Research Article

INTEGRATION OF ROBOT-WSN FOR ANIMAL ACTIVITY MONITORING IN AGRICULTURAL FIELDS WITH IOT IMPLEMENTATION

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Abstract—An agricultural nation's development is mostly dependent on agriculture. Agriculture-related problems have long impeded the nation's progress. Modernising the current conventional agricultural processes with smart agriculture is the only way to solve this problem. Thus, the project's goal is to use IOT technologies and robots with wireless sensor networks to monitor the actions of animals and birds in agricultural fields. These robots live beside sensors and work together to accomplish a task by imposing hardware limitations. A robotic wireless sensor network is described as an autonomous multi-robot system networked together with specific sensing objectives. Three robots are wirelessly connected in our project using NRF24L01 wireless transceivers. deploying the best sensor possible in an agricultural area to transmit a signal that can identify the position of an animal. The closest robot then assumes command and launches an assault on the field animal. These robots are interacting with one another, and one robot is utilising GPRS to transfer the data from all three robots to a cloud database. Through the use of a web application, users can watch cloud data, and then utilise an ultrasonic repellent to terrify animals and birds depending on precise, real-time field data. All of these tasks will be managed by integrating sensors, NRF24L01 modules, and microcontrollers, and they will all be controlled by any distant smart device or computer with an Internet connection.

Key Words: IOT, Agriculture.

I INTRODUCTION

"The discovery of agriculture was the first big step toward a civilized life. "Is a famous quote by Arthur Keith. This emphasizes that the agriculture plays a vital role in the economy of every nation. Since the dawn of history agriculture has been one of the significant earnings of producing food for human utilization. Today more and more lands are being developed for the production of a large variety of crops.

The field of agriculture involves various operations that require handling of heavy materials. For example, in manual ploughing, farmers make use of heavy ploughing machines. Additionally, while watering the crops farmers still follow the traditional approach of carrying heavy water pipes. These operations are dull, repetitive, or require strength and skill for the workers.

A. THE CURRENT STATE OF AGRICULTURAL ROBOTICS:

Today agricultural robots can be classified into several groups: harvesting or picking, planting, weeding, pest control, or maintenance. Scientists have the goal of creating robot farms. Where all of the work will be done by machines. The main obstacle to this kind of robot farm is that farms are a part of nature and nature is not uniform. It is not like the robots that work in factories building cars. Factories are built around the job at hand, whereas, farms are not. Robots on farms have to operate in harmony with nature. Robots in factories don't have to deal with uneven terrain or changing conditions. Scientists are working on overcoming these problems.

B. ROBOTS USED FOR AGRICULTURE:

The number of agricultural robots, agrobots, is increasing each year. The jobs they can do are also increasing with new technology in hardware and software. Robots are milking cows, shearing sheep, picking fruit, weeding, spraying, and cultivating, they use GPS and sensors for navigation. The new robots are getting smaller and smarter.

The Robot-WSN based monitoring of animal activities in agriculture field with IoT application is a system designed to monitor the activity of animals in agriculture fields using wireless sensor networks (WSN), robots, and IoT technology. The system aims to provide real-time monitoring of animal behaviour and movement patterns to help farmers make better decisions regarding their livestock.

The system consists of wireless sensors that are placed in the field to monitor animal activity and movement. These sensors collect data such as temperature, humidity, and animal movement patterns. The data is transmitted to a central control unit, which processes the data and sends it to the cloud using IoT technology.

A robot is used to move around the field and collect data from the wireless sensors. The robot is equipped with sensors and cameras to detect and record animal behaviour. The robot also has the ability to control the sensors, which allows it to change the parameters being measured based on the specific requirements of the farmer.

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

"A Wireless Sensor Network-based System for Monitoring Cows' Behaviour and Health" by Seung-Hwan Park et al. This study proposes a WSN-based system for monitoring cows' behaviour and health in real-time, which can provide farmers with useful information to improve their livestock management.[1] "Robot-WSN based Monitoring of Animal Activity for Precision Livestock Farming" by M. Ramezani et al. This paper proposes a robot-WSN based system for monitoring animal activity in livestock farming, which can provide farmers with real-time data to improve their decision-making process.[2]

"IoT Based Animal Health Monitoring System" by R. Chandrasekaran et al. This paper proposes an IoT-based animal health monitoring system that can help farmers monitor the health of their livestock in real-time and take immediate action when necessary.[3] "Design of a Wireless Sensor Network-based Monitoring System for Agricultural Environment" by Xue Han et al. This study proposes a WSN-based system for monitoring environmental factors in agriculture, which can help farmers optimize their crop production and improve their yield.[4] "A Review of Wireless Sensor Network-based Animal Monitoring Systems" by T. Gao et al. This review paper provides an overview of the existing WSN-based animal monitoring.[5]

