Project Title: Fruit Harvesting Using Robotic Vision

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Project Details:

To create our dataset, we have chosen 2 fruits: strawberry and avocado and have manually captured their pictures at every stage i.e. unripe, partially ripe, ripe and rotten.

These images have then be annotated using an online annotation tool - makesense.ai.

After completing the annotation, we have performed augmentation on our dataset images to increase the size of our dataset and make the model learn better.

Then using a pre-trained YOLOv5 model we have successfully classified most of the fruits in their respective categories.

Problem Statement:

The main project idea proposed is development of a multiclass fruit detection technique utilizing a deep learning framework for increased efficiency, effectiveness and reliability in outdoor orchard scenarios. From the images, the fruit is classified as a particular type of a fruit and stage of it's cycle is determined depending on the color, texture, shape and size. If the fruit ripe, then using inverse kinematics the robot arm plucks it and If unripe or partially ripe, it gives the approximate harvest date.

Need of Project:

About 45% of fruits and vegetables are wasted due to improper harvesting methods. After seeing the quantity of fruits and vegetables that have been thrown away due to poor harvesting methods, we have begun our endeavour to prevent food wastage and provide for people who do not have access to it. Thus, through this project we have designed a fruit detection model utilizing YOLOv5 which will accurately classify the two chosen categories of fruits into their respective growth stage - unripe, partially ripe, ripe and rotten. This approach is a step toward a fully automated fruit harvesting industry in the not-too-distant future. This would also make farmers' lives easier by providing the much-needed assistance in this field.

Proposed Solution:

The input is taken from the robotic camera which goes to detect the fruit from the tree and its position using LiDAR. Using object detection models like YOLOv5, YOLOv6, YOLOv7, and SSD using MobileNetv1, the fruit is divided into 8 categories: unripe, ripe, partially ripe, and rotten strawberry and avocado. If the fruit is rotten, then it gets segregated from the other fruits. The approximate date of harvest is then calculated for the unripe and partially ripe fruits. The harvested fruits are then picked by a robotic arm using inverse kinematics. The Training data is passed directly to object detection models like YOLO and SSD which extracts the features from the data and update the weights and bias using the validation dataset. When the training is completed for multiple epochs , the test data is passed to predict the effectiveness of the model and to predict the category of the fruit.

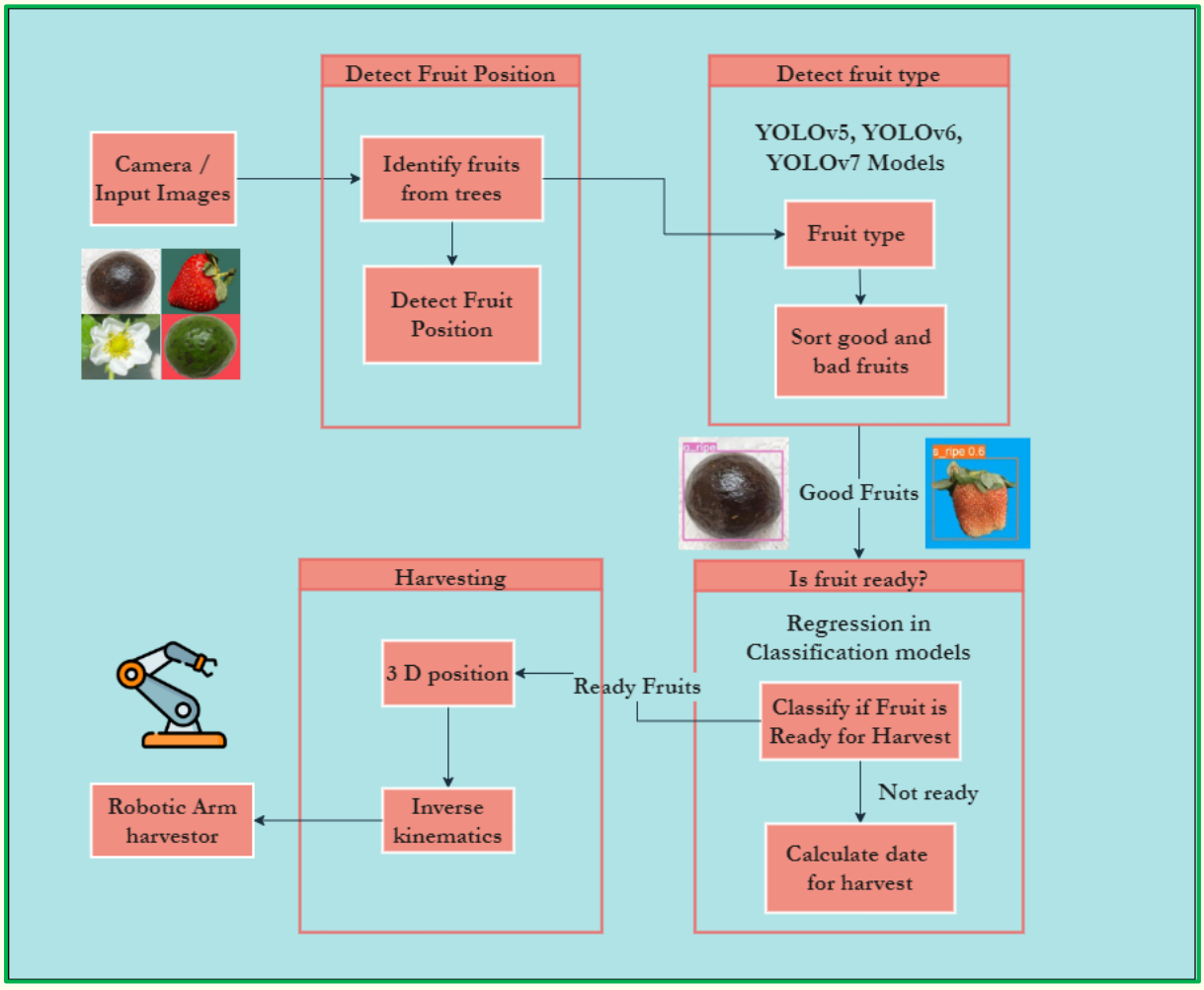
Technology Used:

