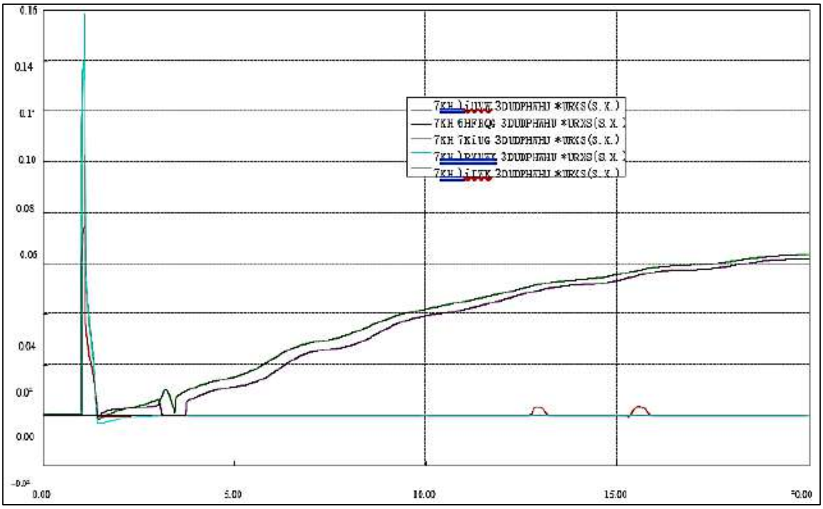

Fig 1: Reactive Power curve of Hengrun PV Power Station

When using the control strategy of constant reactive power, the fast speed active power recovery which means that the photovoltaic power plants resume the full output will lead to the over low of system voltage. The system has not entered the steady state yet, so synchronous machine disturbance makes the terminal voltage of the photovoltaic power stationbe below 0.9pu, which leads the photovoltaic power plant re- enter into the control strategy of low voltage through. After reducing the active power output of the photovoltaic power station, the voltage will gradually increase to more than 0.9pu,which will lead to the system oscillation.

If the speed of active recovery is quite slow, that is, the output active power of photovoltaic power plants is particularly small after 10s of the system failure, the voltage can maintain more than 0.9pu, so there will be no oscillation inthe system.

Analysis of Primary Frequency Modulation Capability of PV Power Plant Model.

In order to analyze the PV system model which can participate in the system primary frequency modulation capability, the model frequency dead-band parameter is set to 0.03Hz, the regulation difference coefficient is 5. The curve ofthe active power of PV power station following with frequencyis shown in Fig.11.

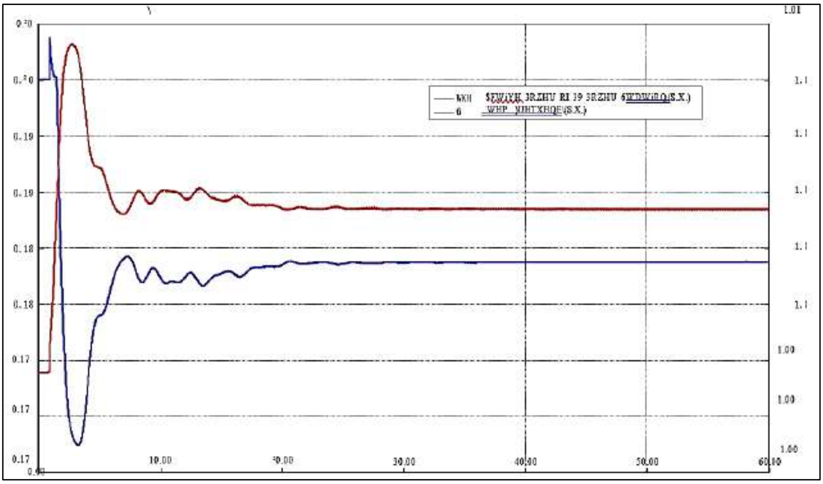

Fig 2: Curve of the Active Power of Power station changes with Frequency

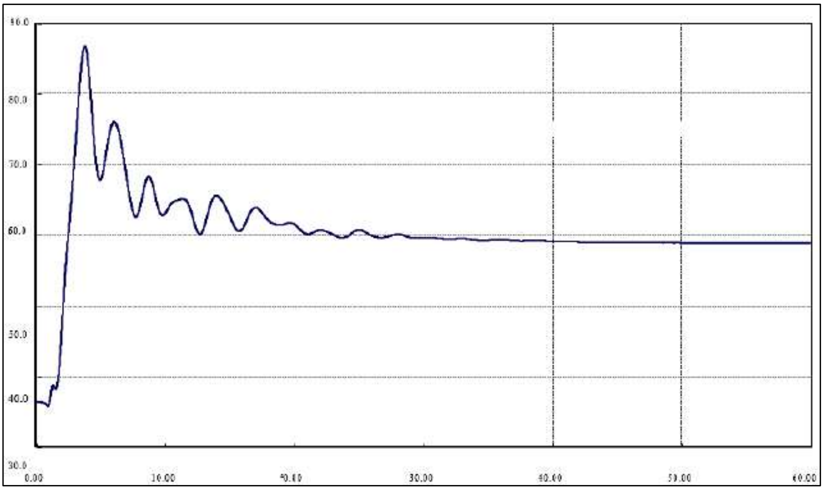

Fig 2: Generator power angle curve

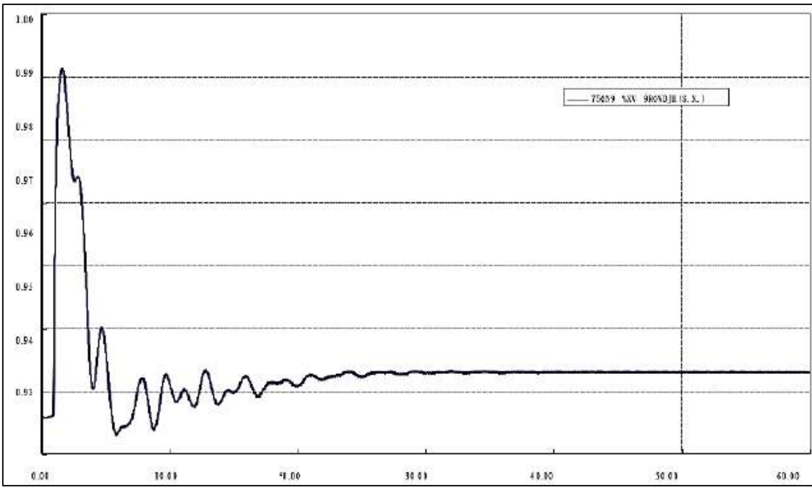

Fig 3: 750kV Bus Voltage curve

The dead zone of the frequency is set to 0.03Hz in the simulation. From the above graph, it is to known that it only cost 3s that the photovoltaic power plants decrease the output of the active power (from 20MW to 17MW) to support the recovery of the system frequency. It is the obvious effect that the photovoltaic power plants participate in system frequency regulation.

Analysis of Influence of Parameters Variation of Active Power Control System on Grid Operation in PV Power Plant.

In order to analyze the influence of parameter variation of active power control system on the operation of power grid, three groups of parameters of active control module are set up when the HVDC project of Xinjiang Power Grid is broken down. Figure 14 is the system frequency change curve when the DC blocking failure occurred using different PV model parameters

Table II: The Parameters of Active Power Control Strategy

Parameters	**Unit**	**Negative dead zonefdb1**	**Positive dead zonefdb2**	**controlfactor-down Ddn**	**control factor-up Dup**
P1	p.u	0	0	5	5
P2	p.u	-0.006	0.006	20	20
P3	p.u	0	0	50	50

Conclusions and Suggestion

This article examines the effects of various factors on the PV model's power angle, frequency, and voltage stability. The following are the outcomes:

i) Simulation curves for five groups of various PV power plant parameters under the same fault condition demonstrate that system power angle, system frequency, and system bus voltage recovery will all change to the same value when the active current rise rate recovery rate is the same.

ii) The PV power plant will participate in system voltage regulation following a three-phase short-circuit failure on the Kashi-Bachu 750kV line if it chooses to operate in the constant voltage control mode.

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Chapter - 23
The Method of Operation Condition Assessment and how it can be Usefully for Protection Systems

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Chapter - 23

The Method of Operation Condition Assessment and how it can be Usefully for Protection Systems

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Abstract

A properly monitored and assessed protective system can improve the dependability and efficiency of power systems. The application of operation condition assessment (OCA) in practical protection systems is covered in this paper along with a methodical and effective approach to OCA. The information transmission technique and device configuration are taken into consideration while creating a protection system operation condition model (PSOCM). Based on the PSOCM, an OCA approach is designed to assess the statuses of devices, information flows, branches of information transmission, and relay functions. To verify the effectiveness of the proposed approach, a master-substation operation condition assessment system (MS-OCAS) is demonstrated. This system uses additional raw data and real-time monitoring.

Keywords: Operation condition assessment, protection system, condition monitoring, fault detection, communication networks

Introduction

Power grids are protected by protection systems, which isolate and eliminate problems as soon as they happen. One of the most important security tasks for power systems is always ensuring the dependability of protective systems, or the protection of primary equipment [1]. The use of sophisticated information and communication technology (ICT) and networked protection schemes has led to the progressive transformation of protection systems into cyber-physical complex systems. As a result, a single failure could eventually cause a power system to cascade into failures or cause improper tripping or malfunctions [2-4]. The operation state of a protection system and its affects have grown increasingly complex in this environment.

An operation condition assessment (OCA) can determine a system's status within a specified time frame using historical or real-time data [5]. Reliability of protective systems can be ensured by using whole-view and realistic OCA results as references for intelligent warning, condition-based maintenance, and problem diagnostics. More real-time monitoring data can be used in the OCA as sensors and condition monitoring technologies advance. The volume, diversity, and time distribution of these real-time data are higher than those of historical data, making them significantly more appropriate for capturing the state of a system at any one time [6-8].

Nevertheless, the current OCA approaches have two difficult issues and drawbacks:

- There is a lack of a comprehensive and systematic approach to OCA because published methods primarily concentrate on individual events or single-function components. Liu *et al.* [2] and Etemadi and Faruzabad [9], for instance, have mostly concentrated on the protective relaying devices' hardware condition. Relay functions have been the primary focus of Zhang *et al.* [11]. But over the past few years, protective relay technologies have advanced from static, single-function relays to contemporary, multifunction digital relays [9, 12]. The statuses of the information and communication networks should also be taken into consideration because, in this setting of limited communication, inaccurate information or communication networks may also have an impact on the protection systems' operational state. The potential hazards that a protection system could encounter from malevolent cyberattacks were examined by Liu *et al.* [3]. Reference [3] highlights the importance of examining the effects that knowledge has on the way protective systems operate.
- The importance of the communication network state for protection systems was highlighted by Dai *et al.* [15] when they proposed a reliability evaluation approach for communication systems in wide-area protection. As a matter of fact, a protection system's ability to perform dependably is contingent upon a number of critical elements, such as functionally sound gadgets, accurate information transmission, and flawless communication networks.
- The monitoring data is not properly exploited, and the assessment efficiency is rather low.

- Conventional assessment approaches, for instance, rely on self-checking and periodic inspections [16], which have disadvantages as system volume increases. These disadvantages include longer outages for periodic inspections, an overabundance of human resources for O&M, the offline nature of assessment results, and a very low assessment frequency. Insufficient raw data for the OCA can currently be obtained from condition monitoring technologies, even though these data are unrelated to the component condition [8].
- This work seeks to overcome these two shortcomings by proposing an organized and effective OCA technique, which is necessary for a protection system that is reasonably appraised and well-monitored. The following succinctly describes the primary contributions of this paper:
- Based on a protection system operating condition model (PSOCM), which depicts the device configuration and information transmission scheme of protection systems, an OCA technique is intended to evaluate the statuses of devices, information flows, information transmission branches, and relay functions.
- The development of a master-substation operation condition assessment system (MS-OCAS). It is made up of the operation condition assessment system in the master station (OCAM) and the operation condition analysis subsystem in substations (OCAS). Effective distributed analysis in substations and centralized analysis in the master station can be realized by the MS-OCAS with
- This is how the rest of the paper is structured. The OCA issue and the protection system architecture are introduced in Section II. In Section III, which shows the target statuses in the OCA, the PSOCM is proposed. Section IV presents an OCA approach for protection systems, while Section V discusses its practical application and Section VI presents the findings of its experiments.

Operation Condition Assessment Issue

The deployment of secondary devices and the connections between them are critical to the execution of basic operations for protection systems, including data gathering, data modification, and indication [17]. The fundamental elements of a protection system include devices, such as protective relaying devices and current or voltage transformers. As a result, evaluating the device state in OCA concerns is crucial. Additionally, we are worried about the device function status, which in this case relates to a protective relaying device's selectivity, speed, sensitivity, and dependability.

However, proper information transportation is just as important to a protection system's regular functioning as well-maintained equipment. In a protection system, different kinds of messages are transmitted across the communication network. In a classical protection system, control commands are often carried by the station bus network in the form of messages described by the IEC 60870-5-103 protocol, while cables transmit the electronic signals. Sampled value (SV), generic object-oriented substation events (GOOSE), manufacturing message specification (MMS) data packages, and other sequences that are transferred from a source device to a destination are considered information flows in an IEC 61850-based protection system [16].

The connections between devices that convey information flows are referred to as "branches" in this study. A branch's procedures are strongly related to its constituent parts. With the exception of the station bay, where devices connect to networks, a typical protection system connects devices primarily via cables to enable peer-to-peer communication. An architecture form of "three layers of equipment, two layers of network" has been adopted for an IEC 61850-based protection system.

The network transports data between the switches and other devices [17]. In particular, a protective system has two primary types of branches (See Fig. 1). The ports remain the two ends of a branch for both kinds and are essential nodes for data transfer. Cables or fibers are used to create physical branches that join device port pairs or a device port and a switch port. Switch port pairs are frequently connected via virtual local-area networks (VLANs), which divide various information flows apart [18, 21]. In summary, the OCA issue also depends on the statuses of these information flows and their transmission branches.

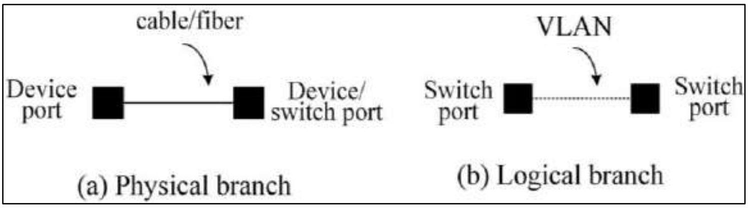

Fig 1: Physical and logical branches in the protection system

A process of information sharing and analysis between various cyber components that ultimately produces relay action results can be used to characterize how the protection system operates [19]. The measures from the condition monitoring procedure should be included in the system output as well, if it is taken into consideration. The OCA procedure may use these outputs as input datasets. In particular, the statuses of the device, information, and branch may be evaluated based on condition monitoring measures, and the relay function status can be evaluated based on the outcomes of relay actions. Refer to Figure 2.

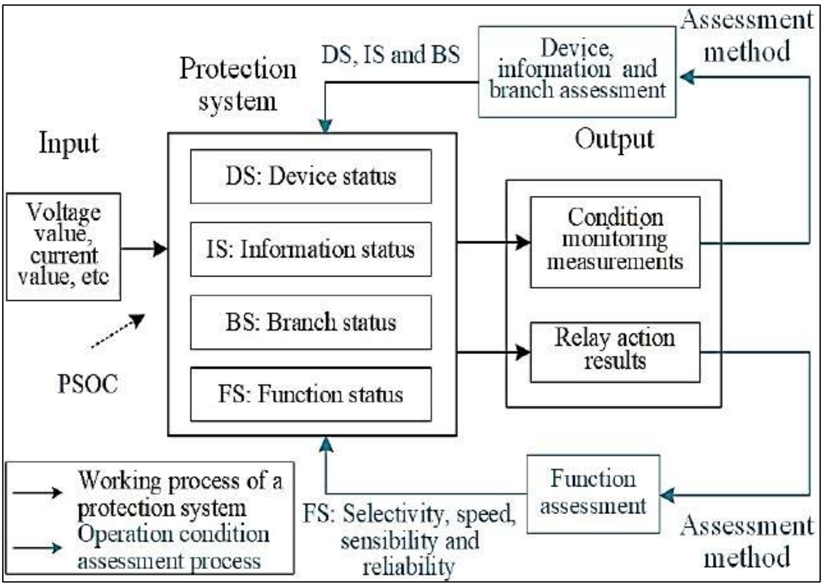

Fig 2: Operation and condition assessment process of a protection system

In summary, the OCA issue primarily relates to a protection system's PSOC, or device status, information status, branch status, and device function status; these can be referred to as DS, IS, BS, and FS, respectively. The OCA is specifically defined as follows:

1) Whether condition monitoring data can be used to evaluate the DS, IS, and BS of a protection system within a given time frame.
2) Whether relay action results can be used to evaluate the FS, or selectivity, speed, sensitivity and reliability of a protective relaying device within a given time frame.

Operation Condition Model for Protection Systems

In order to include the aforementioned distinctive aspects that characterize an operating protection system, we define the idea of the PSOC in this work. As a result, a PSOCM-represented by the multicomponent set O below-is suggested in this section.

$$O = \{D, I, B, F\} \quad (1)$$

Where D and I stand for the protection system's devices and information flows, respectively. The branching between such devices are shown by B. The relay functions are represented by F. The ensuing subsections go into great detail on each PSOCM component. (We will talk about B before I to provide a clear definition.)

Device D

Assume that a protective system consists of K bays and M devices. These devices can thus be written as (2) below, where each element is a specific device, indicated by its subscript and superscript, along with the associated bay.

$$\mathbf{D} = \{D^1_1, D^1_2, \cdots, D^j_i, \cdots, D^K_M\} \quad (2)$$

It's also important to pay attention to the device configuration parameters, which are indicated by Ci, where i is the device's sequence number. The strap combination scheme of a protective relaying device, the relay start-up values (CSi), and the relay setting values (COi) are the fundamental configuration factors that we take into consideration in this study. Straps can be thought of as switches for specific functions; that is, a strap's "on" status denotes a successful connection, whereas its "off" status denotes an interruption [16].

Each strap that the device i contains is represented by the strap description multicomponent set CYi. In essence, the set consists of the receiving straps CRki (which regulates the information receiving process from device i to device k), the publishing strap CPik (which controls the information publishing process from device i to device k), and

$$CYi = \{CPik, CRki, CFi, CMi\} \quad (3)$$

The element of CY_i equals 1 if a strap is ‘‘on’’ and equals 0 otherwise.

Information I

A Ports are essential nodes for information transfer, as was previously stated. As such, in the definition of the branch and information flow model in the subsequent subsections, a port is regarded as a fundamental unit. Let us assume that a protective system has P ports. To characterize the connections between ports, a P × P matrix called DP×P is developed. Its entry dij represents the Branchij that directs from port i to port j.

The information flows carried in Branchij are described in this work by an information description set I-Branchij, the contents of which are the standard names of the physical components. Notably, heterotic elements are allowed in the description set, and this will not happen again in the rest of the work.

I-Branch$_{ij}$ = {hGi,...,hSi,...,hMi} (4) where ‘‘hGi’’, ‘‘hSi’’, and ‘‘hMi’’ refer to GOOSE, SV and MMS messages, respectively.

Branch B

Moreover, there are two types of branches in protection systems. One is physical, whereas the other is logical.

Physical Branch

The physical branch description set P-Branch$_{ij}$, as presented in (5), is defined to indicate the physical components of

Branch$_{ij}$,

P-Branch$_{ij}$ = {hcablei/hfiberi,hporti} (5)

Logical Branch

The logical components of Branchij are indicated by the logical branch description set L-Branchij, where "hnetworki" indicates the specific network that Branchij belongs to-the SV/GOOSE/MMS network-and "hVLANi-ji" is the standard naming of the logical branch pointing from port i to port j. Below, L-Branchij is shown as (6).

L-Branch$_{ij}$ = {hVLAN$_{i-j}$i,hnetworki} (6)

In summary, the connection scheme of a protection system can be shown as (7) below.

B = {D$_{P×P}$,P-Branch$_{ij}$,L-Branch$_{ij}$} (7)

Function F

The function properties of a protective relaying device in terms of selectivity, speed, sensitivity, and reliability are defined by the 1x4 vector matrix F.

$$\mathrm{F}Di = \{Fsel,Fsp,Fsen,Fre\} \tag{8}$$

Relationship between the PSOCM and the PSOC

The PSOCM states that it is possible to identify the target statuses that need to be evaluated, or the PSOC. To show the state of the device's health, configuration, information, networks, cables, fibers, ports, and VLANs, respectively, define SDi, SCi, SI, Snet, Cable, Sfiber, Sport, and SVLAN. S is equal to 1 in aberrant status situations and to 0 in regular status situations. Table 1 lists the related relationships between the PSOCM and the PSOC.

Table 1: Relationship between the PSOCM and the PSOC

	PSOCM	PSOC
D	$\mathbf{D}=\{D_1^1, D_2^1, \mathrm{L}\ , D_i^j, \mathrm{L}\ , D_M^K\}$, C_{Oi}, C_{Si}, $CY_i=\{C_{Pik}, C_{Rki}, C_{Fi}, C_{Mi}\}$	DS: S_{Di}, S_{Ci}
I	$\text{I-Branch}_{ij}=\{<G>,\ldots,<S>,\ldots,<M>\}$	IS: S_{I}, S_{net}, and BS:
B	$\mathbf{B}=\{\mathbf{D}_{P\times P}, \text{P-Branch}_{ij}, \text{L-Branch}_{ij}\}$	S_{cable}, S_{fiber}, S_{port}, S_{VLAN}
F	$\mathbf{F}_{Di}=\{F_{sel}, F_{sp}, F_{sen}, F_{re}\}$	FS: F_{sel}, F_{sp}, F_{sen}, F_{re}

Operation Condition Assessment Method for Protection Systems

Based on the proposed PSOCM and collected monitoring information, an OCA method to assess the PSOC is proposed in this section.

Device Status Assessment Method

The two components of a device, its hardware and software, must be evaluated in order to determine the device's current status. In this research, we use the software status to be represented by the consistency of device configuration settings, and the hardware condition of the device is represented by the health status.

Device Health Assessment Method

A device's health is always seen as a crucial component that needs to be assessed in the OCA. The amount of monitoring data that may be used in OCA is growing thanks to the deployment of condition monitoring infrastructure. Let us assume that the device health status comprises n relevant monitoring items. The results of various monitoring items may fall into distinct ranges and are only indicative of discrete circumstances. Therefore, in order to acquire an overall outcome, a normalized process is required.

A measurement z, whose normal interval is [$Z_{\min}$, H], indicates an optimal condition when it reaches its minimum Z_{min} and an abnormal condition when it is greater than H. In this case, z can be normalized as z^*

$$* (1 - e{-}(z{-}Zmin)2/(H{-}Zmin)2, z \in [Zmin,H] \; z = \quad (9)$$

1, otherwise

A measurement z, whose normal interval is $[L, Z_{max}]$, indicates an optimal condition when it reaches its maximum Z_{max} and an abnormal condition when it is smaller than L. In this case, z can be normalized as z^*

$$* (1 - e{-}(Zmax{-}z)2/(Zmax{-}L)2, \quad z \in [L, Zmax]$$

$$z = \quad (10)$$

1, Otherwise

Zmin, Zmax, H, and L values can be found in the standard [20], which lists all of these measurement items and their rated ranges in China. Equation (11) is proposed to compute device i's health index (HIi) in order to acquire an overall result. Keep in mind that the weightings indicate the relative significance of the different categories of monitoring items. The importance of the monitoring item increases with weight. A greater HIi eventually indicates that the equipment needs more care.

Generally, a threshold σ_i is set to activate an abnormal alarm when the HI_i is greater than its associated threshold. To summarize, the OCA method for device health status is shown in Fig. 3. Note that T is the time interval between two inspections that can be configured.

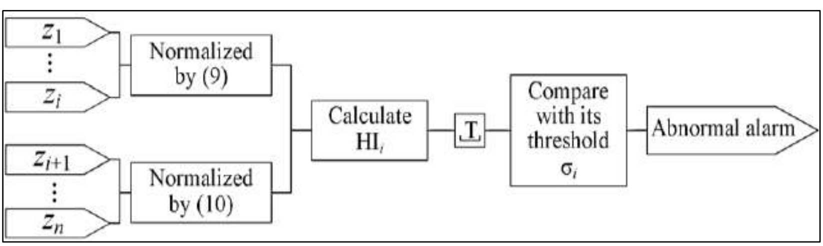

Fig 3: Assessment method for device health status

Device Configuration Assessment Method

Although it hasn't received enough attention yet, the evaluation of device configuration parameters is just as crucial in the OCA as the examination of the health status of the device.

Examining discrepancies between a protective relaying device's configured setting values and start-up values can be done with a consistency detector (Fig. 4). The parameters COi ⋯CMi, which are shown in Fig. 4, were covered in Section III-A. The suggested consistency detector compares the real-time parameters with the pre-stored values when the time reaches a predetermined threshold. Differences are reported with an abnormal alarm. Prior to faultless detection or during the planning phase, the prestored parameters can be set. This work does not address the validity analysis of setting values and start-up values.

