AUTOMATIC HARVESTER FOR TUBEROSE

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ABSTRACT

The paper proposes the development of an automatic harvester for tuberose flowers, which aims to improve the efficiency and productivity of the harvesting process. The machine would use sensors and imaging technology to accurately identify the location and maturity of the flowers, and then use mechanical arms to gently cut and collect the flowers without damaging them. The benefits of an automatic harvester for tuberose include increased efficiency and productivity, reduced labor costs, and improved quality of the harvested flowers. However, developing an automatic harvester for tuberose poses several challenges, such as designing a machine that can accurately identify the location and maturity of the flowers, and ensuring that the harvesting process is gentle enough to avoid damaging the flowers. Overall, the work presented in the paper has the potential to revolutionize the way tuberose flowers are harvested, making the process more efficient, cost-effective, and sustainable.

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1 INTRODUCTION

Interest in agricultural automation has increased considerably in recent decades due to benefits such as improving productivity or reducing the labor force. The development of an automatic harvester for tuberose is an innovative work that aims to improve the efficiency and productivity of harvesting tuberose flowers. The main goal is to create a machine that can accurately and efficiently harvest tuberose flowers without damaging them. This interest stems from the benefits that advanced agricultural automation can provide. Robotic harvesting can improve productivity many-fold by reducing manual labor and production costs, increasing yield and quality, and enabling better control over environmental implications. Robotic harvesting is a promising technology of agriculture in the future. Agriculture has conventionally been a labor - intensive occupation in India. However, the complexity of agricultural environments combined with the intensity of production demands requires robust systems capable of adapting to high crop variability. Two critical aspects for achieving a successful automation of harvesting tasks are detecting flowers in natural conditions and the proper harvesting and manipulation of the detected target products. In agricultural settings, scenes exhibit a large degree of uncertainty; they contain objects with various colors, shapes, sizes, textures, and reflectance properties that change continuously due to illumination and shadow conditions However, in order to provide for the rapidly increasing population, in the face of rising labor costs, there is a need to explore autonomous alternatives in place of traditional methods.

1.1 Objective

- Analysing the method of harvest
- Tracking the labor cost
- Analysing the research gap
- Proposing a novel technique for tuberose harvester
- Developing an efficient robot to harvest tuberose

2. METHODOLOGY

The Fig -1 shown below explains the complete flow of the methodology along with the objectives**.**

