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Crop Yield Prediction Using Image Processing

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Abstract

Agriculture is a major Indian occupation. It Plays a vital role contributing to over 18% of India's GDP and provides jobs to 50% of the population of India Population growth is a major food security challenge. Population growth is increasing the need for farmers to produce more in the same agricultural country in terms of increasing supply. Computing the yield of any fruit or a vegetable takes a lot of computation time and requires too much of processing work. Technology can help farmers to produce more with the help of forecasting. The proposed model assists farmers in predicting crop yields. Fruit images are obtained with integrated charging devices (CCD) and the background of each image will be removed using a different algorithm to separate the fruit area in the input image. Fruits are calculated based on the centroid of the fruit. A machine-based approach is used to filter fruit by predicting the degree of maturity and aims to change the staffing system. The program includes pre-image processing, feature extraction and fruit classification using novel computational techniques such Machine Learning, Artificial intelligent, deep learning and so on. Using K means the highest accuracy of the fruit number algorithm is available. The project presents a computerized concept and techniques for machine learning of tree fruit acquisition, counting and sorting. With the introduction of IoT to use image processing the project assists farmers in predicting the yield. The findings can be stored in a database that enables the farmer to move whenever needed and keep track of the yield.

Keywords: Crop Yield Prediction, Image Processing, Predictive analysis

Introduction

The overall world's population is estimated to be reaching around 10 billion by 2050, which increases the agricultural order in the context of local economic development by 50% compared to 2013. Currently, about 37.7% of the total land is used for crop production. From job creation to National Revenue, agriculture is important. It plays a vital role in the economic prosperity of developed countries and plays a vital role in the economy of developing nations. Agriculture, and its affiliates, undoubtedly provide the largest livelihoods in India, especially in large rural areas. It also contributes to a significant product in GDP. The need of sustainable agriculture, is very important in terms of food security, employment opportunities in rural areas, and environmental technologies such as soil conservation, sustainable natural resource utilization and management and environmental protection, are essential to the overall development of rural areas. Indian agriculture and co-operatives have seen many revolutions such as green, white revolution, yellow and a blue revolution. Agriculture is also the backbone of the Indian economy. The local environment of our country has been very productive in agricultural activities.

The physical characteristics that exist in India, namely, his climate, his soil and his ease have greatly helped him to grow many crops here. From time immemorial, Indians have regarded agriculture as a means of subsistence. Agriculture is the process of producing food, feed, fiber and many other products that you want by growing certain crops and raising pets. The main function of Agriculture is to provide food for the people, to provide for industrial inputs, to employ large numbers of people, to finance agricultural development, the remnants of the country's economy if done well. India has been around for so long and is still an agricultural country that plays a key role in holding it accountable for the overall performance of our country. From the point of view of the contribution of agriculture to the Gross Domestic Product (GDP) of our country, such as food industry, as the livelihood of the majority of our people, as a supplier of wages and other agricultural value to our country's economy cannot be exaggerated. Apple having the scientific name Malus pumila is one of the prominent fruit and stands in the fourth position in terms of most

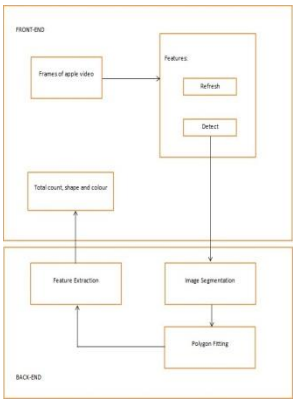
productive fruit in the world after bananas, oranges and grapes. China is the world's largest producer of apples. In India, the area under cultivation of apples has increased by 24% from 1.95 lakh hectare in 1991-92 to 2.42 lakh hectares in 2001-02 although production has increased by less than 1% (example from 11 tons to 12 lakh) [1]. This apple is widely grown in few states such as Jammu & Kashmir, Himachal Pradesh, Uttaranchal, Arunachal Pradesh and Nagaland regions. An agricultural exporter has been setup in Himachal Pradesh, which includes the Shimla, Siramour, Kullu, Mandi, Chamba and Kinnaur regions, with significant potential to increase exports.