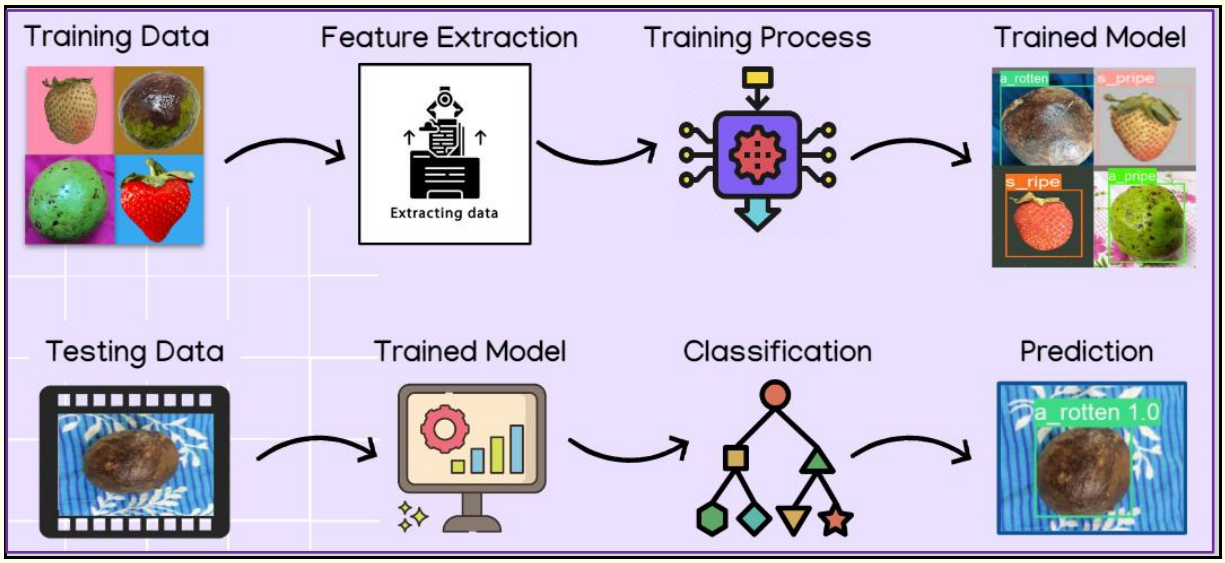
Google Colab, Makesense.ai Tool, Python, Tensorflow, Albumentation Library, YOLO Modelling and Roboflow Tool

Project Outcomes:

The first model YOLO V5 was applied using transfer learning for 50 epochs initially and gave an overall accuracy of 80.65% and then later when epochs was increased to 100 then mAP increased to 95%. The second model SSD with MobileNet V1 was trained for 5 epochs with learning rate of 0.001 and gave us mAP of 71.71 % but for classes strawberry, rotten and strawberry unripe was significantly low 32.68% and 13.69% respectively. The YOLOv6 model was trained for 100 epochs and has mAP of 99.5% but the model seems to perform well in the only the environment on which it is tested and not in realtime environment. The YOLOv7 model was trained for 100 epochs and has a mAP of 96.7% and performs better than YOLOv6 in real time environment.

Modelling:





Results:

Category	SSD with MobileNetv1	YOLOv5	YOLOv7	YOLOv6
S_unripe	13.6	98.3	87	88
S_pripe	86.7	81.4	99.5	100
S_ripe	81.3	76.4	99.6	82
S_rotten	32.4	84.7	89.4	85
A_unripe	84.2	99.5	99.6	100
A_pripe	87.4	99.5	99.6	100
A_ripe	90.7	99.5	99.5	100
A_rotten	97.1	99.5	99.5	100
Overall	71.8	92.3	96.7	99.5

sFuture scope for project enhancement:

- The dataset can be extended to add more fruits which have a color change during their ripening process like litchi, banana and apple.
- Regression can be implemented in the classified categories to predict the probable date of harvest.
- The model can be integrated with a drone or a liDAR robot to pluck and sort fruits according to the needs of user.
- The model can be extended to Explainable AI.