AGRO-BOT: AUTONOMOUS WEED REMOVAL ROBOT

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Introduction:

Agriculture is the backbone of the Indian economy, yet it faces significant challenges in weed management. Weeds compete with crops for nutrients, water, and sunlight, leading to reduced yields and increased production costs. Traditional weed removal methods rely heavily on manual labour, which is both time-consuming and expensive, or on chemical herbicides that pose environmental hazards and health risks.

Agro-Bot is an autonomous agricultural robot designed to address these challenges by detecting and removing weeds using advanced computer vision and machine learning techniques. The system integrates a Raspberry Pi 5 microcontroller, RP-LIDAR A1 sensor, Logitech 720p camera module, ultrasonic sensors, and a high-pressure spray nozzle or servo-controlled mechanical arm to deliver a complete weed management solution. By leveraging AI-based image processing with YOLO and OpenCV, the robot can distinguish between crops and weeds in real-time, enabling targeted and precise action without disturbing surrounding crops.

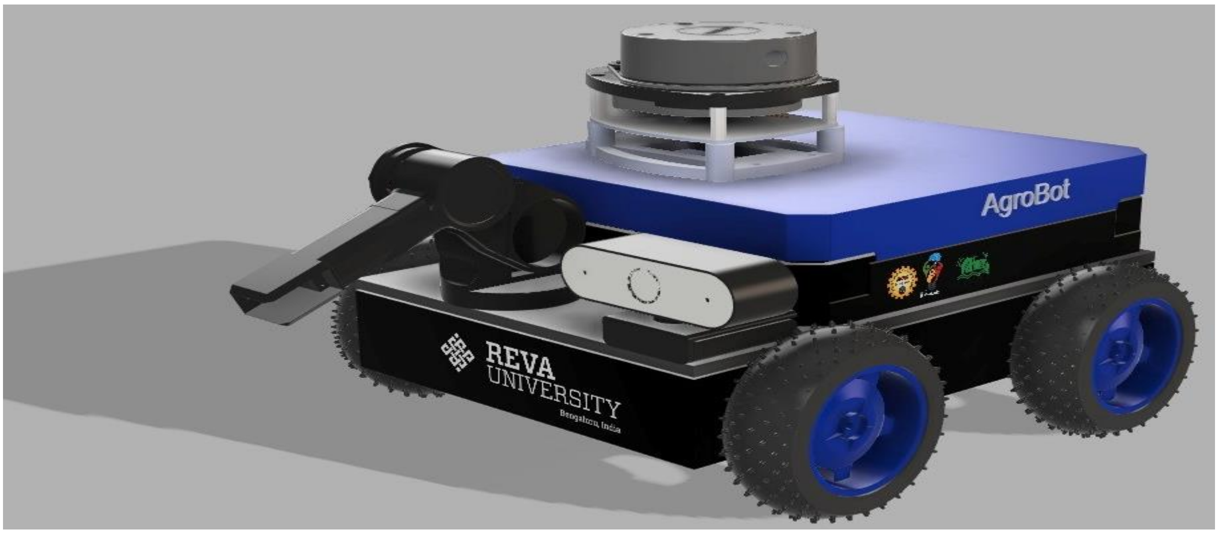


Figure 1: Agro-Bot (visualised with Fusion360)

Objectives:

1. To design and develop an autonomous robot capable of navigating agricultural fields using SLAM and LIDAR-based mapping.
2. To implement a real-time AI-based image processing system using YOLOv8 for accurate crop-weed classification.
3. To integrate a mechanical weed removal mechanism (targeted spray nozzle) for precise, non-invasive weed elimination.
4. To reduce dependency on chemical herbicides and manual labour, promoting eco-friendly and sustainable farming practices.
5. To develop a low-cost, scalable solution suitable for small and medium-scale farmers in Indian agricultural conditions.

Methodology:

The Agro-Bot system is developed in a structured, phased approach integrating hardware assembly, software development, and field testing.

[1] The rover chassis is constructed using laser-cut steel alloy mounted on 30mm diameter wheels, housing Raspberry Pi 5 and Arduino Nano as the co-controllers for the entire system.

[2] A Logitech 720p webcam and RP-LIDAR A1 sensor capture real-time visual and spatial data from the agricultural environment for navigation and weed detection.

[3] Autonomous navigation is achieved through SLAM (Simultaneous Localization and Mapping), enabling the robot to build an internal map and navigate without human intervention.

