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i-manager's Journal on Information Technology provides a forum to the academics, professionals and advanced level students in IT for exchanging significant information, productive ideas associated with information technology and future prospects in the areas of contemporary information and communications technology. Technology changes so rapidly and the Journal aims to publish high quality papers from academia and practitioners in all areas pertaining to Information Technology and disseminate Knowledge on the same.

i-manager's Journal on Information Technology is presently in its 12th Year. The first issue was launched in 2012.

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Researchers and practitioners are invited to submit an abstract (200 words)/Full paper on or before the stipulated deadline, along with a one page proposal, including Title of the paper, author name, job title, organization/institution and biographical note.

Authors of accepted proposals will be notified about the status of their proposals before the stipulated deadline. All submitted articles in full text are expected to be submitted before the stipulated deadline, along with an acknowledgment stating that it is an original contribution.

Review Procedure

All submissions will undergo an abstract review and a double blind review on the full papers. The abstracts would be reviewed initially and the acceptance and rejection of the abstracts would be notified to the corresponding authors. Once the authors submit the full papers in accordance to the suggestions in the abstract review report, the papers would be forwarded for final review. The final selection of the papers would be based on the report of the review panel members.

Format for Citing Papers

Author surname, initials (s.) (2023). Title of paper. i-manager's Journal on Information Technology, 12(2), xx-xx.

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EDITORIAL

The current issue of i-manager's Journal on Information Technology (JIT), (April - June 2023: Volume – 12 Issue - 2) has five peer reviewed research papers that presents various subjects associated with Information Technology.

Anthonia Eghieso Omehia et al. examines the transformative role of ResearchGate in improving collaboration among Library and Information Science (LIS) researchers. By exploring the myriad features and possibilities, this study uncovers how it has redefined the way professionals in LIS engage with one another, share their findings, and contribute to the advancement of their field. The emergence of digital platforms has revolutionized the landscape of academic collaboration, and ResearchGate stands as a beacon of opportunity for researchers in the field of LIS.

Harry Kachule et al. present an IoT-based system, to detect gas leakage and monitor safety whenever gas equipment is being used at home. It will use the Brute Force algorithm and the BCrypt algorithm as well, which is a password hashing function. In Malawi, due to the current shortage of energy and power, people have turned to other sources of energy and power, frequently using gas for cooking and other activities. Therefore, there is a high and increasing number of gas leakage threats, which are becoming a significant concern for daily lives in Malawi.

Francis Makwinja et al. address the pressing challenges faced by ESCOM (Electricity Supply Corporation of Malawi) in effectively managing and optimizing electricity distribution within their infrastructure. This paper introduces an IoT-based industrial management system designed to tackle these challenges and enhance ESCOM's operational efficiency, energy management and overall performance.

Bethapudi et al. presents a review on Blockchain-based Supply Chain Management (SCM) and provides transparency and agreement-outsourced contract manufacturing and enhancing an organization's position as the main leader in responsible manufacturing. In this study, block chain and its effects on SCM are discussed, along with security issues and solutions.

Kondapalli Beulah et al aim to detect gas leakage using a CNN-based approach. Industrial gas-detection sensors and their placement are discussed. Sensor selection and placement are crucial to obtain accurate results. The smart monitoring system of the sensor data and monitoring mechanism are discussed in this study. CNN is promising and more accurate for gas leakage detection than the existing models for gas leakage detection.

We extend our profound thanks to the authors for their contribution towards this issue and we are grateful to the reviewers for spending their quality time in reviewing these papers. Our special thanks to the Editor-in-Chief Dr. Mohammed A. Abdala for his constant support and efforts in further enhancing the quality of the Journal.

Hope this issue imparts an enlightening reading experience! Enjoy Reading!

Warm regards,

Renisha Winston
Editorial Director
i-manager Publications

ARTICLE

LEVERAGING RESEARCHGATE FOR INCREASED COLLABORATION AMONG LIS RESEARCHERS

By

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ABSTRACT

This study examines the transformative role of ResearchGate in improving collaboration among Library and Information Science (LIS) researchers. By exploring the myriad features and possibilities, this study uncovers how it has redefined the way professionals in LIS engage with one another, share their findings, and contribute to the advancement of their field. The emergence of digital platforms has revolutionized the landscape of academic collaboration, and ResearchGate stands as a beacon of opportunity for researchers in the field of LIS. This research examined how the utilization of ResearchGate fosters increased collaboration among LIS researchers. This study employed existing ideas through a literature review. The benefits of leveraging ResearchGate in LIS collaboration are undeniable. This study contributes to the usability of ResearchGate for collaboration among LIS researchers. As LIS researchers collectively forge a path toward a future where collaboration is at the forefront of advancement, ResearchGate has emerged as a pivotal instrument to empower them.

Keywords: Collaboration, ResearchGate, Library and Information Science (LIS), LIS Researchers, Research.

INTRODUCTION

In the dynamic landscape of academic research, the pursuit of knowledge is often magnified by collaborative efforts and sharing of ideas across disciplines. In this digital age, where connectivity has no bounds, researchers in the field of Library and Information Science (LIS) are presented with unprecedented opportunities to connect, communicate, and collaborate. ResearchGate is an online platform that has evolved swiftly into a hub for scholars, scientists, and researchers to converge, exchange insights, and foster interdisciplinary cooperation. In this article, the transformative role of ResearchGate is delved into amplifying collaboration among LIS researchers. By exploring the myriad features and possibilities, this paper uncovers how it has redefined the way professionals in LIS engage with one another, share their findings, and contribute to the advancement of their field. From networking to resource sharing, data dissemination to collaborative projects, this study navigates the realms of ResearchGate and its profound implications for propelling collaborative endeavors among LIS researchers to unprecedented heights.

This paper has objectives related to SDGs

Member of:

1. Literature Review

Kim and Oh (2021) examined whether social and individual motivation factors influence researchers' article-sharing intentions through their use of institutional repository or ResearchGate and how these factors differ between the two types of platforms. A theoretical framework was employed to integrate the theory of planned behavior, community considerations, and reciprocity to examine the social and individual motivation factors affecting researchers' article-sharing intentions through the use of institutional repositories or ResearchGate.

Ahmad et al. (2020) conducted a literature review based on indicators such as the research productivity of each county, annual publications, annual citations, highly cited articles, highly cited LIS journals, most productive institutions in the field of LIS, and the most prolific authors. Documents included in this study were research articles, conference proceedings, book reviews, and editorials. The findings revealed that the USA had the highest overall output of LIS scholarly publications.

Raffaghelli and Manca (2023) investigated the connections between ORDs' publication and social activity to uncover data literacy gaps and whether ORDs publications lead to social activity around ORDs and their linked published articles to uncover data literacy needs. Social activity was characterized by reads and citations based on a non-invasive approach supporting this preliminary study. The eventual associations between social activity and the researchers' profile (scientific domain, gender, region, professional position, and reputation) and the quality of the ORD published were investigated.

Jeng et al. (2017) explored the popularity of Academic Social Networking Sites (ASNSs) among scholars and evaluations of the effectiveness of these ASNSs. However, it is unclear whether the current ASNSs have fulfilled their design goals as the actual online interactions of scholars on these platforms remain unexplored. To fill this gap, a study was conducted using data collected from ResearchGate. Adopting a mixed-method design by conducting qualitative content analysis and statistical analysis of 1,128 posts collected from ResearchGate Q&A, we examined how scholars exchange information and resources and how their practices vary across three distinct disciplines: LIS, history of art, and astrophysics.

Panda and Kaur (2023) examined the ResearchGate platform, an Academic Social Networking Site (ASNS) meant for scientists and scholars to share, communicate, collaborate, connect, and get updated with feeds and scholarly information. This study focused on the top 15 cited Indian researchers and their research performance on ResearchGate. The research data were collected manually and analyzed using several altmetric parameters available on ResearchGate to evaluate the performance of the targeted researchers. For statistical correlation analysis, the researcher was conducted using JASP statistical analysis software (v. 0.16.0.0). The findings revealed that Sujit K Bhattacharya has the maximum citations (17210) among Indian researchers on ResearchGate.

2. The Role of ResearchGate in Academic Collaboration

ResearchGate, which was established in 2008, has emerged as a prominent digital platform that has redefined the landscape of academic collaboration. It was initially conceived as a social networking site for researchers and has evolved into a multifaceted hub that promotes interdisciplinary interaction, idea exchange, and scholarly collaboration (Teixeira da Silva and Dobránszki, 2015). The platform's growth has been fueled by its commitment to facilitating connections among researchers from various disciplines, transcending geographical boundaries and institutional affiliations. With over 20 million registered users and an extensive repository of research outputs, ResearchGate has become a pivotal tool in the arsenal of researchers seeking to expand their collaborative horizon.

Further, ResearchGate's fundamental function is to connect researchers, allowing them to establish professional profiles, follow peers, and endorse their work. This feature enables scholars to build virtual networks and foster connections beyond their immediate academic circles. Such networking transcends the limitations of conventional academic conferences and seminars, facilitating ongoing conversations, idea-sharing, and mutual learning (Thelwall & Kousha, 2015). ResearchGate also provides researchers with the capability to upload and share their publications, thereby enhancing visibility and accessibility. ResearchGate's repository spans a wide array of academic disciplines, allowing researchers in the

LIS to access an extensive body of work relevant to their field.

Through ResearchGate, researchers can create groups that focus on specific topics, allowing for targeted discussions and collaborative ventures. These groups serve as virtual think tanks, where researchers can collectively brainstorm, solve problems, and initiate interdisciplinary studies (Hammarfelt et al., 2016). Furthermore, ResearchGate's interactive features, such as commenting and Q&A sections on research outputs, provide avenues for real-time feedback. Researchers can engage in discussions, clarify doubts, and refine their research based on their peers' insights (Mavragani & Gómez, 2019). Teixeira da Silva and Dobránszki (2015) supports that ResearchGate offers metrics that measure the impact of researchers' work, including the number of reads, downloads, and citations. These metrics can help researchers gauge the reach and significance of their contributions, thereby encouraging their engagement with the scholarly community.

ResearchGate has revolutionized the landscape of academic collaboration by providing a digital ecosystem that facilitates networking, publication sharing, collaboration initiation, real-time interaction, and impact assessment. LIS researchers have much to gain from leveraging this platform to expand their horizons, connect with like-minded peers, and catalyze collaborative efforts that transcend disciplinary boundaries.

3. Importance of Collaboration in LIS Research

Collaboration holds immense significance in the field of Library and Information Science (LIS) research as it contributes to the enrichment of knowledge, innovation, and the holistic development of the discipline. Collaborative endeavors in LIS research enable scholars to pool their expertise, share diverse perspectives, and collectively address complex challenges that span multiple dimensions of information management and dissemination. According to Case and Given (2016), collaborative research brings together experts from various subfields within LIS, such as information retrieval, knowledge organization, and user experience design, to tackle multifaceted challenges collectively.

Collaborative projects between LIS researchers and experts from diverse fields are believed to facilitate innovative approaches and novel insights, leading to the development of holistic solutions (Borgman, 2017). Collaborators in LIS research often possess unique expertise ranging from data analysis to archival management. It also argues that combining these skills enables researchers to tap into a broader array of methodologies and analytical tools, leading to more robust and comprehensive outcomes.

Another important aspect of collaboration is that it fosters rigorous peer review and constructive critiques among researchers. Views that engage in collaborative projects avail LIS scholars of the opportunities and avenues to be exposed to different perspectives and methodologies, leading to thorough evaluations and improvements in research design and execution. While collaborative research encourages the exchange of innovative ideas and best practices, Vonortas and Zirulia (2015) opined that LIS researchers can adapt techniques and strategies from other domains, fostering innovation and developing cutting-edge solutions. Griffin and Hayler (2018) indicated that collaboration allows researchers to share resources, both tangible (data, equipment) and intangible (expertise, methodologies), that accelerate research progress by reducing redundancy, optimizing resource utilization, and promoting efficient data management practices.

LIS research often revolves around global challenges such as digital divide, information literacy, and the preservation of cultural heritage. Collaborative research transcends geographical boundaries, enabling researchers to address these challenges collectively and develop contextually relevant solutions. (Bruce et al., 2014).

4. Leveraging ResearchGate for Enhanced Collaboration

ResearchGate, as a digital platform for academic networking and collaboration, offers substantial potential for enhancing collaboration within the field of LIS. Its features enable researchers to overcome geographic constraints, engage in interdisciplinary exchanges, and foster collective knowledge creation. According to Hammarfelt et al. (2016), ResearchGate provides a space for LIS researchers to connect with peers from various disciplines and allows for the establishment of virtual networks, transcending geographic boundaries and facilitating interactions that spark interdisciplinary discussions and collaborative ventures. ResearchGate's collaboration tools enable LIS researchers from different institutions to collaborate in joint projects. This virtual environment supports team coordination, document sharing, and discussion, fostering collaborative research despite the physical distance.

Significantly, the platform's publication-sharing feature enables LIS researchers to disseminate their research widely. As observed by Thelwall & Kousha (2017), sharing research findings through ResearchGate allows peers to access and build upon each other's work, especially for the purpose of accelerating knowledge dissemination and innovation. Bar-Ilan et al. (2016) adds that ResearchGate's interactive features, including commenting and discussion threads on publications, provide opportunities for real-time idea exchange and constructive feedback. LIS researchers can engage in scholarly discussions to refine their research concepts and methodologies.

In the business of leveraging ResearchGate, LIS researchers can find like-minded peers to collaborate in specific research initiatives. These features facilitate the initiation of collaborative projects, allowing researchers to pool their expertise toward common goals (Thelwall & Kousha, 2015). While validating that collaboration in ResearchGate transcends geographic and institutional boundaries, Borgman (2017) proposed that LIS researchers build a global community. This community can provide diverse perspectives, share best practices, and collaboratively address global challenges. For LIS researchers, this presents an opportunity to access multidisciplinary resources and insights that can enrich their work and inspire interdisciplinary collaboration (Mavragani & Gómez, 2019). Overall, ResearchGate serves as a catalyst for enhanced collaboration in the LIS field, and its features enable researchers to connect, share, and collaborate beyond traditional academic boundaries, thereby enriching the quality and scope of LIS research.

