

MACHINE VISION BASED VEGETABLE RECOGNITION

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Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled “Vegetable Recognition System”, submitted by Sham Biswas, ID No: 151-15-5358 , Neamat Ullah, ID No: 151-15-5033 and Md. Alauddin Mazumder, ID No: 151-15-4820 ,to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 25th November 2018.

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I hereby declare that, this project has been done by me under the supervision of **Md. Tarek Habib, Assistant Professor, Department of CSE** in Daffodil International University. I also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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Abstract

In this project, a new vision system to characterize the recognition of vegetables in images has been developed. It is always related to image processing, which can control the classification, qualification and segmentation of images. It is a recognition system for super market and grocery stores. From the captured images multiple recognition clues such as colour, shape, size, texture and weight are extracted and analysed to classify and recognize the vegetables. The results show that it has good robustness and a very high success. An important characteristic of the proposed algorithm is that it is able to work with several elements inside the camera field of view. This adds flexibility to the application in order to work in the country or in a greenhouse, where the elements are very close to each other and the location of all them must be obtained in real time. This approach is less complex and relatively very faster than other approach. If the system can identify uniquely, the checkout process at superstores will be fast and efficient.

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Chapter 1

INTRODUCTION

1.1 Introduction

One of the biggest changes in shopping experience in supermarkets in the recent five years is the addition of self-checkout. While this reduced the waiting time for available cashiers and the number of staff needed, bringing benefits to both customers and the supermarket, it introduced several new issues. Items sold by weight have to be looked up by the customer in a list of all the products which do not have barcode attached. This can be very time-consuming, tedious and frustrating for the customer. Products sold by weight are mainly fresh fruits and vegetables. With the aim to ease and speed-up the self-checkout experience a solution for automated recognition and classification of fresh produce is proposed in this report.

A simple addition of a camera to the self-checkout counter, which would capture what is placed on its scale, can provide an image of the produce. Using the computer vision and machine learning techniques described below an algorithm can classify the produce into its correct category (eg.: banana, pepper, cucumber...) without further user interaction or rank the categories and offer the user the three most likely categories.

The automatisisation of the recognition results in a number of benefits for both supermarkets and their customers, some of which can be related to increase of revenues. Directly measurable time each customer spends at the self-checkout would decrease. This leads to shorter waiting time in lines and bigger throughput. It is known that the current checkout process is not perfect, according to NCR study 37% of customers (3rd most frequent response out of 11) would appreciate simplification of purchasing items sold by weight.

The other major issue is stealing through self-checkout. It is estimated that more than 1.6 billion of items have been stolen last year just in the UK [3]. Of these 1.6 billion 67% were fresh fruits and vegetables. For shopper it is very tempting to buy everything as the cheapest potatoes or carrots if nobody checks. However, 57% of the cases the thefts were not intentional, the shoppers just gave up on finding the correct item. The majority of these 1.6

billion can be saved by the proposed classification algorithm which cannot be fooled and it will actually help people to not become thieves.

Indirectly, the solution leads to food waste reduction and packaging reduction. A large proportion of fruits and vegetables are being prepacked, so they do not need to be looked up in the lists and have a barcode attached. If one or two pieces in prepackaged bag gets bad, the whole bag is thrown away, including the healthy pieces. This is unnecessary waste. If all fresh produce would be sold by weight the bad pieces can be taken out and the healthy ones used. This is more sustainable, in the interest of supermarket and it offers shoppers a chance to choose the pieces he or she wants.

To achieve the goal of fruit and vegetable classification from live video a processing pipeline will be first developed on static images. Once this is in place and it is reasonably fast it can be inserted in a loop at the beginning of which a new picture is taken and fed to the processing pipeline. A high level processing pipeline is shown in figure 1.1. The first stage of static image processing decides whether the scene has changed from the default and continues only when an object is present in order not to waste computing resources. The second stage is the segmentation of the foreground representing a new object, from the background. The steps of this segmentation consist of background subtraction, morphological operations on binary images, specularities removal, colour clustering and are further discussed. It is assumed that the camera is stationary. This is a reasonable assumption to make as it would be attached to the self-checkout terminal. To identify the segmented object various characteristics called features are computed and stored in a feature vector. In the case of fresh produce the discriminative features are mainly related to the colour, but shape and texture can be determining factors as well. The feature extraction process is discussed. The final stage is the classification into correct categories using machine learning models trained on a manually labelled dataset. Gaussian Bayes classifier is the main model used for the classification as discussed in section 6. The output of the classification is an ordered ranking of possible classes from which the corresponding label is inferred. If even the highest probability is still lower than the defined threshold then the output is nothing which means that the product was not recognised as fruit or vegetable from the trained model.

In supermarkets, fruit and vegetables are often put into semi-see-through plastic bags in order to carry multiple pieces. The blurriness caused by the plastic bag presents a great challenge for the

classification algorithm which, as far as known, was not addressed yet. Techniques for dealing with the plastic bag are discussed throughout the report and especially in the segmentation.

