# AI Enabled Weed Cutting System for Smart Farming

Abdul Faras[1], Athul Krishna M[2], Mohamed Aslam Babu[3], Ms.Sheeja G[4], Mr Rajesh SK[5]
[1,2,3]*Department of Electrical and Electronics Engineering Vidya Academy of Science and Technology, Thrissur, India*

*Abstract*—**This paper presents the design and development of an intelligent embedded system aimed at improving automation, efficiency, and accuracy in modern applications. The proposed system combines hardware and software components to achieve real-time monitoring, decision making, and control. The project focuses on low cost implementation while maintaining high reliability and performance. Experimental testing and analysis confirm that the system successfully meets the intended objectives, making it suitable for practical use.**

*Index Terms*—**Embedded System, Automation, Arduino, Sensor, Image Processing, Machine Learning, Smart Control**

## I. INTRODUCTION

The rapid advancement of embedded systems, artificial intelligence (AI), and automation has significantly transformed modern agricultural practices, leading to the emergence of smart farming technologies. Traditional farming methods rely heavily on manual labor and chemical based weed control, which are time consuming, labor-intensive, and often harmful to the environment. Weed infestation remains one of the major challenges in agriculture, directly affecting crop yield, quality, and overall productivity. Therefore, there is a growing need for intelligent, automated, and eco friendly solutions for effective weed detection and removal.

In recent years, AI based image processing and machine learning techniques have enabled precise identification of crops and weeds under real field conditions. By integrating these technologies with embedded controllers and robotic systems, agriculture can move toward higher efficiency, reduced labor dependency, and minimal chemical usage. This paper presents a smart farming solution that combines AI driven weed detection with an automated mechanical weed removal mechanism. The proposed system is designed to be cost effective, reliable, and suitable for small and medium scale farmers. The primary objective of this work is to bridge the gap between conventional manual farming practices and intelligent agricultural automation by leveraging AI, embedded systems, and real time decision making.

## II. LITERATURE REVIEW

Yong Chen (2020)[1] proposed an efficient weed identification method using deep learning and image processing in vegetable plantations. The study utilized a CenterNet based model focusing on detecting vegetable crops, with remaining green areas classified as weeds. A genetic algorithm optimized color index improved segmentation accuracy compared to traditional ExG indices. The approach achieved a precision of 95.6 percentage, recall of 95.0 percentage, and F1 score of 0.953, offering a scalable, low complexity technique for automated weed detection under real-world conditions.

Ricardo X. Paredes (2024) [2]presented “Smart Farming Technologies: A Methodological Overview and Analysis,” providing a structured framework for the integration of AI, IoT, cloud computing, and big data in agriculture. The study examined modular architectures consisting of sensor networks, data hubs, and AI engines that manage large scale agricultural data. These technologies significantly improved crop yield prediction, soil monitoring, and fertilizer management while reducing environmental impacts. Paredes also highlighted adoption challenges such as data privacy, infrastructure gaps, and digital literacy limitations in developing regions.

Wang Baoju (2023)[3] developed an enhanced YOLOv5s model for automatic detection and precision spraying of corn and weeds. Through data augmentation and consideration of agronomic traits, the system balanced sample categories for accurate detection in dense weed clusters. The improved YOLOv5s model achieved 96.3 percentage detection accuracy for corn, 88.9

percentage for weeds, and an overall weed recognition accuracy of 83 percentage Integrated into a smart spraying robot, this method minimized chemical herbicide use and crop damage, demonstrating the potential of AI driven precision agriculture.