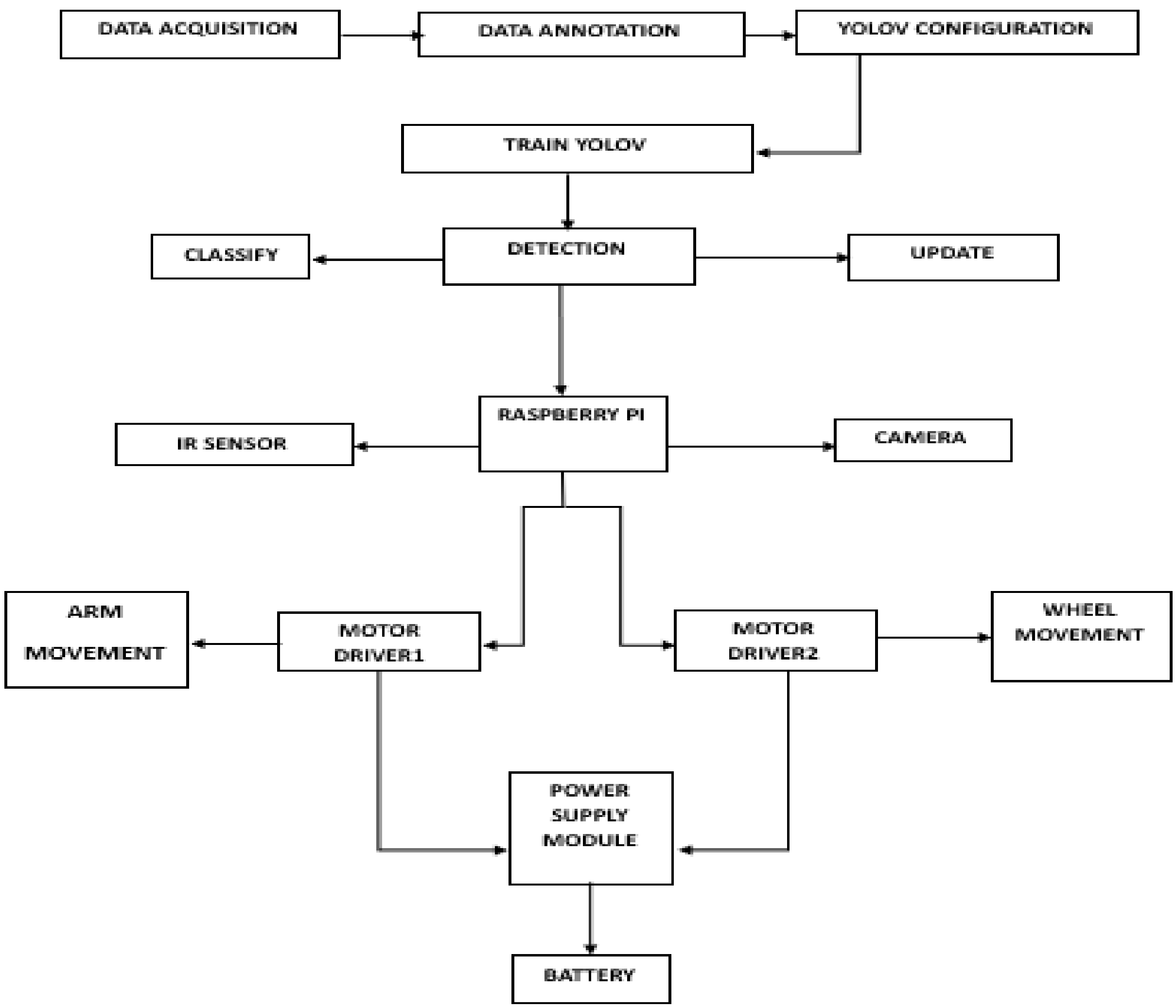

Fig -1 Methodology

2.1 Flow of Methodology

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- First the real-world images of the tuberose/bud are collected with the various background and the angle. The collected image is then trained using various online image processing platforms. Make sense.Ai is a software platform that is used in the work, to label the data for image processing. The collected image data is dumped in the Make sense.Ai and the labelled data set of the images are created. It uses many different AI models that will be able to give user recommendations as well as automate repetitive and tedious activities Labelling of the image is exported in yolo format.
- The labelled dataset generated from Make sense.Ai is dumped in the Roboframe. Roboframe is basically used to annotate the images. Roboframe uses the rectangular box for the annotation of the images.

Roboflow hosts free public computer vision datasets in many popular formats (including CreateML JSON, COCO JSON, Pascal VOC XML, YOLO v3, and Tensorflow TFRecords). The main functions of Roboframe are: Adding Data, Annotating Images, Preprocessing and Augmentations, Preparing Data for Training, Training a Computer Vision Model, Deploying a Computer Vision Model.

- The dataset generated by Roboframe is exported in yolo format.
- Identification and localization of objects in photos is a computer vision task called 'object detection', and several algorithms has emerged in the past few years to tackle the problem. One of the most popular algorithms to date for real-time object detection is YOLO (You Only Look Once), initially proposed by Redmond Yolo v5 algorithm is used for generating the trained dataset in which the annotated dataset is split into classes here the image is split into two classes [bulb, bud].
- The trained dataset that is generated from the yolov5 is dumped into the Raspberry pi board. Raspberry pi board is used as the main board for the image processing as well as the control over all the components in the circuit.
- Hence when the image is detected the result is shown along with the rectangular border with the class of the image along with the accuracy of the class. Web camera is used for the detection of the image/bud that is connected to the raspberry pi board.
- When the camera detects the bud, the Raspberry pi board sends the control to the motor drivers l299d. out of the two l299d motor drivers, driver1 is responsible for the arm movement and the driver2 is responsible for the wheel movement.IR sensor is kept near the arm that is used for the detection of the bud. As the wheel moves towards the bud, the IR sensor near the arm detects the bud.
- Both of the motor drivers are connected to a power supply module that is used to supply the voltage across all the components equally throughout. Lead acid battery of 12 V is used for the power supply. When the web camera detects the bud, the control is sent to both of the motor drivers that controls the movement of the arm as well as the wheels. The arm uses IR sensor to detect the bud, after the detection of the bud. The arm now plucks the bud and places bud on the basket.