Performance will be evaluated based on accuracy (top hit), average rank of the correct label and the top three hit. A standard accuracy is calculated as proportion of correctly classified images over the total number of images. The rank refers to the position of the correct label in the sorted list of predictions according to their likelihood. The top three hit considers an image to be correctly classified if its label appears in the first three most probable classes. This would be considered a success because offering a customer three options to choose from instead of full list would be a huge improvement. The performance evaluation is further discussed.

The idea of fruit and vegetable classification from images in supermarket environment was first proposed. His work developed a classification of fruit and vegetable from static images with a white background. Most of computer vision project in agriculture was focused on quality assessing or detection for harvesting purposes. More details are discussed. A brief history of cash register, groceries checkout and how they evolved to a modern self-checkout is discussed.[1][2]

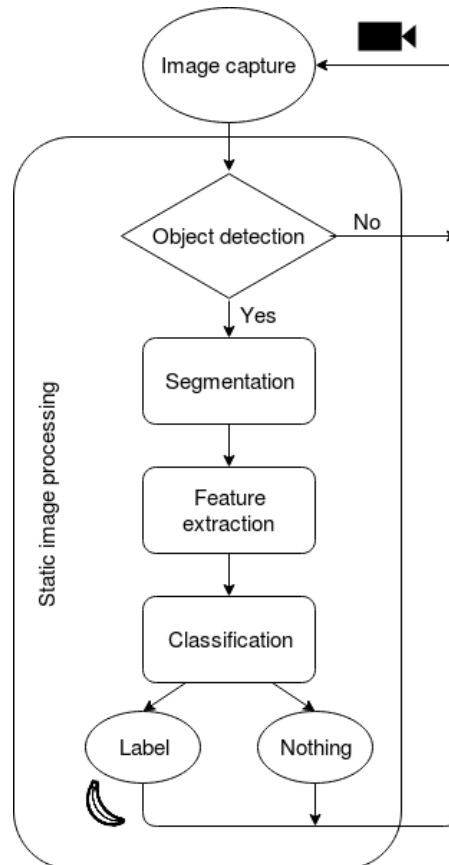


Fig 1.1: Figure shows how vegetable recognition system works

1.2 Contributions

- The classification of the fresh produce placed into a plastic semi-see-through bag. More specifically, the demonstration that clustering of the colours is an effective segmentation technique to distinguish the item in the plastic bag and the plastic bag itself.
- The design and evaluation of the segmentation pipeline, colour based feature extraction pipeline and the classification with a Gaussian Bayes classifier.
- The assignment of prior contribution weights to pixels, which reflect the expected location of an item and reduce the effect of segmentation imperfections.[3]

1.3 Objectives

- Make Auto Machine.
- Automate.
- Create a User-Interface.
- Create a control dashboard.
- Justify the Quality of Fruits.
- Divide Fruits in Different Grade.
- Proper Packaging in Prolonging the Shelf Life of Fruits.
- Enumerate the Criteria for Choosing the Proper Packaging Materials.
- Identify Different types of Packaging Materials
- Different Practices in Packing House Handling
- Pre-Storage Treatment for Fresh Fruits

1.4 Expected Outcome

- Segmentation.
- Automated Quality Verification.
- Improve Fruits Quality.
- Provide Health Ensurity.

- Easily controllable.
- Production Efficiency.
- High Accuracy of Grading.
- High Speed Marketing.
- Low Cost.
- Reduce Labour Intensity.
- Intelligent Reliable Flexible and Effective System

Chapter 2

BACKGROUND STUDY

2.1 Computer vision in fresh produce industry

In the context of the fresh produce industry, computer vision techniques are mainly used for fruit detection for harvesting purposes or for quality evaluation . An automatic spherical fruits recognition system in the natural conditions is proposed . A combination of a laser range-finder model and a dual colour and shape model is used, targeting mainly oranges, apples and other citruses. Quality evaluation based on visual appearance is discussed , who used the Hue, Saturation and Intensity colour model to grade the quality of apples. examined how the reflectance properties of carrots and celeriac changes over a period of 14 days. The aim was to create an alternative quality control in the food industry to the usual analysis of chemical compounds extracted from the produce items. developed automatic detection of skin defects in citrus fruits based mainly on their texture features. All of these studies have in common that they examine particular properties of one class of fruit or vegetable.

