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Design And Development of Smart Cono Weeder using IoT And

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ABSTRACT: Agriculture plays a vital role in the economy, and efficient weed management is essential for improving crop productivity in paddy cultivation. Traditional manual weeding methods are labor-intensive, time-consuming, and physically demanding for farmers working in waterlogged field conditions. To overcome these challenges, this project presents the design and development of an IoT-based Cono Weeder system integrated with solar power for smart and sustainable agricultural operations. The proposed system aims to automate the weeding process, reduce human effort, and improve operational efficiency through the use of modern embedded and communication technologies.

The system is built around the ESP32 microcontroller, which acts as the main control unit for wireless communication, motor control, sensor integration, and web server operation. A web-based control interface enables users to remotely operate the cono weeder using smartphones, tablets, or computers without requiring specialized software installation. The ESP32-CAM module provides real-time live video streaming, allowing farmers to monitor field conditions and navigate the system effectively from a remote location. This remote accessibility improves convenience and reduces the need for constant physical presence in the field.

To ensure safe and reliable operation, the system incorporates an HC-SR04 ultrasonic sensor for automatic obstacle detection. When obstacles are detected within a predefined range, the system automatically stops movement to prevent equipment damage and improve safety. The cono weeder and grass cutter mechanisms are independently controlled, allowing flexible operation based on field requirements. The integration of solar energy through a solar panel and rechargeable battery system further enhances sustainability by reducing dependence on conventional power sources and minimizing operational costs.

The proposed system is designed using low-cost and easily available electronic components, making it affordable and practical for small and medium-scale farmers. In addition to improving weeding efficiency, the project demonstrates the application of IoT, automation, renewable energy, and embedded systems in precision agriculture. The platform is also scalable and can be extended in the future with additional sensors such as soil moisture, temperature, humidity, and crop health monitoring modules. Overall, the IoT-based Cono Weeder system provides an eco-friendly, cost-effective, and intelligent solution for modern smart farming applications.

KEYWORDS: IoT, Cono Weeder, Smart Agriculture, ESP32, Solar Energy, Precision Farming, Automation, Paddy Field Weeding, ESP32-CAM, Ultrasonic Sensor, Remote Monitoring, Web-Based Control System.

I. INTRODUCTION

Agriculture is one of the most important sectors contributing to food production and economic development, especially in countries where farming is the primary occupation. In paddy cultivation, weed management is a major challenge because weeds compete with crops for nutrients, water, sunlight, and space, ultimately reducing crop yield and quality. Traditionally, weeding in paddy fields is carried out manually using conventional cono weeders. Although effective, manual operation requires significant physical effort, consumes more time, and causes fatigue to farm workers due to prolonged work in waterlogged field conditions.

With the advancement of technology, modern agriculture is gradually shifting toward automation and smart farming practices to improve efficiency and reduce labor dependency. The Internet of Things (IoT) has emerged as an important technology in precision agriculture by enabling remote monitoring, automation, and real-time data communication

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between devices. IoT-based systems allow farmers to control and monitor agricultural equipment from remote locations, thereby improving productivity and reducing operational difficulties.

The IoT-based Cono Weeder system is developed to address the limitations of traditional manual weeding methods. The proposed system integrates an ESP32 microcontroller, ESP32-CAM module, ultrasonic sensor, motor driver, and solar-powered battery system to create an intelligent and automated agricultural machine. The ESP32 acts as the central controller for wireless communication, web server hosting, motor control, and sensor management. Through a web-based interface, farmers can remotely operate the weeder using smartphones, tablets, or computers without the need for specialized software.

The system also incorporates live video streaming through the ESP32-CAM module, enabling real-time monitoring and navigation during field operations. An ultrasonic sensor is used for automatic obstacle detection to ensure safe movement and prevent damage to the equipment. In addition, the use of solar energy as a supplementary power source promotes sustainable and eco-friendly farming practices while reducing operational costs.

The proposed IoT-based Cono Weeder not only reduces manual labor and improves weeding efficiency but also demonstrates the practical application of IoT, renewable energy, and embedded systems in agriculture. The project is designed using low-cost and easily available components, making it suitable for small and medium-scale farmers. Furthermore, the system can be expanded in the future with advanced features such as soil moisture monitoring, crop health analysis, GPS-based navigation, and AI-driven automation, contributing toward the development of next-generation smart farming solutions.ent.

