STM JOURNALS

Recent Trends in
Sensor Research & Technology

ISSN: 2393-8765
Volume 11, Issue 3, 2024
September–December
DOI (Journal): 10.37591/RTSRT

https://journals.stmjournals.com/rtsrt

Review RTSRT

Sensor and IoT-centered Smart Agriculture by NodeMCU

Kazi Kutubuddin Sayyad Liyakat[1,*]

Abstract

A style of farming that makes use of technology and data to maximize the throughput and efficiency of farming techniques is stated to as smart agriculture. This method of farming is also often referred to as precision farming or digital farming. The fact that this invention in the agricultural sector has the impending to radically transmute how users cultivate and produce food makes it an extremely hopeful and exciting development. Although Internet of Things (IoT) sensors can collect data regarding agricultural areas and respond appropriately based on customer input, the concept of smart agriculture is still in its infancy. The purpose of this study is to propose the creation of a smart agriculture system that makes use of cutting-edge tools like IoT, NodeMCU, and wireless sensor networks (WSN). To accomplish the purpose of the paper, automation, and developing technologies, like IoT and smart agriculture, will be utilized. Keeping a close eye on the conditions in the surrounding area is one of the most important strategies to boost the quantity of successful crops that are produced. Within the scope of this work, the development of a system that monitors moisture, temperature, and humidity through the utilization of sensors based on a NodeMCU is discussed.

Keywords: NodeMCU, IoT, sensor, smart agriculture, temperature sensor, humidity sensor

INTRODUCTION

Smart agriculture is a farming approach that exploits technology and data to optimize the efficiency and productivity of farming practices [1–5]. This emerging trend in agriculture engineering has impended the need to transfigure the way we cultivate and harvest food, making it a highly promising and exciting development. The most noteworthy role of smart agriculture is to decrease waste and increase crop yields [6, 7]. Farmers can use drones, sensors, and additional cutting-edge tools to gather information on crop health, nutrient levels, and soil moisture, enabling them to make defensible choices [8–10], irrigation, fertilization, and other inputs. This precision farming approach guarantees that crops obtain the exact resources they need, resulting in healthier plants and higher yields.

Furthermore, smart agriculture can lead to more workable and ecologically friendly agribusiness practices. With the support of data and technology, farmers can lessen their usage of herbicides, fertilizers, and pesticides, minimizing their impression of the environment and preserving natural resources. This not only harms the planet but also reduces costs for farmers in the long run [11–14].

In addition to improving crop production and sustainability, smart agriculture offers several economic benefits. By optimizing inputs and reducing waste, farmers can save costs and increase profits. The use of automation and robotics in farming can also lead to reduced labor costs and increased efficiency, allowing farmers to focus on supplementary aspects of their maneuvers [15–20]. Another advantage of smart agriculture is its

*Author for Correspondence
Kazi Kutubuddin Sayyad Liyakat
E-mail: drkkazi@gmail.com

Professor and Head, Department of Electronics and Telecommunication Engineering, Brahmdevdada Mane Institute of Technology, Solapur, Maharashtra, India

Received Date: September 12, 2024
Accepted Date: September 16, 2024
Published Date: September 25, 2024

Citation: Kazi Kutubuddin Sayyad Liyakat. Sensor and IoT-centered Smart Agriculture by NodeMCU. Recent Trends in Sensor Research & Technology. 2024; 11(3): 24–32p.

potential to improve food safety and traceability. With the use of sensors and tracking systems, can farmers observe and record the entire production process, from seed to harvest, ensuring the care and worth of their products? This can be especially beneficial for consumers who are increasingly concerned about the sources and quality of their food [21–24].

Nonetheless, like any new tool, smart agriculture also has challenges and limitations. Early investment in equipment and technology may be expensive for some farmers, making them inaccessible for smaller operations. Additionally, there may be a learning curve for farmers to understand and effectively utilize data and technology [25].

The idea of "smart agriculture" has the power to revolutionize how we manage our natural resources and produce food. It offers numerous benefits, such as increased yields, reduced waste, and improved sustainability, making it a promising solution to the challenges facing the agriculture industry. With further advancements and the adoption of this technology, we may create a more efficient, sustainable, and secure food system for the future. This raises the question of how we can achieve this. What elements are required? Here, we must have a basic understanding of electronics, programming, and NodeMCUs [26].

The integration of IoT in smart agriculture systems has transformed the way farming and food production are approached. Gone is the day of relying solely on traditional farming methods and human labor, and farmers can use cutting-edge technology to monitor and manage their crops and livestock with precision and efficiency. As someone passionate about sustainable agriculture and the future of farming, I am excited to share my thoughts on IoT in smart agriculture systems [27].