5. Role of ResearchGate in Shaping the Future of LIS Research

ResearchGate plays a significant role in shaping the future of Library and Information Science (LIS) research by providing a digital platform that fosters collaboration, knowledge exchange, and interdisciplinary interactions. Its features and capabilities enable researchers to navigate emerging trends, contribute to the evolution of the field, and address complex information-related challenges.

ResearchGate connects researchers from diverse disciplines, fostering interdisciplinary collaboration that transcends traditional boundaries. This interdisciplinary engagement enables LIS researchers to explore emerging areas where information intersects with other fields such as data science, digital humanities, and health informatics. Given the foregoing, ResearchGate paves the way for innovative approaches and transformative insights (Borgman, 2017)

ResearchGate plays a role in facilitating the sharing of preprints, open-access publications, and research data. By embracing open science principles, LIS researchers can collaboratively develop and share tools, methodologies, and best practices, thereby leading to a more transparent and impactful research ecosystem. Furthermore, LIS researchers often grapple with emerging challenges in the digital age such as information overload, digital preservation and information privacy. ResearchGate's collaborative features enable researchers to collectively address these challenges, contributing to the development of effective strategies and solutions to navigate evolving information landscapes. (Bruce et al., 2014).

Overall, ResearchGate's role in shaping the future of LIS research is evident in its capacity to foster interdisciplinary collaboration, accelerate knowledge sharing, and support open science initiatives. This platform empowers LIS researchers to connect, collaborate, and contribute to the evolving landscape of information management, positioning them at the forefront of shaping the field's future.

6. The Features and Benefits of ResearchGate

ResearchGate, as a prominent academic networking platform, offers a multitude of features and benefits that empower researchers across various disciplines, such as LIS, to collaborate, share knowledge, and enhance their academic endeavors. ResearchGate provides researchers with the ability to create comprehensive profiles that showcase their publications, expertise, affiliations, and research interests (Hammarfelt et al., 2016). These profiles serve as digital CVs that facilitate connections with peers and potential collaborators.

Researchers can upload and share their publications on ResearchGate, making their work more accessible to global audiences (Thelwall & Kousha, 2017). This feature aids dissemination, visibility, and engagement with fellow researchers. Furthermore, LIS networking tools enable researchers to connect with peers, follow their work, and build virtual academic communities. This fosters ongoing discussions, collaboration, and the exchange of ideas beyond traditional academic boundaries. (Acuna et al., 2012). Importantly, researchers can track the impact of their work through metrics such as reads, downloads, citations, and RG Score (Bar-Ilan et al., 2016). These insights provide an understanding of their research reach and influence on the academic community.

The benefits of ResearchGate to researchers cannot be overemphasized. ResearchGate increases the researcher's visibility, which leads to more citations and potential collaboration. Another benefit is that ResearchGate networking features enable researchers to connect with experts in their fields and related disciplines, as indicated by researchers. In addition, researchers can receive real-time feedback on their work through comments and discussions that enhance the quality of the research by incorporating diverse perspectives and addressing potential shortcomings.

Furthermore, ResearchGate's collaboration tools facilitate the formation of research teams, enabling researchers to work together, regardless of geographic location. Researchers can explore a wide range of publications on ResearchGate, allowing them to discover related works, trends, and potential collaborators. To assess the research impact of researchers, ResearchGate gauges use metrics to showcase the influence of their research and its contribution to the academic community (Thelwall & Kousha, 2017).

7. Challenges in LIS Research Collaboration

Collaboration in Library and Information Science (LIS) research presents both opportunities and challenges owing to the interdisciplinary nature of the field, the diversity of research methodologies, and the global scope of information-related issues. Collaborators from different disciplines within LIS may have distinct research methodologies, terminologies, and approaches that lead to communication barriers and misunderstandings, making it challenging to integrate diverse perspectives into a cohesive research project. In addition, researchers have access to vast amounts of information and data that can slow down decision making and potentially hinder research progress (Woolley et al., 2010).

Collaborators in LIS research work across different time zones and geographical locations with the potential to delay communication, schedule meetings, and coordinate research activities. (Connell & Young, 2007). Effective communication is crucial for successful collaboration. Miscommunication, language barriers, and differences in communication styles can impede understanding and lead to confusion among the collaborators. In addition, collaborative research demands time and effort from each participant, which can be constrained by individual commitments and teaching responsibilities. These constraints can slow the research process and extend project timelines. Therefore, collaborative LIS research faces various challenges arising from the interdisciplinary nature, diverse methodologies, and varying priorities of collaborators. Successfully navigating these challenges requires effective communication, negotiation, and establishment of clear expectations and guidelines for collaboration.

Conclusion

The emergence of digital platforms has revolutionized academic collaboration, and ResearchGate stands as an opportunity for researchers in the field of Library and Information Science (LIS). By harnessing ResearchGate's power, LIS researchers can transcend the limitations of distance and disciplinary boundaries, thereby opening doors to a new era of collaboration that was previously unimaginable. The benefits of leveraging ResearchGate for LIS collaboration are undeniable. This platform not only connects researchers on a global scale but also fosters interactions that lead to the exchange of ideas, formation of interdisciplinary partnerships, and coalescence of innovative projects. Through its publication-sharing features, collaborative tools, and real-time feedback mechanisms, ResearchGate serves as an essential catalyst to amplify the visibility and impact of LIS research.

ResearchGate provides LIS researchers with a unique opportunity to contribute to the dynamic evolution of their field. This empowers them to share their findings, engage in meaningful discussions, and participate in projects that address the complexities of information management in a rapidly changing environment. As LIS researchers collectively forge a path toward a future where collaboration is at the forefront of advancement, ResearchGate has emerged as a pivotal instrument that empowers them to shape the destiny of their discipline. It not only facilitates the exchange of knowledge, but also cultivates a vibrant community of scholars driven by a shared vision of enhancing the understanding, accessibility, and impact of information. Through ResearchGate, LIS researchers can embrace collaboration as a driving force, propelling their research to new heights and contributing to the dynamic progression of Library and Information Science globally.

Future Work

ResearchGate can further enhance its collaboration features by integrating more advanced project management tools. These tools could include task tracking, timelines, and milestones, making it easier for research teams to coordinate their efforts and manage collaborative research work effectively. Integrating Artificial Intelligence (AI) capabilities can help researchers discover relevant publications, collaborators, and trends more effectively. Advanced analytics can provide personalized insights into research impact and engagement, helping researchers tailor their strategies for greater visibility. Creating virtual spaces for collaborative activities, such as virtual labs or project-specific chat rooms, can provide researchers with a dedicated environment for ongoing discussions, brainstorming, and resource sharing related to specific projects. Improving the integration of preprints, including tools for version control and collaborative editing, could facilitate the faster dissemination of early stage research and encourage collaboration at earlier stages of projects.

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GAS LEAKAGE DETECTION SYSTEM USING IoT

By

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ABSTRACT

Gas leakages are a worldwide threat and adversely affect the lives of all living beings. These gas leakages can increase poor air quality across most parts of the world, which is one of the primary reasons for the declining health and increasing diseases among humans and animals. It is essential to start tracking these gas leakages before they cause problems. In Malawi, due to the current shortage of energy and power, people have turned to other sources of energy and power, frequently using gas for cooking and other activities. Therefore, there is a high and increasing number of gas leakage threats, which are becoming a significant concern for our daily lives in Malawi. Therefore, controlling gas leakage will be essential. With an IoT-based system, a system has been created that can detect gas leakage and monitor safety whenever gas equipment is being used at home. It will use the Brute Force algorithm and the BCrypt algorithm as well, which is a password hashing function.

Keywords: Gas Sensors, Gas detection, IoT Based System, Brute Force algorithm, BCrypt algorithm, Liquefied Petroleum Gas (LPG), Arduino Uno.

INTRODUCTION

The purpose of a gas detection system is to monitor and detect the presence of potentially hazardous gases in the environment. Gas detection systems are used in a variety of settings, including industrial facilities, laboratories, commercial buildings, and residential spaces. The primary goal of these systems is to ensure the safety of people, property, and the environment by providing early warning of gas leaks or the accumulation of toxic or flammable gases (Kumar et al., 2019). Gas detection systems typically consist of sensors, controllers, and alarms. The sensors are designed to detect specific gases or a range of gases depending on their configuration. Common gases that are monitored include Carbon Monoxide, Methane, Hydrogen Sulfide, Ammonia, and various combustible gases. The sensors continuously measure the concentration of these gases in the air. By promptly detecting gas leaks or the presence of hazardous gases, gas detection systems help prevent accidents, fires, explosions, or health risks associated with exposure to toxic gases. They enable a rapid response and evacuation, allowing for effective mitigation measures to be implemented, such as shutting off the gas supply, ventilating the area, or initiating emergency procedures.

Gas detection systems play a critical role in ensuring safety and protecting lives in various industries and environments where the presence of hazardous gases poses a risk (Anusha & Prasad, 2019). These systems are designed to detect, monitor, and alert individuals to the presence of potentially harmful gases in the air. They are widely used in industries such as oil and gas, chemical manufacturing, mining, wastewater treatment, and many others. Gas detection systems are essential tools for maintaining safety in industries where hazardous gases are present. They not only protect human lives but also contribute to environmental protection and regulatory compliance. As technology continues to advance, these systems become even more sophisticated, enabling more accurate and timely gas detection to keep workers and environments safe.

The primary purpose of a gas detection system is to provide early warning and enable a prompt response to gas leaks or the accumulation of toxic or flammable gases. By continuously monitoring air quality, these systems help prevent accidents, explosions, fires, and health hazards caused by exposure to dangerous gases (Falohun et al., 2016). These systems employ various sensors and detectors designed to detect specific gases or volatile compounds in the environment. They can be installed in a wide range of settings, including industrial facilities, laboratories, commercial buildings, and even residential homes, depending on the potential sources of gas hazards. In the event of a gas leak or the presence of hazardous gases surpassing safe levels, gas detection systems trigger alarms and notifications. These alerts can be audible, visual, or sent remotely to designated personnel or monitoring stations (Keshamoni & Hemanth, 2017). Additionally, some advanced systems can automatically initiate safety protocols, such as shutting down equipment or activating ventilation systems to mitigate the risk.

In summary a gas detection system is a critical setup used to detect hazardous gases and ensure safety in various industries and environments. It consists of gas sensors that detect specific gases, a control panel that processes sensor data and triggers alarms, and alarm devices to alert individuals. These systems can be integrated with other safety systems and allow for data logging and analysis. Regular calibration and maintenance are essential for their reliability. Gas detection systems play a vital role in protecting lives, preventing accidents, and maintaining a safe working environment.

1. Related Works

This examines the establishment of a fuel and gas line leak detector. With the assistance of this technology, the presence of gases, including Liquefied Petroleum Gas (LPG) and Methane, in our environment, industries, schools, and hospitals can be detected. If there is any type of fuel and gas line leak that poses a threat to society and the individuals residing in the environment, the MQ5 sensor will automatically detect it, and the designed GSM modem will send a warning signal (Septama et al., 2018; Shrivastava et al., 2013). This signal is delivered to the user whose number is registered within the system or to the monitoring device responsible for overseeing units or managing the infrastructure or organization. This device incorporates a component known as a buzzer, which activates an alarm in the event of fuel and gas line leaks into the environment. The device can be employed in various settings, including oil and gas pipelines, kitchens, and fuel line storage facilities (Apeh et al., 2014). The fuel line leak detection system sends a notification message to the registered mobile phone. The Arduino microcontroller operates as a result of collective research efforts. This fuel line alert system is managed and monitored through the ADAFRUIT web application. Upon receiving a notification, the buzzer activates. With the assistance of this software tool, users can customize the activation of fans and water pumps. This intelligent online device has been proposed for use in various hospitals. In the event of an unexpected fuel line leak, the fuel line sensor integrated into the design sends a signal to the Arduino.

The Arduino then sends a notification to different gadgets concerned within the layout, including hospitals. Alarms are dispatched until the necessary response is received. The system was designed and implemented for ceiling and wall mounting. If the gadget is simply positioned or wall installed and powered, the detection system will send a brief message (SMS) to advise the homeowner of the house in the event of a gas line leak. The system contained all the requirements of a modern gas detection system, such as Arduino, sensors, alarms, and Wi-Fi modules.

2. Methodology

Developing a gas leakage detection system necessitates a systematic methodology to guarantee its effectiveness and safety (Suma et al., 2019). This entails careful planning and design, rigorous testing procedures, and a thorough understanding of the potential risks associated with gas leaks. Moreover, the system should be equipped with reliable sensors and advanced data processing algorithms to promptly detect and respond to any gas leaks, minimizing the risk of accidents and ensuring the well-being of individuals and the environment. Additionally, regular maintenance and calibration are crucial to ensure the ongoing accuracy and reliability of the system over time, making it an essential component in industries where gas leaks pose a significant threat. Figure 1 shows the Iterative model.

Iterative methodology is a software development methodology that involves breaking the project down into smaller pieces, and each piece goes through a cycle of planning, design, development, testing, and feedback. The process is repeated until the final product is delivered. Iterative methodology differs from other methodologies in that it is more flexible and adaptive to changes during the software development process. It enables the project team to deliver a functioning product early in the development cycle, which provides a way to test and obtain feedback from the end-users to improve the product.

