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AGROBOT: A Multitasking Farm Robot

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Abstract: This paper describes an ESP32/8266 and Arduino-controlled multipurpose agricultural manipulator that may be used for fruit harvesting, water sprinkling, and seed sowing. The device incorporates a modular end-effector with water sprinkling and harvesting capabilities, as well as a camera for fruit detection. A servo-controlled hopper is used to automatically plant seeds, with a soft gripper for harvesting in the vicinity. This device, which is powered by rechargeable batteries, automates important agricultural chores and offers a flexible and effective answer for contemporary farming.
Keywords: ESP32, Arduino, manipulator, seed sowing, harvesting, automation.

I. INTRODUCTION

There is pressure on the agriculture sector to meet the rising demand for food while lowering labor costs and increasing productivity. Conventional farming practices are ineffective and time-consuming since they mostly rely on human labor for jobs like planting seeds and harvesting. Consequently, there has been a growing interest in creating automated systems that can perform these crucial functions.

Embedded systems and robotics have become viable options for agricultural automation. For specialized operations like planting or harvesting, several robotic systems have been created; nevertheless, the majority of these systems are limited in their performance and scope. In this article, a multipurpose agricultural manipulator that automates three crucial farming tasks—fruit harvesting, seed sowing, and sowing—is shown.

The system's foundation consists of inexpensive, widely accessible parts like the Arduino and ESP32/8266 microprocessor, which are combined with sensors and a camera to enable autonomous operation. The design of a multipurpose end-effector that integrates fruit harvesting capabilities into a single unit, greatly lowering hardware complexity and cost, is the main contribution of this study. Rechargeable batteries provide mobility and provide prolonged field operation for the system. The format of this document is as follows: Related work is covered in Section II, hardware and system design in Section III, control software in Section IV, experimental results in Section V, and the paper's conclusion in Section VI.

II. LITERATURE SURVEY

The automation of agricultural tasks has been a topic of research for several years. Early robotic systems were developed primarily for single-purpose tasks such as autonomous tractors for plowing or basic seeding machines. Recent advancements have led to more sophisticated systems that incorporate sensor data and AI algorithms for tasks such as fruit picking and weed control. Several studies have focused on robotic arms for precision seeding. These systems often rely on predefined paths and lack real-time adaptability. Robotic fruit harvesters have also been developed, employing various gripping mechanisms to handle delicate crops. However, most existing solutions require separate machines for each task, making them cost-prohibitive for small to medium-sized farms. In this work, we propose a multifunctional system that combines these tasks into a single robotic platform, reducing the overall cost and complexity while maintaining high precision and efficiency.[1]

III. SYSTEM DESIGN

A. Hardware Overview

The hardware design of the multifunctional agricultural manipulator consists of several components, each serving a specific role in automating agricultural tasks. The key hardware elements include:

1) *Microcontrollers (ESP32/8266 and Arduino):* The ESP32/8266 is used for wireless communication and image processing via an attached camera, while the Arduino handles real-time control of the actuators and sensors. This dual-controller setup allows for parallel processing, ensuring that the system remains responsive and efficient.[1]
2) *End-Effector:* The end-effector is the key innovation in this project, designed to perform fruit harvesting tasks. The nozzle is a soft, flexible gripper designed to handle delicate fruits without causing damage.[2]

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Fig1: Gripper with camera

3) *Motors and Actuators:* A combination of servo motors, DC motors, are used to control the manipulator's movement and the opening/closing of the gripper for harvesting. The servo motors also control the seed gate in the hopper during seed sowing.[3][5]
4) *Power Supply(Rechargeable Batteries):* The system is powered by Li-ion batteries, which provide enough energy for the manipulator to operate for several hours in the field. A battery management system (BMS) is integrated to monitor battery health and optimize power usage.[4]

B. Seed Sowing Mechanism

The seed sowing mechanism is based on a hopper system controlled by a servo motor. The hopper holds the seeds and dispenses them one at a time through a small gate at the bottom, which is controlled by the servo. The manipulator moves to predefined positions in the field, drops a seed, and then moves to the next position. The system ensures uniform seed spacing by precisely controlling the timing of seed release and movement between sowing positions.

1) *Hopper Design:* The hopper is a funnel-shaped container that ensures a steady flow of seeds to the outlet. The servo motor operates the gate at the base of the hopper, which opens briefly to allow one seed to fall into the soil.[5][3]

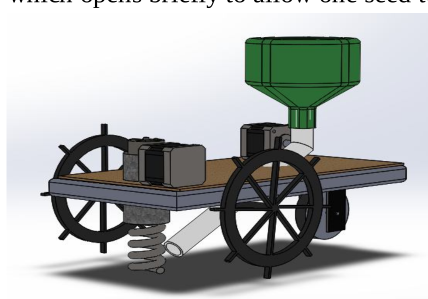

Fig2:Hopper Design

2) *Planting Mechanism:* A small drill or plough is attached to the manipulator, which creates a hole or furrow in the soil before seed release. After the seed is dropped, a covering mechanism places soil over the seed to ensure proper planting.