Fruit and vegetable recognition by fusing colour and texture features was proposed. Their design relies on the background subtraction and classification with a multi-class support vector machine. used fusion of multiple colour channels for multi-class fruit detection from pictures with highly complex back- grounds. However, the bottleneck is the detection speed which takes 28 seconds to process one image. Colour and texture features were derived for fruit recognition using the minimum distance classifier . The texture features are based on the sum and difference histogram of the neighbouring pixels and are presented . With an exception , all the other papers used images of fruits and vegetables on a white background. They report that the main discriminative features between the different classes of fruit and vegetable are based on colour and texture.[4][5]

2.2 Self-checkout

The shopping experience has evolved rapidly over the past century and is being heavily transformed by new technologies and increasing customer expectations. A necessary part of each shopping trip is the payment for the products at the checkout where all the items are reviewed and the final price is calculated. Shops are growing larger offering a wider range of products and, as the number of purchased items was gradually increasing, there was a need for automation of the checkout process. One of the first advances of technology is the mechanical cash register invented in the late 19th century. In 1980s the machine readable barcode system was developed for labelling products with universal identification code which speed up the checkout in food chain stores . This was a big step forward as instead of entering each item code manually it was scanned in an instant. However, not all products can be labelled with a barcode - the main examples are fresh produce, sold by weight, and bread. For these products the identification code has to be entered manually even today.

The idea of an automated self-service checkout system was first patented in 1988 and its main characteristic are very similar to the current self-checkouts . In the proposal from 1988 the issue of unlabelled items remained untouched. This was addressed in a patent from 1990 which describes self-checkout of produce items . The solution consisted of a touch screen interface through which a customer chooses which kind of fruit or vegetable he or she is buying. A diagram taken from the original patent description is shown in figure 2.1. The system is very comparable to what is used in practice today. Five years later the same inventor patented an upgrade of his original idea which involves a video camera recording the scale of the self-checkout counter, transmitting the video stream to the screen of a human operator, who sees video streams from several counters, and manually types in the identification codes of produce. The approach in this paper is building on top of the video camera idea, but, instead of the human operator, a classification algorithm is designed and patented in 1995 using a video camera coupled to a service terminal where a human operator types the identification codes of produce.[6][7]

Here the image shows how automatic system works.

U.S. Patent Oct. 16, 1990 Sheet 3 of 3 4,964,053

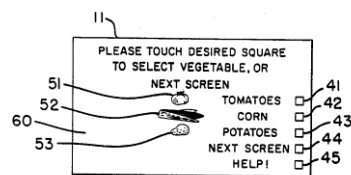


FIG. 5

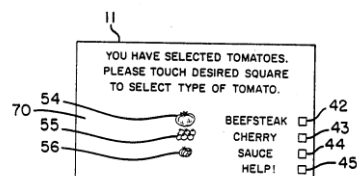


FIG. 6

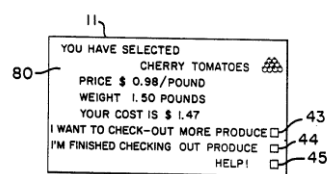


FIG. 7

Self-checkout

Figure 2.1: Diagram explaining the self-checkout process of produce items patented in 1990 using touch screen interface

U.S. Patent June 20, 1995 Sheet 2 of 4 5,426,282

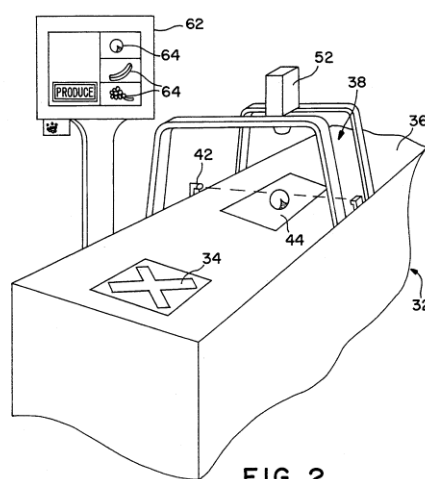


FIG. 2

Figure 2.2: Diagram explaining the self-checkout process of produce items

2.3 Problem Statement

The task here is to automatically detect and classify the vegetables image acquired from Matlab. Assuming that the different images are present and some are overlapped on one another. The task is to separate the images overlapped and recognize them. In this, we have used vegetables image present in Matlab.

2.4 Motivation

The classification technique is used to recognize the vegetable's shape, size, color and texture at a unique glance. Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and attempts to classify each individual pixel based on this spectral information. Two major computer vision problems, image segmentation and object recognition, have been traditionally dealt with using a strict, bottom-up ordering.

Chapter 3

WORKING

The steps of the process are illustrated here with some discussions of each step.

The speed of the object can be determined by using Matlab function. There are various steps involve in this process which are as given :

3.1 Dataset

We can add here any kind of vegetable images. In the code section we just need to add a symbol of the adding vegetable.

3.2 Testset

In this section we test vegetables for recognition.

3.3 Re-Train Model

Now after run the VRS we have to re-train our model for train our dataset. Then the vegetable will be added in the categories section. And new model will be created.