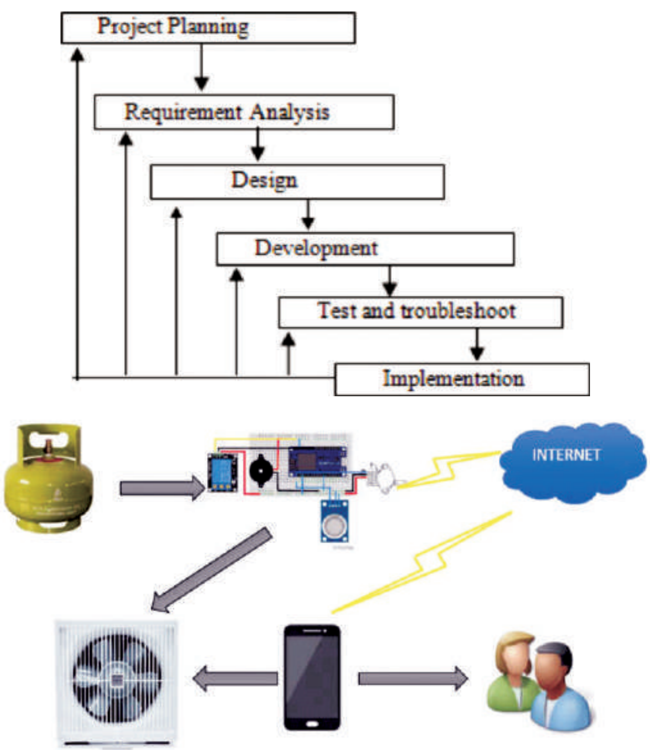

Figure 1. Iterative Model

Iterative = (Plan + Design + Develop + Test) * Feedback

- In project planning, the project team determines the scope of the project, defines the requirements, and sets the goals.
- Requirements analysis involves the process of gathering and defining the needs and constraints of a system or software project.
- In the design phase, the team creates a detailed design of the software, which encompasses architecture, user interface, and database schema as its second part.
- In the development process, the team writes the code for the software and seamlessly integrates it with other components.
- In the realm of test and troubleshooting, software undergoes rigorous examination to confirm its adherence to requirements and absence of defects.
- Implementation involves the transformation of a design or concept into a functional software system by writing the actual code and building the software according to the specifications and requirements identified in earlier stages of the software development life cycle.

3. Algorithm

The Brute Force algorithm is a straightforward method of solving a problem that relies on sheer computing power and tries every possibility, rather than advanced techniques, to improve efficiency. The BCrypt algorithm is designed to protect against brute-force attacks. One of the tools BCrypt uses to make brute force attacks more difficult is slowing down the brute force operation or program that a malicious actor may be using. This means that if a brute force attack is attempted, it will likely take years, if it is successful at all. Figure 2 shows the flow diagram.

Initially, the microcontroller sends a signal to the WIFI module, and if the WIFI module is properly connected to the microcontroller, it sends an acknowledgment signal back to the microcontroller. Then, if there is any gas leakage in the MO sphere, it is detected by the gas sensor unit using the MQ-6 sensor (Yang et al., 2011). After the

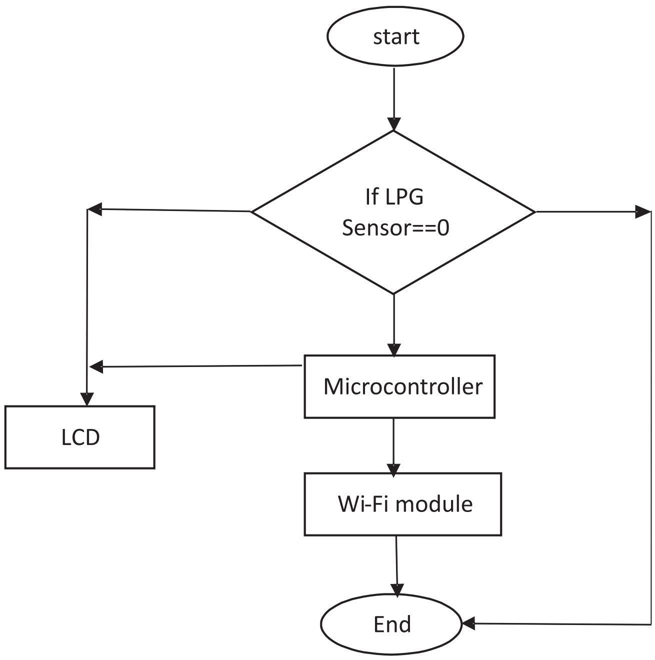

Figure 2. Flow Diagram

sensor unit detects the gas leakage, a signal is sent to the ADC unit of the microcontroller, which then sends an activation signal to other external devices connected to it, such as the buzzer, WIFI module, and LCD display. By following the sequential process, the gas leakage detection system ensures swift and comprehensive response in the event of a gas leak within the monitored area, enhancing safety and enabling remote monitoring and notifications through the WIFI module. Figure 3 shows the Block Diagram.

The LPG gas sensor module's DO pin is directly connected to pin 12 of the Arduino, and Vcc and GND are connected to the Vcc and GND of the Arduino. The LPG gas sensor module consists of an MQ3 sensor, which detects LPG gas (Rimbawati et al., 2019). A comparator circuit is used to convert the analog output of the MQ3

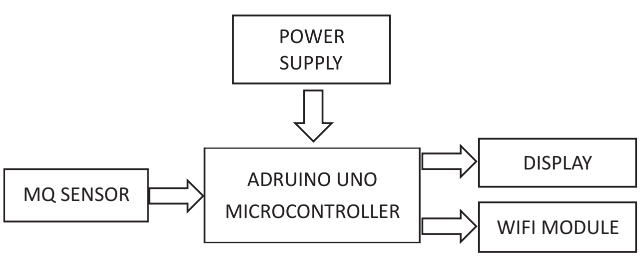

Figure 3. Block Diagram

sensor into a digital signal. A 16x2 LCD is connected to the Arduino in 4-bit mode. The control pins RS, RW, and E are directly connected to Arduino pins 2, GND, and 3, respectively. The data pins D0-D7 are connected to Arduino pins 4, 5, 6, and 7.

4. Survey

A survey was conducted to understand the various criteria such as functionality, usability, reliability, efficiency and relevance of the system.

4.1 Classification of Respondents for the Survey

The survey conducted has a total of 100 respondents, 68 of whom are households aged 20 to 50 years old, and 32 are employees aged 20 to 50 years old. Table 1 shows the distribution frequency for the survey. Figure 4 shows that 68% are households and 32% are employees, totaling 100%. Each criterion was ranked by the respondents.

5. Analysis and Interpretation of Data

After counting the number of ratings for each criterion, the proponents computed the average rating of each criterion using the weighted mean formula. The proponents' computation for each criterion can be seen in Table 2, which shows each of the criteria with their corresponding averages computed by the proponents and their respective verbal interpretations.

Respondents	Frequency
Household	68
Employee	32
Total	100

Table 1. Distribution frequency for Survey

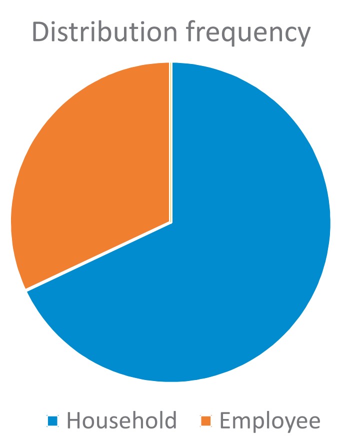

Figure 4. Pie Chart for the Distribution of the Survey

Criteria	Average	Verbal interpretation
Functionality	4.84	Excellent
Usability	4.82	Excellent
Reliability	4.48	Very Satisfactory
Efficiency	4.7	Excellent
Relevance	4.8	Excellent
Overall Result	4.73	Excellent

Table 2. Summary Result of Evaluation of the Proposed Project

Figure 5 shows the bar graph of all criterions. The excellent rating averages for functionality, usability, reliability, efficiency, and relevance are as follows: functionality, 4.84; usability, 4.82; reliability, 4.48; efficiency, 4.7; and relevance, 4.8.

6. System Overview

The home page shows the actual gas values, which are also displayed on the LCD connected to the Arduino. The home page is the page that indicates the presence of a gas leak and the safety of the environment. Figure 6 shows the User Homepage.

The history page displays a chronological record of gas values throughout the week. This information serves as a valuable point of reference both in the present and for future use. Figure 7 shows the History page.

The Map Page displays the actual location to which the system is connected and where it is in operation. This enables safety companies to promptly track gas leaks and take appropriate action in a timely manner. Figure 8 illustrates the Map page.

The settings page is the page that gives the user a wide range of choices to make regarding the system, and it comprises all the subtopics of the system. The user can

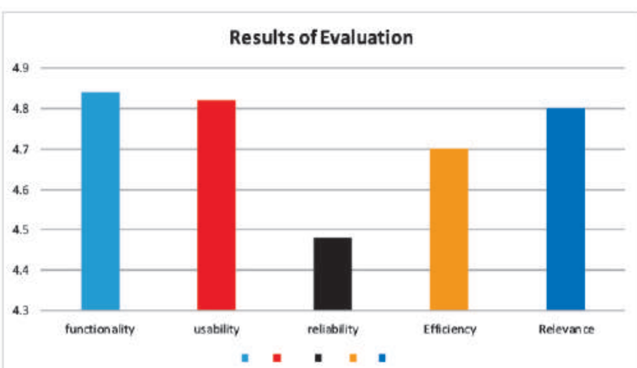

Figure 5. Graph for Evaluation of the System

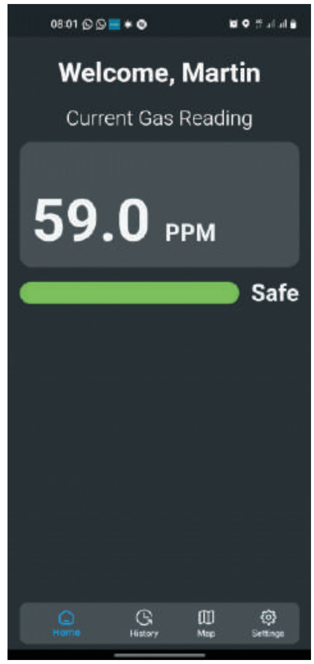

Figure 6. User Homepage

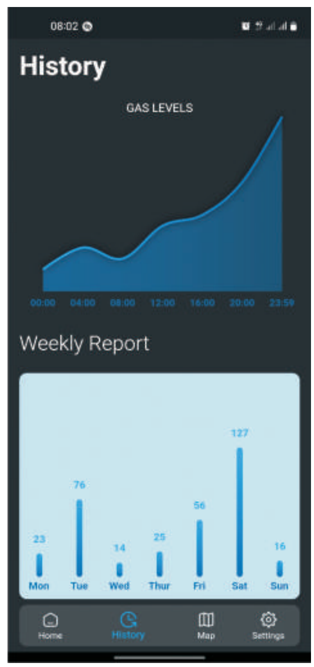

Figure 7. History Page

access other pages using the settings page, and they can also log out using this page. Figure 9 shows the Settings page.

7. Results and Discussion

This technique has been tested for gas leaks with the use of MQ2 gas sensors. MQ2 gas sensors are at the heart of

Figure 8. Map Page

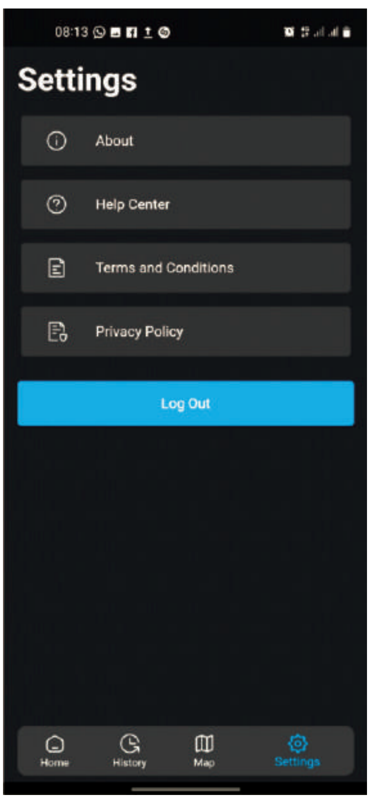

Figure 9. Settings Page

the system. These sensors are capable of detecting the presence of various gases in the environment. When they detect a gas leak, the sensor triggers a response. When a gas leakage is detected, the MQ2 gas sensor sends a signal to the Arduino UNO. The Arduino UNO serves as the central processing unit in this setup. It receives signals from the MQ2 gas sensors indicating a gas leak. Arduino is programmed to respond to these signals promptly. The Arduino UNO communicates with other externally connected devices, such as, LCD Display and WiFi Module. Gas level statistics are sent by the WIFI module to the provided mobile phone. This mobile phone acts as a remote monitoring and notification device. Users receive real-time updates about gas levels in their vicinity through a dedicated mobile app. In case of a gas leakage detection, the mobile phone app provides safety warnings to the users. This is crucial for ensuring the safety of individuals in the area. Users are alerted promptly so that they can take appropriate precautions or evacuate if necessary. In practice, the results are observed by people in the surrounding area. These results are displayed on the LCD, showing the gas levels. The mobile phone device also indicates whether there is a gas leakage, providing users with a safety warning and ensuring their safety.

This gas leak detection system provides a comprehensive and interconnected solution for monitoring and responding to gas leaks. It utilizes MQ2 gas sensors for detection, an Arduino UNO for processing and control, external devices for display and communication, and a mobile phone app for remote monitoring and safety alerts. This integrated approach enhances safety and provides users with valuable information to mitigate the risks associated with gas leaks.

Conclusion

In recent days, the Internet of Things (IoT) has acquired broad prominence and it has paved the way for human beings to live in a smooth, healthy, and simpler way. One particularly promising application of IoT technology is in the field of security, and the suggested gas leakage detector is a prime example of this. The goal of creating this IoT-based gas leakage detector has always been to introduce a safety revolution. Its primary aim is to reduce and ultimately eliminate any large or small risks that may arise from the leakage of toxic and hazardous gases. This is a critical concern not only in industrial settings but also in homes, public spaces, and commercial establishments. The IoT-based gas leakage detector operates by using a network of sensors and connected devices to monitor the air quality in real-time. These sensors are capable of detecting a wide range of gases, including but not limited to Carbon Monoxide (CO), Methane (CH4), and Hydrogen Sulfide (H2S). The data collected by these sensors is then transmitted to a central control unit or a cloud-based platform, where it is analyzed for any anomalies or dangerous gas levels.

