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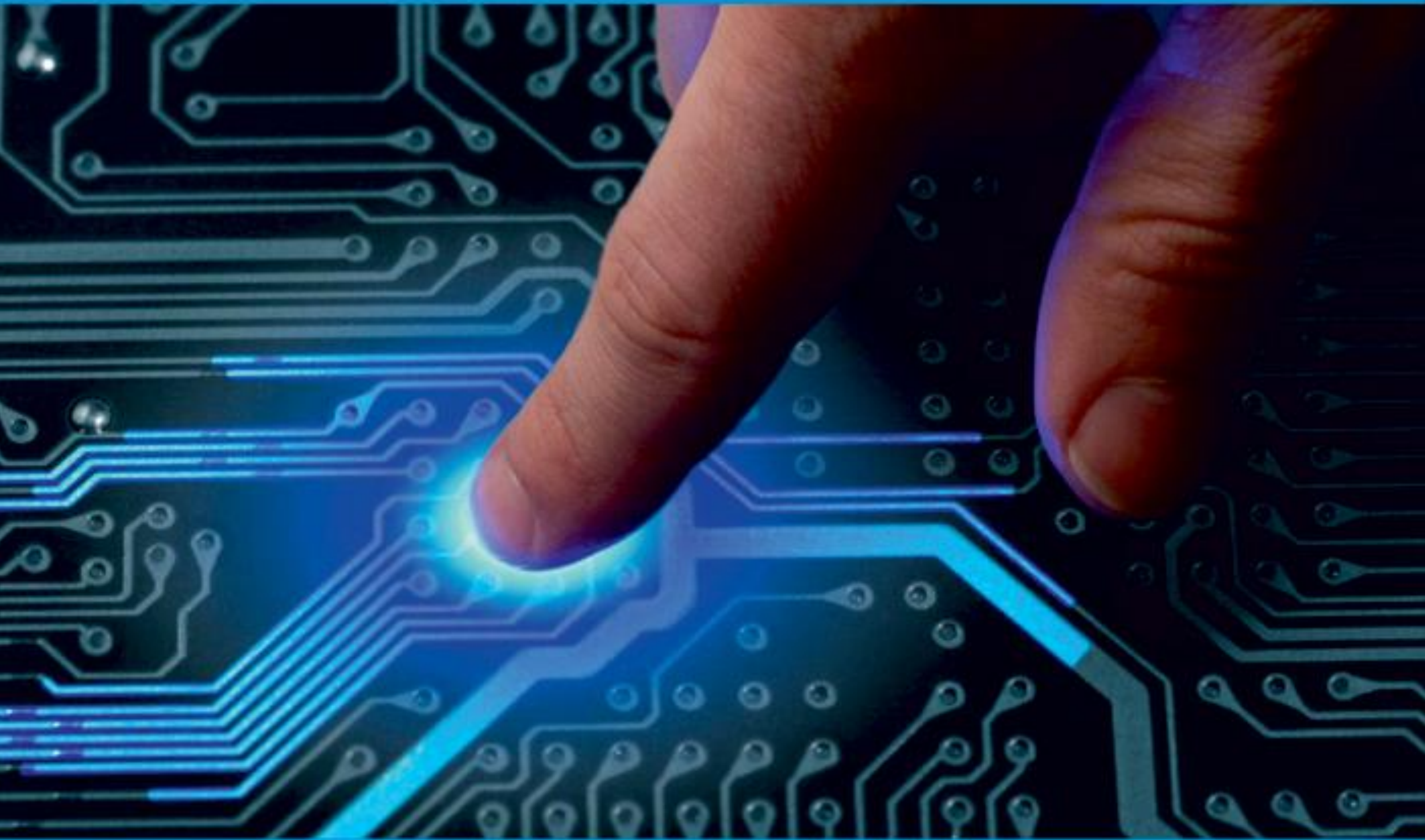

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Machine Learning Based Fruit Quality Measurement System

