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FRUIT HARVESTING DRONE

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ABSTRACT

Fruit plucking during harvesting period involves labor intensive and time consuming steps. Automatic fruit plucking drones has to be developed to avoid the scarcity of labor 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 pluck and hold the fruit. Fruit detection is performed by training different fruit images to object detection algorithms like SSD-Lite. Recognized fruit information is given to user through Raspberry Pi and is displayed in receiver module. Then Raspberry Pi controls the robotic arm automatically to pluck the fruits. Project can be implemented to harvest various kinds of fruits in orchards like apple, banana, guava and citrus etc.

Keywords: Drone, Robotic arm, Image processing, SSD algorithm, Fruit detection

INTRODUCTION

The skilled farm labour in the agriculture is one of the most cost demanding factors. This is due to the rising values of supplies such as migration of large population from rural to urban areas, power, water irrigation, agrochemicals and so on. This puts the farming to be under pressure with small profit margins. Under these challenges food production and harvesting still needs to meet the growing demands of an ever-growing world population and this problem has to be overcome.

The development of a hexacopter with a robotic arm gives a solution for harvesting fruits from heights. The prposed project consist of a hexacopter with a camera on it. Hexacopter will perform an important operation of flying with the help of motors placed on it and detecting fruit with the help of camera. The proposed system will also consist of a robotic arm with a plucker for plucking the fruit from the tree. The copter will be controlled by a controller for flying purpose and to move the drone to the required location. This user friendly approach of flying and controlling of fruit harvesting drone can be managed easily with basic technical information.

LITERATURE SURVEY

Multicopters are gaining more interest in many aerial applications. Multicopters include helicopter, tricopter, quadcopter, hexacopter and octacopters. When one or two of the motors are damaged or not functioning properly due to unpredictable environmental issues or mechanical failures, multirotors can still maintain stable flying. For heavy lift applications hexacopter is preferable than the quadcopter because they give more stability to drone,

provide higher durability and larger payload. Octocopter also has the ability as hexacopter but it cost more price due to increase in number of motors (Ruggiero, 2018).

Hexacopter has been designed, rotation of rotors has two direction i.e. three on counter clockwise and three on clockwise. Thrust was calculated based on the total weight has to lift. Batteries plays important role in flight time, therefore current should be more than motor current. As weight on hexacopter increases flight duration also decreases (Suprapto, 2017).

To pluck fruit, drone has to distinguish the fruits based on the image captured by camera. Binocular stereo vision camera is being used to acquire three dimensional images of the fruit. It also converts the image into hue, saturation, value components of colour model. Different image processing techniques are implemented to remove noise and filter the image acquired. Otsu algorithm is used to segment the pixels of image and least square fitting method is applied to find centre and radius of fruit (Liu, 2019).

Image is acquired using digital colour Charged Couple Device (CCD) through which training dataset is prepared. Colour image of fruits is converted into gray scale to obtain features of the fruits. K-means algorithm is used to segment an image and polygon fitting method is implemented to define boundaries in case of overlying fruits (Rahul, 2018).

A system having robotic arm with 6 Degree of Freedom has designed using six servo motors which is helpful to harvest the fruit from trees and control of servo motor done by Arduino mega. Recognizing of fruit is done based on color. If two or more fruit having same color cannot be distinguish. So, image processing has to be used to identify the type of fruit (Wali-ur-Rahman, 2018).

Grippers are crucial part of the robotic arm because it affects the fruit and the fruit may get damaged if gripper does not work properly. Hard grippers were designed to hold the fruit, it may damage the fruit due to stiff grip and it does not consist the cutter to pluck the fruits. To overcome the above problem, soft gripper has to use an end effector. Gripper consists of four fingers which is flexible works on the fin ray effect. Scissors were mounted on top of the gripper for detachment of the fruit. After cutting, the grasp is maintained to enable the manipulator to transport the fruit to storage place (Eizicovits, 2016).

System uses pre-processing for efficient detection using convolution neural network and all captured frames are resized, a mean value is subtracted from every channel of the image to center the data and the intensity values are scaled. After preprocessing, the images are given to a pre-trained MobileNet SSD model that detects and identifies the objects in the image frame. MobileNets are small and efficient models reducing the size of the network and increasing the throughput of the system (Naskar, 2015).

YOLOv3 predicts object score for each bounding box using logistic regression. Each box predicts the classes the bounding box may contain using multi label classification. YOLOv3 predicts boxes at 3 different scales and uses k-means clustering to determine bounding box priors. A new network is used for performing feature extraction which is a hybrid approach between the networks used inYOLOv2, Darknet-19 and that newfangled residual network stuff. YOLOv3 has good accuracy and works faster and detect smaller objects (Redmon, 2018).

