WeedEx Tracker

Under the guidance of: Mr. U. S. Shirshetti

Aryan V.Chavan
Information Technology
Sou. Venutai Chavan Polytechnic Pune
Pune, India
aryanchavan4126@gmail.com

Aryan N.Dalvi
Information Technology
Sou. Venutai Chavan Polytechnic Pune
Pune, India
aryandalvi526@gmail.com

Piyush V.Bandal
Information Technology
Sou. Venutai Chavan Polytechnic Pune
Pune, India
piyushbandal@gmail.com

Harshada N.Chavan
Information Technology
Sou. Venutai Chavan Polytechnic Pune
Pune, India
chavan.harshada444@gmail.com

Modern agriculture faces significant challenges such as rising labor costs, shortage of workforce, and increasing weed growth affecting crop productivity. This paper presents the design and implementation of the WeedEx Tracker, a smart farming robotic system that assists farmers in weed management and field operations. The system integrates an ESP8266-based controller, camera module for live monitoring, motor driver for movement control, and relay-based actuation for weed cutting and water pumping.

The robot operates through a WiFi-based remote control mechanism, allowing farmers to monitor and control field operations in real time. The system reduces manual labor, improves efficiency, and provides cost-effective solutions for small and medium-scale farmers. The proposed model demonstrates effective weed control, seed sowing support, and irrigation capabilities. Future enhancements include AI-based automatic weed detection and GPS-enabled autonomous navigation.

Keywords — Smart Farming, Weed Detection, ESP8266, Agricultural Robotics, IoT, Automation

INTRODUCTION

Agriculture is a fundamental sector that supports global food production and plays a crucial role in sustaining human life and economic development. However, modern agriculture is facing several critical challenges, including labor shortages, rising operational costs, and inefficient weed management practices. With the migration of rural labor to urban areas, farmers are increasingly struggling to find workers, especially during peak farming seasons. At the same time, the cost of hiring labor continues to rise, making traditional farming methods less sustainable for small and medium-scale farmers.

Weeds are one of the major factors affecting crop productivity. They compete aggressively with crops for essential resources such as nutrients, water, sunlight, and space, ultimately reducing crop yield and quality. If not controlled at the right time, weed growth can significantly impact overall farm output and profitability. Effective weed management is therefore a critical requirement in modern agriculture.

Traditional weed control methods primarily rely on manual labor or the use of chemical herbicides. Manual weeding is highly time-consuming, labour-intensive, and physically demanding, often leading to increased fatigue and reduced efficiency. On the other hand, excessive use of chemical herbicides poses serious environmental and health concerns, including soil degradation, water contamination, and negative impacts on crop quality and biodiversity. These limitations highlight the need for a more efficient, sustainable, and cost-effective solution.

To address these challenges, the WeedEx Tracker system is proposed as an intelligent farming assistant. The system integrates embedded systems, Internet of Things (IoT), and robotic technologies to automate essential agricultural operations such as weed cutting, seed sowing, and irrigation. By combining these technologies, the system aims to reduce manual effort, improve operational efficiency, and support sustainable farming practices.

The proposed system utilizes a camera module for real-time field monitoring and an ESP8266 microcontroller for wireless communication and control. Through a WiFi-based interface, farmers can remotely monitor field conditions and control the robot's movement and operations using a mobile device. This remote accessibility minimizes physical effort, enhances precision in field operations, and enables timely intervention, ultimately improving overall productivity and efficiency in agricultural practices.

VOLUME: 10 ISSUE: 04 | APRIL - 2026 SJIF RATING: 8.659 ISSN: 2582-3930

I.RELATED WORK

The development of smart agricultural systems has gained significant attention in recent years due to the need for increased productivity and reduced manual effort. Researchers have explored various technologies such as robotics, Internet of Things (IoT), and computer vision to improve farming operations, particularly in weed detection and crop management.

2.1 Smart Farming and IoT-Based Systems

With the advancement of IoT, modern agricultural systems are becoming more connected and automated. IoT-based farming solutions enable real-time monitoring of field conditions such as soil moisture, temperature, and crop health. These systems allow farmers to remotely control agricultural equipment and make data-driven decisions. Many studies have demonstrated the use of microcontrollers like ESP8266 and Arduino for developing low-cost smart farming devices, making automation accessible to small and medium-scale farmers.

2.2 Vision-Based Monitoring and Detection Systems

camera-based systems are widely used for crop monitoring, weed detection, and disease identification. These systems improve decision-making and reduce dependency on manual inspection.

2.3 Robotic Systems for Weed Management

Robotic solutions have been developed to automate weed control and reduce reliance on manual labor. These robots typically use sensors, cameras, and mechanical actuators to detect and remove weeds. Some systems are fully autonomous, while others are semi-automatic and require human control. Although these systems improve efficiency and reduce labor costs, they are often expensive and complex, limiting their adoption in developing regions.

