Journal of Current Research in Engineering and Science
Bi-Annual Online Journal (ISSN : 2581 - 611X)
Volume7-Issue1, January 2024
Paper: 27

IMPLEMENTATION OF A PROTOTYPE FOR FARMING ASSISTANCE WITH RASPBERRY PI AND NODE RED

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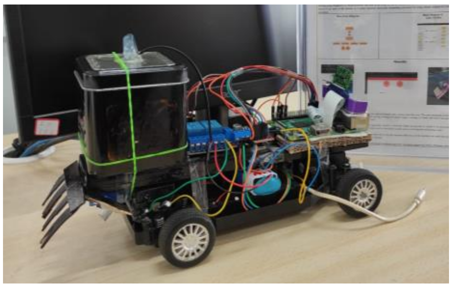
Abstract- **Agriculture is considered the sustenance of mankind as it is the primary source of agricultural raw materials and plays a chief role in the development of the national economy as it provides great job opportunities for people. Unfortunately, traditional farming methods are still used by many farmers, resulting in low crop and fruit yields. However, productivity has improved as automation has been introduced and people have been replaced by automated machines. Smart agriculture is an emerging concept in IoT as it provides information about farmland and can take necessary actions on the user input. As a result, robots are increasing productivity and appearing in large numbers on the job site. Therefore, it is necessary to utilize modern science and technology to increase productivity in the agricultural sector. Hence, this paper proposes a system that helps in tracking field operation management and provides flexibility. This paper was assembled after researching various papers. The proposed system focuses on performing functions such as tillage and seeding using Raspberry Pi microcontroller that acts as the brain of the IoT-controlled robots which are connected to control devices via Wi-Fi. The proposed system is an asset to the farmers as it helps automate physically demanding processes by using robotic systems to cultivate farmland with minimal human assistance.**

Keywords: Agriculture, Farming, Internet of Things (IoT), Wi-fi, Raspberry Pi, Plowing, Seeding

I. INTRODUCTION

A robot is a machine that is capable of performing tasks autonomously, or with minimal human supervision. They can be equipped with sensors and other technologies to help them navigate their environment, and they can be programmed to respond to various inputs and stimuli. An agricultural robot is a robot designed specifically for use in agricultural settings. These robots are typically designed to perform tasks that would otherwise require a significant amount of manual labor, such as planting, harvesting, and weeding crops. There are many different types of agricultural robots, including robots designed to operate on land, in the air, and even underwater.



One of the key advantages of agricultural robots is that they can help farmers increase efficiency and productivity, while also reducing labor costs. Overall, agricultural robots are a promising technology with the potential to transform the way we grow and produce food.

In this paper we implement an IoT controlled agricultural robot that is fitted with a motor which can be used for farming activities like plowing, sowing etc and a live camera feed to monitor the direction of the robot. The camera can be accessed through any web browser and node red is a tool that is used for controlling the bot . By using this technology, agricultural robots can be programmed to perform specific tasks based on real-time data, making them more efficient and effective. Overall, agricultural robots using IoT have the potential to significantly improve agricultural efficiency, reduce waste, and increase yields. However, it is important to note that the adoption of this technology may require significant investments in infrastructure and training, as well as careful consideration of data privacy and security issues.

II. RELATED WORKS

A review of various papers related to agricultural activities using IoT, agricultural robots and research related to machinery used has been completed. Papers that were found to be correlated with smart agriculture are discussed below.

An increase in the competence of some activities of agricultural enterprises was detected by Technological progress.New strategy introduced by authors of paper[1] included combining irrigation and sensing for smart agriculture wirelessly. New approaches for digital agriculture, sensor data collection, irrigation control were studied.A case study was presented that suggested an experiment that was conducted on a farm which utilizes various technologies to monitor the livestock using environmental sensors[1].