3.4 Read the image

In this section our system read the image

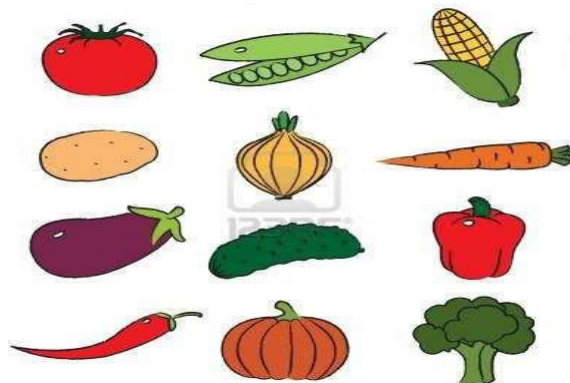


Fig 3.1 Original image

Then our model will be a re-trained model. Here shows us the re-trained vegetable's name.

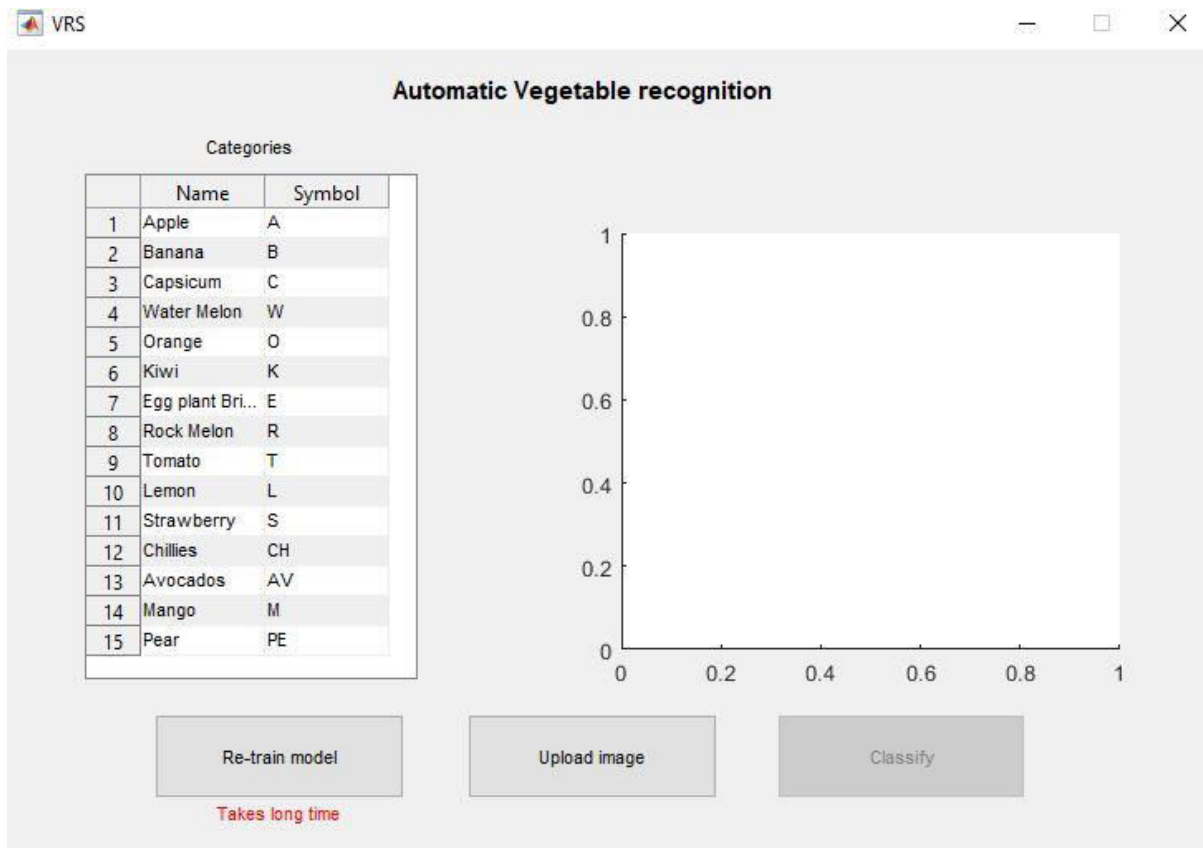


Fig 3.2 Re-train our model

This figure shows us how our system will be trained