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ABSTRACT: In today's world, food processing industries areimmense part of human livelihood be it directly or indirectly.Human population consume enormous amount of foods that aresold in packaged form manufactured in several food processingindustries around the globe. Packaged fruit products such asjuice, jam, jelly, tomato ketchup, fruit cakes etc. are the mostpopular examples of such intake. But, when quality of fruitcomes into the scene, maximum fruit processing industries do stilldepend on direct human intervention. Especially, in the selectionprocess of good quality fruits from a dynamic fruit chain. Thismethod is obviously an error prone task in nature. Henceforth,influenced to abolish this practice, a study is conducted on howautomated quality checking (i.e. ripening percentage) can bedone. To counter this problem, a simple, easy to design andportable solution based on Machine Learning is presented in thispaper. This study has been carried out using a set of Apples (MalusDomestica) to proof of this concept. The preselectedapples are numbered per their ripening (i.e. measure of goodtaste and quality). Later, an Arduino based microcontroller board performs analog read operation, based on which a pre-calibrated indexing table is compared to disseminated trepanning index. This information is instantaneously sent over theMachine Learning based cloud platform for storage, and real-time knowledge processing. This way, this successful experimentation further be modified and optimized to be practically useful infruit processing industry.

KEYWORDS: quality fruit, classification algorithm, support vector machine,Accuracy.

I. INTRODUCTION

Fruit processing is one of the most vital part of food processing industries around the globe. The quality of the fruit must be monitored, and it must be kept from rotting and deteriorating as a result of environmental conditions such as temperature, humidity, and dark. Because of this, it is vital to install quality monitoring systems in grocery stores. In addition to temperature and humidity, the presence of unpleasant odours from the fruits and bugs inside the fruit during transportation. To counter this problem , The whole process is associated with fully automated system run by microprocessor boardWith help of a few passive electric elements, the obtained results are later sent over the remote cloud server for permanent storage and processing.

With the advancement of the lifestyle of human society, extra consideration has been paid towards the quality and variety of food we eat. Many real-life applications have used fruit identification systems, for example, store checkout where it may be very well utilized rather than manual scanner tags. Besides, it can be used as supportive appliances for blind people. Recognizing different types of fruits is a repeated chore in supermarkets, where the cashier has to define each item type that will determine its cost. The skilled farm labour in the horticulture industry is one of themost cost-demanding factors. Under these challenge, fruit production still needs to meet the growing demands of an ever-growing world population, and thiscasts a critical problem to come. A fruit recognitionsystem, which automates labelling and computing theprice, is the right solution for this problem. Since lasttwo decades, many applications are reported for recognizing the kind of fruits. But, in the meantime, nosuch advanced techniques are reported for recognitionof Indian fruits. Therefore, this research is carried outto classify most popular Indian fruits with its varieties.In this study, we consider five most popular Indianfruits, i.e. apple.. This study includes 14 varieties of apple,. Here we have notconsidered the fruit varieties which are neithercultivated in India nor available in the Indian market.Some fruit images are taken from the data set of Fruit360.

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II. LITERATURE REVIEW

[1]Efficient Food Storage Using Sensors, Android and IoTIn this project demonstrates how technology can be utilized in warehouse for preventing loss of food grains and food products. An android app is developed that receives information from the sensors By using this android app the food products can be preserved in a nutritional environment. The smart food storage uses IoT and is cost effective, economical& uses friendly.

[2] Fruit Disease Prediction Using Machine Learning Over Big Data.For the control of the disease in the initial stage itself several images of the day to day condition of the fruit has to be monitored where a slight change calls for a remedy. As the number of images increases obviously **big data** come into play. This paper discusses the existing system in fruit disease detection and also proposes disease prediction using machine learning over **big data**.

[3]Efficient Food Storage Using Sensors, Android and IoT.
An android app is developed that receives information from the sensors By using this android app the food products can be preserved in a nutritional environment. The smart food storage uses IoT and is cost effective, economical & uses friendly.

[4]The ability to identify the fruits based on the quality in food industry is very important nowadays where every person has become health conscious. There are different types of fruits available in the market. However, to identify best quality fruits is cumbersome task. Therefore, we come up with the system where fruit is detected under natural lighting conditions. The method used is texture detection method, color detection method and shape detection. For this methodology, we use image segmentation to detect particular fruit. Fruit Detection project is implemented in MATLAB image processing toolbox. The project is implemented for both Real time and Non-Real time. The proposed method has four stages: First is Pre-Processing and second is Feature Extraction and third is Segmentation and fourth Recognition. In case of Non- Real time, the first stage is used to browse the image, second stage is extraction of the features from images using Grey Level Co-occurrence Matrix (GLCM), RGB and Color Histogram. System will convert the image from RGB to grayscale image for further processing. The color histogram represents the distribution of colors in an image. Since image is captured under different illumination condition. In the third stage, the three extracted image is obtained in the form of red, green and blue. In the fourth stage, the extracted features are used as input to Support Vector Machine (SVM) classifier. Then name of the fruit is output is obtained.

