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Robotic Flying Fruit Picker Using Image Processing And Deep Neural Networks In Horticulture

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***Abstract*—Agriculture, all over the world plays a chiefly role in economy as well as it is considered to be the backbone of economic system for developing countries. But agriculture industry has many problems including the decreasing number of farm workers and increasing cost of fruit harvesting. According to a survey, there is a severe shortage of skilled workers available to pick fruits. Due to this shortage, the wages to be paid to these laborers were hiked rapidly, where most of the farmers were unable to hire workers for such higher wages. This ultimately resulted in the wastage of crop or the ripe fruits are just left in the farm without harvesting. So, to solve this post harvesting problem, Automatic fruit plucking Drone is to be developed to avoid scarcity of labour and to consume less time. In order to make drones automatic, fruits have to be detected and classified properly. Drone need to be stabilized during flight and remotely controlled by the user. Robotic arm with gripper needs to be interfaced with the drone to cut ripen fruit. Project can be implemented to harvest various kinds of fruits like apple, banana, guava and citrus etc.**

Keywords— Raspberry Pi 4;Matlab;Drone; Quadcopter; CNN; Deep learning; Image processing; ; Web Camera; Pushbullet;

I. INTRODUCTION

Agriculture is one of the most important factors that effects a country's growth and future. Like any other industry, Agriculture too have its own problems. Right from the first step i.e preparation of the soil to that of the last step – harvesting, many problems are to be faced by the farmer. According to a recent survey, during lockdown period in (2019) due to shortage of skilled laborers or workers the fruit that has to be harvested remained unpicked in the farms and the entire yield(fruit) became rotten which lead to massive losses.

Although the farmer can directly control how much is planted, there is great uncertainty regarding how much crop will be ready for harvest and how the harvestable crop will be valued on the market. So, the timely access to labour is critical to the success and competitiveness of farm operations. So, at times most of the fruit producers across the world were left in situations like where their entire ripe fruit got rotten in the field itself due to shortage of labourers and increased demand with higher labour charges which are un affordable by a common farmer. So, this problem in the agriculture industry at the stage of harvesting by the involvement of automatic technology. Where the fruit in the field need to be picked up using minimum labour and create a comfortable format for farmers where they can overcome this problem at the time of harvest. So, a system needed to be developed that works in such a way that- it should examine ripe fruit and then cut the fruit automatically. But all this need to minimise the required amount of labour and create an affordable scenario for a common farmer. So the first and foremost thing is that the developed system should be able to take pictures of a required fruit and examine whether the fruit is ready to be cut i.e whether ripen or not. The aim of this work is to define an algorithm that will result in extracted image of the fruit and this resultant image will be able to provide information like whether fruit is ripen, not ripen or rotten. Finally, we detect whether the given fruit image is ready for harvest or not using 9 – Layer convolutional neural network.

And the second thing we need to do is that to implement all this detecting system on to a Drone system. Since in real time the fruits in the farms are situated at heights on trees.

So, an automatic fruit plucking system is developed to to avoid or minimize the preharvesting problems in agriculture.

II. LITERATURE SURVEY

Ruggiero, Fabio, Vincenzo Lippiello, and Anibal Ollero, "Aerial manipulation: A literature review", IEEE Robotics and Automation Letters, vol. 3, no. 3, 1957-1964, 2018.

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III. PROPOSED ARCHITECTURE

The primary goal of the project is to develop an automatic fruit plucking system which can be implemented in areas where there is shortage of labor. And to avoid the fruit wastage and preharvesting problems faced by farmers. The proposed system consists of different units.