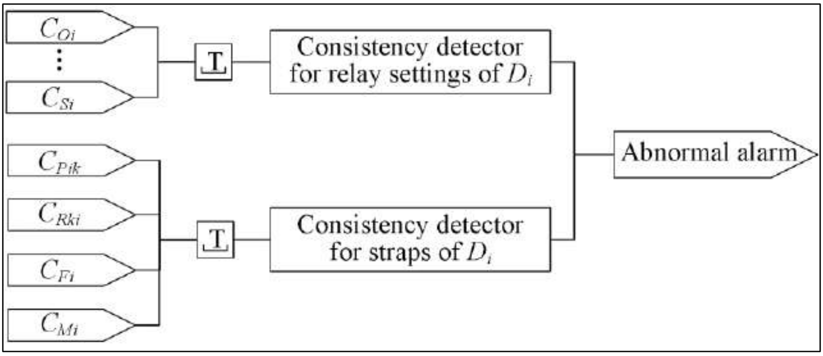

Fig 4: Assessment method for device configuration

With respect to the strap status, the consistency detector in Fig. 4 can also apply the assessment method with several rules. Similar to this, when regulations are broken, that is, when SCi = 1, aberrant alarms are triggered. Two fundamental guidelines for assessing the strap state are as follows.

- When the corresponding primary devices are in the operation or hot-stand-by modes, the protective relaying devices ought to be in the operation mode. In this scenario, the maintenance straps should be turned off, but the publishing, receiving, and function straps should all stay attached.
- A protective relaying device's publishing, receiving, and function straps should be severed during the maintenance mode and replaced with the maintenance strap.

Information Status Assessment Method

Devices and information transfer are critical to the implementation of a protective system, particularly in a networked system. Information status assessment is crucial for a networked protection system since improper information transmission can specifically affect protection systems' efficacy and reliability and can lead to cascading failures of the power system.

The attributes of information in protection systems comprise the data value (DV) and the data category (DC). The publishing time interval (T) and frequency (V) of a data package, which serves as the information carrier, should also be taken into account during the transmission process. Information load (L), throughput capacity (TC), and possibility of information loss (PL) are three fundamental features of a communication network [14]. These properties should normally be inside their proper ranges; otherwise, inaccurate information situations arise.

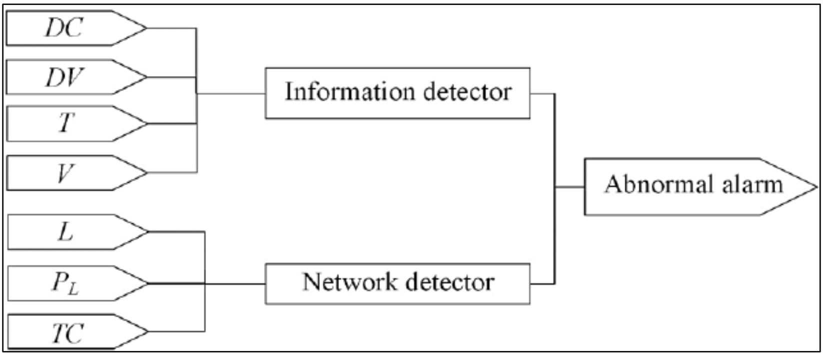

Fig 5: Assessment method for information status

Branch Status Assessment Method

The three branch faults (time delay, error code, and interruption) would result in the loss of data packages and, in the end, data loss alarms, according to the IEC 61850-based substation technical standards [16]. However, before a data packet is effectively delivered to its destination, it usually needs to pass through multiple branches. Therefore, identifying the precise faulty branch among others cannot be done from a single data package data loss notice.

When a branch in a protection system is interrupted, several data loss alerts may sound simultaneously due to the regular occurrence of each information branch carrying multiple pieces of data packages [22]. Given the low likelihood of multifaults, one may determine the position of a detached branch using

$$\mathbf{G} = a\mathbf{D}_{P\times P} + \mathbf{J} - \mathbf{K} \tag{12}$$

Where J stands for the alarm information branch matrix, and the number of alerts in I-Branchij is indicated by the element jij. The element kij, which represents the number of normal information flows in I-Branchij and is equal to the difference value between the sum and the number of abnormal information flows in I-Branchij, denotes the normal information branch matrix K. The most likely defective branch is represented by matrix G's largest element, gij. The starting branch of the alert data package carried by each branch that corresponds to each maximum element in G could be the fault location if there are several maximum elements in G.

To further assess the cause of the failure, the CYi's status in the PSOCM can further be used:

Function Status Assessment Method

To evaluate the FS of a protective relaying device in terms of selectivity, speed, sensibility and reliability, four assessment indexes and several rules are proposed in this subsection.

Assessment Index

Relay tripping data serve as the foundation for many of the current relay function assessment techniques. Recall that in some instances, the relay maintains a steady state even when the time-dial setting causes the measurement value to exceed its setting value. As a result, it is inaccurate to evaluate the relay function solely based on its start-up and tripping outcomes. This paragraph proposes four assessment indexes to analyze the protective relaying device's function. These are based on useful raw data and are described in [13-16].

Starting Distance d_S

The starting distance denotes the relative difference between the relay start-up value and measurement value, which can be calculated as follows:

$$d_{Si} = \frac{CMi - CSi}{CSi} \times 100\% \tag{13}$$

Operating Distance d_O

The operating distance denotes the relative difference between the relay setting values and measurement value, which can be calculated as follows:

$$d_O = \frac{CMi - COi}{COi} \times 100\% \tag{14}$$

Operating Frequency f_O

The operating frequency indicates the number of times when the measurement value passes across the setting boundary after the relay’s set up and before the fault is cleared. A count function Count () is defined; it is incremented each time the number inside the bracket crosses zero. f_O can be computed as follows:

$$f_O = Count\ (C_{Mi} - C_{Oi}) \quad (15)$$

Start-Operate Interval t_{OS}

The start-operate interval refers to the time between a relay start up and operation. Suppose that the start-up time of a relay is t_S, and the time when it sends control command is t_O.

Therefore

$$tOS = tO - tS \quad (16)$$

Assessment Conditions

These assessment guidelines use overprotection (such as an overcurrent relay) as an example. It should be noted that PMf and PBf represent the primary and secondary protection of the malfunctioning component, respectively, and PMf −1 and PBf −1 represent the primary and secondary protection of the neighboring nonfault component, respectively. It is important to remember that the protection system typically uses redundant protection schemes. The assessment procedure for the duplicated arrangement is the same as for the single one since, under normal ircumstances, duplicate protective relaying devices should function in the same way. To make things simple, we use the single set protection as an example to show how the assessment technique works. a: CHOICE Rule: For PMf −1, the initial distance should be less than zero, but for PBf −1, it should be

$$(M < 0\ {}^{d}S,f-1\ dSB,f-1 > 0 \quad (17)$$

$$tOSB,f-1 > tOSB,f > tOSM,f \quad (18)$$

Speed

Rule: The start-operate of $P^{M}{}_{f}$ should be less than its rated value T_{Ni}

$$tOSM,f < TN,f \quad (19)$$

Sensibility

Rule: The operating frequency of $P^{M}{}_{f}$, $P^{B}{}_{f}$ and $P^{B}{}_{f-1}$ should be at least one.

$${}^{f}OM,f \geq 1$$

$fOB,f \geq 1$ (20)

$\lfloor f^{B}_{O,f-1} \geq 1$

Reliability

Rules for the faulted component: The starting distance and the operating distance of $P^{M}{}_{f}$ should both be greater than zero,

and so are those of $P^{B}{}_{i}$

$(M > 0, dS,f\ dSB,f > 0,$

$dOM,f > 0\ dOB,f > 0$ (21)

Rules for the adjacent unfaulted component: The operating distance of the main protection should be negative, whereas that of backup protection should be positive (See (17)).

Rules for distant components: The operating distance of their main protection should all be less than zero.

$dOM,f-2, dOM,f-3, \cdots, dOM1 < 0$ (22)

Assessment Method

Define the assessment vector for the relay function as AF = [af 1, af 2, af 3, af 4, af 5, af 6], where each element from af 1 to af 6 corresponds to the individual results of (17) through (22). When the circumstances match the applicable equation, the element equals zero; otherwise, it equals one. Fig. 6 illustrates the relay protection function assessment technique. RO stands for refuse operation, MO for mal-operation, and HF for hidden failure.

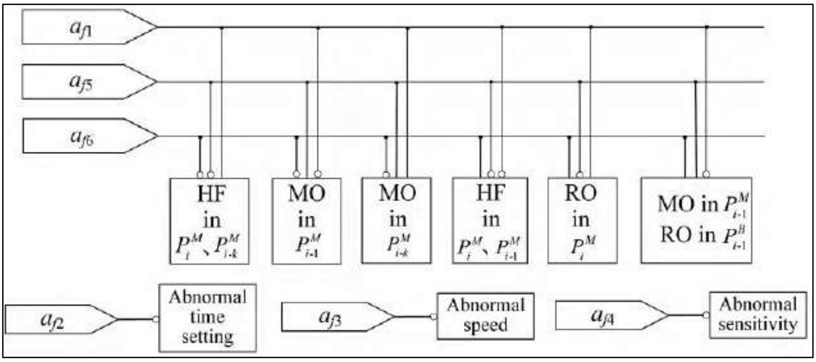

Fig 6: Assessment method for relay protection function

In summary, the entire PSOC assessment procedure is depicted in Fig. 7. The DS relies its judgment on a preset time threshold, but the IS assesses data instantly. The BS evaluation is started to find the branch that isn't working properly when an anomalous IS alert occurs. The FS is inspected in the event of a line fault.

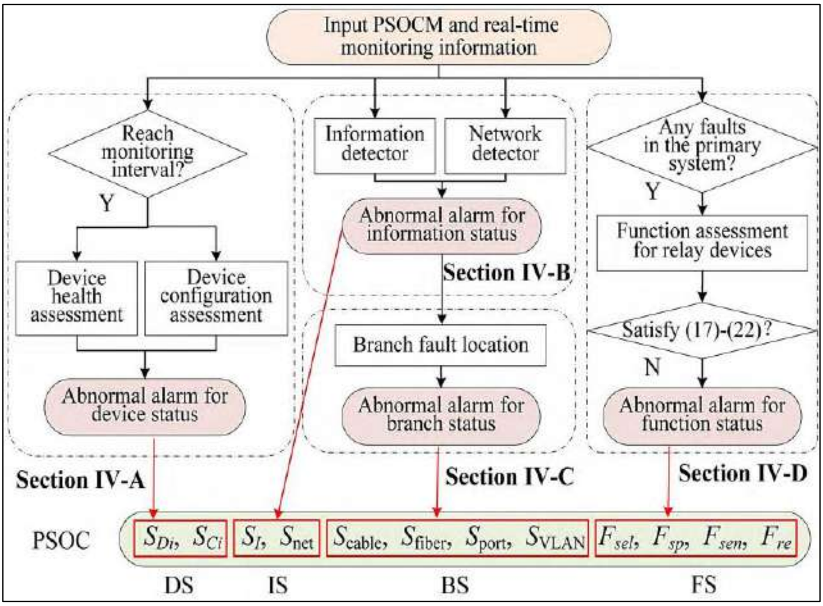

Fig 7: Operation condition assessment method for protection systems

Implementation

This section presents a potential OCA method implementation plan based on an IEC 61850-based protection mechanism. This research proposes an MS-OCAS that may implement distributed analysis in substations and centralized analysis in the master station, thereby reducing the information transmission and analysis workloads between the maintenance station and the master station.

Architecture and Function of the MS-OCAS

The architecture of the MS-OCAS is shown in Fig. 8. This system consists of an OCAS and an OCAM.

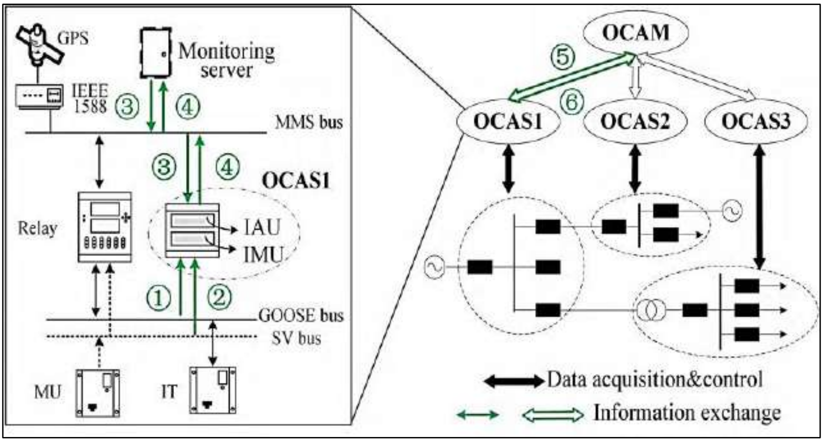

Fig 8: Architecture of the MS-OCAS

In an IEC 61850-based substation, each OCAS is located between the process bay and the station bay with the purpose of monitoring and identifying faults related to operation conditions. The OCAS is built using an embedded technique that combines an information analysis unit (IAU) and an information monitoring unit (IMU) into a single integrated device in order to save wiring. The IAU is regarded as the local monitoring and analysis center, whereas the IMU gathers monitoring data in the substation. The goal of the OCAM is to evaluate the FS of every protection system by gathering the OCA and relay action results from every OCAS and sending the evaluation results back to the relevant substations.

As shown in Fig. 9, there are five modules in an OCAS:

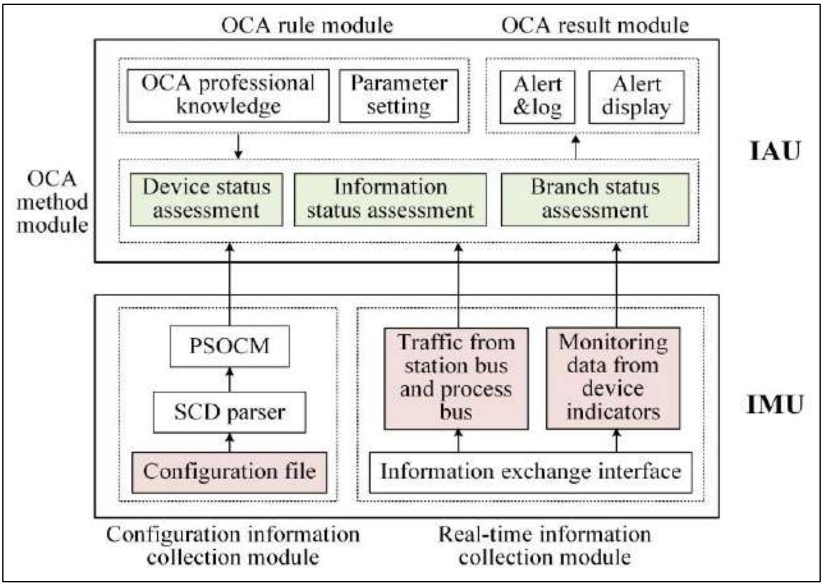

Fig 9: Software of the OCAS

Configuration Information Collection Module

In this module, the PSOCM is generated based on the configuration information from the substation configuration description (SCD) file using the SCD parser.

Real-Time Information Collection Module

This module captures and parses monitoring data from device indicators and sensors in real time via the information exchange interface. GOOSE/SV information flows from the process bus, MMS information flows from the station bus.

Operation Condition Assessment Method Module

The OCA approach to evaluate the DS, IS, and BS covered in Section III is programmed in this crucial module of the OCAS IAU. In the meantime, the OCA method for the FS is contained in that of OCAM.

Operation Condition Assessment Rule Module

Professional expertise and configuration-specific data collected during the assessment procedures are preconfigured and saved in this module. For instance, the consistency detector's criteria are set to 5%, the GOOSE messages are normally published every 5 seconds, and the status monitoring interval is set to 4 hours.

Operation Condition Assessment Result Module

The assessment results along with the alerts are displayed on the screen of the monitoring server in the substation and recorded in log files.

Information Exchange

The dispatch communication network built by a high-speed and reliable fiber network is deployed between substations, which the MS-OCES can use as an information exchange platform. This system allows the use of the publish/subscribe mechanism, which includes request, inform, and confirm. The green arrows in Figure 8 illustrate the MS-OCES information sharing method. Table 2 contains the associated data or datasets for every number in Fig. 8 that are based on IEC 61850 procedures.

Table 2: Information exchange in the MS-OCAS

No	Information resource	Information destination	Information exchange
①	GOOSE bus	IMU	dsGOOSE in the process bay
②	SV bus	IMU	dsSV in the process bay
③	MS	MMS bus	dsTripInfo，dsSetting，
④	MMS bus	IMU	dsParameter，dsRelayEna，dsWarning, device monitoring information
⑤	IAU	MMS bus	DS, IS and BS
⑥	MMS bus	MS	
⑦	MS	OCAM	DS, IS, BS and relay action results
⑧	OCAM	MS	FS

Experimental Results

Description

The authors collaborated with NARI-Relays and the Guangdong Power Grid Co. Ltd. Dispatching and Control Center to confirm the efficacy of the suggested system and method.

Electric Co. Ltd. and has developed an MS-OCAS prototype

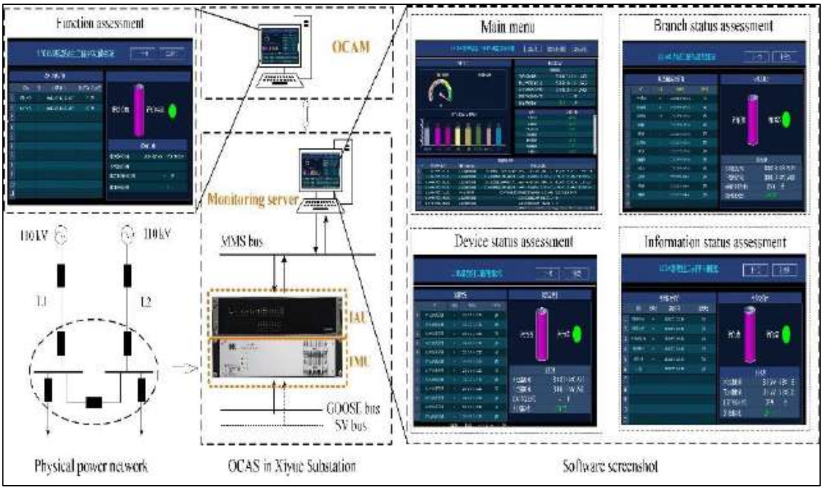

Fig 10: MS-OCAS in the Xiyue substation

and affiliated software. This prototype was installed in the Xiyue substation, a 110 kV IEC 61850-based substation in Foshan city in China, and has operated for 12 months.

The matching protection system of the major devices in the dashed box in the left corner of Figure 10 served as the experiment's assessment object. The "networked sampling and networked tripping" concept is applied by the protected relaying device, which is a single set. The process bay and station bay's communication networks are set up using a single star architecture. The software displayed all OCA findings as colored cylinders (see screenshots in Fig. 10).

Strap switching and device status monitoring data were not visible prior to the MS-OCAS installation. A typical time-hierarchical OCA technique was used to assess the PSOC, consisting of daily routine inspection (RI), quarterly inspection (QI), and periodical inspection (PI) that was carried out every three years, or 1095 days [20]. Notably, because each inspection item requires hours of offline testing, a significant amount of downtime time is unavoidable throughout the PI.

Following the installment, a consistent frequency of collection and transmission of the unobservable data was established. In order to get adequate monitoring data for the protection system, temperature sensors, moisture sensors, and online insulation inspectors were implemented. Moreover, the OCAS prototype only sent an average of 11 Kbit/s and a maximum of 12 Mbit/s of data packets. Due to its 100 Mbps.

Results

The OCAS found 3 branch interruptions and 1 device malfunction during the testing run. Furthermore, our system found a hidden failure of L1's backup protection following a single-phase ground fault (See Fig. 11). Table 3 compares the experiment outcomes with and without the prototype, where NI stands for the number of inspection items and TI stands for inspection interval (days).

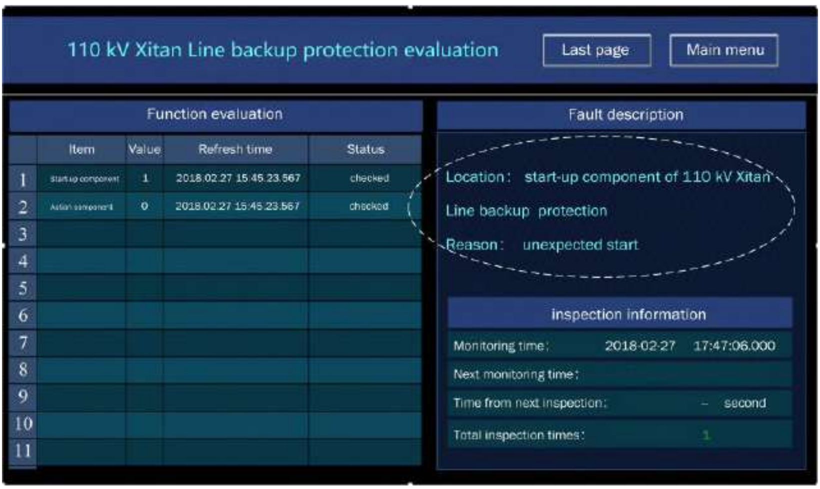

Fig 11: A function status assessment result (translated in English version)

Table 3: Experimental results

Category		Without prototype	With prototype	Result
T_I	DS	RI: 1 QI: 90 PI: 1095	1/6	6 times↑ 540 times↑ 6570 times ↑
	IS	—	Real-time	Offline → online
	BS	—	Alert-driven	
	FS	PI: 1095	Event-driven	
N_I	RI	14	4	71.4% ↓
	QI	10	0	100%↓
	PI	11	1	90.9%↓

The experimental results demonstrate that, since the inspection time threshold was set at 4 hours, the TI of the DS increased impressively-6 times in the RI, 540 times in the QI, and 6570 times in the PI. The IS, BS, and FS evaluations were conducted online instead of offline. In total, 14, 10, and 11 inspection items are needed in RI, QI, and PI, respectively, per the technical criteria in [20]. With the prototype, the O&M staffs are only needed for extra assistance with 4 RI and 1 PI inspection item (RI: abnormal noise, smoke or burn, blockage, or outside wiring inspections, PI: equipment external inspection). Consequently, 71.4% of RI, 100% of QI, and 90.9% of PI inspection items.

Experimental Conclusions

The experimental findings demonstrate that the suggested approach can provide the OCA of protection systems with significant guiding benefits. More specifically, using the regularly gathered monitoring data, the substation's DS, BS, and IS may be evaluated locally. Motivated by the principal malfunctions, the FS can be evaluated using trip data and additional unprocessed data from pertinent substations, and concealed malfunctions can be found in accordance with external problems.

Additionally, the created MS-OCAS has a quick anomaly detection time, resulting in an effective OCA for security systems. The inspection frequency has increased significantly in comparison to previous OCA methods, ensuring the protection systems' reliability in a shorter amount of time.

Conclusion

To address the OCA issue, this research has created an OCA model and approach based on collected monitoring data. The PSOC's architecture, essential parts, and information sharing system are then displayed, along with the MS-OCAS, which can assess it both centrally and dispersedly.

The proposed OCA technique allows for a thorough assessment of the PSOC by considering not only device status and relay operations but also the impact of communication networks and information flows on protective systems. The previous offline evaluation technique is further transformed into an online and real-time method by carefully mining the value of the collected monitoring data.

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Chapter - 24
Indian Power System Frequency Analyses

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Chapter - 24

Indian Power System Frequency Analyses

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Abstract

A crucial parameter for the consistent operation of power networks is frequency. Globally, the normal frequency is hardly deviated from by major power systems. Due to the increasing percentage of generation based on renewable energy, the main sources of the variance are changing renewable generation, dynamically altering demand, and shifting generation. Various controls have been put in place to handle variations in frequency. Frequency quality is important to system operators because various frequency control techniques adhere to their predetermined parameters. Frequency variations affect the power system's dynamics, and historical data analysis is necessary to make meaningful conclusions. In the short, medium, and long terms, this kind of pattern analysis can be a crucial part of operational planning.

Keywords: Real time systems, power systems, frequency estimation, power system protection, power system relaying, voltage, power system measurements, control systems, distortion measurement, frequency measurement

Introduction

Power system functioning on all global grids has always depended heavily on the stability and regulation of the power system frequency. The need to keep frequency within the intended range is becoming more and more difficult these days. The system operator plays a crucial role in sustaining the real-time frequency in the age of growing power markets and the integration of technological improvements in the power sector. The issue has been made worse by the extensive incorporation of unreliable renewable energy sources. It has become more difficult to control the system frequency with little inertia when non-spinning decoupling mass of renewable energy replaces synchronous generation with rotating elements.

There has been a lot of discussion in the literature about controlling frequency through primary, secondary, and tertiary control. Nonetheless, there is a dearth of literature on the subject of using historical frequency data to evaluate power system behaviour. Electric power systems are using advanced measuring techniques by installing multiple new measurement equipment and making dramatic changes to how information and communication technologies are deployed.

An enormous amount of power system data is being produced by high frequency synchronized wide-area measurement devices at control centers. This study presents an analysis of historical data from January 2015 to December 2019 from phasor measuring units of various stations in various time frames. First, using poor data identification techniques, the frequency data utilized in this work was cleaned. Next, specific station data was chosen based on the maximum amount of high-quality data that was available. Subsequent subsections feature studies of the average frequency for every month of the year, every day of the week, every hour of the day, every time block of the day, and every minute.