[5]The highlight of this research work is to discover the ethylene gas level used for ripening of fruits by detecting ethylene gas (C2H4 in ppm) level employing soft sensor built using image processing and Artificial Neural Networks (ANN) algorithms. Methods/Statistical Analysis: The proposed method relies on the color which denotes the various stages in ripening and in turn indicates the amount of ethylene gas required. The changes in color, texture, intensity variation, mean, variance and standard deviation extracted from the images are the features which enable the personnel to determine the amount of ethylene gas. The Feed Forward Neural Network (FFNN) is used for ethylene gas estimation. This is made possible using Back Propagation Algorithm (BPA) for training the FFNN. As a part of image processing the intensity values in color images and its variation are tracked by dithering which is used as a unique feature input to train the FFNN. Major Findings: The novelty of the proposed method depends on the FFNN estimating the ethylene gas needed for ripening process in a feed forward fashion thereby providing the precision and recall values spontaneously for every instance. Application/Improvements: Earlier a circuit with capacitance model is used to generate ethylene gas for this purpose.

[6]This paper sheds light on the advancements made in the agricultural industry. Digital image processing techniques are now widely used for the maturity estimation of fruits. This work aimed to study and analyze the various algorithms and feature extraction techniques that are now used for the extracting features from the captured digital images. Thus, it is important for the suppliers to label the quality of fruits. In this paper, we are inspecting the quality of fruits based on size, shape and color and also by its weight. All these algorithms are implemented using RASPBERRY PI development board which will become an independent and cost effective system. All the interfacing of the components will be carried out and will make a cost effective embedded system prototype for the determination of size, shape and color of the fruit. Same system can be utilized for other fruits also. Advantages and disadvantages of various classifiers have been classified. It was observed that for achieving high accuracy a compromise had to be made with high computational complexity.

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[7]This paper presents a novel approach to fruit detection using deep convolutional neural networks. The aim is to build an accurate, fast and reliable fruit detection system, which is a vital element of an autonomous agricultural robotic platform; it is a key element for fruit yield estimation and automated harvesting. Recent work in deep neural networks has led to the development of a state-of-the-art object detector termed Faster Region-based CNN (Faster R-CNN). We adapt this model, through transfer learning, for the task of fruit detection using imagery obtained from two modalities: colour (RGB) and Near-Infrared (NIR). Early and late fusion methods are explored for combining the multi-modal (RGB and NIR) information. This leads to a novel multi-modal Faster R-CNN model, which achieves state-of-the-art results compared to prior work with the F1 score, which takes into account both precision and recall performances improving from 0.807 to 0.838 for the detection of sweet pepper. In addition to improved accuracy, this approach is also much quicker to deploy for new fruits, as it requires bounding box annotation rather than pixel-level annotation (annotating bounding boxes is approximately an order of magnitude quicker to perform). The model is retrained to perform the detection of seven fruits, with the entire process taking four hours to annotate and train the new model per fruit.

[8]Grading and classification of fruits is based on observations and through experiences. The system utilizes image-processing techniques to classify and grade quality of fruits. Two dimensional fruit images are classified on shape and colour based analysis methods. However, different fruit images may have similar or identical colour and shape values. Hence, using colour or shape features analysis methods are still not effective enough to identify and distinguish fruits images. Therefore, we used a method to increase the accuracy of the fruit quality detection by using colour, shape, and size based method with combination of artificial neural network (ANN). Proposed method grades and classifies fruit images based on obtained feature values by using cascaded forward network. The proposed system starts the process by capturing the fruit's image. Then, the image is transmitted to the processing level where the fruit features like colour, shape and size of fruit samples are extracted. After that by using artificial neural network fruit images are going through the training and testing. In this proposed paper neural network is used to detect shape, size and colour of fruit and with the combination of these three features the results obtained are very promising.