IoT and WSN based autonomous farming robot. Arsalan khan, Mudassar Bashir, IEEE paper, 2020 Master and slave robots incorporate the wireless sensor network and are connected via the NRF protocol for reliable sharing of sensor data. The master robot also transmits this data to the IoT server. The highlighting features of this research include weeds detection through image processing and sensors for gathering light, moisture, humidity, temperature parameters.[6] UAV-Driven sustainable and Quality- Aware data collection in Robotic WSN. Omer Melih Gul, IEEE paper, 20220020 This article investigates energy-aware data collection in robot network clusters. In each cluster, a cluster head (CH) robot allocates one collaborative task to each cluster member (CM) robot and collects data from CMs whereas a UAV collects data from CH robots by visiting a subset of them due to its battery limitation. To complement the state-of-the-art, UAV decision for visiting the subset of CHs is constrained to multiple factors including residual battery capacity, as well as locations and data qualities of all CH robots. Non visited CH robots use CH robots as relay nodes for data forwarding.[7] An indoor security system with a jumping robot as the surveillance terminal,IEEE,2011 The remote house owner will get these photos through Internet. A prototype system has been implemented and some performance tests have been done. Experimental results show that the robot can jump up on a desk of 105cm high to perform the surveillance task. A 3k-byte captured photo can be transmitted to the gateway in 3.68s with 0.1% loss rate by 5 hops [1] .[8] Wireless Sensor Network Based Navigation of Micro Flying Robots in the Industrial Internet of Things,IEEE,2018 In this paper, wireless sensor network based safe navigation algorithm for micro flying robots in the industrial Internet of things (IIoT). A micro flying robot cannot be equipped with heavy obstacle detection sensors for local navigation.[9] Soft-WSN: Software-Defined WSN Management System for IoT Applications,IEEE,20160020 In this paper , software-defined wireless sensor network architecture (Soft-WSN)—an effort to support application-aware service provisioning in Internet of Things (IoT). Detailed architecture of the proposed system is presented involving the application, control, and infrastructure layers to enable software-defined networking (SDN) in IoT.[10]

A Novel Wireless Sensor Network Frame for Urban Transportation,IEEE,2015 WSN-UT enables users to obtain traffic and road information directly from the local WSN within its wireless scope instead of the remote ITS data center. WSN-UT can be configured according to different scenario requirements. A three-level subsystem and a configuration and service subsystem constitute the WSN-UT network frame, and the service/interface and protocol algorithms for every subsystem level are designed for WSN-UT.[11] A Study on the Application of WSN

Positioning Technology to Unattended Areas,IEEE,2015 This proposed Euclidean algorithm is able to achieve 3D positioning of network nodes and effectively enlarge the network positioning coverage by upgrading the positioned node with adequate accuracy to proxy anchor. Second, since unattended areas are mostly non-line-of-sight (NLOS) environments and node positioning accuracy is affected by NOLS factors, a 3DL-N positioning algorithm is proposed by introducing the way of making up for node positioning error based on the 3DL algorithm.[12] Multi-Robot Information Gathering for Precision Agriculture: Current State, Scope, and Challenges,IEEE,2021 This creates a corresponding need for information at a fine spatial and temporal resolution. Autonomous multi-robot systems (e.g., unmanned ground and aerial vehicles) are some of the most promising approaches for such information collection in open-air farms.[13] Dynamic Modeling and Identification of an Agriculture Autonomous Vehicle,IEEE,2016 The vehicle under study is a quadricycle (ATV) that has been modified and adapted to work in an autonomous way. It has been presented simulation proofs and experimentation with the real vehicle that allows guaranteeing the performance of the developed models.[14] An Offline-Merge-Online Robot Teaching Method Based on Natural Human-Robot Interaction and Visual-Aid Algorithm,IEEE,2022 This article proposes an offline-merge-online robot teaching method (OMORTM). Specifically, a virtual-real fusion interactive interface (VRFII) is first developed by projecting a virtual robot into the real scene with an augmented-reality (AR) device, aiming to implement offline teaching. Second, a visual-aid algorithm (VAA) is proposed to improve offline teaching accuracy. Third, a gesture and speech teaching fusion algorithm (GSTA) with the fingertip tactile force feedback is developed to obtain the natural teaching pattern and improve the interactive accuracy of teaching the real or virtual robot. More specifically, through the VRFII, the operator can use the GSTA and the VAA to teach the virtual robot naturally and safely, and then the real robot reproduces the motion of the virtual robot.[15]

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.

