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Smart Grocery Grading System

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Abstract: ***This paper discusses a Smart Grocery Grading System, capable of performing non-destructive testing on produce and assessing their freshness based on a number of key factors such as discolouration, external bruising etc.***
The system works on the principle that an image of the fruit or vegetable is captured and fed to the trained neural network. The network then assesses the image based on its training parameters and determines if the fruit or vegetable is fresh or rotten. The primary objective of this system is to provide the general populace with an accurate means of estimating the edibility of grocery before purchasing it.
The system is designed such that it is cost effective and is capable of returning accurate results in real time.
Keywords: Neural network, Grocery Grading System, Freshness, Image Processing, Machine Learning, Classification.

I. INTRODUCTION

One of the most prominent means of income for India has always been it's agricultural produce. A very wide variety of fruits and vegetables are cultivated here, owing largely to the largely varying climate spread across the country, each suitable for different sorts of produce.
Data shows that India is just below China in the fruit production market, ranking second in the world. However, most of the labour required for this is done manually.
This project aims to help in streamlining this process by using Machine Learning to determine efficiently and accurately what would otherwise take loads of time if done physically, grading produce suitable for consumption based on their freshness. As of today, most of this inspection is done by select individuals, who base their decisions based on previous experience. This is still very error prone because the freshness of produce is often times influenced by factors not discernible to the human eye. Using modern technology to rectify this, our project helps grade the freshness of produce taking a wide variety of factors into consideration.

II. LITERATURE SURVEY

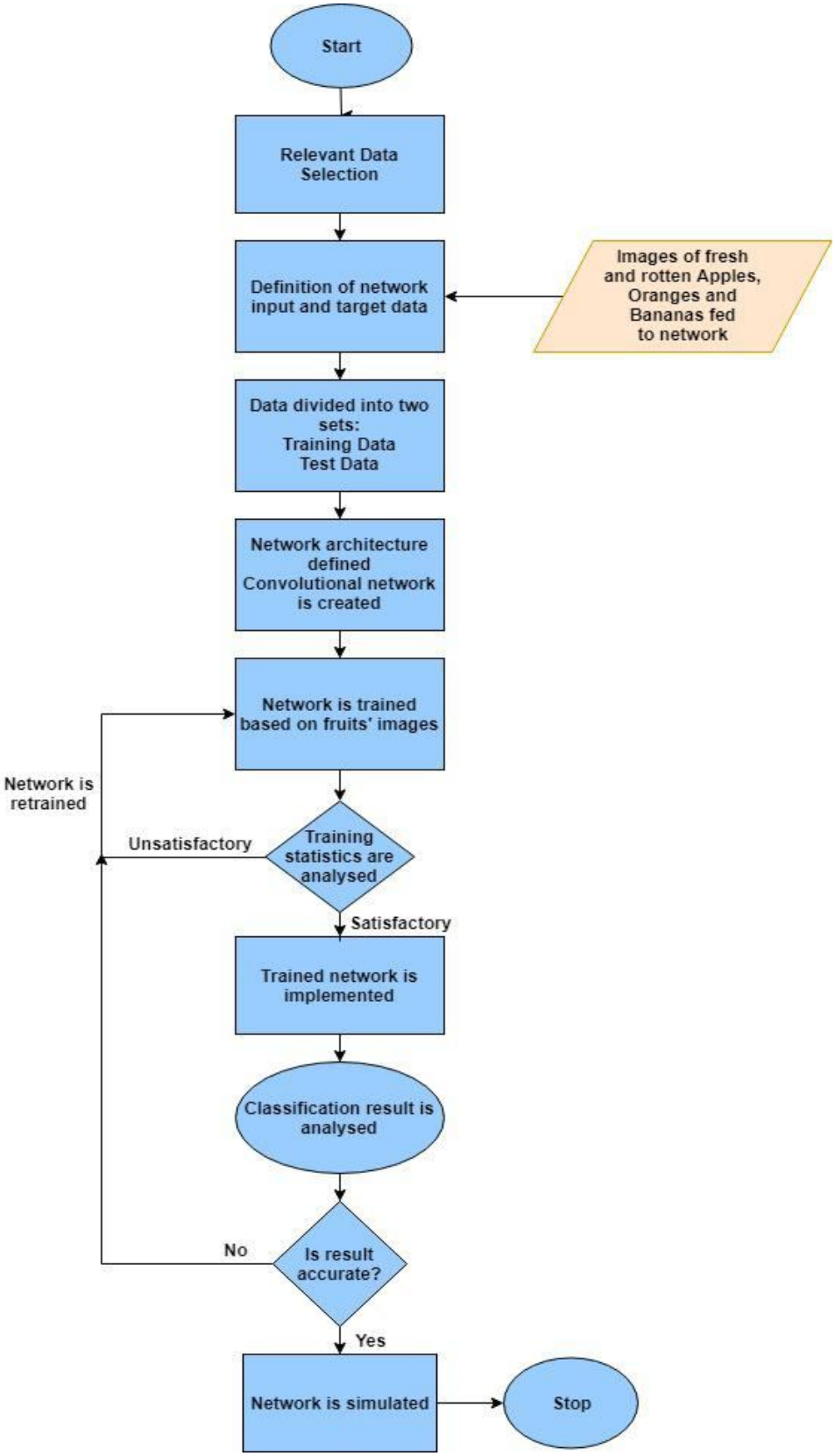
Megha P. Arakeri, Lakshmana [1] presented a method for automatic grading of tomato using computer vision techniques.
Mr. Sumit S. Telang and Prof. S.M. Shirsath [2] graded good or bad quality of fruits based on colour and size detection algorithms.
Monika Jhuria, Ashwani Kumar, Rushikesh Borse [3] developed and implemented a neural network for disease detection in leaves and mangoes.
Rashmi Pandey, Sapan Naik, Roma Marfiata [4] reviewed and documented various experimental results based on fruit grading using image processing.
Rupali S. Jadhav, Prof S.S. Patil [5] demonstrated a fruit grading system using a conveyor belt based on colour and size of fruits.
The authors of [6] performed tests on tomatoes for defect detection in fruits.

