



RESULT ON RENEWABLE ENERGY-BASED SMART FERTIGATION CONTROLLER USING NPK SENSOR

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Abstract:

Agriculture needs good control over water, fertilizers, and energy to make crops grow better and help farming stay sustainable. Old ways of using fertilizers usually relied on looking at the fields by hand and sticking to set times, which often led to wrong use of nutrients, unbalanced soil, and using too much fertilizer. Smart fertigation systems help fix these problems by using IoT, soil nutrient sensors, and real-time tracking. This review looked at NPK-based soil checks and IoT-enabled fertigation, especially focusing on monitoring nitrogen, phosphorus, and potassium to make farming more precise. The system used an ESP32 microcontroller, an NPK sensor, a soil moisture sensor, and a DHT11 sensor to constantly monitor soil nutrients and environmental conditions. The data was shown on an LCD screen and sent via Wi-Fi to the Blynk IoT platform for remote viewing. Based on the real-time NPK levels, the right amount of fertilizer was decided, and the correct fertilizer pump was turned on manually. Solar power was added with a solar charge controller and a battery to cut down on using regular electricity and support eco-friendly farming. The studies showed that combining NPK sensors, IoT, fertigation, and renewable energy offers a great way to use fertilizers better, save resources, cut down on manual work, and help make precision agriculture more sustainable.

Keywords: Renewable Energy, Smart Fertigation, NPK Sensor, Internet of Things (IoT), ESP32, Soil Moisture Sensor, DHT11 Sensor, Blynk IoT Platform, Precision Agriculture, Solar Energy.



1. INTRODUCTION:

Agriculture needs efficient handling of water, fertilizers, and energy to boost productivity and make better use of resources. In the past, farmers relied on manual checks and fixed timetables for irrigation and fertilizing. This often-caused incorrect use of fertilizers, unbalanced nutrients, wasted water, and more work for farmers. Smart fertigation systems offer a better way to manage agricultural resources by mixing irrigation, fertilizing, sensing, and monitoring. The Internet of Things (IoT) made it possible to keep track of soil and environmental conditions continuously using sensors and wireless connections. NPK sensors checked the levels of nitrogen, phosphorus, and potassium in the soil, helping farmers understand what crops need in terms of nutrients. Soil moisture sensors provided details about water levels, while temperature and humidity sensors kept an eye on the surrounding environment. Real-time nutrient monitoring helped make smarter decisions about fertilizers and was a key part of precision farming. IoT-based fertigation systems collect sensor data and send it to monitor platforms. An ESP32 microcontroller acts as the main processor, and Wi-Fi connects the system to the Blynk IoT platform. This lets users see real-time data on soil and environmental conditions and decide on fertilizer needs based on NPK levels. Similar IoT-based methods have been used for automatic irrigation and fertilization in precision agriculture. Using renewable energy was also important in making agricultural monitoring systems more sustainable. Solar-powered fertigation systems cut down on reliance on regular

electricity and helped make farming more energy-efficient. The proposed system combined solar power, NPK sensing, soil moisture tracking, environmental monitoring, and IoT communication to help manage fertilizers and resources better. The review covered current and new methods for smart fertigation, NPK-based soil monitoring, IoT-enabled farming systems, and solar-powered fertigation. Bringing together these technologies was expected to reduce unnecessary fertilizer use, improve resource efficiency, cut down on manual checks, and support sustainable precision agriculture.

2. LITERATURE SURVEY:

M. Zulkahairi et al. [1] proposed an IoT-based fertigation system for agriculture using an ESP32 controller. The system monitors electrical conductivity (EC), temperature, humidity, and water level to automate fertilizer and irrigation management, reduce fertilizer wastage, and improve crop productivity.

P. Tondhare et al. [2] presented a review on the use of soil NPK sensors in smart agriculture. The study highlights the importance of real-time soil nutrient monitoring for precision farming and discusses different NPK sensing technologies and their applications.

S. Adak et al. [3] developed a smart agriculture system using NPK sensors for fertilizer optimization in guava farming. The proposed system improves soil health assessment and enables efficient fertilizer management, resulting in enhanced crop productivity.



L. Kumar et al. [4] designed a soil nutrient monitoring system using Arduino and an NPK sensor. The system measures nitrogen, phosphorus, and potassium levels in real time, helping farmers make informed fertilizer management decisions.

