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AUTOMATED ANIMAL ACTIVITY MONITORING IN AGRICULTURE WITH ROBOT-WSN SYSTEMS AND IOT INTEGRATION

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Abstract—This paper presents an innovative approach to monitoring animal activities in agricultural fields through the integration of a robotic system and a wireless sensor network (WSN) enabled by Internet of Things (IoT) technology. As modern agriculture increasingly relies on technology to enhance productivity and sustainability, effective monitoring of livestock behavior becomes crucial for optimizing farming practices. The proposed system utilizes a robot equipped with various sensors to collect real-time data on animal movements, feeding habits, and overall health status. This data is transmitted wirelessly via the WSN to a centralized IoT platform, allowing farmers to access critical insights and make informed decisions remotely. The implementation of this monitoring system not only enhances operational efficiency but also reduces labor costs and improves animal welfare by facilitating timely interventions. Through comprehensive testing in agricultural environments, the system has demonstrated its effectiveness in accurately tracking animal activities and providing actionable feedback. The findings of this research underscore the potential of combining robotics, WSNs, and IoT to revolutionize agricultural practices, paving the way for smarter, more data-driven farming solutions. This study contributes valuable insights into the development of automated monitoring systems that can significantly enhance productivity and sustainability in the agricultural sector.

Keywords—Agriculture, IOT.

I INTRODUCTION

“The integration of technology in agriculture has become increasingly vital in addressing the challenges of modern farming, such as labor shortages, resource management, and the need for improved productivity and sustainability. Among the innovative solutions emerging in this field, the monitoring of animal activities through robotic systems combined with wireless sensor networks (WSNs) stands out as a promising approach. Animals play a crucial role in agricultural ecosystems, and understanding their behavior is essential for optimizing feeding, health management, and overall productivity. Traditional methods of monitoring livestock often rely on manual observation, which can be labor-intensive and prone to human error.

This paper introduces a novel system that leverages robotics and IoT technology to enhance the monitoring of animal activities in agricultural settings. The proposed system employs a mobile robot equipped with an array of sensors capable of tracking various parameters, such as movement patterns, grazing habits, and environmental conditions. These sensors collect real-time data, which is transmitted wirelessly through a WSN to a centralized IoT platform. Farmers can access this data remotely, enabling them to monitor animal behavior and make informed decisions to improve management practices.

The integration of IoT in agriculture not only facilitates the efficient gathering of data but also enables advanced analytics to derive actionable insights from the collected information. By automating the monitoring process, farmers can significantly reduce labor costs and improve response times to any issues that may arise within the livestock population. Additionally, this technology enhances animal welfare by ensuring timely interventions based on real-time observations.

Through the implementation of this robotic and WSN-based monitoring system, this research aims to demonstrate the effectiveness of combining cutting-edge technologies to optimize agricultural practices. The findings will provide valuable insights into the potential of robotics and IoT in transforming traditional farming methods, ultimately contributing to the advancement of smart agriculture and sustainable farming practices. As the agriculture sector continues to evolve, adopting such innovative solutions will be crucial for meeting the demands of a growing global population while ensuring the well-being of both livestock and the environment..

II OBJECTIVES:

- To design a moving mechanism Master robot to monitor the agriculture field.
- To communicate between Master to Node sensor by Wireless Sensor Network.
- To placement the Node sensor in agriculture field using Optimization Algorithm.
- To Repel animal using Ultrasonic Repeller.
- To implement IoT cloud to intimate the farmer.
- To find accurate location of the animal placing the sensor in the field.

III LITERATURE REVIEW

The literature on robotic monitoring systems in agriculture reveals a growing interest in leveraging advanced technologies to enhance livestock management and agricultural practices. Various studies highlight the potential of integrating robotics and wireless sensor networks (WSNs) to address challenges faced by modern farmers, such as labor shortages, inefficiencies in monitoring animal health, and the need for data-driven decision-making.

Research by Kankare et al. (2019) discusses the implementation of autonomous robots for monitoring livestock, emphasizing the advantages of using mobile platforms equipped with sensors to gather data on animal behavior and environmental conditions. Their findings indicate that robotic systems can effectively cover large areas, significantly reducing the time and effort required for manual observation while providing accurate real-time data.

