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AUTOMATED ARECANUT HARVESTING ROBOT USING COMPUTER VISION

[1]ASHIK T NAIK, [2]SRUJAN J SHETTY, [3]MOHAMMED SAVAD, [4]SANTHOSH HEGDE, [5]PAVITRA KUMARI

[1234] Students, [5] Asst. Professor,
Department of Mechatronics Engineering,
Mangalore Institute of Technology & Engineering, Mangalore, India.

Abstract: This project aims to address the labour-intensive process of arecanut harvesting by developing an Automated Arecanut Harvesting Robot that utilizes Computer Vision technology. The objective is to create a low-cost and efficient robot capable of harvesting arecanut with minimal human intervention. The Automated Arecanut Harvesting Robot will be equipped with a set of features that include a robotic arm for collecting the arecanut and transporting the arecanut to a respective collection bin based on three different stages. The robot's control system will be based on a microcontroller that uses a set of sensors and robotic arm for precise positioning and movement. Computer Vision technology is utilized in the project to enable the robot to identify ripe arecanut bunches and determine the best approach for harvesting them. The system uses image processing techniques such as object detection, colour segmentation, and feature extraction to analyse the arecanuts' shape, size, and colour. The methodology used in developing the Automated Arecanut Harvesting Robot involves prototyping and testing different designs and configurations. Significant findings and results include the successful integration of Computer Vision technology into the robot's control system, allowing it to harvest arecanut with a high degree of accuracy. The potential impact of this project is significant, as arecanut harvesting is a labour-intensive process that requires a large workforce. The Automated Arecanut Harvesting Robot can significantly reduce labour costs and increase productivity, making it an essential innovation in the field of agriculture.

Keywords**: Automated Arecanut Harvesting, Agriculture adherence, Computer Vision, Image Processing, Pick and Sort, Robotic Arm, Segregation.**

I. INTRODUCTION

The agriculture industry has many problems, including the decreased number of farm workers and increasing in the cost of harvesting. Saving labour work and scale up in agriculture is necessary in solving these problems. In recent years, the automation of agriculture has been advancing to reduce the human effort. However, much of the work in the field of harvesting is done manually. To development of an automated harvesting robot is a viable solution to these problems. The Automated Arecanut Harvesting Robot involves two main tasks: (1) To detect and pick the arecanut using vision sensor and robotic arm, (2) To separate the arecanut based on the different stage of the ripeness using image sensor. Using MATLAB, the image of arecanut will be fed to the "Arecanut Robot Harvesting". When the robot detects the arecanut with the help of vison sensor it moves towards it and with the help of the Image sensor it classifies the arecanut based on the ripeness latter on using the robotic arm it picks the arecanut and puts in the separate container

OBJECT DETECTION –

Object detection is a computer vision task that involves identifying and localizing objects within an image or video. The process of object detection involves analysing an image to determine the presence and location of certain objects in the image. Image processing is a branch of computer science that involves the analysis and manipulation of images. It encompasses a wide range of techniques, including image enhancement, restoration, segmentation, and recognition.

Object detection using image processing involves the use of various algorithms and techniques to analyse an image and locate objects within it. This process typically involves several steps, including image pre-processing, feature extraction, object localization, and classification. One popular approach to object detection using image processing is the use of convolutional neural networks (CNNs), which are deep learning algorithms designed to analyse images and extract relevant features. These features are then used to classify and locate objects within the image. Object detection has numerous applications in fields such as security, robotics, and autonomous vehicles. It can be used for tasks such as facial recognition, object tracking, and object identification in real-time video streams.

ROBOTIC ARM –

A 6 degree-of-freedom (DOF) robotic arm is a type of industrial robot that has six axes of motion, allowing it to move and manipulate objects in six different directions. These directions include three rotational axes (pitch, roll, and yaw) and three translational axes (x, y, and z).

The six DOF robotic arm typically consists of a base, followed by a series of links or segments that can rotate around one or more axes. The end of the arm usually includes a tool or gripper that can be used to grasp, hold, or manipulate objects.

A key advantage of 6 DOF robotic arms is their versatility and precision. They can be programmed to perform a wide range of tasks, from simple pick-and-place operations to complex assembly and welding processes. They are commonly used in manufacturing, automotive, aerospace, and medical industries.

To control a 6 DOF robotic arm, a computer or controller is typically used to send commands to the motors and actuators that control the movement of each axis. Advanced programming techniques, such as kinematics and inverse kinematics, are often used to optimize the arm's movement and ensure that it can reach its target with the highest level of precision and efficiency possible.