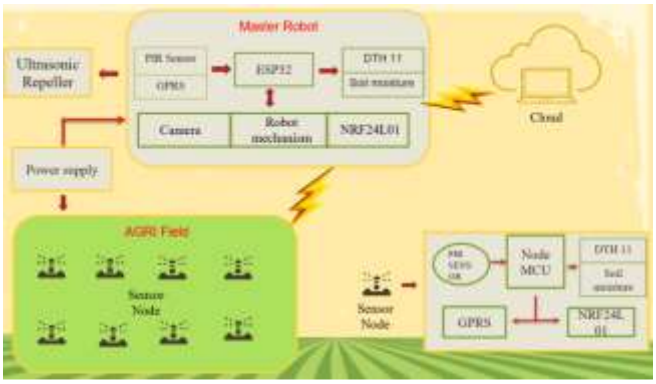


FIG 1. HARDWARE REQUIREMENT

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:

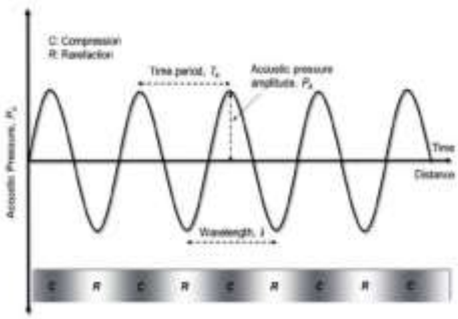


FIG 3. WAVE DIAGRAM FOR ULTRASONIC REPELLER

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:

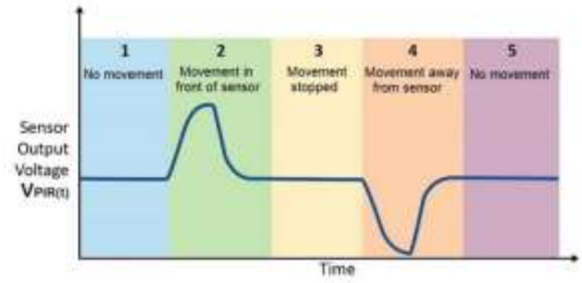


FIG 5. WAVE DIAGRAM FOR PIR

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 (I²C), 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, I²C 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 a Xtensa 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.

FIG 7. ESP32

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.