First, the use of IoT in agriculture has greatly improved the overall productivity and profitability of farms. With sensors, drones, and other IoT devices, agriculturalists can collect real-time data on the temperature, humidity, soil moisture, and other vital factors that affect crop growth. This enables farmers to decide on pest management, fertilization, and irrigation with knowledge, resulting in healthier and more abundant crops. In addition, IoT devices may monitor livestock health and comfort, enabling farmers to provide timely care and improve animal welfare.

Furthermore, the use of IoT in agriculture has significantly reduced the environmental impact of farming. By accurately measuring and controlling inputs, such as water and fertilizers, farmers can minimize waste and prevent overuse, which leads to soil degradation and water pollution. This not only benefits the environment but also helps farmers save on costs and increase their profits. Furthermore, IoT devices can detect changes in weather patterns and alert farmers to potential risks, allowing them to take preventive measures and mitigate the impact of natural disasters on their crops [28].

The most impressive aspect of the IoT in smart agriculture systems is its capability to automate many labor-intensive tasks. Through the use of smart sensors and actuators, farmers can remotely control irrigation systems, adjust lighting and temperature in greenhouses, and operate machinery. This not only lone hoards time and physical labor for farmers but also allows for more precise and efficient resource management [29]. Farmers can make data-driven choices for future scheduling and optimization by analyzing the data gathered by IoT devices to find patterns and tendencies. Of course, similar to any technology, there are also some issues and concerns related to IoT use in agriculture. The initial cost of implementing IoT devices and the need for reliable internet connectivity in rural areas may be barriers for some farmers. There are also concerns about information privacy and security, as sensitive information about farming practices and crop yields is collected and stored [30]. However, these challenges can be addressed and managed using appropriate regulations and protocols.

INTERNET OF THINGS

IoT is a rapidly growing phenomenon that revolutionizes how we live and cooperate with technology. As consumers, we have been able to experience the benefits of IoT firsthand, and we must say, we are

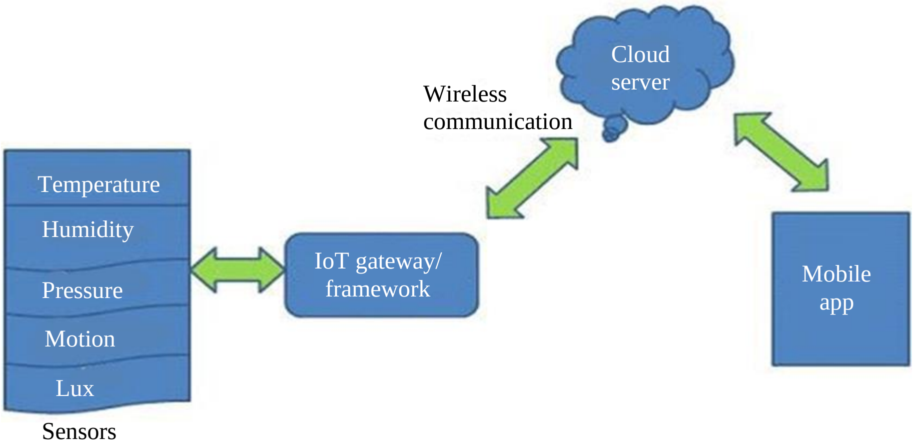

Figure 1. IoT structure.

impressed. First, the convenience that IoT brings to our daily lives is unparalleled. With the use of smart devices such as speakers, thermostats, and home security systems, I can control and monitor my home from anywhere in the world. This has not only made my life easier but also more efficient, as I no longer must worry about forgetting to turn off the lights or adjust the temperature before leaving the house [31]. The IoT structure is illustrated in Figure 1.

Moreover, the integration of IoT in various industries has greatly improved efficiency and productivity. For instance, in healthcare, the use of wearable devices and sensors has allowed remote patient monitoring, leading to faster diagnosis and better treatment. In farming, IoT sensors collect records of soil moisture and temperature, helping farmers make informed decisions about irrigation and crop management. These are just a few examples of how IoT is transforming industries and making our world a better place [32].

However, as with any new technology, there are concerns regarding privacy and security. With the huge amount of data collected and transmitted through IoT devices, there is a jeopardy of this information dwindling into incorrect hands. It is crucial for companies to prioritize security measures and for individuals to be aware of risks and take necessary precautions. Overall, we believe that the benefits of IoT far outweigh these concerns. There is immense potential for innovation and improvement in various aspects of our lives. As we continue to see advancements and developments in this field, I am excited to see how IoT will continue to shape our future [33].