Impact of Poor Frequency

Synchronous generation has been a main source of generating in most power systems. The components of these sources rotate at different speeds depending on frequency. A producing unit operating at a low speed due to an extremely low frequency will require the trip of a load in order to safeguard the turbine blades of the generator. A high frequency will cause the unit to trip due to an overspeed problem and a loss of attraction between the magnetic fields of the rotor and stator. Extremely high speeds may cause damage to the components of the generator unit. The frequency change also affects the system impedances. Variations in the system impedances may have an impact on the loadings and voltages throughout the power system.

Errors in electrical measurement-based time instruments, tripping of motors and generating units, and loss of auxiliary drive motors are all observed in real-time operations during low frequency periods. In a similar vein, high frequency has an impact on power system performance. It is crucial to maintain a steady power supply frequency since the everyday appliances in our homes and workplaces are built to function at a set frequency with a strict tolerance. Additionally, frequency following mode is typically used by wind and solar power facilities. Because the operation of PLL in renewable energy facilities depends heavily on grid frequency, any changes to the regular frequency have an impact on PLL operation.

Balance of Power

As was mentioned in the preceding paragraph, a considerable deviation in frequency can have an influence. The frequency rarely deviates much from its nominal or reference value under typical circumstances. According to India's energy regulator, the user or state.

Electricity firms are prohibited from abruptly changing their load by more than 100 megawatts. As a result, load fluctuations are minimal and the equilibrium between supply and demand is preserved, causing the system to operate at its nominal frequency. Any major and abrupt shift in either generation or load throws off this delicate balance. One of the largest synchronized electricity systems in the world, the Indian grid runs at a nominal frequency of 50 Hz. The Indian electrical regulator has maintained the frequency spectrum between 49.90 Hz and 50.05 Hz. Significant control and market-based reforms have contributed to keeping the frequency in the limited frequency range.

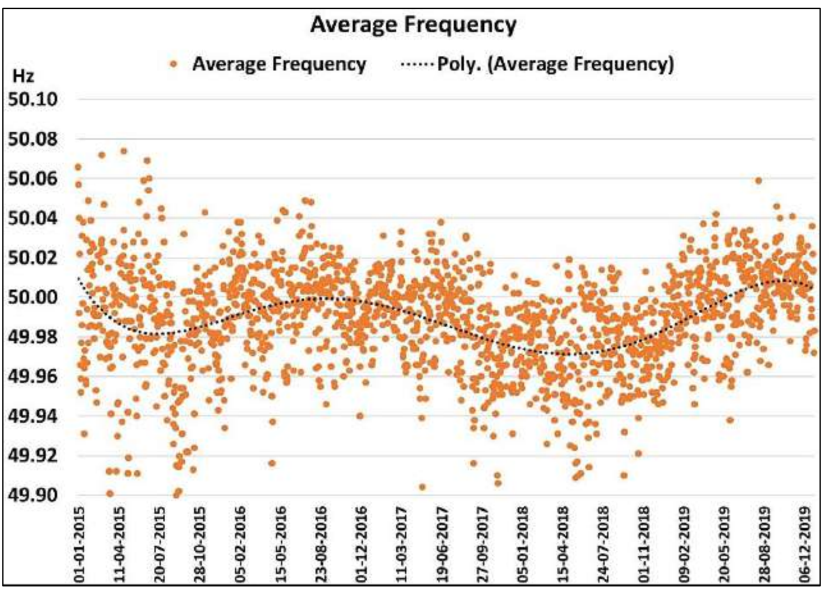

Fig 1: Average Frequency of Indian Power System

Data Selection and Cleaning

Complete frequency data at a 10-second sample rate from phasor measuring units spanning five years was gathered from multiple regional sites. The following step involved cleaning the data and choosing, from among the more than 200 stations that were available, the best frequency data for a certain station.

A data point in a data set that is isolated from every other observation and falls outside of the data set's general distribution is called an outlier. These data points lead to a number of issues when we do statistical analysis, forecasting, predictive modeling, and other analyses. Here, the Z score technique is utilized to eliminate the outliers in the frequency data in order to avoid these problems when examining the frequency trends and pattern. The Z-score method is predicated on a Gaussian distribution of

$$Z = (x_i - \mu)/\sigma$$

Where

xi is data point.

μ is mean of data set.

Ơ is standard deviation of data set.

It is necessary to specify a threshold while calculating the Z-score of each sample on the data set. Two, three, or four standard deviations from the mean can be the threshold. We have selected a threshold of 3 in the frequency data set, and it has nearly discovered.

0.2% data are outliers. The PSEUDO code used for outlier detection is

```
outlier ← [ ]  //Empty array for outlier value
j  ← 0
threshold ← 3
mean← mean(data)     //Mean value of data set
std← stdev(data)  //Standard deviation of data set
for (i← 0 to n) //Loops iterate no. of data points times
    z ← (data[i] – mean)/std if (absolute_value(z) > 3) outlier[j] ← data[i]
    j ← j+1
print(outlier)
```

After the outliers were eliminated, the data gaps were adjusted to equal the average of all frequencies from all stations at that particular bad data instant. The best frequency data for a given day is then chosen based on the factors of least number of outliers, maximum phasor measurement unit availability, and largest number of good quality tags attached to the data.

Big Data Analytics

The previous ten years have seen a tremendous collection of data due to the digital revolution. The idea of the Internet of Things (IoT) led to a rise in measurement equipment. This component of the power industry has also grown at an unprecedented rate, and new data mining techniques are being developed thanks to PMU's availability of high resolution, correct data. PMUs are utilized by synchronized technologies and systems to track electrical values (such as voltage, current phasors, and frequency) at certain points within an electric power grid. PMUs use the measured voltage and currents to estimate phasor values, which are typically 25 or more observations per second. They then time-stamp these phasor values, or synchro phasor data, using the GPS signal as a reference clock to ensure time alignment.

In 2012, the Indian Power System began experimenting with PMUs in a pilot project that involved about 60 PMUs reporting to the National Control Center. PMU deployment at nearly all of the significant nodes in the Indian power system is part of a full-fledged PMU project, made possible by the PMU's usefulness in system operation and subsequent event analysis. The PMU data meets the requirements for big data. The PMU data in the Indian Power system exhibits the three V's of big data, as defined in [2]: volume, velocity, and variety. The scope of big data has expanded with the inclusion of two V's in the model, and numerous studies have detected five V's [3, 4].

Figures 2 and 3 display the load curve and frequency profile for an average day in the Indian power system. A thorough grasp of the size and operation of the power system can be gained by closely observing the two figures. The average frequency for each month of the year, each day of the week, each hour of the day, each time block of the day and the average frequency for each minute of t are all analyzed in following subsections.

The total number of data points divided by the total number of data points is the average frequency. In the event that frequency is regularly distributed, the average frequency represents the frequency's central value. The average frequency is particularly useful for comparing performance over equal durations, but it may not be a fair measure of performance because it does not reveal information regarding outliers. Since frequency is a nominal value with approximative symmetry, average values serve as a good representation of it. In the study, standard deviation is also employed when the average yields equivocal results.

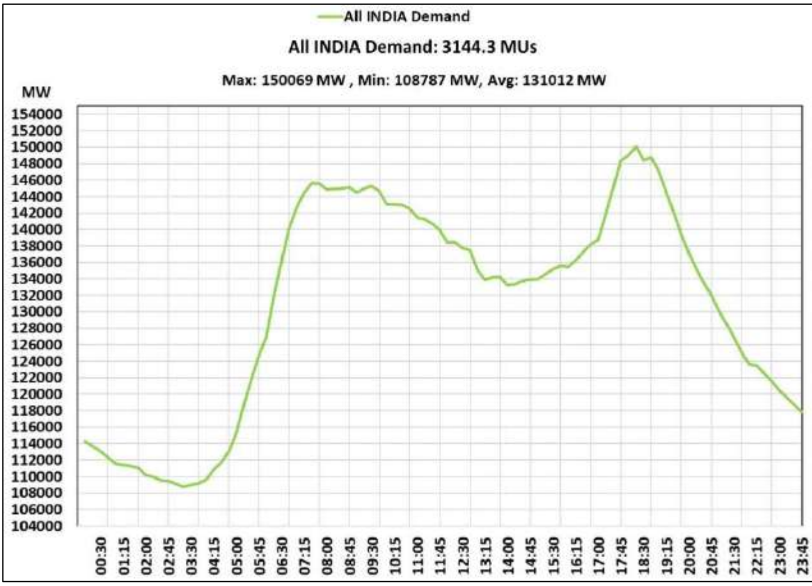

Fig 2: Load curve of a typical day

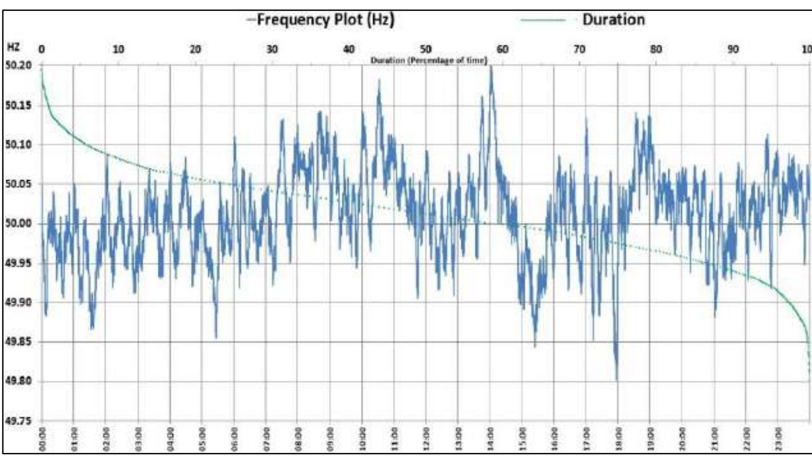

Fig 3: Frequency profile from 0000 hrs to 0024 hours

Mean Frequency for Every Month of the Year

For a span of five years, the monthly average frequency data was computed. Figure 4's bar chart layout displays the average monthly frequency during a 60-month period. 49.988 Hz is the average frequency during the course of this 60 months. Underfrequency months are those in which the frequency was less than 49.988 Hz, and over frequency months are those in which the frequency was greater than 49.988 Hz. Plot observation shows that the summer months with strong demand are often underfrequency months, while the winter months with low demand are above frequency months. Summertime months typically have low average frequencies because of high demand and insufficient spinning reserves.

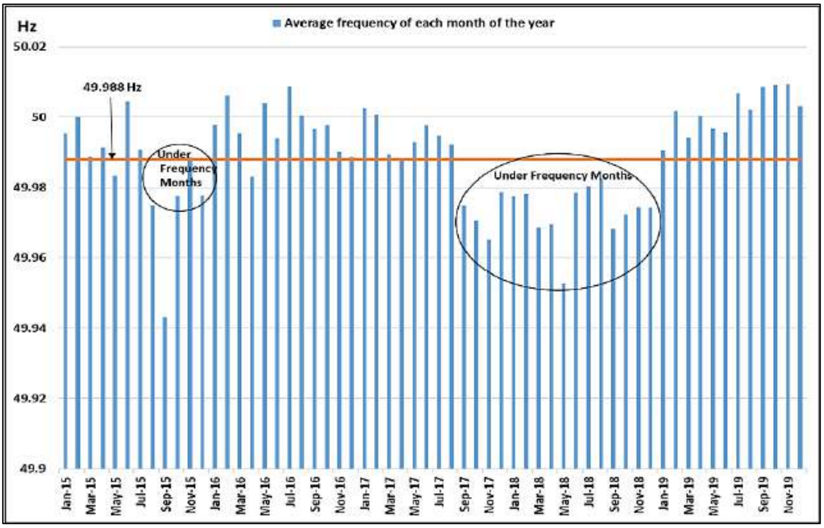

Fig 4: Average frequency of each month of the year for 60 consecutive months

Average Frequency for Each Day of a Week

The fundamental power system frequency and demand link is validated by the average frequency value over long time periods, such as a month. An analogous approach was used to determine a correlation between the average frequency over a given day and the days of the week. Figure 5 below shows the average frequency for each day of the week over a five-year period. When compared to other days, Sunday's frequency was noted to be consistently high. Because of Sunday's low demand, frequency stayed high for the most part. The frequency varies significantly during the week, with Tuesdays often seeing the lowest frequency. A short-term, week-ahead unit commitment plan that takes into account the units' minimal uptime and downtime can be beneficial.

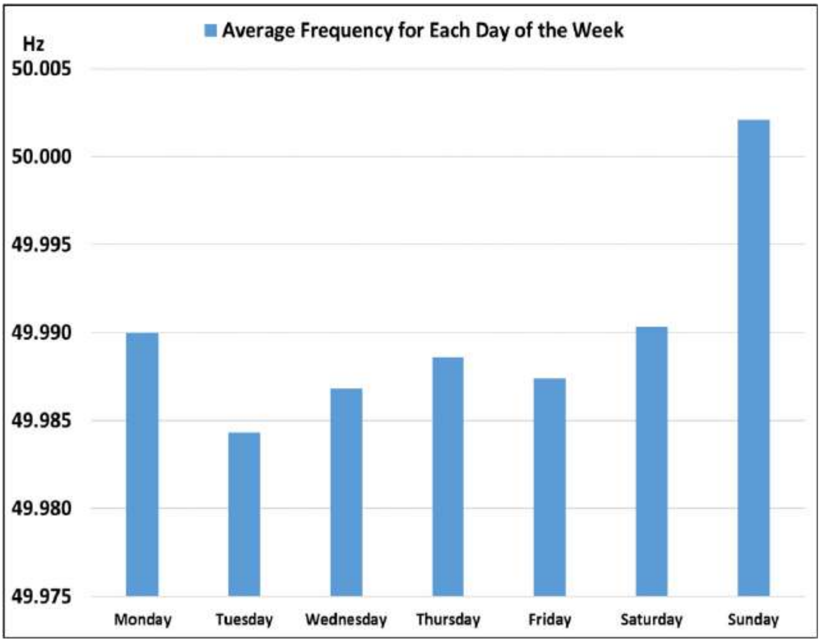

Fig 5: Average Frequency for each day of a week

Average Frequency for Each Hour of the Day

In figure 2, the usual day load curve is displayed. It is evident that large ramp rates in demand are typically linked to peak demand periods, which occur in the morning and evening. The average frequency for each hourly value of the day is plotted for a five-year period in order to study this feature; the plot is shown in Fig 6. The highest frequency variation is seen to occur during periods of strong ramp up and down. When demand is ramping down, the frequency is above nominal values, and it is below nominal values during periods linked to high ramp up periods. At night, when demand is at its lowest, it is also anticipated that the frequency will be higher than minimum.

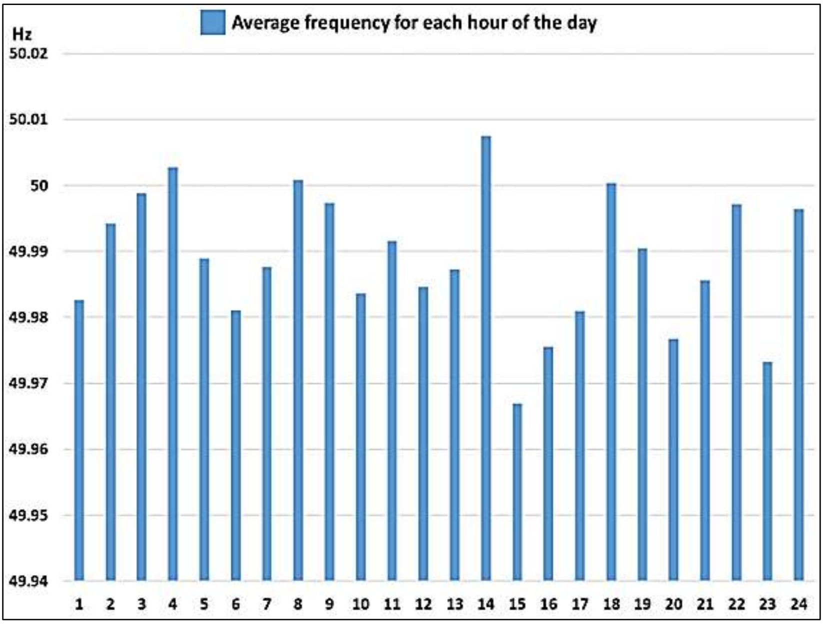

Fig 6: Average frequency of an hour

An intriguing finding in Figure 6 is that, although though the average frequency is 50 Hz during the 1700-1800 hours, the hour is typically linked to a shift in demand because of lighting loads around dusk. When operating, there are occasionally noticeable significant fluctuations in the frequency as it shifts from being over- to under-frequency. Therefore, the Standard Deviation may be a more useful statistical measure to evaluate the frequency behaviour at this specific moment. The measurement dispersion for a series of measurements is indicated by the standard deviation of the data set (in this case, the reference frequency is 50 Hz). A low standard deviation indicates that the dataset's majority falls within a 50 Hz range. Figure 7: Standard deviation of hourly frequency.

Average Frequency for Each Minute of an Hour

According to theory, the most obvious findings are those that can be seen by looking at average frequency plots across longer time periods. The primary determinants of average frequency are variations in demand within the day and across the season. A system operator is very interested in predicting the frequency behavior over shorter time intervals, such the next five minutes. The center values are determined by the average frequency of an hour, as stated in the preceding section, but it is crucial to determine how widely distributed the frequency is throughout the hour's duration. Figure 8 shows the average frequency of a minute in an hour during a five-year period. The following is the conclusion drawn from this minute-by-minute frequency plot:

- At the beginning and conclusion of each hour, frequency is higher. The argument can be supported by the significant fluctuations in load at hourly boundaries in the schedule. Significant differences in frequency result from abrupt, significant scheduling adjustments. Due to a decreased ramping tendency, loads do not keep up with the hourly schedule adjustments, which leads to high frequency at hourly boundaries.
- In the middle of the hour, frequency is at relatively lower values; this is typically the result of load generation achieving balance following a significant schedule adjustment.

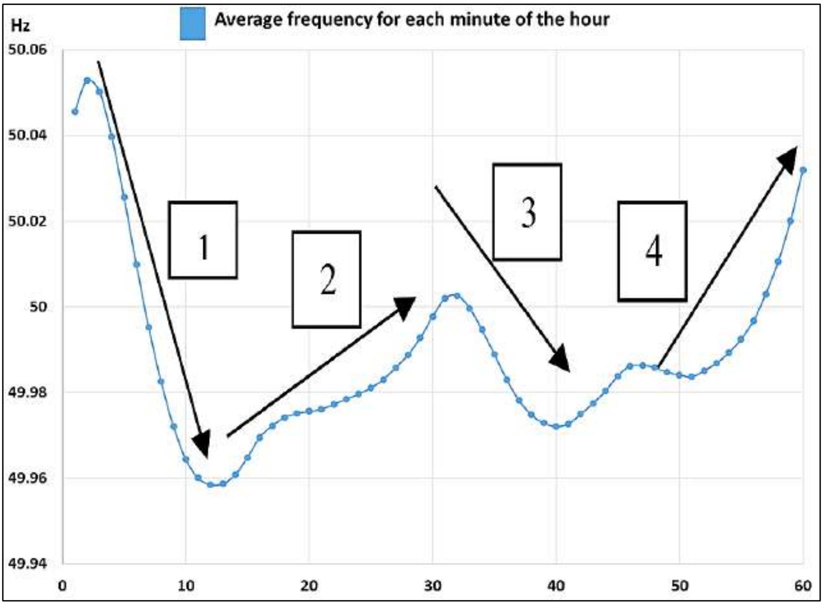

Fig 8: Average frequency of a minute and its spread in an hour

- Upon scrutinizing the frequency plot closely, one can discern four distinct parts within the plot and four terminal points within an hour.

There is a noticeable jump in frequency at the end of every scheduling interval. The frequency takes about three to five minutes to drop to a lower amount. The generation changes almost instantly at the start of a new scheduling time-block, and the intricate dynamically fluctuating power system takes some time to settle into its new operational condition. A full explanation of how the scheduling interval affects frequency variation may be found in [9].

Average Frequency for Each Minute of 15 Minute Time Block

The examination of frequency fluctuation within a fifteen-minute scheduling block provides additional understanding of the Indian power system. Figure 9 shows the evolution of frequency within a time block. The average frequency of each minute of a fifteen-minute time block was averaged for data spanning five calendar years. It is evident that the frequency stays higher than the 50 Hz reference frequency in the first few minutes of every time block. The frequency begins to decrease after the first few minutes, and by the tenth minute of a time block, it has dropped to its lowest point, which is roughly 49.977 Hz. At the conclusion of a time block, frequency increases once more until it reaches 49.995 Hz.

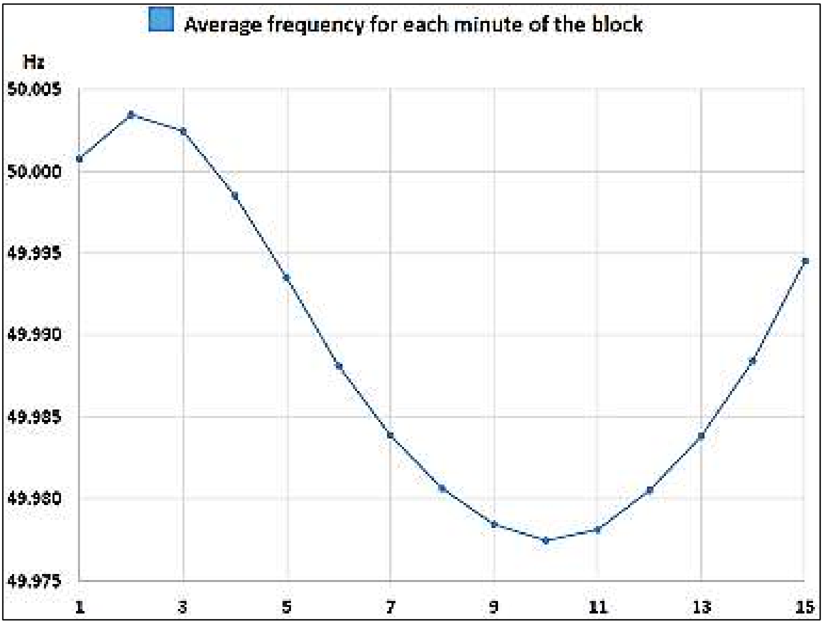

Fig 9: Average frequency for each minute of a time block

The absence of the frequency spread around the nominal frequency inside a time block suggests that several frequency controls are actively regulating the frequency changes. Nearly all of the world's main power networks exhibit substantial variances at the boundary of each time block. Over a five-year period, the SD values of each minute of an hour interval, when averaged, show a significant change near the hour's boundary. Figure 10 shows the SD trend. It is anticipated that the massive synchronized grid of the Indian power system, which has high levels of inertia, will have significant frequency variations following any abrupt imbalance in either generation or load.

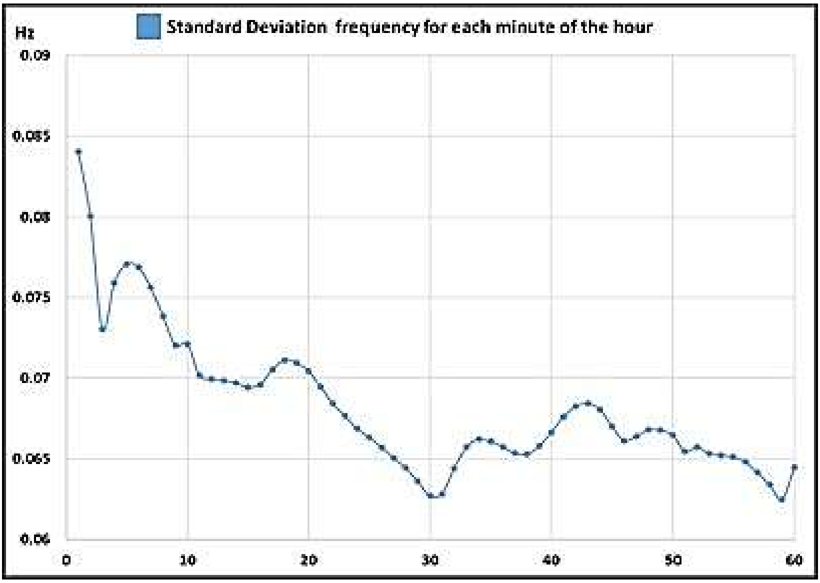

Fig 10: SD values for each minute of an hour

Histogram

A plotted histogram is used to verify the highest frequency sets across different ranges. It can be noted in figure 11 that maximum sets are at 50 Hz frequency and no of samples reduces as the frequency deviates from 50 Hz. Future renewable generation coupled with reduced inertia will lead to a rise in the number of samples outside of 50 Hz. Maintaining appropriate levels of inertia and taking appropriate action to reduce the short circuit level and system inertia can be aided by monitoring the frequency histogram.

