

# An IoT Based Real Time System for Weed Identification and Selective Removal in Mixed Farming Environment

Atik Attar, Bhuvan H P, Akshay R, Chandan Krishna Y E, Prof. Sandip K V

Dept. Information Science and Engineering

Global Academy of Technology, Bengaluru, India

sandip96kv@gmail.com, atikattar812@gmail.com bhuvanhp006@gmail.com

iamakshayraj4@gmail.com, yechandankrishna@gmail.com

**Abstract:** *Weed growth is one of the major challenges in agriculture that significantly reduces crop productivity and increases farming costs. Traditional weed removal techniques such as manual weeding and chemical herbicide application are labor-intensive, time-consuming, and environmentally harmful. To address these challenges, this paper presents the implementation of an autonomous weed detection and removal system using deep learning and robotic automation. The proposed system utilizes YOLOv5, a real-time object detection algorithm, to detect weeds such as Nutsedge, Morning Glory, and Goosegrass in agricultural fields. A camera mounted on a Raspberry Pi-based rover captures real-time images, which are processed using the trained deep learning model to identify weeds and determine their coordinates. Based on the detection results, the rover navigates toward the weed and activates a mechanical cutting mechanism for removal. The system operates autonomously and reduces manual labor, herbicide usage, and operational costs. Experimental results demonstrate that the proposed system achieves high accuracy and real-time performance, making it suitable for precision agriculture applications.*

**Keywords:** Weed Detection, YOLOv5, autonomous rover, Deep Learning, Precision Agriculture, Sustainable Farming

## I. INTRODUCTION

Agriculture plays a crucial role in ensuring food security and supporting the global economy. However, weed infestation remains one of the most significant challenges faced by farmers. Weeds compete with crops for nutrients, sunlight, and water, leading to reduced crop growth and lower agricultural productivity. Traditional weed removal techniques such as manual weeding require significant labor and time, while chemical herbicides may harm soil quality and increase environmental pollution.

With the advancement of artificial intelligence and robotics, automated weed detection systems have gained attention in precision agriculture. Deep learning-based object detection algorithms provide efficient solutions for identifying weeds in real-time conditions. Among these algorithms, YOLOv5 has shown promising performance due to its speed and accuracy.

This paper focuses on implementing an autonomous weed detection and removal rover using YOLOv5. The system integrates computer vision, embedded systems, and mechanical actuation to detect weeds and remove them automatically. The proposed system aims to reduce labor costs, minimize herbicide use, and improve agricultural productivity.



## **II. RELATED WORK**

Recent advancements in deep learning and robotics have enabled significant improvements in automated weed detection and precision agriculture. Several researchers have proposed various machine learning and computer vision-based approaches for weed detection and removal.

In recent studies, Convolutional Neural Networks (CNNs) have been widely used for weed classification and detection. Researchers developed CNN-based weed detection systems that analyze plant features such as color, shape, and texture to distinguish weeds from crops. These approaches demonstrated improved accuracy compared to traditional image processing techniques but required high computational power for real-time deployment.

Object detection models such as YOLO (You Only Look Once) have gained popularity due to their real-time detection capabilities. Several studies implemented YOLO-based weed detection systems to identify weeds in agricultural fields. These systems achieved high detection accuracy and faster inference speeds, making them suitable for robotic applications in agriculture.

Some researchers also developed autonomous robotic platforms integrated with computer vision systems for weed removal. These systems used cameras mounted on mobile robots to detect weeds and apply targeted herbicide spraying or mechanical removal. The integration of robotics and deep learning significantly reduced manual labor and improved weed removal efficiency.

In addition, lightweight embedded systems such as Raspberry Pi and Jetson Nano have been used in precision agriculture applications. These systems enable real-time weed detection while maintaining low cost and power consumption. The combination of deep learning models and embedded hardware has made automated weed detection systems more practical for small and medium-scale farms.

Although existing research provides effective weed detection methods, many systems are either expensive or require high computational resources. The proposed system addresses these limitations by implementing a cost-effective Raspberry Pi-based autonomous rover using YOLOv5 for real-time weed detection and removal. The proposed approach improves detection accuracy while maintaining affordability and ease of deployment in agricultural environments.

## **III. PROPOSED SYSTEM**

The proposed system includes an autonomous rover designed for weed detection and removal in agricultural fields. It integrates both hardware and software components to identify weeds using image processing and deep learning techniques. The rover navigates autonomously through the field and takes pictures, classifying them in real time and triggers weed removal actions. The central hardware modules of the system components include a Raspberry Pi, camera, motor drivers, chassis, battery and communication module

A. Raspberry-Pi: The Raspberry Pi is the central processing unit of the rover in charge of carrying out image processing and control algorithms. It processes images captured by the camera, detects weeds using the trained YOLOv5 model, and issues navigation and actuation commands. Its Linux-based operating machine running flexibility provided in this system learning inferences in real time.

