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FAILSAFE ALGORITHM MANAGEMENT IN SMART FARMING IOT CONTROL SYSTEMS

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ABSTRACT

Internet of Things (IoT) technology is an important component in the modern smart farming system and plays a key role in improving the efficiency of various aspects of the farm such as greenhouse troubleshooting, farm data tracking, smart farm control and many more. Previous research has established that with the help of IoT technologies, who will be in-charge of the data monitoring of the farm, owners are able to perform necessary farming tasks including seeding, fertilising, watering and so on at the perfect moment to ensure maximum agricultural yield. Multiple sensors are used to measure the crucial environment parameters are implemented to collect the farm data and transfers to the backend server by the IoT module in order to perform necessary data analysis thus completing the IoT usage in the given farm. The reliability and time accuracy of the data collected by the sensor is crucial for the following control system. To date, only a limited number of Smart Farming IoT system architectures have been identified, as well as the failsafe data management issues of the IoT modules in designated farm types is yet to be resolved. this paper is that researchers develop a data failsafe management algorithm compatible with Arduino embedded system platform which works together with backend server to manage and transfer the data received from the sensors autonomously. Unlike conventional smart farming IoT architecture, the proposed system is equipped with multiple data storage media located in different parts of the system preventing data losses during unwanted occasions. This review paper talk about implementing failsafe architecture into IoT smart farming systems. Besides, the system proposed in this research could fit with various wireless connectivity arrangements while ensuring the smoothness of the network traffic. Expected results showed that the proposed IoT architecture resolved the data loss issues during the internet outage thus improved the IoT control system. Therefore, all the benefits brought to the farm by implementing IoT technologies are well preserved.

Keywords: *Smart Farming, Internet of Things (IoT), ESP32, IoT Connectivity, IoT Failsafe Algorithm, Failsafe Data Management*

1. BACKGROUND

In the history of farming technology development, automated farming has always been one of the key technology which received the most attention. This is due to the improvement in terms of efficiency after the implementation of farming machinery. Due to the increment of population causes outrageous food demand, there is nearly 60% of the world's population treated agriculture as their main source of income especially in some agricultural-dependent country according to the National Food and Agricultural Organization (FAO) [1]. Even after the utilization of large capacity farming machinery, lack of manpower still remained an unsolved problem.

After the introduction of smart farming technology, automation and robotics were brought to the field of agriculture. Farmers' working efficiency were drastically improved as many jobs were handled and itinerated through farming robots. The key technology joining the two is the advancement of IoT technology, from various sensors to the actuators. Farm data collection which dominates the entire system by providing crucial data to all control algorithms and modules. Therefore, several research concludes that farm management and feature packed monitoring system of farm parameter such as ambient temperature, ambient humidity, soil moisture and many more had been widely used in modern farms located in cities or rural areas and farming activities could be drastically improved in terms of efficiency with the help of unmanned automated vehicle (UAV) or robots [2].

In terms of structure and approach, the smart farming system differs greatly from conventional farming in many aspects. While smart farming systems use a variety of sensors and cameras to obtain farm data, conventional farming systems rely on human observation and human experiences to detect the farm and corps state. As a result, some metrics might be monitored remotely or acquired in real-time by the sensors, greatly increasing the accuracy of an analysis of farm conditions. The information saved in the IoT system's backend could be further processed and analysed by the intelligent deep learning algorithm to help farmers use various materials like fertilisers, water, insecticides, and other things which eventually helped to reduce cost. Besides by taking corrective actions in the earlier times, smart farming system could also improve the crops' growth quality. Farmers would be able to identify problem and perform corrective actions in the early stage.

The goal of Internet of Things technology implemented into smart farming use cases are mostly very clear. Due to its low bandwidth long range transmission. Hardware and software architecture or algorithm build for this particular use cases would really come in handy. A research about the future trends of control and operation had clearly stated that the Internet of Things technology has brought possibility to Automation Cloud where the cloud consists of nearly 'unlimited' computing power and the advancement of network technology, the calculations needed to be integrated into the performance limited microcontroller were gradually decreasing. With the help of Big Data technology to analyse huge sets of non-structured data, a scheduling algorithm to perform specific operations could be more universal and can suit more use cases which could eventually help with the performance of the microcontroller equipped in the IoT module as well [3].