The initial objectives are to export apples to neighboring countries and western Asia as well as countries in Southeast Asia. With the increase in the yield of apples in the State, the Government is taking useful and efficient measures to market its products without providing packaging, transportation, to ensure appropriate supply of apples under the Market intercession scheme, so that farmers get paid prices in the market. Smart farming based on IoT technology will help the farmers and agriculturists to reduce waste and improve yield by reducing the amount of fertilizer used, to the amount of travel produced by farm vehicles, and allows for efficient use of resources such as water, electricity, etc. Farming solutions are a system designed to monitor the field of crops with the help of sensors. IoT enabled applications for smart agriculture focus on helping farmers by ensuring high yields, profitability and environmental protection. The usage of IoT technology to ensure efficient use of all the resources to achieve higher crop yields by reducing the operational and managerial costs is called precision Agriculture. IoT in agricultural technology contains specialized devices, wireless communication devices, software and IT enabled services. There has been a very significant contribution of agriculture in the Indian economy and it is being improving over several years. According to the economic survey, the share of agriculture in gross domestic product (GDP) reached about 20% for the first time in the last 17 years making a significant contribution to GDP performance for the 2020-2021 financial year. Modern farm and agricultural activities have changed over the years as a result of technological advances, including sensors, devices, machinery, and information technology.

Block Diagram of the proposed system

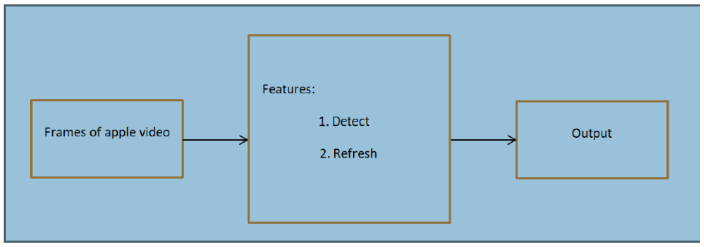
The block diagram for the crop yield detection is shown in Figure 1 and the design is divided into two phases – Front end and back end. In the front end, a GUI is built consisting of buttons such as refresh and detect in it.

Figure 1. Block Diagram of the crop yield detection



At the backend on clicking the detect button, the software will run and the crops will be detected and an estimation result will be given at the end. The Graphical User Interface for the proposed system of yeild estimation is shown in figure 2.

Figure 2. Block Diagram of GUI



In this GUI the frames of an input video are loaded. The feature buttons available are the refresh and the detect buttons. The refresh button loads the video from beginning. On clicking the detect button,

The buttons can be created as per the wish of the developer. The GUI is developed using a Python's GUI module. The classic GUI library for Python used is Tkinter. Python when combined with Tkinter supplies a rapid and simple way to make GUI applications. Tkinter supplies a considerable object-oriented interface to the Tk GUI toolkit.

Tkinter is very user friendly and using Tkinter, creating a GUI application is very simple. Tkinter provides various controls, such as buttons, labels and text boxes used in a

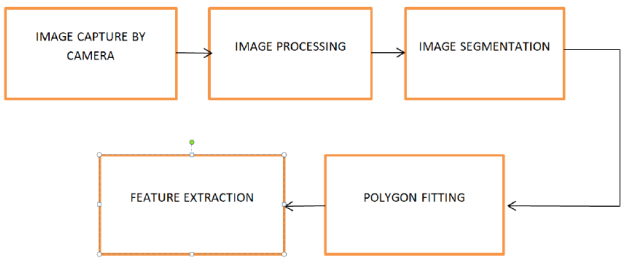
GUI application. These controls are commonly called widgets. All Tkinter widgets have access to specific geometry management methods, which have the purpose of organizing widgets throughout the parent widget area. Tkinter exposes the following geometry manager classes: pack, grid, and place.

The following steps are performed for the implementation:

- The Tkinter module should me imported.
- Next the GUI application should be created.
- We add one or more of the above-mentioned widgets to the
- GUI application.
- Enter the main event loop to hold action against each event triggered by the user.

The overall blocks needed for the implementation of yield estimation is shown in the Figure 3. The individual blocks and their functionality are illustrated below.