Monitoring gas reservations and detecting gas leakages is crucial for both household and industrial safety. Identifying gas leaks has historically posed significant challenges, but innovative solutions are emerging to address this issue. This study presents a novel approach that relies on microcontrollers to enhance gas reservations and gas leak detection systems. Traditionally, gas reservations and leak detection have often relied on conventional methods, such as visual inspection or chemical sensors. However, these methods may have limitations in terms of accuracy, sensitivity, and real-time monitoring capabilities. The advent of microcontroller-based systems offers a promising alternative to improve the efficiency and reliability of gas monitoring and leak detection.

This advanced sensor enhances gas cylinder safety and convenience. It monitors and identifies gas levels, proactively notifying users for timely refills. It automates reordering when levels are low, ensuring a constant supply. Integration with alert systems ensures swift response to gas-related issues, enhancing safety further. This device offers affordability and efficiency, enhancing gas safety. It detects leaks, preventing accidents, and simplifies gas handling. Real-time data, automated refills, and leak detection promote responsible gas management for a safer and efficient system.

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IoT-BASED INDUSTRIAL ENERGY MANAGEMENT SYSTEM

By

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ABSTRACT

The ESCOM (Electricity Supply Corporation of Malawi) currently faces difficulties in monitoring and controlling critical parameters, such as electricity generation, transmission, and distribution in real-time. Inefficient energy management, lack of fault detection mechanisms, manual interventions, and limited data-driven decision-making capabilities are hindering ESCOM's ability to deliver reliable and efficient electricity services to the people of Malawi. The main objective of this work is to address the pressing challenges faced by ESCOM (Electricity Supply Corporation of Malawi) in effectively managing and optimizing electricity distribution within their infrastructure. This paper introduces an IoT-based industrial management system designed to tackle these challenges and enhance ESCOM's operational efficiency, energy management, and overall performance.

Keywords: IoT, Industrial Management, ESCOM, Energy Management, Real-time Monitoring, Data Analytics.

INTRODUCTION

Electricity is undeniably the lifeblood of modern society, fueling our social and economic development in profound ways. The relentless march of technological advancement has lured us into integrating electricity-driven elements into virtually every facet of our lives, whether it's the bustling commercial sector or the comfort of our homes (Han et al., 2014). These innovations have not only improved our quality of life but have also driven industries, powering progress and innovation across the globe. However, as we become increasingly dependent on electricity, new challenges have emerged. It has become imperative to explore and implement strategies for managing the supply-demand balance of electricity with greater efficiency, security, and reliability. Additionally, ensuring coordinated multi-way communication is crucial for the enhanced monitoring and control of the network and user assets. In this rapidly evolving landscape, electricity has transitioned from a mere commodity to a dynamic and interconnected system that requires constant vigilance and innovation (Huiyong et al., 2013).

In the context of Malawi's energy landscape, the nation currently relies on three primary sources for power generation: hydro, solar, and thermal (Diesel Plants) (De Matos et al., 2014). Among these, hydroelectric power stands out as the dominant contributor, accounting for over 90% of the national grid's electricity supply. The power generated from these diverse sources is funneled into the national grid, a complex network of high-voltage transmission lines. Within this grid, electricity is transmitted over vast distances at high voltages to reach various load centers (Sakr et al., 2018). These load centers play a pivotal role in the electricity distribution process, where the high voltages are meticulously stepped down to suitable levels for diverse customers. Depending on their requirements, electricity is distributed as either three-phase or single-phase, ensuring a tailored approach to meeting the demands of a diverse array of consumers.

Despite the technological marvels that underpin our electrical infrastructure, these generating plants, much like any other machinery, are susceptible to a range of faults. These faults can originate from both internal and external sources, including other power generation facilities and the system as a whole. The interconnected nature of Malawi's hydro generating stations, facilitated by interconnector lines at 66KV and 132KV, implies that a significant fault in one part of the system can reverberate through the entire network, impacting even the healthiest machines in the system.

Electricity has become the life force behind our modern way of life, fostering economic growth, technological progress, and improved living standards. Yet, as we continue to integrate electricity into every aspect of our existence, it becomes imperative to address the challenges of supply-demand balance, security, and reliability. In Malawi, where hydroelectric power reigns supreme, the interconnected nature of the grid underscores the need for vigilant monitoring and fault management to ensure a continuous and stable power supply for the nation.

1. Related Works

Wei et al. (2016) explain an IoT-based energy-management platform for industrial facilities. the purpose of this study is to present an IoT-based communication framework with a common information model to facilitate the development of a Demand Response (DR) energy management system for industrial customers. Additionally, we developed and implemented an IoT-based energy-management platform based on a common information model and open communication protocols, which takes advantage of integrated energy supply networks to deploy DR energy management in an industrial facility.

Bagdadee et al. (2020) present a brief review of the IoT-Based Energy Management System in the Smart Industry. Energy demand for IoT applications is growing. In this particular situation, energy management is an important issue because of high energy savings and efficient energy crisis reasons. In this paper, IoT energy management tends to achieve green energy response and communication from supply and demand. As a result, smart industrial planning must be able to use energy productively to overcome related difficulties.

Saleem et al. (2021) describes Design, Implementation, and Deployment of an IoT Based Smart Energy Management System. The application of SM spans over a wide range of advantages, including accurate billing data, information of utilization at the user end, the establishment of two-way communication and remote control of the user equipment. SM is the most essential element of a smart power grid that with the help of any smart energy management system (SEMS), assesses, measures, controls, implements and communicates power allocation, utilization, and consumption at both, single device, and network level. Data provided by the SMs is used by power supply companies to revolutionize power distribution and consumption through various techniques such as, non-intrusive load monitoring and demand-side management (DSM). For efficient data gathering and utilization, internet of things (IoT) is emerging as a key partner in the power industry leading to effective resource management.

2. Methodology

The work consists of two main sections: the Microcontroller region and the Mobile App. The Microcontroller region continuously sends data to the Mobile App, while the Mobile App controls a set of relays by sending commands. The system operates independently for each component attached to the relay. The core of the project is an Arduino Uno board, which receives power from the connected computer. To interface with the Arduino board, various components such as sensors, a signal conditioning unit, a rectifier, a driver circuit, and an LCD display are connected to their corresponding pins on the controller. These components collect data and interact with the Microcontroller region.

A Mobile application serves as the user interface to control the industrial components. The Mobile App displays the status of each system and allows the user to control them. To establish communication between the Microcontroller and the Mobile App, an ESP8266 module is used. This module acts as an interface between the microcontroller and the Mobile App developed on the computer. The Mobile App enables the user to switch appliances on and off, providing control over the connected components. The status of each power consumption terminal is displayed on the computer, allowing the user to monitor the energy usage. The Mobile App, coupled with the ESP8266 module, acts as a powerful tool in industrial automation. It empowers users with real-time information, remote control capabilities, and energy consumption monitoring, all contributing to a more efficient and sustainable industrial operation.

The integration of the Microcontroller region with the Mobile App and ESP8266 module is a key aspect of this proposed methodology, enhancing the overall functionality and usability of the industrial control system. The integrated approach not only improves the efficiency and control of industrial processes but also enhances the accessibility of monitoring and control through the user-friendly Mobile App. The ESP8266 module plays a pivotal role in ensuring the real-time exchange of data, making this methodology a robust and versatile solution for industrial automation and control systems. Overall, the proposed methodology involves integrating the Microcontroller region, consisting of the Arduino Uno board and connected components, with a Mobile App. The Mobile App provides a user-friendly interface for monitoring and controlling the industrial components, and the ESP8266 module facilitates communication between the Microcontroller and the Mobile App. Figure 1 shows the system architecture.

3. Algorithm

In an IoT-based industrial energy management system, efficient energy consumption and optimization are crucial for cost savings and environmental sustainability. To achieve these objectives, advanced data analysis techniques are employed. Three commonly utilized algorithms in this context are linear regression, decision tree, and random forest (Huang et al., 2009).

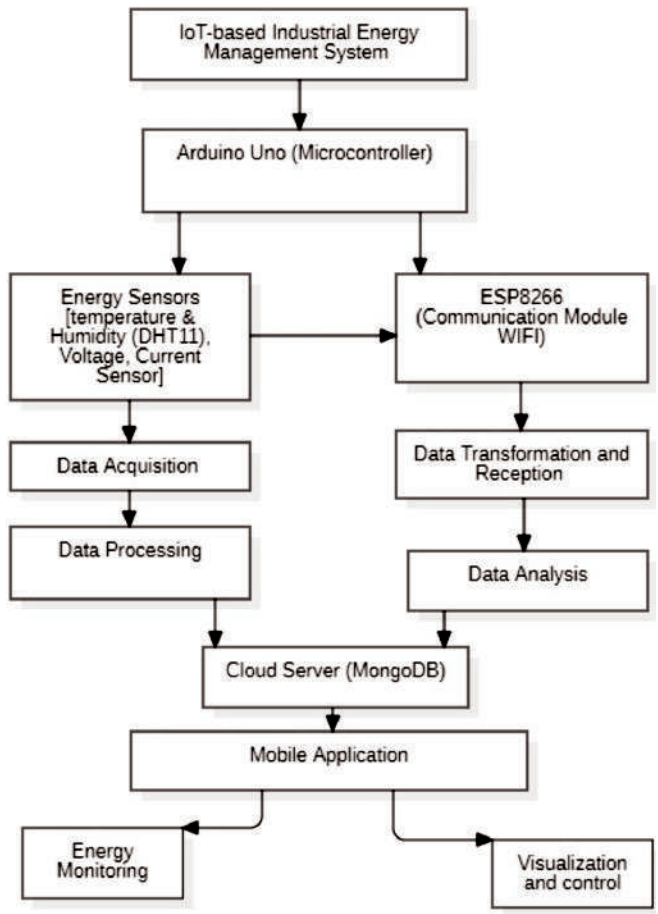

Figure 1. System Architecture

3.1 Linear Regression

Linear regression is a simple and widely used algorithm for predicting numeric values based on historical data (Qiu et al., 2006). In an industrial energy management system, linear regression can be used to predict energy consumption based on various input parameters such as temperature, humidity, occupancy, and time of day. The Arduino Uno can collect sensor data from different sources, and this data can be fed into a linear regression model. The trained model can then make predictions about future energy consumption based on real-time sensor inputs.

3.2 Decision Tree

A decision tree algorithm is a non-linear predictive model that uses a tree-like structure to make decisions based on a set of input features (Yu et al., 2009). In an energy management system, decision trees can be used to analyze the relationship between different factors and energy consumption patterns. The decision tree algorithm can be trained using historical data collected by the Arduino Uno, including sensor readings, energy consumption data, and other relevant parameters. The resulting decision tree can be used to classify or predict energy consumption based on real-time sensor inputs.

3.3 Random Forest

Random forest is an ensemble learning method that combines multiple decision trees to make more accurate predictions. In an industrial energy management system, a random forest algorithm can be used to improve the accuracy of energy consumption predictions. The Arduino Uno can collect sensor data, and multiple decision trees can be trained using this data. The predictions from each decision tree are then combined to produce a final prediction, which tends to be more robust and accurate compared to a single decision tree.

Incorporating these algorithms into an IoT-based industrial energy management system empowers organizations to make data-driven decisions, optimize energy consumption, and reduce operational costs. Moreover, these techniques contribute to environmental sustainability by minimizing energy wastage and reducing carbon emissions, aligning with global efforts to combat climate change. As technology continues to evolve, these algorithms, along with other advanced data analytics methods, will play an increasingly vital role in achieving energy efficiency in industrial processes. Figure 2 shows the comparison among several algorithms in terms of accuracy.

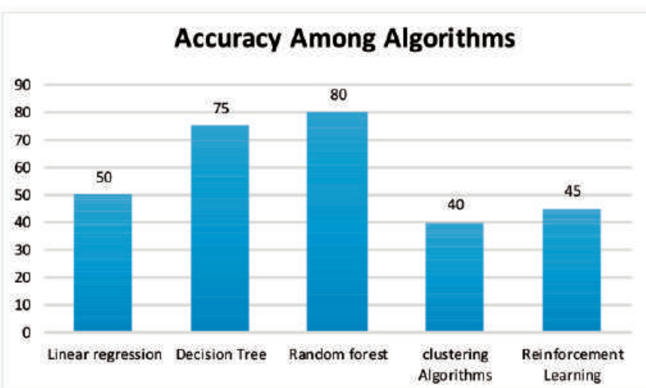

Figure 2. Chart of Comparison

4. Analysis and Interpretation of Data

After counting the number of ratings for each criterion, the proponents computed the average rating of each criterion using the weighted mean formula. Table 1 shows each of the criteria with their corresponding averages computed by the proponents and their respective verbal interpretations.

Figure 3 shows the bar graph of all criterions. The rating excellent averaged of functionality is 4.84 while the rating excellent averaged of Usability is 4.82 and the rating excellent averaged of Reliability is 4.8 and the rating Very Satisfactory averaged of Efficiency is 4.84. And the rating excellent averaged of relevance is 4.8.

5. System Implementation

5.1 Landing Page

The mobile application's landing page serves as a central hub for users to control and manage their devices (Gomes et al., 2015). It prominently displays the devices available, including the fan, AC motor, current transformer, and bulb, allowing users to easily identify and select the device they wish to control. With intuitive controls integrated into the landing page, users can remotely operate the devices, adjusting settings such as

Criteria	Average	Verbal Interpretation
Functionality	4.84	Excellent
Usability	4.82	Excellent
Reliability	4.8	Excellent
Efficiency	4.84	Excellent
Relevance	4.8	Excellent
Result	4.73	Excellent

Table 1. Summary Result of Evaluation of the Proposed Project

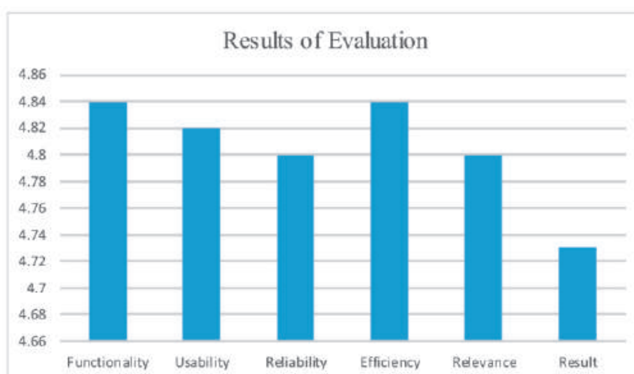

Figure 3. Results of Evaluation

on/off toggles, fan speeds, motor operations, current transformer readings, and bulb brightness. Figure 4 shows the system landing (automation) page.