III. PROPOSED METHODOLOGY

Fruits and vegetables are the most important sources of our daily nutrition. The quality of fruit is a major aspect from the point of view of consumers. Measures of fruit quality include both the internal and external properties. The internal quality mainly is determined by aroma, flavour, taste, texture, nutritional quality (e.g. soluble sugar content, starch, organic acids, soluble solids content, carotenoids, total flavonoids, total phenolics, antioxidant activity, etc.), flesh firmness, diseases, and chemical residues. The external quality mainly concerns the appearance, size, colour, and bruises. How to measure fruit quality has always been one of the most attractive research topics in the food industry. At present, most of the available investigative methods are still destructive and labourand time-consuming. Several methods require sample preparation as well as costly instruments and chemicals which cannot be used for large-scale sample evaluation. With the increasing demands for real-time detection of fruit quality,ML based fruit evaluation methods have been greatly developed. However, problems like low detection accuracy and poor model adaptability still remain in the fruit quality detection system. Thus, it is necessary to develop CNN and SVM , for highly efficient, simple, accurate, and low labour cost techniques for fruit quality determination. This Special Issue is focused on new CNN and SVM methods for the evaluation of fruit quality. New (like high precision equipment for experimental research, handheld equipment with low costs and reliable data for field workers, market managers and consumers, etc.), new or improved non-destructive methods for quality evaluation (including developing software for data mining and analysis, and construction of large databases for accurate prediction models) are encouraged. The quality detection technologies can be based on imaging properties. These technologies can be used for real-time inspection of fruit quality during growth and postharvest life.

ADVANTAGES

Manual interruption can be avoided so that labor cost can be reduced.It is more efficient.It can be possible to sort the fruits based on shape,color and quality.The accuracy is more than the manual picking for the sorting of fruits.

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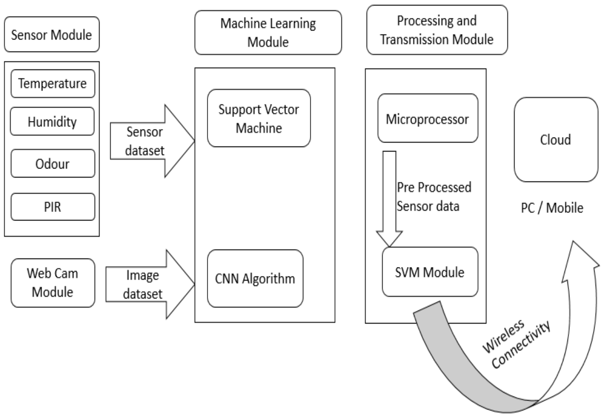
PROBLEM IDENTIFICATION

The main objective is to assess the correctness in classifying data with respect to efficiency and effectiveness of such algorithm in terms of accuracy, precision and grading points.
To select the best features and perfect parameter values of the machine learning classifiers.
To prove that fruit quality detection can automatically find the best model by combining feature preprocessing methods and all algorithms.
To Predict Fruit Quality , this study is based on support vector machine algorithm for the dataset.

IV. ARCHITECTURE DIAGRAM



In this figure1.1, We have considered Fruit data set from Kaggle .

1) IoT module: The embedded part of the system consists of Raspberry Pi 3B+ microcontroller. The code for the functioning of camera and ML algorithms are places into class 10 memory card, which has been inserted in the Raspberry Pi. The expected range of threshold values of parameters (temperature, humidity, methane, PIR) are stored in the dataset created using excel. Using DHT11, MQ5, PIR sensors , the parameters of fruits are measured and is given to the ML algorithm like
Support Vector Machine.
2) Machine learning module: We are using 2 machine learning algorithms. Support Vector Machine (SVM) , which is used to
generate prediction from sensor data. Convolutional Neural Networks (CNN) which are used to generate prediction from imagedata.

Proof of concept Implementation :

An overview of Implemented system is given in Fig1.1. Along with the integration and set up of required hardware units', the major implementation was performed on the software level in terms of the following.

1) Freshness Identification: Each fruit have different temperature and humidity levels to maintain freshness. Also, when the fruits decay, it can be due to bacterial presence thereby produce a foul smell. When fruit goes bad and starts to become pungent, it is most often due to the growth of spoilage microbes such as bacteria, yeasts and mold. Odours can come from two sources: chemicals that are released from the food as the microbes decompose it, or chemicals produced directly by the microbes themselves.