Similarly, work by Kóczy et al. (2020) explores the application of WSNs in conjunction with robotic systems for livestock monitoring. The study highlights how WSNs enable seamless data transmission from various sensors to a central management system, facilitating efficient monitoring and control. This integration not only improves data accuracy but also enhances the farmers' ability to respond quickly to any issues that arise, ultimately leading to better animal welfare and productivity.

Moreover, the incorporation of IoT technology into agricultural monitoring has been extensively examined. According to Zhang et al. (2021), IoT-enabled systems allow for real-time data analytics and remote access to monitoring information, empowering farmers to make informed decisions based on actionable insights. Their research emphasizes the importance of connectivity and data management in transforming traditional agricultural practices into more intelligent and responsive systems.

In addition, studies have investigated specific sensor technologies used for monitoring animal activities. For instance, wearable sensors have been explored by Bouzembrak et al. (2022) for tracking individual animal movements and health metrics. This approach provides a deeper understanding of animal behavior, enabling targeted interventions and improved management practices tailored to the specific needs of each animal.

Despite the advancements in this field, challenges remain regarding the scalability and cost-effectiveness of implementing robotic monitoring systems in diverse agricultural environments. Future research will need to focus on addressing these barriers while exploring the potential for greater automation and integration with existing agricultural practices.

In summary, the literature demonstrates a clear trend toward the adoption of robotic systems, WSNs, and IoT technology in the agricultural sector. These innovations hold significant promise for enhancing animal monitoring, improving farm efficiency, and promoting sustainable agricultural practices. This study aims to build on these findings, contributing to the ongoing development of intelligent monitoring systems that can further revolutionize livestock management in agriculture.

IV. PROPOSED METHODOLOGY

The device aims at monitoring animal and bird's activities in agriculture field using robots and wireless sensor networks through IOT technologies. These robots cohabit with sensors and cooperate together to perform a given task collectively by presenting hardware constraints. We define a Robotic Wireless Sensor Network as an autonomous networked multi-robot system that aims to achieve certain sensing goals. In our project three robots are wirelessly connected through wireless transceivers called NFR. These robots are communicating each other and Robot3 is used to send the all three robot's data to the cloud database using GPRS. By using web application, the cloud data are monitored by user and based on that accurate real time field data animals & birds is scared using ultrasonic Repeller. Controlling of all these operations will be through any remote smart device or computer connected to Internet and the operations will be performed by interfacing sensors, NFR modules, and with micro-controller. The proposed system detects the movement of animal using pir sensor. If the movement occurs the video will send to the cloud using GPRS. Then the nrf24l01 will send the signal to the nearest robot and the Ultrasonic Repeller will produce the sound.

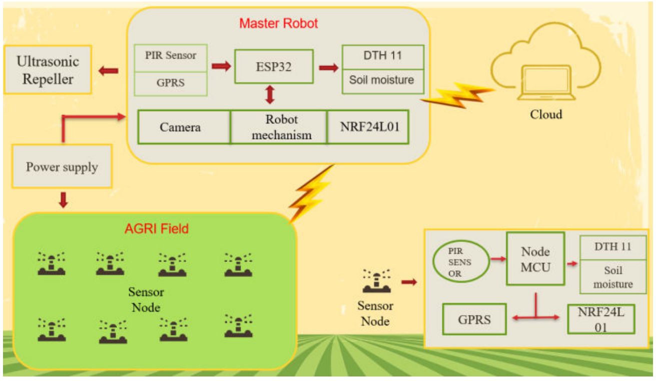


FIG 1.HARDWARE REQUIREMENT

V. HARDWARE SPECIFICATION

A. *ULTRASONIC REPELLER*

FIG 2. ULTRASONIC REPELLER

An ultrasonic Repeller is a device that uses high-frequency sound waves to repel pests such as rodents, insects, and birds. These devices emit a sound that is inaudible to humans but is unpleasant to pests, causing them to leave the area. The sound waves are usually in the range of 20-50 kHz and can be generated by electronic devices or by using ultrasonic transducers. Ultrasonic pest Repeller's are often used as an alternative to chemical pest control methods, as they are considered to be more environmentally friendly and less harmful to humans and pets. However, their effectiveness is still debated and some studies have shown that pests may become habituated to the sound waves over time, rendering the Repeller ineffective.