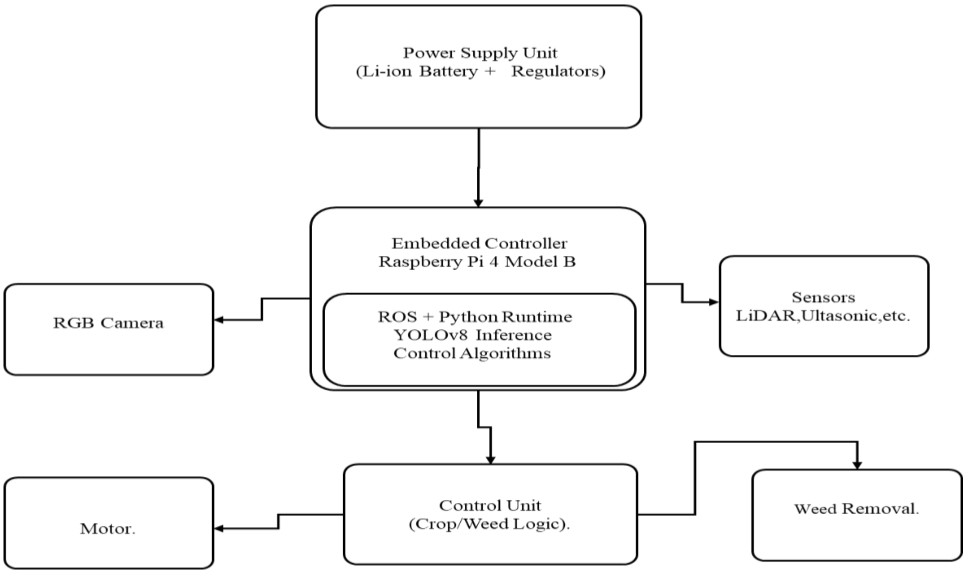
[4] An AI-based image processing model trained using YOLOv8 implemented with Tensorflow on labeled crop-weed datasets classifies weeds in real-time video frames captured by the onboard camera.

[5] Upon weed detection, a high-pressure spray nozzle delivers precise, targeted weed removal at root level with minimal crop disturbance.

[6] Ultrasonic sensors assist in real-time obstacle detection and dynamic path correction to ensure safe navigation around crops and farm infrastructure.

[7] Soil moisture sensors and GPS modules monitor field conditions and track the robot's position throughout operation.

[8] The system is tested in controlled agricultural plots to evaluate detection accuracy, navigation stability, and weed removal efficiency.



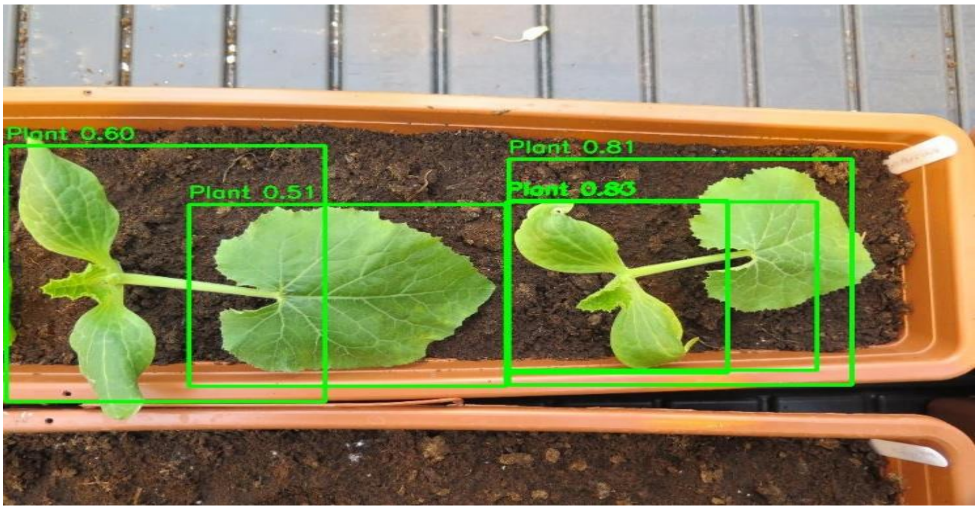


Fig 3: Plant Detection (highlighted in Green Border)

Result and Conclusion:

1. The Agro-Bot prototype has been successfully designed, currently under development with key subsystems implemented. The robot chassis has been assembled using laser-cut steel alloy with all core hardware: Raspberry Pi 5, Arduino Nano, RP-LIDAR A1, Logitech 720p camera, DC motors with motor drivers, and ultrasonic sensors: integrated and configured for coordinated operation.
2. On the software front, initial implementation of computer vision using OpenCV and YOLO has demonstrated the ability to classify crops and weeds from live camera input. Basic navigation using SLAM has been initiated and obstacle detection via ultrasonic sensors is functioning as expected. The system has shown promising detection accuracy in controlled test environments.

3. In conclusion, Agro-Bot presents a viable and intelligent solution to one of agriculture's most persistent challenges. By combining embedded systems, AI, and robotics, the project contributes to the advancement of precision and smart farming, offering a scalable and affordable alternative to chemical-intensive and labour-heavy traditional practices.

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Future Scope:

The future scope of this project includes:

1. Improvement of weed detection accuracy using advanced deep learning models such as YOLOv8 or Transformer-based architectures trained on diverse crop datasets.
2. Integration with IoT platforms for remote monitoring, real-time alerts, and cloud-based analytics to support data-driven farming decisions.

3. Incorporation of a solar-powered system to enable continuous operation with improved energy efficiency and reduced operational costs.
4. Extension to support multi-crop and multi-weed adaptability for deployment across varied agricultural environments.
5. Development of a fully autonomous fleet system coordinating multiple Agro-Bot units for large-scale commercial farming operations.