A. Fruit Detection unit
B. Drone unit (Quadcopter)
C. Notification unit
D. Gripper unit.

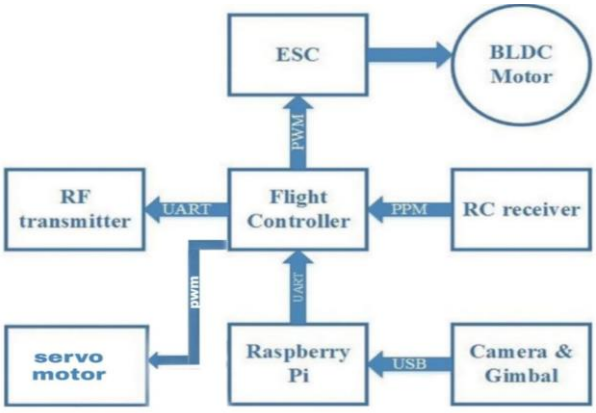

Figure1: Drone System Flow Chart

A. Fruit detection unit:

The fruit that is to be harvested need to be identified whether it is ripen, not ripen or rotten. This is done through CNN using large amounts of dataset used for testing and training purposes. An this enables us to identify the ripen fruit that is to be cut. This unit involves Raspberry pi 4 model, Web Cam and Mat lab as key components. A simple webcam or Pi-cam incorporated with Raspberry pi 4 acquires the images of the fruit and this image data is used as input for the developed algorithm, which gives the required result i.e it identifies the Ripen fruit.

B. *Drone unit :*

In real time, the fruit that is to be harvested is situated at some certain heights on trees. So, all this detection system should work in aerial areas i.e on trees. This is done through a simple Drone system (Quadcopter) that is able to reach (fly) to certain heights with required stabilization, then detect the fruit that is to be harvested and then cut the ripen fruit.

C. **Notification unit:**

The state of the fruit is to be notified to the user who is controlling the drone system. This unit sends a message to the user about the state of the fruit - i.e, whether the fruit is a ripen one or not. And if the detected fruit is ripen, then the message sent to the user is: "Ripen- cut the fruit." And if the detected fruit is not ripen, then the message sent to the user is "Not Ripen- "Do not cut the fruit". This is done through "Matlab Pushbullet". And it is designed in such a way that, the notification is only sent when the output is greater than 90% i.e Ripen fruit score greater than 90%.So, on using this notification that is sent to the smart phone, the decision can be made whether to cut the fruit or to not cut the fruit.

D. *Gripper unit:*

The last task that is to be done is to harvest the fruit after the detecting the ripen fruit. This is done using a Gripper mechanism which is controlled buy the Fly sky Transmitter receiver system. The required size of the gripper consisting of metal blades is incorporated to the Drone system. So after receiving the notification from the notification unit, on using the Fly sky transmitter Receiver we can control the gripper to cut the fruit.This ultimately cut the ripen fruit.