The development and use of technology in the agricultural industry have generated a great deal of interest in study during the past few decades. Smart farming and automation have been positioned as revolutionary catalysts for boosting productivity, lowering the need for human labour, and strengthening agricultural sustainability in previous studies, which have highlighted their transformative potential. However, the majority of these studies have concentrated on the technological use of Internet of Things (IoT) devices in farming operations, the capabilities of sensors and actuators, and the advantages of unmanned autonomous vehicles (UAV) or robots for data collecting and farm management [1,2]. Despite the fact that these studies emphasise significant aspects of smart farming technology, they frequently ignore the difficulties, particularly those resulting from the complex interactions between hardware and software elements within the IoT modules. The potential of low-bandwidth, long-range transmission and cloud computing in IoT technologies to enhance smart farming systems is extensively explored in the literature [3]. Yet few studies examine how resilient these systems are to power outages and connection problems, as well as how these disruptions affect data storage and retrieval. Additionally, the potential of brownout reset timers and failsafe algorithms to address these issues hasn't been fully investigated.

The current study, in contrast, advances this discourse by critically analysing the weaknesses of IoT modules and their effects on smart agricultural systems in addition to acknowledging the revolutionary possibilities of IoT technology. The study reveals the complex interactions between hardware and software in these systems and highlights potential problems that can occur and jeopardise system performance. In order to improve system resilience and reliability, it also suggests a novel strategy for protecting data in a variety of fail scenarios. This strategy incorporates failsafe algorithms and brownout reset times. By providing essential insights to agricultural stakeholders on how to maximise the functionality and dependability of smart farming systems in the face of inescapable technological disruptions, this new viewpoint contributes to filling the gap in the literature.

2. INTRODUCTION

The latest IoT technologies used in modern smart farming have more benefits than drawbacks. Smart farming systems can increase crop productivity and efficiency at a reduced cost while also producing better crops. It is also a fact that by using it at the right time, this strategy could enhance farm resources. The IoT system for smart agriculture is affected by numerous issues.

2.1 Modern Smart Farm Parameters

There are many researches and surveys done regarding the modern farm parameters. Empirical research and development finished in terms of the smart fish farm control has clearly stated that in order to achieve the artificial intelligence (AI)

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powered fish behaviour monitoring, the necessary parameters needed included the water PH, ppm of dissolved oxygen, water temperature, water turbidity and many more [4]. An IoT based Smart AgroTech system is developed by a group of developer in the context of urban farming that considers humidity, temperature, and soil moisture as necessary farming parameters to be collected. Afterwards, these parameters will be sent to the internet through ESP8266 and will be further monitored and performed necessary farm control using the "Thing-Speak" server around the globe [5].

In the smart energy management cloud platform developed with real-time monitoring has included an artificial intelligent capable wind farm. There are several parameters required to be collected in the IoT perception layer included ambient temperature, real-time wind speed, ambient pressure, power yield, device vibration and so on. These parameters were very useful in the proposed automatic control strategy [6]. As for the IoT-Agro system development further concluded that additional parameter related to the IoT infrastructure other than conventional farm parameters were collected such as the deep learning model parameters [7].

2.2 IOT Architecture

The IoT system architecture used in smart farming often consists of a network of sensors and devices that gather data on various farm characteristics such soil moisture levels, temperature, humidity, and weather conditions. This is because of the needs and requirements. Then, this data is transmitted to a cloud-based platform, where machine learning algorithms analyse and process it to generate insights and suggestions for farmers. Several studies have highlighted the effective design of the IoT architecture for smart farming as well as the key elements that make up the complete system. The sensor layer, network layer, service layer, and application layer make up this system. The software failsafe management algorithm could pair with the IoT module combined with the sensor layer ensuring the safety of the data harvested transferring through the network layer to the backend server. The backend server algorithm located at the service later could perform cross check which double check the accuracy of the data collected before presented to the user.