Figure 3. Block Diagram of the Proposed Model



The image acquisition part for the proposed system is illustrated in the section below.

- **Image Acquisition:** The image is acquired by means of digital color charged coupled device (CCD) camera. Images are captured in various weather natural lighting conditions such as full sun- front lighting and back lighting, full sun- fruits in the shadow and in cloudy conditions. Same tree

image is acquired at various angle of aperture. All the collected images transferred into computer through USB port. By collection of image a big dataset is prepare and this dataset is use as input to train the machine. Charge-coupled device (CCD) which is use to capture image of tree fruits includes an image sensor, and it senses the amount of light rays strike on the area of the CCD sensor and amount of light converted into an electric signal. CCD image sensor output is in an analog format.

- **Image Processing:** In this is called image processing phase, once the image is acquired some preprocessing has to be performed to modify the image into suitable form and set of rules is applied to train and test image. Digital image is displayed on screen of computer as pictures, which are understandable by the computer, and that images are changed into tiny dots. Grayscale image processing is used to detect fruit from image. Color image processing is used to obtain features of fruits.
- **Image Segmentation:** The process of cutting of background, adding and extract common feature analysis of image focused at separating an input image into area that has strong relation with objects or areas of interest has called as Image segmentation. In image segmentation, removed data mostly depend on the exactness of the operation. If objects in image cannot be distributed accurately, it is difficult to understand for object detection, measurement and classification. Hence, it impacts on interpreting and understanding that image.

For segmentation part to be implemented, initially background leaves, branches are eliminated. This is done by using a masking and overlying operations on image. K-Means algorithm, one of the most reliable and efficient, is used to segment the input image.

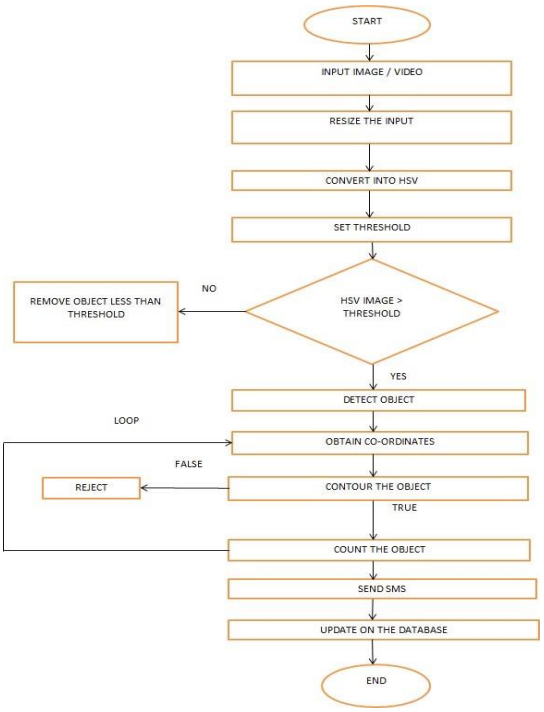
The segmentation of individual section of the image involves the alignment together of alike pixels to form areas signifying single objects within the image. Hue saturation value (HSV) color space transformation of RGB input image provides better segmentation result with K-means clustering algorithm.

- **Polygon Fitting**: Overlying of circles has to be performing to get the required boundaries of fruit region. Circle fitting algorithm is use to fit circle into scattered pixel data. First, the co-ordinates of the edge pixels have to found. Then the mean of pixels has to calculate. Then the center of the clusters by using the mean has computed. With the help of circle, overlying it is possible to get perfectly segmented required fruit region.

Implementation of the Crop Yield Detection

The flowchart comprising of various steps for the implementation of the crop yield detection are shown in figure 3. The acquired image is preprocessed for size adjustment and converted in HSV format. Based on the threshold fixed, the acquired imaged is compared against the threshold and background subtraction is carried out. The object detection is done based on the comparison against the threshold set. Then next part of the algorithm would be to get the coordinates or position of the object so that the counting of the objects can be done based on the contour of the object. Once the counting of the identified objects are done, the sms message is sent to the user and a database will be updated. This database will have the overall count of the identified objects and will provide the yield of the crop.