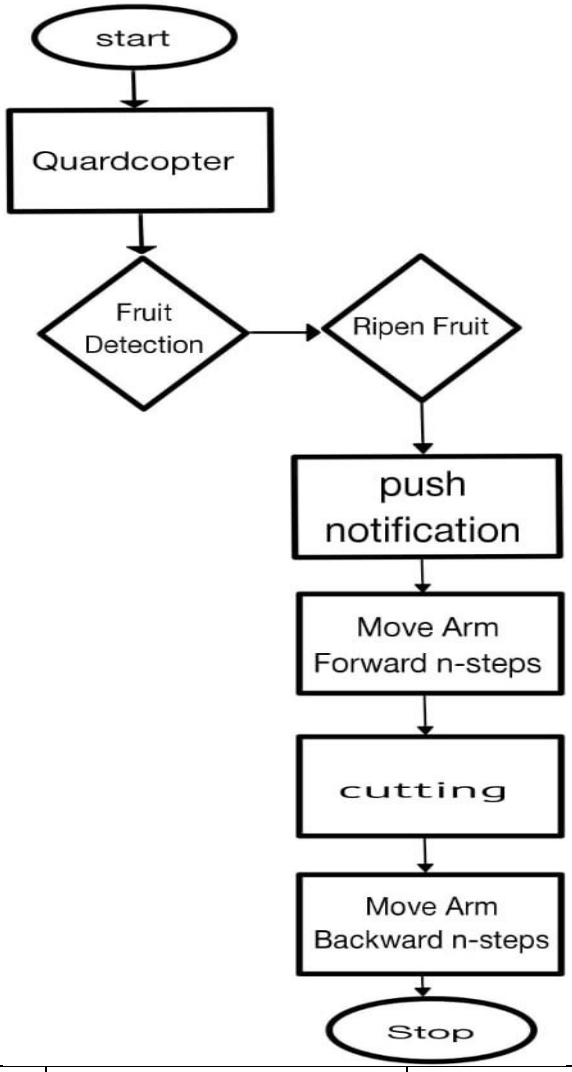

Figure2: Block Diagram

S. No	Component	Description
1.		Raspberry pi 4 model B is the latest product in the popular Raspberry pi range of computers.
2.		Web cam is used to acquire the image data of the fruits.
3.		A2212 is a brushless outrunner dc motor specifically made to power Quadcopters.
4.		Simonk 30A BLDC ESC Electronic speed controller is specifically made for quadcopters and multimotors.
5.		The Tower pro MG90s Mini Digital Servo 180^0 rotation servo. It is a Digital Servo Motor which receives and processes PWM signal faster.
6.		Pair of propellers of required size are used to create the thrust and make the drone fly.
7.		450mm Quad frame built from quality materials. The main frame is glass fiber while the arms are constructed from ultra durable polyamide nylon.
8.		The gripper consisting of MG Gear servo motor is controlled using Fly Sky. This enables to cut the ripen Fruit.
9.		The Fly sky Fs- i6 is a great low cost entry level 6-channel 2.4 G Hz Transmiter and Receiver that uses solid and reliable Automatic frequency Hopping Digital System (AFHDS).

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IV. IMPLEMENTATIWITH HELP OF FLOWCHART. THE FLOW CHART IS GIVEN AS

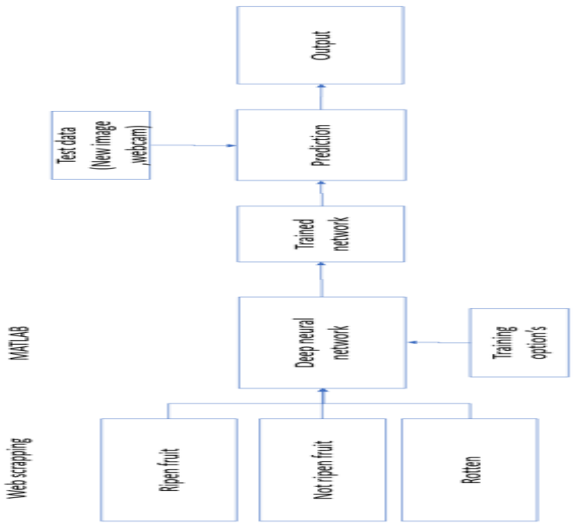

Figure 3: Block diagram for fruit detection system

IV. IMPLEMENTATION

The suggested system should firstly be able to identify the Ripen Fruit. This is done by the developed algorithm using CNN (Convolutional Neural Network), which is developed in Matlab which have many inbuilt functions in it. In the fruit detection unit, first step is Web Scraping i.e collection of datasets of fruit images. Nearly 7500 images were collected from Kaggle. This data set is used for both testing and training. The type of net used in CNN is Alex Net in the proposed model.

The developed Deep Neural network works efficiently with a high accuracy is able to identify whether a fruit is ripen, not ripen or rotten.

The developed algorithm is then incorporated with Raspberry pi 4 model, which supports Pi- cam module or webcam. So the webcam then acquires the input images from the trees and detects the state of the fruit (Ripen or not).

But all this system needed to be worked out well in aerial areas i.e in real time the fruits are situated at certain heights on trees. So, the model developed should be able to cut the fruit right from the tree.