PROPOSED SYSTEM

The projected system block configuration of the smart agriculture system using NodeMCU [34] is shown in Figure 2. In this system, we proposed or employed four moisture sensors [35], 1-temperature sensor [36], and 1-humidity sensor [37] connected to NodeMCU-2 [38].

Components Required

- NodeMCU-2
- PCB [39]
- 4-channel ADC [40]
- Moisture sensor [41]
- DHT11 [42]

Steps of Connection and Experimentation

1. Must upload the code after creating all of the connections.
2. Attach the NodeMCU Vin to every Soil Moisture Sensor Vcc.
3. Attach the NodeMCU Vin to the Multiplexer Vcc.

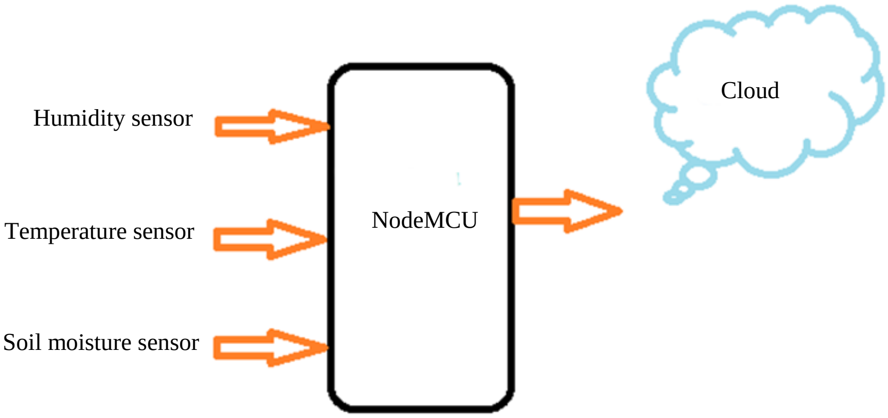

Figure 2. Proposed system structure.

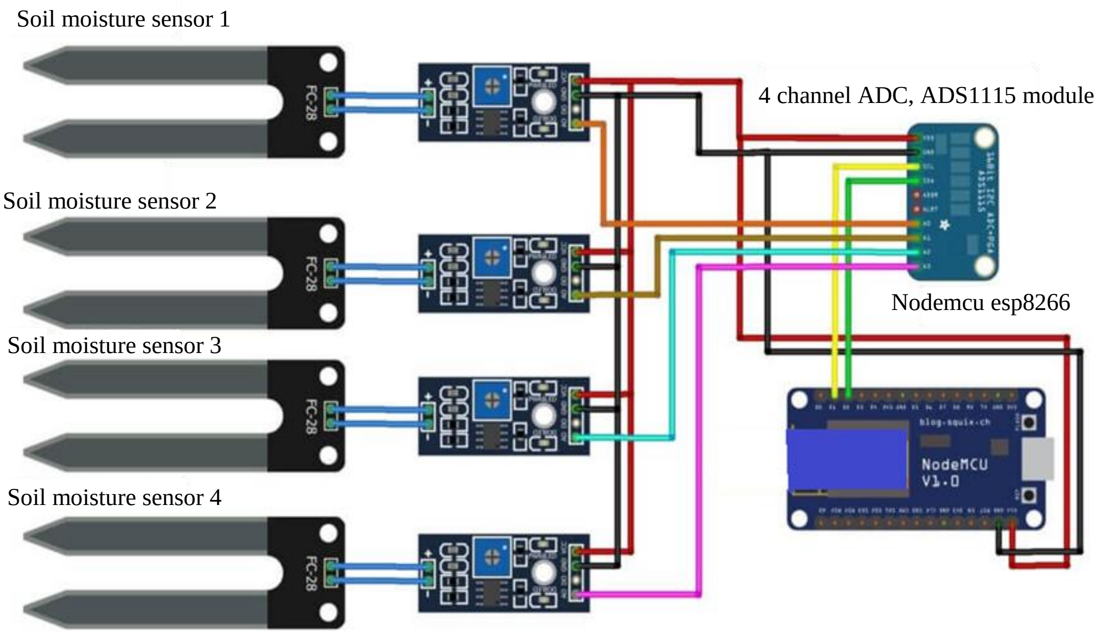

Figure 3. Soil moisture sensor connection.

4. Attach the ADC multiplexer's GND to the NodeMCU GND and all the soil moisture sensors ground to the NodeMCU GND.
5. As shown in Figure 3, the multiplexer was connected to the output of the soil moisture sensor.
6. Connect other sensors like temperature and humidity to NodeMCU as shown in Figure 3.
7. Attach NodeMCU d3's DHT 11 output pin to it.
8. The output of soil moisture sensors is coupled to A0.
9. Attach NodeMCU Vin to the DHT 11 Vcc.
10. Link NodeMCU GND to the DHT 11 GND.

