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CROP DEFENDER

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ABSTRACT

The post-COVID-19 age is redefining farming by using technology to ensure optimum output and produce safety. In the industrial supply chain, a contactless approach combined with dependability and safety is crucial. CareBro, the suggested solution, is essential to ensure that the farm is run entirely remotely and autonomously without requiring physical presence. In an Internet of Things setting, the smart farm sensorics and the onboard edge computing capabilities interact. This guarantees smooth farming and permits ethical insect control, higher crop yields, and irrigation management. Through the cloud, the CareBro and the farmer are constantly in communication, enabling real-time monitoring and decision-making. therefore guaranteeing the ideal farm management solution for farmers throughout our nation, whether they are large- or small-scale, urban or rural.

Keywords: Internet of Things, Edge Computing, Thingspeak Cloud, Arduino IDE, Sensorics, Off-grid, sustainability, autonomy, and ethics

I. INTRODUCTION

Crop Defender is a cutting-edge agricultural technology that revolutionizes crop security and boosts overall farm output by using the Internet of Things (IoT). With the problems of climate change, insect infestations, and limited resources, this state-of-the-art technology offers a proactive and effective way to protect crops.

Fundamentally, Crop Defender builds an intelligent and networked agricultural environment by integrating sensors, IoT devices, and powerful analytics. The technology monitors many environmental conditions by carefully placing a network of sensors across the countryside. These sensors gather data in real time on a variety of variables, including temperature, humidity, light intensity, and soil moisture.

The capacity of Crop Defender to recognize and identify possible crop dangers is one of its primary features. The system uses machine learning algorithms and clever sensors that are outfitted with image recognition capabilities to detect pests, illnesses, and other crop-damaging elements. This lessens the effect on agricultural productivity by enabling farmers to quickly react to new challenges and carry out focused treatments. Furthermore, Crop Defender utilizes control systems and automated actuators that are remotely handled via an intuitive interface. This enables farmers to respond quickly to the information that the Internet of Things sensors offer. For example, the system may accurately and effectively trigger automatic pesticide dispensers in the case of a pest infestation, therefore minimizing the need for broad chemical treatment. Comprehensive analytics also use the real-time data that Crop Defender collects. A single dashboard provides farmers with access to comprehensive reporting and analytics that provide insightful information on crop health, resource management, and overall farm performance. Farmers are better able to use resources efficiently, make well-informed choices, and ultimately improve the sustainability of their farming methods thanks to this data-driven strategy.

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In conclusion, Crop Defender represents a paradigm shift in modern agriculture by harnessing the capabilities of IoT to create a resilient and responsive crop protection system. By seamlessly integrating technology into farming practices, Crop Defender not only safeguards crops but also contributes to sustainable and efficient agriculture in the face of evolving environmental challenges.

1.1: Problem Statement:

The increasing demand for sustainable agriculture has led to the adoption of modern technologies, including Internet of Things (IoT), to enhance crop management practices. However, the agricultural sector faces a critical challenge in the form of pest and disease infestations, which can result in significant yield losses and economic hardships for farmers. The absence of an efficient and automated Crop Defender using IoT exacerbates this problem, as current pest control methods often rely on manual monitoring and delayed responses

Traditional pest control methods lack real-time data and insights, making it challenging for farmers to promptly identify and address potential threats. Moreover, the variability in environmental conditions and the diversity of pest species further complicate the task of implementing effective preventive measures. The existing gap in utilizing IoT technologies for proactive crop defense hinders the agricultural sector's ability to optimize resource utilization, reduce pesticide usage, and ensure sustainable farming practices.

Additionally, the lack of a comprehensive Crop Defender using IoT contributes to the environmental impact of agriculture through the indiscriminate use of pesticides. This not only raises concerns about ecological balance but also poses potential health risks for consumers due to residual pesticide content in crops. The absence of an integrated and intelligent system for pest and disease monitoring and management limits the overall productivity and profitability of the agriculture sector.

The problem at hand is the absence of a robust, scalable, and real-time Crop Defender utilizing IoT technologies to provide farmers with timely and accurate information about pest and disease threats, enabling proactive and sustainable crop protection. Addressing this issue is crucial for ensuring food security, economic stability for farmers, and environmental sustainability in the agricultural domain. The development of an effective Crop Defender using IoT is essential to mitigate the challenges associated with pest and disease management, promoting a more resilient and efficient agricultural ecosystem.