II. LITERATURE REVIEW

The rapid advancement of IoT technology and automation has significantly transformed modern agricultural practices. Smart farming systems are increasingly being developed to reduce manual labor, improve operational efficiency, and support sustainable agriculture. Several studies have focused on IoT-based monitoring systems, solar-powered agricultural equipment, and automated farming technologies, which provide a strong foundation for the development of the IoT-based Cono Weeder system.
Research on IoT-based agricultural monitoring systems has shown that embedded systems and wireless communication can be effectively used for real-time monitoring of agricultural parameters such as temperature, humidity, and soil conditions.

These systems help farmers monitor field conditions remotely and improve decision-making through real-time data collection and analysis. Automation through IoT technology has also been shown to reduce human intervention and improve productivity in agricultural operations.

Studies related to smart environmental monitoring in agriculture have emphasized the importance of remote access and sensor-based monitoring systems. By integrating sensors with IoT platforms, agricultural conditions can be continuously monitored and controlled efficiently. Such systems improve crop management and enable precision farming practices by providing accurate environmental information to farmers.

Research in smart agriculture frameworks has demonstrated the effectiveness of integrating sensors, microcontrollers, and communication modules for automated farming applications. These systems enable remote operation and monitoring through web-based or mobile interfaces, thereby improving operational efficiency and reducing dependency on manual labor. Wireless communication technologies play an important role in enabling real-time control and monitoring of agricultural equipment.

Several studies have also focused on solar-powered agricultural systems for sustainable farming applications. These systems integrate solar panels, rechargeable batteries, and energy management units to power agricultural devices efficiently. The use of renewable energy reduces dependence on conventional electricity, lowers operational costs, and supports environmentally friendly farming practices. Solar-powered automation has been identified as an effective solution for rural agricultural areas where electricity availability may be limited.

Research on agricultural robots and automated weed control systems has highlighted the benefits of automation in reducing physical strain on farmers and improving field operation efficiency. Automated systems using motors, sensors, and embedded controllers can perform agricultural tasks such as weeding, grass cutting, and field monitoring with

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greater consistency and precision compared to manual methods. Obstacle detection and remote operation features further improve safety and ease of operation.

Studies involving IoT-based agricultural robots have also demonstrated the importance of real-time communication, sensor integration, and remote accessibility in precision farming. These systems improve crop management, reduce labor requirements, and increase productivity by enabling farmers to monitor and control operations remotely. Renewable energy integration further enhances system sustainability and operational flexibility.

From the reviewed literature, it is evident that IoT, automation, and solar energy technologies have significant potential in modern agriculture. However, limited work has been carried out specifically on IoT-enabled automated cono weeders for paddy cultivation. Therefore, the proposed project focuses on developing a low-cost, solar-powered IoT-based Cono Weeder system with real-time monitoring, obstacle detection, and remote control features to improve efficiency, sustainability, and productivity in paddy field operations.

III. RESEARCH METHODOLOGY

The research methodology for the IoT-based Cono Weeder system involves the design, development, implementation, and testing of an automated agricultural machine for paddy field weeding applications. The methodology begins with identifying the limitations of traditional manual weeding methods, such as high labor requirements, physical strain, and low operational efficiency. Based on these challenges, an IoT-enabled automated solution powered by solar energy was proposed to improve agricultural productivity and reduce human effort.

The first stage of the methodology involves reviewing existing literature related to IoT in agriculture, solar-powered farming systems, embedded systems, and automated weed control technologies. This study helped in understanding the current advancements in smart farming and selecting suitable hardware and software components for the proposed system.

The hardware design phase includes the selection and integration of components such as the ESP32 microcontroller, ESP32-CAM module, L298N motor driver, DC motors, HC-SR04 ultrasonic sensor, solar panel, rechargeable battery, and mechanical cono weeder structure. The ESP32 serves as the central control unit responsible for wireless communication, web server hosting, motor control, and sensor management. The ultrasonic sensor is used for obstacle detection, while the ESP32-CAM provides real-time video streaming for remote monitoring.

The software development stage focuses on programming the ESP32 using the Arduino IDE environment. A web-based control interface is developed to allow users to remotely operate the system using smartphones, tablets, or computers through Wi-Fi connectivity. The control system includes movement control, grass cutter operation, obstacle detection logic, and live video streaming integration. Sensor readings and control commands are processed in real time to ensure smooth operation.

The power management system is designed using a solar panel and rechargeable battery arrangement to provide sustainable energy for field operation. Solar energy is utilized to reduce dependence on conventional power sources and improve the system’s eco-friendly performance. The battery stores energy for continuous operation during low sunlight conditions.