5.2 Monitoring Page

The monitoring page displayed in the screenshot below provides users with real-time insights into device status and performance within an industry setting. Users can track and monitor various devices, observing details such as device names and statuses. Additionally, the page offers temperature and humidity monitoring capabilities, enabling users to assess and maintain optimal environmental conditions (Tsirmpas et al., 2015). By visualizing this information through tables, grids, or charts, the monitoring page facilitates effective device management and ensures that the industry operates within desired parameters. Figure 5 shows the system monitoring page.

5.3 Stats Page

The stats page provides the user with a comprehensive overview of electricity usage. It includes charts depicting daily, weekly, and monthly electricity consumption,

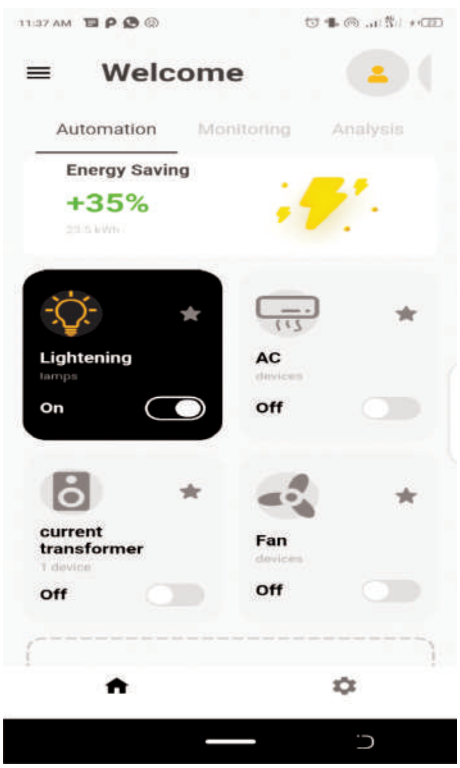

Figure 4. System Landing (Automation) Page

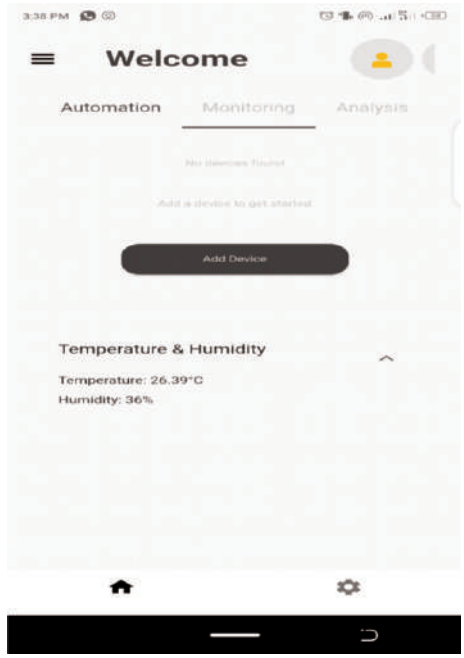

Figure 5. System Monitoring Page

allowing users to track their energy usage patterns over time. Additionally, the page displays information about energy consumption by individual devices, providing insights into the specific devices contributing to overall energy usage. This data can help users identify energy-intensive devices and make informed decisions regarding energy conservation (JeyaPadmini & Kashwan, 2015). The UI design of the stats page may vary depending on the specific system or application it belongs to, but it typically features visually appealing charts and clear representations of energy consumption data (Kumar, 2014). Figure 6 shows the mobile app stats page.

6. Results and Discussion

The proposed IoT-based industrial energy management system, utilizing Arduino Uno and a mobile app for monitoring and control, has been implemented and evaluated. Here, the key results are presented, and their implications for industrial energy management are discussed.

6.1 Continuous Data Monitoring

The microcontroller region successfully sends data continuously to the mobile app, allowing real-time

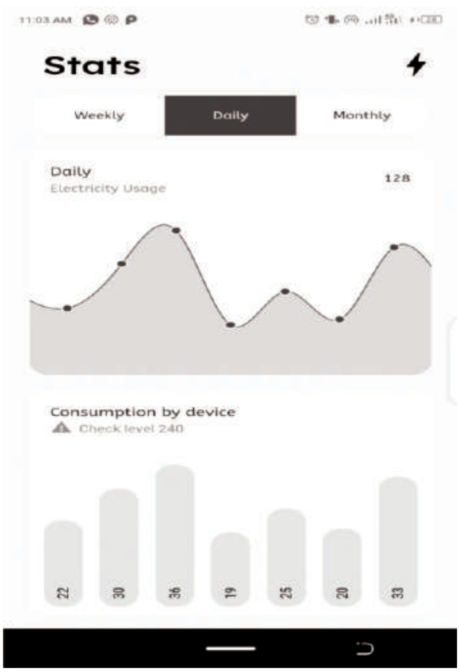

Figure 6. Mobile App Stats Page

monitoring of energy-related parameters. This enables stakeholders to track energy consumption, production levels, and other relevant metrics. The mobile app provides an intuitive user interface for accessing and visualizing this data.

6.2 Control of Industrial Components

The system effectively controls a set of relays through commands sent via the mobile app. Users can remotely switch on/off appliances and manage different energy-consuming systems. This enables efficient energy management by allowing selective activation/ deactivation of components as per requirements, leading to potential energy savings.

6.3 Integration of IOT and Mobile App

The integration of ESP8266 as an interface between the microcontroller and the mobile app enhances communication and enables seamless control and monitoring capabilities. This combination provides a convenient and accessible platform for users to interact with the industrial energy management system.

6.4 User Interface and Status Display

The mobile app serves as a user-friendly interface, displaying the status of each system and power consumption terminals. Users can easily access information about energy usage patterns, identify inefficiencies, and take appropriate actions for optimization.

6.5 Algorithmic Analysis

The application of linear regression, decision tree, and random forest algorithms to the energy data collected from industrial systems allows for further analysis and prediction of energy consumption patterns. These algorithms can provide insights into the relationships between input variables and energy consumption, enabling proactive energy management strategies.

The successful implementation of the IOT-based industrial energy management system opens up several opportunities for optimizing energy consumption and improving overall efficiency in industrial settings (Mohanty et al., 2014). By continuously monitoring and controlling energy-consuming systems, stakeholders can identify areas of improvement, implement energy-saving measures, and make informed decisions regarding resource allocation.

However, it is important to note that the accuracy and performance of the implemented algorithms (linear regression, decision tree, and random forest) in predicting energy consumption may vary depending on the specific dataset and system characteristics. Further evaluation and fine-tuning of these algorithms may be required to enhance their predictive capabilities. Figure 7 and 8 shows the ThingSpeak output for temperature.

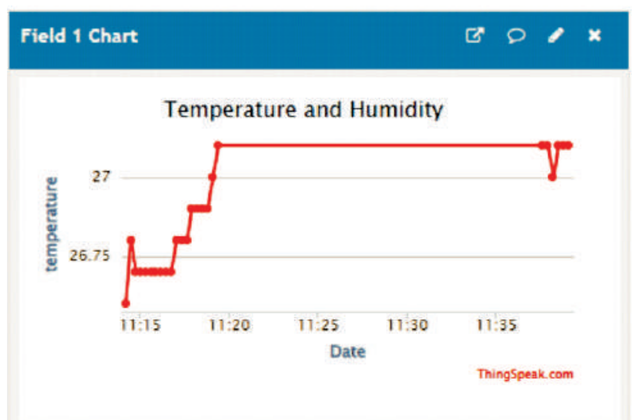

Figure 7. ThingSpeak Output for Temperature

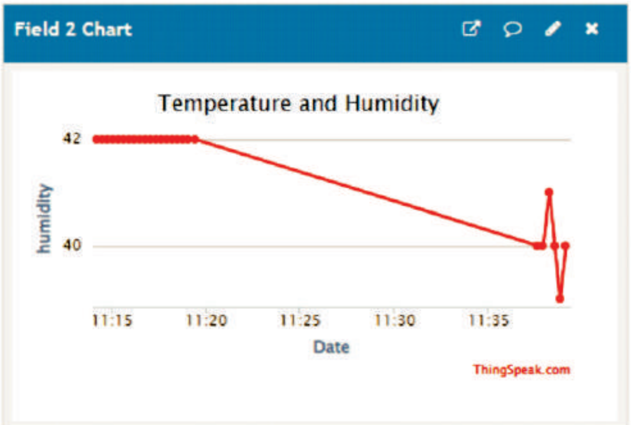

Figure 8. ThingSpeak Output for Temperature

Conclusion

The incorporation of machine learning algorithms can enhance the system's predictive capabilities, allowing ESCOM to forecast energy demands accurately. This predictive analytics feature can lead to even more substantial cost savings by optimizing energy distribution and avoiding peak demand charges. Additionally, the data collected by the IoT devices can be analyzed to identify long-term trends and patterns, aiding ESCOM in making informed decisions regarding energy infrastructure investments and sustainability initiatives. Furthermore, by leveraging machine learning, ESCOM can proactively detect and mitigate potential issues in the energy grid, improving overall reliability and reducing downtime. This not only enhances customer satisfaction but also contributes to a more stable and efficient energy supply for the entire region. Moreover, the insights gained from data analysis can inform the development of energy conservation programs, helping ESCOM promote responsible energy usage among consumers and reduce the environmental impact of energy generation. In the long run, these advancements can position ESCOM as a forward-thinking and environmentally-conscious utility provider.

Furthermore, ESCOM can leverage the insights gained from these energy usage reports to offer tailored recommendations to their clients, helping them identify specific areas for improvement and implement more efficient energy practices. By promoting such collaboration and information sharing, ESCOM not only enhances its client relationships but also actively participates in the collective effort to reduce the carbon footprint in the region. This commitment to sustainability aligns with global environmental goals and positions ESCOM as a leader in responsible energy provision.

The integration of Arduino Uno and a mobile app in an IoT-based industrial energy management system not only provides immediate benefits but also paves the way for a more sustainable and efficient future in the energy sector. ESCOM's investment in this technology is likely to yield long-term benefits, both in terms of cost savings and environmental impact, making it a prudent and forward-looking choice for the company.

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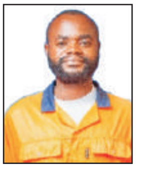

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BLOCKCHAIN-BASED SUPPLY CHAIN MANAGEMENT (SCM)

By

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ABSTRACT

A blockchain is a decentralised, unchangeable ledger that makes it easier to track assets and record transactions in a corporate network. In a blockchain network, anything valuable may be recorded and traded, lowering the risk and increasing efficiency for all parties. It has the potential to drive cost-saving efficiencies and enhance the consumer experience through traceability, transparency, and tradeability. Blockchain-based Supply Chain Management (SCM) can provide services to participants to inquire about product details, cost, quantity, quality, availability of products, location and other significant information. It provides transparency and agreement-outsourced contract manufacturing and enhances an organization's position as the main leader in responsible manufacturing. In this study, blockchain and its effects on SCM are discussed, along with security issues and solutions.

Keywords: Blockchain, Security, Supply Chain Management (SCM), Decentralization, Phishing, Crypto Currencies.

INTRODUCTION

Information is essential to a business. It is best if it is received quickly and accurately. Blockchain is the best technology for delivering this information because it offers real-time, shareable, and entirely transparent data that are kept on an immutable ledger and accessible exclusively to members of a permissioned network (Sahoo et al., 2022). A blockchain network can track orders, payments, accounts, and production. Traditional database methods present a number of difficulties in storing financial transactions.

Transactions must be monitored and verified by a dependable third party to prevent legal problems. The existence of this centralized authority not only makes the transaction more difficult but also establishes a weak spot. Both parties can be harmed if the main database is compromised. Blockchain eliminates these problems by developing a decentralized, unchangeable mechanism for transaction recording (Agarwal et al., 2022). Blockchain generates separate ledgers for both the buyer and seller in the case of real estate transactions. All transactions are subject to both parties' approval and are automatically updated in real time in both ledgers. Any tampering with earlier transactions taints the entire ledger. These characteristics have made blockchain technology useful across a range of industries, including the development of virtual currencies such as Bitcoin (Biktimirov et al., 2017).

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1. Key Elements of Blockchain

The key characteristics of blockchain technology are as follows.

1.1 Decentralisation

In the context of blockchain, decentralization refers to the transfer of power and responsibility from a centralized entity (an individual, an organization, or a group) to a dispersed network. Transparency in decentralized blockchain networks helps players build less trust in each other. These networks also prevent users from interfering with one another in ways that would impair the network's performance (Blossey et al., 2019).

1.2 Immutability

Something can never be altered or changed if it is immutable. Once someone adds a transaction to the shared ledger, it cannot be changed by another participant. To correct an error in a transaction record, a new transaction must be added and both transactions are accessible to the network.

1.3 Consensus

Blockchain systems create regulations regarding participant consent for recording transactions. New transactions can only be recorded until the majority of network users have given their approval.

2. Structure of Blockchain

Blockchain is a ledger that tracks agreements or transactions between nodes or other network users (Yaga et al., 2019). In a blockchain, a block is typically formed after a transaction is submitted and accepted by all other users. Each block is composed of data, timestamps, block hash value, and hash value of the block before it. As each block records the hash value of the previous block, establishing a chain, the blocks are cryptographically connected. The hash value of the block is altered when a transaction is modified, severing the block's cryptographic connection. Figure 1 shows the structure of a blockchain (Chang et al., 2022).