R. Adhikari et al. [5] proposed a real-time soil nutrient monitoring system using NPK sensors for precision agriculture. The system integrates sensor data with predictive analysis to improve nutrient management and crop monitoring.

V. Vidanapathirana et al. [6] developed a pomegranate farming monitoring system using machine learning and IoT technologies. The system monitors environmental conditions, detects diseases, and recommends suitable agricultural practices to improve pomegranate yield and quality.

U. Ahmad et al. [7] proposed a solar-powered IoT-based fertigation system for smart irrigation and fertilizer management. The system automatically controls irrigation and nutrient supply while improving water-use efficiency and supporting sustainable agriculture.

D. Sonal et al. [8] evaluated the impact of integrating real-time NPK sensors into smart farming systems. Their research demonstrated that continuous nutrient monitoring enhances fertilizer efficiency, crop productivity, and environmental sustainability.

M. Cefola et al. [9] investigated the effects of low-input fertigation treatments on pomegranate fruit quality. Their study showed that optimized fertigation strategies improve fruit quality while reducing water consumption and fertilizer input.

S. Hiranur et al. [10] reviewed the application of NPK and moisture sensors for soil nutrient detection. The study emphasizes the importance of real-time monitoring for improving irrigation scheduling, fertilizer application, and crop yield.

R. Tricabo-Colón et al. [11] studied the effects of drip irrigation and fertigation on carbon and nitrogen dynamics in pomegranate orchards. Their findings indicate that optimized fertigation practices improve nitrogen use efficiency while minimizing nutrient losses.

A. Rezaei et al. [12] proposed an IoT-based automated irrigation and fertilization system for precision agriculture. The system combines multiple environmental sensors with wireless communication to automate irrigation and nutrient delivery, reducing water consumption and labor requirements.

V. Sakle et al. [13] presented a comprehensive review of NPK sensor technologies for smart agriculture. Their study discusses different sensing techniques, challenges, and future developments in soil nutrient monitoring systems.

T. Adamo et al. [14] proposed an IoT-based microservices framework for optimizing irrigation and fertigation in smart agriculture. The framework enables efficient resource management through cloud computing, sensor networks, and real-time decision-making.



P. Mohan et al. [15] developed an IoT-based crop recommendation system using NPK sensors. The system analyzes soil nutrient levels and recommends suitable crops and fertilizer requirements, improving precision farming practices.

N. Zulkahairi et al. [16] proposed a smart fertigation system integrated with a mobile application and fuzzy logic optimization. The system automates fertilizer scheduling and irrigation control, improving efficiency while minimizing resource wastage.

N. Tanari et al. [17] investigated the effect of fertigation of primary nutrients on pomegranate fruit productivity and quality. The study concluded that balanced nutrient application through drip fertigation significantly enhances fruit yield and quality.

L. Ricci et al. [18] investigated the qualitative and biochemical characteristics of pomegranate fruits grown under reclaimed water and low-input fertigation treatments. Their study demonstrated that optimized fertigation strategies can maintain fruit quality while improving water-use efficiency and supporting sustainable pomegranate cultivation.

T. Adamo et al. [19] proposed an IoT-based microservices framework for optimizing irrigation and fertigation in smart agriculture. The framework integrates IoT sensors, cloud computing, and real-time monitoring to automate irrigation and nutrient management, resulting in efficient resource utilization and improved crop productivity.

Jain et al. [20] reviewed various IoT applications in precision agriculture and concluded that IoT technologies, including smart irrigation, soil monitoring, environmental sensing, and cloud-based monitoring, improve resource utilization, increase crop productivity, reduce manual effort, and support sustainable farming practices.

Table 1 Literature Review

Ref. No.	Paper / Project	System Architecture	Methodology	Key Findings	Advantages
[1]	IoT-Based Fertigation System	ESP32, EC, temperature, humidity, water level sensors	Automated fertigation using IoT	Reduced fertilizer wastage and improved crop productivity	Automatic irrigation and remote monitoring
[2]	Review of Soil NPK Sensors	NPK sensing technologies	Literature review	Real-time nutrient monitoring is essential for precision farming	Covers different NPK sensor technologies