III. PROPOSED SYSTEM OVERVIEW

The proposed system seeks to implement a reliable way to enable detection of the freshness of grocery by means of image processing and machine learning. Figure 1 shows an overall flowchart for the working of the system.

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IV. WORKING

A. *Hardware*

The proposed Smart Grocery Grading System uses a Raspberry Pi Model 3 B paired with a Pi Camera for live image detection. The image is captured and passed to the neural network which classifies it and returns the prediction result.
The network is trained using a Graphics Processing Unit, an NVidia graphics card in this case, allowing for extremely fast training of a large database with reduced training time.

B. *Software*

The network itself employs the use of Python, a general purpose programming language suitable for training our network on. Tensor Flow, an open source Python library required for machine learning applications as well as Keras, another open source Python library used to implement deep learning algorithms are essentials for this project and have thus been used as well. These libraries use basic OpenCV commands.
An application for the Apple iPhone has been developed alongside as well which employs the network through a self-developed app to classify various produce in real time.

C. *Methodology*

Keras using TensorFlow as a backend is used to train the neural network. It has 6 layers and works on the principle of convolution. A convolutional neural network is used since it can scale full images better than a regular neural network and hence can constrain the network architecture in a more sensible way.

D. *Database*

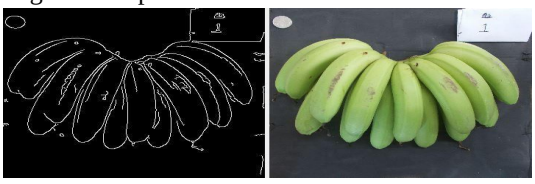
The current database used to train the network consists of 1000 images each of Fresh Apples, Fresh Oranges, Fresh Bananas, Rotten Apples, Rotten Oranges, Rotten Bananas and Background images.

E. *Image Processing*

The image of the fruit or vegetable is captured using the Pi Cam connected to the Raspberry Pi. Edge detection is then performed on this image to distinguish the produce from its surroundings.

F. *Edge Detection*

Edge detection works by identifying points in a digital image at which the image brightness has discontinuities i.e. where the boundaries of the fruit and background meet. The points at which image brightness changes sharply are organized into a set of curved line segments termed edges. These edges are mapped and pixels are generated at these points of difference to clearly outline the borders, thereby helping in detecting the fruit placed in front of the camera.



G. *Feature Extraction and Selection*

In order to detect whether the fruit or vegetable is fresh or rotten, the colour statistical and color texture features for individual Red (R), Green (G) and Blue
(B) channels are initially extracted as given below:

1) Color Statistical Features: The following statistical features are extracted from each color channel.