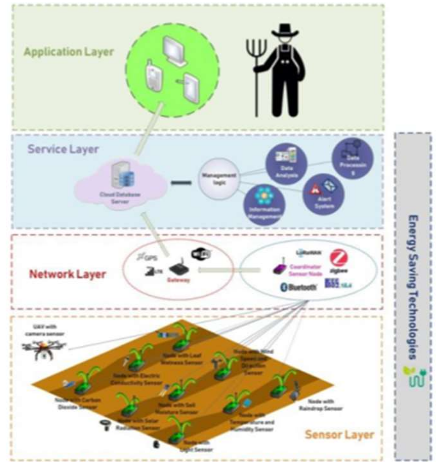

Figure 1: Smart Farming IoT Layer

To provide a more complete picture of farm conditions, the proposed architecture may incorporate additional data sources such as satellite imagery and weather forecasts. The more data fed into the system, the less amount of incorrect result generated from the system [8].

2.3 IOT Module Data Transmission

The development of smart farming has been extremely difficult due to the IoT module's data transmission capabilities. There are several connectivity protocol used by IoT devices such as Wi-Fi, Bluetooth, Zigbee, Lora WAN, NB-IoT and so on. All of them have their ups and downs thus allows them suit different use cases. The critical environment in which the IoT module was installed and the constrained networking resources had a significant impact on the performance and long-term viability of wireless data transmission. According to the results of numerous investigations and research projects carried out by restricted devices and networks will require distinct energy efficiency considerations for the system. The study also offered a system for a multi-layered network that comprises of two networks deployed in the same area with a threshold established to verify the weight payload and separate heavy loads from the primary network or divide into fragments to transfer at a different timeframe. The result were promising presented at Cooja simulator where the energy conserved prolong the lifespan of the battery in the IoT module [9].

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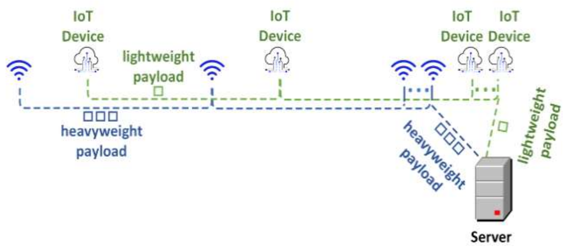

Figure 2: Distributed Network

Besides, previous studies conducted has explored the capability and suitability of ESP32 in the use of smart farming as it is capable of Wi-Fi and Bluetooth capability. The combine use of both technologies allow the network failsafe to be hardware capable [10]. The proposed failsafe management strategy could work with Wi-Fi and uses Bluetooth to achieve nearfield module to module cross check communication and connectivity verification.

2.4 IOT Connectivity Failure

The abrupt failure in connection like an IoT module is one of the more worrying challenges in the field of smart farming IoT integration. Samuel et al. (2016) conducted research and analysis that led them to the conclusion that signalling and bandwidth problems are the most obvious element influencing the smart farming sector in the context of machine to machine (M2M) communication. According to the study, limited bandwidth may lead to less signal loss but lower transfer efficiency [11]. To help ensure that remote IoT devices used in smart farming have more dependable connectivity. Using two separate connectivity types in conjunction is one of the more robust alternatives (transfer tiny but real-time data with low bandwidth solution and accumulative sequential updated data with high bandwidth). An IoT fire alarm system's reliable connectivity strategy has been proposed for utilizing uninterrupted radio frequency (RF) to communicate environmental sensor data to the control panel (FACP). On the other hand, the monitoring data was sent from FACP to the backend over Wi-Fi, which has a larger bandwidth [12].

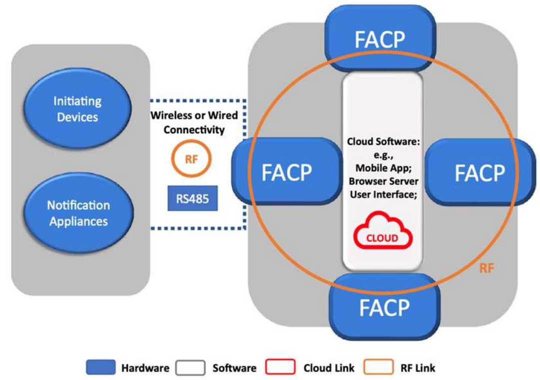

Figure 3: IoT Fire Alarm System Working Hierarchy

2.5 IOT Data Lifecycle

There are several articles discusses the lifecycle of data in an Internet of Things (IoT) system, which includes several stages such as data production, collection, aggregation, filtering, pre-processing, storage, and analysis. Data collection from sensors and aggregation inside the IoT framework is the first step in the process. The collected data is then sent to the hub or gateways where it is further filtered and analysed. Aggregation and fusion techniques are used to compress the volume of data and make it more efficient for transmission. Pre-processing is also necessary to manage missing data and combine data from several sources into a single schema. To ensure data to be organised and stored effectively, and data that is not immediately needed must be archived for long-term preservation. Lastly, data analysis is done to analyse and check the previous data, forecast future patterns, or find anomalies and many more [13].