3. SOFTWARE AND HARDWARE

3.1 SOFTWARE

The algorithm for detection and classification of tuberose is discussed in detail in the section. YOLO object detection algorithm is used for detection and classification.

Joseph Redmon et al. introduced You look only once also known as YOLO in 2015. YOLO is a convolutional neural network (CNN) for doing object detection in real-time. The algorithm applies a single neural net5 work to the full image, and then divides the image into regions and predicts bounding boxes and probabilities for each region. These bounding boxes are weighted by the predicted probabilities. Some improvements were done over years and YOLOv2 and YOLOv3, v5 versions were introduced respectively in 2016, 2018.Our model uses YOLOv5 and it provides good results regarding object classification and detection. In the previous version of Yolov3 Darknet-19 is used. Yolov3 uses darknet-53. Darknet is a framework used for training neural networks written in C language.

3.1.1 Configuration Module

First step is to create a method to connect with user's local network of cameras through internet or use the internet accessible IP cameras. In this paper, the proposed solution uses IP cameras. To connect camera to the application, users have to provide their camera IPs/or anything equivalent to it like RTSP URL, etc. These IPs will be saved in database for reuse. Fig – 2 describes the software flow.

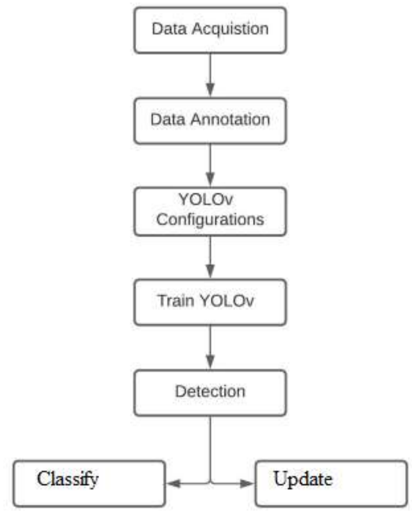

Fig - 2: Software flow diagram

3.1.2 Data Acquisition

To use the YOLO algorithm for data acquisition, you would first need to train the model using a large dataset of labelled images. This involves providing the model with images and their corresponding object labels. Once the model has been trained, it can be used to detect objects in new images or video streams. The output of the model includes the class labels and bounding box coordinates of the detected objects. This information can then be captured and stored in a database or other storage system for later use in training or testing machine learning models. Data acquisition using the YOLO algorithm can be a powerful tool for building object detection models that are tailored to specific applications. By using a large and diverse dataset of labelled images, you can train a model that is highly accurate and able to detect a wide range of objects. This can be especially useful in fields such as robotics and autonomous vehicles, where accurate object detection is critical for safe and effective operation.

3.1.3 Data Annotation

To train YOLO we need to annotate images for object detection models. Our dataset should be well annotated. There are different types of annotations available. Here a bounding boxes method is used. It creates a rectangle area over images that are present in our dataset. Since Annotation needs more time we are using a tool called Label IMG to annotate our data. The YOLOv5 configuration involved the creation of two files and a custom Yolov5 cfg file.

3.1.4 Algorithm

Step 1: Start the program.

Step 2: Input image is loaded.

Step 3: YOLOv5 trained weights are loaded from the disk.

Step 4: tuberose Detected and marked by means of object detection algorithm.

Step 5: After detection resultant image is displayed.

Step 6: Classify the Type.

3.1.5 YOLOv5 Configuration

YOLOv5 configuration first creates a “obj.names” file which contains the name of the classes which the model wanted to detect. Then the “obj.data” file train’s data directory, validates data. Next is training of YOLOv3 in which an input image is passed into the YOLOv5 model. This will go through the image and find the coordinates that are present. It divides the image into a grid and from that grid it analyzes the target objects features. Here 80 percent data is used for training, and remaining 20 percent is used for validation. Now weights of YOLOv5 trained on the dataset are created under a file. Using these trained weights detection of objects can be achieved .