Figure .1: Rain Protection in agriculture sector

1.2: Problem Scope:

The problem scope revolves around the inadequacies in current agricultural practices, particularly in the realm of pest and disease management. The absence of an efficient and automated Crop Defender utilizing IoT technologies is a critical challenge within the agricultural sector. The scope of the problem encompasses various dimensions:

1. Pest and Disease Threats:

- The primary focus is on addressing the prevalent threats posed by pests and diseases to crops. This includes a diverse range of pests and diseases that

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can adversely impact crop health and yield.

2. Manual Monitoring Limitations:

- The problem scope extends to the limitations of existing manual monitoring methods. Traditional practices lack real-time data collection, making it difficult to promptly identify and respond to emerging pest and disease issues.

3. Environmental Variability:

- The challenges associated with varying environmental conditions are within the scope. The system should be adaptable to different climates and environmental factors that influence the prevalence of pests and diseases.

4. Resource Optimization:

- The scope includes the need for optimizing resource utilization in agriculture. An efficient Crop Defender should help farmers reduce unnecessary pesticide usage, thereby minimizing environmental impact and lowering production costs.

5. Sustainable Farming Practices:

- The problem extends to the broader goal of promoting sustainable farming practices. The Crop Defender using IoT should contribute to environmentally conscious and sustainable agricultural operations.

6. Data-Driven Decision-Making:

- The scope includes the integration of real-time data and insights into agricultural decision-making processes. The system should empower farmers with actionable information to enhance their ability to proactively manage pest and disease threats.

7. Economic Stability for Farmers:

- Ensuring economic stability for farmers is a significant aspect of the problem scope. The Crop Defender should contribute to minimizing yield losses, thereby safeguarding the livelihoods of farmers.

8. Reducing Pesticide Risks:

- The scope encompasses the goal of minimizing the risks associated with pesticide usage. The system should facilitate targeted and informed pesticide application, reducing potential health risks for consumers and the environment.

9. Scalability and Adaptability:

- The problem scope extends to the scalability and adaptability of the proposed solution. The Crop Defender using IoT should be applicable to diverse crops, farm sizes, and geographical locations.

10. Integration with Agricultural Practices:

- The integration of the Crop Defender with existing agricultural practices and workflows is within the scope. The system should complement and enhance the efficiency of farmers' day-to-day activities.

Figure.2 Smart Agriculture using IoT

1.3: Advantages of using Home Automation using IOT

1. Real-Time Monitoring:

- The implementation of a Crop Defender using IoT provides real-time monitoring of crop health, enabling farmers to

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promptly detect and respond to emerging pest and disease threats.

2. Early Detection and Intervention:

- The system facilitates early detection of pest infestations and diseases, allowing farmers to intervene proactively. This helps prevent the escalation of issues and minimizes potential yield losses.

3. Data-Driven Insights:

- By utilizing IoT technologies, the Crop Defender generates data-driven insights. This empowers farmers with valuable information for decision-making, optimizing resource utilization and improving overall agricultural practices.

4. Reduced Pesticide Usage:

- The intelligent monitoring system enables targeted and precise application of pesticides, reducing the overall quantity of chemicals used. This not only lowers production costs but also minimizes environmental impact and health risks.

5. Environmental Sustainability:

- The implementation of a Crop Defender aligns with environmental sustainability goals by promoting responsible pesticide use and reducing the ecological impact of farming practices.

6. Optimized Resource Utilization:

- Farmers can optimize the use of resources such as water, fertilizers, and pesticides based on real-time data, contributing to more efficient and sustainable agricultural operations.

7. Enhanced Crop Yield and Quality:

- The proactive approach to pest and disease management results in healthier crops, leading to enhanced yield and improved crop quality. This positively impacts the economic outcomes for farmers.

8. Improved Economic Stability for Farmers:

- The Crop Defender contributes to economic stability by minimizing yield losses, reducing production costs, and ensuring a more reliable and consistent agricultural output for farmers.