2) Construction of dataset: For the sensor values, we create a excel table as dataset which has 5 columns: temperature, humidity, methane, PIR, status. If the output from all sensors are in threshold value, then status is 1. Otherwise if any one of the sensor values vary from threshold, then the status is 0. For image dataset collection, the training dataset and the testing dataset is obtained by capturing images from webcam and a mobile phone. Approximately 13,599 images contain fruits like apple, orange and bananas .

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V. MODULES

DATASET COLLECTION

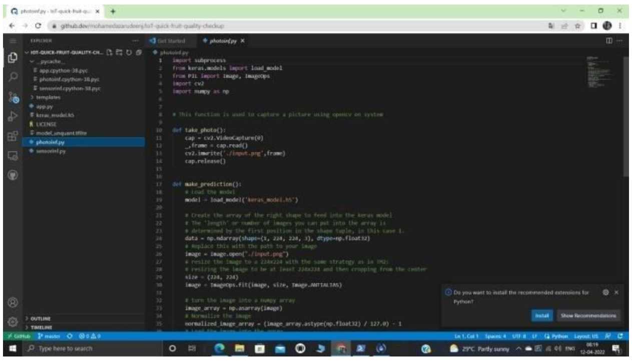
Deep learning models were trained and tested for two data sets. The first data set consists of 8791 apple images where 4693 images are of defected apples and the remaining 3946 images are from healthy class [17]. The data set images have been taken from an Internal Feeding Worm (IFW) database of the Comprehensive Automation. The data set contains images for four cultivars of apple: Fuji, Golden Delicious, Red Delicious, and York. Each cultivar has images from various stages of ripening of healthy and defected apples. The dataset includes two groups of dataset where both were collected. The images of defected apples have visible dark spots on outer skin due to damage from internal feeding worms. The images of individual apples have been clipped to 120 × 120 pixels size for image processing tasks. The distribution of the healthy and defected classes for these cultivars is presented. Since cultivars do not significantly affect the learning of the algorithm, we considered the grading as a binary classification problem by combining the cultivars into their respective external state (i.e. Healthy and Defected). shows few samples from apples' data set.

DATA PREPROCESSING

The obtained data contains missing values which could lead to in- consistency. Data need to be preprocessed to gain better results to increase the algorithm's performance. The outliers must be re- moved, and variable conversion must also be carried out. The dataset may contain missing values. The missing values cannot process by the programming hence these values need to convert into numerical values. Pre-processing is aimed at improving the data which suppresses unwanted distortions.

TRAINING A CNN MODEL

The concept of Transfer learning is used here, where the model is first pre-trained on a dataset that is different from the original. This way the model gains knowledge that can be transferred to other neural networks. The knowledge gained by the model, in the form of "weights" is saved and can be loaded into some other model. The pre-trained model can be used as a feature extractor by adding fully-connected layers on top of it. The model is trained with the original dataset after loading the saved weights.



FEATURE EXTACTION

After image segmentation, features are estimated for further analysis. These features are the basic factors in a computer vision system as they consist of effective data for image perceptive, interpretation, object classification. In this process, extracted features form feature vectors that are classify to recognize the input. These feature vectors defines the object shape uniquely and precisely. The feature extraction aim is to enlarge the rate of recognition by extracting the features. In the food industry, these features give the explicit data that can be considered for quality assessment and analysis. Color, textural and morphological features are frequently used to analyze the defect and maturity of the fruits.Future design can be modified by increasing size of conveyor belt so that is possible to perform quality inspection of large fruit than apple.