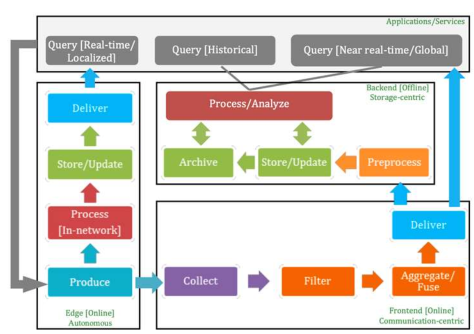

Figure 4: IoT Data Lifecycle

It is clear to say that the Internet of Things (IoT) and artificial intelligence (AI), two emerging technologies, have ushered in a new paradigm for smart farming. These technologies offer creative

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methods for resource optimisation, yield enhancement, and cost reduction—a focus that earlier studies have fully demonstrated.

In this regard, numerous studies have examined the key elements of contemporary farming [4][5], the fundamental elements of IoT architecture in agriculture [6][7], the problems and potential fixes relating to the data transmission from IoT modules [9][10], connectivity issues and potential failsafe mechanisms [11][12], as well as the data lifecycle in IoT systems [13]. These studies taken as a whole have built a strong foundation for comprehending the uses and consequences of IoT and AI in smart farming.

Nevertheless, despite these noteworthy advancements, a number of problems continue, frequently as a result of the intrinsic complexity of these systems. The management of system vulnerabilities, particularly those resulting from power and connectivity losses, is a topic that lacks research in the literature. Given the potentially serious effects of such disruptions on data integrity and the general operation and efficiency of IoT systems, this is a topic that needs more investigation. By concentrating explicitly on these noted issues related to erroneous data in IoT systems for smart farming, our research attempts to further the findings of earlier studies. The realisation that even the most sophisticated IoT devices can malfunction due to unforeseen power and connectivity losses, resulting in inaccurate data collection, transfer, and processing, is what spurred this focus. These errors can therefore have a substantial negative impact on the decision-making and backend control algorithms, resulting in less-than-ideal agricultural results.

In order to protect the integrity of data as well as the general operation and efficiency of the IoT system, we therefore want to explore methods to reduce potential failures and interruptions and to further our understanding of these problems. To do this, we'll look at how IoT systems operate in a variety of failure scenarios, like power outages and connection failures, and we'll propose methods for data saving in these situations as well as for validating the data stored when the system recovers. This will set our work apart from the existing body of research in terms of motivation and findings. Our research strives to strengthen the core basis upon which these functions lie – the reliability and robustness of IoT systems in smart farming. While the majority of current research focuses on leveraging IoT and AI to enhance farm monitoring, resource management, and decision-making processes. Such a strategy, in our opinion, is essential for the development of smart farming going forward since it addresses the "silent" problems that, if not addressed, could weaken the potential advantages of this cutting-edge industry. In doing so, we hope that our work will help smart farming operations remain resilient and sustainable in the face of a world that is becoming more complicated and unpredictable.

3. METHODOLOGY

As the title suggested, in the interest of improving the dependability and performance of smart farming IoT, the research study's objective is to provide a solution enhancing smart farming IoT control system architecture that uses failsafe algorithm management. To achieve this, it is essential to carry out a thorough literature research on the development and implementation of failsafe algorithm management IoT control systems for smart farming. The discovery, selection, and assessment of relevant scholarly literature are all steps in the technique for this literature review. Till today smart farming has become increasingly popular, plenty of researches and case studies were proposed in this field utilizing IoT technology in various smart farming conditions.