RESULTS AND DISCUSSION

Once the connections are finished, as shown in Figures 3 and 4, the link transfers the specified code (Figure 5) to NodeMCU. Initially, the Thing Speak Channel (Figure 6) was created for a smart agriculture system using IoT. The sensor output is displayed on the channel created, as shown in Figure 7.

Smart agriculture using IoT holds immense potential for transforming agricultural practices and enhancing efficiency, sustainability, and food security [43]. However, overcoming the challenges of cost, data management, and technical expertise is paramount for successful implementation. Addressing

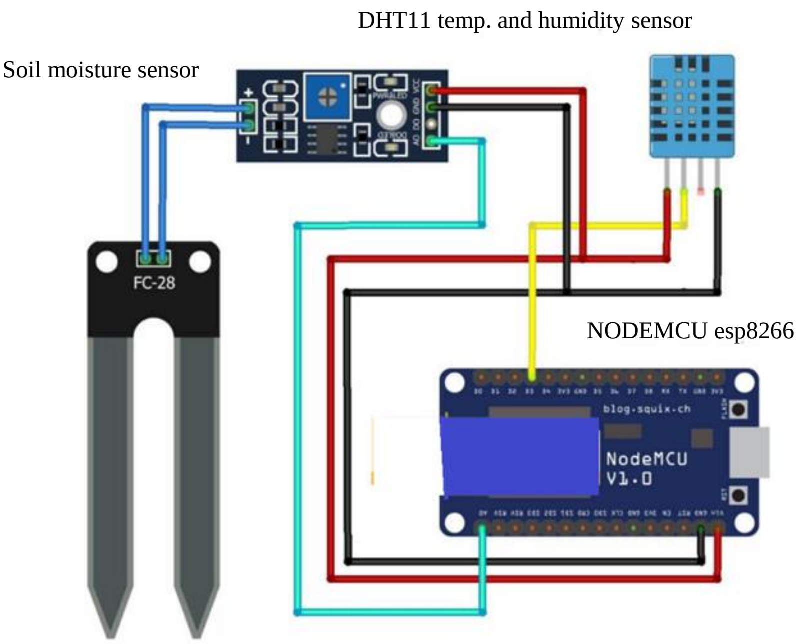

Figure 4. Sensors connections with NodeMCU.

```
#include <ESP8266WiFi.h>
#include <ESP8266HTTPClient.h>
#include <Adafruit_ADS1015.h>
WiFiClient client;
String thingSpeakAddress= "http://api.thingspeak.com/update?";
String writeAPIKey;
String tsfield1Name;
String request_string;
HTTPClient http;
 Adafruit_ADS1115 ads;
void setup()
{
 Serial.begin(115200);
 delay(3000);
 WiFi.disconnect();
 Serial.println("START");
 WiFi.begin("DESKTOP","asdfghjkl");   // Wifi ("ID","Password")
 while ((!(WiFi.status() == WL_CONNECTED))){
 delay(300);
 Serial.println("...");
```

Figure 5. Code for NodeMCU.

ethical concerns and mitigating potential societal disruptions is critical. By embracing innovation while addressing existing experiments, we can unlock the full latent of smart agriculture to form a more sustainable and resilient food system for the future.

The core of smart agriculture lies in its capability to collect and analyze huge amounts of records from sensors deployed across farms [44]. These sensors, connected to the internet, can monitor crucial parameters such as soil moisture, temperature, light intensity, and even crop health.