Figure 4. Implementation of the crop yield detection



Tkinter is a very usefl and a standard GUI library for Programming in python. The combination of Python with Tkinter provides a more efficient, faster and easy way to create GUI applications. The program is mainly divided into two windows: The first window consists of:

Step1: Input image source is taken as video or from web camera.

Step2: The obtained input image is converted from RGB to HSV format.

Step3: After conversion the next step is to find the size and shape of the fruit.

Step4: The color of interest lower bound and higher bound are chosen Step5: With the help of lower bound and higher bound filter is created

Step 6: The region of color of interest is counted.

Step 7: All the filter images and count of fruits image on laptop screen is plotted.

Step 8: Send SMS with all the counts of the fruits at the end of the run

Step 9: Upload all the counted fruits data to firebase cloud for future reference.

The second window consists of:

Tinker is the python library to create GUI

Step1: an interactive GUI for the project is made from tkinter

Step2: click on apple button to choose image for processing

Step3: backend code final.py is called.

Step 4: final. py gives the count, shape and size of the fruit s which is later show on the GUI

Literature Review

In this section, various methods of acquisition are discussed. This includes interviewing and testing of various research projects that can be used to make our software or serve as a basis on which the proposed software can be built.

Nigam A et al. [5]: This survey focuses on enhacing chop making through several machine acquiring techniques. Tests are performed on agricultural databases. Random Forest acquiring variants, XGBoost, Logistic Regression, Linear Regression, and ANN have been utilized to gain a better detector to yield correct prediction. These algorithmic programs are utilized in Python 3.7 utilizing the various libraries built: Numpy, Sikik-read, Pandas and Keras. The needed hardware configuration is 8GB RAM with Intel i5 processor. This money present several acquiring algorithmic program for machine crop prediction as attested by various factors. Tests have been performed on the Indian authority database and is found that the Random Forest Regressor supplies accuracy considered to be highest of the produce forecast. The without a break Simple Recurrent Neural Network exemplar perform greater in predicting rainfall. LSTM is ready forecasting of temperature.

Thomas van Klompenburga et al. [6]: Mechanical learning is an important decision-making tool for predicting crop yields, including supporting decisions on where plants should be grown and what to do during crop growth. Various algorithms are used to support prediction of crop yields. They have developed a Systematic Literature Review (SLR) to extract and integrate algorithms and features used in yield prediction studies. According to the search criteria, 567 relevant subjects from six electronic profiles, of which 50 subjects were selected for further analysis using inclusion and exclusion criteria. They carefully researched the selected studies, analyzed the methods and features used, and made suggestions for further research. According to their analysis, the most commonly used features are heat, rain, and soil type, and the most widely used algorithm is Artificial Neural Networks for these types. After this observation based on the analysis of 50 machine-readable papers, they conducted additional searches in the electronic information archives to identify in-depth reading lessons, reached up to 30 study-based papers, and produced in-depth reading algorithms. According to this additional analysis, Convolutional Neural Networks (CNN) is the most widely used algorithm for learning these subjects.

Mishra S et al. [7]: Performing the statistics mining strategies based on climate and crop fabrication statistics various predictions can be composed as attested by knowledge collected where twist is assisted to increase productivity of crops. DSS will have to be implemented to help farmers for preventing the overheads of decisions regarding soil as well as crop to be cultivated. An application scheme DSS is used which provides assistance for analysts to foretell and identify databases from a raw dataset or models of commerce to analyze a plight and get results by fabrication decisions. Scheme used here will assist people to make necessary changes which were earlier used in utilizing inefficient insignificant methods.

Akash Ashapure et al. [8]: Current duration have observed immense rise in not only Unmanned Aircraft Entity (UAS) but also sensor tech which made it possible to derive tall temporal and spatial resolutions information more than crops growing all season. Unbiased research was to design a machine acquiring framework for tomato which is marketable and surrender abdicates estimation utilizing multiple source and spatio-temporal secluded sensing databases. This proposed machine learning examples as said by ANN and it takes UAS based multi-temporal options, excessive greenness Index besides weather databases that is humidity, precipitation, temperature, etc. as input and predicts yield. Moreover, produce prediction maps can be utilized to optimize field management practices.