From the paper[2] we found a report, which predicted that to balance the world population, which was an estimate of 9.6 billion people, we must increase production of food till the rate of 70 percent in the year 2050. The Authors [2] proposed a system that remotely monitors parameters such as moisture, temperature, water content and fertility of the plant. An algorithm was created to code the microcontroller. After energy and water wastage was tested the generated data was stored using cloud technology.

Findings from the authors of [4] revealed that there was a strategy developed which monitors criterias such as moisture,temperature, humidity or animal movements with the use of Arduino board.If there was a case where any discrepancy was detected the model alerts the farmer via the smartphone which has the application installed via an SMS as well as a notification.

It was proposed in [3], that a robot that was proficient enough of conducting operations such as motorized plowing, sowing, delivery, fruit picking and pesticide spraying was developed. The model can cater to manual control whenever necessary and is able to maintain an overview of humidity with the use of humidity sensors. The main hardware requirements include a jumbo microcontroller which will oversee the consolidated mechanism. Authors also mention using GSM modules to alert the farmers via SMS.

From the authors of [5] it was noticed that the model used for plowing and dropping seeds into the plowed land was using an IoT controlled robot. It could perform various agricultural tasks, such as plowing, seeding, spreading fertilizers and reaping without the need for human intervention. It can perform all the mentioned tasks using only the field length and width as input.

The architecture and performance of activities like plowing and seeding done by robots that use IOT was also studied from [6]. The developed robot focuses on agricultural purposes like plowing, sowing and mud leveling. The robot is also battery operated and can operate in any weather conditions. The suggested structure of [6], states that it makes use of a mechanical device that supervises the field. The device consists of two motors and a power source that provides the robot with movement in forward and backward directions, and also makes use of sensors of four types. These are sensors that sense temperature, ultrasonic waves, pH and a level sensor which senses the required parameters. It also makes use of a microcontroller that connects to Wi-Fi which not only monitors but also provides the results of the sensors used. The robot does the activities of plowing, sowing and sprinkling water automatically.

The idea for our project was taken from [7]. It discusses that the most advantageous feature of indoor farming is that it can mass-produce nourishing food utilizing less agricultural land and manpower. This smart farming management system uses readily available sensors and hence makes indoor farming easier and cheaper. The entire farm could be easily monitored with the help of a line-following robot. Primary farm tasks such as supplying water, providing acceptable lighting, fertilizing trees, etc. can be done either automatically or manually [7]. This model uses transmitters that send the system's data to the robot and the gas sensors to monitor the amount of carbon and detect the amount of smoke in the room.

From [8] it was observed that as the community grows, it leads to an increased demand for healthy foods. As a result, indoor farming is gaining popularity. This paper introduces a system through which an indoor farm can be managed at a very low cost. Due to this, it is possible to provide each plant with specific light for photosynthesis, limit the concentration of CO_2 and water the plants when necessary. You can also control the entire configuration from anywhere via the mobile application. The system includes an assistant robot that fertilizes the plants on the farm and monitors the entire farm in real time. Robots allow users to predefined tasks or use the app to give instructions anytime, anywhere.

The author of this paper [9] aims to take advantage of emerging technologies such as IoT and smart agriculture. Monitoring ecological factors is crucial for improving the yield of crops. This article includes keeping track of the temperature and humidity in an agricultural area using a single CC3200 chip and various sensors. A camera is linked to the chip and it sends the pictures to mobile farmers via MMS using Wi-Fi. Microcontrollers, Wi-Fi modules and network processors are on the same chip which makes it portable. Changes in environmental conditions will have an impact on the total crop yield. Plants require precise conditions for their optimal growth and health and hence monitoring these conditions is very crucial. TMP007, a Temperature Infrared thermopile sensor is used. The HDC1010 sensor monitors the humidity of the air within the agricultural sector. The camera interacts with the Camera Amplifier of CC3200 via PCB Camera sensor MT9D111 and is used to capture the live images of the field and is posted to the farmer via GPRS.