ARECANUT HARVESTING ROBOT –

A rover that can detect and pick objects using a 6 DOF robotic arm is an autonomous robotic system designed to navigate and interact with its environment. The rover typically includes a set of sensors, a control system, and a 6 DOF robotic arm with an end-effector that can grasp and manipulate objects. The sensors on the rover are used to detect and identify objects in the environment, such as rocks, tools, or other objects of interest. These sensors can include cameras, LIDAR, sonar, or other technologies that can provide information about the position, shape, and texture of the objects in the environment. Once an object has been detected, the rover's control system uses this data to plan a trajectory for the 6 DOF robotic arm to move and manipulate the object. The control system can use advanced algorithms, such as inverse kinematics, to calculate the optimal path for the arm to reach the object and grasp it with the end-effector. The 6 DOF robotic arm typically consists of a series of segments or links, each of which can rotate around one or more axes. The end-effector can be designed to include various types of grippers or tools, such as suction cups or mechanical grippers, depending on the application. Once the object has been grasped, the rover can then move the object to a desired location, such as a storage area or a processing station. The control system can use the data from the sensors to adjust the trajectory of the rover and the arm in real-time, ensuring that the object is transported safely and efficiently. This type of rover with a 6 DOF robotic arm has numerous applications in fields such as agriculture, mining, and space exploration. For example, it can be used to collect and transport samples of soil, rocks, or other materials, or to perform maintenance tasks on remote infrastructure.

II. Arecanut Harvesting Robot Using Tensorflow lite

This project can also be built using pure image processing techniques. Such techniques work well for a particular object for which image processing logic is written. However, if the object is replaced, the image processing part of the code needs to be modified for the new object. Also, if multiple overlapping arecanut are present in a frame, then such a technique would be difficult to implement. Now, the approach used in this arecanut harvesting project involves harnessing the benefit of Machine Learning. Which allows the robot to track 3 different types of arecanut just by changing one line of code.

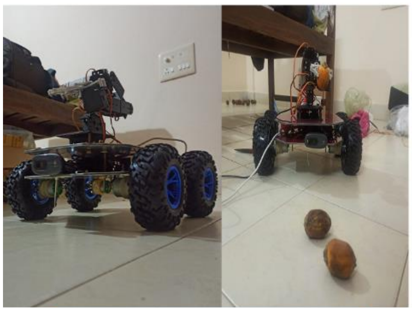

Fig1-Arecanut Harvesting robot

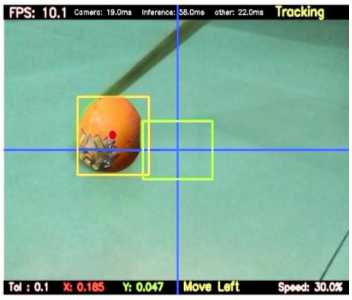

Fig2-Robots Camera view

Arecanut Tracking mechanism –

We need to specify the name of the arecanut that needs to be tracked. It is done in the beginning of the code. It helps the code to discard other arecanut present in the frame and only consider the specified arecanut (s) for tracking. When a frame is fed to the ML model, the model returns the names of all arecanut present in the frame. Now, the code can check whether the specified arecanut is present in the list of objects returned by the model. If present, then the code moves on to the tracking part.

Locating The Areca in The Frame –

The location parameter returned by the model provides the top left and bottom right coordinates of the arecanut. Which are used to calculate the centre of the object as shown below. The centre is marked with a red dot. The dot follows the centre as the object moves.

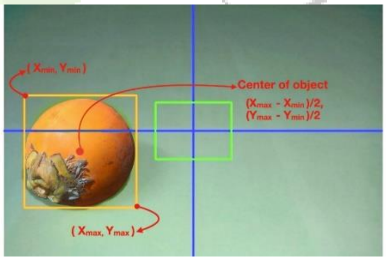

Fig3- Determining the location of arecanut

DEFINING THE TOLERANCE ZONE –

Tolerance zone is the area around the center of the frame within which the centre of the object must fall to stop the tracking. If the red dot (centre of the areca) is outside the tolerance zone, the robot continues to move and track the arecanut. The tolerance value determines the size of the tolerance zone.