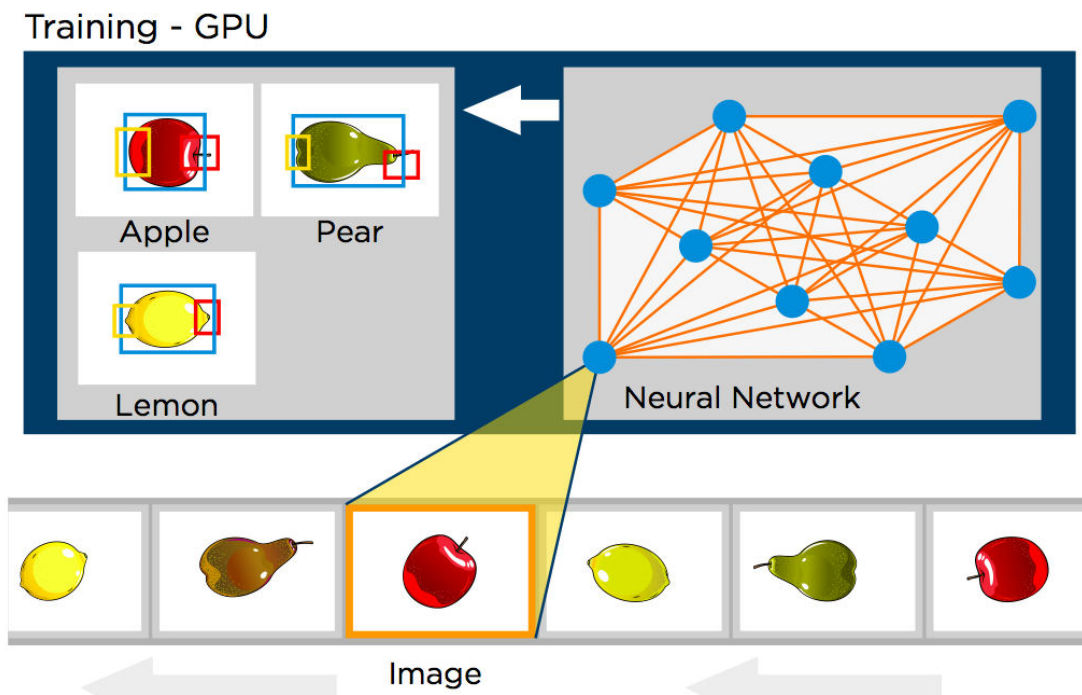


Fig 3.3 Train our system

3.5 Upload Image

After trained our dataset we can upload any vegetables image for classify.

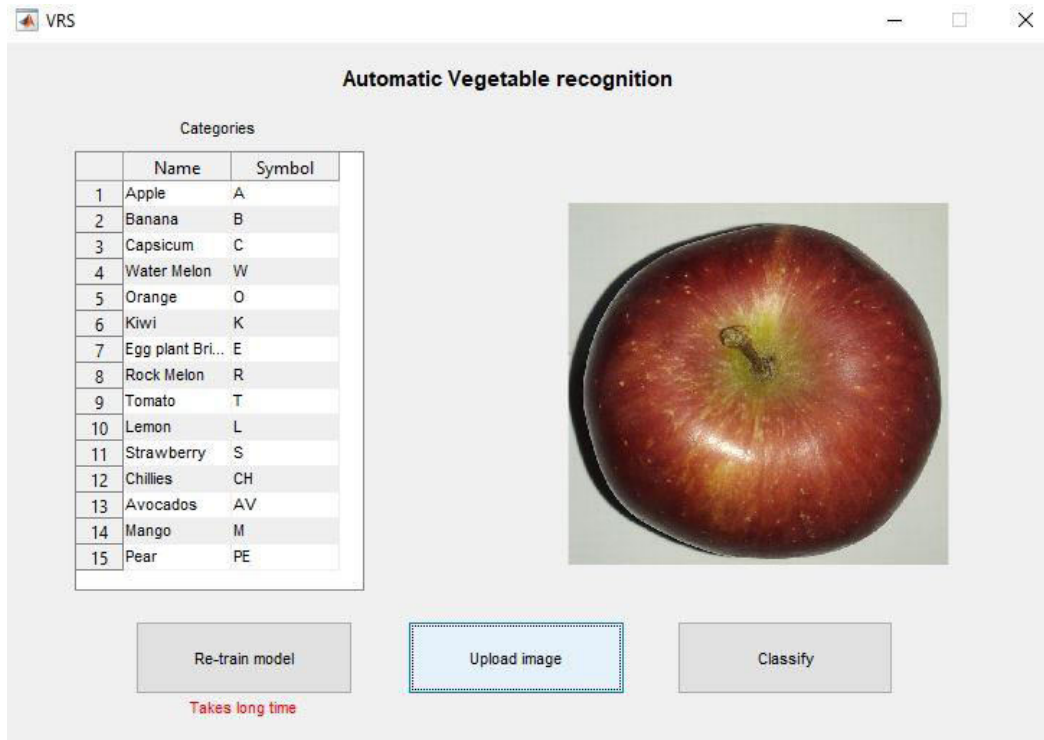


Fig 3.4 Upload images by click Upload Image
Then if we click the classify button then it classify the vegetable showing name.