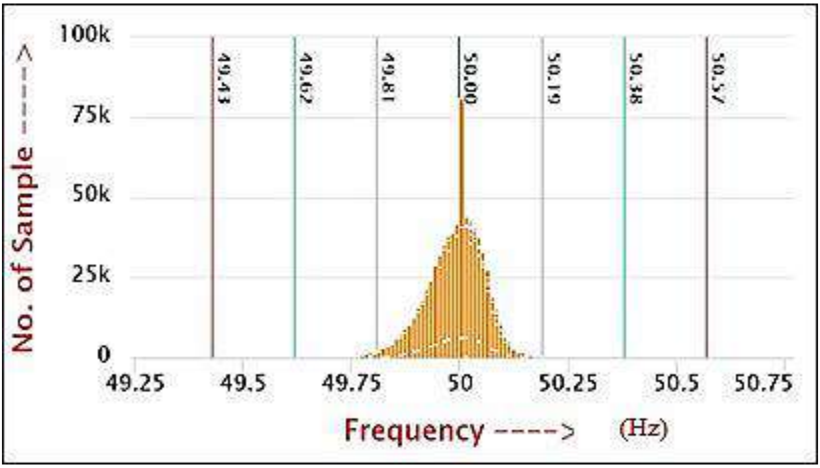

Fig 11: Histogram of Five-year Frequency data sets

Large interconnected grids reduce the dangers of significant frequency deviations, but to effectively manage the excursions, frequency control systems must be put in place. In [10], a stochastic model that is able to factor the scheduling time block has been considered as a better model for the power system. The parameters in the power grid model will undoubtedly increase as synchronous generation is replaced with low-inertia inverters.

Conclusion

The frequency of the Indian electricity system has been evaluated using the high-resolution PMU data collected over the preceding five years. Through the analysis of this data, it was possible to identify areas in which further developments are required to ensure optimal system performance and to obtain a better understanding of how the Indian power system operates over time. The analysis of month-and day-wise average frequency data demonstrated effective long-and short-term generation planning, including unit commitment, and optimization of the annual unit outage plan.

The daily analysis also underscored how important it is to arrange and keep adequate spinning reserves while conducting business. The impact of the demand ramp on the system frequency was also illustrated by the hourly frequency analysis for each day. The high ramping resource required during the high demand ramp period resulted from this research. The minute-by-minute analysis of frequency data for every hour and time block (15-minute interval) showed how schedule changes affect frequency, especially at the hourly and time block boundaries. The frequency fluctuation inside a time block illustrated the importance of scheduling with smaller interval time blocks to achieve effective load-generation balance. A five-year interval of increased frequency was also reported.

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Chapter - 25
An Overview of the Obstacles and Problems Facing Electric Cars in India as Well as the Vehicle to Grid Optimization

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Chapter – 25

An Overview of the Obstacles and Problems Facing Electric Cars in India as Well as the Vehicle to Grid Optimization

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Abstract

One viable way to cut greenhouse gas emissions is through the use of electric automobiles. Not only do electric cars not only decrease the reliance on fossil fuels while simultaneously lessening the effects of pollutants that deplete the ozone layer and encouraging the widespread use of renewable energy sources. Electric car production and network modelling continue to change and face constraints in spite of extensive study on the features and qualities of electric vehicles as well as the makeup of their charging infrastructure. The study addresses the many modelling approaches and optimization techniques used in the studies of the market penetration rates of electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, and battery electric vehicles. The report is unique in that it addresses the fundamental obstacles and inadequate charging infrastructure for a growing nation like India. When renewable energy sources are unavailable, there is now an additional power source thanks to the development of the innovative Vehicle-to-Grid concept. We come to the conclusion that considering the unique qualities of electric vehicles is crucial to their mobility.

Keywords: Electric vehicles, vehicle to grid, optimisation technique, CO_2 reduction, nickel metal, hydride battery, locally linear model tree, convex programming, dynamic programming, stochastic dynamic programming, time weighted dot product based nearest neighbour, modified pattern sequence forecasting, support vector regression

Introduction

With the rapid increase in the Indian Automobile market, Electric Vehicles (EVs) are turning into a promising channel towards improving air quality, energy security and economic opportunity. The government of India recognizes the urgency to look at sustainable mobility solutions to reduce dependency on imported energy sources, reduced greenhouse gas emissions and mitigate adverse impacts of transportation including global warming. The carbon dioxide emission can be reduced by taking precautionary measures to reduce the catastrophic climate change that threatens the species of this planet. Major endeavours have been taken for minimal use of fossil fuels for power generation, transport propulsion, reduction of energy consumption and protection of carbon sequestration. EVs could be the alternative to decrease the carbon dioxide gas emission [1].

Though the use of EVs has begun, people are still depending upon fossil fuel powered vehicles. However, the EVs are facing challenges on life cycle assessment (LCA), charging, and driving range compared to the conventional fossil fueled vehicles. The CO_2 emitted from Electric vehicle production is (59%) more than that of the ICEV. The ICEV generates 120 g/km of CO_2 emission on a tank to wheel basis, but from the point of view of the LCA, this increases to 170-180 g/km. While EV has zero emissions of CO_2 on a tank to wheel basis, we estimate that the average CO_2 is measured over the life cycle of a vehicle rather than over a vehicle. The total CO_2 emission over its full life time varies significantly depending on the power source where the vehicle is manufactured and driven [2].

Harmful emission from the transport sector, and investment by different OEMs, there arises a concern for growing more and low cost EVs in the forthcoming years. Several factors such as technological advancement, reduction in the cost of a vehicle, Govt policy support, vehicle purchasing incentives, parking benefit, and good public charging infrastructure facility could result in the uptake of EVs in India. As the production of EVs is very low, the overall share of EVs in the Indian market is negligible.

EVs can be

i) Electric two wheelers (E2Ws) like electric bicycles and electric scooters.

ii) Three wheelers like E- rickshaws.

iii) Four-wheeler consists of electric cars.

India's first electric car company "The Reva Electric car" which launched its car in the early 2000s focuses to produce affordable cars through advanced technology. The only BEV manufacturer, Mahindra Electric mobility Ltd is leading in the Indian market. Other major HEV manufacturer companies operating in Indian markets are Toyota Kirloskar

Motor Pvt. Limited, BMW AG, Volvo Car Corporation and Honda Motors Co. Ltd. Some of the other models were Mahindra e2oPlus, Mahindra e-Verito, Mahindra e-KUV 100, Eddy Current Controls Love Bird, Atom Motors Stellar, and Tata Tiago Electric [3].

In 2014, India's overall greenhouse gas emission amounted to 3202 million metric tonnes of carbon dioxide equivalent, which accounted for 6.55% of global greenhouse gas emissions. In India, 68% of greenhouse gas emission come from the energy sector, followed by agriculture, manufacturing processes, improvements in land use and forestry, and waste adding 19.6%, 6.0%, 3.8% and 1.9% relative to greenhouse gas emission [4].

An electric vehicle can be used as a flexible load for standardizing the grid with a substantial share of fluctuating renewable energy generation [5]. The owners of the Electric vehicle do not have a transaction in the electricity market due to the low power of a single transaction [6]. Some authors [7, 8, 9, 10, 11, 12] considered a current practice for the estimation of current smart policies, which were established in advance for changing scenarios and are exogenous. To exploit the full potential of an EV, flexible load, and smart charging strategies should be executed. In another study by [13] revealed that, the EV users organized themselves to impart to the aggregator as far as timing and energy necessity. The timing requirement defines the time by which a charging operation must be completed, whereas the battery level supports the energy requirement. In a similar study conducted by [14] indicated that a decentralised framework and a central entity should provide the pricing signal to owners of electric vehicles expecting the centralised and decentralised frameworks to overlap.

Brady and Mahony, 2016 [15] studied the stochastic simulation methodology of an electric vehicle for generating a dynamic travel schedule and charging profile for the propulsion of the EVs in this real world. They concluded that when the conditions of parking time distribution are increased, the parking time distribution accuracy, as well as the overall accuracy of the model, would be improved. Morrissey *et al.*, 2016 [16] studied some electric vehicle consumers and revealed that they prefer charging their vehicles at their home during peak electricity demand in the evening. Foley *et al.*, 2013 [17] studied the impact of EV charging under peak and off-peak charging scenarios in a single extensive electricity market in Ireland and found that the peak charging is detrimental compared to off-peak charging. Doucette and Mc Culloch, 2011 [1] conducted a study on the BEV and the PHEV to determine their carbon dioxide emission level and compared their results with CO_2 emission from Ford Focus. Steinhilber *et al*., 2013 [18] studied the essential tools and strategies for introducing new technology and innovation by exploring key barriers to an EV in two countries. Yu *et al*., 2012 [19] introduced a driving pattern recognition technique for evaluating the driving range of the EVs based on the trip segment partitioning algorithm. Hayes *et al*., 2011 [20] investigated for different driving conditions and topographies by building up a vehicle model. Salah *et al*., 2015 [21] studied the EVs charging impact on Swiss distribution substation and found that higher penetration level and dynamic tariff increases the risk of overloads at some locations. These parameters are then compared with each other by their range type. The impact of various classifications of charging methodology of electric vehicles on the national grid and the storage utilization has been presented by [22, 23, 24, 25, 26] studied the model-based non-linear observers for estimating the torque of permanent magnet synchronous motor for hybrid electric vehicles. The maximum transmissible torque method is determined by [27, 28] for increasing the antiskid execution of the torque control framework and to improve the stability of the Electric vehicles. Lu *et al*., 2013 [29] made a review of key issues for Li-ion battery management in an Electric vehicle. The issue such as voltage of the battery cell, battery state estimation (battery SOC, SOH, DOD and SOF), battery equalization and uniformity and fault analysis of the battery can provide motivation for the research and design of the battery management system. Reviews on optimal management strategies, energy management system and the modelling approach for electric vehicles were studied by [30, 31, 32, 33].

EVs can also interact with the grid via charging and discharging. Different modes of interfacing with the grid, are Grid-to-Vehicle (G2V), Vehicle to Grid (V2G), and Vehicle to Building (V2B).

In G2V, the EV is charged from the grid while in V2G, the vehicle discharges power to the grid. In V2G, there is a capability to control the bi-directional flow of electrical energy between a vehicle and electric grid at regular intervals. The integration of electric vehicles into the power grid is called the vehicle to grid system. Here the energy flows both to and from the vehicle, making it into a portable battery store. In V2B, the energy transfers from the battery to a building.

This paper presents an overview of the barriers and challenges of an

Electric vehicle in the Indian context and is the main novelty of this paper.

As the EV market expands, the focus should be on the actual adoption action of EV and not just on the intervention. Furthermore, the gap between intention and actual behaviour is important to consider. Consumer knowledge and skills for estimating and comparing the financial benefit and cost of EV are the major research gap of the current research. Future studies on how to inform customers may have implications for knowing the financial benefit and cost of EV's by policy makers and marketing specialists.

The objective of this study is to identify the essential methods, barriers, and challenges of using a battery-operated vehicle in a developing country like India.

To identify the reasons why electric vehicle could not get much attention in India.

To create awareness about the added advantages of battery-operated vehicles over conventional fossil fueled vehicles in India.

To study different Government initiatives taken in promoting Electric/Hybrid Vehicles.

Methodology

We have studied various types of electric vehicles exiting at present across the world. Besides this, we have figured out the barriers of EV in the Indian market. Different types of optimisation techniques are also discussed and are presented in Table 2. The detailed overview on Electric Vehicles was studied and is presented in Fig. 1. This paper is structured into a few segments such as: Section 2 describes the methodology. Section 3 explains the overview of all types of electric vehicle configuration followed by its charging scenario in Section 4 and the barrier of EV in Section 5. The optimisation technique for EV and V2G is presented in Section 6, followed by a conclusion in Section 7.

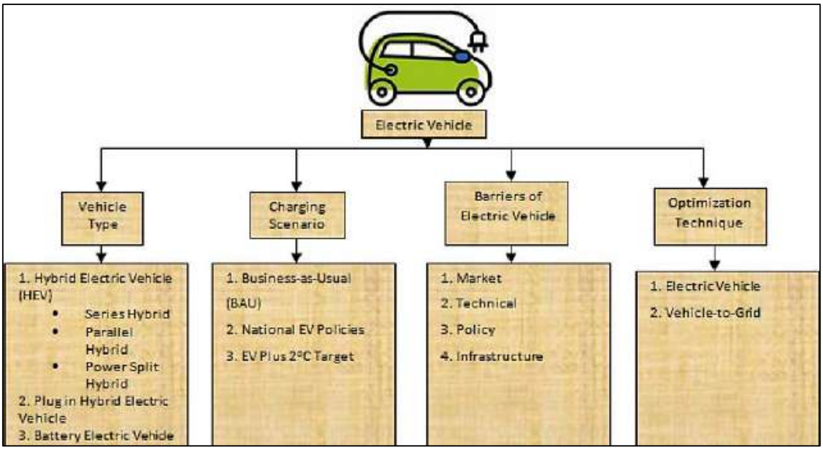

Fig 1: Overview of the Electric Vehicle

Electric Vehicle Overview

The grail behind the electric vehicle is to replace an internal combustion engine with an electric motor which is powered by the energy stored in the batteries through power electronic traction inverter. The Electric motor uses 90-95% of input energy to power the vehicle, which makes it a very efficient one. The key components of an Electric car are battery, charging port, charger, DC/DC converter, power electronics controller, regenerative braking, and drive system.

The purpose of the electric motor is that it utilizes the electrical energy stored in batteries for powering the Electric vehicle. The EVs become environment-friendly as they are recharged with lower emission power sources. The cells are charged from the electric grid. The primary function of the battery is to provide power to the Electric car for making it in running condition. Generally, EVs use lithium-ion batteries because they are more efficient than other cells due to their lightweight and negligible maintenance. The manufacturing of these Li-ion batteries is bit expensive as compared to the nickel-metal hydride and lead-acid batteries. Depending upon the climatic location and maintenance schedule, the Li-ion batteries last up to 8 to 12 years.

The charging port is the point that permits the vehicle to connect with an external power supply system through a charger to charge the battery.

The function of the charger is to take AC supply from the power source using a charge port and converts it into DC power for charging the battery. It also monitors the voltage, current, temperature and state-of-charge of the battery while charging it.

The DC/DC converter converts high voltage DC from the battery to low voltage DC power to run the vehicle accessories. The power electronics controller controls the speed of the traction motor and torque by managing the flow of electrical energy from the traction battery.

The regenerative braking plays an essential role in maintaining vehicle strength and achieving improved energy. This braking method uses the mechanical energy from the motor and converts kinetic energy into electrical energy to give back to the battery. Regenerative braking also enhances the range of the EV, so it is widely adopted in all hybrid and BEV models. Here the electric motor generates forward momentum when the car moves forward, and when the brake is applied, it can be used to charge the batteries, which is known as regenerative braking. It can recover 15% of used energy for acceleration. Being an effective component, it is unable to recharge the electric vehicle fully.

The role of the drive system is to generate motion by transferring the mechanical energy into the traction wheel. Based on the use of the components, the electric vehicle has several internal configurations and does not require conventional transmission. For example, some design uses multiple smaller motors intended for powering each wheel individually. On the other hand, a large electric motor possibly is coupled to the rear wheels using differential housing. The electric-powered vehicle utilizes much simpler components when compared with the elements of a gasoline-powered car engine. However, electric vehicles would not go much faster as a gasoline powered car can.

Types of Electric Vehicles

Several countries have developed the EVs, but the broader market of EVs comes from China, UK, USA, and Germany. The EV market is growing remarkably across the world. The vehicles can be arranged into three groups: Hybrid Electric Vehicles (HEV), Plug-in-Hybrid Electric Vehicle (PHEV) and Battery Electric Vehicle (BEV).

Hybrid Electric Vehicle

A hybrid electric vehicle consists of IC engine and electric motor. Here the batteries get charged by the engine and by the energy generated when decelerating and braking. In the current scenario, they are referred to as hybrid vehicles because they combine a combustion engine and an electric motor as a power converter.

Hybrid electric vehicle technology is deployed worldwide as they have many advantages of offering contemporary performance with no worry about the charging infrastructure dependency. They can also reduce fuel consumption to a great extent through electrification of powertrain. The HEV can be connected in many topologies depending upon the type of hybrid system. These are series hybrid, parallel hybrid, and power-split hybrid.

In a series hybrid, the electric motor is the only means to provide power to the wheel. The motor gets the power either from the battery or from the generator. Here the batteries are being charged through an IC engine to provide power for driving electric motor. The computer decides amount of power originates from battery or the engine/generator. Both the engine/generator and the utilisation of regenerative braking energize the battery pack [34]. The series HEV usually have a bigger size battery pack and large motors with a small internal combustion engine. They are assisted by ultra-caps, which help in improving the efficiency of the battery, thereby decreasing the loss. During braking, they take regenerative energy and deliver peak energy during acceleration.

Their advantages of using series hybrid drive train are

i) Ideal torque-speed characteristics of electric motor make multi-gear transmission un necessary.

ii) Mechanical decoupling between the internal combustion engine and drive wheels allows the IC engine operate at its narrow optimal region. However, a series hybrid drive train has some disadvantages.

They are

i) The overall efficiency be reduced because the energy is converted twice, i.e., from mechanical energy to electrical energy and then to mechanical energy.

ii) Here big traction motor and two electric machines are required because it is the only torque source of a driven wheel. These vehicles are typically used in a military vehicles, commercial vehicles, and buses since they have adequate space for their large engine/generator system [35].

In a parallel hybrid, the engine is connected directly to the wheels, which leads to smaller energy loss and less flexibility in the mutual positioning of the powertrain components compared with the series HEV drivetrain as well. Here the power is supplied from engine, motor, or from the combustion of both motor and engine to the wheel. Parallel hybrid can drive the vehicle individually or together (the combination of single electric motor and ICE). Generally, it has small battery packs that rely upon regenerative braking to keep it recharged.

In Power-split hybrid system, motor, generator, and the engine, all are attached to a transmission with a planetary gearbox. They can be arranged in both series and parallel configurations in a single frame. Here the battery and the engine alone or together can power the vehicle, and the battery can be charged simultaneously through the engine. Different speed and torque of every component are employed to decide the power delivered to the wheel. The speed and load can be varied to get maximum engine efficiency. The power flow of parallel HEV is shown in Fig. 2.

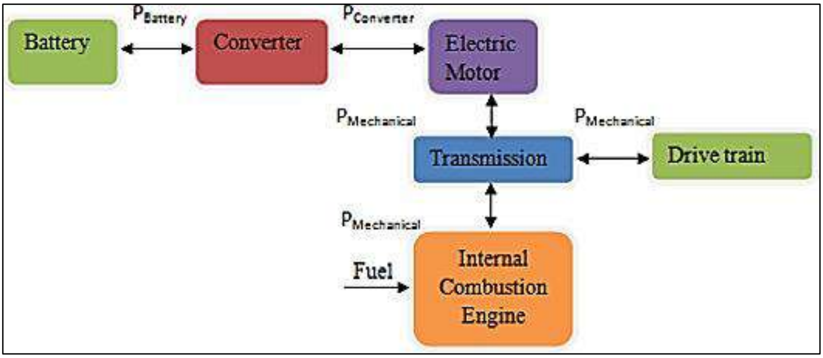

Fig 2: The power flow of parallel Hybrid Electric Vehicle

Plug-in Hybrid Electric Vehicle

Plug-in hybrid electric vehicle (PHEV) comprises of an internal combustion engine and an electric motor. These vehicles are powered by gasoline and have a large rechargeable battery, which is charged up with electricity. The benefits of Plug in Hybrid Electric Vehicles are:

Less Petroleum use

PHEV use about 30-60% less oil than conventional vehicle. Since electricity is mostly produced from domestic sources, plug in hybrid reduces the dependency of the oil.

Greenhouse Gas Emission

Usually PHEV emit less greenhouse gas than conventional vehicle. However, the amount of gas emission depends on how electricity is produced. Nuclear and hydropower plants for example are cleaner than coal fired power plant.

Recharging Take Time

Recharging with a 120 V household outlet may take several hours whereas with a 240 V, home or public charger it take 1 to 4 h. The fast charge of upto 80% of the capacity take as little as 30 min. However these vehicle do not need to be plugged in. They can only be fueled with gasoline, but without charging, they will not achieve maximum range or fuel economy.

Estimating Fuel Economy

Environmental Protection Agency provides a fuel economy estimate for gasoline only and for electric only or gas and electric operation both for combined city highway driving as a plug in can run on electricity, gasoline or combination of two.

The largest solar-powered charging station was launched in China in 2015, which is equipped for charging 80 EVs in each day. It also launched a pilot project in Shanghai for testing the ability of the electric vehicle to incorporate sustainable power source with the electric grid. Japan has likewise included more electric charge points powered by solar photovoltaic system than petrol stations in 2015. The top five countries selling electric vehicles as in 2018 are China, European countries, the US, California, and Norway [36]. Several new models are being announced by the manufacturing companies that is likely to be available at low price in the following years. Plug-in electric vehicle has become one of the promising gateways for the reduction of CO_2 emission and reduce dependency on the use of fossil fuels.

Many studies were conducted globally on hybrid electric vehicles. Related works presented by Galus and Andersson, 2008 [37] uses an agent-based approach, while Waraich *et al.*, 2013 [38] used micro-simulation for plug-in hybrid electric vehicle based on technical constraints and individual objectives. The model-based non-linear observers (MBNOs) are developed for HEV by Yang *et al.*, 2007 [24] for estimating the torque of permanent magnet synchronous motor. Wu *et al.*, 2016 [25] conducted a study on the stochastic framework for energy management in the smart home by using energy storage of plug-in electric vehicle and photovoltaic power supply. For optimal control, Tesla model S of 85 kWh battery pack and Nissan Leaf of 24 kWh battery pack brings about 493.6% and 175.89% less than those without optimal control. In China, Zou *et al*., 2013 [39] conducted an investigation on the heavy-duty parallel hybrid electric truck by building up a feed-forward model for examining optimal energy management strategy and concluded that the dynamic programming algorithm improves the mileage of the hybrid-electric truck. In another study made by Hu *et al*., 2017 [40] in China revealed that convex programming based on an optimal control scheme has an extremely close accuracy to the dynamic programming, which approximately runs 200 times faster. The daily cost of 0.85$ is fundamentally not as much as that in the heuristics PHEV scenario. A similar study conducted by Wu *et al*., 2016 [41] in Chengdu, China, based on stochastic dynamic programming problem for optimising the electric power allocation amongst utility grid, home power demand, and plug-in electric vehicle battery. Hu *et al*., 2016 [42] conducted a study in China and found that the capacity choice can be flexible, and the life cycle cost can be improved when there is an advance in fuel cell service life. By using a 10 Ah of Li-battery, their system showed better performance by 1.4% than the existing one. The small and large capacity Li batteries resulted a higher life cycle cost. Bashash *et al*., 2011 [43] found that the multi-objective genetic algorithm optimizes the charge pattern of a PHEV. It not only minimizes the cost for petroleum and electricity but also the total battery health deterioration over a 24-hour naturalistic drive cycle. The Pareto font of optimal charge pattern is obtained from the results of this optimization. This Pareto font specifies that, for a PHEV to be rapid charged, one should minimize the battery degradation and energy cost. The result is obtained by utilizing an electrochemistry-based model of anode-side SEI development in lithium-ion batteries. SEI growth is a prime aspect that governs the degradation of the battery. Hadley and Tsvetkova, 2009 [44] made a study on the impact of penetration of PHEV into the power grid and found that the kind of generation used to recharge PHEV and emission greatly depends upon the time and area of recharge. Kelly *et al*., 2012 [45] studied on the load profile charging and gasoline consumption of PHEV in USDOT's, National household Travel survey based on driving pattern data. They took the information about 17,000 electric vehicles for tracking their battery SOC for determining timing, quality of gasoline consumption, and amount of electricity for a fleet of PHEV. They also examined the PHEV characteristics based on their charging location, charging rate, size of the battery, and charging time. A similar study conducted by [46] about the challenges and policy option of PHEV into the power grid. Various other studies conducted across the globe on plug-in hybrid electric vehicles are presented in Table 1.

Table 1: Studies on plug-in hybrid electric vehicles

Authors	Place and country	Outcome
Bradley and Frank (2009) [47]	USA	Basic design consideration for Plug in electric vehicle, its architecture, energy storage trade off, energy management system, drive train component function and grid connections are presented.
Darabi and Ferdowsi (2011) [48]	USA	The Plug-in electric vehicle charging load profile and suggested policies for three charging scenarios in United States are described.
Hajimiragha *et al.* (2010) [49]	Ontario, Canada	1. An optimization model is developed based on the zonal pattern of base-load generation capacity from 2009 to 2025, of Ontario's electricity-transmission network. 2. The maximum penetrations of PHEVs in Ontario's transport sector are established to find the viability of charging PHEVs during off-peak periods
Peterson *et al.* (2010) [50]	United States cities	1. Economics of using PHEV using vehicular batteries for storing generated energy at off peak hours for vehicles use in peak hours is studied. 2. The maximum benefit every year is $ 142–249 out of three US cities with no battery degradation cost.
Qiang *et al.* (2008) [51]	China	1. An adaptive algorithm is used to find the remaining energy of battery in hybrid electric vehicle and to identify the SOC of the battery. 2. The adaptive algorithm has high robust property, noise-immune ability and accurate for use in Hybrid electric vehicle applications.
Villalobos *et al.* (2016) [52]	Borup (Denmark)	1. Multi-objective smart charging algorithm for Plug in electric vehicle has been presented. 2. This new methodology is helpful to the stake holders as it allows effective integration of plug-in electric vehicle in a low voltage distribution network
Weis *et al.* (2014) [53]	United States	Mixed integer linear programming model is created to determine the capacity expansion, plant dispatch, and PHEV charging based on New York Independent system operator
Zoepf *et al.* (2013) [54]		Used random coefficient mixed logic model to model the charging operation at the end of PHEV journeys
Goel & Sharma (2020)	India (Present Study)	This paper discusses the impact of EV and V2G technologies on the distribution system, their benefits, challenges, and their optimisation techniques.