3.1 Problem Selection

In order to fill this research gap, our study plans to add a failsafe management algorithm to the IoT module and a second failsafe data processing method to the backend. By preventing data loss at every node, this technique is designed to assure data conservation in the event of power or connection losses. We'll look at these areas to address the following research questions:

1. To study the used of IoT for smart farming systems.
2. To develop the failsafe management algorithm to integrated in IoT for smart farming.
3. To test and evaluate the performance of failsafe management algorithm in IoT for smart farming.

The suggested algorithm can help all IoT-based smart farming systems globally by assuring data integrity and reliability, which will ultimately contribute to better decision-making and increased total production in the agricultural sector.

3.2 Literature Screening Criteria and Search Strategy

We thoroughly scanned the databases in Web of JATIT, IEEE Xplore, and Springers. The keywords given in the abstract were combined with other words to create our search terms.

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The literature selection criteria were:
1. Peer-reviewed articles in scientific journals.
2. Published in English between 2013-2023.
3. Explicit focus on the impact of increased global temperatures on terrestrial animal species diversity.

3.3 Smart Farming powered by advanced IoT Technology

After the introduction of IoT into Smart Farming, A considerable amount of literature has been published on IoT Smart Farming. IoT technology is able to be utilized in many types of farm. These studies has drastically improved the farming efficiency in many ways by the addition of IoT. Most of these studies had implemented AI deep learning to help with the IoT Farm Monitoring system to perform some automated decisive tasks. several systematic reviews and integration of IoT in smart farming have been undertaken in the field of IoT powered smart farming as well. Empirical research conducted concludes the types of data harvested in a smart farm and proposed a use case where big data played its role in the smart farm control system. The paper suggested the usage of machine learning techniques co-operating with the data collected by the sensors proved to be helpful in smart farming data analysis as well [14]. Besides, several systematic reviews and integration of IoT in smart farming have been undertaken in the field of IoT powered smart farming as well. Besides, an IoT based Smart AgroTech system is developed suiting the application of urban farming that considers humidity, temperature, and soil moisture as necessary farming parameters to be collected. With the data, the system can decide the initiation and breakage of the actuators depend on the farm condition which can achieve farm monitoring and remote farm control by farm owner afterwards. The proposed system contained some critical limitations including system incompetence, long data transmission time and potential data loss during wireless transmission [5]. The system uses ESP8266 as their IoT module microcontroller which coped with the current research. The failsafe algorithm and backup storage module recommended as a future development could assist the Agrotech system as the pre-uploaded data could be secured and won't be simply deleted without permissions from the server.

Apart from that, another development done introduced a complete smart farming system packed with farm monitoring, farm automation and growth stage classification of mushroom using AI Image recognition [20]. The mushroom image model trained in the system is highly depended on the accuracy of the image captured and the visual recognition model trained afterwards which guided the farm automation system powered by ESP32 will be corrupted if incorrect data was fed into the system. The scenario was further proven not to be a special case through the research conducted development of an IoT controlled plant disease recognition system. The system uses a low-cost IoT device as IoT smart farm control and data collector which data loss could happen at any time [17]. This technology gets even well known in East Africa according to a paper deducing that east African agriculture is beginning to integrate artificial intelligence (AI) technologies to improve agricultural productivity, connecting farmers to markets, and assist in crop disease identification. Several platforms such as Apollo Agriculture, Tulaa, AGIN, and UjuziKilimo, created to give smallholder farmers access and manage agricultural data. The utilization of big data and the possible bias of AI, on the other hand, might lead to a new kind of colonialism that would govern knowledge and labor. To guarantee that the advantages of smart farming are distributed fairly, critics have asked for greater social justice techniques that take into account societal hierarchies of inequality [18].

Other than that, there are several articles comparing and concluding the mass IoT smart farming approaches and proposed a massive IoT system for the use of smart farming of different state. The article also compared the technological solution and smart farming strategy of both countries towards solving their problem of limited water resources, drastic climate change, water quality, limited human resources and many more [19].

According to the assessment above, there are several applications for IoT technology in smart farming. We can see the difficulties and the research gaps that exist in numerous areas where hardware failsafe technology and software failsafe algorithms could potentially be utilized.