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***

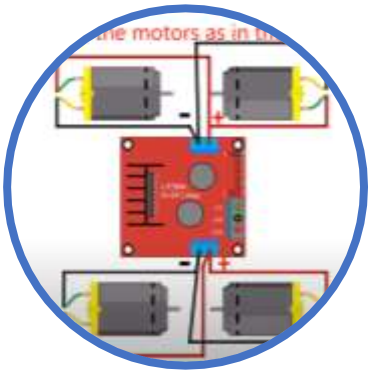


FIG 9. MOTOR DRIVE & MOTOR

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

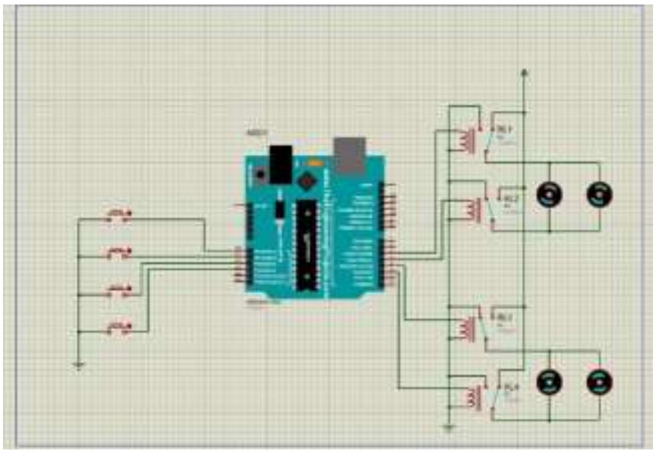


FIG 10. STIMULATION

VI. OPTIMIZATION METHOD

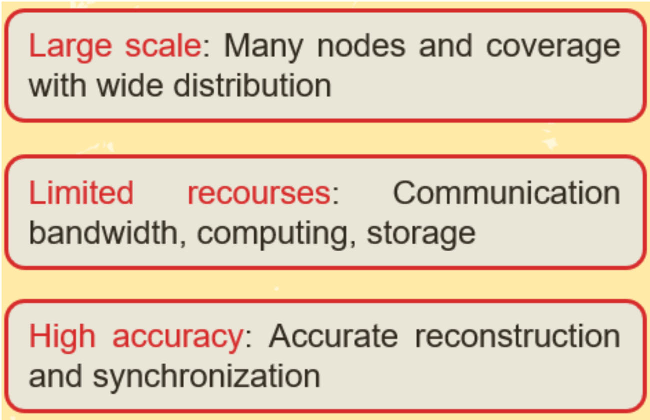


FIG 11. OPTIMIZATION

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

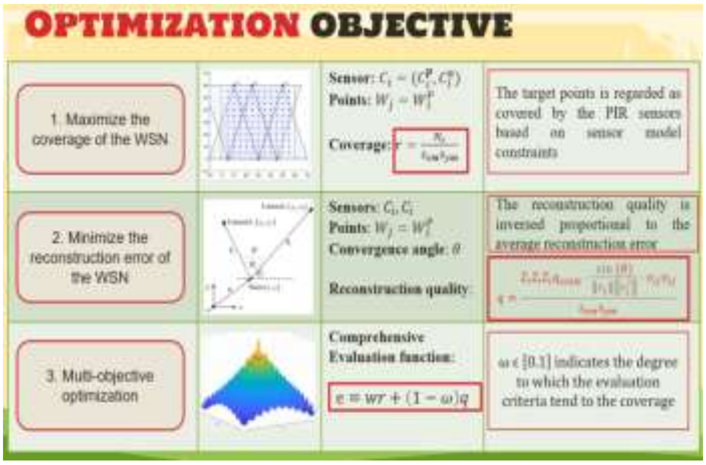
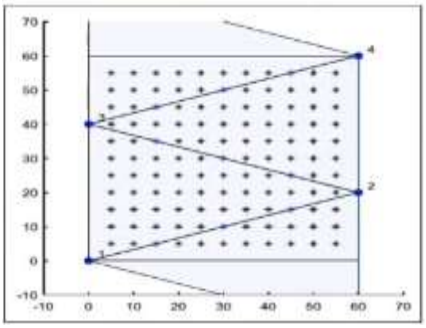
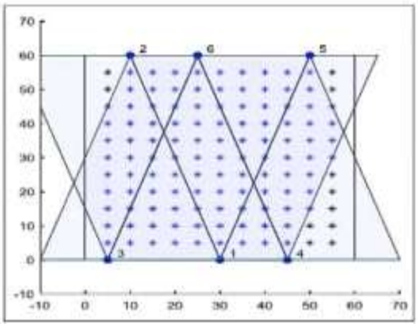


FIG 12. OPTIMIZATION OBJECTIVE

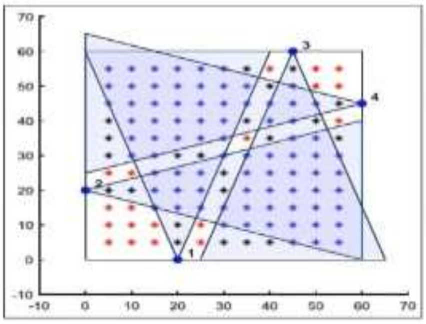
B) COMPARISON BETWEEN DIFFERENCE OBJECTIVES



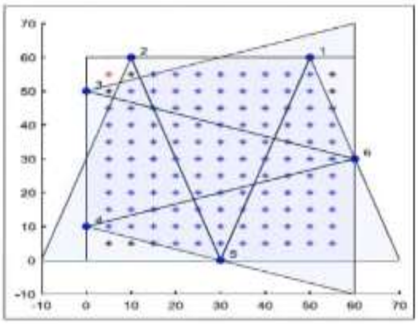
a) Maximize the 1-coverage with four sensor