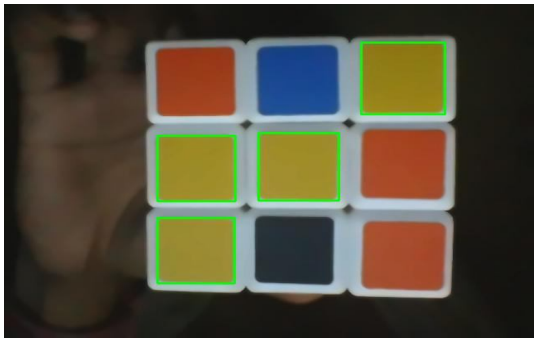
$$Color\ \ mean(\mu) = \frac{1}{N}\sum_{i=1}^{N} P_i$$

$$Standard\ \ Deviation(\sigma) = \left(\frac{1}{N-1}\sum_{i=1}^{N}(P_i-\mu)^2\right)^{\frac{1}{2}}$$

$$Skewness = \frac{\sum_{i=1}^{N}(P_i-\mu)^3}{N\sigma^3}$$

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The colour of the fruit or vegetable plays an essential part in determining its freshness. Hence, the colour feature is extracted from the grocery image to classify it as fresh or rotten. The R, G, B values of the image are extracted and their average is calculated according to the following equations.



$$Mean\ R = \frac{R}{N}$$

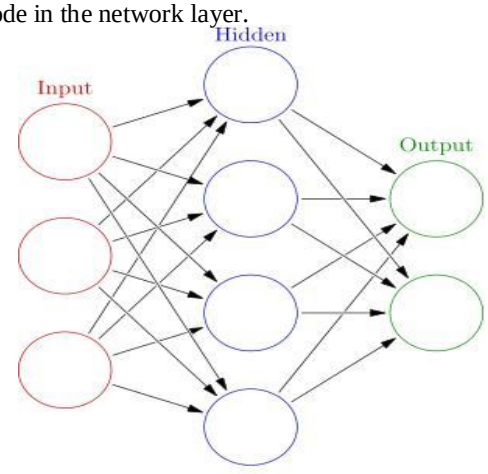
$$Mean\ G = \frac{G}{N}$$

$$Mean\ B = \frac{B}{N}$$

Where, Mean R = mean value of red layer, Mean G = mean value of green layer, Mean B = mean value of blue layer, R = Red pixel, G = Green pixel, and B = Blue pixel.
The network then determines whether produce in an image is fresh or rotten by comparing their colour to a predetermined threshold set by the network during training, based on which it makes its decision.

H. Classification

The various features extracted in the previous step are fed to the multilayer neural network, which consists of a set of interconnected neurons to map the input features to the output, illustrated in figure The neural network's learning is supervised and the weights are adjusted by the back propagation procedure.
The network uses RELU activation function followed by batch normalization.
The POOL layer comprises of a 3 x 3 POOL size to quickly reduce spatial dimensions from 96 x 96 to 32 x 32.
The network architecture also utilizes dropout. The concept behind it being that nodes are randomly disconnected from the current layer to the next layer, resulting in natural introduction of redundancy into the model i.e. prediction of a certain class, object, edge, or corner is not limited to one single node in the network layer.



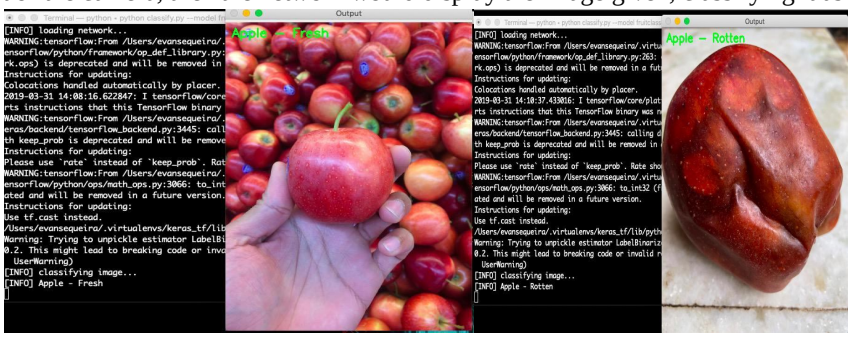
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V. CORE ML

The iOS application was built using Apple Core ML, which allows integration of trained neural networks into an application as well as Swift, a programming language designed for Apple devices.

The output of the network is given based on the image that is fed into it. The network receives the image, sifts through the data it was trained on and based on this, classifies the object contained in the image as either a fresh or rotten apple, banana, orange or if it is none of these, then as background. This result is then displayed alongside the image on the screen. So, for instance, if a fresh apple is placed in front of the camera, then the network would display the image given, classifying it as 'Apple - Fresh'.