[3]	Smart Agriculture using NPK Sensors	NPK sensor, IoT controller	Soil nutrient monitoring and fertilizer optimization	Improved soil health and crop productivity	Accurate fertilizer management
[4]	Arduino-Based Soil Nutrient Monitoring	Arduino, NPK sensor	Real-time measurement of NPK	Helps farmers make fertilizer decisions	Low-cost and simple design
[5]	Real-Time Soil Nutrient Monitoring	NPK sensor with predictive analysis	Data acquisition and nutrient prediction	Improved nutrient management	Supports precision agriculture
[6]	Pomegranate Farming Monitoring System	IoT sensors, Machine Learning	Environmental monitoring and disease detection	Improved pomegranate yield and quality	Crop-specific monitoring
[7]	Solar-Powered IoT Fertigation System	Solar panel, IoT controller, irrigation unit	Automated irrigation and fertilizer control	Improved water-use efficiency	Renewable energy and automation
[8]	NPK Sensor Integration in Smart Farming	NPK sensor, IoT	Continuous soil nutrient monitoring	Improved fertilizer efficiency and crop productivity	Real-time nutrient monitoring
[9]	Low-Input Fertigation for Pomegranate	Drip fertigation system	Experimental fertigation study	Improved fruit quality with reduced water and fertilizer	Saves water and fertilizer
[10]	Review of NPK and Moisture Sensors	Soil moisture and NPK sensors	Literature review	Real-time sensing improves irrigation scheduling	Explains sensor applications
[11]	Drip Irrigation and Fertigation in Pomegranate	Drip irrigation and fertigation	Field experiment	Improved nitrogen-use efficiency	Reduced nutrient losses
[12]	Automated Irrigation and	IoT sensors, wireless	Automated irrigation and	Reduced labor and water	Fully automated operation
	Fertilization	communication	fertilization	consumption	
[13]	Review of NPK Sensor Technologies	Various NPK sensing methods	Literature review	Discusses challenges and future trends	Comprehensive review
[14]	IoT Microservices Framework	IoT sensors, cloud computing, microservices	Cloud-based irrigation and fertigation	Efficient resource utilization	Scalable cloud architecture
[15]	IoT Crop	NPK sensor,	Soil nutrient	Improved crop	Supports



	Recommendation System	IoT platform	analysis and crop recommendation	selection	precision farming
[16]	Smart Fertigation using Fuzzy Logic	IoT, mobile application, fuzzy logic	Intelligent irrigation scheduling	Improved fertigation efficiency	Remote monitoring and control
[17]	Fertigation in Pomegranate	Drip fertigation system	Nutrient application experiment	Increased fruit yield and quality	Optimized nutrient management
[18]	Low-Input Fertigation using Reclaimed Water	Reclaimed water with drip fertigation	Fruit quality analysis	Maintained fruit quality with reduced water usage	Sustainable cultivation
[19]	IoT Microservices Framework	IoT sensors, cloud platform	Real-time irrigation and fertigation management	Efficient resource utilization and crop productivity	Cloud-based monitoring
[20]	ML-Enabled IoT System for Soil Nutrient Monitoring and Crop Recommendations	NPK, FC-28, DHT11, JXBS-3001 sensors, IoT, MQTT, Machine Learning	Sensor data were uploaded to the cloud, where ML predicted crops and fertilizer requirements	Improved productivity through intelligent crop recommendations	Remote monitoring, real-time analysis, and precision farming

Proposed Methodology:

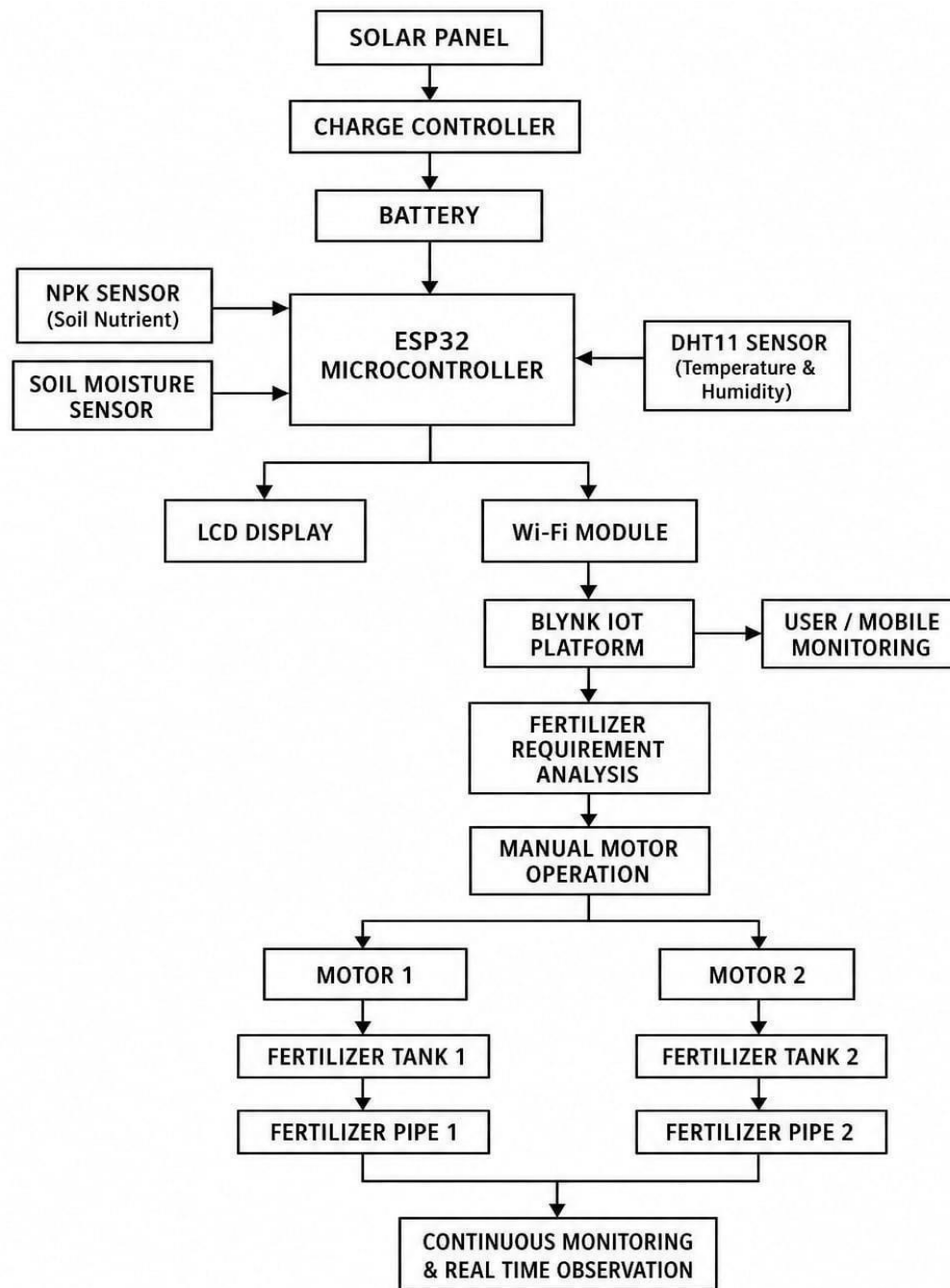


Figure A: Block Diagram of Proposed System

The proposed approach combines IoT technology, NPK sensing, environmental monitoring, and renewable solar energy to create a smart fertigation monitoring system. A solar panel was used to produce electricity, which was controlled by a solar charge controller and stored in a rechargeable battery to power the system. The NPK sensor checked the levels of nitrogen, phosphorus, and potassium in the soil, while the soil moisture sensor measured how wet the soil was, and the

DHT11 sensor tracked temperature and humidity.

The data from these sensors was sent to the ESP32 microcontroller, which acted as the main control unit. The processed information was shown on an LCD screen and sent via Wi-Fi to the Blynk IoT platform, letting the user check the data from anywhere. Using the real-time NPK readings, the user decided how much fertilizer was needed. Two motors were connected to separate fertilizer tanks, and when fertilizer was needed, the user manually turned on the correct motor to release the fertilizer through the linked pipe. After applying fertilizer, the system kept watching the soil and environmental conditions, giving the user real-time updates so they could make more fertigation choices as needed.