MATERIALS AND METHOD

Block diagram of the proposed system is shown in Figure 1 which consists of some of the blocks like Transmitter, Hexacopter, Raspberry pi 4, Image processing, gripper, VL53L1X and camera.

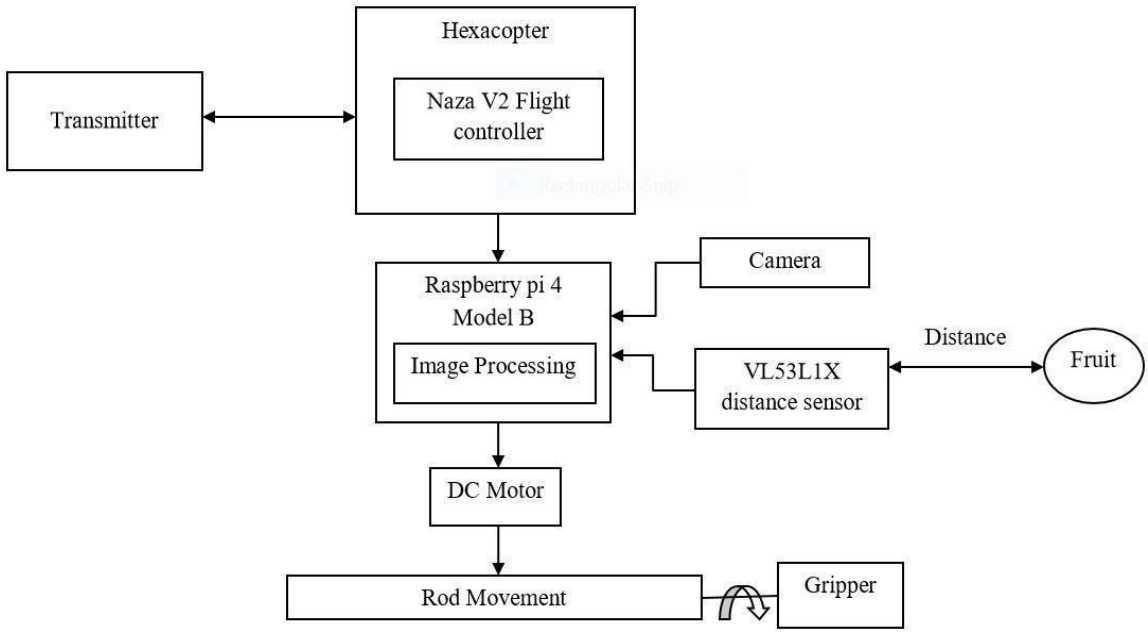

Figure 1: Block Diagram

Transmitter enables the user to control the drone from a distance using 2.4 gigahertz spread spectrum radio signals. Commands to control flight and position of drone is sent through the channels or gimbals. By using these channels speed and yaw of the drone is controlled. Received video can be viewed by interfacing mobile to transmitter.

Hexacopter is an Unmanned Aerial Vehicle uses six rotors for flight purpose and can lift more weight. Flight controller receives the commands from transmitter and alters the speed and direction of the drone. Naza V2 flight controller determines how to manipulate the motors when command from the user for the multi-rotor is fed to the controller. Raspberry pi 4 Model B is the micro-controller of the system. It controls robotic arm movement based on the distance given by distance sensor and gripper action to hold fruits. Image processing and recognition of fruits is also done in Raspberry pi. Camera module is interfaced to Raspberry pi which captures the real time video and transmits to Raspberry pi. Raspberry pi transmits video to transmitter to know the position of fruit in tree. Image processing is used to analyze and manipulate the digital images captured by camera. Captured video will be converted into image and undergoes image processing to classify and detect different fruits and identify the position of fruit in the tree.

VL531X is a time of flight sensor which identifies the distance between the fruit detected and the robotic arm so that the arm can move to the given distance to pluck the fruit. DC Motor is interfaced with Raspberry pi to control the movement of metal rod attached to pluck the fruit based on the distance obtained from VL53L1X. Gripper is provided at one end of the arm to pluck and hold the fruit without any damage. Raspberry pi controls the action of gripper with end-effector mechanism.