VI. CONCLUSION

This paper discussed a method to accurately detect the grade of freshness of a fruit or vegetable based on image processing and machine learning. The software would first detect the produce and then classify it as fresh or rotten based on it's training parameters with a rough accuracy of 90%. The obtained results can be used to ascertain edibility of a fruit or vegetable without the need of human intervention.

VII.FUTURE SCOPE

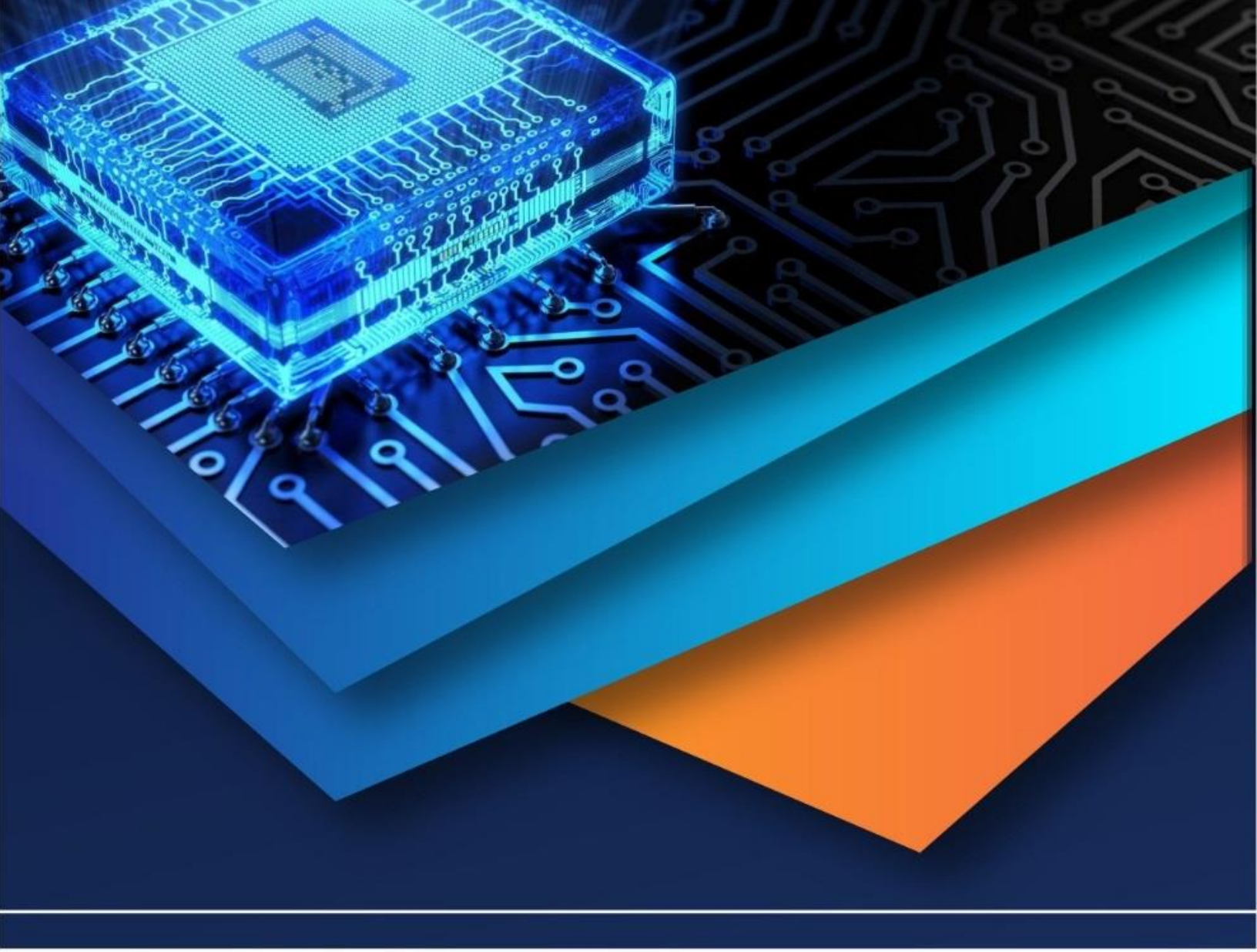
This project can be further improved by training the network on a wider range of fruits and vegetables. In its current state, the system is able to give a result based on one fruit or vegetable at a time, due to the presence of only one camera. Multiple cameras can be added to the hardware at multiple angles to include the ability to estimate a bulk quantity of produce at once.

A real time inventory system can also be implemented that stores the detected produce in memory which further helps in keeping track of its freshness.

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