3.4 IOT System Failsafe Strategy

A small sample was chosen because of the expected difficulty in obtaining the strategy of failsafe management algorithm towards IoT powered smart farming applications. A paper proposed discusses a testing pico-hydroelectric plant run in the remote Nepalese town of Moharigaun. To gain control of extra electrical power during periods of low demand, a Prioritized Dump Load Control System (PLCS) was developed and put into use. The extra electricity is put to good use by the locals, who

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prioritise heating water tanks and methane digesters. To protect the charge controllers and system from harm caused by power outages or excessive voltage as the electricity usage of the village was not consistent throughout the day, a failsafe subsystem has been created and put into use. It was a compact IoT system thus the monitored data is stored in a MySQL database on a computer, and visualized using a web page hosted by an Apache server running on the same computer. For hydroelectric power plants to run safely and effectively, the Failsafe dump load carrier board is essential. It help protect the hydro-hydroelectric system from harm and lowers the probability of electrical breakdowns by directing excess power into a heat bath or back into the river. A crucial part of the PLCS (Power Load Control System) utilised in the proposed hydroelectric power plant is the Failsafe dump load carrier board shown in the figure below. It makes sure that extra power produced by the turbines is securely dissipated, avoiding system damage and lowering the possibility of electrical fires [16].

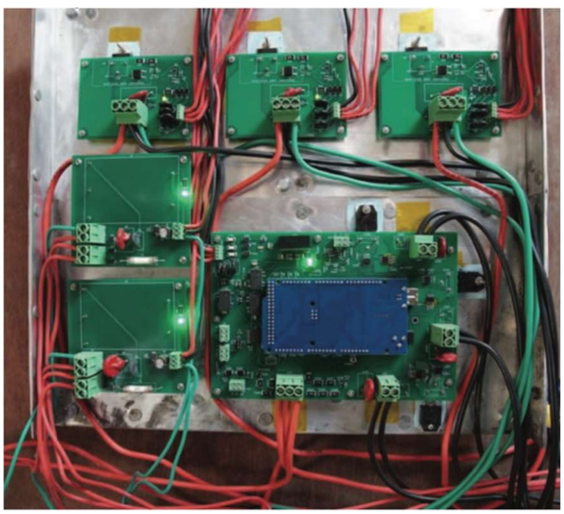

Figure 5: Power Load Control System Hardware Overview

3.5 IOT Backend Data Management

There are several advantages of using failsafe in IoT backend data handling. Preventing and reducing downtime is one of the key advantages. Farm owners may make sure that their IoT systems continue to function even in the case of failures or outages by putting failsafe measures in place, such as redundancy, backups, and disaster recovery plans. The improvement of data correctness and dependability is another reason why of failsafe IoT data handling is necessary especially in smart farming as real-time accurate data is required by further processes node. Any cluster of incorrect data may cause chronic issue to the automation system. A proposed research regarding the use of IoT devices to monitor and foresee conveyor belt maintenance requirements in the conveyor belt sector could clearly prove our point. In order to manage and combine data from many sources, including IoT devices, ERP systems, and CRM systems, the article suggests using a Cloud Storage Hub (CSH). The paper also discusses the difficulties associated with combining and aggregating data from various sources and suggests a procedure for establishing and operating a CSH for Enterprise Data Management [13].

A complimentary research has suggested a IoT backend data management framework which would play an important role in smart farming IoT use case. The proposed framework for IoT data management consists of six layers that map closely to the phases of the IoT data lifecycle. These layers include the Things Layer, Communication Layer, Data/Sources twin layers, Federation Layer, Query Layer, and Application/Analysis Layer. The Things Layer is concerned with the storage of temporary data, whereas the Data Layer is the central component of data management and is concerned with durable data storage. Federated data management entails the independent administration of local sites' data, with optional membership in the data federation available only when resources permit such membership. When their energy-constrained resources let it, the many sub-systems can then join a database federation if they believe their data is pertinent to a query [19].