WAVE DIAGRAM FOR ULTRASONIC REPELLER:

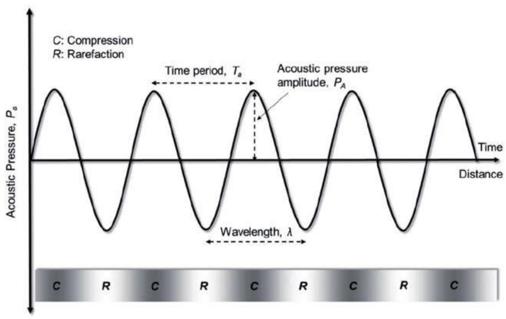


FIG 3. WAVE DIAGRAM FOR ULTRASONIC REPELLER

B. ***PIR SENSOR***

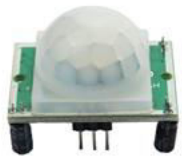


FIG 4. PIR SENSOR

A rechargeable battery, storage battery, or secondary cell (formally a type of energy accumulator), is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction.

WAVE DIAGRAM FOR PIR:

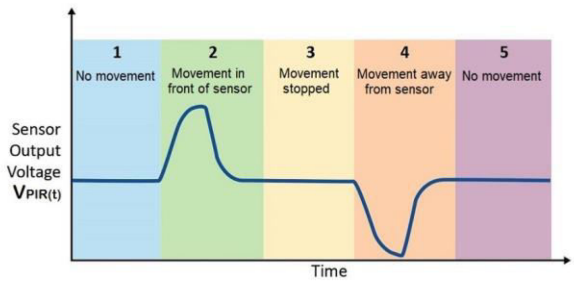


FIG 5. WAVE DIAGRAM FOR PIR

C. ***ARDUINO***

- Must be a DC adapter (i.e. it has to put out DC, not AC);
- should be between 9V and 12V DC (see note below);
- must be rated for a minimum of 250mA current output, although you will likely want something more like 500mA or 1A output, as it gives you the current necessary to power a servo or twenty LEDs if you want to.
- Must have a 2.1mm power plug on the Arduino end, and
- The plug must be "centre positive", that is, the middle pin of the plug has to be the + connection.

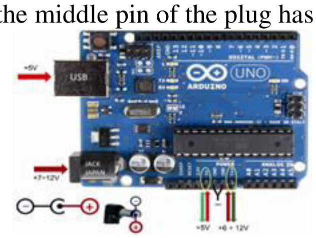


FIG 6. ARDUINO

D. ***I²C***

Inter-integrated circuit (I^2C), pronounced either "i-squared-c" or "i-two-c," is the final communication protocol we'll cover in this tutorial. Though its implementation is the most complicated of the three protocols, I^2C addresses several drawbacks in the other communication protocols, giving it an advantage over the others in some applications. These include:

- The ability to connect multiple masters to multiple slaves
- Synchronicity (just like SPI), which means higher speed communication
- Simplicity: implementation only requires two wires and some resistors

E. ***ESP32***

ESP32 is a low-powered, low-cost microcontroller (MCU) board, with both Wi-Fi and Bluetooth built in, and is based on a dual-core processor mechanism. The first one is a powerful processor, such as aXtensa LX6 (~240 MHz) with 512 KiB memory and the second an ultra-low coprocessor (ULP) with only 8 KiB memory designed to run when ESP32 is in deep-sleep mode.

Other components include around 48 I/O pins (variable); an array of peripheral interfaces including temperature, hall effect, and capacitive touch sensors; and an 8-centimeter LCD panel, prominently visible here in an ESP32-WROVER board by Express if Systems.