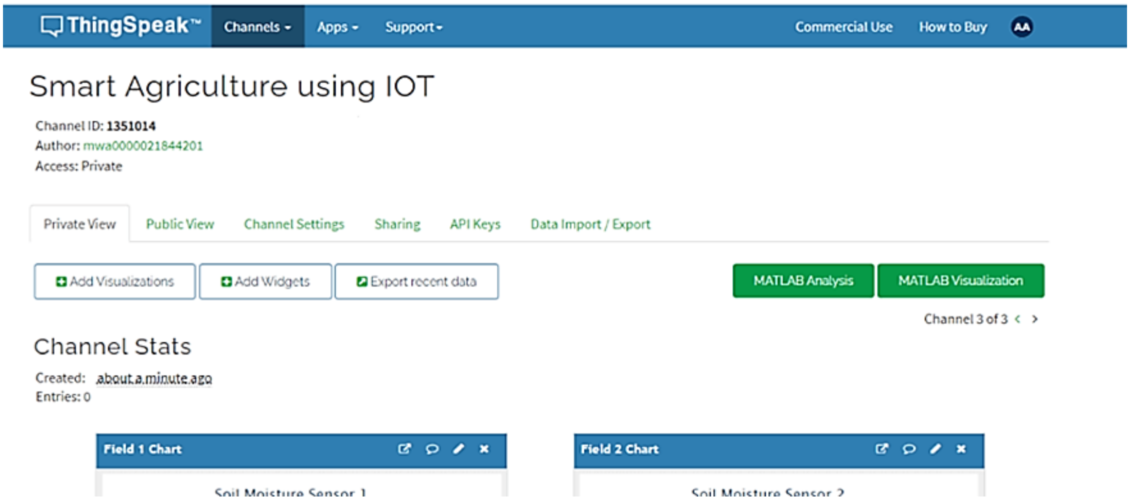

Figure 6. Things speak of the proposed system.

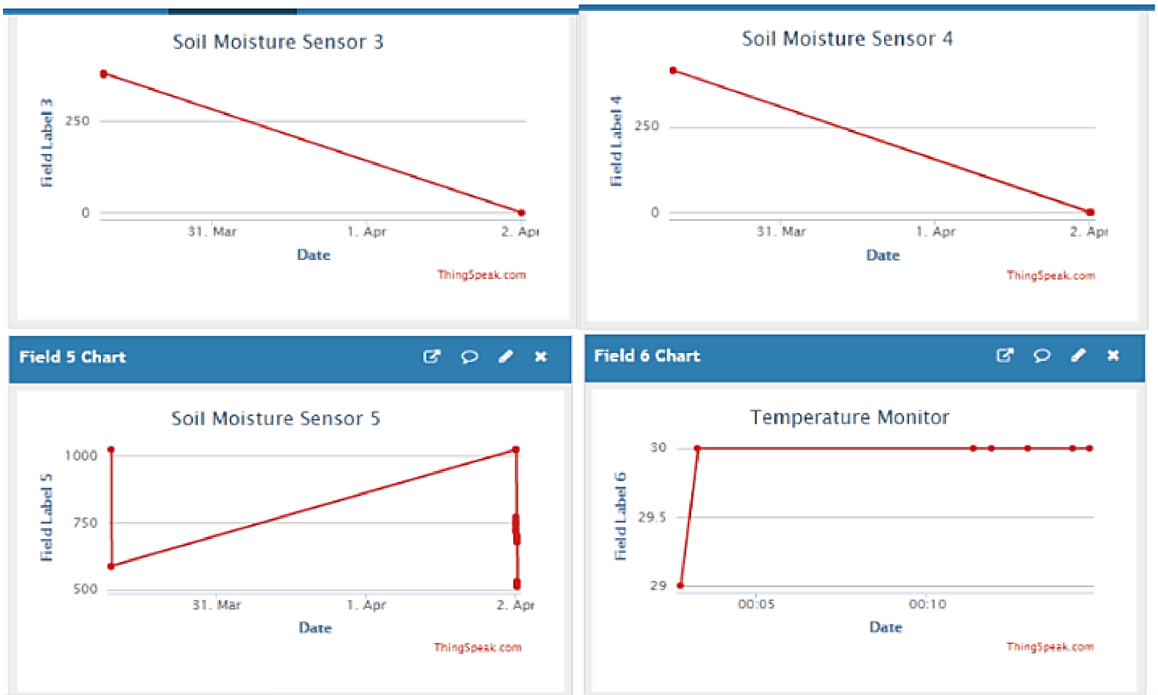

Figure 7. Output of system.

Although the allure of data-driven insights is immense, the human element remains crucial. Smart agriculture tools equip farmers with valuable information, but it is their expertise and understanding that translate these data into actionable strategies. This calls for a shift in mindset, from reactive to proactive, and from intuition to data-driven decision-making [45].

Addressing these challenges requires collaborative efforts among governments, research institutions, and private companies. Initiatives such as promoting digital literacy, providing financial incentives, and developing open-source data platforms can accelerate smart agriculture adoption.

The following are some of the key benefits of smart agriculture:

- *Enhanced efficiency:* IoT sensors monitor various environmental factors, such as soil moisture, temperature, and light levels. This real-time data allows for optimized irrigation, fertilization, and pest control, minimizing resource wastage and maximizing yields.