Medar, R et al. [9]: Naive Bayes system and K-Nearest neighbour method. Accuracy can be obtained by utilizing these two methods. To foretell the yield surrender abdicate rate a java application is created. This application can add on three parts. 1st dealing with datasets, 2nd testing those datasets and thirdly to analyze them. Two methods of ML have been considered as told above. During testing any part of the process can be chosen and perform testing like by choosing specific plant, specific area or season results of

yields can be obtained. During analyzing, we can give a complete dataset and accuracy of these two methods can be obtained. This assists in predicting the best process.

Shiv Ram Dubey et al. [10]: Lately, commerce has doubled across the globe. Plenty of fruits are imported. Manual identification involves consumption of time. This labor presents a segmentation of fruits with K-means clustering unsupervised algorithm. The colours are utilized for deficiency segmentation. Deficiency segmentation is conducted in two separate stages. The pixels are clustered by their color and spatial features. Utilizing this procedure, it's possible to enhance the algorithmic effectiveness bypassing option extraction for any pixel. But the color is not mainly utilized for imperfection segmentation, it generates a lofty discriminating power for diverse regions of image. The simulation results explain that the proposed advance is promising.

Inkyu Sa et al. [11]: This notes advances to detection of fruit utilizing deep CNN. It’s aim is to produce an accurate, rapid and dependable fruit detection system, which is a crucial element of an autonomous agricultural robotic platform; Current labor in deep neural networks has led to the development of a state-of-the-art thing detector termed Faster Region-based CNN (Faster R-CNN). This model is adapted through transfer learning for detection utilizing RGB and NIR. Before time and tardy fusion methods are explored for combining the multi-modal (RGB and NIR) information. Moreover , this advance is additionally much quicker as it needs bounding box annotation. The exemplar is retrained to compose the detect several fruits.

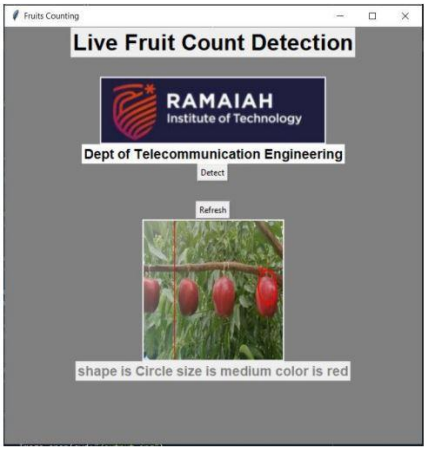
Muhammad Ayaz et al. [12]: This article provides an overview of wireless sensors and IoT applications in the field of agriculture. IoT devices and intercommunication strategies connected with various wireless sensors came across in agriculture applications and have undergone detailed analysis. To enhance the efficiency and make it more effective, the unmanned aerial vehicles are incorporated for crop surveillance and other profitable applications. New emerging and state-of-the-art architectures with IOT enabled and platforms are utilized in agriculture. Finally, they identify common and coming day’s patterns of IoT and highlight potential research challenges in the field of agriculture.

D. Aggelopoulou et al. [13]: This study conducted in Central Greece recommends that apple flowering maps are utilized for management decisions. In April 2007, when the plants are about to bloom, photos of these plants were taken using random sampling method. In September 2007, surrender renounce mapping was conducted measuring surrender renounce per ten trees and this situation was recorded. Utilizing these statistics a vision based algorithm was designed to predict the tree surrender renounce by analyzing the characteristics of the tree at rotund bloom. The rebases results were presented for the evaluation, where the fault of the design predicted yield was set at 18%. The results of this work signifies that potential yield can be predicted before time in any given season.