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

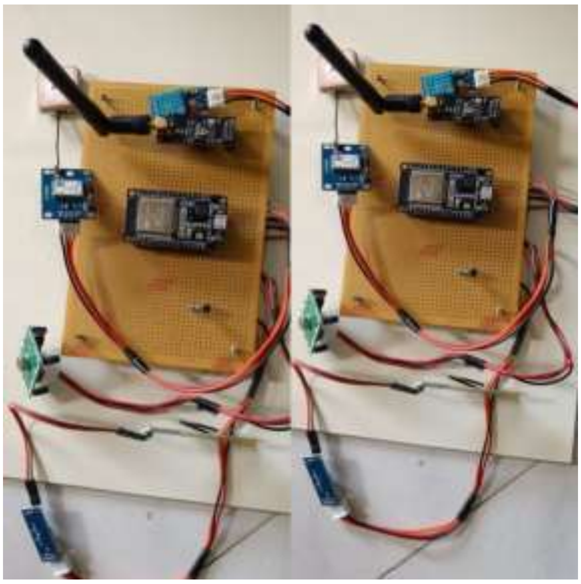


FIG 14. PROTOTYPE IMPLEMENTATION NODE 1 & NODE 2 FOR ROBOT WSN

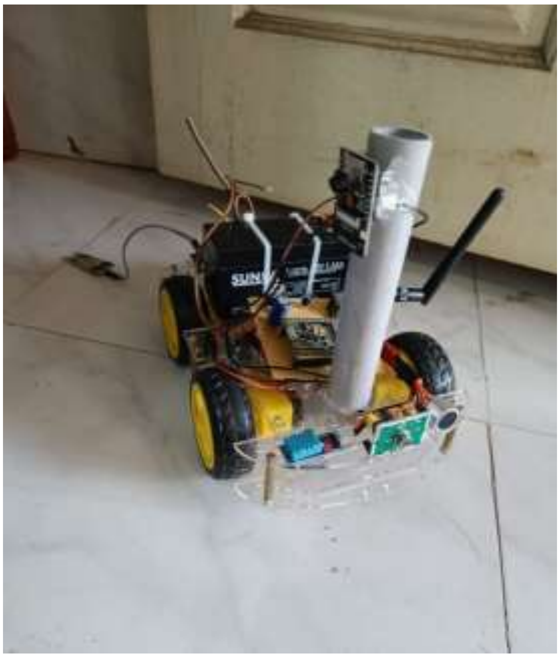


FIG 15. SURVEILLANCE MASTER ROBOT FOR AGRICULTURE FIELD

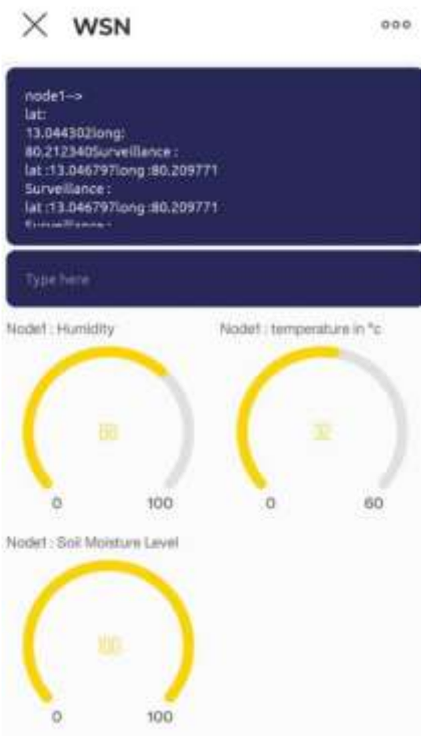


FIG 16. IOT CLOUD NODE 1 FOR TEMPERATURE, HUMIDITY & LOCATION

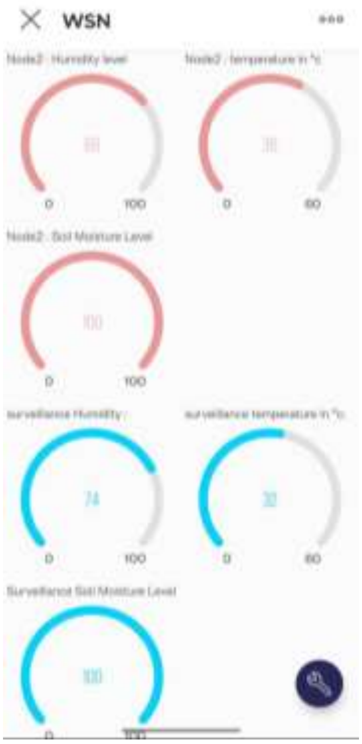


FIG 17. IOT CLOUD NODE 2 & MASTER ROBOT FOR TEMPERATURE, HUMIDITY

CONCLUSION

This project introduces wireless technology in the field of agriculture. To protect the fields from animal activity is too hard for the farmer. So, this device can surveillance the fields from animal. Provides a flexible user interface to farmer to control the machine effectively. It reduces manual labour requirement which is a boon to the farmers as finding the animal in field. The robot can work in any sort of climatic condition as well as can work nonstop unlike humans. The time required to carry out the five functionalities reduces considerably comparison with carrying out the same activities manually. It is a onetime investment which increase the production we reduce the waste compare to overall farming cost considerably. This robot acts as a gateway to automated smart farming.

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