2.1 Blockchain In Supply Chain Management (SCM)

Supply chain organizations can use blockchain to document production updates to a single shared ledger, providing total data visibility and a single source of truth, and can access a product's status and location at any moment because transactions are constantly time-stamped (Dursun et al., 2022). Blockchain technology in supply chain networks enables companies to react quickly to recall. It keeps track of every action food products take before reaching the grocery shelves. Consequently, businesses can find defective products within seconds. The immutable and transparent record of all supply chain transactions is a hallmark of blockchain. This makes it easier to track things from their point of origin to their final destination, enhances accountability, and lowers the possibility of fraud. It is used in many industries, such as food and agriculture, pharmaceuticals, manufacturers, and mining (Chang et al., 2019).

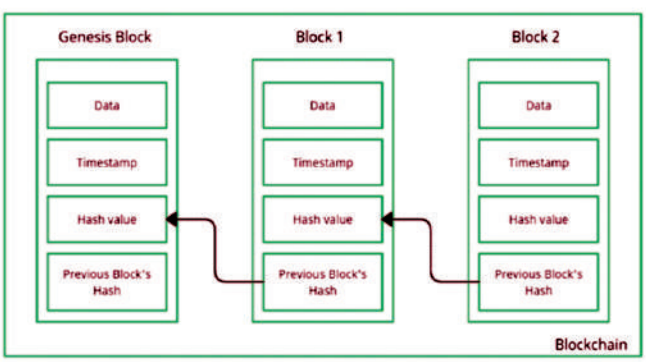

Figure 1. Blockchain Structure

Blockchain enables businesses to comprehend their supply chains and interact with customers using authentic, verifiable, and unchangeable data (Saberi et al., 2019). By gathering important data points, such as certificates and claims, and then making this information freely accessible to the public, transparency helps foster confidence. Figures 2 and 3 shows the traditional supply chains and supply chains with supply blockchain.

3. Importance of Blockchain Technology for Supply Chains

3.1 Increasing Supply Chain Complexity

In the past, supply chains were linear and had a limited number of partners. The supply chains of today are highly complicated and frequently not chronological. With several suppliers, manufacturers, logistical partners, storage partners, and other parties involved, modern supply chains are multi-tiered networks. It is challenging to carry out actions that are visible and efficient when the system grows extremely complex. Blockchain technology provides the inherent transparency, distribution, and immutability that supply networks require (Gurtu & Johny, 2019). Figure 4 represents the blockchain-based product management.

3.2 Increased Illegal Activities and Fake Goods

Assuring the legality of raw materials and components is one of the main issues faced by supply chains (Lyasnikov et al., 2020). It is difficult to track each step in a supply

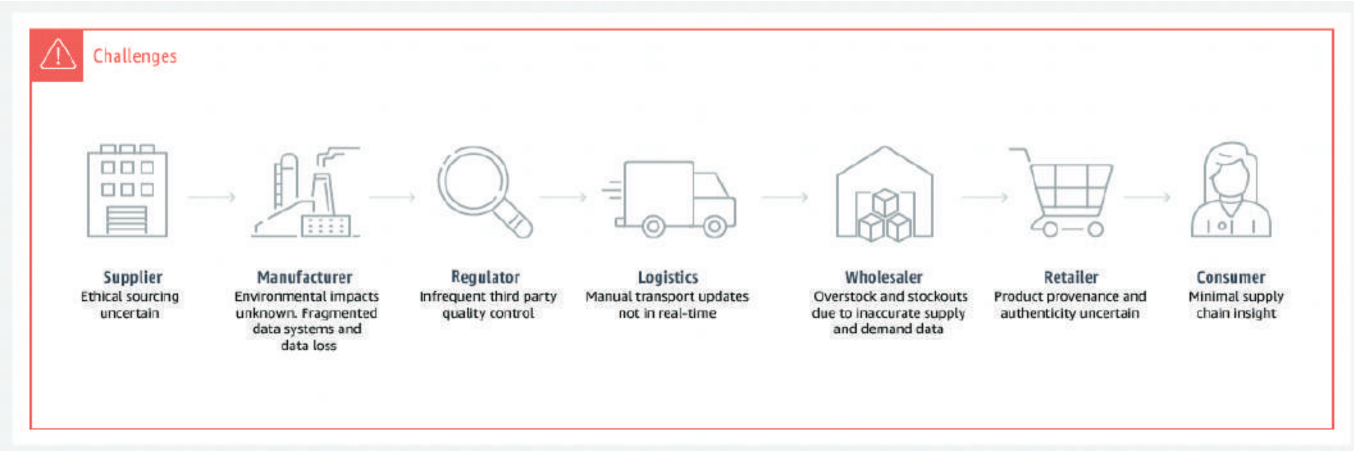

Figure 2. Traditional Supply Chains

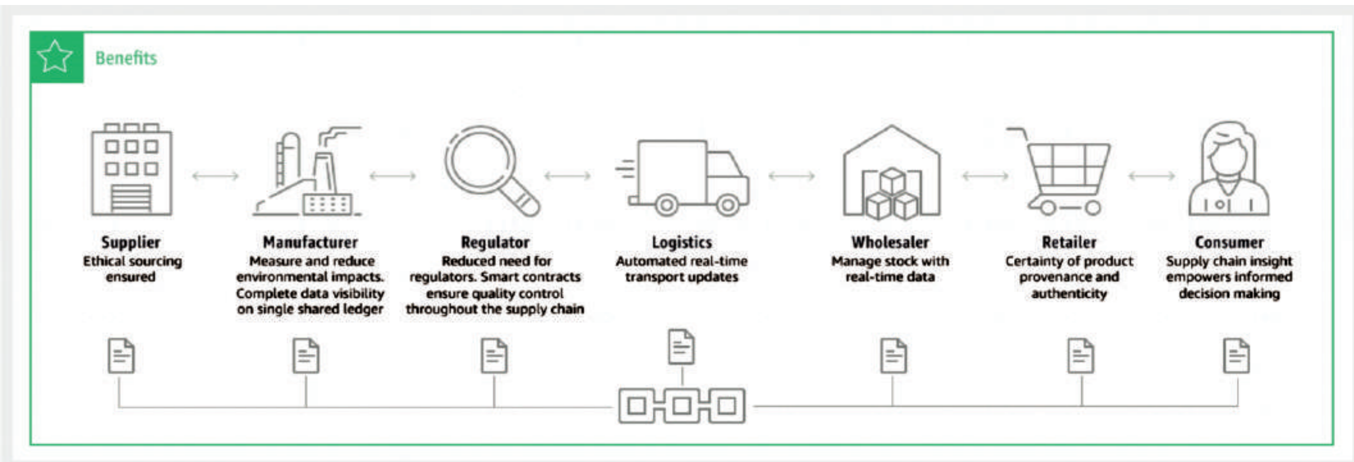

Figure 3. Supply Chains with Blockchain

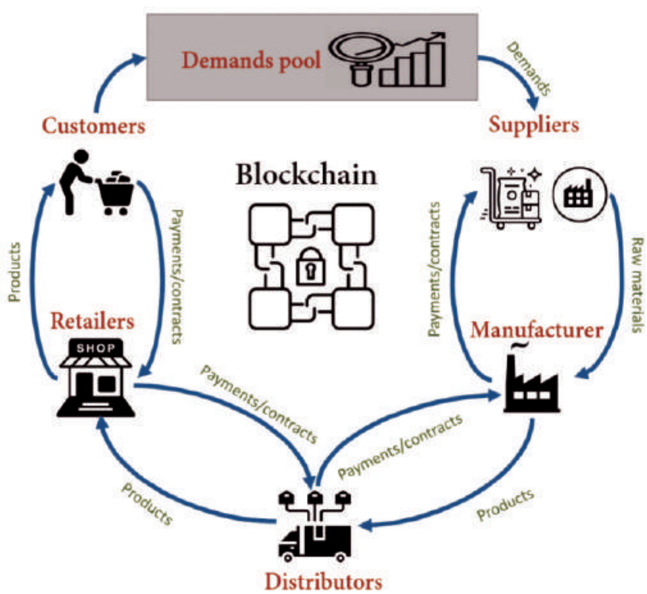

Figure 4. Blockchain-Based Product Management

chain when it spans numerous locations and has hundreds of partners. For example, it can be challenging to determine whether a supplier obtains raw materials through unethical practices. Another problem is determining whether things are genuine or fake. Fake goods may infiltrate the supply chain if there is no system in place to track each product back to its source. Therefore, supply chains require technology that enables networks to track every product back to its source. The traceability of the blockchain ledger technology is a key characteristic (Sahoo et al., 2022).

4. Security Issues in Blockchain for Supply Chain Management

The transfer of goods and services from one location to another is important in supply chain management. The procedure entails several exchanges between numerous stakeholders, including producers, suppliers, distributors, and clients (Chang et al., 2022). These transactions generate a significant amount of data, which must be handled, tracked, and documented. Due to its intrinsic characteristics such as immutability, transparency, and decentralization, blockchain technology offers a perfect option for controlling supply chain activities. However, the effectiveness of supply chain management depends on the security of the blockchain networks (Hasan et al., 2022).

4.1 51% Attack

When one company or group controls more than 50% of the computer power on a blockchain network, this is called a 51% attack. Therefore, they can manipulate the network, change transactions, and participate in double spending.

One of the important concepts is that computing power is crucial for obtaining majority control over the hash rate of a blockchain using malicious entities. The result of a 51% attack is that a compromised blockchain can result in the reversal of transactions and the possibility of double spending. In 2018, some of the popular cryptocurrency platforms faced issues regarding 51% attacks. These platforms are Ethereum classic, Zencash, and Verge (Bhushan et al., 2022). In addition, enterprises almost lost $20 million dollars per annul due to a 51% attack. To avoid this attack on the blockchain, SCM must take some careful measures. These are continuous monitoring of mining pools, taking care of the fast hash rate, and not participating in the use of proof-of-work consensus mechanisms.

4.2 Phishing and Malware Attacks

Blockchain is no exception to the prevalence of malware and phishing scams in the digital world. These assaults may lead to the loss of private keys, which are required to access blockchain wallets (Kakarlapudi & Mahmoud, 2021). Users should be cautious when using connections or communications that seem suspicious and take care to protect their private keys. One of the most promising techniques is a phishing attack used by hackers. This technique was formally an attempt to obtain user credentials. In this technique, hackers send emails to wallet key owners by pretending to be an authentic authority source. Such types of emails request information regarding user credentials through fake hyperlinks. When hackers can access the credentials and sensitive information of a user, the users as well as the blockchain network are open to subsequent attacks. The growing number of phishing attacks on blockchain networks has created profound levels of concern in recent times.

The first blockchain hack online was in June 2011; in this attack, the cyber criminal was able to hold the auditor's credentials and then access the system unauthorisely. Then, the attacker was able to change the value of 1 BTC to 1 cent. The second blockchain hack occurred in March 2014. In this attack, he made use of bugs in the code, edited the transaction, and performed double spending. In this attack, the attacker changes the sender's signature and transaction ID before storing it in the ledger. By using the transaction ID, overwriting the transaction details is possible and can block the receiver, so that he cannot receive the funds further and only the attacker can.

In 2012, the overall loss of Bitcoin was $430,000 by hacking the user wallet and decrypting it from the linode's server. Bitcoin started using Bitgo's multi-signature wallet just a year before the attack. However, the wallet has certain challenges and vulnerabilities. The above issues lead to the hacker being able to attack and stole the BTC. Immediately after this attack, the company issued BFY tokens to compensate its customers (Uddin et al., 2023).

4.3 NiceHash Attack

A federal indictment was put on three North Korean computer programmers who participated in a wide-ranging criminal conspiracy to conduct a series of destructive cyberattacks, to steal and extort more than $1.3 billion of money and cryptocurrency from financial institutions and companies, one of which was NiceHash, in 2017, where $75 million was stolen (NiceHash, 2021). Another blockchain attack is the Slovenian exchange platform, where NiceHash was attacked. Immediately after this attack, Facebook announced that almost $80 million was hacked. The company evaluated the reason for these issues and how to prevent them from future days; as a result, the company suspended all transactions for a period of 24 hours.

4.4 Centralization & Interoperability

Blockchain is meant to be decentralized; however, in reality, most blockchains are centralized. This suggests that a small number of people or entities control the vast bulk of the network's computing power, thereby creating serious security issues. Blockchain interoperability is the ability of different blockchains to communicate and exchange data with one another. It might be difficult to monitor and verify transactions across different blockchains owing to fragmentation caused by a lack of interoperability, which poses a security concern.

4.5 Blockchain Endpoint Vulnerabilities

Another important instance of security risk in blockchain security is the vulnerability of the blockchain endpoints. One of the latest concerns in blockchain technology is security. For example, Ethereum trading or investment could result in a large amount of Ethereum being stored in a virtual savings account. The actual blocks in the blockchain are safe for hackers, and the wallet accounts are not safe. Moreover, many third-party vendors are important for blockchain transactions. A few third-party vendors include blockchain payment platforms, payment processors, and smart contracts. These third party vendors in blockchain can increase the vulnerability to hacking due to weaker security in apps and websites.

4.6 Routing Attack

One of the most important concerns for security and privacy is the blockchain in terms of routing attacks. Most applications in blockchain depend on a large volume of data transfer in real time. The main aspect of routing attacks in blockchain security is the obscurity. But the users of blockchain could not be able to identify the threats of routing attacks normally as everything appears in blockchain is normal. Routing attacks are generally used to extract confidential data or remove monetary benefits without disturbing the network users. Therefore, it is very open that routing attacks can be harmful as they are able to impose the reasonable damage before detection.

4.7 Blockchain Code Bugs

An example of a blockchain security breach is protocol source code. This occurred in 2010, when bad codes were used in the Bitcoin protocol and made it faulty. Using this attack, the hacker generated 184,467 billion coins, and the maximum delivery of Bitcoin was 21 million. However, the creators of blockchain Satoshi Nakamoto and Developer Gravin Anderson fixed the issue within a few hours.

4.8 Smart Contract Bugs

Due to weakness in the solidity language, the smart contract code can be vulnerable and attacked by an attacker. These are DAO, underflow, overflow, and re-entrance attacks.