3. RESULT:

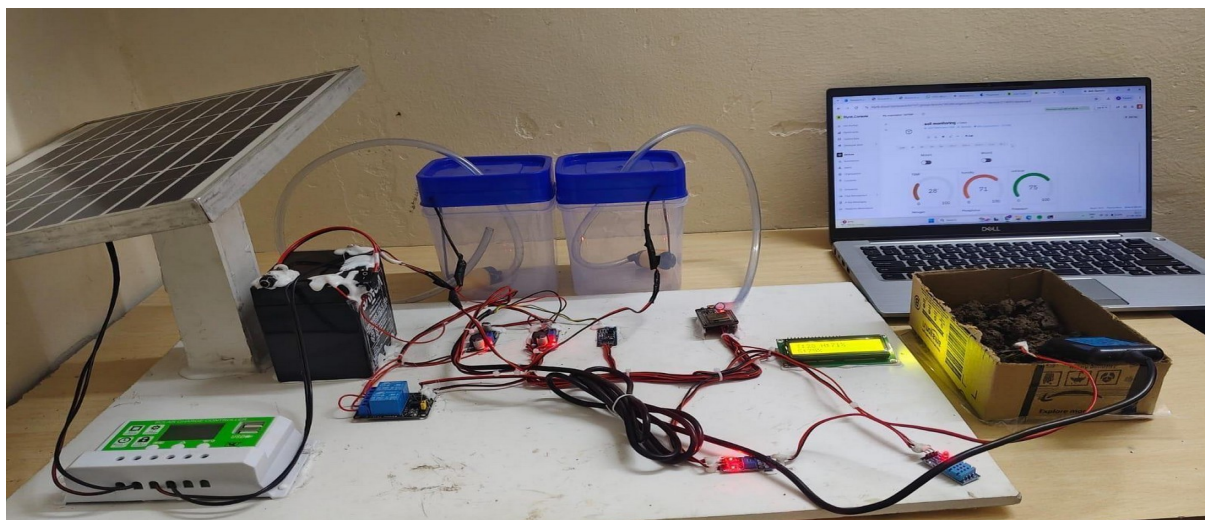


Figure 1 Set-up

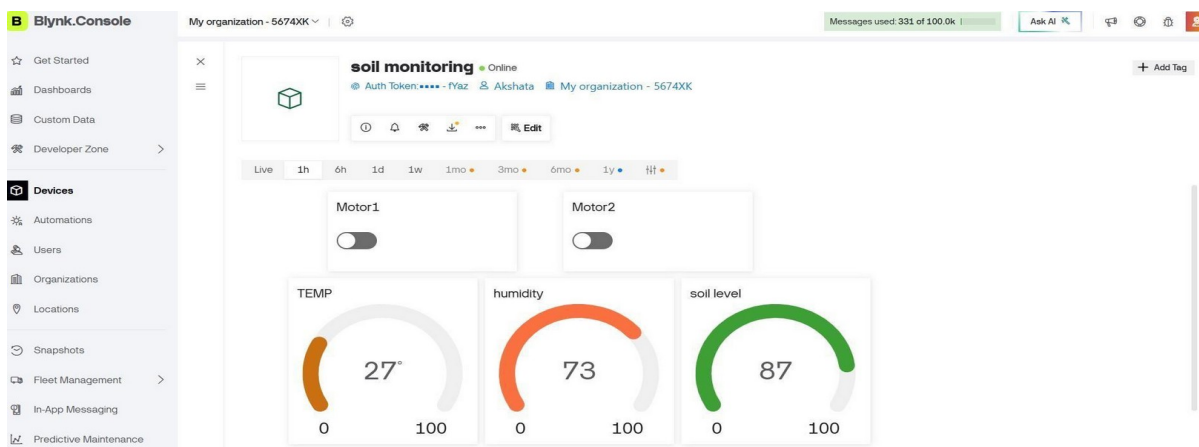


Figure 2 Blynk Dashboard

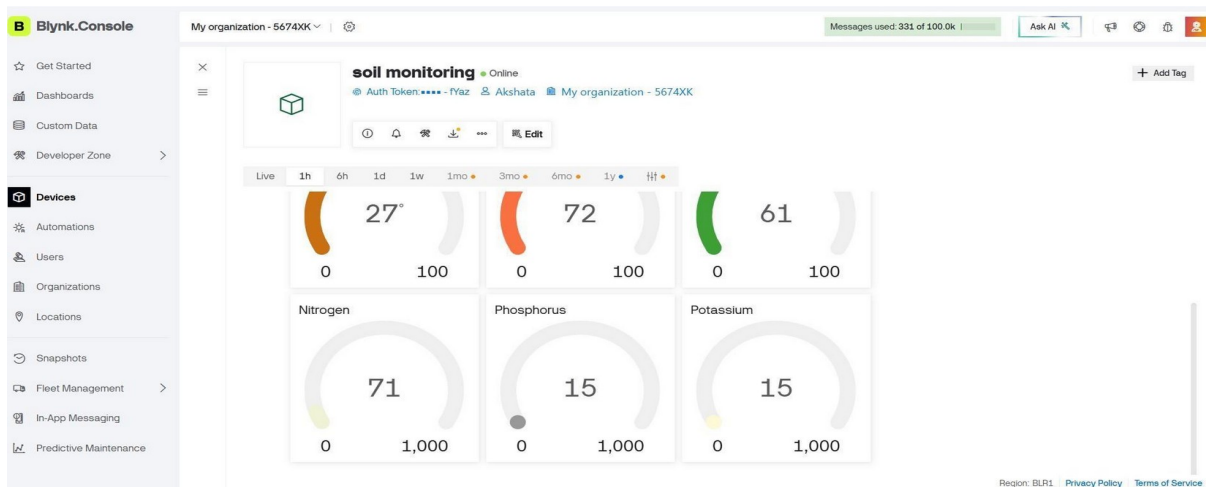


Figure 3 Blynk Dashboard

Fig1 shows that Experimental Setup, The prototype setup consists of a solar panel, ESP32 controller, sensors, water containers, and connected electronic components for real-time agricultural monitoring. Fig2 shows that Blynk Dashboard, the dashboard displays real-time values of temperature (27°C), humidity (73%), and soil moisture (87%), showing the monitoring status of the system. Fig3 shows that Blynk Dashboard, the dashboard, shows updated sensor readings, including temperature (27°C), humidity (72%), soil moisture (61%), along with additional nutrient-related readings for monitoring soil conditions. The results showed that the IoT-based Smart Fertigation Monitoring System worked well in checking soil moisture, temperature, humidity, and NPK levels as they happened. It uses the ESP32 microcontroller, soil moisture sensors, DHT11 sensors for temperature and humidity, and NPK sensors. The data from these sensors was shown on an LCD screen and sent to the Blynk IoT platform via Wi-Fi, allowing people to check the field conditions from a distance. The system helped make better decisions about using fertilizer based on real-time data, which in turn reduced the use of too much fertilizer, saved water, and cut down on the need for manual checks. The use of solar power along with a rechargeable battery provided a reliable and eco-friendly power source, cutting down on the need for regular electricity. Overall, the system proved to be effective in using resources better, managing fertilization more efficiently, and helping to make pomegranate farming more sustainable and precise.

4. CONCLUSION:

The proposed IoT-based Smart Fertigation Monitoring System offers an efficient, cost-effective, and sustainable way to manage modern pomegranate farming. It combined an ESP32 microcontroller with soil moisture, DHT11, and NPK sensors to monitor soil moisture, temperature, humidity, and nutrient levels in real time. The system used a solar panel along with a rechargeable battery to keep it running smoothly without relying on traditional electricity sources. The data collected was sent to the Blynk IoT cloud platform, allowing farmers to check field



conditions from anywhere and decide when to water or apply fertilizer. This method helped use water and fertilizer more wisely, cut down on manual work, boost crop yields, save natural resources, and support precision farming. The system provided a dependable, eco-friendly, and scalable solution for sustainable agriculture. It could be made even more advanced by adding automatic irrigation, weather forecasts, artificial intelligence, and machine learning for better farming management.

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328. Mr. Zade Mahesh Mahadev published a paper in Anveshana’s International Journal of Research in Engineering and Applied Sciences on “EFFICIENT ROUTING AND DATA FUSION IN IOT-WSNS FOR RESILIENT FOREST FIRE MONITORING” AIJREAS VOLUME 10, ISSUE 9 (2025, SEP) (ISSN-2455-6300) ONLINE

329. Mr.M.M.Zade Presented the Paper on “Touchless Fingerprint Recognition System” (Paper-ID 907) in International Conference on “Advanced Technologies for Societal Applications: Techno-Societal 2022 organized by Shri Vithal Education & Research Institute(SVERI), Pandharpur from 9th December 2022 to 10th December 2022.



330. Mr. Mahesh M Zade, “Performance analysis of PSNR Vs. Impulse Noise for the enhancement of Image using SMF”, Journal of Applied Science & Computations (JASC UGC Approved), Volume VI, Issue II, Feb.2019
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