The proposed system in [10] uses the NodeMCU microcontroller where the ESP8266 Wi-Fi module is installed. Smartphones with the Blynk app are used as the user interface. Sensors such as rain sensors, soil moisture sensors and temperature sensors are used with DC motors and deek robots. At the humidity level, NodeMCU decides whether the crops are watered or not using the appropriate functions. The user gets the notifications of each sensor readings on the Blynk app. In this application, the farmer controls the DC motor by using the user interface.

In paper [11] we are using a NodeMCU ESP8266 microcontroller. Running natively at 80 MHz, this low-cost device can go up to 160 MHz. We can connect additional modules to expand its functionality. The MCU is programmed with the Arduino IDE including libraries. The proposed model uses a humidity and temperature sensor, a soil moisture sensor, servo motor and gyro sensor. To store the data, ThinkSpeak cloud is used. All the sensor datasets are sent to the cloud for analysis and use machine learning techniques for crop prediction.

This device [12] monitors the greenhouse or the farm and according to the readings of various kinds of sensors such as the UV, IR, soil nutrient, temperature, humidity and soil moisture sensor. It provides the farmers with different types of reports about the current conditions so that the farmer can act quickly. Prompt measures taken by the farmer will benefit in increasing agricultural productivity. The appropriate use of natural resources will also ensure that the product is environmentally friendly. The proposed system will increase the quality and quantity of crops by properly monitoring different current conditions. Current data of the various sensors can be seen on laptops and smartphones.

According to the authors of [13], farmers spend most of their time comprehending and keeping track of the crop conditions compared to actual field work. As a result, the use of wireless sensing can be facilitated to provide accurate monitoring of crops along with using smart tools for crop harvesting in order to save both their time and efforts. Thus, the manuscript proposes the viability of using Cloud technology and IoT to process, store, and analyze field data in order to produce better and faster outcomes while reducing the burden of manual agriculture.

In paper [14], we learn and understand how traditional agricultural products cannot guarantee the quality of agricultural products and require higher time, efforts, manpower along with high material resources. The paper explores how IoT technology can be used over the old traditional methods to ensure fine management of agricultural production and its environmental monitoring by proposing a 4 layer architectural application of IoT technology for intelligent agriculture.

Exploring modernization of agricultural farms with minimum human involvement, the authors of [15] exhibit the major segments of smart farming based on IoT. The article uses IoT, computer networking and its various protocols along with other technologies such as big data analytics and cloud computing which proposes the development of different aspects of farm management. Thus the paper explores the feasibility of different technologies with IoT to further accommodate the sending and receiving of agriculture data which can overall reduce the overhead which comes with traditional farming methods.

III. METHODOLOGY

Introduction of IoT in the field of agriculture can be brought about in various approaches but the methodology building of remote vehicle is as follows:

Define Requirements: Start by defining the requirements and specifications for the robot, such as the plowing depth, the speed, the size of the plow, the camera resolution, the connectivity options, and the power management features.

Design Architecture: Based on the requirements, design the architecture of the IoT system that will control the robot, including the microcontrollers, and the communication protocols. Determine how the system will manage the data collected by the sensors and the camera feed.

Develop Hardware: Develop the hardware components of the agricultural robot, including the plow, the motor, the battery, the camera, and the communication module. Make sure that the hardware components are compatible with the IoT architecture and can be controlled remotely.

Develop Software: Develop the software that will control the hardware components of the agricultural robot and manage the data collected by the camera. Implement the communication protocols that will enable the robot to connect to the IoT network and receive commands from a remote device.

Test and Validate: Test the agricultural robot in a real-world environment, such as a farm or a field.

Verify that the robot can plow, that the camera feed is stable and clear, and that the IoT connectivity and power management features are working as intended. Validate the results against the initial requirements and specifications.

Iterate and Improve: Based on the testing and validation results, iterate and improve the design of the agricultural robot and its IoT system. Incorporate feedback from users, farmers, and technicians, and refine the software and hardware components to optimize the performance and the user experience.