METHODOLOGY

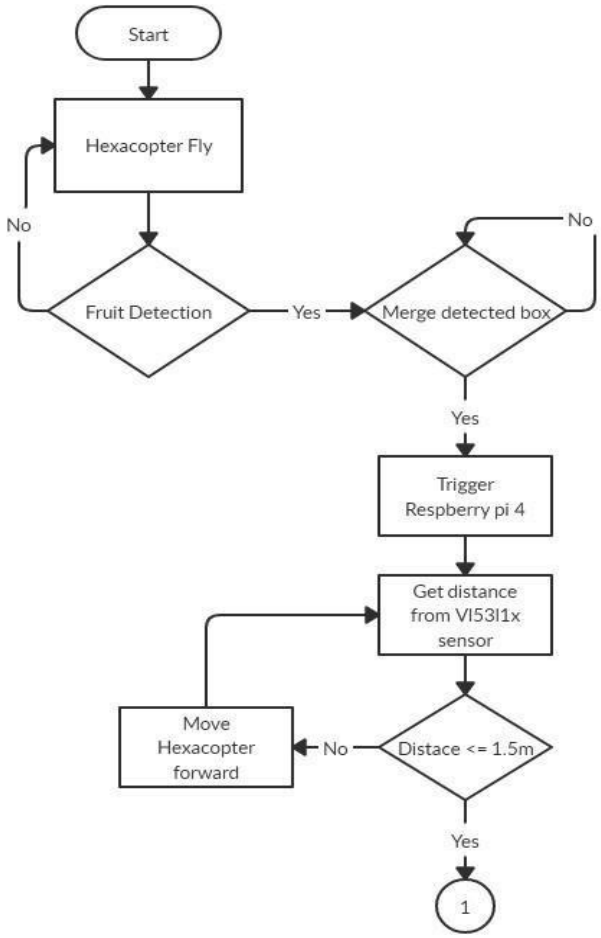

Figure 2: Flowchart

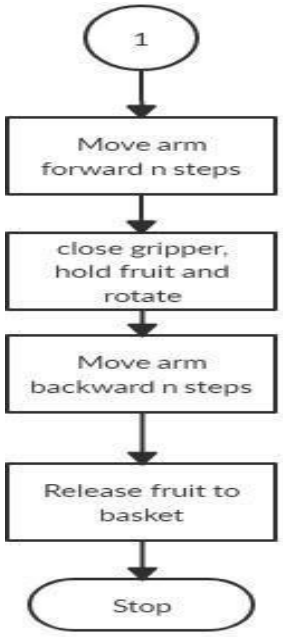

Figure 3: Flowchart (continued)

The flow of working of the proposed project is as shown in Figure 2 and Figure 3. The hexacopter will be made to fly until the fruit is detected. Once the fruit is detected the detected box is made to merge into another predefined bounding box. After the box is merged

for specific amount of time the raspberry pi triggers the VL53L1X to get the distance between the arm and the fruit. The distance measured by the sensor must be less than 1.5m. If the distance is greater than 1.5m then the hexacopter is moved forward till the distance becomes less than or equal to 1.5m. Once the distance becomes less than 1.5m the robotic arm is moved forward to the given distance with help of dc motor. The gripper placed at one end of arm holds the fruit and rotates to pluck the fruit. Then the robotic arm moves backwards which is equal to the distance it moved forward and releases the fruit in the basket.

RESULTS

The proposed fruit harvesting drone has been developed with the mentioned specifications. The hexacopter with six rotors is developed and is shown in Figure 4. The robotic arm used for forward and backward movement horizontally to reach the fruits with gripper at one end is as shown in Figure 5. The gripper is attached with two gears at one end which helps in opening and closing of it. Gripper helps to harvest and hold the fruit. The overall proposed fruit harvesting drone system is shown in Figure 6. In order to harvest fruit the model must recognize fruits which is done by image processing shown in Figure 7 processes upto 4 frames per second.

Figure 4: Hexacopter

Figure 5: Robotic arm with gripper

Figure 6: Fruit harvesting drone

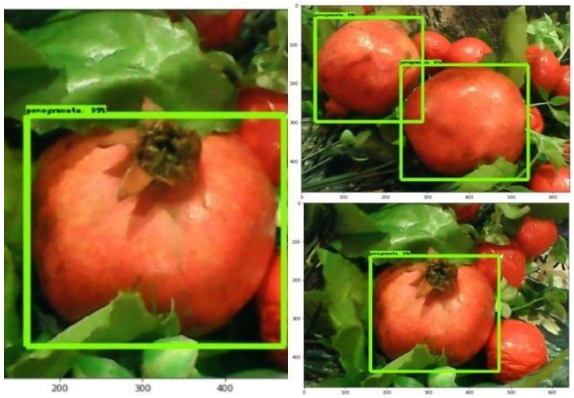

Figure 7: Fruit detected

CONCLUSIONS

The project proposes an efficient fruit harvesting system by providing vision system and robotic arm for hexacopter can lift a payload of 1kg. The camera interfaced to copter provides information of the fruit by undergoing image processing using SSD model with processing speed of 4 frames per second. Robotic arm action is done automatically and it can move upto 1m. The copter has flight duration of approximately 20minutes and stabilized during flight mechanism. The robotic arm with gripper is being designed to facilitate holding of fruit and blades are provided at the top for easy detachment of fruit from tree without causing any damage to fruit. Finally, the robotic arm will harvest the fruit detected. A significant amount of manual work can be reduced along with number of labors which benefits the agriculturists by saving time and money.

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