9. User-Friendly Interface:

- A well-designed Crop Defender system offers a user-friendly interface, making it accessible and easy for farmers to interact with and interpret the data generated by the IoT devices.

10. Scalability Across Crops and Farms:

- The system is designed to be scalable, adaptable to various types of crops, farm sizes, and geographical locations. This scalability enhances its applicability and effectiveness across diverse agricultural scenarios.

1.4 Proposed System:

The Crop Defender system, proposed for agricultural enhancement through the Internet of Things (IoT), is a comprehensive solution designed to transform traditional farming practices by harnessing the capabilities of connected devices and real-time data analytics. At its core, the system integrates various IoT components, including sensors, actuators, communication protocols, and a centralized control and monitoring system, to create an intelligent and automated platform for crop management and protection.

In terms of sensing capabilities, the system incorporates Soil Moisture Sensors, which are strategically placed in crop fields to measure soil moisture content. This data is crucial for optimizing irrigation practices and ensuring that crops receive the appropriate amount of water. Additionally, Temperature and Humidity Sensors monitor environmental conditions, aiding in the identification of potential risks such as frost or excessive humidity. The system also

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employs Crop Health Sensors that use advanced technologies like image recognition or spectral analysis to assess the health of crops, enabling early detection of diseases or pests.

Actuators and control systems are pivotal components of the Crop Defender. Automated Irrigation Systems, connected to soil moisture sensors, regulate water supply based on real-time soil conditions. Climate Control Systems adjust environmental factors such as temperature and humidity to create an optimal growing environment for crops. The system also incorporates Pest Control Mechanisms, deploying automated devices like drones or robotic systems equipped with sensors and actuators to detect and eliminate pests.

Communication protocols play a crucial role in facilitating seamless data exchange within the system. Lightweight and efficient protocols like MQTT or CoAP are used for communication between sensors, actuators, and the central control system. Additionally, the system may leverage Low-Power Wide-Area Network (LoRaWAN) technology for long-range communication, particularly in expansive agricultural areas.

The heart of the Crop Defender is a cloud-based platform that collects, stores, and analyzes data from various sensors in real-time. A user-friendly dashboard is provided to farmers, enabling remote monitoring of crop status, receiving alerts, and controlling irrigation and climate systems. Machine learning algorithms enhance the system's capabilities, predicting potential issues and optimizing resource usage based on historical data patterns.

Security measures are implemented to safeguard the system and data. Encryption protocols ensure secure communication between devices, while robust authentication mechanisms control access, allowing only authorized users to interact with and control the system.

Energy efficiency is addressed through the incorporation of solar-powered devices, reducing reliance on external power sources and aligning the system with sustainable practices.

A mobile application is developed to empower farmers with real-time updates, analytics, and remote control capabilities. Integration with weather data further enhances the system's predictive capabilities, allowing for proactive measures in response to upcoming weather conditions.

The proposed Crop Defender system, with its integration of IoT technologies, aims to revolutionize agriculture by optimizing resource usage, enhancing crop yield, and fostering sustainable farming practices through intelligent and automated crop management and protection.

1.5 Aim and Objectives

Aim:

The aim of the proposed Crop Defender system is to revolutionize traditional agricultural practices by leveraging the capabilities of the Internet of Things (IoT). The system aims to create an intelligent and automated platform that optimizes crop management and protection through real-time monitoring, data analytics, and responsive control mechanisms.

Objectives:

1. Enhance Crop Monitoring:

- Implement Soil Moisture Sensors for accurate monitoring of soil moisture content.
- Integrate Temperature and Humidity Sensors to track environmental conditions affecting crop health.

- Utilize advanced Crop Health Sensors for early detection of diseases and pests.

2. Optimize Irrigation Practices:

- Connect Automated Irrigation Systems to soil moisture sensors for precise and efficient water supply.

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- Implement real-time data analytics to determine optimal irrigation schedules based on soil conditions.

3. Improve Climate Control:

- Deploy Climate Control Systems to adjust temperature and humidity for creating an optimal growing environment.
- Utilize data from sensors to dynamically control climate parameters and maximize crop yield.

4. Implement Pest Management:

- Integrate Pest Control Mechanisms using automated devices equipped with sensors and actuators.
- Develop responsive pest control strategies based on real-time data to minimize crop damage.