FIG 7. ESP32

F. GPRS:

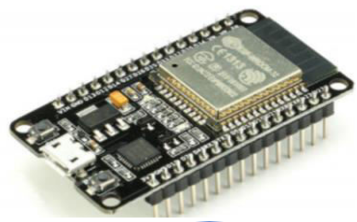
GPRS stands for General Packet Radio Service. It is a mobile data service that enables cellular devices to transmit and receive data over the internet. GPRS is a packet-switched technology that divides the data into small packets and transmits them over the network. This allows for faster data transfer rates than traditional circuit-switched technology.
GPRS is commonly used for mobile internet access, email, multimedia messaging, and other data-intensive applications. It is also used for machine-to-machine (M2M) communications, such as remote monitoring and control of devices.

G. NRF24L01:

The NRF24L01 is a 2.4 GHz wireless transceiver module, designed for low-power, short-range wireless communication in embedded systems. It is commonly used in applications such as wireless sensor networks, home automation, remote control, and wireless toys. The NRF24L01 module supports a range of data rates from 250 kbps to 2 Mbps, and can operate at distances up to 100 meters in open space. It uses a frequency-hopping technique to minimize interference with other wireless devices operating in the same frequency band.

FIG 8. NRF24L01

H. MOTOR DRIVE & MOTOR



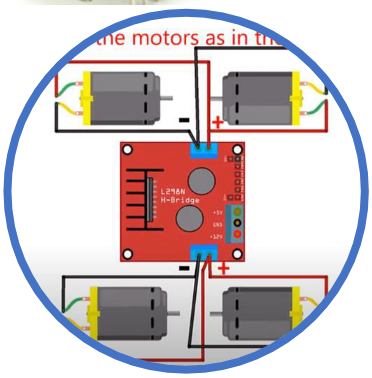


FIG 9. MOTOR DRIVE & MOTOR

i) Motor drive:

This L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.

ii) Motor:

A DC motor or Direct Current Motor converts electrical energy into mechanical energy. A direct current (DC) motor is a fairly simple electric motor that uses electricity and a magnetic field to produce torque, which turns the rotor and hence give mechanical work.

STIMULATION

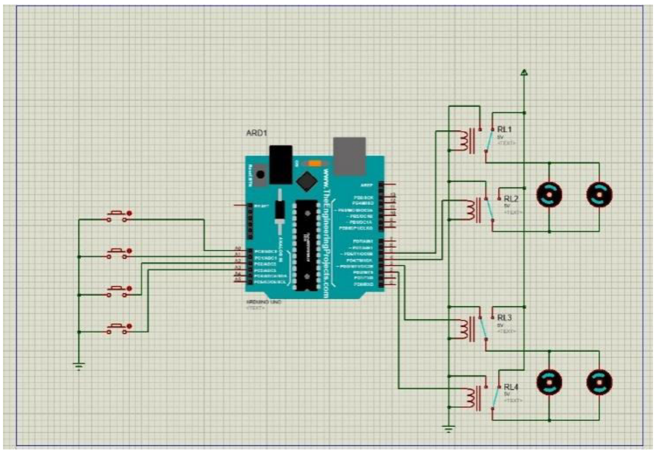


FIG 10. STIMULATION

VI. OPTIMIZATION METHOD

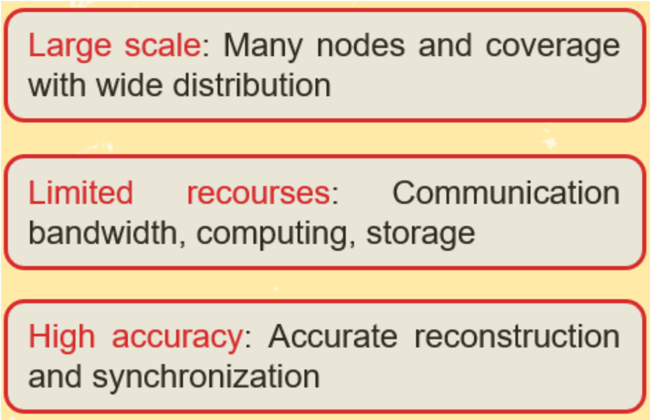


FIG 11.OPTIMIZATION

A) INTELLIGENT OPTIMIZATION

1. Genetic Algorithm (GA)

An intelligent optimization algorithm, which refers to Darwin's theory of evolution and simulates the process of biological evolution

- complicated and runs slowly
- Less parameters to be set
- not easy to fall into the local optima

2. Particle swarm Optimization (PSO)

Originated from the research of bird predation behavior.is to regard a bird as a particle and use the sharing of information between individuals to make the population gradually evolve from disordered to ordered.