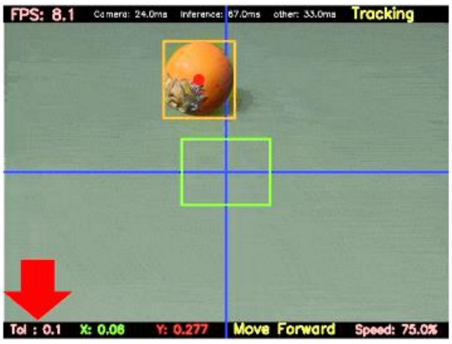

Fig4- Defining the tolerance zone

CALCULATING THE DEVIATION OF THE CENTER OF THE ARECANUT FROM THE CENTER OF THE FRAME–

The distance of centre of the arecanut from the centre of the frame can be calculated along the horizontal and vertical axis. This distance is denoted as 'X' (horizontal deviation) and 'Y' (vertical deviation) on the frame. Both these values are compared with the tolerance value. If any of these values is more than the tolerance value, the robot continues to track.

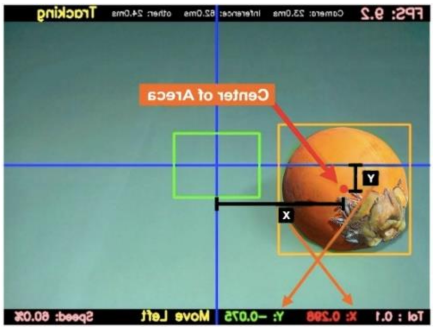

Fig5- Calculation of position of arecanut

III. MODEL REPRESENTATION

ROVER

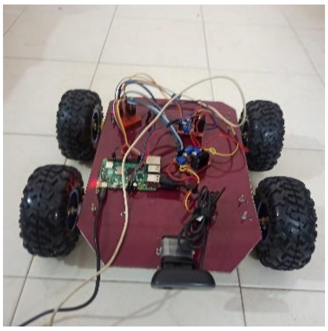

Fig6- Rover

The working model consists of two main concepts, the base robot which uses Raspberry Pi 4 as its microcontroller and a Robotic arm component set which uses Arduino as its controller. The Figure 6 is how the bot looks when the covering is taken, the circuit and major components like motors can be seen with the wheels attached.

ROBOTIC ARM

Fig7- Robotic arm

The arm's structure is made up of 11 servo brackets, which were designed using SolidWorks software to fit the six servo motors that control its movements. The two Large U-shaped brackets used in the base provide the necessary stability to support the robotic arm's weight, while the two U-shaped brackets used in the arm help to ensure that the arm remains rigid and accurate in its movements. The total height of the robotic arm is around 43.6cm, making it a compact and efficient design that can be used in a variety of different environments. Overall, this design is a great option for anyone looking to build a precise and versatile robotic arm.

Fig8- Rover with Arm

IV. RESULT AND DISCUSSION

The automated picking of areca nuts using image processing and separation based on three stages of ripeness using colors green, orange, and brown has the potential to improve the efficiency and accuracy of the areca nut harvesting process. By using image processing and color-based sorting, the proposed system can identify and sort areca nuts based on their ripeness, which is a crucial factor in determining their market value. Based on the working conditions of the proposed system, it is expected to have a significant impact on reducing labor costs for farmers. The system can perform the task of identifying and sorting areca nuts quickly and accurately, which can save significant amounts of time and labor costs for farmers. Furthermore, the proposed system can increase the productivity of the areca nut harvesting process. By automating the sorting process, farmers can increase the number of areca nuts sorted per unit of time, which can lead to an increase in overall productivity. Overall, the automated picking of areca nuts using image processing and separation based on three stages of ripeness using colors green, orange, and brown has the potential to revolutionize the areca nut harvesting process. It can improve the efficiency and accuracy of the harvesting process, reduce labor costs, and increase productivity. With further research and development, the proposed system can become a game-changer in the agricultural industry.

V. CONCLUSION

The proposed system shows promise for automating the areca nut harvesting process and reducing labour costs for farmers. The system uses image processing and separation based on colour to identify and sort areca nuts according to their ripeness, which is a significant factor in determining their market value. The system's accuracy and efficiency were evaluated, and it was found to perform well in identifying and sorting areca nuts based on their colour. The proposed system has limitations, including its reliance on colour as the sole criteria for sorting areca nuts, and its inability to identify and sort areca nuts based on other quality parameters such as size and shape. There are potential future scopes for the proposed system, including integration with other technologies, optimization of the algorithm, extension to other crops, real-time monitoring and analytics, and sustainability and environmental impact. Further research and development of the system are needed to address the limitations and explore the potential future scopes of the system. Overall, the proposed system represents an innovative approach to automating the areca nut harvesting process and has the potential to benefit farmers by reducing labour costs and improving the efficiency and accuracy of the harvesting process.

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