4.9 Transaction Privacy Leakage

Another difficulty in blockchain technology security is the breach of transaction leakage. Transactions are transparent over the blockchain, so the behavior of users is traceable on the blockchain. Thus, security should be provided for transactions in the blockchain, and users must have a private key for their transactions.

4.10 Scalability

Scalability is a major issue for blockchains, especially as technology continues to advance. As more users join a network, the demand for computational power and bandwidth increases, potentially resulting in bottlenecks and network congestion. In addition, blockchain encryption techniques may be vulnerable to quantum computing, a new computing paradigm. The potential exposure of blockchain technology to hacker attacks presents a security risk.

5. Improvement of Blockchain Security for Supply Chain Management

Several steps can be taken to improve the security of blockchain networks to reduce security risks related to supply chain management on the blockchain. The following are a few possible actions.

5.1 Auditing

This process thoroughly checks blockchain protocol codes vigorously before launching. Thus, we can easily detect bad code.

5.2 Utilization of Multifactor Authentication

Multifactor authentication adds an extra layer of security and aids in preventing unauthorized access to the blockchain network. Regular upgrades to the blockchain network's software help fix any potential security flaws.

5.3 Utilization of Smart Contract Audits

Smart contract audits assist in locating weaknesses in the smart contract code and guard against monetary loss.

5.4 Supply Chain Visibility

Supply chain visibility aids in spotting supply chain weaknesses and deters theft, fraud, and other nefarious behaviour.

5.5 Utilization of Encryption

Encryption adds a layer of protection to protect sensitive data. In the event of a security breach or other malicious action, regular backups help prevent data loss.

5.6 Blockchain Analytics

Blockchain analytics tools are used to identify any shady activity occurring within the blockchain network, and to stop fraud, theft, and other nefarious actions.

6. Benefits of Using Blockchain in Supply Chain

Figure 5 presents the benefits of blockchain.

6.1 Transparency

Every member of a blockchain can view every transaction. Transactions between two parties, such as manufacturers and retailers, may not be visible to a third party in typical supply chains. Each transaction in the supply chain is added as an immutable tamper-proof block using blockchain technology. All parties engaged in the supply chain can see each transaction. Supply chains are more open to the blockchain technology (TIBCO, n.d).

6.2 Enhanced Security

Execution errors are particularly likely in supply chain networks with hundreds of parties and thousands of transactions per day. These mistakes can involve missed shipments, inaccurate inventory data, and payment problems. The real-time detection of these execution faults is challenging in conventional supply chains. Verifying the source of this issue may require extensive investigation and document analysis. Execution mistakes may not be discovered after regular audits. A diagrammatic representation of the benefits of blockchain is represented in Figure5.

6.3 Immutability

Data cannot be changed or removed from the blockchain after it has been recorded without the network consent. Information about the supply chain cannot be altered without authorization, owing to its immutability, which guarantees data integrity.

6.4 Reduced Costs

The cost of running a supply chain can be reduced with the aid of blockchain technology. Blockchain can aid in lowering costs and boosting efficiency by automating inventory management, minimizing paperwork, and eliminating the need for intermediaries.

6.5 Enhanced Security

Blockchain transactions are tamper-proof because they are encrypted with a private key (or the user's digital signature) that initiates the transaction. Each partner in a supply chain with numerous partners has its own digital signature. The user's digital signature is used to safeguard transactions, such as purchase orders, when they first begin. The transaction is unchangeable, and the recipient party, such as a supplier, can confirm that the purchase order originated from a legitimate consumer. Counterfeiting a transaction is not possible because

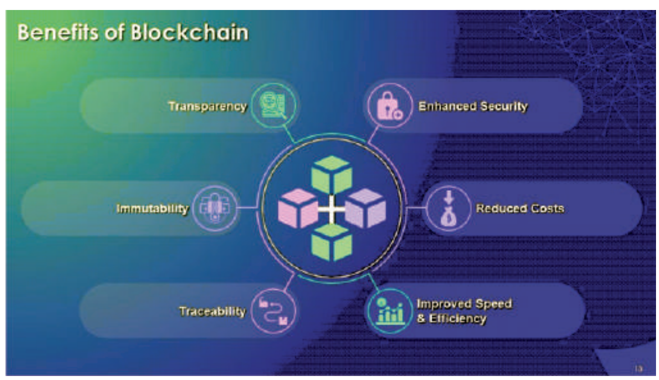

Figure 5. Benefits of Blockchain

every transaction in the supply chain is added to the blockchain as a new block. A blockchain creates a reliable sequential audit trail for all transactions that cannot be altered. Every transaction is permanently recorded using blockchain technology. A blockchain-based supply chain makes it easier and faster for firms to identify and address execution issues, thus saving time and money.

6.6 Improved Speed and Efficiency

Blockchain technology accelerates supply chain activities. Manual- or paper-based processes are digitized. Blockchain technology provides high-speed operations that are extremely responsive to changes in business conditions by streamlining real-time data flows among all supply chain players. All contracts and transactions are maintained using blockchain technology in a tamper-proof ledger. This indicates that the supply chain network contains business logic.

7. Challenges Using Blockchain in Supply Chain

7.1 Processing Large Data Sets

There is very little data on conventional blockchain applications such as cryptocurrencies. While carrying out blockchain transactions, it is simple to validate the data. Complex supply chains have large volumes of data and hundreds of transactions. Accurately streamlining this vast volume of data is crucial for integrating the blockchain into supply chains.

7.2 Blockchain Technology Standardisation

Blockchain technology vendors must standardize their offerings to be quickly adopted by numerous businesses. Some of these standards specify how two parties might concur on a block before validating it, what kind of encryption to use, or how to resolve transactional disputes.

7.3 Interoperability

Many businesses use traditional Enterprise Resource Planning (ERP) systems to handle their transactions. It could be challenging to completely replace one system before using a blockchain-based solution or to adapt these systems to use blockchain technology. It is crucial that blockchain-based solutions and legacy systems work together to some extent.

7.4 Transaction volume Management

Compared with supply chain transactions, the number of transactions per second in traditional cryptocurrency applications is quite low. High computing power is required to fully digitalize complicated supply networks. The processing speed of the blockchain network may be a constraint on how quickly transactions take place in the supply chain based on blockchain technology.

8. Applications of Blockchain in Supply Chain Networks

Transparency, traceability, and tamper-proofing are guaranteed using the blockchain technology. As blockchain technology is decentralized, it naturally satisfies the needs of supply chain networks. From financial transactions to product tracing, blockchain technology has a wide range of applications in supply chains (Rosencrance, 2023).

8.1 Finding the Source of a Product

In the majority of supply chains, raw materials come first and finished goods come last. Blockchain technology tracks a product's travel from raw material suppliers to consumers. It could be challenging for the manufacturer to establish the precise location of damaged items from many different suppliers and process them in several different factories. This problem is solved using blockchain technology, which provides traceability. With the aid of blockchain technology, the manufacturer can identify the exact shipping vessel from which the product originates. Every step in a product's journey through the supply chain results in a blockchain transaction. By ensuring product traceability, blockchain reduces product recall and revenue loss.

8.2 Making Payments using Cryptocurrency

Blockchain technology can be used to control financial flow in the supply chain, although it has not yet been widely adopted. For financial exchanges, some organizations have begun implementing blockchain-based technology such as Bitcoin. Blockchain-based money flow is transparent, simple to follow, and does not require centralized oversight.

8.3 Organising Participant Contracts

Supply chain partners can conduct smart contracts using blockchain technology. Thousands of contracts and partners are involved in complex supply chains. Each contract may be incorporated into a blockchain transaction as a block. Each of these contracts remains tamper-proof because blockchain transactions are immutable; no party can change or alter the contract.

8.4 Participant Contract Organisation

Supply chain parties can execute smart contracts using blockchain technology. In intricate supply chains, thousands of contracts and hundreds of partners exist. A blockchain transaction may contain a block that represents any of these contracts. As blockchain transactions are immutable, no party can amend or alter any of these contracts, keeping them impervious to tampering.

Conclusion

Blockchain technology is the most advanced and provides a flexible and perfect solution to the many challenges faced by conventional supply chain models. Individuals and organizations can grow and operate transparently with blockchain. Important challenges in blockchain technology include tampering actual data with malicious data, which are captured online. Blockchain technology provides an ideal solution for managing supply chain operations because of its inherent features such as immutability, transparency, and decentralization. However, the security of blockchain networks is critical to the success of supply chain management. The security risks associated with blockchain for supply chain management include malicious attacks, smart contract vulnerabilities, supply chain vulnerabilities, and insider threats. Various measures can be taken to enhance the security of blockchain networks, including the use of multi-factor authentication, regular updates, smart contract audits, supply chain visibility, encryption, regular backups, and blockchain analytics. By implementing these measures, the security of the blockchain network and the supply chain can be enhanced.

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A STUDY ON GAS LEAKAGE DETECTION – A REVIEW

By

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ABSTRACT

Gas leakage is of significant concern in industrial, residential, and commercial settings. It can lead to disastrous consequences such as explosions and fires, making its detection a critical issue. The accurate and timely detection of gas leaks is crucial for preventing catastrophic accidents and ensuring the safety of people and property. The aim of this study is to detect gas leakage using a CNN-based approach. Industrial gas-detection sensors and their placement are discussed. Sensor selection and placement are crucial to obtain accurate results. The smart monitoring system of the sensor data and monitoring mechanism are discussed in this study. CNN is promising and more accurate for gas leakage detection than the existing models for gas leakage detection.

Keywords: Gas leakage, Machine Learning (ML), Convolutional Neural Network (CNN), Random Forest.

INTRODUCTION

Gas leakage poses a serious safety risk in various commercial and residential situations. Gas leaks that are explosive, flammable, or toxic can have disastrous effects on human health, property, and life. To ensure early detection and a rapid response to gas leaks, it is imperative to create trustworthy and effective gas leakage detection systems (Dadkani, et al., 2021). Improved gas leakage detection systems are now possible because of the developments in gas-sensing technology. Due to their capacity to deliver thorough and precise gas-leak information, multiple gas sensors that can detect several types of gases have grown in popularity. These sensors can concurrently detect various gases, making it possible to identify gas leaks early and improve safety precautions (Joshi et al., 2019). This study aimed to analyze and condense the most recent methodologies, strategies, and developments in gas leakage detection systems that utilize many gas sensors. It also aims to provide readers with a thorough overview of the ongoing research and development in this area, while highlighting the benefits, drawbacks, and future uses of these systems (Sharma et al., 2021). An overview of the Systems for Detecting Gas Leaks provides a summary of gas leak detection systems, highlighting the value of early detection and the requirements for several gas sensors. . Metal oxide semiconductors (MOS) are a type of gas sensor technology that are reviewed here and are used in gas leakage detection systems.

Different configurations involving several gas sensors, including parallel sensor arrays, sequence sensor arrays, and hybrid topologies, have been explored. The benefits and drawbacks of each configuration, as well as how they affect gas leakage detection performance are described (Feng et al., 2019). The methodologies and techniques used for data fusion and analysis in gas leakage detection systems are currently being investigated. Machine learning techniques, pattern recognition methods, and signal processing algorithms are discussed to understand the data gathered from various gas sensors. The effectiveness of the gas leakage detection systems was evaluated using performance measures. The sensitivity, selectivity, reaction time, and false alarm rate criteria of the system were reviewed (Kopbayev et al., 2022).

Present case studies from real-world situations or experimental findings from ongoing studies demonstrate how various gas-leak detection systems operate. Prospective directions for the future are discussed, such as wireless communication and remote monitoring for the timely detection and prevention of gas leaks (Khan, 2020). These goals will enable this in-depth assessment to provide researchers, engineers, and business experts with a consolidated and current understanding of gas leakage detection employing numerous gas sensors. The results of this review can be used to design gas leakage detection systems that are more trustworthy and effective, thereby boosting safety precautions in various industrial and home settings. Systems for detecting gas leaks are essential for guaranteeing safety and avoiding dangerous circumstances in various industries (Xu, 2021). Gas leakage detection systems are frequently used in chemical facilities to monitor the presence of dangerous and combustible gases, such as ammonia, chlorine, hydrogen sulphide, and volatile organic compounds (VOCs). Gas leakage detection systems are used by oil and gas plants to detect pipelines, storage tanks, and processing unit leaks to stop potential explosions and environmental harm caused by the escape of dangerous gases such as methane or hydrogen.

1. Sensor Selection and Placement

Selecting appropriate sensors for the target gas is the first stage in the development of a gas-leakage detection system. Different gases require different types of sensors, such as poisonous or combustible gas sensors. These sensors are used to gauge the levels of gases in the environment. Sensitivity, response time, and accuracy are important considerations when selecting sensors (Nikolic et al., 2021). Sensors should be placed strategically in locations where gas leaks are most likely to occur, such as gas pipelines, storage tanks, or appliances. Additionally, sensors should be positioned at various heights because the dispersion patterns of some gases may be altered depending on whether they are lighter or heavier than air. Figure 1 represents the industrial gas sensors.

The system must activate proper alarm and safety devices to notify inhabitants and stop additional harm as soon as a gas leak is detected. Remote notifications, visual indicators, and audible alarms can be used to alert those near a leak. Effective and timely warnings can provide valuable time for evacuation or other risk-reduction measures (Isreal et al., 2017). The gas leakage detection system should have safety features such as automatic shutoff valves or ventilation systems, in addition to sirens. These controls can assist in containing the leak, isolating the afflicted areas, and lowering the danger of explosion or ignition. The coordination of safety measures can be further improved by integration with building management or home automation systems. Additionally, the gas leakage detection system must be constantly checked for its performance and reliability. Regular maintenance, sensor replacement, and system testing are vital for ensuring the functionality of a system during critical situations.