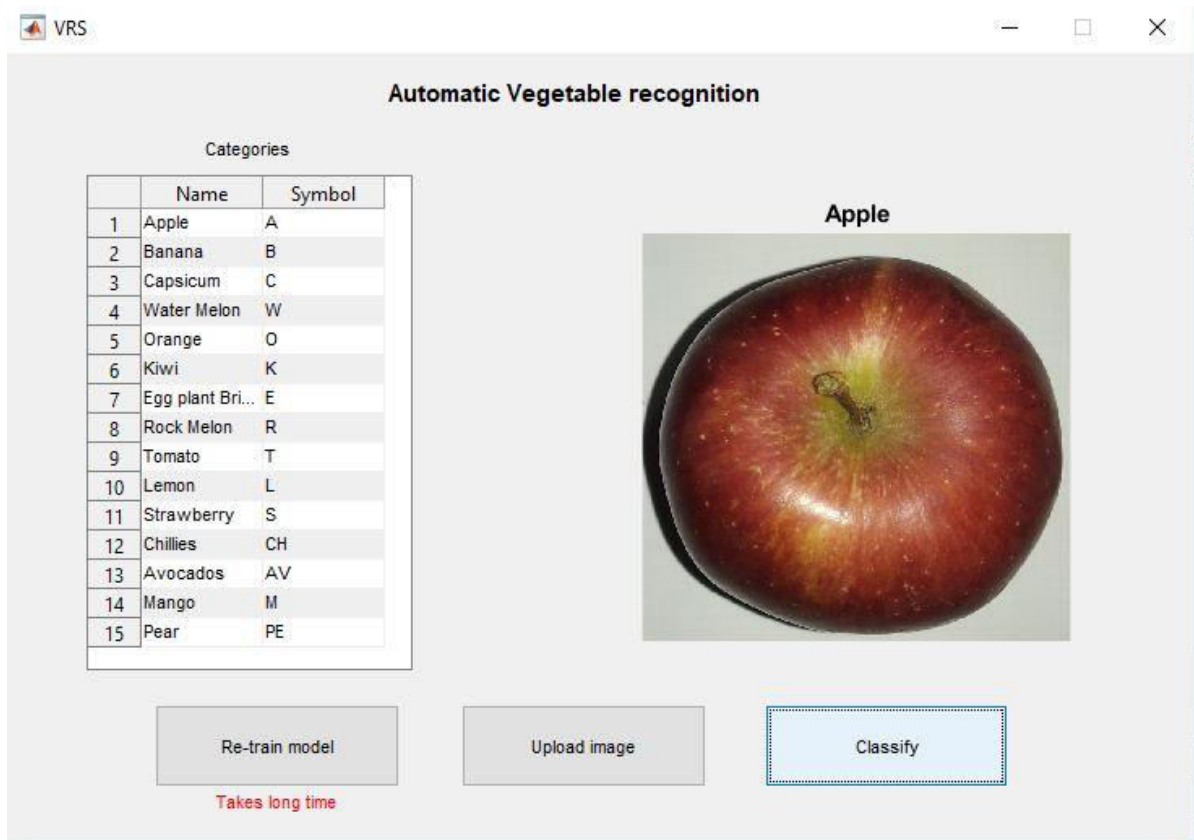


Fig 3.5 Click Classify to recognize the vegetables

Now the name of the vegetable will show on the top of vegetable.

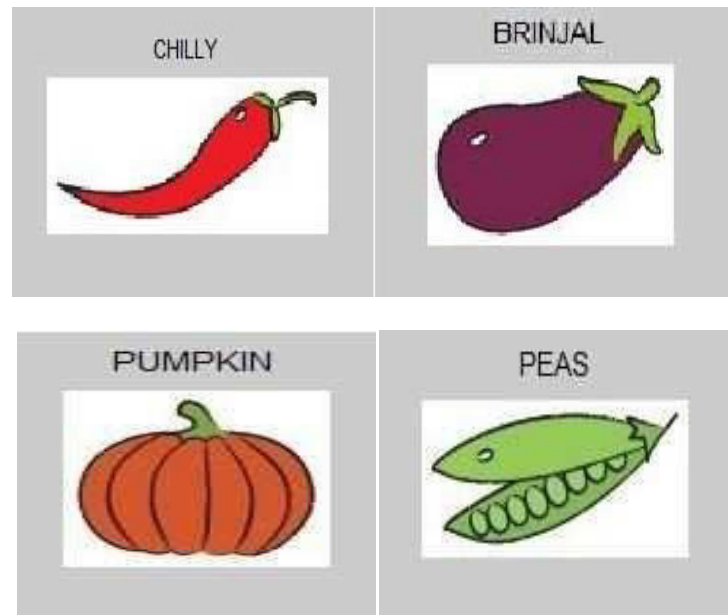


Fig 3.6 Extracted frame

Chapter 4

APPLICATIONS

4.1 Technical Issue

This technique of using matlab code can be use in various purpose which are given below :

- Locate tumors and other pathologies
- Measure tissue volumes
- Surgery planning
- Face recognition
- Fingerprint recognition
- Iris recognition and many more.