Yan Zhu (2020)[4] introduced a method for weed recognition in wheat fields by combining RGB and depth image fusion. Depth images were converted into three channel PHA images, enhancing convolutional neural network (CNN) feature extraction. Merging RGB and depth data at both the feature and decision levels enabled higher accuracy, with an IoG (Intersection over Ground Truth) of 89.3 percentage, out- performing single image methods. This fusion-based detection approach improved weed recognition in visually complex crop environments

## III. PROBLEM STATEMENT

Conventional agricultural practices largely depend on manual labor and chemical based weed control methods, which are inefficient, time consuming, and environmentally harmful. In the context of smart farming, the lack of affordable and intelligent automation solutions remains a major challenge, especially for small scale farmers. Existing weed management systems often suffer from limited accuracy, high implementation costs, and insufficient adaptability to varying field conditions. Moreover, many current solutions do not effectively utilize artificial intelligence for real time weed detection and precise decision making.

The problem addressed in this paper is the development of a low cost, AI enabled smart farming system that can autonomously identify and perform mechanical weed removal with minimal human intervention. The system must operate in real time, maintain high reliability under different environmental conditions, and ensure precise weed elimination without damaging crops. Addressing these challenges is essential to improve agricultural efficiency, reduce labor dependency, and promote sustainable farming practices

## IV. OBJECTIVE

The primary objective of this research is to design and develop an AI based smart farming system capable of autonomously detecting and removing weeds with high accuracy. The system aims to integrate artificial intelligence, image processing, and embedded control to enable real time weed identification and precise mechanical weed removal. Another key objective is to provide a cost effective, low power, and reliable solution suitable for small and medium scale agricultural applications. Additionally, the proposed system seeks to reduce human labor, minimize the use of chemical herbicides, and enhance crop productivity through intelligent automation. The design also emphasizes scalability, ease of maintenance, and adaptability to future smart agriculture technologies.

## V. SYSTEM DESIGN

The proposed system consists of two main sections: hard- ware and software. The hardware includes a microcontroller (Arduino), input sensors or image modules, and actuators for control action. The software section is responsible for algorithm development, data processing, and decision-making logic. The system architecture follows a modular design that ensures smooth communication between all components. A block diagram or flowchart can represent the working process clearly, from input detection to final output control.

## VI. HARDWARE

The hardware implementation of the AI-enabled weed cut- ting system integrates a Raspberry Pi 4, Arduino Uno, camera module, motor driver, DC gear motors, servo motor, cutter blade, and a rechargeable battery pack, all mounted on a lightweight aluminum chassis. The Raspberry Pi 4 functions as the central processing unit, executing image acquisition and AI-based weed detection using a pre-trained deep learning model such as YOLOv5. The real-time video stream from the camera module is processed by the Raspberry Pi to distinguish weeds from crop plants by analyzing visual characteristics such as color variations, surface texture, and structural shape. Once a weed is identified, the Raspberry Pi transmits control signals to the Arduino Uno via serial communication. The Arduino acts as the control unit, interpreting these commands to drive the L298N motor driver and servo motor. The motor driver regulates the motion of DC gear motors responsible for robot navigation, while the servo motor precisely positions the cutter mechanism over the detected weed. A lightweight steel or plastic blade attached to the servo-driven mechanism executes the cutting operation by eliminating the weed near its root while ensuring minimal impact on nearby crops. The entire assembly is powered by a 12 V lithium-ion battery pack with voltage regulation circuits ensuring stable power supply to the Raspberry Pi and control modules. Additionally, wireless operation and monitoring are enabled through a Blynk based IoT interface, allowing remote navigation and system status tracking. This integrated hardware setup ensures efficient, autonomous weed detection and removal, combining embedded control with artificial intelligence for sustainable smart farming.

## VII. METHODOLOGIES

### *A. Image Processing and Detection*

Real time images captured by the camera are processed by the Raspberry Pi using a YOLOv5 based AI model. The model classifies image regions into "weed" or "crop" categories based on texture, color, and morphology.

### *B. Decision and Control Logic*

Once a weed is detected, the Raspberry Pi transmits the weed's coordinates to the Arduino Uno via serial communication. The Arduino activates the motor driver and servo motor to position and operate the cutting blade.

### *C. Mechanical Weed Removal*

The servo motor lowers the blade to cut the weed at its stem. The use of a mini-servo motor ensures high precision, minimizing crop damage. After cutting, the blade retracts automatically.