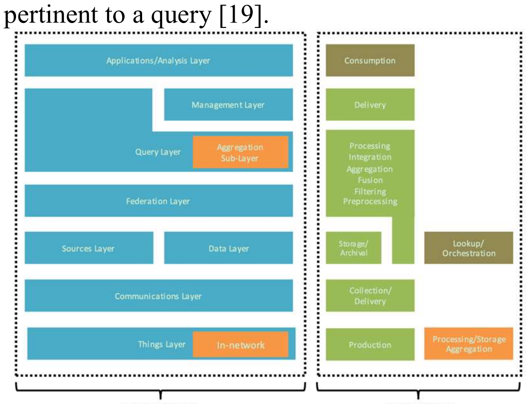

Figure 6: Improved IoT Data Lifecycle

A thematic approach will be used to examine and synthesise the data gathered from the chosen research. The architecture of IoT control systems for smart farming, the design and implementation of failsafe algorithms, and the difficulties and possibilities related to implementing these systems in agriculture are some of the subjects that will be examined in the literature study.

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3.6 Research Gap

As it has been the literature on IoT in smart farming offers significant insights on a variety of topics. However, there is still a glaring gap in the literature about the application of failsafe management algorithms created especially for IoT systems used in smart farming. This gap is particularly obvious when considering how to guarantee data accuracy and conservation in the event of power and connectivity disruptions. Therefore, the goal of our research is to close this gap by creating and implementing a reliable failsafe management algorithm that can successfully handle connectivity and power outages in a smart farming IoT system, ensuring data accuracy and preservation even under challenging circumstances.

4. RESULTS

Based on our review on the topic of Smart Farming IoT, we can conclude that majority of the research focuses on using IoT in smart farming automation and to collect data to train the smart farming artificial intelligent (AI) model. The goals are mostly to utilise the self-decision and self-control. The result shown in the research which has tested the IoT system with a designed rig powered by ESP8266 was as below. The average error was further reduced to 2.59% compared to 2.93% initially.

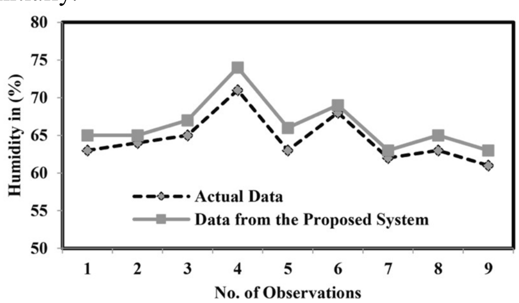

Figure 7: Humidity Comparison

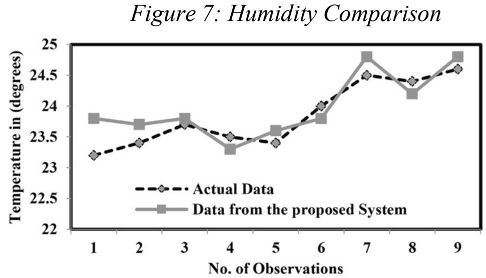

Figure 8: Temperature Comparison

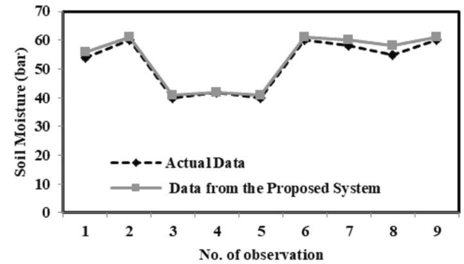

Figure 9: Soil Moisture Comparison

The paper also mentioned that the graphs above illustrate the deviation of actual data and proposed system data, with little displacement observed for soil moisture, greater displacement for temperature, and displacement due to technical inaccuracy and lack of sensitivity for humidity. The inaccuracy is drastically improved when compared with the 'ThingSpeak' measurement [5].

Furthermore, the experiment and test performed to test out the failsafe system included IoT Hydro-electric system had met their expected improvement. The remote Nepalese community of Moharigaun successfully deployed the power loss control system, with the exception of a few minor packet loss-related difficulties that have eventually been fixed. The system has been running for a year, producing up to 6.6kW of power without any issues, and by providing the villagers access to energy for lights and hot water, it has enhanced their quality of life. Due to the system's effectiveness, authorities from the local government and communities around have expressed interest in expanding the concept and lowering expenses [19].