A drone system is proposed in this model i.e Quadcopter system. This consists of 4 rotors. So known as Quadcopter. Quadcopter in this model consists of mainly A2212 DC motor, 450mm Quadframe, Propeller pair, Simonk Electronic Speed controller and Tower pro Mg 90's Servo motor (180^0).

Apart from these components, to control the drone system Fly Sky Transmitter receiver is used which is a kind of remote controller. This controls the yaw, pitch, roll of the Quadcopter. The programming done in Clean flight platform

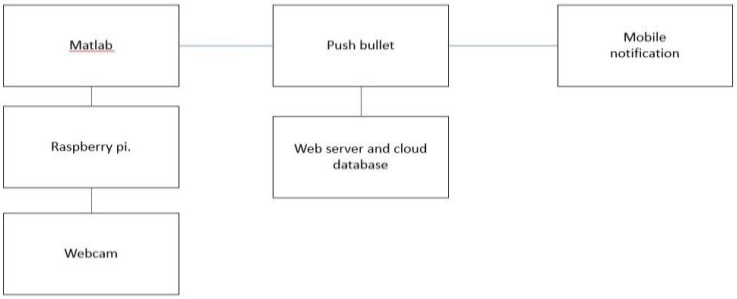

Figure 4: MAT LAB Pushbullet Block diagram

So, the developed program in the clean flight platform enables the user to control the drone and to make the drone system fly in required direction and required height through Fly Sky Transmitter Receiver.

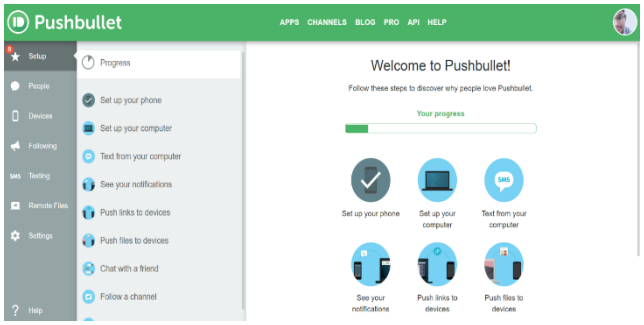

Figure 5: Push Bullet setup

And the Raspberry pi incorporated with the drone system is made to fly to harvest the fruit.
But to cut the fruit the user need to get the information from the drone system.It is that the user controlling the drone will be notified about the state of the fruit whether it is ripen or not.

This is done thorugh Matlab Pushbullet. It is one of the features provided by the Matlab. This feature in the model sends the user a notification regarding whether the fruit is Ripen or Not Ripen and to cut the fruit or to not cut the fruit basing on the output in Matlab.

Using the Pushbullet API key and on adding the Pushbullet libraries in the Matlab, the message or notification will be sent to specified account.It is done in such a way that, the notification is only sent when the output is greater than 90% i.e Ripen fruit with score greater than 90%.

So, with this notification that is sent to the user's smart phone, the decision can be made whether to cut the fruit or not. For example, when the detected fruit is ripen one, then the user receives a message "Ripen – cut the fruit". If the

identified fruit is Not Rippen, then the user receives "Not ripen- Do not cut the fruit".