3.1.6 Yolo V 5 Training:

The Yolov5 training helps is creating the data set. The data set is then used to train the specifications to distinguish the bulb and the bud in the input image taken by the camera. The algorithm compares the trained dataset with the input image obtained by the camera.

3.1.7 Detection

Tuberose detection module

The IPs stored in the database are used as input for object detection module and OpenCV is used for any image processing related tasks. For object detection, a pretrained YOLOv5 model is employed. YOLOv5 is better than previous proposed algorithms hence it is the preferred choice for object detection model. YOLO recognizes objects more precisely and faster than other recognition systems. It can predict up to 80 classes. It can be easily trained and deployed in a production system. YOLO is based on a single Convolutional Neural Network (CNN). The CNN divides an image into regions and then it predicts the boundary boxes and probabilities for each region. It simultaneously predicts multiple bounding boxes and probabilities for those classes. YOLO sees the entire image during training and test time so it implicitly encodes contextual information about classes as well as their appearance. The real-time recognition system will recognize multiple objects from an image. The backbone of YOLOv5 is CSPDarknet-53. Darknet is an open-source neural network framework written in C and CUDA and it is used to train new YOLO models and run the existing ones. After the training is done the results are stored in a .weights file. The darknet model which is in .weights format is now converted to a TensorFlow model in .pb format. The saved model in .pb format is used for object detection. YOLOv5 sends the coordinates of detections along with confidence score which is used as input for OpenCV to draw bounding boxes on the detections and count these detections.

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3.1.8 Classification Using Yolo

To perform classification using YOLO for tuberose, the first step is to train a deep neural network using a large dataset of tuberose images. The neural network is trained to identify the unique features and characteristics of tuberose flowers, such as their shape, color, and texture. Once the neural network is trained, it can be used to classify tuberose flowers in new images. The YOLO algorithm analyzes the image frame in real-time and identifies the location and boundaries of tuberose flowers within the frame. The neural network then applies the trained classification model to each identified flower to determine its type or variety.

3.2 HARDWARE

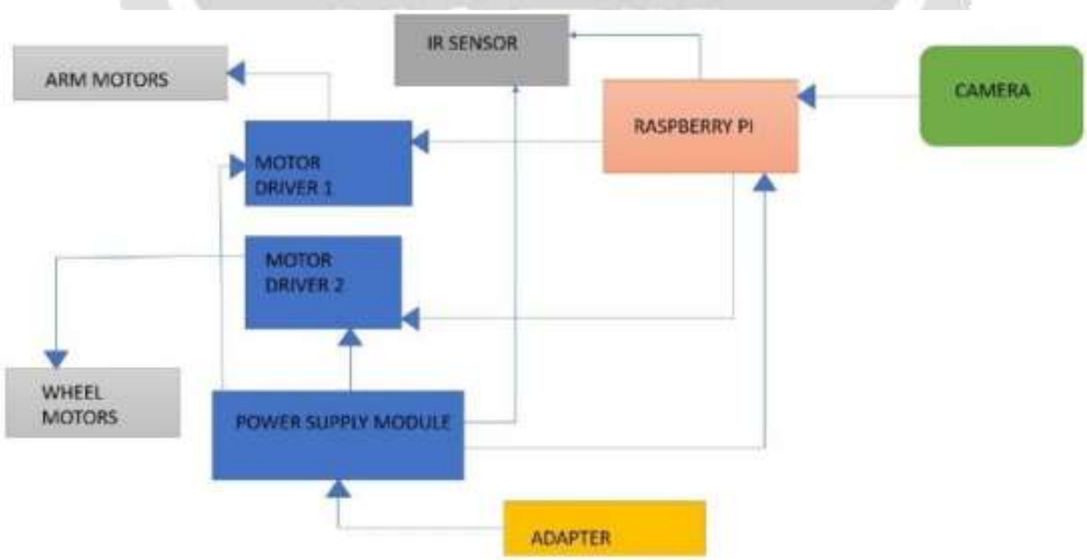

Fig - 3: Hardware flow diagram

3.2.1 Raspberry Pi 4

Raspberry Pi 4 is a small, low-cost, single-board computer that is the latest model in the Raspberry Pi series. It has a faster CPU, support for up to 4GB of RAM, dual-band wireless networking, and two 4K display support. It has several ports and a 40-pin GPIO header for connecting sensors and other electronic components. It is commonly used for educational purposes, hobbyist projects, home automation, and small-scale computing tasks.