Experimental Results and Discussion

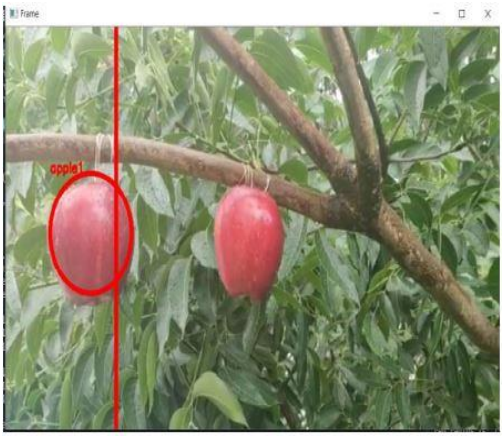
The software provides facilities like importing the video from a designated file location. Detect and refresh are the operational buttons which are present on the GUI as shown in the figure a. Features like the shape, colour and the size of the detected fruit will be will be given after analyzing the complete video input as shown in the figure 5.

Figure 5. GUI Displaying the Output



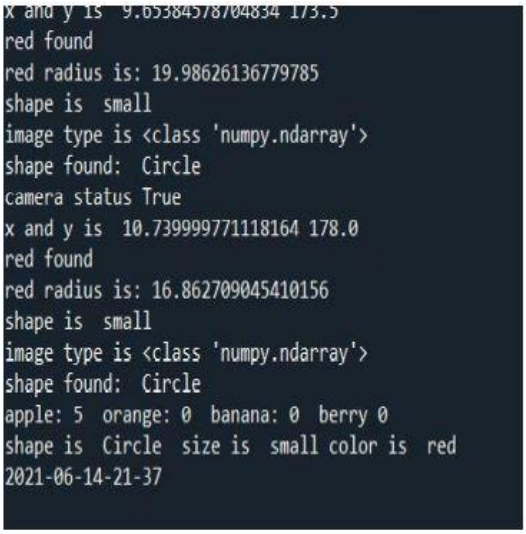
- Image is held as input from dataset of apple fruit which is accessible either online or offline video by capturing an offline video of the apple fruit. The images acquired by digital camera can also be considered as input. Daytime image is considered for the implementation and the pre-processing of the acquired images is done by adopting a few computer vision based OpenCV libraries in python which can be imported such as numpy, scipy, scikit, matplotlib and so on. Then the K-means clustering algorithm is applied to identify the fruits which is as shown in the figure 6. Additionally, a threshold is set up so as to avoid the detection of the same fruit multiple times as shown in the figure 6.

Figure 6. Detection of Apples



- After analyzing the input in the form of the video using the algorithm and the mentioned libraries, for every apple detected, the co-ordinates, the shape and the color will be mentioned individually as shown in the figure 7. On completion of the given input, the total number of apples will be given along with its shape, size and also the color as well as the date of the operation being performed as shown in figure 7.

Figure 7. Yield of Apples as Output



- As mentioned in the above discussion, the total count of the apples detected using the K-means clustering algorithm will also be stored in the database along with the date and time of the performed operation as shown in figure 8. The same data of the crop yield will also be sent as a short message service (SMS) to the farmer or the person in charge of the field as shown in figure 9.

Figure 8. Data stored in Cloud

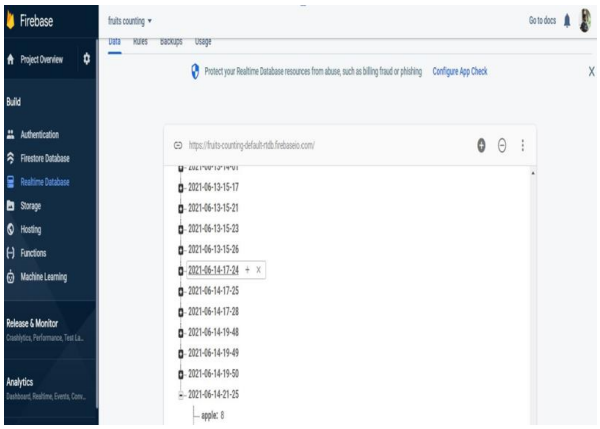
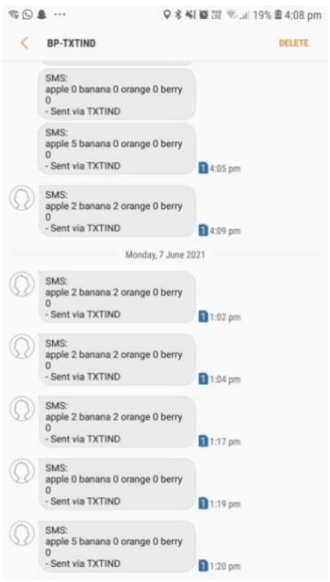