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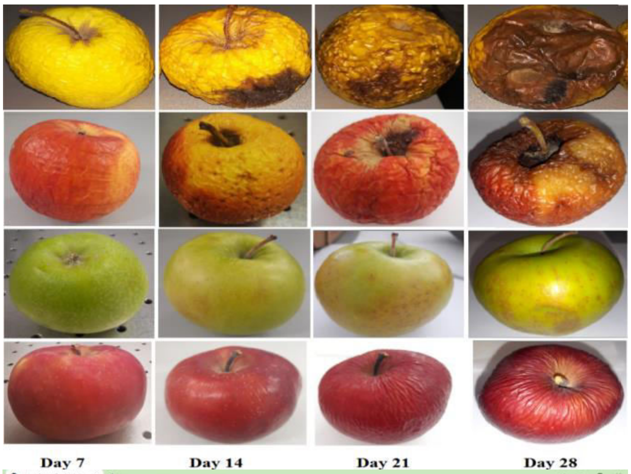
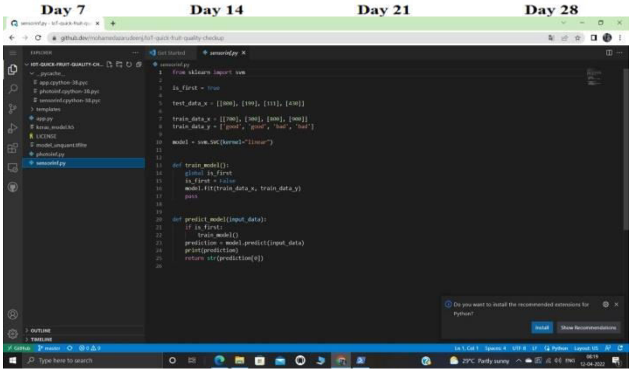
SVM SENSOR DETECTION

Training a model simply means learning (determining) good values from the labelled data. It is an iterative phase where a data scientist continually train and test machine learningmodels to discover the best one for the given task. Deep feature extraction is based on the extraction of features acquired from a pre-trained CNN. The deep features are extracted from fully connected layer and feed to the classifier for training purpose. The deep features obtained from each CNN network such as
AlexNet, GoogleNet, ResNet-18, ResNet-50, VGGNet-16 and VGGNet-19 are used by SVM classifier. After that, the classification is performed and measures the performance of all classification models. The fruit recognition model using deep learning features by SVM classifier is shown in the convolution layer, formats of enrolled channels are utilised. Each one channel is limited spatially (traverse along with height and weight) but enlarges with the complete deepness of input volume. The images that have, Height H, Depth D and Width W shading channels (i.e., H D, W), the enrolled
channels isolate an image width as W1¼((WeFþ2p))/
(Sþ1), here F speaks to the spatially expands neuron
estimate; p is the main part of zero padding, and S is
the size of way. Thus, the height is partitioned by H1¼((HeFþ2p))/(Sþ1); depth D1 is the extent of the
number of channels K. For instance, an image having
28283 (3 is for the shading channels), if the open
field (or channel) has a size of 553 (altogether
75neurons þ 1bias), a 5x5 window with profundity
three moves along the width and height and produces a
2-D activation map.





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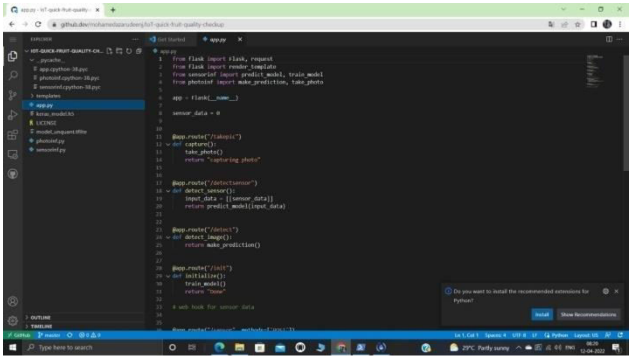
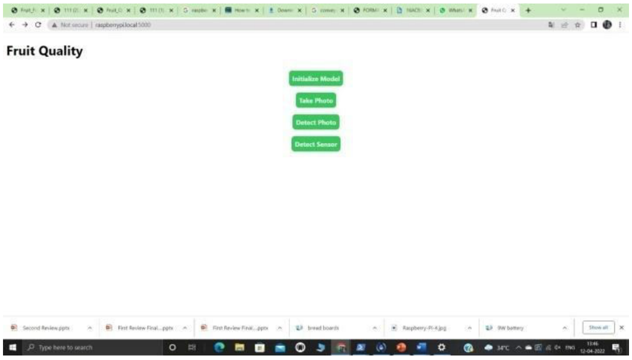
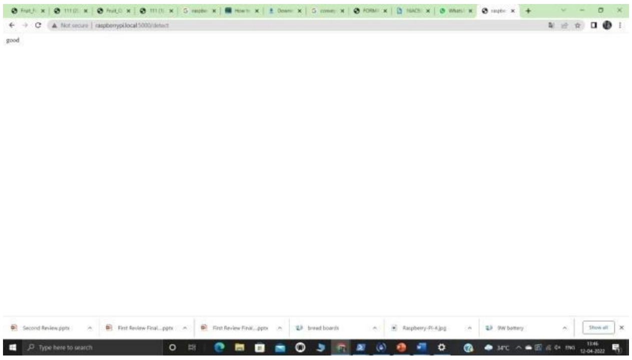
DASHBOARD WEB APPLICATION