Vincenzo *et al.*, 2009 [55] estimated the life of lithium batteries used in PHEVs application under vehicular activity and real driving cycles. An aging model based on the concept of accumulated charge for estimation of battery life. Design optimisation of a lithium-ion cell battery pack for a PHEV and BEV is presented by [56]. When the Plug-in hybrid electric vehicle is large enough, then it can be a back up for the excess of renewable energy and stored energy can be used later for driving need or to provide power [57]. The development in the barrier, trends, and economic feasibility of plug-in electric vehicles in the United States and the impact of PEV on a distribution network have been presented by many researchers [58, 59, 60, 61, 62].

Battery Electric Vehicle

The battery electric vehicle also termed as BEV is fully electric vehicle. It has no gasoline engine, but consists of high-capacity rechargeable battery packs that can be charged from an external source. The battery-electric vehicle utilizes the chemical energy stored in rechargeable batteries to run the electric motor and all electronics involved internally. The BEV could not only reduce the carbon dioxide emission from the light-duty vehicle fleet but also reduce the dependency on fossil-fueled vehicles (Andwari *et al.*, 2017) [63]. The BEVs are said to hold the largest share in the Indian market, contributing more than 70% trade-in 2017, which is expected to grow in the coming years. Though the BEVs dominated the sale over PHEV in many countries until 2014, there is a rapid growth of PHEV in the last two years, and the sale has gone almost equal with the BEV. In view of sorts of batteries utilized in the Indian market, it can be classified as Lead-acid batteries, Nickel-metal hydride batteries, and Lithium-ion batteries. In India, the state of Maharashtra has the highest selling volume of Electric cars in 2017. There are similar kinds of literature that study the comparative strategy for estimating the SOC and SOH of hybrid and battery electric vehicles [64, 65, 66, 67, 68]. The H_{inf} observer-based fault estimation of battery in HEV application have been presented by [69] and the algorithm for determining the temperature and thermal life of traction motor in commercial HEV has been discussed by [70].

Andy *et al.*, 2010 [71] proposed two steps model that first segments the road traffic and their respective demands into a hierarchy of clusters, in a natural and automatic manner, followed by optimization by using linear programming for assigning the stations to the demand cluster. This work is believed to be useful for city planning, and for designing a refuelling infrastructure in an urbanized area for BEVs. Cuma & Koroglu, 2015 [72] did a comparative review in the estimation strategy and different methodologies used in hybrid and battery electric vehicles. Battery Electric Vehicles (BEVs) satisfy two conditions i.e. an electric motor is powered by a battery that replaces the ICEV and the tank, and when not in use, the vehicle is plugged into the charging port [31, 73, 74].

The strategy for estimating the SOC of the lead-acid battery has been presented in [75, 76]. The traditional methods such as the Open circuit voltage and the Ampere-hour (Ah) counting are examined by [77, 78]. The SOC of sealed lead-acid batteries was estimated by using the Fuzzy logic-based algorithm [79]. Robat & Salmasi, 2007 [76] determined the SOC online by the locally linear model tree (LOLIMOT) method, which is a kind of neuro-fuzzy network. The hybrid and electric vehicles consider lithium-ion batteries due to their high possessing power, long life cycle and energy [80, 81].

Based on technology classification, an EV can be categorised by considering their qualities, for example, charging time of the batteries, driving range of an EV, and the maximum load the vehicle can take. The charging time and the driving range are essential attributes that are distress to the customer. Charging time mainly depends upon the capacity of the battery and kinds of batteries employed. The driving range could be as low as 20 km to as high as 400 km for every charge [82]. Likewise, the top speed could go up to 160 km/hour in a few EVs, with a charging time of less than 8 h and tends to be higher in some vehicles. In developing countries like India, the hybrid electric vehicle has been a growing interest in recent days due to the significant improvement in EVs. In future, a lot of innovations are expected to change the EV scenario as EV manufacturer look forward to reducing the production cost.

The overview of electric Vr. Hybrid difference is presented in Table 2.

Table 2: Difference between Electric Vehicles Vs. Hybrid Vehicle

Empty Cell	Electric Vehicle	Hybrid Vehicle
CO_2 Emission	Low	Medium (50-60% of Internal Combustion Engine)
Price Range	High	Similar to Internal Combustion Engine
Fuel Usage	None	40-60% of Internal Combustion Engine
Charging	Required	Not Required
Equipped Charging facility in India	Low	High
Powered by	Electric Engine	Internal Combustion Engine and Electric Engine

Battery Thermal Management System

The use of EV will increase in near future and so priority is given to the need of developing effective batteries. The thermal degradation of the batteries is a big challenge for better BTMS which affect the range of the EV. The main objective of the BTMS is to control the temperature of the battery cell and thus improve the battery life. Li ion batteries are usually preferred for their energy storage in electric vehicle. There are many challenges such as low efficiency at high and low temperature, decrease life of electrodes at high temperature and the direct effect on the performance, reliability, cost and protection of the vehicle and the safety issues related to thermal runaway in lithium ion batteries. So an effective thermal battery management system is therefore one of the most crucial technology for long term success of an electric vehicle. Normally the temperature ranges from 25 °C to 40 °C is the optimal working conditions for the Li-ion batteries. When the temperature of these batteries is higher than 50 °C, it degrades the life of the battery.

Hybridization Factor

The vehicles can also be classified depending upon their hybridization factor. The hybridisation of vehicles helps in improving the mileage, generally communicated as mile per gallon (MPG) or miles per gallon gasoline-equivalent (MPGe). MPGe can be utilised for Plug-in hybrid electric vehicles, where 33.7 kWh electrical energy is the equivalent to the energy of one gallon of gasoline [83].

The hybridization factor of hybrid or electric vehicle is the ratio of the total power from the electric motor to the total power and is expressed as [31] (1)HF=PEM/(PEM+PICE).

Where P_{EM} is the total power from Electric motor and P_{IEC} is the total power of internal combustion engine. HF is 0 for a conventional car, whereas it is 1 for all-electric vehicles.

Electric Vehicle Scenario in India

Currently, the EV market is extremely small in India. The sale of electric cars has become dormant at 2000 units per year for the last two years [84]. But there is a vision for 100% electric vehicle sale by 2030 and since we are in 2020, the compound annual growth rate is 28.12% [85]. India's first electric car Reva (Mahindra), was introduced in 2001, and since its launch, it could able to sell a few units. In 2010, Toyota began Prius hybrid model, followed by Camry hybrid in 2013. Electric buses and hybrid vehicles have been commenced as a pilot proposal in a few cities.

The Bangalore Municipal Transport Corporation recently introduced electric transport on a dense corridor in the city. A survey was carried out in Ludhiana city, which demonstrated that 36% of the existing car and two-wheeler owners were enthusiastic about shifting to electric vehicle [82]. Telengana state Government is also encouraging the use of EVs and announced that the EV owners would not pay any road tax. In 2018, the Telengana State Electricity Regulatory Commission (TSERC) approved a charging tariff of INR 6 for EVs. The TSERC also fixed the cost of service for the entire state at INR 6.04/kWh. Hyderabad metro rail has also signed a partnership with Power Grid Corporation of India Ltd to provide EV charging facilities at metro stations. Hyderabad metro rail will be the first metro rail in the country to have EVs charging stations to be monitored and operated by power grid [86]. Hyderabad Government is also thinking of replacing diesel-run public transport vehicles with electric vehicles. This year, the New Delhi Govt. got approval for setting up 131 numbers of public charging stations in the capital. In November 2018, the Delhi Govt. released a draft policy that is aiming to convert 25% of their vehicles to EVs by offering various incentives and by setting up charging infrastructures in both residential and non-residential areas. This policy is intended to develop a charging point at every 3 km by offering a subsidy of 100% (up to INR 30,000) and waive out the road tax, parking charges, and registration fee for EV by 2023. In Mumbai-Pune highway, a Private firm named Magenta Power is also working for setting up EV charging infrastructure [87].

Scheme for Purchasing Electric Vehicle in India

Central Govt and state Govt have launched various schemes and incentives to promote electric mobility in India. Some of the schemes are mentioned below.

National Electric Mobility Mission Plan (NEMMP) 2020 was declared by the Government of India to enhance the national energy security, mitigating the harmful effect of fossil fuel power vehicles on the environment and development of domestic manufacturing capabilities (GoI, 2012). The NEMMP 2020 could help with the sale of 6-7 million units of electric vehicles, which in turn could be able to save 2.2-2.5 million tonnes of fossil fuel. The vehicular emission and CO_2 emission could be lowered to 1.3-1.5% in 2020 as a result of this new plan. According to this plan, 5-7 million electric vehicles can be deployed by the end of 2020. It also emphasizes the importance of Government incentives and coordination between industry and academia. The Government of India is also making arrangement for 100 GW of solar based power generation by 2022, which could improve the reliability and use of renewable energy that will be helpful for charging stations of EVs.

The Government of India has launched a plan on Faster Adoption and Manufacturing of Electric Vehicle (FAME II) to empower quicker adoption of an electric and hybrid vehicle. This scheme also encourages purchase of EVs by providing various incentives and setting up of charging infrastructures. In February 2019, cabinet cleared 10,000 crore for FAME II for its implementation from April 1st 2019 for a period of three years [88]. The EV manufacturers are eagerly waiting for this single policy scheme to be implemented for creating a roadmap of the EV ecosystem together with charging infrastructure and manufacturing incentives.

Similarly, NITI Aayog's transformative mobility report of 2017 has set a roadmap for using pure electric vehicles following the development of the EVs technology and necessity to reduce energy demand in the automobile sector. It is said that if India adopt transformative solution of shared connected electric mobility,100% public transport vehicle and 40% private vehicles, then it can become all electric by 2030 [89].This vision needs to be spread out to have all electric vehicles in near future.

The Society of Indian Automobile (SIAM) along with other automobile manufacturers aim in achieving selling of hundred percent pure EVs (battery electric and fuel cell vehicles) for intra-city public transport fleets by 2030 [90].

Under this scheme,

i) 40% of new electric vehicle sale is expected to put on the market by 2030.

ii) 60% of new electric vehicle sale to employ greener technology like hybrid and other alternative fuel by 2030.

To ensure smooth functioning of the scheme, Government, Industry and various stakeholder should come forward to collaborate and invest in long term plan to make hundred percent electric vehicle regime.

Barriers for EVs in the Indian Market

Barriers for EVs in the Indian market can be addressed from various perspective such as technical barriers, policy barriers, and lack of infrastructure.

These are shown in Fig. 3.

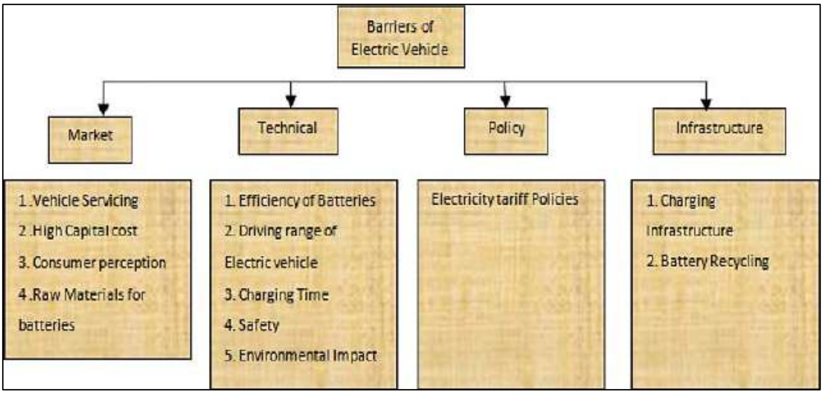

Fig 3: Different types of barriers for EV

Market

Vehicle Servicing

In order to take proper care of the electric car, a trained technician should be available to repair, maintain, and find troubleshoot of the electric vehicle. They must be able to apply their skills to rectify the problem as quickly as possible.

High Capital Cost

The battery packs of an electric vehicle are expensive, and also it needs replacement more than once in its lifetime. The gas-powered cars are cheap when compared with electric vehicles.

Consumer Perception

Consumer perception plays a vital role in attracting new customer and retains an existing customer. Despite the growing range in the auto market with a broader range of electric vehicles, the choice of buying an electric car is limited and is expected to continue over time. So, there should be aware of the company offerings to the customer by means of advertising, social media, or another channel. Studies show that the lack of knowledge associated with the Government scheme, economic benefit, and awareness of the vehicular technology can have a direct impact on the electric vehicle adoption.

Raw Materials for Batteries

The raw materials for EVs batteries include lithium, nickel, phosphate and manganese, graphite, and cobalt, which are rare earth material. For an internal combustion engine, aluminium copper and steel are required. The catalysers for combustion automobiles need platinum, rhodium, and palladium to filter the toxic gases. These all are scare material, and the availability of this material may not be available enough for battery production. The lithium-ion batteries alone consume 5million tons/yr of nickel, which could lead to 10–20 times more consumption of lithium and cobalt in future.

Technical

Battery Lifespan/Efficiency

The electric cars are usually created by using electric motors, batteries, chargers and controllers by replacing fuel tank and gasoline engine of a conventional vehicle. As the EVs batteries are designed for a long life, it wears out in due course of time. Currently, most manufacturers are offering eight years/100,000-mile warranty for their batteries.

Driving Range of Electric Vehicle

A driving range is recognized as the main barrier of Electric vehicle typically because EVs has a smaller range as compared with the equivalent ICE vehicle. The distance an electric vehicle can travel on a full charge or full tank is considered as a significant drawback to uptake the EV in the global market. Most of the BEV provides a driving range of less than 250 km per recharge. However, some of the latest models can offer up to 400 km [91]. By now, PHEV is offering a range of 500 km or more due to the availability of liquid fuel internal combustion engines. The driver must plan their trip carefully and may not have the option for a long-distance trip. This makes the magnitude of driving range as a barrier.

Charging Time

Charging time is closely related to the issue of driving range. With a slow charger, the EV can take up to 8 h for a full charge from the empty state using a 7 kW charging point. The charging time mainly depends upon the size of the battery. Bigger the size of car batteries, longer the time it takes to recharge the battery from empty to full state. Also, the charging time of the battery directly depends on the charging rate of the charge point. Higher the charging price of the charge point, lower will be the time taken by the battery to get fully charged. In the current scenario, rapid chargers are used to charge the vehicle in a faster way reducing the time required. The commercially available electric cars are compatibles with charge points having a higher maximum charge rate than they can handle. This indicates that the battery can be charged at a maximum rate that they can handle without any fault. However, the charging rate of the battery with rapid charger reduces with a decrease in temperature or at cold temperature. The EV chargers are categorized in accordance with their charging speed at which their battery gets recharged.

There are three fundamental kinds of EV charging, for example Level 1, Level 2, and DC fast. Level 1 charging utilizes a standard 120 V outlet by converting AC to DC using an on-board converter. It takes 8 h to charge the EV with 120 V outlets for a range of approximately 120-130 km. Level 1 charging is basically done at home or in the working environment. Level 2 chargers are typically set up at a public place or workplace that can be charged with a 240 V outlet. It takes 4 h to charge the battery for a range of 120-130 km. With DC fast charging, the change from AC to DC occurs in the charging station that has the fastest charging arrangements. This permits stations to supply more power, charging vehicles in a quicker way. It can charge the battery in 30 min for a range of 145 km.

Safety Requirements of Electric Vehicle

The Electric vehicle must meet the safety standard as specified by state or local regulation. The batteries should also meet the testing standards that are subject to conditions like overcharge, temperature, short circuit, fire collision, vibration, humidity, and water immersion. The design of these vehicles should be such that they should have safety features like detecting a collision, short circuit, and should be insulated from high voltage lines.

Environmental Impact

Generally, the electric vehicles do not pollute the environment, but the elements of the batteries are extracted from mines or brine in the desert. This extraction has a low environmental impact on mining.

Policy

To speed up the Indian electric vehicle revolution, the Government of India is planning to subsidize EVs charging infrastructure in the country. The ministry of power has also recently clarified that the EV charging station requires no license to operate in India, which can boost nationwide EV charging station infrastructure. The Govt. should not only slash applicable rate for Goods and Service Tax (GST) on Li-ion batteries, provide incentives and concessions to EV buyers, but also should provide incentives for shifting the public transport sector to Electric vehicle.

Infrastructure

Charging Infrastructure

More charging infrastructure is required for a larger number of electric vehicles and hence, higher demands for electrical energy. Due to the lack of existing charging infrastructure in India, the sale of the electric vehicle is low.

The chargeable batteries ought to be appreciated by EV manufacturers from a design point of view so that discharge batteries might be replaced by completely energized batteries. During the off-peak time, at reduced electricity tariff, the charging station can plan to charge their batteries. There should also be an option for setting up a charging point at home for this vehicle as people would have to start their day by charging their electric vehicle in their residence. In the absence of charging infrastructure at residence, people would rather prefer to charge their vehicle at their workplace or in a suitable charging station where they have to stop over two to three hours or more. Such a location, like home and workplace, is ideal for slow charging and places like highways and commercial complexes where vehicle halt for a shorter duration, fast charging would be the best option. It may also be noted that fast charging of 30 min or less, the EV must be capable of taking high current and voltage or both. This will not only increase the cost of the EV but also have a negative impact on the life of the battery. So, a combination of slow and fast chargers could be the best option for the EVs.

Battery Recycling

The batteries used in Electric vehicles are generally planned to last for a limited lifetime of the vehicle but will wear out eventually. The pricing for battery replacement is not properly informed by the manufacturers, but if there is a need for battery replacement outside its warranty period, then it adds the expenses by dumping the old battery with a new one. The chemical elements of the batteries like Lithium, Nickel, Cobalt, Manganese, Titanium not only increases the cost-effectiveness of the supply chain but also have environment concern during scraping of the battery elements.

Optimization Technique

Application of Optimization Technique for EVs

In this paper, the charging demand of EV is characterized by various frameworks in different geographical locations. The framework consists of Random utility model, Activity-based equilibrium scheduling, Driving pattern recognition, Stochastic model, Trip prediction model, Probabilistic model, Fuzzy based model and Data mining model, Forecasting model, Distributed Optimization, Hybrid particle swarm optimization, Ant colony optimization and Household Activity Pattern, Particle swarm optimisation, linear programming, multi-objective and adaptive model which are summarised below. The scope of this study was to investigate the potential benefit of charging characteristics of all EVs. Various studies conducted worldwide by different authors for finding the optimisation technique of Electric Vehicles. These are listed in Table 3.

Table 3: Studies on optimisation technique of electric vehicle and their outcome

Sl. No.	Author	Model used	Outcome
1.	Arias and Bae, (2016) [92]	Forecasting model	1. Simulation results with case studies of the EV charging demand on the power system have been presented. 2. Case studies of EV have been taken by considering four forecasted sample days. These may be the charging demand on a weekly basis and also during weekends of winter and summer.
2.	Ghanbarzadeh *et al*., (2011) [93]	Hybrid particle swarm optimization and Ant colony optimization	1. Sensitivity analysis was carried out to find the relationship between V2G and the reliability level. 2. Unit commitment problem is solved by these two optimization techniques. 3. The total cost of the system increases as the reliability limit decreases.
3.	Khayati and Kang (2015) [94]	Household Activity Pattern Problem	1. The BEV can be charged for obtaining sufficient range covering capability at a cheaper operational rate. 2. Two scenarios are applied here from the California State-wide travel survey. First circumstances are based upon reported pattern sequence and second are based on activity participation sequence, intra household

			interaction and activity allocation amongst household members.
4.	Lam and Yin's (2001) [95]	Activity and time-based utility theory model	Activity based model is developed as a time-dependant variation inequality problem, that is solved by a heuristic solution algorithm based on space-time expanded networks.
5.	Majidpour *et al*., (2016) [96]	Four different algorithms used: MPSF, SVR, RF and TWDP-NN	Two different data sets used to compare the forecasting of EVs. The station records are direct measurements of quantities at the outlet.
6.	Muratori *et al*., (2013) [97]	Large scale stochastic model of driving pattern	1. It enables us to evaluate the impact of PHEV on the electric grid especially at the distribution level. 2. The tool also compares different vehicle types.
7.	Daina *et al*., [2017] [98]	Random utility model	1. This model can integrate the activity-based demand modelling system for integrated transport and energy system. 2. Empirical version of this random utility model is estimated by using two discrete data sets for finding attributes of charging choice such as energy, charging time and charging cost.
8.	Neaimeh *et al*., (2015) [99]	Probabilistic approach	1. It uses two unique datasets of real-world EV charging profile and residential smart meter load demand for finding the effect of the EVs on distribution networks. 2. This approach demonstrated to reduce the impact on the distribution system by spatial and temporal diversity of EV charging demand.
9.	Nourinejad *et al*. [2016] [100]	Activity-based equilibrium scheduling	1. This algorithm proves to converge a local optimum in a computational experiment designed to exhibit a single optimal solution. 2. This algorithm can result in a 20% increase in social welfare when compared with a vehicle to grid case.
10.	Sundstrom and Binding, (2012) [101]	Trip prediction model	The model uses a semi-Markov chain to predict the next approaching locality and dump time at the contemporary area of an EV.
11.	Tan *et al*., (2014) [102]	Distributed Optimization	When Alternating direction method of multipliers-based distribution scheduling method is used, the demand response was flattened and the electricity bill was reduced for each user.
12.	Wang *et al*., (2016) [103]	Driving pattern recognition method	1. Range anxiety is evaluated in a traffic assignment problem by setting a distance limit. 2. The linear approximation algorithm could solve an alternative problem formulation.

13.	Xydas *et al.*, (2016) [104]	Fuzzy based model and data mining model	1. Data mining model was developed to study the EV charging load in one area. 2. Fuzzy based model was developed to discover the characteristics of EV charging demand in various geographical region.
14.	Yagcitekin and Uzunoglu (2016) [105]	Smart charging management algorithm strategy	1. Helps in routing the electric vehicle to the most suitable charging point. 2. The algorithm not only prevents the overloading of the transformer but also decreases the charging cost.

Vehicle to Grid Technology

The V2G concept was first introduced by [106]. Under this concept, the parked EV can supply electrical power to the grid and have a bi-directional charger, i.e., it can either deliver power to the grid or can be used to charge the battery. In V2G and Grid to Vehicle, the impact of bidirectional charging of Li-ion cells has been proposed to find its cell performance [107]. Overview of employing energy storage technology in the planning and operation of a distribution system is presented by [108, 109]. They studied the battery technology and policy of V2G technology. They provided a methodology to manage battery degradation, which can be used for extending the life of the battery used in the electric vehicle. Kester *et al.*, 2018 [110] made a comparative study in Nordic countries on how hundreds of experts related to electric mobility replicate policy suggestions for V2G and EVs. Dubarry *et al.*, 2017 [111] made an experimental study on how the Li-ion battery is degraded from the impact of V2G operation. They also found the impact of bi-directional charging for maximizing the profit of EV users by using commercial Li-ion cells. Another study made by [112] used an empirical model to find the V2G viability taking into consideration the energy cost and battery longevity for battery degradation. Habib *et al.*, 2015 [113] made a comparative review on the charging strategy of an EV in addition to V2G technology to investigate their impact on the power distribution network. They also stated that the charging strategy and vehicle aggression could make V2G technology economically viable. There are numerous advantages of the V2G system, however if we increase the number of PEV, then it may have a direct impact on the dynamics of power distribution system and performance of the system through overloading of transformers, cables, and feeders. This lessens the effectiveness as well as requires extra generator starts and creates voltage deviation and harmonics [114, 115]. The Vehicle to Grid charging system is shown in Fig. 4.

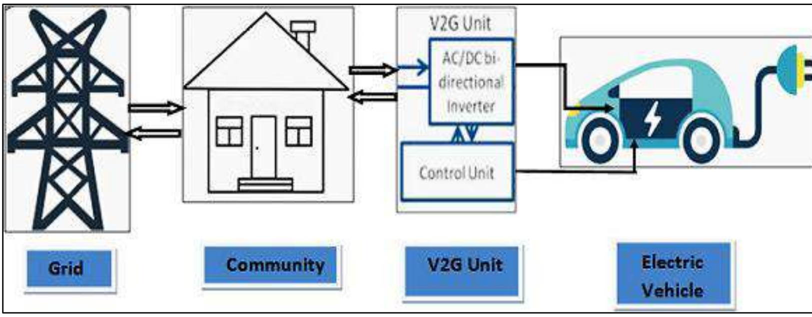

Fig 4: Vehicle to Grid charging

Application of Optimization Technique for V2G

Various control strategies are proposed for optimal performance of V2G. Many authors across the globe have investigated challenges to V2G and different optimisation techniques. The strategy published by different authors across the globe is reviewed and presented in Table 4.