4.2 Pseudocode

```
function VRS_OpeningFcn(hObject, ~, handles, varargin)
Categories = {'Apple'
'Banana'
'Capsicum'
'Water Melon'
```

```

'Orange'
'Kiwi'
'Egg plant Brinjal'
'Rock Melon'
'Tomato'
'Lemon'
'Strawberry'
'Chillies'
'Avocados'
'Mango'
'Pear'
'Lichi'};
Symb = {'A'
'B'
'C'
'W'
'O'
'K'
'E'
'R'
'T'
'L'
'S'
'CH'
'AV'
'M'
'PE'
'Li'};
set(handles.uitable1,'Data',[Categories Symb],...
'ColumnName',{'Name' 'Symbol'})

```

4.3 RGB

The RGB color model is an additive color model in which red, green and blue light are added together in various ways to reproduce a broad array of colors. The name of the model comes from the initials of the three additive primary colors, red, green, and blue.

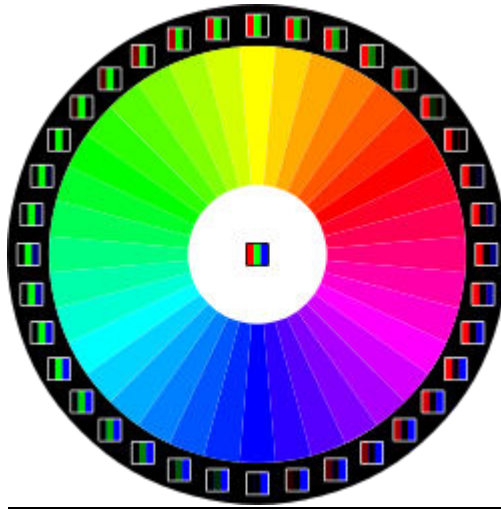


Fig 4.1: RGB

4.4 HSV

HSL (hue, saturation, lightness) and HSV (hue, saturation, value) are alternative representations of the RGB color model, designed in the 1970s by computer graphics researchers to more closely align with the way human vision perceives color-making attributes.

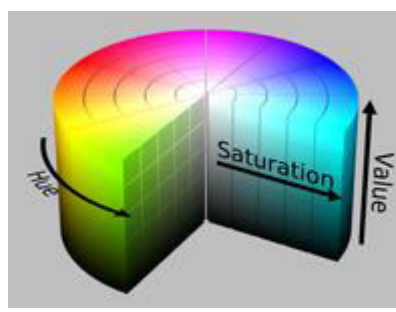


Fig 4.2: HSV

4.5 Flow Chart Works

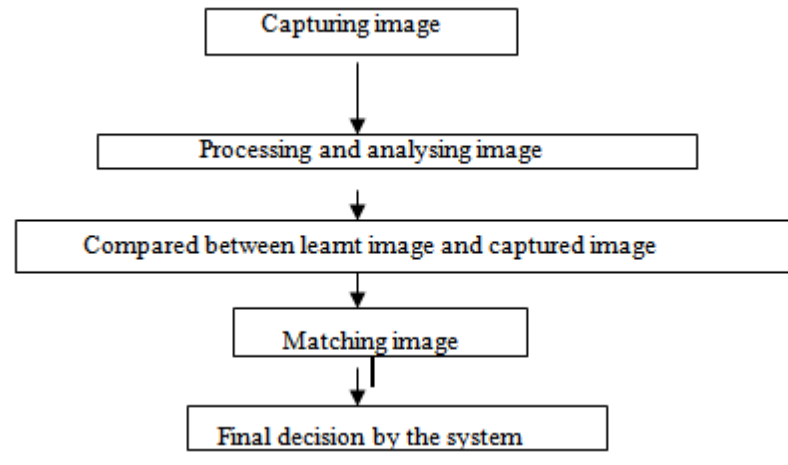


Fig 4.3: System's working process

After capturing the image, apply the following steps as in the learning process. Convert image to HSV model.