Web application is developed for the purpose of displaying the result for the both sensor detection and image detection.This creation of web application is done in HTML5.It is created in the Pycharm platform. The Raspberry pi4 manages to collect data from the , ESP8266 , MQ4gas sensor, 9W Batteries, values to string, display whether Good or bad and sense the water content by MQ4 sensor(ethanol gas sensor) pass data to the Flask server. First the standard CNN AND SVM for interfacing Raspberry pi4 imported and software Serial library for serial communication with the Wi-Fi module is imported. The variables representing quality to read the sensor data are initialized.







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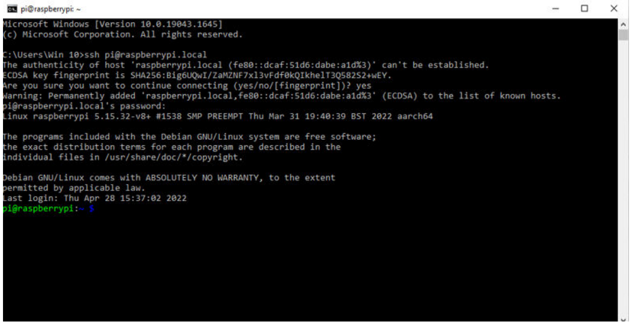
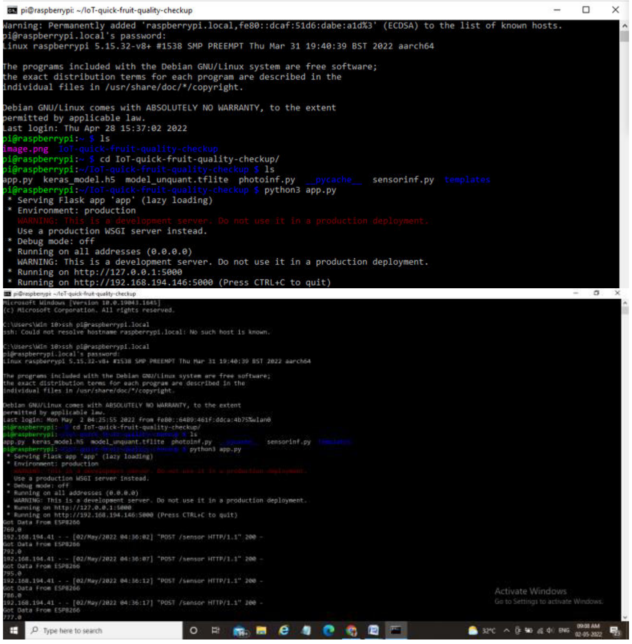
MODEL PREDICTION





VI. CONCLUSION

In this paper, we proposed fruit quality measurement system that is used to predict the freshness of fruits. The identification of fruit freshness will help the user to decide whether it is consumable or not. This method will help in reducing human labor and loss of income due to rotted fruits. Also enables to gain trust among the customers. The method can only help to find out the external changes in fruit using the camera. The IoT-based online measurement approach using smart sensors can address the critical needs of reducing fruit waste, increasing transportation efficiency, and tracking fruit contamination. Based on the monitoring of the fruits before transportation, during transportation and while storage with the help of the machine learning it founds that there is any rotten in the fruits then they will be classified as errors using the CNN and support vector classifier. Based on the result from the CNN and Support Vector Machine the system categorize fruit with contamination and healthy fruit.

In future, if we could adapt the method of spectroscopy, it can easily identify the internal defects of fruits. Spectroscopy is the study of the interaction between matter and electromagnetic radiation.

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