Figure 9. SMS Alert



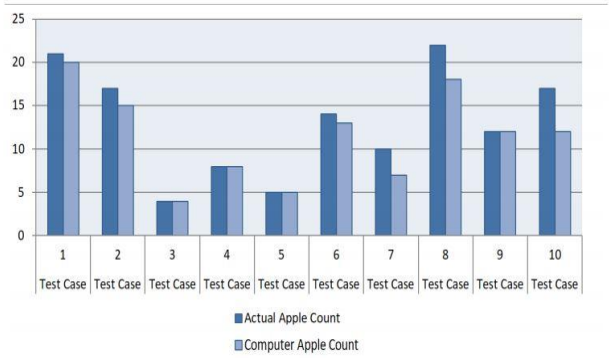
- Once the fruit is recognized, the algorithm continues to detect the other fruits of the particular color as long the input video frames are running. Subsequently the counts of the number of fruits present in these frames are displayed and the data is also sent to be stored in the cloud. The model's output is considered to be an error value if the difference between predicted center and the actual centre of the player is more than 5 pixels. All the parameters of the software and its performance are listed in table 1:

Table 1: Statistics of developed model and data

Parameter	**Values**
Image extraction rate	20 FPS(average webcam)
Raw frame size	1280×720
Processed frame size	1280×720
No of testing frames	200 frames
Successful detection	178 frames
Unsuccessful detection	22 frames
Average absolute error	11%
Accuracy	89%

- For the prediction of the apple count using k means clustering, 10 test cases were considered with a range of apples from 0-25. Each test case presents with accuracy according to the number of apples in that particular test case. As the number of apples varies in each test case, the accuracy varies accordingly. As mentioned in the above table 1 the accuracy obtained is 89% and the plot for various test cases vs. the apple count is shown in the below figure 10.

Figure 10. Calibrated crop yield vs. the actual count of apple block



Conclusion and Future Work

The module and usable yield prediction system is designed to use RGB and K means algorithm. This project is basically a farmer can analyze agricultural data predictions to predict the production of crop yield forecasts using image processing. The basics of computer vision are used to trace three colors red and blue through this easy to see fruit. The Farmer can therefore keep track of the yield obtained. However, this task can be very difficult and challenging as you need a lot of relevant data to produce the right result. Data classification and data storage according to their properties and characteristics is done with k-means clustering algorithm. This provides an exciting outcome that can help farmers improve their crop production. The project concludes with the recent construction of computer vision using the OpenCv platform and machine learning algorithms in the agricultural industry especially in the fruit industry. Image imaging is used to accurately identify each fruit, in a plant using a standard RGB digital camera in combination with machine learning capabilities. Acquisition of tree fruit image acquisition, image processing including image enhancement, image extraction and image element separation followed by image fragmentation, polygon equation, fruit detection and calculation is done within 2sec as soon as the input is inserted. The advanced method does not require an increase and decrease in the threshold values for each apple image to be identified because image classification is done based on computer visualization OpenCv, numpy, scipy, scikit, matplotlib libraries use the adoption of this new technology in identification, calculation and fruit planning will be of great benefit to the farmer.

Future Scope of The Work

Currently, the entire harvesting process is only performed on software with minimal hardware usage. The project can be developed in a variety of ways using the methods discussed below:

• A project that uses a specific algorithm can be trained to get low quality video.

• The project can also be upgraded where the system should be able to get it right at high installation speed.

• With the help of hardware, various types of data can be extracted and can be used for other analytical purposes. • The project can be trained to find scattered apples.

• The software used is not limited to apples as shown above, but can be used on other fruits as well.

• The project can be used in real-time programs such as UAVs.

• The project can be done with the help of advanced sensors and GPS modules to locate the deviant and rehabilitate the farmer.

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