II.SYSTEM ARCHITECTURE

A modular and layered architecture is essential for ensuring reliability, scalability, and real-time responsiveness in autonomous robotic systems. The proposed WeedEx Tracker Target Tracking and Firing System follows a structured embedded architecture that integrates sensing, processing, actuation, and verification layers. The architecture is designed to establish a closed-loop control framework where real-time sensory input continuously influences mechanical output actions. The system ensures stable power distribution, synchronized motion control, and safe firing verification through coordinated subsystem interaction.

A. Structural Layer Analysis

The proposed architecture is partitioned into four interconnected functional layers:

I. Physical Actuation Layer

This layer represents the tangible mechanical and electrical components of the system, including:

- DC Motors for movement
- Gear motors with wheels
- Water pump
- Cutter mechanism
- Camera module

These components directly interact with the physical environment. The actuation layer performs movement, rotation, and firing actions based on processed control signals.

II. Signal Conditioning and Power Management Layer

This layer ensures stable electrical operation and signal integrity. It includes:

- 2V Battery
- Solar Panel
- 7805 Voltage Regulator
- Power distribution circuits

This layer regulates voltage, reduces electrical noise, and ensures stable power supply to all components. It prevents microcontroller malfunction and supports smooth operation of motors and control signals.

III. Control and Processing Layer

The core intelligence of the system resides in this layer, primarily managed by the ESP controller. Its responsibilities include:

- ESP8266 (NodeMCU)
- L298N Motor Driver
- Relay Modules

This layer implements a closed-loop tracking system that continuously adjusts the pan–tilt mechanism to keep the target properly aligned.

IV. User Interaction

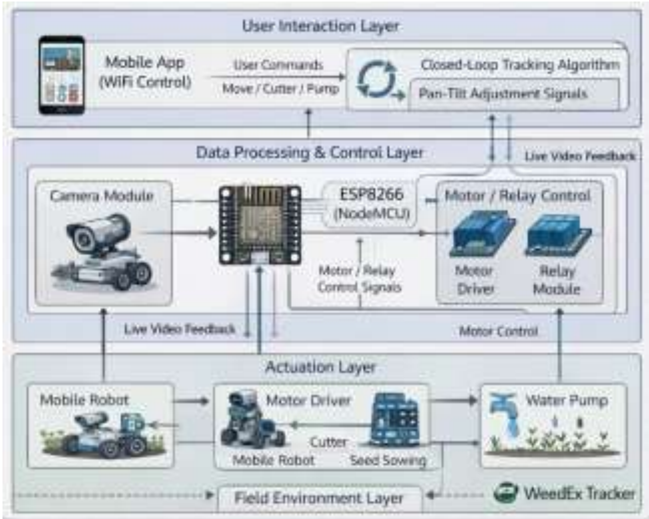
This layer manages external input and system validation, including:

- Mobile device (WiFi control)
- Camera monitoring interface

This layer provides an interface between the user and the system, enabling easy control and monitoring of the robot. It primarily consists of a mobile device connected through WiFi and a camera-based monitoring interface. The user can send commands such as movement direction, weed cutting, and water pumping through a mobile application or web interface.

The camera module provides live video streaming of the field, allowing the user to observe real-time conditions and make informed decisions. This layer ensures remote accessibility, reduces the need for physical presence in the field, and improves operational efficiency and user convenience.

.



IV.FEATURES

The WeedEx Tracker system offers several important features that improve efficiency and reduce manual effort in agricultural operations:

- WiFi-Based Remote Control
The system allows users to control the robot remotely using a mobile device through a WiFi connection.

- Live Camera Monitoring
A camera module provides real-time video streaming, enabling users to monitor field conditions continuously.

- Weed Cutting Mechanism
The robot is equipped with a cutter system to remove weeds effectively, reducing manual labor.

- Seed Sowing Capability
The system supports basic seed sowing functionality, assisting in planting operations.

- Water Pumping System
A relay-controlled water pump enables irrigation, improving water management in the field.

- Motorized Movement Control
DC motors allow the robot to move in multiple directions such as forward, backward, left, and right.

- Low-Cost Implementation
The system uses affordable and easily available components, making it suitable for small farmers.

- Reduced Manual Effort
Automation of tasks minimizes physical workload and saves time during farming operations.

- Modular Design
The system is designed in modules, allowing easy upgrades and modifications.

- Scalability for Future Enhancements

Features like AI-based weed detection and autonomous navigation can be added in future versions.