Table 4: Reviews on Vehicle to Grid Technology

Sl. No.	Author	Control technique/ components/Type of model/Scheduling	Outcome
1.	Saber, Venayagamoorthy [2010] [116]	Intelligent unit commitment (UC) with Vehicle to grid(V2G) optimization	1. UC with V2G optimization problem was solved by balanced hybrid Particle swarm optimisation, by handling variables in binary and integer form. 2. For optimization of generating units, binary PSO is applied but for balanced PSO, gridable vehicles optimisations are applied. 3. The UC with V2G not only reduces the operational cost and emission but also increases profit, reserve and reliability. 4. 50,000 gridable vehicles are simulated by considering a 10 unit system charged from renewable sources. Here two data sets are considered for finding the fitness function one is for cost and another for emission. 5. The best outcome is \$ 5, 59,685 production cost with 2, 55,764 tons emission or \$ 560,254 production

			cost with 255,206 tons emission.
2.	Kam and Sark [2015] [117]	Three control algorithm (Two are based on real time with and without V2G option and another is linear programming)	1. The control algorithm decides the charging pattern of the Electric Vehicle and in V2G, it acts as an electricity storage device. 2. The algorithm uses real time information, so it is unable to optimize the charging pattern for a longer time. 3. With real time algorithm and real time control, the EV use only solar power to make the batteries charge unless there is high demand for solar power to make a trip.
3.	Jian *et al*. [2014] [118]	Double-layer optimal charging (DLOC) strategy	1. DLOC strategy can significantly reduce the computational complexity. 2. With the expansion of the size of PEVs and charging posts involved, the computational difficulty will turn out to be enormously high.
4.	Jian *et al*. [2015] [119]	Novel optimal scheduling scheme for V2G operation	1. The optimal scheduling scheme solves the problem by updating the optimisation model and rescheduling the triggering events which include PEV when connected and unexpectedly when it is disconnected from the grid. 2. This scheme can deal with the uncertainty that emerges from the stochastic connection of electric vehicles. 3. In V2G operation, the Plug-in electric vehicle looks forward to serve as a novel distributed energy storage system by helping them and accomplish the balance between supply and demand of power grid making the fluctuation in power load profile smooth. 4. The proposed scheduling effectiveness is verified by using a lot of simulation tests.
5.	López *et al*. [2015] [120]	Optimisation based model	1. Agents are modelled through optimization problems. The daily electricity load curve has a chance of getting flattened and the demand gets shifted from one time period to

			another in response to hourly prices. 2. The final load curve can be reduced to more than 70% with considerable reduction amongst maximum hourly and minimum demand value
6.	Noori *et al.*, (2016) [121]	Agent based model and exploratory modelling	1. Revenue and emission saving for V2G technology for five regions in the US is modelled. 2. Emission saving from V2G technology can save up to 5, 00,000 tons of CO_2 emission by the end of 2030.
7.	Saber *et al.*, (2010) [116]	Particle Swarm Optimisation	1. Particle Swarm Optimisation solves V2G scheduling problem. 2. Gradable vehicle is charged from the grid at off peak load and in peak load hours, it discharges into the grid.
8.	Sarabi *et al.*, (2016) [122]	Free pattern search	1. A copula function analyzed the interdependency of stochastic variables. 2. V2G bidding capacity is determined utilizing a free pattern search optimization method.

Tulpule *et al.*, 2013 [123] showed the feasibility study in a parking lot at a place of work in USA, OH, Columbus, Los Angeles, and CA and compared it with the home charging system in terms of carbon dioxide emission and its expenditure. A similar study performed by [124] also considered the parking lot in USA, NJ, and New Jersey and employed a simple approach for determining the driving needs that could be met by solar power in summer but not in winter. Many authors have considered the EV fleets at a different city or regional level. One such study made by [125] in Kansai Area, Japan, and combined 1 million EVs with 1 million heat pumps for reducing excess of solar power by 3 TWh by using smart charging method. The Batteries used in EVs do not have any significant impact on the grid due to their small size, as revealed by [126]. However, V2G faces many socio-technical barriers due to their large-scale deployment [127]. For evaluating V2G economics, Kempton and Tomic, 2005 [128] expressed the lifetime of the battery energy as a function of battery capacity, battery cycle lifetime, and it's DOD. The energy transfer of V2G has already been carried out in different countries to regulate varying, unpredicted energy demand or variation in supply availability. Ekman, 2011 [129] studied the cooperation between large EV fleets and high wind energy penetration in Denmark.V2G concept for Electric vehicle can either be hybrid, fuel cell, or pure battery vehicle. These hybrid vehicle drive train, fuel cell, and battery EVs have been analyzed for various energy markets peak load, base load, spinning reserve, and regulation services [106]. Several elements must be met to enable V2G;

These are

i) The vehicle must have a connection with the grid for transfer of electrical power.

ii) Communication either control or logical connection concerning grid operation.

iii) Onboard metering device of the vehicle.

Drude and Ruther, 2014 [130] expressed the role of building-integrated grid-connected PV generation in a commercial building in a warm and sunny climate. Previously vehicles were only able to charge and were not able to discharge, so supporting the grid was not possible at that time [131, 132]. Reviews of technologies, benefits, costs and challenges of the vehicle to grid technology have been mentioned by [133, 134, 135, 136]. The optimal management of V2G system and a residential micro grid and the feasibility of electric vehicle contribution to grid ancillary services have been presented by [137, 138, 139, 140, 141] presented a case study in the US where the Plug-in Electric vehicle is compared with hybrid electric vehicles, where it is seen that the CO_2 emissions are reduced by 25% in the short term and 50% in the long term basis by using a mix of generating power plants.

V2G capable vehicles provide possible backup for renewable power sources such as wind and solar power supporting efficient integration of intermittent power production [142, 143, 144, 145]. The electric vehicle enables G2V and V2G to maximize profit in the smart distribution system. The multi-objective multiverse optimisation algorithm is used for minimizing the impact of charging and discharging of EVs on the grid [146].

The aggregator of a V2G system collects individual PEV data, detects, and records the SOC of individual Plug-in electric vehicles to provide interfacing to independent system operators [147]. The aggregator of a V2G system is shown in Fig. 5.

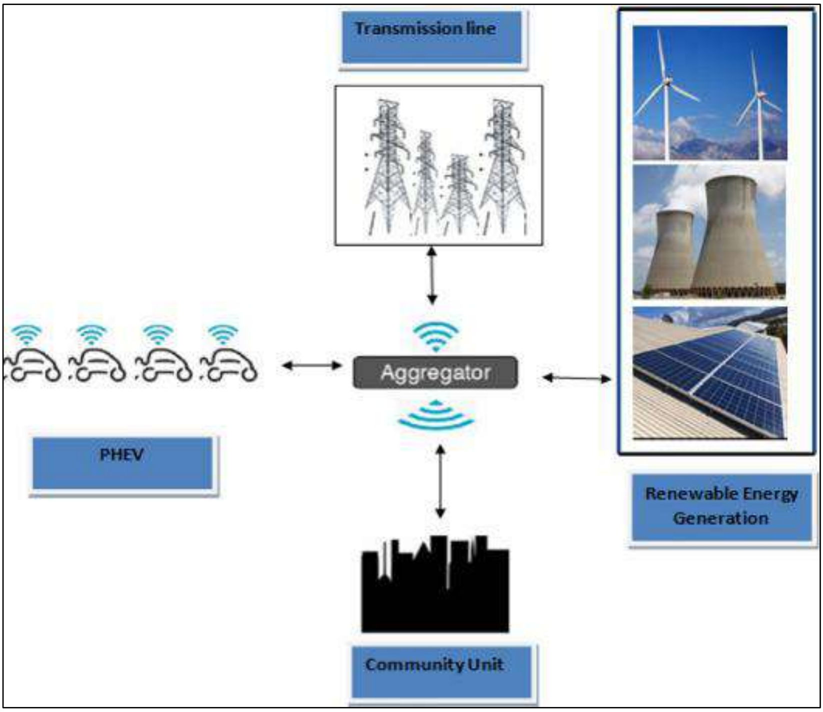

Fig 5: Aggregator of a V2G system

Conclusion

Hybrid, Plug in Hybrid and Electric Vehicles are capable of increasing the fuel economy of vehicles but with an increase in the cost of buying compared to traditional vehicles. In general their decreased consumption of petroleum and increased productivity offers economic benefit to buyers, society, automakers and policymakers over the lifetime. This paper provides a detailed overview of the literature, overview, and guidelines for HEV, PHEV and BEV penetration rate studies into the Indian Market. The recent initiatives and various subsidies by the Indian Government will help push the e-mobility drive in India. The development of a new concept of Vehicle-to-Grid can either deliver power to the grid or can be used to charge the battery when non-conventional energy sources are not available. This technology is an important aspect of energy security, renewable energy, and giving a great scope to deal with global warming issues. This paper provides a summary of an electric vehicle's barriers and problems in the Indian context and is the main novelty of the paper.

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Chapter - 26
Review on Research Trends on Electric Vehicles

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Chapter - 26

Review on Research Trends on Electric Vehicles

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Abstract

Vehicle electrification has been acknowledged as a critical component of sustainable transportation and a critical component of achieving global climate change targets. An impartial and quantitative assessment of research trends is the main emphasis of this integrated and aerial view of academic research on electric vehicles (EVs). The results indicate that in recent years, the distinct trending topics in EV research have been

i) Charging infrastructure.

ii) EV adoption.

iii) Thermal management systems.

iv) Routing difficulty.

Even while the term "hybrid electric vehicle" (HEV) has been popular, its usage has either decreased or plateaued in recent years in most of the main EV research subfields. The results offer unbiased suggestions regarding the present paths that electric vehicle research is taking. The identification of the references that have contributed most to the development of each main line of EV research is a secondary outcome.

Keywords: Electric vehicles, vehicle electrification, climate change, carbon emission, temporal research trends

Introduction

The history of Electric Vehicles (EVs) is as old as the history of the automobile. Actually, the first experimental light-weight EVs appeared already in the mid-1830 s, and at the beginning of the 20th century, they were the most common vehicle type in the US. However, by the end of World War I, they had lost the race against the internal combustion engine (ICE) vehicle and disappeared from the market (Høyer, 2008). While a number of factors contributed to the success of the ICE vehicle, limited range and expensive batteries, were major contributors (Duarte *et al*., 2021, Patil *et al*., 2022). These two barriers have continued to hinder EVs from gaining real market breakthroughs through the decades (Chakraborty *et al*., 2020).

There have been waves of EVs during the last 100 years, pushed by policy to address resource constraints related to fossil fuels, primarily during World War II to save fuel prioritised for the military, and during the 70s, due to the oil crisis. From the 90s onward, the curbing of emissions—at first mainly related to local air quality and later carbon emissions affecting climate change-has been the main political motivator. In California, the promotion of EVs started in the 90s to address smog issues, especially in Los Angeles, leading to the Zero Emission Vehicle mandates instituted by the California Air Resources Board. Even though these were amended to Lower Emissions Vehicles, they still had an influence on technological development such as batteries for hybrid EVs (Bedsworth and Taylor, 2007).

Commercial modern hybrid vehicles were first available in Japan strongly pushed by governmental initiated R&D support programs to advance, at first, battery EVs, and later, other alternative fuel vehicles (Åhman, 2006). Pushes from the government have either been directed toward R&D support for the industry, not surprisingly prevalent in car-producing countries such as Japan and Germany (Altenburg *et al*., 2016) and/or market support. The most prominent example of market support is probably Norway which also has the largest market share with 86% of new sold cars in 2021 (IEA, 2022). The background of the success is a long history of high subsidies that started already in the 1990 s making EVs price competitive with conventional vehicles (Figenbaum, 2017). China is one of the countries that has pushed hardest for EVs, especially after 2009. The strong push is motivated both by air quality and the opportunity to leap-frog technical development and seriously compete in the automotive industry (Daina *et al*., 2017, Altenburg *et al*., 2022). In the EU, the tightening of tail-pipe CO_2 targets for the automotive industry has in recent years led to increased market shares of EVs (Iwan *et al*., 2021).

Driven by the political push in several countries, the research and development of EVs have significantly intensified since the 1990 s which can be observed in an increasing number of patents being registered (Wolbertus *et al*., 2021, Altenburg *et al*., 2022). The effects of this development on the scientific literature have, so far, not been documented. There have been several reviews concerning EVs, but these have mainly been focused on specific subjects within the field such as consumer preferences (Liao *et al*., 2017) and adoption (Coffman *et al*., 2017); incentives (Hardman, 2019); business models (Ziegler *et al*., 2022); charging infrastructure (Shareef *et al*., 2016, Funke *et al*., 2019); connections with the electric grid (Richardson, 2013); environmental impacts (Hawkins *et al*., 2012a, Hawkins *et al*., 2012b). However, there is, to our knowledge, no overall computational review of the literature on EVs, its different components and fields, and connections and how these have developed over time at a broader scope. Different topic experts within the field of EV may have different perceptions about the composition and research trends of the field. The current work is aimed to address this knowledge gap by providing an *objective* and *quantitative* determination of the trends in EV research. We believe that, given the multidisciplinary nature of the research on EV, scholars and practitioners can benefit from a broad-scope computational analysis of the literature, providing insights that otherwise are not obtainable from conventional literature analyis with smaller scope. This can encourage synergy and collaboration between scholars that reside in various sectors of this research, and more importantly, can provide an objective categorisation of research streams within the field along with a quantitative determination of the extent of activities within each stream and their variations over time.[1] This ultimately leads to the determination of hot topics, cold topics and emerging topics within this research field. A side outcome of the analyses is the determination of the fundamental references that have been instrumental to the development of each research stream within the field of EV. This can facilitate future conventional reviews within this field. The analyses identify temporal variations and trends in EV literature based on objective metrics obtained from nearly 34,000 articles on EVs. Overall, the findings of the study provide objective indications as to the directions to which the scholarly literature of EVs is currently headed.

Methods and Data

Search Strategy: The underlying data for the study was sourced from the Web of Science (WoS) Core Collection. The choice of database is based on the fact that WoS data has more specificity, while e.g. Google Scholar is not capable of generating the needed data. WoS and Scopus have shown to have high overlapping content (Mongun & Paul-Hus, 2016). A simple term-based search query string was formulated as (TI="electric vehicle*" OR

AK="electric vehicle*") and applied to the Advanced Search section of the WoS.[2] In this query, TI and AK respectively specify Field Tags for Title and Author Keywords of articles. The number of identified items prior to 1990 was insignificant, so the results were confined to 1990–2021. No restriction was set on the document type. Therefore, the search essentially identifies any document indexed by the WoS and published since 1990 till December 2021 that have mentioned electric vehicle(s) in their title or keyword list. Nearly N = 34,000 articles were identified and their details were exported and stored in the form of text files. This information includes for each document, the title, list of authors and their affiliations (country and institute), journal name, year of publication, abstract text, keywords and reference list. All search queries have been made in English which excludes literature only published in local languages and thus might miss some developments and trends happening within national research communities.

Visaluisation of Similarities Analysis: Scientometric methods were used on the data to obtain high level insight on the development EV literature. The method of Visualisation of Similarities (VOS) (Van Eck *et al.*, 2010) was employed to discover divisions of the EV literature. Additionally, VOSviewer software and its embedded text mining algorithms were used to identify specific phrases from each publication's title and abstract and to identify clusters of such terms.

In the VOS method, the similarity between any two objects i an j is shown by their Euclidean distance, τij, and is measured via Equation (1) where σij is the number of co-occurrences of objects i and j, while δi and δj represent their respective number of total occurrences (Haghani *et al.*, 2021): $(1)\tau ij=\sigma ij\delta i\delta j$

A two-dimensional mapping is provided as the outcome of the analysis by minimising the weighted sum of the squared Euclidean distances between all pairs of elements (Equation (2).$(2)MinVP1,\cdots,Pn=\sum i<j\tau ij\|Pi-Pj\|2$

An additional constraint is that the average distance between pairs of objects has to be equal to unity. Equation (3) is used to find the spatial locations of items where $Pi=(xi,yi)$ is the vector of position for item i in a two-dimensional map, and $\|\cdot\|$ signifies the Euclidean norm.$(3)s.t.\sum i<j\tau ij\|Pi-Pj\|n(n-1)/2=1$

The outcomes of this analysis constitute the core component of the findings presented in the following section, titled "composition and macroscale trends of EV research".

Document Co-Citation Analysis: Major topics within the EV literature, their temporal trends and influential references were investigated using the methodology of *Document Co-citation Analysis* proposed by Chen (2010). This method essentially investigates the reference lists of all N = 34,000 EV articles and identifies clusters of references that are often cited jointly in EV papers. The method rests on the assumption that groups of reference that are often co-cited represent the *knowledge foundation* of a certain topic/stream. As result, by identifying such clusters, the following can be obtained.

i) One can objectively determine fundamental references of each research stream through the number of times they are referenced in EV papers (i.e., local citation count) as well as sudden spikes in frequency of being referenced (i.e., local citation burst) as well as the frequency of times that they are cited jointly with references of other clusters, known as *centrality*, a metric of the broadness of impact for the reference.

ii) Through inspection of the cohort of EV papers that created (cited) each cluster of references, one can identify the topic that the cluster represents.

iii) By analysing citation activities of these citing articles (i.e., EV papers) over time, one can determine temporal variation in the magnitude of research on each of the topics and determine areas of research that are trending or those that are slowing down.

This methodology has been illustrated in an abstract way in Fig. 1. Note that in this context, EV papers within the dataset of N = 34,000 articles are referred to as citing articles, to contrast with their frequently *cited references*. The cited references, clearly, could be EV papers themselves (i.e., be present in the dataset of citing articles too) or be outsiders of EV research, references not necessarily related to EV, but frequently cited by EV papers, and hence important to knowledge development on EV.

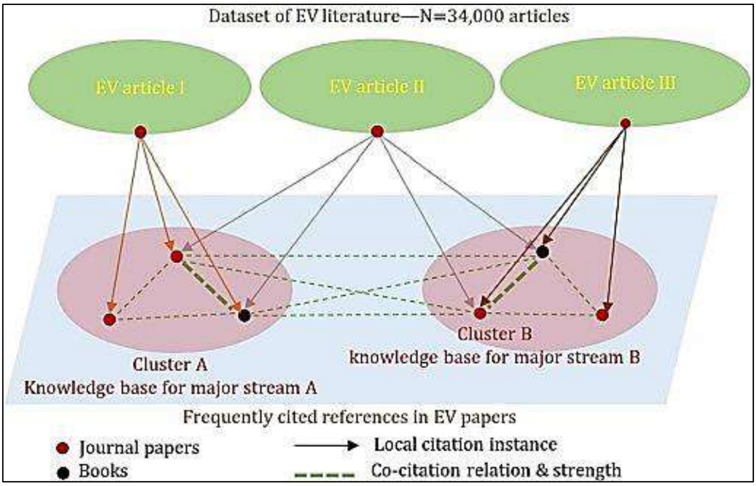

Fig 1: An abstract illustration of the concept of document co-citation network

The outcomes of this analysis are presented in the section titled "temporal trends and influential references in EV research".

Composition and Macroscale Trends of EV Research

Geographical and field Distribution of EV Research

Geographical origins of EV studies were analysed using country affiliation of authors listed on the set of N = 34,000 articles in the data. Data showed that nearly 27.5% of EV articles (n = 9,346 items) have, at least, one author affiliated with institutes of China. Other countries whose authors/institutes have a strong presence in EV research are the USA (n = 5,466), Germany (n = 2,048), India (n = 2,010), and Canada (n = 1,746) (see Fig. 2 (a) and (b) for more details). The dominance of contributions of authors from China over the last decade has been such that the rate of accumulation of studies in this research (i.e., the number of papers published annually) has been constantly consistent with the rate of publications from China (See Fig. 2 (c)). The dominance of research in China shows that the governmental push toward EVs to increase competitiveness of China as an automotive power has had an effect on academia as well (Altenburg et al., 2022). The rate of publications in any other one of the top five countries has been slower than China during the last decade. However, since 2019, the number of EV publications originating from China appears to have flattened out and instead, the biggest (relative) growth rate of EV research is currently observed in India.

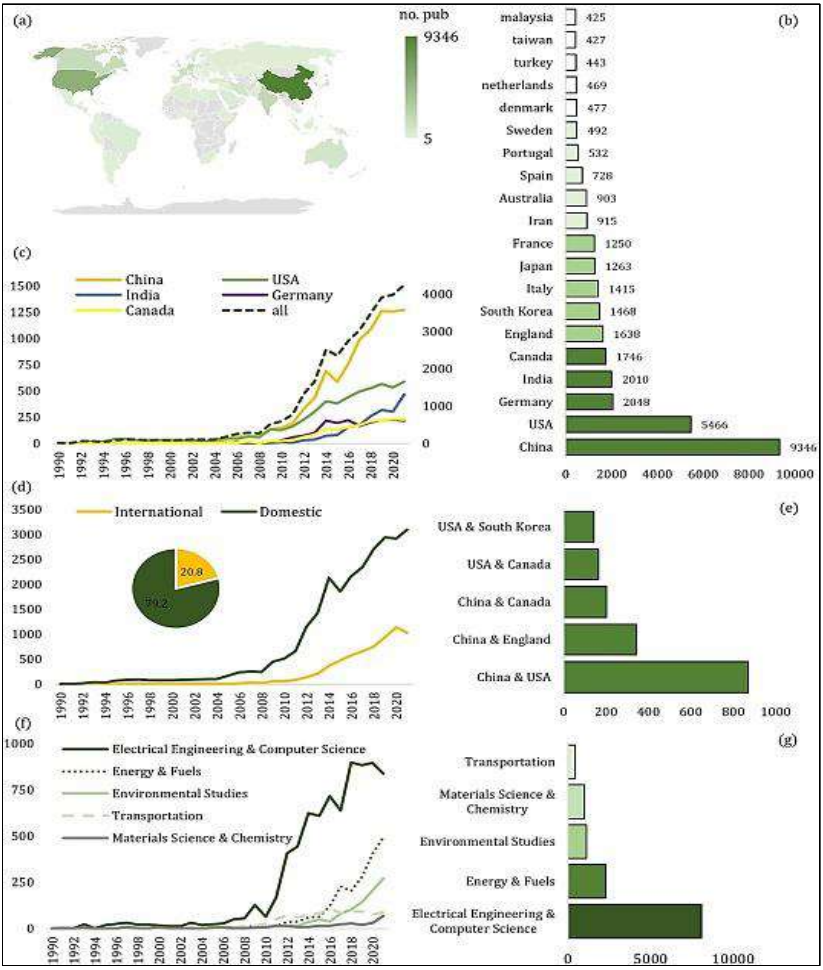

Fig 2: (a) Primary origins of EV research based on the number of scholarly publications, (b) top twenty countries active in EV research, (c) variation of the magnitude of EV research in in top five countries over time, (d) the extent of domestic and international collaboration in EV research and its variation over time, (e) strongest links of country collaboration in EV research, (f) variation in the magnitude of EV research activity (reflected in the number of publications) across major disciplines, (g) the share of EV publications distributed across major disciplines

The extent of international collaborations was also investigated based on the country affiliation of authors listed in the papers. Articles with at least two authors affiliated with organisations of two different countries were deemed international collaborations. Data showed that only 20.8% of EV research has overall been comprised of international collaborations. Instead, 79.2% of studies have been domestic research (Fig. 2 (d)). This is slightly less than the overall degree of international collaboration in scholarly literature in general, estimated to be around 25% (Haghani *et al*., 2022). The closest attempt to analysing collaborations in fields adjacent to EV research is the study of Aleixandre-Tudó *et al*. (2019) where a triangle of international collaboration in Renewable Energy research was identified but no quantitative estimate has been provided comparable to that of the current study [3].

Data also shows that the gap between domestic and international publications has been increasingly widening. Strikingly, during 2021, the number of internationally collaborated EV papers showed a drop compared to 2020 whereas the number of domestic papers continued to grow strongly, an observation that appears to be in contrast with most other areas of scholarly research (Haghani and Bliemer, 2023), and an indication that the state of international collaboration in EV research may still not be quite strong compared to many other research fields and topics.

The strongest link of collaboration between countries is observed between China and USA with n = 870 joint papers. This is followed by collaborations between China and England, China and Canada, USA and Canada, and USA and South Korea. These constitute the five strongest links of country collaboration in EV research (Fig. 2 (e)).

The impact of international collaboration on the overall impact of research has been a matter of investigation by several studies. It has been shown that research that entails international collaboration is overall more impactful than purely domestic studies (Van Raan, 1998). This is an indicator that in most fields, including EV, more impactful findings can emerge as a result of a higher level of international collaborations between scholars of that field. This may be particularly the case in a multidisciplinary topic such as EV.

The distribution of EV research across various fields of research was also investigated. To this end, the WoS categories in which the source (journal) of each article has been indexed, were used as the main determinant. The number of such categories was very large, but the majority of the fields could be aggregated across five major disciplines:

1) Electrical Engineering & Computer Science (comprised of WoS

categories Engineering Electrical & Electronic, Telecommunications, Computer Science & Information Systems, Computer Science Theory & Methods, Computer Science Artificial Intelligence, Computer Science Interdisciplinary Applications, Computer Science Hardware Architecture, Computer Science Software Engineering, Computer Science Cybernetics).

2) Energy & Fuels (comprised of the WoS category Energy and Fuels).
3) Environmental Studies (comprised of WoS categories Environmental Studies, Environmental Sciences, Engineering Environmental and Green & Sustainable Science Technology).
4) Transportation (comprised of WoS categories Transportation Science & Technology and Transportation).
5) Materials Science & Chemistry (comprised of WoS categories Materials Science Multidisciplinary, Materials Science Coating Films, Materials Science Characterization Testing, Chemistry Physical, Electrochemistry, Chemistry Multidisciplinary, Chemistry Analytical, Chemistry Applied, Chemistry Inorganic Nuclear, Chemistry Organic, Engineering Chemical, Materials Science Composites, Materials Science Biomaterials, and Nanoscience Nanotechnology).