B. Camera: A high-definition camera is mounted on the rover to take continuous images of the field as it moves. The camera provides clear, high-resolution visuals even under variable lighting conditions to assure consistent weed identification. These images are analyzed by the Raspberry Pi using pre-trained deep learning models to detect and classify weeds.

C. Motor Drivers: The rover's mobility is powered by two DC motors controlled by an L298N motor driver. The Raspberry Pi sends PWM signals to the driver, which controls the speed and direction of movement. The navigation algorithm determines the path that the rover will follow in its motion ensure full field coverage while avoiding obstacles.

D. Rover Chassis: The mechanical framework of the rover is designed for stability and portability, it houses the motors, camera, Raspberry Pi, and battery providing a sturdy structure able to crossing over irregular and soft farming grounds.



E. Battery: A rechargeable lithium-ion battery powers the entire system, including the Raspberry Pi, camera and motors. The power system is optimized for prolonged field operation ensuring autonomy recharging.

F. Wi-Fi Module: Without frequent Wi-Fi communication module allows for remote monitoring and controlling the rover using a mobile system or laptop interfaces. This feature allows users to change operational parameters such as navigation speed or detection sensitivity and to receive real-time performance feedback during operation, the rover travels across the field along a predefined path continuously capturing image processing and analysis. YOLOv5 model running on the Raspberry Pi identifies weeds in each frame to distinguish them from crops. While navigation is guided by detection results, actuation commands, enable efficient, collision-free motion and accurate weed removal.

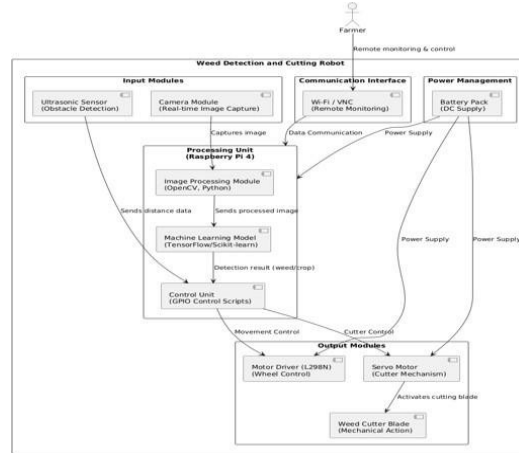


Fig. 1: Flowchart of the weed detection process

The core process is a seamless loop of detection and action: 1. Continuous Scanning: During this process, the rover navigates along a very precise, pre-set path across the field and continuously captures images of the ground. 2. Real-Time Classification: YOLOv5, which runs directly on the powerful Raspberry Pi, takes those images and instantly identifies any weeds from crops, based on learned features such as colour, texture, and leaf shape. 3. Targeted Removal: Once a weed has been identified, the position of the weed is instantly calculated, and the corresponding actuator—a micro-sprayer or mechanical cutter—is triggered to effect precise removal, while protecting the neighbouring crop. This integrated approach of autonomous movement, machine vision, and deep learning significantly reduces both manual labour and destructive broad-spectrum herbicides, thus making the farming highly efficient and environmentally sound.

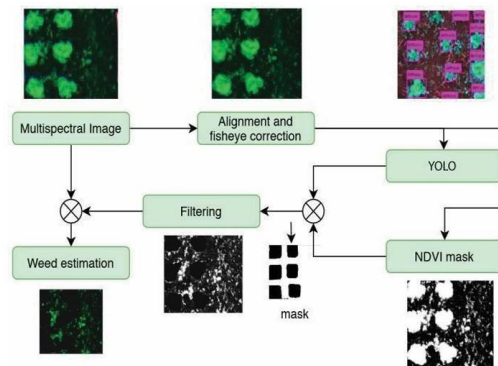


Fig. 2. Flow Diagram for model working System



**IV. RESULTS AND DISCUSSIONS**

A. Quantitative Analysis: The evaluation of the YOLOv5 was made on a custom dataset of crop and weed images under various field conditions. The model achieved a precision of 0.84, a recall of 0.87 and an mAP@0.5 of 0.82, confirming its strong performance for real-time agricultural deployment. Inference speed on the Raspberry Pi 4 averaged 25 frames per second(FPS), demonstrating suitability for embedded applications. The performance metrics are the described infrastructure is summarized in Table I.