- *Improved resource management:* By leveraging data from sensors, farmers can achieve precision in resource utilization. These include targeted water usage, efficient fertilizer application, minimized pesticide use, boosted sustainability, and reduced environmental impact.
- *Predictive analytics:* Data analysis of sensor readings coupled with weather forecasts enables farmers to predict crop health, disease outbreaks, and potential yield losses. This allows proactive interventions and mitigation strategies to prevent financial losses and ensure crop security.
- *Remote monitoring and control:* IoT devices allow farmers to remotely monitor their fields and manage operations from anywhere with an internet connection. This enables timely intervention, reduces labor costs, and allows efficient resource allocation.
- *Increased transparency and traceability:* Smart Agriculture systems can track each stage of the agricultural process from seeding to harvesting. This provides greater transparency throughout the supply chain and enables consumers to make more knowledgeable choices.

CONCLUSION

The environmental impact of farming has been greatly mitigated by the use of IoT in agriculture. Farmers can reduce waste and avoid overuse, which can result in soil degradation and water pollution, by precisely measuring and managing inputs such as water and fertilizers. This helps farmers save expenses and boost their earnings in addition to helping the environment. IoT devices can also identify variations in weather patterns and warn farmers of possible hazards, enabling them to take precautions and reduce the effects of natural disasters on their crops. The integration of IoT into smart agriculture systems has brought about many benefits and opportunities for the agricultural industry. From increased productivity and profitability to improved environmental sustainability and automation, the impact of the IoT on farming is undeniable. For IoT security, we will propose a KK approach in the future, and we will work on the AI IoT-based agriculture sector and the KSK approach for the agriculture sector.

REFERENCES

1. Liyakat KKS. Machine learning approach using artificial neural networks to detect malicious nodes in IoT networks. In: Udgata SK, Sethi S, Gao XZ, editors. Intelligent Systems: Proceedings of 3rd International Conference on Machine Learning, IoT and Big Data (ICMIB 2023). Singapore: Springer Nature; 2024. p. 123–34. DOI: 10.1007/978-981-99-3932-9_12.
2. Pradeepa M, Jamberi K, Sajith S, Bai MR, Prakash A, Kutubuddin SKL. Student health detection using a machine learning approach and IoT. In: Mysore subsection International Conference (MysuruCon). IEEE; 2022. DOI: 10.1109/MysuruCon55714.2022.9972445.
3. Liyakat KKS. Detecting malicious nodes in IoT networks using machine learning and artificial neural networks. In: International Conference on Emerging Smart Computing and Informatics (ESCI). Pune, India. 2023. p. 1–5. DOI: 10.1109/ESCI56872.2023.10099544.
4. Kasat K, Shaikh N, Rayabharapu VK, Nayak M, Sayyad LK. Implementation and recognition of waste management system with mobility solution in smart cities using Internet of things. In: Second International Conference on Augmented Intelligence and Sustainable Systems (ICAISS). Trichy, India: IEEE; 2023. p. 1661–5. DOI: 10.1109/ICAISS58487.2023.10250690.
5. Liyakat KKS. Machine learning approach using artificial neural networks to detect malicious nodes in IoT networks. In: Shukla PK, Mittal H, Engelbrecht A, editors. Computer Vision and Robotics: Proceedings of CVR 2023. Singapore: Springer Nature; 2023. p. 27–37. DOI: 10.1007/978-981-99-4577-1_3.
6. Kazi K. AI-driven IoT (AIIoT) in healthcare monitoring. In: Nguyen TVT, Vo NTM, editors. Using traditional design methods to enhance AI-driven decision-making. Hershey, PA: IGI Global; 2024. p. 77–101. DOI: 10.4018/979-8-3693-0639-0.ch003.
7. Kazi K. Modelling and simulation of electric vehicle for performance analysis: BEV and HEV electrical vehicle implementation using Simulink for E-mobility ecosystems. In: Kassarwani V, Nagpal N, editors. Hershey, PA: IGI Global; 2024. p. 295–320. DOI: 10.4018/979-8-3693-2611-4.ch014.
8. Kazi KS. Computer-aided diagnosis in ophthalmology: A technical review of deep learning applications. In: Garcia MB, Almeida RP, editors. Transformative approaches to patient literacy and healthcare innovation. Hershey, PA: IGI Global; 2024. p. 112–35. DOI: 10.4018/979-8-3693-3661-8.ch006.