Deploy and Maintain: Deploy the agricultural robot in the field and monitor its performance and maintenance needs. Provide support and updates to users and farmers as needed.

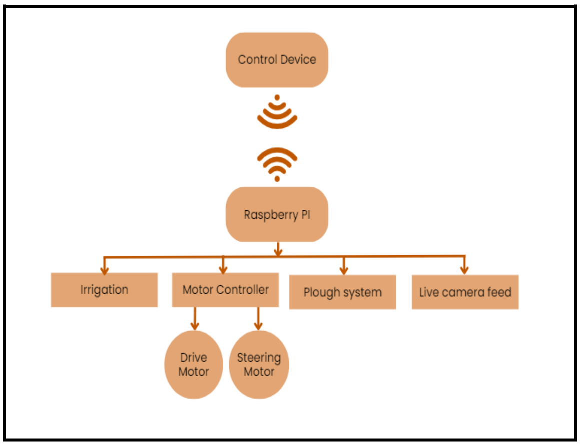


Fig. 3.1: Design Methodology

The brain of the vehicle is essentially a Raspberry Pi controller that controls all the other systems such as the motor , plough system , seed dropper etc. It hosts its own local server and can be accessed via any web interface. Node red is a flow based tool that is used to build the control flow, it makes these controls available through its dashboard which is a web UI . The vehicle can be driven around anywhere by looking at the camera attached to the vehicle and the farmer can control the plough with the help of an on screen UI joystick controls. The live camera feed is also available as a web UI hosted by the raspberry pi so that driving and monitoring is made easy. The communication is done through a local wireless connection to reduce latency and improve security. Not only can the farmer drive the vehicle remotely but also control other machinery on the vehicle with the help of the node red dashboard. Attached below are some of the pictures from our project that include live camera interface, node red flow design and the actual prototype of our robot.

IV. ANALYSIS

Table 1 Comparison of our Research

Sl. No	Outcomes from the papers that were referred	Outcome of our paper
1.	Use of bluetooth in [3]	This paper uses a more advanced technology which is Wi-fi
2.	Use of smart irrigation system mounted on top of a crane in [1]	We use a ground vehicle which is more durable and more easily implemented
3.	Use of sensors like leaf wetness, soil ph detection, animal detectors etc.	No use of complicated sensors and is a very budget friendly project that any farmer can afford.
4.	[1] uses old microcontrollers like arduino which uses older computer languages.	Our project makes use of newer technology like Raspberry-pi and node red.
5.	[6] has the same essence as our project but focuses more on the man power and does not have user friendly interfaces.	We have created an app that can be accessed with any web interface and also added a live camera hence the farmer can control our bot from anywhere.

As we can see from the comparison table we have reached a solution which is the most cost effective and multipurpose for a farmer.

Accordingly we have come up with the following test cases which were tried and tested by our remote controlled vehicle:

- **Connectivity Test:** Verify that the robot can connect to the IoT network and receive commands from a remote device. Test the robot on different WiFi networks and mobile data networks. Check if the robot can maintain a stable connection and respond to commands in real-time.
- **Robot Movement Test:** Verify that the robot

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can move in a straight line, turn, and maneuver around obstacles.

- **Plowing Test:** Verify that the robot can effectively plow the soil in a designated area, such as a field, and that the plowing depth is consistent.
- **Live Camera Feed Test:** Verify that the live camera feed from the robot can be accessed and viewed from a remote device, such as a smartphone or a laptop.
- **Video Quality Test:** Verify that the video quality of the live camera feed is clear and sharp enough to provide useful information about the plowing process.
- **Remote Control Test**: Verify that the IoT device can be used to remotely control the robot's movement and plowing operations, and that the commands are executed correctly.
- **Durability Test:** Verify that the robot can withstand the wear and tear of regular use, such as exposure to dirt, dust, and moisture.
- **User Experience Test:** Verify that the overall user experience of using the IoT-controlled agricultural robot is positive and intuitive, and that any issues or errors are easy to troubleshoot and resolve.