In determining the allocation of each study, only those that purely belonged to the subcategories of only one of these five major/aggregate disciplines were considered and not those of any other. Results showed clearly that EV is predominantly Electrical Engineering research, followed by Energy & Fuels, Environmental Studies, Materials Science & Chemistry and Transportation (See Fig. 2 (f), (g)). Since 2010 especially, EV research has been growing very steeply in Electrical Engineering, although since 2017 this trend has changed and there are signs of research developments slowing down in Electrical Engineering (Fig. 2 (f)). Instead, in more recent years (i.e., 2016 and onwards), the growth of EV research within the Energy & Fuels as well as Environmental Studies disciplines has been most notable. The growth of EV research in the Transportation as well as Materials Science domains remains relatively modest and fluctuating.

Discussions and Conclusions

Electrification is a key technology within the transport field to reach climate goals. While the history of electrification is as old as the history of the automobile, it is not until the last 20 years that we see that the research has really gained momentum. In this paper, we have studied the scholarly research trends by analysing patterns of document co-referencing of the period 1990-2021. Our results show several interesting trends, gaps, and need for future development of EV research, industry, and policy.

The dominant research fields have been electrical engineering & computer science. We see a certain levelling off in research activity in these fields during recent years. However, we believe this might be a temporary result given the continued need for research and development of autonomous driving technologies in EV. These will be necessary to improve transportation safety and efficiency and to minimise energy consumption by optimising driving patterns and reducing traffic congestion. However, this development needs to be aligned with policies not to induce more traffic and thus energy demand (Sprei, 2018).

Energy & fuels and environmental studies are gaining in activity (even though the narrower environmental assessment of EVs has peaked). With more EVs on the road, the demand for electricity to power these vehicles will increase, impacting the energy sector. Thus, we see that this is an area with expected growth, especially related to the integration of renewable energy. For example, research trends in the United States have shown that EV adoption is driving a transition to cleaner sources of electricity generation, such as wind and solar power (Taalbi *et al*., 2021).

In addition, the development of new battery technologies for EVs has led to innovations in energy storage, which has applications beyond the transportation sector. Advances in battery technology could lead to the creation of more efficient and cost-effective energy storage solutions for renewable energy sources like wind and solar power. In China, the government is investing heavily in the development of advanced battery technologies for both EVs and energy storage applications (Li *et al*., 2019).

Furthermore, the adoption of EVs will also impact the oil and gas industry as it reduces the demand for fossil fuels used in transportation. This shift towards electric vehicles will create new challenges and opportunities in the energy industry, requiring a comprehensive understanding of the relationship between EVs and energy-related fields. Future research could develop this further by investigating how EV research trends compare to other energy-related fields to better understand the broader implications of

EVs on the energy sector. By studying the trends and identifying the uniqueness of EV research, we can develop a comprehensive approach to meet the energy needs of the future while reducing carbon emissions. This can be achieved by analysing and comparing research trends in other domains, such as renewable energy, energy storage, and sustainable transportation. Overall, the relationship between EVs and energy-related fields is complex and multi-dimensional. As such, a comprehensive understanding of this relationship is essential to effectively address the challenges and opportunities posed by the growing adoption of EVs.

We find relatively low international collaboration within EV research compared to other fields. Thus, further efforts can be made to improve this since, generally, research with international collaboration is more impactful than purely domestic studies (Van Raan, 1998). Special efforts should be made to incorporate researchers from emerging economies and developing countries that also need to transition to EVs to reach climate targets. Even from an industrial strategic point of view, international collaboration is required to achieve standardisation, reduce costs, increase interoperability, and ensure safety and reliability for consumers. This requires greater collaboration between governments, industry, and academia to align regulations and incentives with technological advancements and consumer needs.

EV adoption and market development is one of the growing research clusters and is predicted to continue growing given the challenges lying ahead to reach 100% BEV penetration in all markets. While most of the research, so far, has focused on early adopters, more focus is needed on reaching mainstream consumers and laggards. Increased public education and awareness are needed about the benefits of EVs in reducing greenhouse gas emissions and combating climate change. Thus, more research is needed to understand how this is done effectively and relates to attitudes in different socio-demographic groups. Research is also needed on how incentives can be implemented in different markets, the effects on government revenues and expenditures, and how incentives in the end should be phased out.

Closely related to EV adoption and market development is the development of charging infrastructure where we find a growing research activity that is not expected to saturate in the near future given the policy interest among others in the EU with the new Alternative Fuel Infrastructure Regulation (AFIR) mandating the deployment of charging and hydrogen refuelling in its member states. Challenges related to charging infrastructure deployment will be even more prominent with the electrification of heavy-duty vehicles as well.

Our findings are in line with other reviews such as (Broadbent *et al*., 2022) that identified gaps in the areas of battery technology, charging infrastructure, and policy frameworks to support the uptake of EVs. Other researchers have emphasised the need for interdisciplinary research to address complex issues related to EVs. For instance, in Debnath *et al*. (2021), it is argued for more research on the social, economic, and political dimensions of EV adoption, including issues related to equity and access to charging infrastructure.

From the research clusters, we find, not surprisingly, that different battery-related research has been central to EV research. Research and development efforts should continue to focus on improving battery technology to continue to decrease the cost of EVs. In addition, increased investment in the recycling and reuse of EV batteries is necessary to reduce waste and minimise the environmental impact of the EV industry. We thus see a continuous need for interdisciplinary research combining areas such as environmental research, chemical and material sciences, and electrical engineering on this topic.

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Chapter - 27
A Review on Electric Vehicles and Renewable Energy Synergies in Smart Grid

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Chapter - 27

A Review on Electric Vehicles and Renewable Energy Synergies in Smart Grid

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Abstract

The environment and the world's energy system currently face formidable obstacles. Energy usage is more environmentally friendly in the context of the energy internet as transportation fleets switch to electric, plug-in, and fuel cell vehicles. In order to guarantee energy security, avoid air pollution, and encourage energy conservation and emission reduction, the smart grid's electric car, renewable energy synergies are of utmost importance. The combination of renewable energy and electric vehicles, however, is fraught with difficulties because of the randomness, intermittent nature, and electrical nature of renewable energy. This article first illustrates the smart grid design and the relationship in electric vehicles, renewable energy sources. The effects of electric vehicles and the growth of renewable energy sources are then examined, and the main technique, such as smart charging, coordinated scheduling, and energy management, is looked into based on the particular problem. Additionally, synergy effects on the economy and environment are studied. After discussing the current development's issues, a brief overview of the future prospects for renewable energy and electric vehicles is provided.

Keywords: Smart grid, renewable energy source, electric vehicle, energy internet

Introduction

Due to the greenhouse gases released by the use of fossil fuels, the world's energy system and ecosystem are currently facing enormous problems. Due to its potential to lower emissions, boost the use of renewable energy sources (RESs), and reduce fuel consumption, electric vehicles (EVs) are growing in popularity. Five million EVs will be sold in China by 2020, and more than 30 million will be sold worldwide [1]. With the advancement of EVs, the demand for charging will dramatically rise. Since 75% to 80% of the electricity in our nation is produced by burning coal, the carbon emissions of electric vehicles that are charged via the grid are equal to those of conventional fuel vehicles [2]. The best strategy to minimize carbon will therefore be to increase the use of renewable energy sources in the grid. emissions. Currently, renewable energy sources include biomass, solar, wind, and other sources. The limitations of nature, energy density, development costs, technical level, and power generating efficiency, among other factors, make the use of wind and solar energy for charging electric vehicles more practical. Energy use will switch to renewable energy sources, the transportation fleet will switch to electric vehicles, and the internet technology will be used to revolutionize the power grid with the introduction of Energy Internet in combination with new energy technology and information technology. The synergy of EVs and RESs will be encouraged by a smart grid architecture [3].

Smart Grid

The addition of EVs gradually resulted in the formation of a new smart grid. When EVs are taken into account as a load, optimal charging can be accomplished using technical and economical techniques to schedule charging time, allowing for peak-load shifting, increasing system efficiency, and minimizing the impact on grid security. When considered as distributed energy storage units, EVs are able to contribute electricity to the grid, enhancing the power system's safety and dependability. V2G technology allows for two-way communication between the grid and EVs. In comparison to the conventional grid, the smart grid applies significant amounts of distributed generation that uses RESs as fuel. These generations struggle to manage the load due to the intermittent nature of distributed energy sources like solar and wind energy. Smart grid adjustments are necessary. Figure 1 depicts the smart grid's architectural layout. AMI is a piece of electronic equipment that can record and gather real-time data on consumer electricity use [4]. HANs serve as the functional entity that permits message transfers with home display devices and access to metering equipment [5]. Users' ability to actively interact with the electrical grid is one of the key characteristics of the smart grid. Users can use AMI to acquire power usage and costs to choose how to charge their electric vehicles, which helps EVs and RESs work together more efficiently.

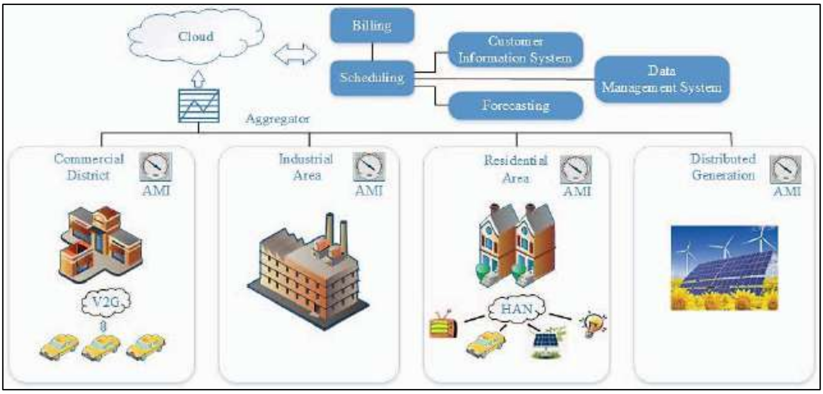

Fig 1: Smart grid architecture

Key Technical Issues

The viability and utility of combining EVs and RESs were extensively researched. Electric vehicle charging is given a strong boost by the availability of abundant renewable energy. Reference [5] examined the combined manner and adaptability of RES and EV charging and discharging facilities. They conclude that it is possible to provide the microgrid with the ideal configuration for fusing RESs and EVs. The integrated system's use in microgrids will enable the synergy effect, a win-win outcome. However, due to the intermittent and erratic nature of RESs, numerous issues, including power grid voltage deviation, frequency deviation, harmonic injection, voltage fluctuation, and flicker, would arise when they are all included into the grid at once. The effects of using PV arrays to charge EVs were covered in reference [6]. The findings indicate that PV can only temporarily match the demand for electric car charging. In reference [7], it was suggested that charging stations may use energy storage systems to store excess electricity produced by renewable energy sources so that consumers could continue to receive electricity even when there was not enough generation. Intermittency of renewable energy can be reduced thanks to energy storage technologies, but doing so will require significant investment, delaying the timeline for RESs. By creating intelligent charging, synergistic dispatch, and energy management technologies, the smart grid will lessen the impact that EVs and RESs have on the system. Intelligent charging technology. The charging duration and speed are adjusted using intelligent charging technology in accordance with the power supply [8]. Offers a design for a solar-powered home EV charging station. The authors provide different EV charging control topologies and arrive at the best charging method. In [9], a case was examined. The intermittency problem with renewable energy sources may be resolved using V2G technology, and the results show that intelligent charging technology can effectively reduce the fluctuation issue in the distributed grid brought on by the production of renewable energy. Investigated in [10] are the charging characteristics of EVs and the utilization status of RESs. Heuristics were used to create an intelligent charging model and lessen the power system's exposure to load instability. The intelligent charging techniques suggested in [10-12] can decrease. In order to reduce the grid-connected wind power's cost of recharging and to maximize the financial gains of EV owners and power companies, policymakers should consider how EVs and RESs interact.

Synergistic Dispatch Technology

When large-scale EVs and RESs connect to the grid, the traditional centralized control is replaced by distributed control. The ability of the power system to respond is faced with additional obstacles due to the erratic charging habits of consumers and the intermittent nature of renewable energy sources. Investigating the synergistic dispatch concerns of EV and RES generation is therefore required. The impact of EVs and solar systems on the demand for electricity was examined in [13]. According to the findings, PV diffusion reduces the grid's overall electrical load by 19.7%. The generated energy from other conventional energy sources can be decreased by the coordinated dispatch of EVs and RESs [14]. Explored coordinated energy dispatching in microgrids with wind power generation and EVs. The results show how energy dispatch based on interruptible and variable-rate energy dispatching can achieve better matching between power generation and needs. Grid-connected EVs, wind, and solar energy were all taken into account at once in [15] while setting up a multi-objective coordinated scheduling model. The output volatility of RESs can be efficiently controlled by scheduling the charging and discharging period in a way that benefits both the user and the device.

Energy Management Technology

According to a proposal made in [16], a programmable V2G energy management system might boost the income of providers and owners of EVs while reducing the intermittent nature of solar energy. Described in [17] is a smart charging station. The EV charging is managed so that charging during peak load times has no noticeable effect on the grid. Grid-connected photovoltaic generation, the utility, or both provide the power necessary to charge plug-in hybrid vehicles. In order to maximize the use of available electricity and maintain grid stability, there is a three-way interaction between the grid, EVs, and solar power.

The advancement of the technologies stated above can better match the load and power fluctuation of RESs generation, increase equivalent load rate, and lessen the impact of intermittent RESs.

Benefit Analysis

Ecological Benefits

The most efficient strategy to cut emissions will be to charge EVs with RESs because the traditional grid generates the majority of its energy through the combustion of coal. In [18], the carbon emissions of EV charging stations powered by solar energy at work were investigated. According to the findings, solar-powered EV charging can save carbon emissions by 0.6 tons per car year, or by 55% less than charging at home at night. Another 0.36 tons of CO_2 will be saved if the EVs and PV are dispatched using the best control tactics.

Economic Benefit

Many researches also focus on the economic benefits for charging providers, EV owners, and power grid businesses. The synergy of EVs with RESs can reduce carbon emissions, which benefits the environment. The cost of operation for charging providers has an impact on the development of EVs and RESs. The unit commitment (UC) problem can be used to model the operational costs of the electricity system. The following are examples of UC problems:

$$OC = \sum_{i=1}^{N} \sum_{t=1}^{T} [FC_{it}(P_{it}) + MC_{it}(P_{it})] + ST_{it} + SD_{it} \tag{1}$$

Where OC is the cost of operating the system, FCit(Pit) is the cost of fuel, MCit(Pit) is the cost of maintenance, STit is the cost of starting, and SDit is the cost of shutdown. The operation cost of the system is assessed in [19-21] taking into account the sporadic nature of solar and wind energy as well as the randomization of EVs as load, energy storage, and energy sources. The cost of operation can be reduced. with the grid, RESs, and EVs all working together. The charging cost is what motivates EV owners to charge their vehicles with RESs. EVs can be controlled loads when charging and discharging. Owners of EVs can save 91.6% on charging fees if we can manage their charging behavior, causing them to be discharged at high electricity prices and charged at low ones [22]. For power grid businesses, producing costs, total life cycle costs, and transmission costs are of particular importance. Energy use and storage costs will go down as EV and RES penetration increases. 20% of the cost of overall generating may be saved [23].

Conclusion and Prospect

This study reviews and analyses the grid impact, important technologies, economic, and environmental benefits. In the upcoming work, we still need to enhance the performance of the current technologies. The algorithm optimization of control scheduling Most scientists focus on investigating charge control strategies, coordinated dispatch, and energy management using optimization algorithms. However, the soft computing approach has several flaws, like the EV and RES's insufficient penetration. The control rules algorithm can become very complex and take a very long time to run when there are a lot of sources and EVs. These problems need to be solved in the future. The utilization of EV batteries to store the extra power produced by RESs and release it to earn revenue when the grid is underutilized, EVs can be thought of as distributed energy storage units. The method described above will, however, result in more battery charging and draining cycles. As is well known, the Li battery's capacity will reach with an increase in charging and discharging cycles, the effect was considerably reduced. Therefore, it is necessary to conduct further research on extending battery life and to present a strategy that balances profitability and battery life.

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Chapter - 28
A Comparative Review of the Use, Difficulties and Future of Renewable Energy

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Chapter - 28

A Comparative Review of the Use, Difficulties and Future of Renewable Energy

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Abstract

The population rise has led to a substantial increase in energy demand. Aside from this, increased energy use is required for economic and technological advancement. However, the world's precious energies are finite. Additionally, it is crucial to increase the usage of traditional energy sources because they produce significant amounts of greenhouse gases that harm the planet's ecology. However, our civilization cannot really advance without energy. So, in order to rescue the earth, we must choose some other energy sources. That sustainable and renewable sources of energy should be used. A variety of renewable energy sources can be found around the world in various regions. The key benefits of renewable energy are its minimal impact on the ecology, its ability to be produced even in inclement weather, and its overall effectiveness as a weapon against environmental pollution. It significantly affects economic expansion, employment development, and energy security. However, there are certain issues with the storage of renewable energy. Scientists and investors are working nonstop to find a solution. The installation of a renewable energy system might occasionally be complicated by public opposition. Opportunities for employment and some facilities lessen opposition to the use of clean energy. The public's knowledge of renewable energy and its benefits aids policymakers in their decision-making. An extensive experiment on sustainable energy is currently underway, according to a study of review publications on the subject. This work has produced a concept regarding various applications of renewable energy, their application challenges, and their resolution. Additionally, it has been noted that in the coming years, the use of renewable energy will increase dramatically due to improved technology and storage arrangements, growing government initiatives to minimize carbon emissions for economic growth, and other factors.

Keywords: Renewable energy, solar energy, wind energy, hydro energy, tidal energy, geothermal energy, biomass energy, utilization, future prospect

Introduction

In the past several years, there has been a substantial change in the world economy. Because to industrialization, there is a daily rise in energy demand. Fossil fuels continue to be the world's primary energy source, yet they are a finite resource. The fact that fossil fuels will run out in a few years poses a threat to mankind. In addition to this, there are numerous other ways that the usage of traditional energy sources pollutes the environment. We must find an alternative energy source to prevent these issues. We can consider sustainable energy at this point. The sustainable energies are eco- friendly and economic. The proper use of renewable energy may undoubtedly replace the use of conventional source of energy. Environmental pollution can be easily controlled by the use of sustainable energy. We can obtain and use this renewable energy almost anywhere in the world and throughout the year without endangering the environment [1]. It is possible to find endless amounts of unconventional energies in this globe. Utilizing sustainable energy contributes to a reduction in the amount of carbon in the atmosphere. In the future, it lessens the worry about an energy catastrophe. Utilizing renewable energy sources can promote economic development and advance the green revolution [2]. Some nations today are battling a lack of energy supplies. Some nations in Asia and Africa are also experiencing economic lags as a result of the energy crisis. This is the cause of the widespread loss of a decent level of living. These issues can be resolved by making significant use of renewable energy. While some developing nations are lucky to have non-conventional energy resources, their usage processes still need to be improved. If they are successful in utilizing their renewable energy resources, their entire economic, lifestyle, and power-generation scenario will alter [3]. Significant eco-system indicators include the greenhouse effect and weather changes. Because of this, various nations are working to create new technologies that utilize renewable energy sources and have also made the decision to lessen carbon emissions into the atmosphere. Their initiative to develop novel technology in the area of unconventional energy is a sign of the use of sustainable energy [4]. Reduced atmospheric carbon emissions are necessary to protect our planet from the greenhouse effect. We need to stop using traditional energy sources in order to create an eco-friendly environment. We must make use of renewable energy sources. This will contribute to a better environment. Long-term energy needs will also be met with the aid of sustainable energy [5]. In order to use energy effectively and achieve feasible evolution, alternative sources of energy are crucial. Mankind has a challenge to reduce the carbon discharge in the atmosphere. But in spite of this challenge the world economy is still depending on conventional energy resources. Increasing requirement of natural gas is an indication of less greenhouse gas out flow and it is also a symbol of non-conventional energy utilization [6]. One of the most important factors in the development of renewable energy is financing for sustainable energy. Investors are drawn to funding for renewable energy sources. Investors are also considering their responsibilities in relation to this kind of investing. Regarding this, they are considering concerns pertaining to politics, society, technology, the economy and the environment [7]. Competent authorities are working to implement new strategies for the use of renewable energy in an effort to stop climate change. Along with creating new automation, this project also improves employment opportunities. Making use of unconventional energy also helps humanity save money [8]. The general public is crucial to the development of renewable energy. They respond to renewable energy in different ways. Researchers and decision-makers keep tabs on how the public feels about renewable energy. Their acceptance of unconventional energy enables the responsible authority to select a strategy for utilizing various energy sources [9]. Natural treasures that are found almost everywhere and all year round are unconventional energies. These energy resources are easily usable thanks to various mechanisms. Our ecosystem is not negatively impacted. The answer to the coming energy dilemma is renewable energy sources. These renewable energies are accessible to us with just one investment. We must accept these energies on a global scale if we want a secure environment. Solar, wind, hydropower, tidal, geothermal, and biomass energy are the most efficient renewable energy sources [1, 2, 3].

Solar Energy

The most widely used source of reliable, safe, and secure power is solar energy. A small portion of this enormous source is what we are using. Both active and passive solar energy can be classified as solar energy [10, 11]. J. Li and J. Huang [12] It has been found that solar energy is a somewhat superior choice for sustainable energy. It is a crucial energy source for creating a greener planet. They observed that there are several barriers to using solar energy as a replacement for conventional energy. To address these issues, the policymaker needs to take some action. O.A. Al-Shahri, F.B. Ismail, M.A. Hannan, and other authors [13]. Observed that using sustainable energy helps to lower power supply costs and greenhouse effect. They discovered that the key challenge to enhancing energy preservation performance is the improvement of many functional factors of solar energy. They used a variety of improvement strategies to increase the deployment of solar energy's effectiveness. Solar energy was described by J. Zhang *et al*. [14] as a solution to the world's future energy needs. Unused solar energy can be successfully transformed into electrical energy. Numerous semiconductors have developed over time and are crucial for the use of solar energy. Due to its excellent optical or electrical properties and suitable band distance, Cadmium Sulfide (CdS) is most effective in this context. According to J.S. Roy *et al*. [15], the proper use of solar energy in accordance with general need is a crucial issue. They designed an extremely concentrated solar energy delivery system (ECoSEnDS) to use for day illumination and waste water cooling. The aforementioned gadget can be used to treat wastewater using solar energy in addition to providing day lighting with the aid of suitable semiconductor micro photo catalysts. With the aid of a finned solar collector filled with paraffin, Bo Xu *et al*. [16] investigated solar collectors with energy storage. They discovered that as air movement increases, heat absorption efficiency does as well. In their observations, they noted the average paraffin temperature, the temperature of the exit air, and the efficiency of heat absorption with various types of air circulation. They also observed that under unfavorable conditions, the efficiency of heat absorbing drops and energy collection duration increases. They came to the conclusion that a solar collector and energy storage enable to fully utilize solar energy, which is good for the environment. According to Laibao Liu *et al*. [17], as the solar/wind adequacy factor increases, so does the purchasing power of a single source of energy. The differences between a hybrid wind/solar system and a single wind/solar system are smaller for large areas. They advised local cooperation since it lowers production costs, lessens solar/wind energy generation fluctuations, and improves the system as a whole. Malik, S.A., and Ayop, A.R.

Noted that a key factor in a society's willingness to accept new technologies is the level of education available to its citizens [18]. They suggested that a project for the disadvantaged community to generate their own solar electricity might be useful to defend their predicament. Because their economic situation and educational level are crucial for the adoption of solar PV technology, policymakers find it easier to establish such projects among the less educated people. They also came to the conclusion that appropriate education and understanding of new technology are crucial for economic development. According to Tervo *et al.* [19], an appropriate storage system is required for the continuous supply of sustainable energy. In this regard, thermal storage is a better means of sustaining solar power. They suggested a solid-state heat engine replacement for solar-thermal conversion made up of a photovoltaic cell, thermal radiation cell, and solar absorber. They discovered a limited solar restoration effectiveness of 45% for one sun with absorber and single-junction cells in the same region and 85% for solely intense sunlight.