- relatively simple
- fast convergence speed
- prone to premature convergence to the local optima

GA + PSO = COMBINED ALGORITHM

COMBINED ALGORITHM

Use the result of the PSO as the initial value of the GA to avoid the algorithm from falling into the local optimal solution as much as possible while speeding up the execution speed.

Global Optimization

Fast Convergence

1. MODEL ESTABLISHMENT

* SENSOR MODEL
* SPACE MODEL
* COVERAGE MODEL
* RECONSTRUCTION MODEL

2. OPTIMIZATION ALGORITHMS

* Coverage
* Reconstruction error
* Multi objective optimization
* Fast deployment approach

3. EXPERIMENTAL EVALUATION

* Comparison between different objectives
* Comparison between different approach
* Comparison between different sampling parameters
* Comparison between different search methods

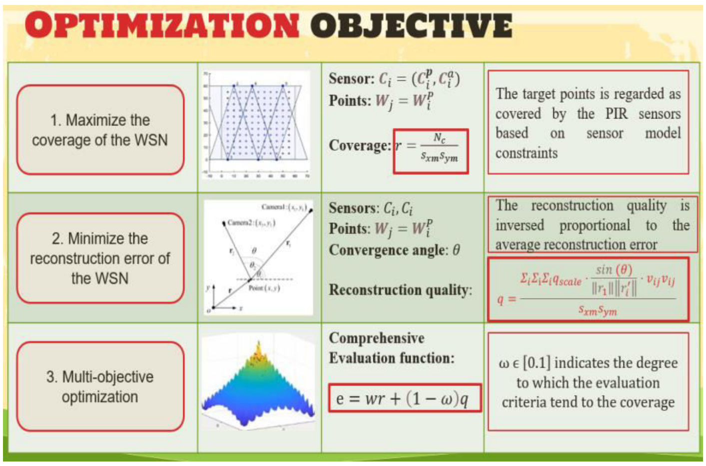
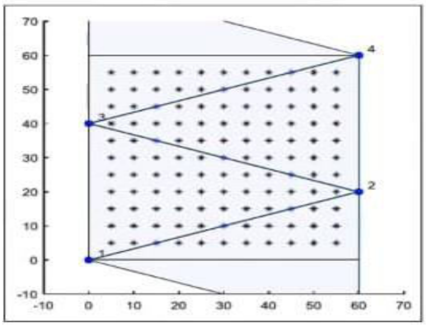
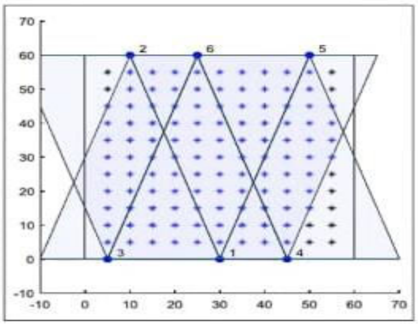


FIG 12. OPTIMIZATION OBJECTIVE

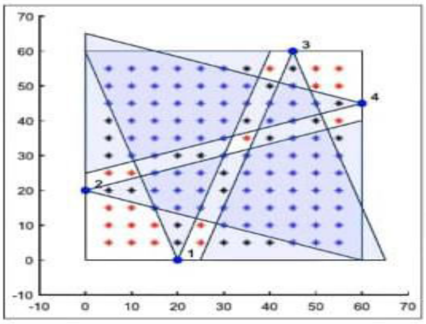
B) COMPARISON BETWEEN DIFFERENCE OBJECTIVES



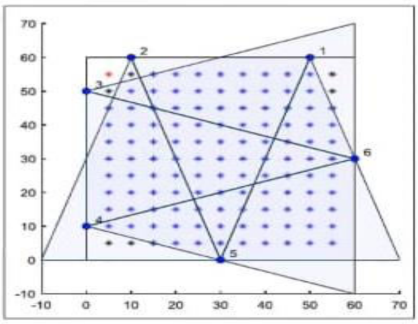
a) Maximize the 1-coverage with four sensor



b) Maximize the 2-coverage with six sensor



c) Maximize the 2-coverage and reconstruction quality with four sensor



d) Maximize the 2-coverage and reconstruction quality with six sensor

- The network coverages of the four placement are 100%, 91%, 52%, 94%, respectively. The deployments are verified to have reasonable sensor placement and meet the requirements of optimization goals, which is as expected.