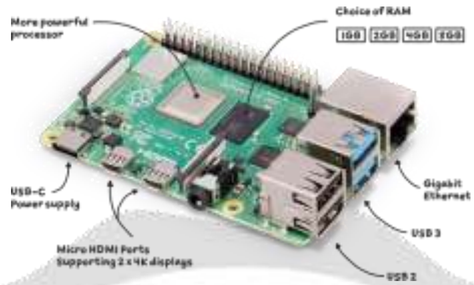

Fig - 4: Raspberry pi 4

3.2.2 Motor driver l239 d

The l293d is a motor driver IC that is commonly used to control DC motors. It can drive up to two DC motors bi-directionally and provides an output current of up to 600mA per channel. The l293d is also designed to drive inductive loads such as relays, solenoids, and stepper motors. It has built-in flyback diodes to protect the chip from voltage spikes generated by inductive loads. The l293d can be controlled using a microcontroller or any other digital logic circuit. It is commonly used in robotics, home automation, and other projects that involve motor control.

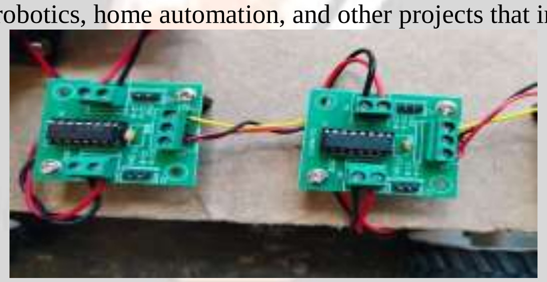

Fig - 5: Motor driver l239d

3.2.3 Power supply module

Power modules are high-power electrical components that contain a single or several components combined into a functional, isolated unit. They typically have a base plate for mounting a heat sink and electrical contacts that allow for quick and easy mounting and removal. By manufacturing the component as a module, improved power handling, reliability, and decreased parasitic circuit elements are all possible.

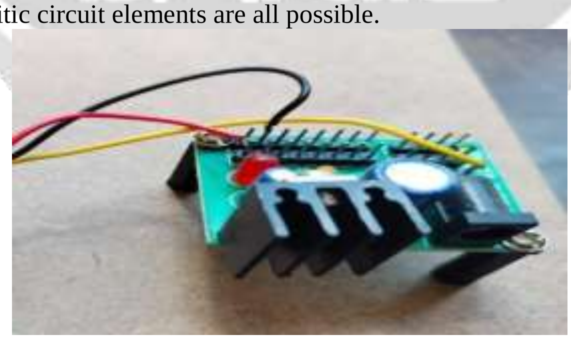

Fig - 6: Power supply module

3.2.4 IR Sensors

IR sensors, or infrared sensors, are electronic devices that detect infrared radiation emitted by objects. Infrared radiation is a type of electromagnetic radiation with a longer wavelength than visible light, and it is emitted by all objects that have a temperature above absolute zero.IR sensors can be used in a variety of applications, including temperature sensing, motion detection, and object detection. They work by detecting changes in the amount of IR radiation that they receive, which can be caused by changes in temperature or the presence of an object.

Fig - 7: IR Sensor

3.2.5 DC motors

A DC motor is a type of electric motor that converts electrical energy into mechanical energy. It consists of two main parts: the stator and the rotor. The stator is the stationary part of the motor and contains the magnets, while the rotor is the rotating part of the motor and contains the armature. When a current is applied to the motor, it creates a magnetic field in the stator. The armature, which is connected to a shaft, rotates within this magnetic field. The rotation of the armature creates a torque that drives the motor.

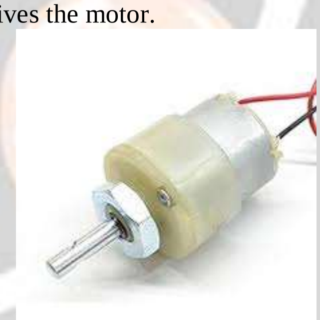

Fig - 8: DC motors

3.2.6 Gears

A spur gear is a type of gear with straight teeth that are parallel to the axis of rotation. It is one of the simplest and most common types of gears, and is used in a wide range of applications. Spur gears are often mounted on parallel shafts, with one gear driving the other. When the teeth of two spur gears mesh together, they transfer torque and rotation between the two shafts. The ratio of the number of teeth on each gear determines the speed and torque of the system.