Wind Energy

Another sustainable energy source is wind energy. The key perk of this energy use is that it continues to function in inclement weather. The placements of the wind turbines are particularly important to achieve maximum efficiency since they improve the system's efficiency. The recommended altitude for wind turbines is roughly 30 meters, and this is where they are typically installed. In relation to the blade diameter, the wind turbines are spaced 5-15 times apart. A windmill with a horizontal axis and one with a vertical axis performs equally well. Air flow is a crucial factor in how well a windmill performs. It performs ineffectively when the air flow is less than 13 km/h and performs optimally when the air flow is around 22 km/h. Three-bladed horizontal axis windmills with a power output capacity of 50 to 350 kW have become more common recently. The global green movement has a weapon in this energy producing system, and it also offers a solution to the coming energy crisis [1]. Wind energy is a sustainable and pollution-free source of energy, according to Hui Liu *et al.* [20]. A lot of work has been done recently to maximize the use of wind energy. They discussed many upgrade techniques to improve prediction efficiencies in various ways. According to Sneh Deep *et al.* [21], of all non-conventional energy sources, wind energy has grown to be the most prosperous sustainable energy supply. When calculating wind energy using data from wind flow statistics, they discovered that the actual wind energy is overestimated. Depending on where it located geographically, this error varies. They indicated that two variables needed to be accurately estimated in order to determine wind power using the two parameter Weibull model. The accessibility option can be determined using this way. To determine the available wind power, they also suggested using the Weibull model with three parameters. Sustainable energy sources have been found to be crucial for a nation's development, according to P. Borawski *et al.* [22]. They used a variety of academic articles and statistical data to track the development of wind energy in the EU. They discovered the maximum average wind speed. Accordingly, Germany, Spain, the United Kingdom, and France all used energy. They were also aware of this development in nearly all of the EU's member states. The use of wind energy has increased significantly during the past few years, according to Y. Gao *et al.* [23] who evaluated China's wind energy future. They saw that the Qinghai Tibet Plateau, Hexi Corridor, and Eastern Inner Mongolia all have access to favorable and acceptable wind energy. Utilizing this energy is a simple way to substitute using traditional energy sources. A reliable mechanism for preserving the collected energy is needed in order to use this enormous amount of energy. It also requires a considerable upfront investment for large-scale storage arrangements. For the next generation's preservation of wind energy, they indicated that battery energy storage stations would be a preferable alternative. They came to the conclusion that this recommendation might be used everywhere. According to D.L. Bessette and S.B. Mills [24], wind energy is the primary sustainable energy substitute in the US at the moment. The future of wind energy depends on enough resources, electricity supply methods, and public awareness. The use of wind energy helps to strengthen the economy and provides a solution to any potential energy crises. To educate the public about wind energy is a significant problem for scientists and policymakers. The public's perception of wind energy influences where to put new wind turbines. They found that installing production-related equipment, expanding employment opportunities, and providing some community facilities lessen community opposition to the use of wind energy. They suggested that this policy would be useful to the decision-maker for the installation of a wind turbine.

Tidal Energy

Our planet's surface is covered in water to a significant extent. This enormous body of water serves as a sustainable energy source. India has thousands of kilometers of coastline as a result of its location. The water stream offers many chances for use. The water stream can be converted into electrical power. The energy solidity at a suitable location by the sea is roughly 65 MV/mile. This energy can be partially transformed into wave-driven electrical energy. During a natural disaster, there are various challenges with collecting or using tidal energy [1]. Some European nations are making an effort to increase their use of renewable energy sources, according to N. Isaksson *et al.* [29]. One of these is tidal energy. Tidal energy equipment has a negative impact on marine wildlife despite its significance in the green energy revolution. The author offered several suggested methods for calculating the effects of tidal energy devices on seabirds. According to C.J. Mejia-Olivares *et al.* [30], the entire region of Latin America is beginning to understand the significance of the green energy revolution. The enormous tidal energy is unknown to the nations of Latin America. An enormous tidal range is present in Mexico, to the north of the Gulf of California. Because of this, it might be a good place to use tidal energy. They conduct their experiment by using tide level forecasts from a depth-averaged bar tropic hydrodynamic model. In addition, they used a 0-D function modeling to determine the power that might be produced from a particular area. Their research demonstrates that the range of annual power production is 20 to 50 kWh/m2. H.-B. Goh, *et al.* [31] discovered that the cape is a crucial location for capturing tidal energy. In their experiment, they used the numerical model for Tg Tuan Cape. Evaluation of tidal power utilization's potential and effects was done close to the cape. The results of the experiment showed that the pointy portion of the cape would be a good location for tidal energy production. They found an inverse link between velocity changes and depth after making more observations about the effects of depth and stream velocity on eight different variables. The competent authorities should benefit from their observations when choosing a location to harness tidal energy.

Geothermal Energy

Geothermal energy is the name for the heat energy that our earth has stored. This energy is usable as renewable energy and is free of pollution. Magma, scorching rock on the surface, and heated water or streams are the sources of this heat energy. This heat can be used by using a heat pump. Homes can be heated or cooled using geothermal energy [1, 32]. Y. Wang *et al.* [33] clarified that geothermal energy is unquestionably reliable for the production of renewable energy. The green world benefits from it. It is abundantly present in nature and requires a minimal installation fee. Geothermal energy is abundant in China. By using this energy, they can balance the demand for natural energy in eastern and western China. China has just started to gradually deploy geo thermal energy. The writers focused on the current state of geothermal energy use in China while taking into account all the challenges related to economic, political, technical, and the environment. They made several recommendations for the development of geothermal energy in China. Geothermal energy is becoming more and more popular, which may influence China's future development. S. Di Fraia, *et al.*

[34] identified a number of issues with the Island's use of conventional energy for waste water treatment. It costs more, and the system encounters several challenges. They recommended a geothermal energy system for energy production, sludge management, and waste water treatment because of this. Utilizing the Engineering Equation Solver environment, an exergoeconomic analysis is used to analyze this design. The results of the reactivity test show that the heat from geothermal resources has a significant impact on how well the system works and how much it costs to operate. To cut down on exergoeconomic costs, they also offered other improvement techniques. The overall hourly exergoeconomic cost of the system products drops to its lowest level when the temperature of the geothermal resource reaches roughly 110 °C and 58.91% of the drying agent flow is recycled. According to Taghizadeh- Hesary *et al.* [35], Japan's power consumption has altered significantly since the Fukushima nuclear accident. In an effort to increase the usage of renewable energy, they turned back to conventional energy. The writers looked into Japan's lack of attention to geothermal energy. They looked at the problems from a social, legal, financial, economic, and technical standpoint. Data from 1974 to 2017 were used in the analysis, which was done using a Vector Error Correction Model (VECM). The results show that there is still a relationship between the parameters, public opinion, installation costs, and levy plans. In terms of producing geothermal energy, the last one is more crucial. In this situation, a grant may prompt a range of responses. The opposition to geothermal energy was also mentioned, along with ecological issues and public outcry.

Biomass Energy

Energy derived from living things is called biomass. A society's future can be altered through the wise use of biomass energy. There is a vast supply of biomass naturally available in India. Biodegradable garbage can be used to generate this energy. The term "biomass energy" refers to combustibles made from plant and animal waste. A portion of the biomass is organic. In biomass, the solar energy has been chemically conserved. During chemical reactions, this energy is released [36]. Z. Wang *et al.* noted that there is disagreement over the impact of biomass application. Few investigations focused on the outcome of using biomass for energy. Some event had a negative impact. The authors looked into the benefits of biomass energy spending in the BRICS nations between 1990 and 2015. They can assess the challenges posed by cross-sectional dependence and slope heterogeneity by using economic methodology.

Conclusion

The earth's traditional energy resources are depleting quickly. As a result, fossil fuel must be replaced. We should utilize less conventional energy in order to preserve the planet for future generations. The best options to a potential energy crisis are renewable energies. Utilizing sustainable energy in the right ways is a step toward a worldwide green revolution. The availability of renewable energy is abundant around the planet. The challenges of implementing sustainable energy are continuously being addressed by scientists, academics, and decision-makers. The need for new methods to use renewable energy is a challenge to technologists. In addition to this, a key factor in the use of unconventional energy is the general public's awareness of renewable energy. The various applications of renewable energy and their application challenges have been established in this study. According to this study, the use of renewable energy will increase dramatically over the next few years due to increased government policies restricting carbon emissions for economic growth and proper storage arrangements.

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Chapter - 29
Overview of Electricity Markets and Opportunities for Distributed and Renewable Energy Sources to Participate in the Market

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Chapter - 29

Overview of Electricity Markets and Opportunities for Distributed and Renewable Energy Sources to Participate in the Market

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Abstract

Overview of the electricity markets and opportunities for distributed and renewable energy resources to participate in the marketThe paper's major goal is to provide a thorough examination of market structures in Europe, North America, and Australia as well as to identify barriers to and opportunities for complete market integration for distributed and renewable energy sources. By using examples of the most developed markets, laws and operational market principles from various continents are compared to show how different technologies may profit from selling items on the market throughout a range of time frames. Recent European agreements have established a framework for equal access to the market for all enterprises in this vein. In light of the fact that co-optimized participation in various markets maximizes benefits for new entrants, the article analyses how applying segments and concepts from the US and Australian markets could aid in achieving this in Europe.

Keywords: Distributed energy resources, electricity markets, renewable energy, market products

Introduction

Power system development dates back to the late 19th century. They evolved from modest systems that supplied a few bulb strings to gigantic systems that served 500 million people in 35 different nations, such as the European ENTSO-E power system. They have been run by vertically organised, heavily monopolised public utilities since the early stages of the creation of the power system. The majority of electricity generation consisted of sizable, centrally located thermal and hydro power plants that were connected to high voltage lines. As a result of the energy crisis in the latter half of the 20th century, the issue of scarce energy resources and rising costs emerged. Governments all over the world began integrating renewable energy sources (RESs) along with the liberalization and restructuring of the power sector in order to provide a solution to a long-term dilemma.

By introducing sustainable energy production, RESs integration competes with traditional thermal energy sources, and the development of electricity markets attracts private capital to an industry that has previously been mostly supported by the government. Early investments in RESs technology were too risky and expensive financially. Therefore, greater compensation was needed to entice investors. It was made possible by set feed-in rates that were paid to the owners of RESs. Feed-in tariffs are no longer practical, and new policies are needed to reach the planned RESs share. Partially subsidizing RESs measures like market premium payments or contracts for difference, where RESs sell their electricity as any other market participant but nevertheless receive additional compensation up to a certain amount over the market price, are the first steps. However, the generation of non-dispatchable RESs has the unfavorable effects of increased variability and unpredictability on power networks. Variability increases demand more high-ramp flexibility, whereas unpredictability increases require more flexibility reserve. Partially subsidizing RESs measures like market premium payments or contracts for difference, where RESs sell their electricity as any other market participant but nevertheless receive additional compensation up to a certain amount over the market price, are the first steps. However, the generation of non-dispatchable RESs has the unfavorable effects of increased variability and unpredictability on power networks. Variability increases demand more high-ramp flexibility, whereas unpredictability increases require more flexibility reserve. The distributed energy resources (DERs) discussed in this study are viewed as grid users who are connected to the distribution network and have the ability to adjust their operating point in response to market or network signals.

In terms of power system flexibility, DERs such as demand response, electric vehicles, microgrids, energy storage, small-scale RESs, etc., could be used in conjunction with large-scale RESs. Both RESs and DERs ought to be permitted to take part in electricity markets on an equal footing with traditional power facilities. Due to the unique characteristics of DERs, it is important to be aware of the following energy market factors in order to support DER participation:

New goods at power exchanges; the length of trading intervals; gate closure periods; coordination of the day-ahead and intraday markets; and the coordination of the electricity market and balancing market.

Clean Energy for All Europeans

At the end of 2016, the European Commission put up a set of measures to maintain the clean energy transition to the low-carbon electricity system. "Clean Energy for All Europeans" is the name of the programme [1]. One of the driving concepts is that the future of the European energy market will revolve around customers and DERs. New players should be allowed to engage in the market individually or through aggregation in order to counteract the unpredictable and weather-dependent generation from RESs and give the electricity system the ever-increasing flexibility it needs. Day-ahead and intraday market gate closure times and bid sizes become crucial in such DERs-focused markets. At organised electricity markets with anonymous bidding, a bigger volume of energy traded results in less prejudice against participants with lower trading capacities and more trading chances for them. A shorter gate closure time brings trading closer to real time, which results in better RES balance and greater DER flexibility. Smaller RESs and DERs can participate in markets and use their flexibility at a higher value because to smaller bid sizes. As a result, the proposed Regulation on the Internal Electricity Market [2] specifies minimum limitations for both features. For instance, when the gate closes Article 7 of [2] defines:"…as close to real time as possible…":

- "…at least as the intraday cross-zonal gate closure time determined in Regulation (EU) 2015/1222" [3]–

Where

It Says: "At most one hour before…"

- "…at least as short as the imbalance settlement period in both day-ahead and intraday markets".

The European Commission's objective of harmonizing the national markets is largely the reason why severe regulations are implemented in this document for various electricity market aspects. Minimum standards need be met in order to establish a unified power market spanning the European Union. EUPHEMIA, which stands for EU + Pan-European Hybrid Electricity Market Integration Algorithm, is the name of the algorithm used to couple prices across national electricity markets. To maximize total welfare and improve the transparency of price and flow computation, EUPHEMIA is used to determine energy allocation and electricity prices across Europe.

Electricity Markets

Either vertically integrated monopolies or liberalised marketplaces can control the power sector. Market-based power systems are structured as bilateral or pool-based, with a limited number of concurrent markets, including financial (long-term hedging), day-ahead scheduling, and intraday (or real-time) markets. Frequency control ancillary services, also known as balancing services, can be purchased through a market mechanism separate from energy markets. You can set up balancing markets separately or co-optimize them with the energy market. Financial markets discuss hedging agreements that have nothing to do with the actual delivery of power and are outside the purview of this study. Day-ahead spot markets typically operate as follows: bids for power supply and demand are made, and the market clearing price is determined based on the points where the supply and demand curves intersect (demand curves are frequently projected).

Analogously, balancing services can be marketed. A supply curve is formed when service bids are arranged in increasing order. Service requirements are represented by a demand curve. The cost of the service depends on where the two crosses. In Europe, intraday markets are often continuous, with all prices established on a pay-as-bid basis. To support day-ahead auctions, the intraday market functions as a balancing market.

During the trading session, pricing for the same product may change. The following sections include descriptions of several sorts of developed markets, with a focus on those in Europe, the United States, and Australia.

One. Europe

Although each EU member state administers its own electricity market, the ultimate objective is to integrate all of them into a unified EU market. The ability to trade both on a bilateral basis and on the organized power market (power exchange, where transactions in a way produce the national electricity price) within the same geographic area is a key characteristic of national markets. The amount of electricity exchanged in organized power markets relative to total system consumption can be calculated using a statistic called liquidity of organized power market. The likelihood that RESs and DERs will participate in the market is increased by improved market liquidity. Table 1 displays the liquidity of the organized electricity markets in Europe (using 2015 official market reports for each market in question as a guide).

In Europe, the markets for electricity and balancing are always split into two distinct markets. The major justification for this structure is the existence of two distinct organizations for controlling the operations of the electrical market: transmission system operators (TSOs), who are in charge of system balancing, and market operators, who typically take the form of power exchanges.

While TSOs are in charge of transmission grid and system balancing, or organised balancing markets, so-called Nominated Electricity Market Operators (NEMOs) are in charge of organised electricity trading. A member state may have more TSOs (natural monopolies, each operating a particular area of the national transmission grid) and more NEMOs (as rivals). When a nation has many NEMOs, it creates rivalry between the power exchanges, which encourages them to develop more flexible products and improve the efficiency of their algorithms. Nord Pool and EPEX are thoroughly examined as examples of successful electricity markets in Europe.

Two, Nord Pool

Although Nord Pool is a NEMO in 13 European nations, it dominates the combined Nordic/Baltic power market, which is in the Nordic and Baltic countries [4]. Due to network congestion, the market is split into 15 separate bidding zones, each of which can have a different electricity price.

A Day in Advance Market Provides Four Unique Products

- A single hourly order in which the participant in the market defines the volume of purchases or sales for each hour.
- Block orders, which include a defined volume and price for at least three (for the Nordic and Baltic regions) or two (for the GB region) hours in a row.

A cluster of sale and/or buy blocks called a "Exclusive Group" (Euphemia optimised) can only have one block activated.

- Flexible order, where a market participant can specify the amount of energy he is willing to sell or buy at a predetermined order price limit.

Four distinct product types are also available on an intraday market: 15-min, 30-min, hourly, and block products.

Through the appropriate distribution of balancing services, each TSO in the Baltic/Nordic region manages the balancing of its region. Even though a single Nordic Balancing Power Market is now being developed [5], auctions are still run independently in each nation.

Three, EPEX SPOT

In seven of the EU's member states-Germany, Austria, France, Switzerland, the United Kingdom, Belgium, and the Netherlands-EPEX SPOT is the most pertinent NEMO [6].

Individual hours, block orders, and intelligent blocks are available on a day-ahead market. Smart blocks can be exclusive block orders (a set of block orders in which only one block order can be executed) or linked block orders (a set of block orders with a linked execution constraint).

Except for the UK, all other nations have single hour or block orders for the intraday market goods. Half-hour orders are continuously available on the UK intraday.

Germany has introduced a day-ahead 15-min auction following the hourly auction in addition to the hourly day-ahead and intraday, while half-hour auctions are conducted in the UK.

Balancing markets are typically set up independently by each TSO. The first country to implement a combined tender for operating reserves was Germany. The primary control reserve market is open to all German TSOs as well as Belgian, Dutch, French, and Austrian TSOs. Additionally, for secondary and tertiary reserve, all German TSOs follow the same tendering process [7].

Four. North America

Both conventional wholesale electricity markets and regional electricity markets are used to structure the power markets in North America (the USA and Canada) [8]. Traditional markets have vertically integrated utilities that supply customers based on final prices that are controlled. Trading is accomplished through bilateral transactions. Regional transmission operators (RTOs), whose duties include managing the power grid and the power market, coordinate regional electricity markets. Regional electricity markets may allow for bilateral trades, although these are also controlled by computer algorithms. Currently, there are two RTOs in Canada, AESO and IESO, and seven RTOs in the USA, including CAISO, MISO, SPP, ERCOT, PJM, and ISONE (about 2/3 of the USA's demand is met by RTOs). Energy and balancing services are frequently purchased using the same algorithm that co-optimizes the procurement of energy and balancing services since USA RTOs are the organizations responsible for market organization and transmission system operations. Due to its extensive system needs, this type of purchase boosts overall social welfare and makes better use of system resources. Because balancing services require flexible resources, the previously described cooptimization increases the value to DERs. The CAISO power market is described in depth as an example of a USA RTO.

Fifth, CAISO

The California Independent System Operator oversees the management of the power grid and the organization of the power market in California and a portion of Nevada [9]. Different laws and requirements are used in the CAISO electricity market depending on the participants. The technical and economic statistics that multi-stage conventional generators submit include starting and generation costs, ramp rates, maximum/minimal generation, and minimum up/down time [10]. A piecewise linear curve with up to 10/5 distinct configurations is how day-ahead/real-time bids are presented. A generator may bid as a limited conventional generator if its minimum production is quite close to its maximum production [11]. Through the Participating Intermittent Resource Program, intermittent resources can take part in the electricity market and submit their forecast in real-time without incurring additional imbalance penalties if they provide a different amount of energy than anticipated [12].

Demand can also participate as a participating load or a demand response in a day-ahead, real-time, and balancing market.

Customers who use demand service providers to bid on their demand response services can benefit more in both day-ahead and real-time markets. In the real-time and balancing markets, participating loads can offer non-spinning reserve and demand reduction [13].

Both a pump-storage resource and a nongenerator resource are available to provide storage units with flexibility. Depending on the needs of the system, non-generator resources can function as a load or a generator and can be dispatched across their whole capacity range. When pumping water to reservoirs at higher altitudes, a pump-storage serves as both a load and a generator [13]. Data for pump storage participation is comparable to that for multi-stage conventional generators. Electricity and balancing services, including regulation up/down, spinning reserve, and non-spinning reserve, are co-optimized in both day-ahead and real-time markets. Spinning and non-spinning reserves are referred to as tertiary reserve, whereas regulation is automatic secondary reserve.

Six, Australia

Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia, and Tasmania are the six states that make up the National Electricity Market, which is run by the Australian Energy Market Operator (AEMO) [14]. The domestic power market is set up as a pool market. With the exception of WEM [15], the remainder of the nation is supplied by vertically integrated businesses or through trade agreements. Both the market operator and the power system operator are AEMO. As a result, it balances markets and organizes the electrical industry. Generators are required to submit three different sorts of bids: daily bids, default bids, and re-bids, while AEMO determines the electricity demand. Re-bids are a real-time market, whereas daily bids can be thought of as a day-ahead market. In order to guarantee supply security, default bids, which reflect generators' marginal costs, are only activated when daily bids are not made.

The major difference between the markets in the EU and the USA is that all bids are re-submitted in 5-minute intervals, and the spot price is determined by averaging six dispatch prices over the prior intervals across a half-hour. Frequency Control Ancillary Services (FCAS), also referred to as balancing services, are arranged into eight distinct services that are organized separately from the electricity market: regulation FCAS raise/lower, contingency FCAS fast raise/lower (6 seconds), slow raise/lower (60 seconds), and delayed raise/lower (5 minutes) [16].

The capacity of generators and loads that have already been assigned for energy production or consumption is what defines offers and bids for FCAS services. After reviewing all submitted bids, if system FCAS standards are still not satisfied, AEMO may alter accepted offers on the electrical market in order to meet FCAS requirements. As a result, this procedure can be thought of as a form of partial co-optimization between balance and electricity (FCAS).

Comparison

Electricity market bids are defined quite differently in the EU and the US. The European Commission encourages equity among all participants in the electrical market, including traditional generators, RESs, DERs, etc., through the proposal of a new electricity package [1]. NEMO's design complies with the Commission's new proposal because the same items are accessible to various technologies. NEMO's products are therefore generally designed to work with all technologies and are not technology-specific. Demand bids are distinguished from supply bids by the presence of a negative sign. Despite the requirement to balance a discrepancy between the amount of energy actually generated and the amount predicted, RES employ the same products as conventional generators.

The RTO design provides various programs and access for varying technologies. Demand response bidders submit a range of prices, whereas traditional generators submit variable cost bids. Which they are able to alter their consumption. The RESs don't lieu of submitting traditional bids, they submit their real-time market forecasting where the idea is to reduce their energy for unbalance. The American design does foster technological disparity, on the other Contrarily, by creating more niche products, it creates a Market innovators have easier access to the market. The day-ahead market is similar in that bids are made (although they are viewed differently) and the market clearing price is established for one day in advance (day-ahead market specifications are shown in Table 1).

The strategies used by the real-time and intraday markets differ. Table 2 displays a few parameters.

Table 1: Market parameters comparison-day-ahead market

Electricity market	Gate Closure	Trading span	Bid size	Smallest bid span	Floor price	Price Cap
Nord Pool	12:00 D-1	24 h D	0,1 MW	1 hour	-500 EUR/MWh	3000 EUR/MWh
EPEX – Germany/Austria	12:00 D-1	24 h D	0,1 WW	1 hour	-500 EUR/MWh	3000 EUR/MWh
EPEX 30 min UK	15:30 D-1	48 half hour D	0,1 MW	30 min	-500 EUR/MWh	3000 EUR/MWh
EPEX 15 min Germany	15:00 D-1	96 quarter hour D	0,1 MW	15 min	-3000 EUR/MWh	3000 EUR/MWh
CAISO	10:00 D-1	24 h D	-	1 hour	/	$1000 /MWh
AEMO	12:30 D-1	24 h D	-	5 min	-$1000 /MWh	$12,500 /MWh

EPEX and NordPool, two explored EU intraday markets, employ a continuous trading platform where supply and demand bids are combined and the price is set on a pay-as-bid basis. Different rules are used in the OMIE intraday market, and more details are available in [17]. Alternatively, the real-time market in the USA (and re-bids in Australia) serves as a correction of the day-ahead unit commitment decisions, with just a redispatch of online participants being made in order to match the actual power system conditions. Intermittent sources may gain more advantages if day-ahead and intraday markets in the EU were more closely connected.

Better source utilization results from balancing markets and co-optimizing the production of electricity. A single organization in command of both markets is a must for such algorithms, though. TSOs and NEMOs should collaborate closely in order to implement such algorithms throughout the EU. The first step might be to incorporate the Australian design, which modifies energy dispatch when inadequate reserve is allocated in the market for market balancing. The introduction of shorter-term products into the market to enable better inter-hour balancing for intermittent RESs and DERs is one of the justifications for the German and UK second day-ahead auction. The Australian case demonstrates that 5-min based day ahead bids and re-bids have no detrimental effects on market functionality.

For flexible DERs, scarcity pricing is a crucial aspect. When there is a need for a lot of flexibility, the pricing should reflect actual conditions without being bound by a market cap or a floor price. As seen in Table 2, the price cap and floor price are present in all day-ahead markets. In [1], the European Commission makes a removal recommendation.

Table 2: Market parameters comparison-intraday market

Electricity market	Gate Closure	Opening	Smallest bid span
Nord Pool – Nordic/Baltic	1 hour before delivery	After day ahead prices are set	15 min
EPEX – Germany	30 min before delivery	After day ahead prices are set	15 min
CAISO	75 min prior H-1	After day ahead prices are set	5 min
OMIE	5 min prior dispatch	After day ahead prices are set	5 min

Conclusion

The most dynamic component of today's power networks, the European electricity markets are always evolving and keeping up with cutting-edge commercial ideas and technologies.

The purpose of electricity markets around the world is the same—to enable electricity dispatch at fair pricing for both producers and consumers-but how they do this is frequently different. In order to determine the best energy market design for European markets in the new RESs & DERs-oriented environment, expertise and tried-and-true principles should be taken into account. In general, market characteristics such as 5-min bids, electricity and balancing services co-optimization, intraday market as redispatch of a day-ahead unit commitment, higher degree of deregulation, better adaptation of the bids to the various market participants, etc., should be thoroughly analyzed in future works.

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