V. RESULTS

Figure 6: Drone system with Gripper mechanism

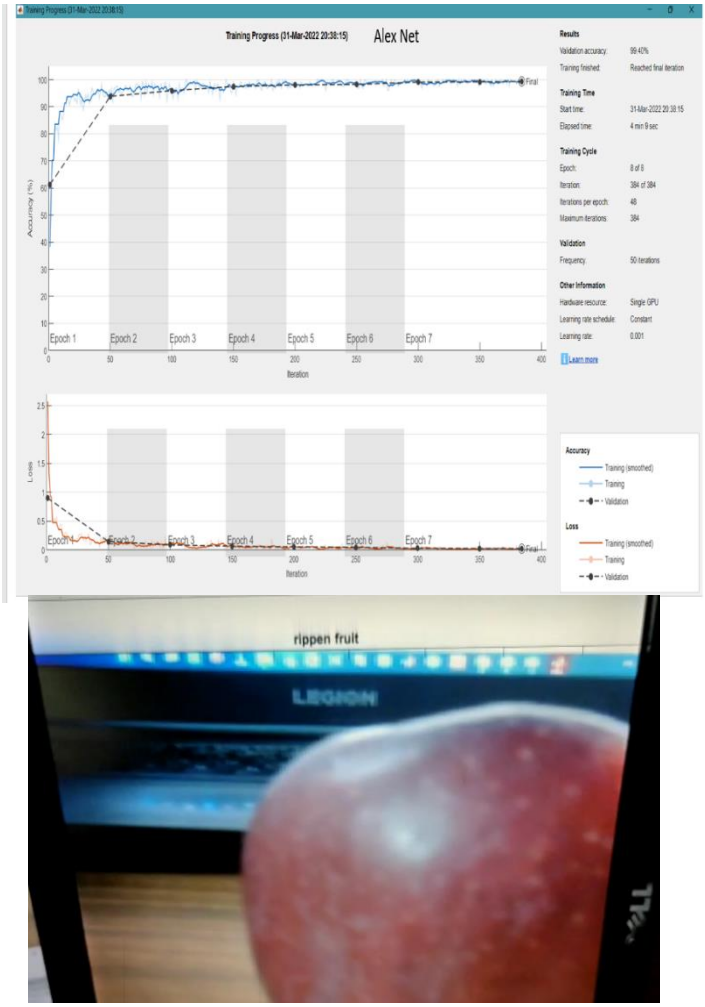

Figure 7: Alex Net training curve

Figure 8: Ripen Fruit Detection

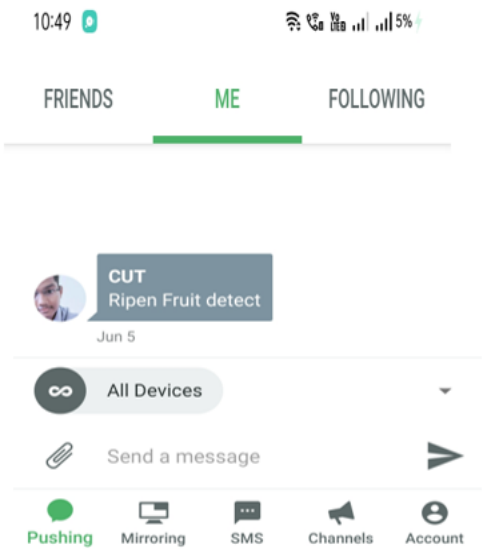

Figure 9: Notification sent to smart phone (PushBullet)

VI. CONCLUSION

The central theme of this model revolved around the development of Fruit plucking system that ensures less labour involvement that results in pr3eventing **Preharvesting** problems in Agriculture industry.

Adoption of the **Aerobatic Harvesting** system as proposed in this research thesis will certainly save the valuable efforts of farmers avoiding the fruit wastage in the field due to labour shortage or high demand of labourers (high wages).

Certainly, the intended purpose of proposed model is not to replace the role of laborers completely, but to introduce a vote of confidence and by implementing this system in the required areas / fields where is shortage of labour to avoid fruit wastage in fields.

In future, the proposed framework can be extended to a range where the model involves minimum or no human involvement to harvest the fruit, where the system entirely works independently and the harvesting process takes place automatically. The already available data may seem insufficient due to the novelty in challenges encountered by researchers while developing the model. This may be supplemented by stronger body of drone system which can be implemented to harvest fruits like Mangoes where more obstacles are present . Another direction which may be explored is determining and cutting the fruit automatically without human involvement.

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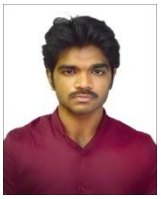

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