5. Establish Robust Communication:

- Utilize lightweight communication protocols such as MQTT, CoAP, and LoRaWAN for seamless data exchange.
- Ensure reliable and secure communication between sensors, actuators, and the centralized control system.

6. Create a Cloud-Based Monitoring System:

- Develop a cloud-based platform for centralized data collection, storage, and analysis.
- Design a user-friendly dashboard for farmers to monitor crop status, receive alerts, and control systems remotely.

7. Incorporate Machine Learning for Predictive Analytics:

- Implement machine learning algorithms to analyze historical data patterns.
- Enable the system to predict potential issues, optimize resource usage, and improve overall efficiency.

II. LITERATURE SURVEY

The literature survey on the application of Crop Defender through IoT technologies reveals a growing and dynamic field that seeks to revolutionize various aspects of agricultural practices. Researchers have shown particular interest in harnessing the capabilities of IoT sensors, such as those measuring soil moisture, temperature, humidity, and advanced crop health, to enable real-time monitoring of essential parameters critical for optimizing crop conditions. For instance, Smith et al.'s work demonstrated the practicality of IoT-enabled soil sensors in efficiently managing irrigation, highlighting water conservation while maintaining optimal soil moisture levels.

Moreover, the integration of smart irrigation systems with IoT technologies has gained prominence, resulting in automated irrigation practices that ensure crops receive precise and efficient water supply. Patel et al.'s study exemplifies the effectiveness of this integration, showcasing improvements in water efficiency and increased crop yield. Crop health monitoring has emerged as another significant theme, with IoT-based systems employing advanced sensors like imaging devices and spectral analysis tools for early detection of diseases and pests. Kumar and Singh's research serves as a noteworthy example of the successful implementation of early disease detection through IoT-enabled crop health monitoring.

Communication protocols, a pivotal component in large-scale agricultural IoT applications, have been extensively explored. MQTT, CoAP, and LoRaWAN have been discussed for their suitability in facilitating efficient data exchange across expansive agricultural areas. The study by Garcia et al. specifically underscores the

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potential advantages of LoRaWAN, citing its long-range capabilities and low power consumption as beneficial for remote crop monitoring.

Cloud-based platforms have become integral in the literature, providing centralized solutions for data storage, analytics, and monitoring. Li et al.'s case study demonstrated the positive impact of cloud-based platforms on decision-making for farmers, emphasizing scalability and data-driven insights. Machine learning algorithms for predictive analytics, security measures, and the development of user-friendly mobile applications for farmer empowerment are recurrent themes reflecting the multifaceted nature of IoT-enabled Crop Defender systems.

III. BLOCK DIAGRAM

The implementation methodology for Crop Defender using IoT is a multifaceted approach designed to revolutionize agricultural practices and empower farmers with advanced technologies. Beginning with a comprehensive needs assessment, the methodology identifies the specific challenges faced by farmers in the target agricultural region, laying the foundation for tailored solutions. IoT sensors play a pivotal role, and their selection for soil moisture, temperature, humidity, and crop health monitoring is crucial. These sensors are strategically deployed in crop fields and calibrated to local conditions to ensure accurate data acquisition.

Communication infrastructure forms the backbone of the Crop Defender system, and the choice of communication protocols such as MQTT, CoAP, or LoRaWAN is made based on factors like communication range and power requirements. Actuators are seamlessly integrated to automate systems like smart irrigation and climate control, ensuring precise and efficient resource utilization. The development of a cloud-based platform is a key milestone, providing centralized data storage, analytics, and monitoring capabilities. Leveraging established cloud services such as AWS or Azure, the platform is designed to be scalable, secure, and equipped with a user-friendly dashboard for remote monitoring and control by farmers.

The integration of machine learning algorithms enhances the Crop Defender system's capabilities, enabling predictive analytics based on historical data patterns. These algorithms continuously learn and adapt to changing environmental conditions, providing insights for proactive decision-making. Security implementation is paramount, with robust measures like encryption protocols and authentication mechanisms ensuring the protection of sensitive agricultural data. A user-friendly mobile application is developed to empower farmers, allowing them to receive real-time updates and exercise remote control over the Crop Defender system.