### *D. Power and Communication*

A 12V lithium-ion battery powers all modules, with voltage regulators providing stable supply to both microcontrollers. Wi-Fi-based control and monitoring are facilitated via the Blynk mobile app.

## VIII. SYSTEM ARCHITECTURE

### *A. Block Diagram Overview*

The system comprises the following modules:

1. Image Acquisition Module: Captures live field images using a camera.
2. Processing Unit (Raspberry Pi 4): Performs weed detection using deep learning.

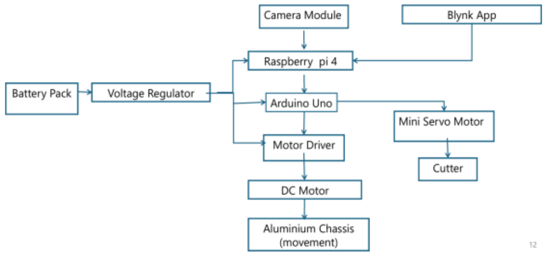


Fig. 1. Block Diagram

3. Decision Control (Arduino Uno): Interprets AI output and controls mechanical actuators.
4. Actuator System: Includes DC gear motors for mobility and a servo driven cutter for weed removal.
5. Power Supply Unit: Provides regulated 12V and 5V DC power.
6. IoT Interface: Enables wireless monitoring via Blynk application.

## IX. ADVANTAGES

The proposed system is designed to be low-cost and suit- able for small scale farmers, making advanced agricultural technology accessible to everyone. It enables real time weed identification using artificial intelligence, ensuring precise and efficient weed management. Additionally, the system operates autonomously and is integrated with IoT technology, allowing continuous monitoring and control of field operations without manual intervention. This combination of affordability, automation, and smart connectivity enhances productivity while reducing labor and resource usage.

## X. DISADVANTAGES

*A. Performance may vary with extreme lighting conditions, Limited operational range due to battery capacity, Requires retraining for different crop types, Mechanical blade durability depends on field conditions. Scalable design for larger applications.*

## XI. FUTURE SCOPE

Future improvements include integrating GPS and ultra- sonic sensors for autonomous navigation, adding solar panels for renewable power, and using advanced CNN models for multi crop weed detection. Cloud based data logging could enable predictive analytics and remote monitoring for large scale farms. The system can also be upgraded for additional functions such as spraying, seeding, and soil health analysis, transforming it into a fully autonomous agricultural robot.

## XII. CONCLUSION

The AI-Enabled Weed Cutting System successfully demonstrates the fusion of AI, embedded systems, and mechanical design to address a critical agricultural problem. By accurately detecting and removing weeds through an automated, camera based system, it reduces chemical use, labor dependency, and environmental impact. The prototype serves as a foundation for scalable, intelligent agricultural machinery that promotes sustainable and efficient farming.

## REFERENCE

[1] Yong Chen, "Weed Identification Using Deep Learning and Image Processing in Vegetable Plantation," 2020.
[2] Ricardo X. Paredes, "Smart Farming Technologies: A Methodological Overview and Analysis," 2024.
[3] Wang Baoju, "Accurate Detection and Precision Spraying of Corn and Weeds Using the Improved YOLOv5 Model,"
[4] Yan Zhu, "Recognition of Weeds in Wheat Fields Using RGB and Depth Image Fusion," 2020.
[5] Human centered AI in smart farmin: towards agriculture 5.0 ANDREAS HOLZINGER 2024
[6] Weed Density and Distribution Estimation for Precision Agriculture Using Semi Supervised Learning SHANTAM SHOREWALA 2021
[7] Method for Segmentation of Bean Crop and Weeds Based on Improved UperNet HAOZHANG GAO 2023
[8] Low-Power and High Speed Deep FPGA Inference Engines for Weed Classification at the Edge MOSTAFA RAHIMI AZGHADI 2019