These were the following outcomes from our project

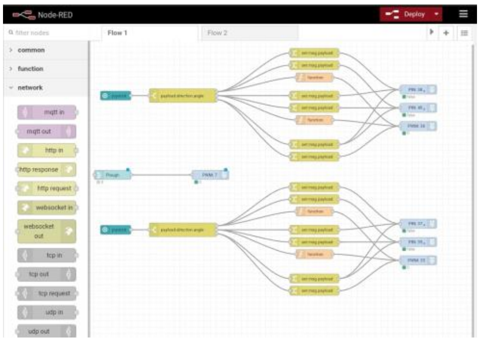

Fig 4.1: Node Red Flow

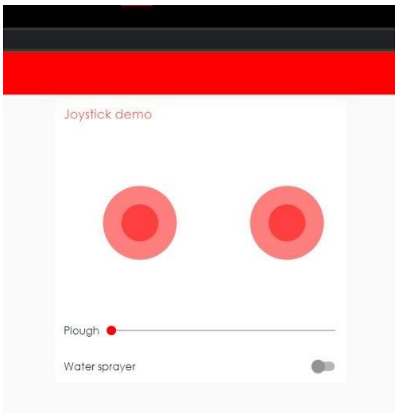

Fig 4.2: Vehicle Control Interface

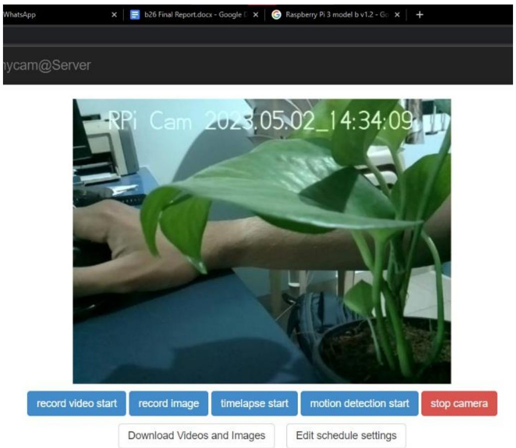

Fig 4.3: Live Camera Feed

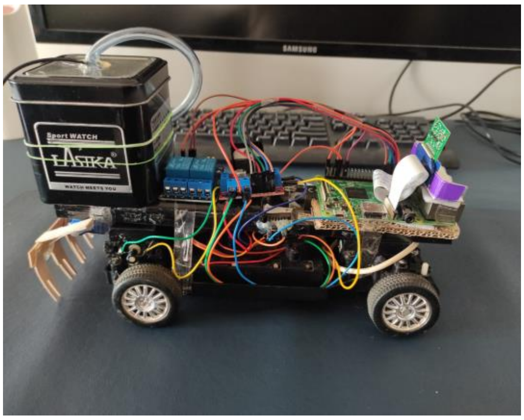

Fig 4.4: Prototype

V. CONCLUSION

Traditionally farming is done by human beings with the help of bullock carts, tractors and tillers etc. The main problems in the agricultural field include lack of labour availability, lack of knowledge regarding soil testing, increase in labour wages, wastage of seeds and more wastage in water. The idea of applying robotics technology in the field of agriculture is very new.

Our vehicle can offer a number of benefits to farmers and other operators. Our robot allows for remote operation, which can be especially useful in situations where an operator is unable to be physically present at the machine, such as in the case of large fields or difficult terrain. WiFi control also allows for precise control of the tractor, which can be beneficial in tasks such as planting and cultivating crops.

Additionally, remote control can improve safety on the farm, as it allows the operator to remain a safe distance from the tractor and any potential hazards. It can also increase efficiency, as the operator can make precise movements and adjustments to the tractor without having to physically be present at the controls.

Overall, the use of our tractor can provide a range of advantages to farmers and other operators, improving safety, efficiency, and precision in a variety of tasks.

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