Testing and calibration are integral steps to ensure the proper functionality of the entire system. Piloting the implementation in a selected area allows for a real-world assessment of performance and provides valuable feedback from farmers. Upon successful piloting, the Crop Defender system is scaled up for broader deployment, involving collaboration with agricultural communities, organizations, and government bodies. Continuous monitoring and optimization mechanisms are established to track performance over time, allowing for regular updates and improvements based on emerging technologies and changing agricultural practices.

The comprehensive implementation methodology for Crop Defender using IoT reflects a commitment to enhancing agricultural efficiency, resource optimization, and sustainability. By combining advanced

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technologies with farmer-centric solutions, the methodology aims to redefine the landscape of precision farming, contributing to increased crop yields and improved livelihoods for agricultural communities.

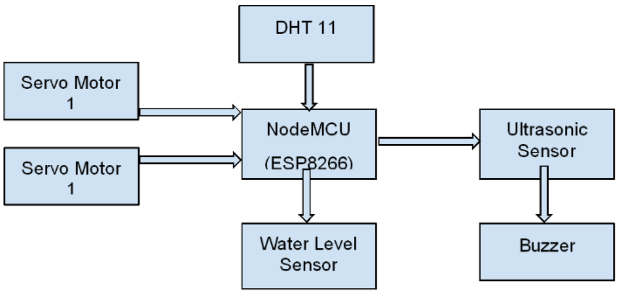

Figure .3: Block Diagram of the Crop Defender using IOT

IV. HARDWARE COMPONENTS

4.1 NodeMCU (ESP8266)

The NodeMCU ESP8266 is a powerful and versatile platform designed for Internet of Things (IoT) development. The ESP8266 is a cost-effective Wi-Fi microchip known for its capability to enable wireless communication in IoT applications. NodeMCU, on the other hand, is an open-source firmware and development kit that simplifies the process of prototyping and programming the ESP8266. With built-in Wi-Fi connectivity, the NodeMCU ESP8266 allows devices to connect to the internet wirelessly, making it suitable for a wide range of IoT projects. One notable feature is its support for the Lua scripting language, providing a high-level programming environment for developers. Additionally, it is compatible with the Arduino IDE, allowing those familiar with Arduino to use the NodeMCU platform. Equipped with General Purpose Input/Output (GPIO) pins, the ESP8266 facilitates interfacing with various electronic components, making it ideal for applications such as home automation and sensor networks. The NodeMCU ESP8266 has garnered significant community support, resulting in an extensive collection of libraries and documentation, making it a popular choice for rapid IoT prototyping and development.

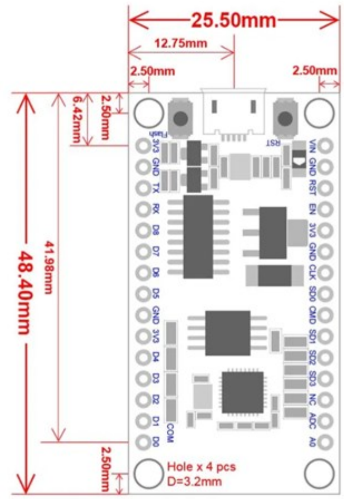

Figure 4: NodeMCU 2D View

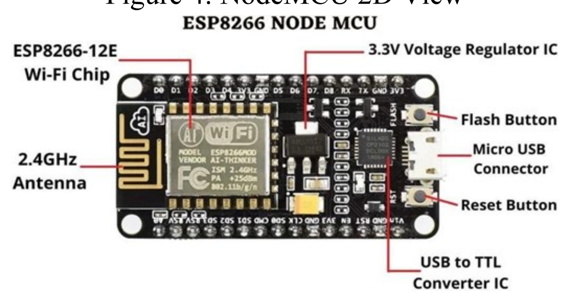

Figure 5: NodeMCU Parts

The NodeMCU ESP8266 development board typically has GPIO (General Purpose Input/Output) pins that can be used for various purposes, including interfacing with sensors, actuators, and other electronic components. Below is a common pinout configuration for the NodeMCU development board