V.METHODOLOGY

The methodology of the WeedEx Tracker system follows a structured approach that converts user inputs into controlled robotic actions for performing agricultural tasks. The system integrates real-time monitoring, wireless communication, and actuator control to achieve efficient operation.

- 5.1 Data Acquisition

The system collects real-time visual data using a camera module mounted on the robot. The camera provides continuous live streaming of the field, allowing the user to observe crop conditions and identify weed growth.

5.2 User Input and Communication

The user sends control commands through a mobile device connected via WiFi. These commands include movement directions (forward, backward, left, right) and operational controls such as activating the cutter or water pump. The ESP8266 microcontroller receives these commands wirelessly.

5.3 Data Processing and Control Logic

The ESP8266 processes the received commands and determines the required action. Based on the input, it generates control signals for different components such as motors and relays.

5.4 Actuation Mechanism

The processed signals are sent to the motor driver and relay modules. The motor driver controls the movement of DC motors, enabling the robot to navigate the field. The relay module activates the weed cutting mechanism and water pump as required.

5.5 System Output

The robot performs the desired agricultural operations such as movement, weed cutting, seed sowing, and irrigation. Meanwhile, the camera continuously provides live feedback to the user, ensuring effective monitoring and control.

VI.IMPLEMENTATION

The implementation of the *WeedEx Tracker* system involves the integration of hardware components and software modules to perform real-time monitoring and control of agricultural operations. The system is designed to ensure efficient communication between the user and the robotic platform.

6.1 Hardware Components

The system consists of the following key hardware components:

- ESP8266 (NodeMCU): Acts as the main controller for processing commands and managing system operations.
- L298N Motor Driver: Controls the movement of DC motors.
- DC Motors and Wheels: Enable movement of the robot in different directions.
- Relay Module: Controls the weed cutter and water pump.
- Camera Module: Provides live video streaming for monitoring the field.
- Power Supply (Battery & Solar Panel): Supplies power to the system components.
- Voltage Regulator (7805): Maintains a stable voltage supply.

6.2 Software Tools

The system uses the following software tools for implementation:

- Arduino IDE: Used for writing and uploading code to the ESP8266.
- Embedded C / Arduino Programming: Used to develop control logic for the system.
- ESP8266 WiFi Libraries: Enable wireless communication between the robot and mobile device.

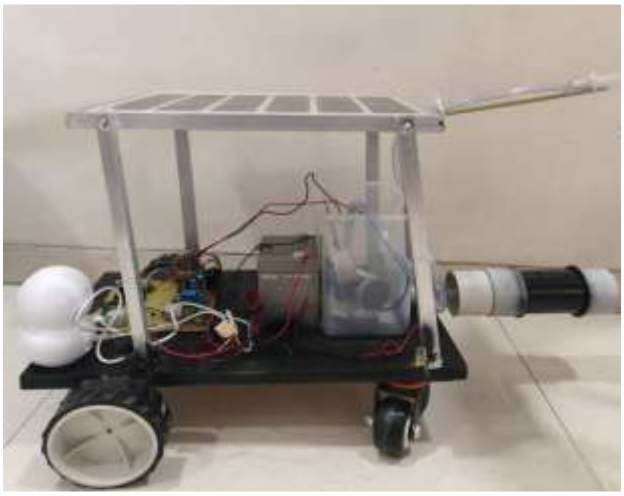
6.3 System Integration

All hardware and software components are integrated to form a complete working system. The ESP8266 receives commands from the user via WiFi and processes them to control motors and relays. The motor driver manages robot movement, while the relay module controls the cutter and water pump. The camera continuously provides live feedback to the user.

6.4 Prototype Development

A working prototype of the WeedEx Tracker was developed using the above components. The robot was tested in a controlled environment to verify its movement, remote control functionality, and ability to perform tasks such as weed cutting and irrigation. The system demonstrated reliable performance and effective operation.

VOLUME: 10 ISSUE: 04 | APRIL - 2026 SJIF RATING: 8.659 ISSN: 2582-3930



VII. PERFORMANCE ANALYSIS

The performance of the *WeedEx Tracker* system was evaluated based on its efficiency, response time, reliability, and overall impact on farming operations. The system was tested under normal working conditions to analyze its effectiveness in real-time applications.

A. Efficiency

The system uses computer vision techniques implemented with OpenCV and Python to identify targets in live video streams.
Experimental observations show that the system can successfully detect objects in most normal lighting conditions with high accuracy. Compared to manual observation, automated detection improves the speed and consistency of identifying targets.

B. Response Time

The communication between the mobile device and the ESP8266 occurs through WiFi, enabling quick transmission of commands. The system responds to user inputs with minimal delay, ensuring smooth and real-time operation.

C. Operational Accuracy

The robot performs actions according to the commands given by the user with good accuracy. The movement control and relay operations function correctly, allowing precise execution of tasks like weed cutting and water pumping.