After development, the system undergoes testing and evaluation in simulated agricultural conditions. The testing process includes verification of motor control, wireless communication, obstacle detection, video streaming, and solar charging performance. The operational efficiency, reliability, safety, and responsiveness of the system are analyzed to ensure proper functionality.

Finally, the results obtained from the testing process are analyzed and compared with conventional manual weeding methods. Based on the observations, the performance of the IoT-based Cono Weeder system is evaluated in terms of labor reduction, operational efficiency, sustainability, and cost-effectiveness. The methodology demonstrates the practical implementation of IoT, automation, and renewable energy technologies in precision agriculture applications.

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IV. RESULTS AND DISCUSSION

The developed IoT-based Cono Weeder system was successfully designed, implemented, and tested for paddy field weeding applications. The system demonstrated effective automation of the weeding process while reducing the need for continuous manual labor. The integration of IoT technology enabled smooth wireless communication and remote operation through a web-based control interface. The ESP32 microcontroller efficiently handled motor control, sensor operation, and real-time communication, ensuring stable system performance during testing.

The web-based control interface functioned successfully on smartphones, tablets, and computers without requiring additional software installation. Users were able to control the movement of the cono weeder and grass cutter remotely through Wi-Fi connectivity. The ESP32-CAM module provided real-time live video streaming, allowing operators to monitor field conditions and navigate the system effectively from a remote location. This feature significantly improved operational convenience and reduced the need for physical presence in the field.
The HC-SR04 ultrasonic sensor successfully detected obstacles during operation and automatically stopped the system when objects were identified within the predefined distance range. This improved operational safety and prevented potential damage to the equipment. The obstacle detection system responded accurately under normal testing conditions and enhanced the reliability of the automated vehicle in uneven field environments.

The solar-powered energy system effectively supported the operation of the cono weeder. The solar panel and rechargeable battery combination provided sufficient power for motor operation, wireless communication, and sensor functioning. The use of renewable energy reduced dependency on external power sources and demonstrated the feasibility of sustainable agricultural automation. The system also showed low power consumption due to the energy-efficient nature of the ESP32 microcontroller.

During testing, the automated weeding mechanism achieved more consistent and uniform operation compared to traditional manual weeding methods. The system reduced physical strain on operators and improved overall working conditions, especially in waterlogged paddy fields. Remote operation capability allowed users to supervise and control the machine safely from field boundaries, increasing convenience and reducing operator fatigue.
The overall results indicate that the proposed

FIG: 1

V. CONCLUSION

The IoT-based Cono Weeder system successfully demonstrates an innovative and efficient approach to modern agricultural automation in paddy cultivation. The project integrates IoT technology, embedded systems, solar energy, and automated control mechanisms to reduce manual labor and improve weeding efficiency. The developed system enables remote operation and real-time monitoring through a web-based interface and live video streaming, providing greater convenience and flexibility for farmers.

The integration of the ESP32 microcontroller, ESP32-CAM, ultrasonic sensor, motor driver, and solar-powered battery system ensured reliable performance during operation. Features such as obstacle detection, wireless communication, and independent control of the weeder mechanisms enhanced the safety, functionality, and usability of the system.

The use of solar energy also contributed to sustainable and eco-friendly farming by reducing dependency on conventional power sources and lowering operational costs.

The results obtained from testing confirmed that the system can effectively automate paddy field weeding operations while improving consistency and reducing physical strain on farm workers. The project also demonstrated that low-cost and easily available components can be utilized to develop practical smart farming solutions suitable for small and medium-scale farmers.

Overall, the IoT-based Cono Weeder system serves as a promising solution for precision agriculture and establishes a strong foundation for future developments in agricultural automation. The system can be further enhanced with advanced technologies such as GPS navigation, AI-based weed detection, cloud data storage, and additional environmental sensors to support fully autonomous smart farming applications in the future.

VI. FUTURE WORK

- GPS-based autonomous navigation can be added for automatic field movement.
- AI and image processing can be integrated for smart weed detection.
- Additional sensors like soil moisture and temperature sensors can be included.
- Cloud storage and data analytics can improve monitoring and decision-making.
- Mobile application support can be developed for easier system control.
- The system can be extended for spraying, seed sowing, and fertilizer distribution.
- Improved battery and solar systems can enhance operating efficiency.
- Future upgrades can make the system fully autonomous for smart farming applications

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