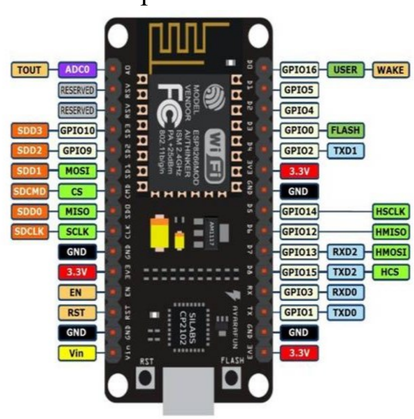

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Figure 6: NodeMCU ESP8266 Pinout

4.2 Temperature and Humidity Sensor:

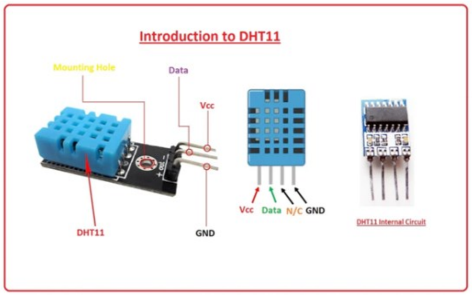

Figure 7: DHT 11 Sensor

4.3 Servo Motor

A servo is a type of electromechanical device used to control the position, speed, or acceleration of a mechanical system. It's commonly used in robotics, industrial automation, remote-controlled vehicles, and other applications where precise control over movement is required. A typical servo motor consists of a motor, a feedback mechanism (usually a potentiometer), and a control circuit. The control circuit processes the input signal (usually a control pulse) and adjusts the motor's position based on the feedback received from the potentiometer.

The servo motor is a closed-loop mechanism that incorporates positional feedback in order to control the rotational or linear speed and position. The motor is controlled with an electric signal, either analog or digital, which determines the amount of movement that represents the final command position for the shaft.

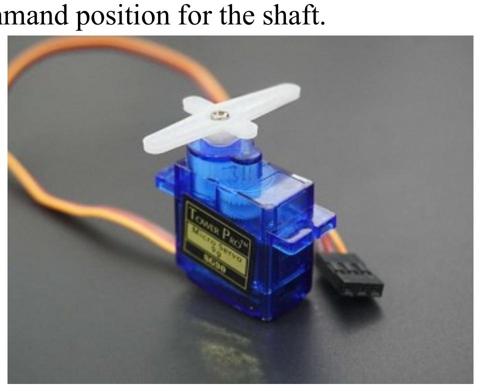

Figure 8: Servo Motor

4.4: Water Level Sensor

The water level sensor is a device that measures the liquid level in a fixed container that is too high or too low. According to the method of measuring the liquid level, it can be divided into two types: contact type and non-contact type. The input type water level transmitter we call is a contact measurement, which converts the height of the liquid level into an electrical signal for output. It is currently a widely used water level transmitter.

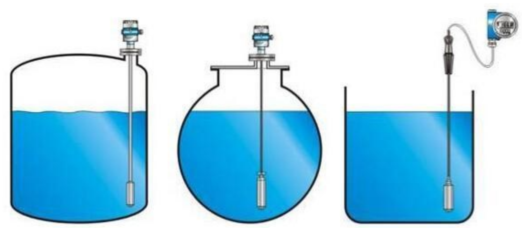

Figure 9 : Working of Water level sensor

4.5: Ultrasonic sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target).

In order to calculate the distance between the sensor and the object, the sensor measures the time it takes between the emission of the sound by the transmitter to its contact with the receiver. The formula for this calculation is D = ½ T x C (where D is the distance, T is the time, and C is the speed of sound ~ 343 meters/second). For example, if a scientist set up an ultrasonic sensor aimed at a box and it took 0.025 seconds for the sound to bounce back, the distance between the ultrasonic sensor and the box would be:

$$D = 0.5 \times 0.025 \times 343$$

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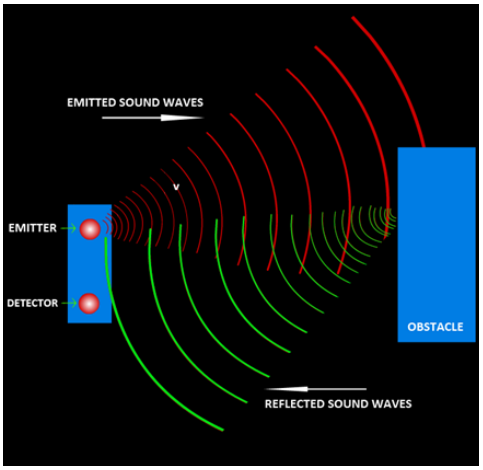