9. Magadum PK. Machine learning for predicting wind turbine output power in wind energy conversion systems. Grenze Int J Eng Technol. 2024;10:2074–80.
10. Nerkar PM, Dhaware BU. Predictive data analytics framework based on heart healthcare system (HHS) using machine learning. J Adv Zool. 2023;44(Sp Issue):3673–86.
11. Neeraja P, Kumar RG, Kumar MS, Liyakat KKS, Vani MS. DL-based somnolence detection for improved driver safety and alertness monitoring. In: IEEE International Conference on Computing, Power and Communication Technologies (IC2PCT). Greater Noida, India: IEEE; 2024. p. 589–94. DOI: 10.1109/IC2PCT60090.2024.10486714.
12. Liyakat KKS. Explainable AI in healthcare. In: Kamaraj AA, Acharjya DP, editors. Explainable artificial intelligence in healthcare system. 2024. ISBN: 979-8-89113-598-7. DOI: 10.52305/GOMR8163.
13. Liyakat KS. ChatGPT: An automated teacher’s guide to learning. In: Bansal R, Chakir A, Ngah HF, Rabby F, Jain A, editors. AI algorithms and ChatGPT for student engagement in online learning. Hershey, PA: IGI Global; 2024. p. 1–20. DOI: 10.4018/979-8-3693-4268-8.ch001.
14. Veena C, Sridevi M, Liyakat KKS, Saha B, Reddy SR, Shirisha N. HEECCNB: An efficient IoT-cloud architecture for secure patient data transmission and accurate disease prediction in healthcare systems. In: Seventh International Conference on Image Information Processing (ICIIP). Solan, India: IEEE; 2023. p. 407–10. DOI: 10.1109/ICIIP61524.2023.10537627.
15. Prasad KR, Karanam SR, Ganesh D, Liyakat KKS, Talasila V, Purushotham P. AI in public-private partnership for IT infrastructure development. J High Technol Manag Res. 2024;35:100496. DOI: 10.1016/j.hitech.2024.100496.
16. Nagrale M, Pol RS, Birajadar GB, Mulani AO. Internet of robotic things in cardiac surgery: An innovative approach. Afr J Biol Sci. 2024;6:709–25. DOI: 10.33472/AFJBS.6.6.2024.709-725.
17. Kazi KSL. IoT driven by machine learning (MLIoT) for the retail apparel sector. In: Tarnanidis TK, Papachristou E, Karypidis M, Ismyrlis V, editors. Driving green marketing in fashion and retail. Hershey, PA: IGI Global; 2024. p. 63–81. DOI: 10.4018/979-8-3693-3049-4.ch004.
18. Kazi KSL. Machine learning (ML)-based braille Lippi characters and numbers detection and announcement system for blind children in learning. In: Sart G, editor. Social reflections of human-computer interaction in education, management, and economics. Hershey, PA: IGI Global; 2024. p. 16–39. DOI: 10.4018/979-8-3693-3033-3.ch002.
19. Kazi KSL. Artificial intelligence (AI)-driven IoT (AIIoT)-based agriculture automation. In: Satapathy S, Muduli K, editors. Advanced computational methods for agri-business sustainability. Hershey, PA: IGI Global; 2024. p. 72–94. DOI: 10.4018/979-8-3693-3583-3.ch005.
20. Kutubuddin K. Vehicle health monitoring system (VHMS) by employing IoT and sensors. Grenze Int J Eng Technol. 2024;10:5367–74.
21. Kutubuddin K. A novel approach on ML based palmistry. Grenze Int J Eng Technol. 2024;10:5186–93.
22. Kutubuddin K. IoT based boiler health monitoring for sugar industries. Grenze Int J Eng Technol. 2024;10:5178–85.
23. Gupta B, Kumar PK, Singh A, Sabharwal R, Asokan P. The role of artificial intelligence in driving agricultural revolution. J Agric Eng Res Technol. 2024;3:221–9.
24. Kazi KSL. Machine learning-based pomegranate disease detection and treatment. In: Zia Ul Haq M, Ali I, editors. Revolutionizing pest management for sustainable agriculture. Hershey, PA: IGI Global; 2024. p. 469–98. DOI: 10.4018/979-8-3693-3061-6.ch019.
25. Khadake SB, Patil VJ. Prototype design & development of solar based electric vehicle. In: Proceedings of the 3rd International Conference on Smart Generation Computing, Communication and Networking (SMART GENCON); 2023 Aug 23-25; Bangalore, India. IEEE; 2023. p. 1–7. DOI: 10.1109/SMARTGENCON60755.2023.10442455.
26. Patil VJ, Khadake SB, Tamboli DA, Mallad HM, Takpere SM, Sawant VA. Review of AI in power electronics and drive systems. In: Proceedings of the 3rd International Conference on Power Electronics and IoT Applications in Renewable Energy and its Control (PARC); 2024 Feb 23-25; Mathura, India. IEEE; 2024. p. 94–9. DOI: 10.1109/PARC59193.2024.10486488.