VII. SOFTWARE SPECIFICATION

i) ARDUINO IDE – 1.8.5

arduino is an open-source electronics platform based on easy-to-use hardware and software. arduino boards are able to read inputs - light on a sensor, a finger on a button, or a twitter message - and turn it into an output - activating a motor, turning on an led, publishing something online. you can tell your board what to do by sending a set of instructions to the microcontroller on the board. to do so you use the arduino programming language (based on wiring), and the arduino software (ide), based on processing.

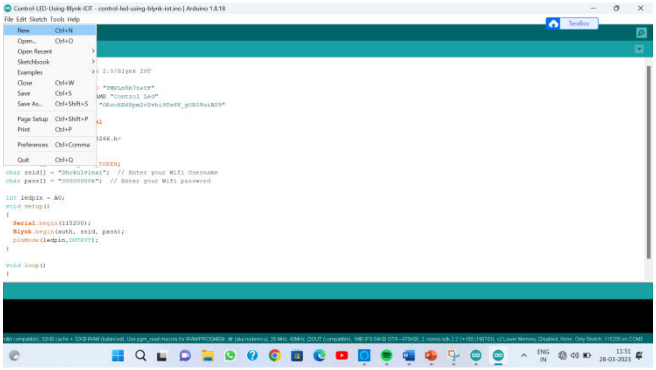


FIG 13. ARDUINO IDE

ii) EMBEDDED C:

Embedded c is a set of language extension for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems. Historically embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

Embedded C uses most of the syntax and semantics of standard C, e.g., main () function, variable definition, data type declaration, conditional statements (if, switch, case), loops (while, for), functions, arrays and strings, structures and union, bit operations, macros, etc. During infancy years of microprocessor-based systems, programs were developed using assemblers and fused into the EPROMs. There used to be no mechanism to find what the program was doing. LEDs, switches, etc. were used to check for correct execution of the program. But they were too costly and were not quite reliable as well. As time progressed, use of microprocessor-specific assembly-only as the programming language reduced and embedded systems moved onto C as the embedded programming language of choice. C is the most widely used programming language for embedded processors/controllers.

RESULTS:

SYSTEM IMPLEMENTATION

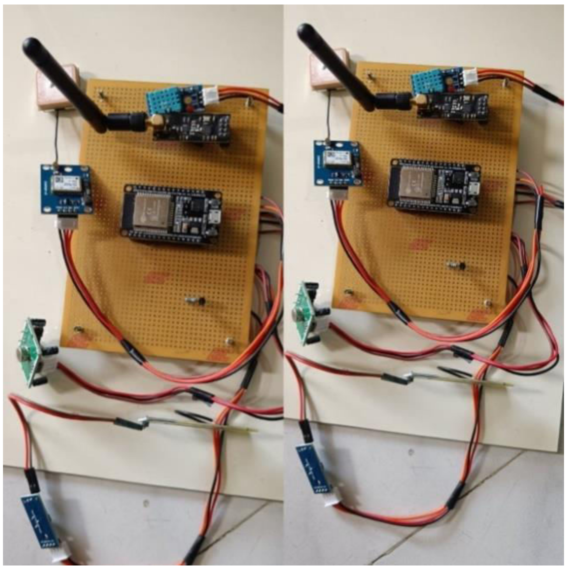


FIG 14. PROTOTYPE IMPLEMENTATION NODE 1 & NODE 2 FOR ROBOT WSN

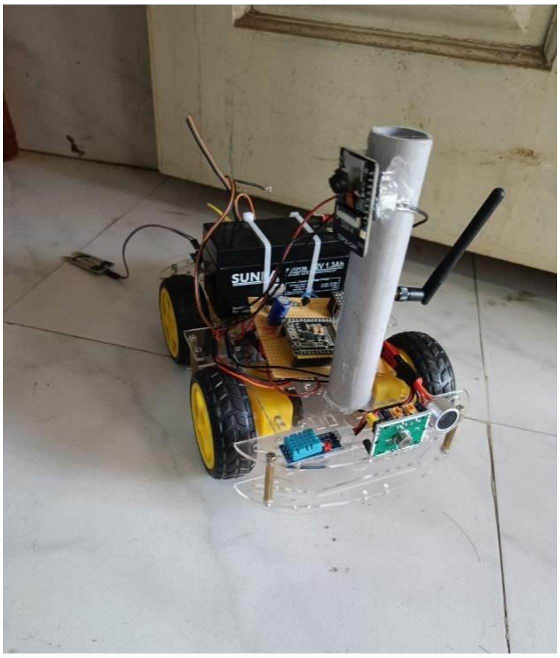


FIG 15. SURVEILLANCE MASTER ROBOT FOR AGRICULTURE FIELD

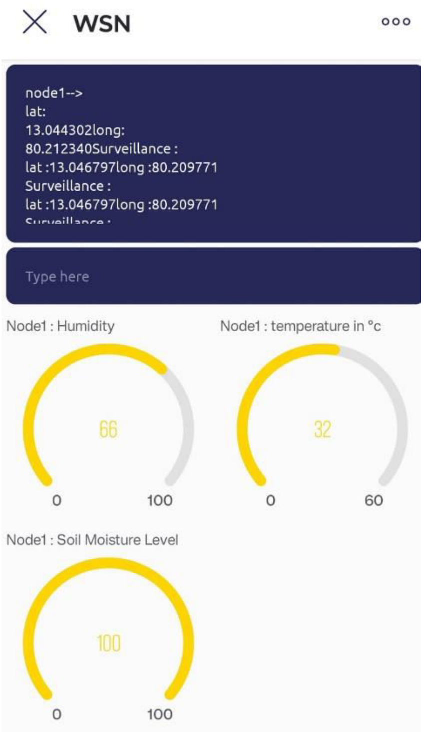


FIG 16. IOT CLOUD NODE 1 FOR TEMPERATURE, HUMIDITY & LOCATION

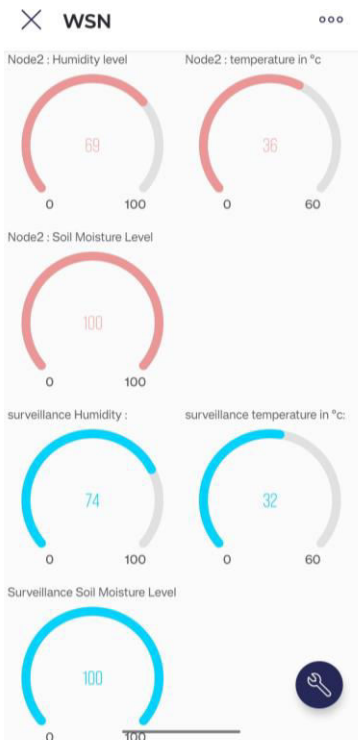


FIG 17. IOT CLOUD NODE 2 & MASTER ROBOT FOR TEMPERATURE, HUMIDITY

CONCLUSION

In conclusion, this research demonstrates the significant potential of integrating robotic systems with wireless sensor networks (WSNs) and Internet of Things (IoT) technology for monitoring animal activities in agricultural settings. The proposed system not only automates the collection of critical data on livestock behavior but also enhances the efficiency and effectiveness of farm management practices. By providing real-time insights into animal movements, feeding habits, and overall health, the system empowers farmers to make informed decisions, ultimately leading to improved productivity and sustainability. Furthermore, the remote monitoring capabilities reduce the need for manual labor and enable timely interventions, thereby enhancing animal welfare. The findings of this study contribute to the growing body of knowledge on smart agriculture and highlight the transformative impact of technology on traditional farming practices. As the agricultural sector continues to evolve, the implementation of such advanced monitoring solutions will be essential for meeting the challenges of modern farming, ensuring food security, and promoting sustainable practices in livestock management. This work paves the way for future research and development in the field, encouraging further exploration of innovative technologies to optimize agricultural outcomes.

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