

# **Design and Development of a Vision-Guided Autonomous Robotic System for Sustainable Cotton Harvesting**

## **1. Introduction and Background**

Cotton is one of the most valuable cash crops in India and plays a crucial role in the country's agricultural economy. Despite advances in farming technology, cotton harvesting still poses significant challenges. Traditional methods depend heavily on large, expensive machines and chemical defoliants that increase production costs and harm the environment. These practices not only degrade soil quality but also affect fiber yield and long-term sustainability.

## **2. Problem Statement**

While existing large-scale harvesters are effective for industrial farms, they are impractical for small and medium-scale farmers due to their high cost and heavy structure. The continued use of defoliants contributes to soil pollution and ecological imbalance. Therefore, there is a growing need for a compact, environmentally friendly, and cost-effective alternative that can automate cotton picking with precision and minimal soil impact.

## **3. Research Objectives**

The proposed research focuses on creating a lightweight, vision-guided, autonomous cotton-picking robot designed for sustainable farming operations. The main objectives are:

- To design and develop a small-scale robotic platform capable of navigating cotton fields autonomously.
- To integrate a vision-based perception system for accurate cotton boll detection and picking.
- To test and simulate the robot's navigation and picking performance under realistic field conditions.
- To evaluate its performance in terms of accuracy, precision, recall, and overall navigation success.

## **4. Proposed Methodology**

The system will be built on Clearpath's Husky platform. The entire setup will be simulated in the Gazebo environment, where a virtual cotton field will be created for autonomous navigation testing.

The navigation system will use GPS and map-based guidance, supported by data from an RGB-depth camera. For perception, the system will employ a YOLOv8n-seg model to detect and segment cotton bolls in real time. All functions will be integrated into the Robot Operating System (ROS) for modular control and testing.

## **5. Expected Outcomes**

The project aims to produce a scalable prototype and a simulation framework for lightweight autonomous cotton harvesting. The proposed robot is expected to reduce soil compaction, operational costs, and environmental impact while improving the quality and efficiency of

cotton picking. This framework could also serve as a foundation for future research in agricultural robotics and precision farming.

## **6. Potential Impact**

This research contributes to the advancement of sustainable agriculture by integrating artificial intelligence, computer vision, and robotics into real-world farming applications. Beyond cotton, the developed system could be adapted to other crops, making it a step forward toward smart, autonomous, and sustainable agricultural systems that address both economic and environmental needs.

## **7. Keywords**

Autonomous robot, precision agriculture, cotton harvesting, computer vision, YOLOv8, ROS, GPS navigation, sustainability.