Protecting residential and commercial environments from the risks associated with gas leaks requires a well-designed gas-leakage detection system (Korlapati et al., 2022). The precise and prompt identification of leaks is made possible by the thoughtful placement and selection of sensors as well as cutting-edge signal processing and data analysis methods. The overall safety and reaction capabilities of the system are improved by

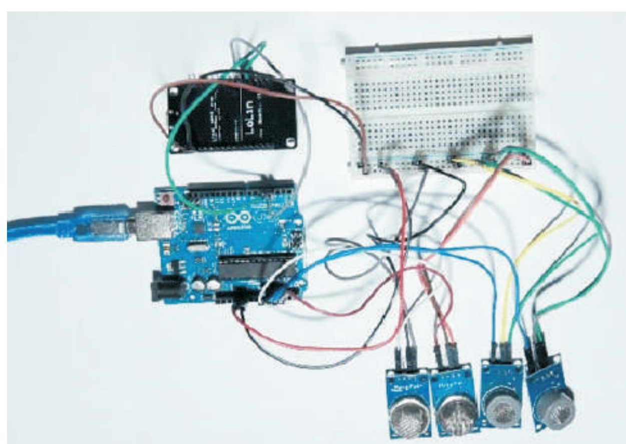


Figure 1. Industrial Gas Sensors

incorporating efficient alarm and safety measures (Krishnamurthi et al., 2020). Systems for detecting gas leaks are essential for preventing accidents, saving lives and maintaining property. These systems can provide early warnings and enable rapid actions, thereby reducing the potential risks posed by gas leaks.

2. Smart Monitoring System

Utilizing IoT and smart monitoring systems for applications such as environmental monitoring, workplace safety, and interior air quality control, the integration of gas sensors is possible. By identifying and keeping track of the amount of dangerous gases in the environment, gas sensors play a critical part in these systems. The combination of gas sensors and IoT has made it possible to monitor gases effectively and in real time, because of technological improvements. Figure 2 shows the architecture of the CNN.

Small low-power sensor nodes containing gas sensors, communication modules, and computing power constitute these networks (Wang et al., 2021). A distributed sensing network is created through communication between nodes and a centralized monitoring station. This makes it possible to gather and analyze data in real time, thereby providing fast information on the levels of gas concentration in the monitored area. Gas monitoring systems can take advantage of connectivity and cloud computing by combining gas sensors with IoT platforms. Table 1 lists the gas sensors and sensitive gases detected by the sensors.

Internet connectivity allows gas sensor nodes to be monitored remotely and controlled at any location. Additionally, by enabling data collection and storage in the cloud, this connectivity makes data available for additional analysis and decision-making. Data gathered from gas sensors can be processed and analyzed to find trends and spot anomalies using Artificial Intelligence (AI) techniques. ML models can learn from prior data to anticipate gas concentrations, evaluate potential dangers, and produce early warnings or alarms. These methods make it possible to take preventative actions and make proactive decisions to reduce gas-related risks. There are many advantages of integrating gas sensors with WSNs, IoT, AI, and ML approaches in a variety of application domains. Real-time gas monitoring in industrial settings can aid accident prevention and worker safety. Alarms and emergency procedures can be launched during the early detection of gas leaks or abnormal gas levels. Gas monitoring systems in smart cities can help safeguard the environment by monitoring air quality and identifying pollution sources. In indoor environments, gas sensors can ensure the well-being of occupants by detecting the presence of harmful gases such as carbon monoxide. R-CNN training is based on object classification and regional recommendations. Region-Based Convolutional Neural Network (R-CNN) is a type of ML model that is an object detection framework specifically for object detection. Gas leakage detection can use R-CNN, which uses a CNN to classify image regions within an image. Instead of classifying every region using a sliding window, the R-CNN detector

Sensor	Sensitive Gases Detected
MQ2	Butane, LPG, Smoke, Methane
MQ3	Ethanol, Smoke, Alcohol
MQ5	Natural Gas, LPG
MQ7	Carbon Monoxide
Mq135	Air Quality (Benzene, Smoke)

Table 1. Gas Sensors and Sensitive Gases Detected

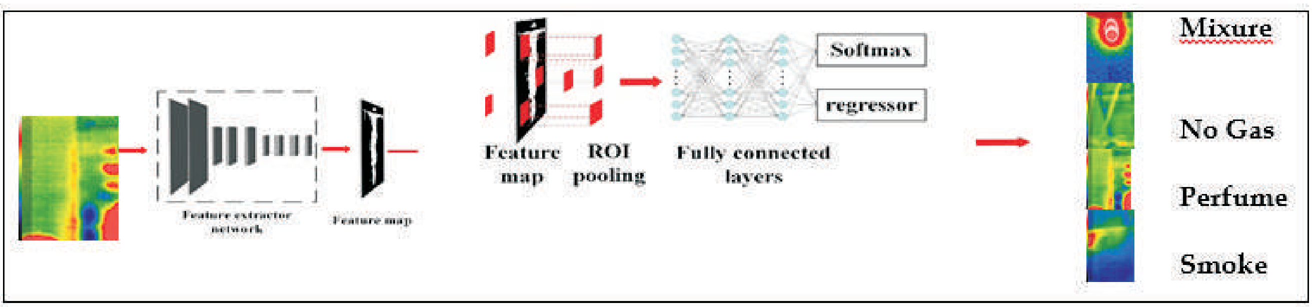


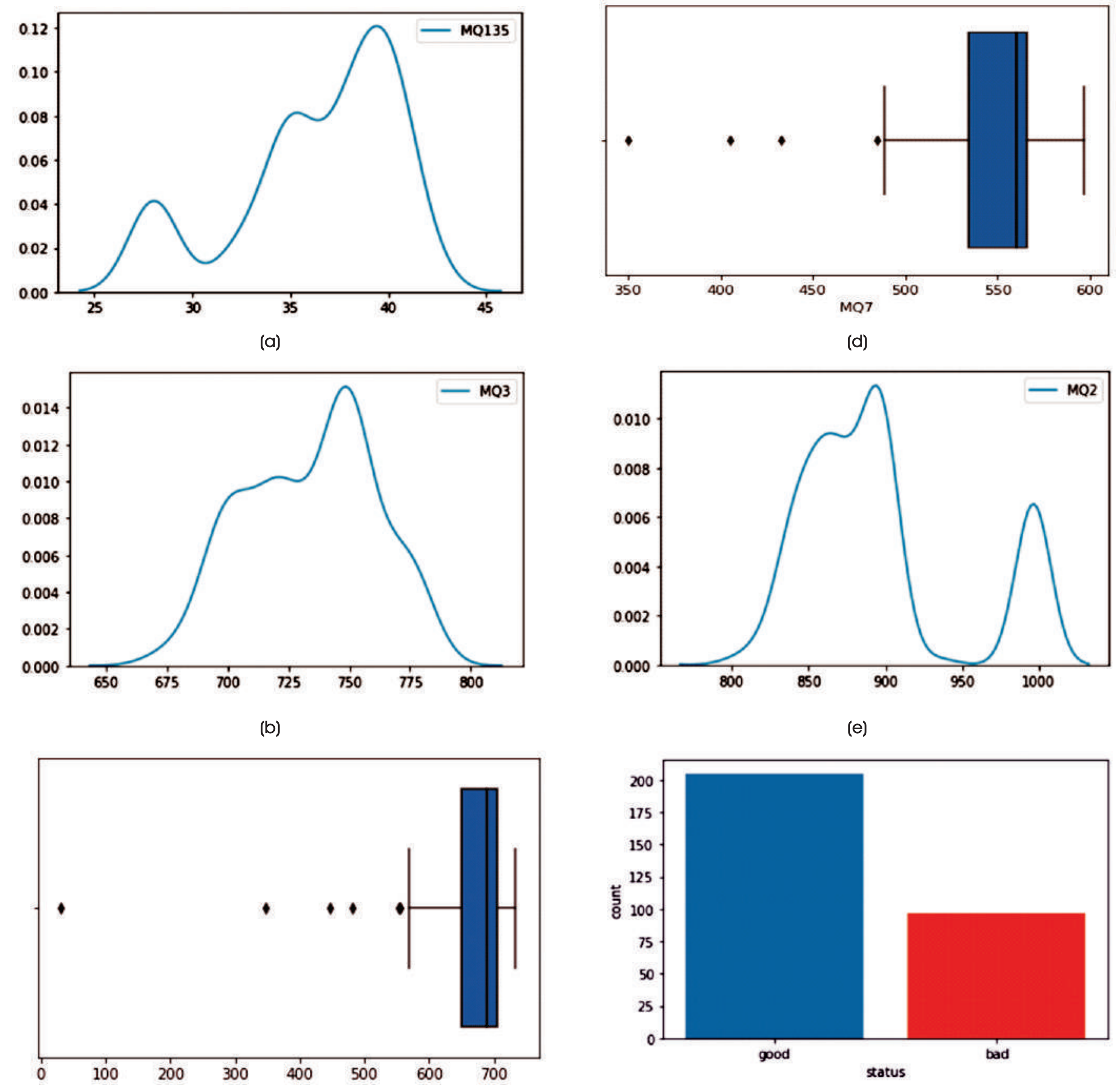
Figure 2. CNN-Based Gas Detection

processes only regions that are likely to contain an object.

3. Sensor Data in Gas Detection

This study on gas leakage detection systems contributes to improved safety standards for various industries and residential environments. Nanomaterial-based gas sensors, miniature gas sensors, and gas sensor arrays with pattern recognition are recent developments in gas sensor technologies. Recent developments in nanomaterials, miniaturization, and creation of gas sensor arrays with pattern recognition have led to notable advancements in gas sensor technology (Lun & Xu, 2022). Figure 3 shows the graph of the sensor data in gas leakage detection.

CNN proves to be promising and more accurate in gas



(a) (d) (b) (e) (c) (f)

Figure 3. Sensor Data and Gas Leakage Detection. (a) MQ 135 Sensor Data, (b) MQ 3 Sensor Data, (C) MQ 5 Sensor Data, (d) MQ 7 Sensor Data, (e) MQ 2 Sensor Data, (f) Gas Leakage or not

leakage detection when compared to traditional models such as random forest, decision tree and logistic regression (Shi et al., 2020). Figure 4 shows the comparison between the traditional models and CNN in gas leakage detection.

4. Discussion

To avert accidents, preserve lives, and limit property damage, early gas-leak detection is essential. The purpose of this study was to discuss the outcomes and ramifications of using several gas sensors to detect gas leaks. Multiple gas sensors should be carefully placed in the monitored area to create a gas-leakage detection system. Each sensor is capable of detecting chemicals, such as methane, propane, and carbon monoxide, which are frequently linked to gas leaks. The sensors continuously scan the surrounding air; if the concentration of any gas exceeds a set limit, an alarm is set off to notify those who should be informed. Compared to a single-sensor technique, the use of gas sensors has several benefits in the detection of gas leaks. First, using several sensors, the system can identify various types of gas leaks because it can detect a large variety of gases. This minimises the possibility of false negatives or false positives by ensuring an extensive and trustworthy detection method. Second, greater localization of gas leaks is made possible by the spatial distribution of gas sensors. This technology can more precisely triangulate the leak source by examining the output from various sensors. With this knowledge, quick action can be taken to stop leaks and avoid any danger. In addition, the use of redundant sensors provides system redundancy and strengthens it (Damaševičius et al., 2023).

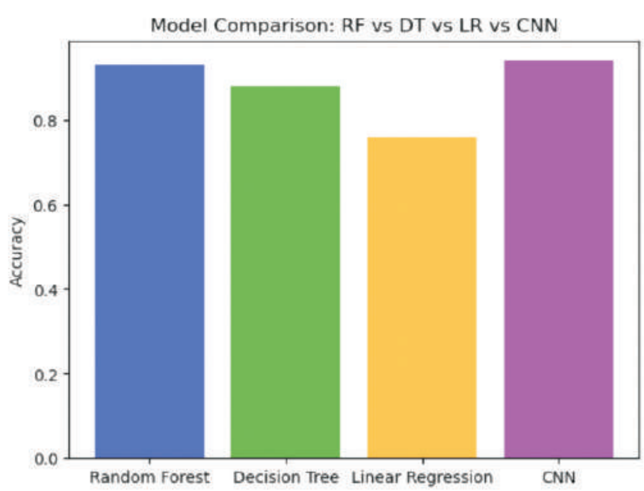


Figure 4. Model Comparisons of Random Forest, Decision Tree, Logistic regression and Convolution Neural Networks

Another area of advancement in gas-sensor technology is miniaturization. Traditional gas sensors are bulky and require complex instrumentations. However, miniaturization of gas sensors has led to the development of small, portable, and wearable devices with enhanced functionality. Miniaturized gas sensors offer several advantages, including improved accessibility, real-time monitoring, and cost-effectiveness. These sensors can be integrated into smartphones, smart watches, and other wearable devices, enabling individuals to monitor air quality and gas exposure in real time. Moreover, the small size and low power requirements of these sensors make them suitable for applications in areas such as personal safety, indoor air quality, and pollution monitoring. Furthermore, advancements in ML and AI have significantly enhanced the capabilities of gas-sensor arrays. These algorithms can learn and adapt to different environments, improve sensor selectivity, and reduce the number of false positives. Machine learning algorithms combined with gas sensor arrays enable real-time monitoring, predictive maintenance, and early warning systems, making them valuable tools for a wide range of applications (Nazemi et al., 2019). Recent advancements in gas sensor technologies, particularly nanomaterial-based sensors, miniaturized sensors, and gas sensor arrays with pattern recognition, have opened up new possibilities for gas-sensing applications (Surucu et al., 2023). These advancements have improved sensitivity and selectivity, enabling their use in diverse fields, such as environmental monitoring, industrial safety, healthcare, and smart cities. As these technologies continue to evolve, we can expect further improvements in their gas-sensing capabilities, leading to safer and healthier environments.

Conclusion

Gas leakage detection using Convolution Neural Networks (CNN) is an innovative approach for detecting gas leaks in real time. It involves capturing images of gas leaks using a camera and a CNN model to detect the presence and severity of the leak. The CNN model should be trained on a labelled dataset of gas leak images and optimized to detect gas leaks accurately. This system can provide real-time monitoring and detection of gas leaks by utilizing a camera to capture images of gas leaks and a CNN model to detect the presence and severity of the leak. This study revealed that CNN is promising and more accurate for gas leakage detection than traditional models such as random forest, decision tree, and logistic regression. With larger datasets and many sensors, the accuracy and efficiency of gas-leakage detection can be improved.

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