5. SUMMARY OF FINDINGS

By utilising cutting-edge technology like sensors, automation, and data analytics, IoT smart farming is quickly replacing conventional farming methods. Yet, a failsafe management system at both the perception layer and the network layer is necessary to guarantee the success of IoT smart agricultural systems. A failsafe management system at the perception layer would ensure that the sensors and devices are functioning correctly and that any issues or malfunctions are detected and addressed in a timely manner. More importantly, a failsafe management system deployed at the network layer would ensure that the network is functioning optimally, and that any disruptions or failures are quickly detected and resolved. This is particularly important for critical systems such as irrigation and climate control, where even a small disruption can have a significant impact on crop yields. Instead of

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utilizing a more advance or suitable network protocol, the failsafe management system and IoT module optimization which focusing on Arduino IDE supported devices inspired by this review could assist the smart farming IoT module by conserving the data collected during poor connection periods. With an accurate data input, the performance of the following systems down the line could be drastically improved. This raises interest to the research of which the failsafe management system's workload can be separated into different parts of the system while individual module failsafe algorithms will be implemented. This review have given a better picture for researchers towards the current trend and development stages of smart farming IoT. The limits and challenges were clear and were believed could be improved after the utilization of the failsafe management system. The literatures proposed a complete system development were listed below

Table 1: List of Inspiring Articles, their Data Source, Type of studies, Objectives and Result.

Article and Source	Type of Study	Objectives	Result
IoT based smart agrotech system for verification of Urban farming parameters	Development	Implement IoT work with Agrotech into urban farm	Data collection error minimize to under 3%
IoT enabled mushroom farm automation with Machine Learning to classify toxic mushrooms in Bangladesh	Development	Using IoT as data collection media on an AI visual powered farm automation	Reaches 100% highest accuracy with six ensemble classifier. The system usability scale score is 82%
AgroLens: A low-cost and green-friendly Smart Farm Architecture to support real-time leaf disease diagnostics	Development	Implement machine vision to identify leaf disease	Accuracy reach 97.42% achieved by AlexNet

5.1 Scope of the Review

This research and review focused on Smart Farming IoT Systems running on microprocessor supporting wireless connectivity and build-in flash memory, which may limit the generalizability of our conclusions to systems using different hardware or software configurations. This is due to IoT systems are highly complex and their performance and reliability can be influenced by a wide range of factors, from network reliability and sensor accuracy to power supply stability and software robustness. While our review attempted to take a holistic approach, it was not possible to cover all these aspects in depth.

6. CONCLUSIONS:

The incorporation of failsafe methods for organising information at the level of both IoT modules and the backend server is the main emphasis of this literature review as it navigates the challenging landscape of IoT Smart Farming systems. Our research highlights the importance of this element in assuring a revolutionary and sustainable future for agriculture. This complex interplay is essential to the success and resilience of the modern farming environment.

The results demonstrate that successful smart agricultural systems are built on precision and reliability of data inputs. The importance of components like ESP32 and ESP8266 modules, which serve as the vital channel for sending data obtained from sensors to the cloud, is emphasised. However, the majority of present system architectures glaringly lack failsafe data management solutions, making these systems vulnerable to data loss or failure and jeopardising the sustainability and productivity improvements promised by smart farming.

The implementation of failsafe data management systems becomes more of a requirement than a luxury in order to close this gap and reduce the vulnerabilities of IoT Smart Farming systems. Robust backend data checking algorithms must be added to these systems to ensure proper data transfer during network outages. These algorithms must be able to monitor data flow in real-time and detect any errors or inconsistencies. The presence of a power outage detection mechanism is essential to reinforce the system against data loss. The success of IoT-integrated smart farming is dependent on these parameters, which promise improved system dependability and resilience.

This evaluation sets the path for future research to concentrate on creating customised failsafe data management systems that can adapt to the varied needs and circumstances of various agricultural landscapes by identifying these shortcomings and potential solutions. This procedure will undoubtedly accelerate the development of IoT solutions for smart farming, putting us one step closer to realising a modern and resilient agricultural sector.

In conclusion, the adoption of reliable and durable failsafe data management solutions is crucial for the smooth transition from conventional farming practises to an IoT-integrated paradigm. It is crucial to make sure that failsafe management systems become a staple of the architecture of IoT Smart Farming systems as we go towards this technologically sophisticated future. By doing this, we not only protect agricultural productivity and sustainability, but also lay a solid groundwork for the enormous potential of smart farming to be fully realised.

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