C. Harvesting Mechanism

The end-effector is designed for dual functionality:

1) *Fruit Harvesting:* Surrounding the central nozzle is a soft gripper mechanism. This gripper consists of flexible "fingers" made from silicone or other soft materials to handle fruits gently. When the camera detects a ripe fruit, the gripper extends, closes around the fruit, and pulls it off the plant. The gripper is designed to handle fruits of varying sizes without causing damage.[7]

IV. SOFTWARE AND CONTROL

A. Control System

The control system is based on the integration of the ESP32/8266 and Arduino. The ESP32 handles higher-level functions, including camera input and wireless communication, with camera integration achieved using OpenCV for fruit detection. Meanwhile, the Arduino is responsible for controlling the actuators that perform tasks such as seed sowing and harvesting.

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1) *ESP32 (Image Processing and Wireless Communication):* The ESP32 processes images from the camera to detect ripe fruits. Simple color recognition algorithms are used to identify fruit ripeness based on pre-set color thresholds. The ESP32 also communicates with a base station or cloud platform for remote monitoring and control.[6]

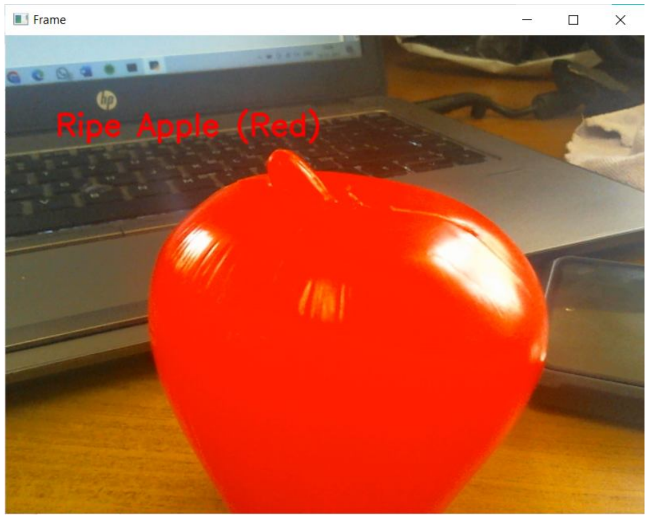

Fig3: Color detection through OpenCV

2) Arduino (Task Execution): The Arduino handles motor control for seed sowing and the gripper's actions during harvesting. It operates in real-time, responding to sensor inputs and commands from the ESP32.[7]

B. Task Automation

1) *Seed Sowing:* The system follows a predefined path through the field, dispensing seeds at regular intervals. Seed spacing can be adjusted based on the type of crop being planted.[3]
2) *Fruit Harvesting:* The camera continuously scans for ripe fruits. Once a fruit is detected, the system moves the manipulator to the correct position, activates the gripper to pick the fruit, and stores it in a designated container.[9]

Fig4: Harvesting

C. Power Management

The system includes a battery management module that monitors power levels and optimizes energy use. When idle, the system enters a low-power mode to conserve energy.[8]

V. EXPERIMENTAL RESULTS

The multifunctional manipulator result should be tested in a small agricultural field. The following metrics have to be measured to evaluate its performance:

1) *Seed Sowing Accuracy:* The system should be able to sow seeds with an average spacing error of ±5 mm, which is well within acceptable limits for most crops.
2) *Fruit Harvesting Success Rate:* The manipulator harvested 85% of the ripe fruits detected, with minimal damage to the crops. The soft gripper proved effective in handling fruits of varying sizes and shapes.[10]