Metric	Value	Description
Precision	0.84	Ratio of correctly identified weeds among all detections
Recall	0.87	Ability to detect actual weeds present in the field
F1-Score	0.85	Harmonic mean of precision and recall
mAP@0.5	0.82	Average detection accuracy at 50% IoU threshold
Inference Speed	30 FPS	Average frames processed per second
Navigation Accuracy	±2 cm	Deviation from weed center position

**B. Model Training and Validation:**

The model was trained by YOLOv5 training logs are analyzed as follows box, objectness, and classification loss steadily decreased across 100 epochs, as Illustrated in Figure 5. The Precision–Recall PR curve in Figure 6 has a precision of 0.8 and recall of 0.86, while the mAP curves Figure 7 shows mAP@0.5 = 0.821 and mAP@0.5:0.95 = 0.789, confirming model convergence and detection stability .

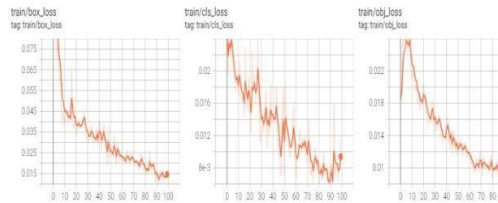


Figure 5 : Loss metrics for class, object and box.

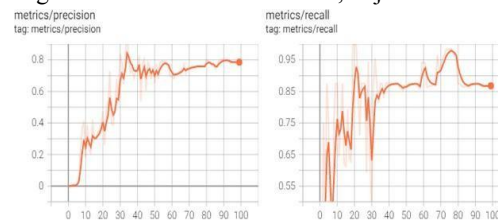


Figure 6 : Precision and Recall



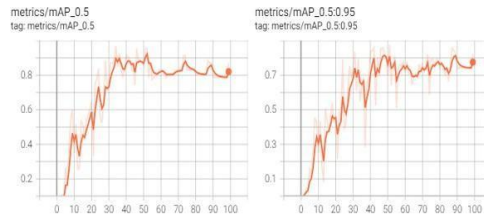


Figure 7 : mAP:0.5 and mAP:0.5::0.95

**C. Qualitative Results:**

Qualitative analysis was performed using images from field trials. The YOLOv5 model Successfully detected weeds and crops in real time and displayed bounding boxes on live video feeds. Figure 8 shows the detection of weeds with precise position marking. Super Improved image resolution preprocessing, clarity from the camera's 480 × 360 resolution, thus leading to more accurate detections and Reduced false positives. The system demonstrated stable navigation and actuation: the rover correctly oriented itself using a PID based system with detected weeds Feedback loop and successfully triggered the Weed cutter.



Figure 8 : Detection of weeds with position

**D. Discussion:**

Compared to traditional techniques, which rely on manual labor or chemical herbicides, the proposed YOLOv5-based rover achieved a reduction of manual effort by approximately 89.4%, while enabling targeted weed removal. This system's real-time adaptability, lower power consumption, and computational Efficiency makes it suitable for small- and medium-scale farms. The experimental results confirm that combining deep learning, image preprocessing, and embedded robotics can revolutionize weed management by improving Sustainability, reducing chemical usage, and that can be done by enhancing the productivity of the overall field.

**V. CONCLUSION**

The proposed autonomous weed detection and Removal rover is cost-effective and an efficient solution for precision agriculture. Through integrating deep learning-based image detection capability, coupled with real-time robotic navigation, system effectively distinguishes weeds from crops under diverse environmental conditions. The model YOLOv5 achieved high accuracy with a precision of 0.84, recall of 0.87, and an mAP@0.5 of 0.82, which proves its reliability for field deployment. This rover, powered by a Raspberry Pi and equipped with an HD camera, it successfully demonstrated autonomous navigation and targeted weed removal. By efficiently using paths, planning and feedback



control, the system maintained navigation accuracy of  $\pm 2$  cm, processing 25–30 frames per second in real time. This reduces dependence on manual labor and minimizes herbicide usage, contributing to farming that is sustainable and eco-friendly. Compared to traditional weed management methods, which are labor-intensive and although less ecologically damaging than this latter approach, scalability, affordability, and automation. The Results confirm that deep learning combined embedded systems can provide high performance without requiring expensive hardware. This system, in the future, can be enhanced by through the integration of GPS based navigation, solar-powered operation, multi-Spectral imaging for improved weed classification accuracy, and increasing the training dataset and optimizing the model for edge computing hardware will further increase detection precision and real-time responsiveness. Overall, the developed system demonstrates the potential of artificial Intelligence and robotics are transforming conventional agriculture sustainable, into a more autonomous, and intelligent practice.

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