27. Khadake SB. Detecting salient objects of a natural scene in A video using spatiotemporal saliency & color map. JournalNX - A Multidisciplinary Peer Reviewed Journal. 2021;2:30–5. 28. Dolli SP, Rathod KS, Waghmare OP, Deshpande AV. An overview of intelligent traffic control system using PLC and use of current data of vehicle travels. JournalNX - A Multidisciplinary Peer Reviewed Journal. 2021;1–4
28. Khadake SB. Detecting salient objects of a natural scene in A video using spatiotemporal saliency & color map. JNX. 2021;2:30–5.Dolli SP, Rathod KS, Waghmare OP, Deshpande AV. An overview of intelligent traffic control system using PLC and use of current data of vehicle travels. JournalNX - A Multidisciplinary Peer Reviewed Journal. 2021;1–4.
29. Patil VJ, Khadake SB, Tamboli DA, Mallad HM, Takpere SM, Sawant VA. A comprehensive analysis of artificial intelligence integration in electrical engineering. In: Proceedings of the 5th International Conference on Mobile Computing and Sustainable Informatics (ICMCSI); 2024 Mar 12-14; Lalitpur, Nepal. IEEE; 2024. p. 484–91. DOI: 10.1109/ICMCSI61536.2024.00076.
30. Khadake S, Kawade S, Moholkar S, Pawar M. A review of 6G technologies and its advantages over 5G technology. In: Pawar PM, Ronge BP, Gidde RR, Pawar MM, Misal ND, Budhewar AS, More VV, Reddy PV, editors. Techno-Societal 2022. Cham: Springer International Publishing; 2024. p. 1043–51. DOI: 10.1007/978-3-031-34644-6_107.
31. Dudgikar B, Akbar Ingalgi AA, Gensidha Jamadar A, Onkar Rameshchandra Swami, Suhas Balram Khadake, Shreya Vikram Moholkar. Intelligent battery swapping system for electric vehicles with charging stations locator on IoT and cloud platform. Int J Adv Res Sci Commun Technol. 2023;3:204–8. DOI: 10.48175/IJARSCT-7867.
32. Padavale P, Dhere M, Bharati M Lingade. Automatic hand dispenser and temperature scanner for Covid-19 prevention. Int J Adv Res Sci Commun Technol. 2023;3:362–7. DOI: 10.48175/IJARSCT-11364.
33. Suhas B. Detecting salient objects in a video by using spatio-temporal saliency & colour map. Int J Innov Eng Res Technol. 2021;3:1–9.
34. Kashid PJ, Kawade AM, Khedekar SV, Mallad HM. Electric vehicle technology battery management - Review. Int J Adv Res Sci Commun Technol. 2023;3:319–25. DOI: 10.48175/IJARSCT-13048.
35. Wale Anjali D, Dipali R. Smart agriculture system using IoT. Int J Innov Res Technol. 2019;5:493–7.
36. Kazi K. Model for agricultural information system to improve crop yield using IoT. J Open-Source Dev. 2022;9:16–24.
37. Liyakat S. Intelligent watering system (IWS) for agricultural land utilising Raspberry Pi. Recent Trends Fluid Mech. 2023;10:26–31p.
38. Sunil Shivaji Dhanwe et al. AI-driven IoT in robotics: A review. J Mech Robotics. 2024;9:41–8.
39. Liyakat KSS, Liyakat KKS. Nanomedicine as a potential therapeutic approach to COVID-19. Int J Appl Nanotechnol. 2023;9:27–35p.
40. Liyakat KKS. Intelligent watering system (IWS) for agricultural land utilising Raspberry Pi. Recent Trends Fluid Mech. 2024;10:26–31.
41. Liyakat KKS. IoT and sensor-based smart agriculturings driven by NodeMCU. Res Rev Electron Commun Eng. 2024;1:25–33.
42. Liyakat KKS. Smart agriculture based on AI-driven IoT (AIIoT): A KSK approach. Adv Res Commun Eng Innov. 2024;1:23–32.
43. Kazi K. Complications with malware identification in IoT and an overview of artificial immune approaches. Res Rev J Immunol. 2024;14:54–62.
44. Khadake SB, Chounde A, Gopnarayan BB, Patil KB, Kamble SS. Human health care system: A new approach towards life. Grenze Int J Eng Technol. 2024;10:5487–94.
45. Khadake SB, Patil VJ, Mallad HM, Gopnarayan BB, Patil KB. Maximize farming productivity through Agriculture 4.0 based intelligence, with use of Agri tech sense advanced crop monitoring system. Grenze Int J Eng Technol. 2024;10:5127–34.