Fig - 9: Gears

3.2.7 Servo electric grippers

Servo electric grippers are devices that use servo motors to control the opening and closing of gripper jaws or fingers. They are commonly used in industrial automation applications to pick and place objects with precision and accuracy. Servo electric grippers are composed of several components, including the gripper fingers or jaws, a servo motor, a position sensor, and a controller. The servo motor is responsible for driving the gripper jaws or fingers, while the position sensor provides feedback to the controller about the position and orientation of the object being gripped. The controller then adjusts the position of the gripper jaws or fingers based on this feedback, ensuring accurate and consistent gripping.

Fig - 10: Servo electric grippers

3.2.8 Web camera

A web camera, also known as a webcam, is a type of digital camera that is designed to capture and transmit video and audio in real-time over the internet. It is commonly used for video conferencing, online meetings, and live streaming. Web cameras typically consist of a lens, image sensor, microphone, and USB or wireless connectivity. They may be built into a computer or other device, or they may be external and connected via USB or wireless.

Fig - 11: Web camera

3.2.9 Battery

A 12V lead acid battery is a type of rechargeable battery that is commonly used in a wide range of applications, including automotive, marine, and off-grid power systems. It is composed of several lead-acid cells connected in series, each of which produces 2 volts. The lead-acid battery works by converting chemical energy into electrical energy. Each cell contains a positive electrode made of lead dioxide, a negative electrode made of lead, and an electrolyte solution of sulfuric acid and water. When the battery is charged, the chemical reaction converts the lead dioxide and lead plates into lead sulphate, and the sulfuric acid is converted to water. When the battery is discharged, the reverse reaction occurs, converting the lead sulphate back into lead dioxide and lead, and releasing electrical energy.

Fig - 12: Battery

4. IMPLEMENTATION

The implementation starts by classifying the images into bud and tuberose with the help of Roboflow. The set of images are then trained, which generates the data set. YOLOv5 and ClearML are used to extract the data that is generated. Then in the end, with the help of command python detect.py an accurate image of the desired sample is obtained as shown in Fig - 13.

Fig - 13: Detection

The following pictures demonstrates the actions of detecting the tuberose flower and plucking it with the help of gripper. The gripper holds the flower and takes it in backward motion, where the basket is present. The gripper opens and drops the tuberose flower into the basket. The gripper closes and moves in the forward direction. Once the arm comes back to its position, it waits for camera to detect next tuberose and repeats the same actions.

Fig - 14: Collection of the flower by the gripper

Fig - 15: Gripper moving back after plucking

Fig - 16: Gripper dropping the flower into the basket

Fig - 17: Gripper moving forward and taking its position

4. CONCLUSION & FUTURE SCOPE

Development of Automatic Tuberose Harvesting Robot using YOLOv5 algorithm and Python codes has brought numerous benefits to the agricultural industry. The implementation of this innovative technology has improved the efficiency and accuracy of tuberose harvesting process, while reducing the cost of labor. Applying YOLOv5 algorithm has played a significant role in the success of the Automatic Tuberose Harvesting Robot. Its ability to accurately detect and identify tuberose flowers has led to better yields and higher-quality tuberose flowers. The use of this algorithm has also minimized damage to the plants, resulting in increased plant health and longevity. The Python codes used in the development of the robot have provided a flexible platform for customization and updating. The codes can be easily modified to optimize the robot's performance for specific needs, making it a valuable tool in the agricultural industry. Furthermore, the implementation of the Automatic Tuberose Harvesting Robot has led to significant cost savings. The need for manual labor as well as overall cost has been reduced, which benefits the farmers. This technology has made the harvesting process more efficient and cost-effective, making it accessible to more farmers.

On the basis of the paper, the future scope can be focused on the following

- Integration of various sensors and other image processing techniques for detecting and locating tuberose flowers.
- Testing and validation of the prototype robot in a real field.
- Assessment of the economic feasibility and market potential of the robot. Documentation of the design, development, and testing process, along with recommendations for further improvements and future research.

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