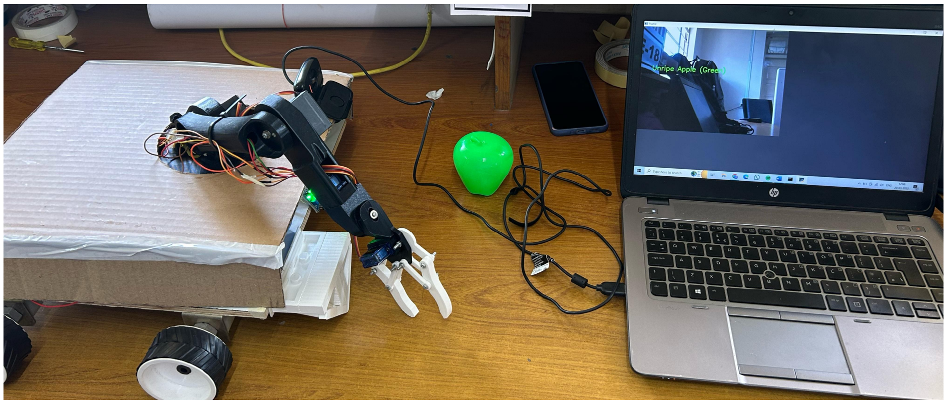

Fig5: Final Manipulator Design

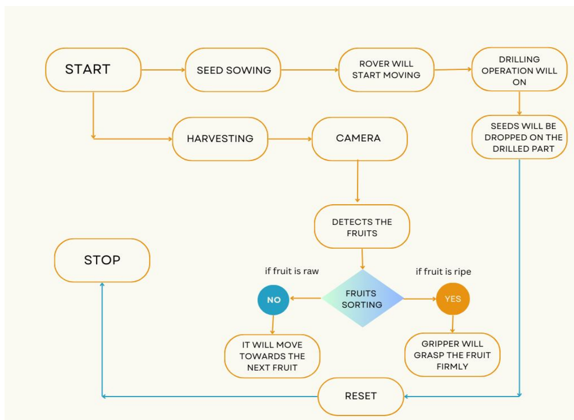

Fig6: Working of Robot

VI. CONCLUSIONS

This paper presents a multifunctional agricultural manipulator capable of automating seed sowing and fruit harvesting using a combination of ESP32/8266 and Arduino. The integration of a camera for fruit detection and a multifunctional end-effector enhances the system's versatility.

VII. ACKNOWLEDGMENT

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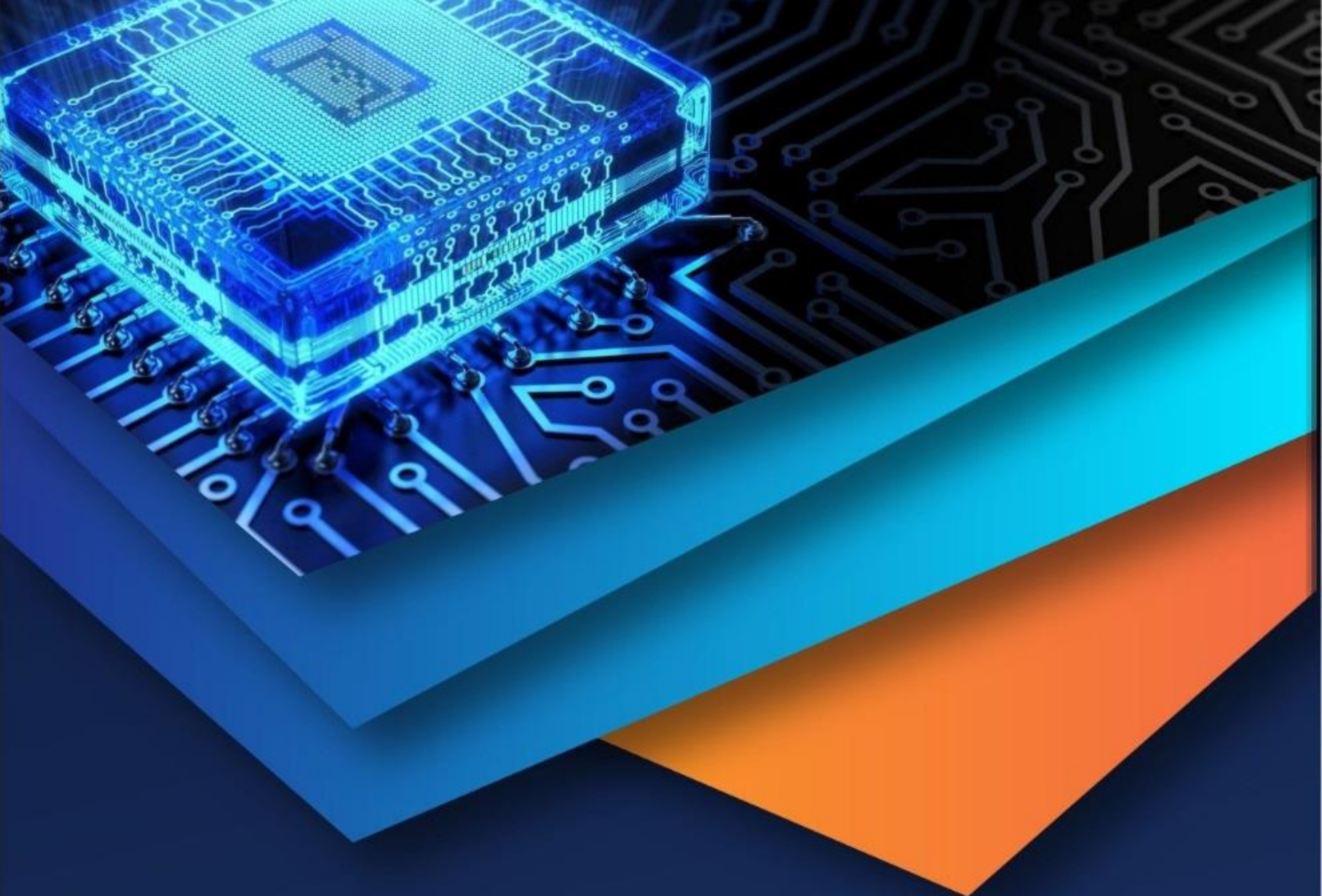

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