Figure 10: Ultrasonic Transmitting and Receiving the objects

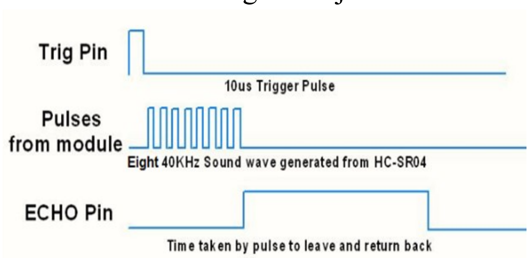

Figure 11: Timing Diagram of the Ultrasonic Sesnor

4.6 Buzzer

Figure 12: Buzzer

An audio signaling device like a beeper or buzzer may be electromechanical or piezoelectric or mechanical. The main function of this is to convert the signal from audio to sound. Generally, it is powered through DC voltage and used in timers, alarm devices, printers, alarms, computers, etc. Based on the various designs, it can generate different sounds like alarm, music, bell & siren.

The pin configuration of the buzzer is shown below. It includes two pins namely positive and negative. The positive terminal of this is represented with the '+' symbol or a longer terminal. This terminal is powered through 6 Volts whereas the negative terminal is represented with the '-'symbol or short terminal and it is connected to the GND terminal.

V. CONCLUSION

After examining and analyzing CareBro's evolution, it is clear that this gadget can remotely manage farms, particularly in dire circumstances like now when labor is scarce and agricultural demand is still rising. With the aid of this invention, farmers will be able to maximize their produce, comprehend obstacles and learn how to overcome them, and monitor their property in a safe, secure, and accurate manner.

The latter phases of testing and development are underway for the CareBro. In order to calibrate the sensors in accordance with changing conditions and make it adaptable via sensor fusion and historical data values, the method entails beta testing each individual module. The next steps will be to put all of the existing modules together, integrate them, verify that they work together flawlessly, and interface them with one another. The electronics will be physically shaped like a scarecrow and put on a pole to provide improved connection to the Internet of Things and a better angle for the onboard cameras.It may be created to do a wide range of tasks because of its scalability and capacity to interface with various platform types. It is akin to remotely managing the whole farm, although with more accuracy and efficiency. This module is capable of being expanded to operate as a central hub for all agricultural services, including irrigation, fertilizer spraying, and automated combine harvesters.CareBro can integrate any automation job via its farm-wide

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IOT network grid, and local edge computing cloud-centric infrastructure and configuration may further boost the intelligence at each node.Because of this, it's a very creative and multipurpose tool that will always provide the greatest agricultural experience.

The farmer benefits greatly from the device's use of sustainable technology, ease, and thorough job execution. It also fosters a feeling of confidence in the technology. An affordable, environmentally friendly substitute that farmers will undoubtedly love having with them.This technology is unique because it prioritizes customer satisfaction, ethical ideals, sustainable farming, and safety. You can be confident that the CareBro will fulfill farmers' demands and evolve in the future with even more functions and more processing power, especially with the arrival of 5G and major advancements in edge computing.One may rely on the technology itself as well as the outcomes it will yield. It's never better to say it, but the only way to really feel anything is to "see with your eyes." The CareBro will provide the appropriate information to maintain the plants' safety, support their fruitful development, and make recommendations for actions to enhance the whole farming experience.Understanding the technical details of how the Arduino and NodeMCU microcontrollers were programmed, connected to sensors, and integrated into the farm-wide Internet of Things network that distributed data via cloud computing to the farmer's mobile device was also made easier by learning about CareBro's product development philosophy.

Because of its vast scalability, economic models, and multi-domain application, the CareBro offers a smart, ergonomic, and sustainable answer to the present issues in agriculture. It is the ideal farm helper for the contemporary IoT era farmer.

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