D. System Reliability

The system demonstrates stable performance during continuous operation. The hardware components work efficiently without major interruptions, ensuring consistent functioning in normal environmental conditions.

E. Cost Effectiveness

Overall, the Mini PASEO system improves operational efficiency compared to manual target tracking. Automated detection and tracking reduce human effort, increase monitoring accuracy, and enable faster response to moving targets. These improvements demonstrate the effectiveness of the proposed system for applications such as surveillance, robotics, and automated tracking systems.

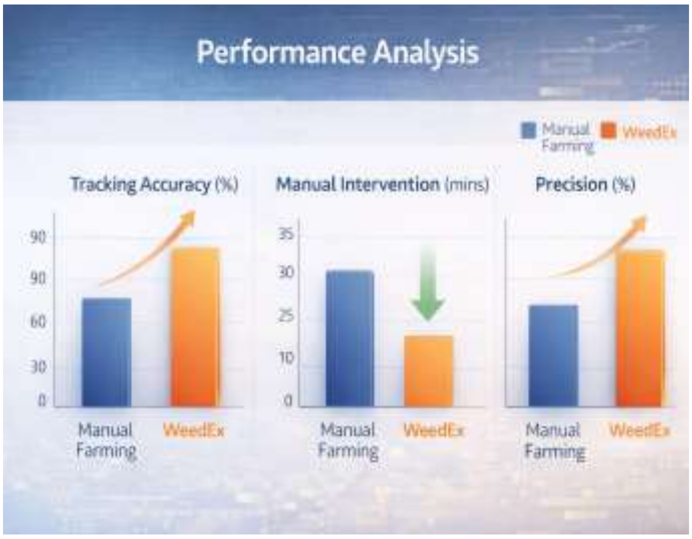
F. Limitations

Despite its advantages, the system has certain limitations:

- Performance may decrease with weak WiFi connectivity
- Requires manual control for operation
- Limited efficiency in large-scale farming areas

G. Overall Performance

Overall, the WeedEx Tracker system improves farming efficiency by reducing manual effort, saving time, and providing real-time control. It proves to be a reliable and cost-effective solution for smart farming applications.



*VIII.*CONCLUSION

The *WeedEx Tracker* system provides an efficient and cost-effective solution to the growing challenges in modern agriculture, including labor shortages, increasing operational costs, and ineffective weed management practices. By integrating embedded systems, IoT, and robotic technologies, the system successfully automates essential farming operations such as weed cutting, seed sowing, irrigation, and real-time field monitoring.

The implementation of a WiFi-based control mechanism using the ESP8266 microcontroller enables farmers to remotely operate the robot with ease. The inclusion of a camera module allows continuous monitoring of field conditions, improving decision-making and operational accuracy. The system reduces manual effort, saves time, and enhances productivity, making it highly beneficial for small and medium-scale farmers.

Experimental results show that the system performs reliably under normal conditions, with quick response time and stable operation. The use of low-cost and easily available components makes the solution practical and accessible, especially in rural areas.

Although the current system requires user control and is limited by factors such as network dependency and manual operation, it establishes a strong foundation for future improvements. Advanced features such as AI-based weed detection, fully autonomous navigation, GPS integration, and smart sensor-based monitoring can further enhance the system's capabilities.

In conclusion, the WeedEx Tracker demonstrates how modern technology can be effectively applied to agriculture to achieve smarter, more efficient, and sustainable farming practices.

IX.REFERENCES

[1] G. Bradski and A. Kaehler, *Learning OpenCV: Computer Vision with the OpenCV Library*. Sebastopol, CA, USA: O'Reilly Media, 2008.

[2] R. Szeliski, *Computer Vision: Algorithms and Applications*. Springer, 2011.

[3] S. Thrun, W. Burgard, and D. Fox, *Probabilistic Robotics*. MIT Press, 2005.

[4] J. Redmon et al., "You Only Look Once: Unified, Real-Time Object Detection," in *Proc. IEEE Conf. Computer Vision and Pattern Recognition (CVPR)*, 2016.

[5] D. Forsyth and J. Ponce, *Computer Vision: A Modern Approach*. Pearson Education, 2012.

[6] A. Bewley et al., "Simple Online and Realtime Tracking," in *Proc. IEEE Int. Conf. Image Processing*, 2016.

[7] A. Rosebrock, *Practical Python and OpenCV*. PyImageSearch, 2016.

[8] ESP8266 Documentation, "ESP8266 WiFi Module Datasheet," Available: https://www.espressif.com

[9] Arduino, "Arduino IDE and Embedded Programming," Available: https://www.arduino.cc

[10] L298N Motor Driver Datasheet, STMicroelectronics.