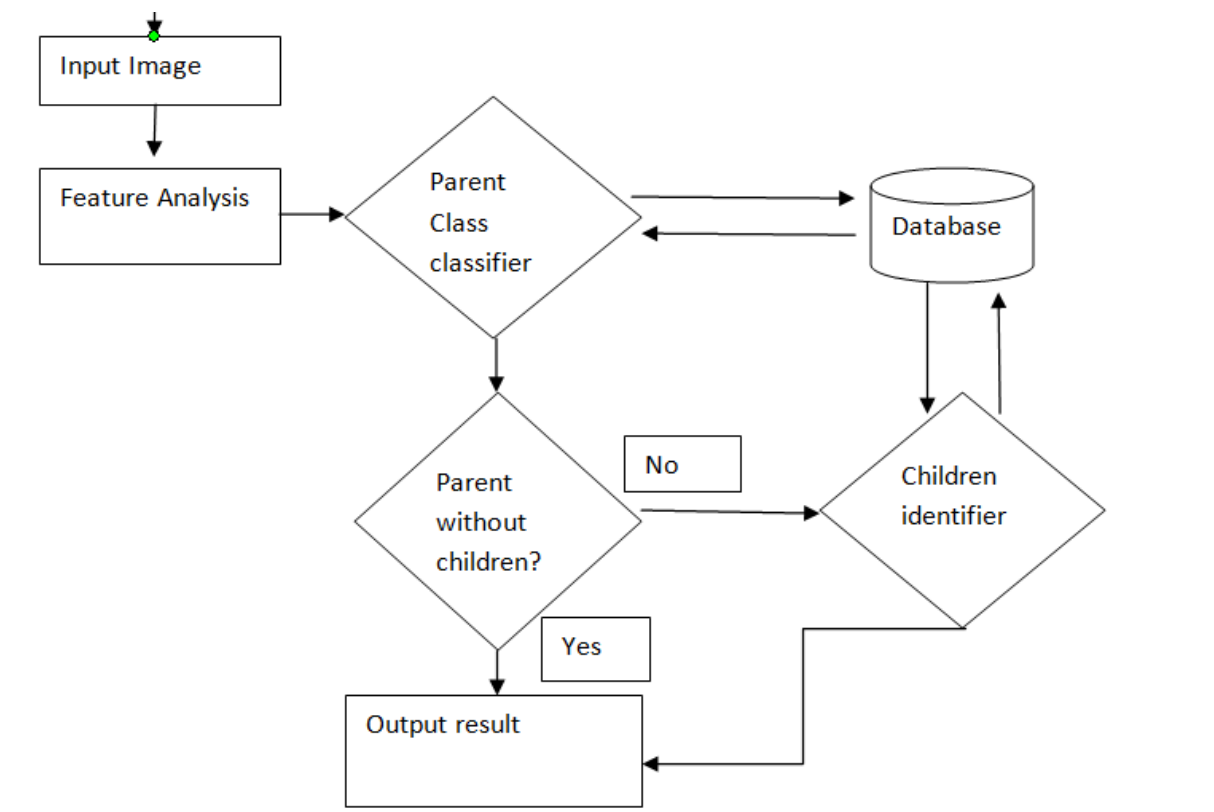


Fig 4.4: Learning Process

4.6 Accuracy

This project was based on color, texture, shape and size through comparing image histograms to find the best matching image. Our experimental results proved that this application shows accuracy with 96.55% of identifying vegetables, Figure 4.5 shows samples of learnt images and tested images. A histogram is a graphical representation showing a visual impression of the distribution of data. It is an estimate of the probability distribution of a continuous variable.

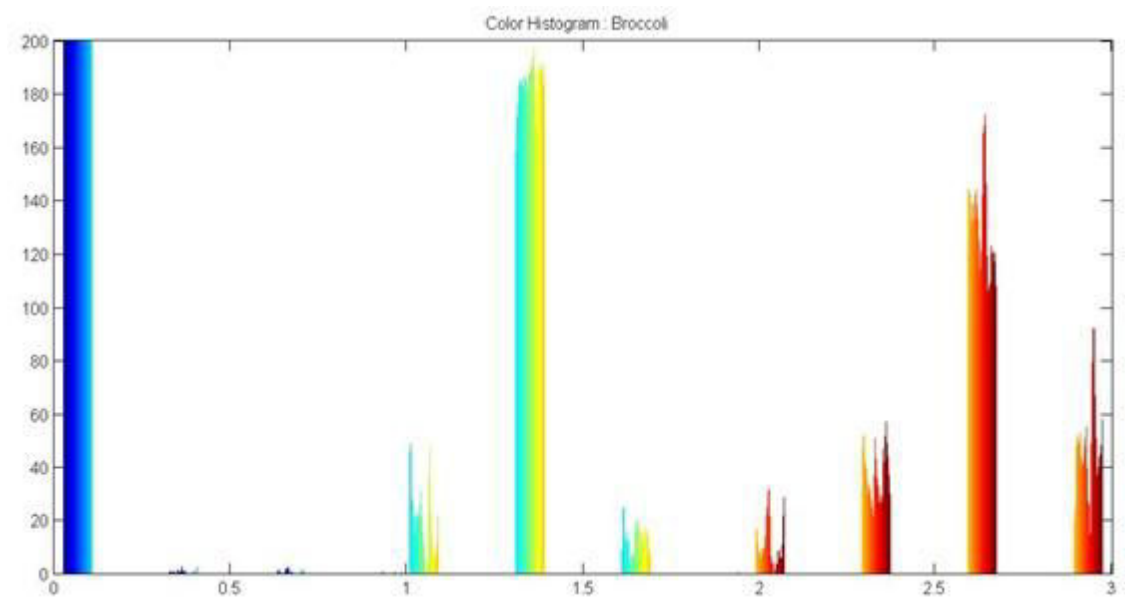


Fig 4.5: Color Histogram of Apple for database

For any given image we can Compute H, S, V histogram and recognize that image for the particular vegetable. For example, apple, violet cabbage. The database has all the information to indentify a vegetable from others. Figure 4.5 shows the color histogram of apple which is stored in the database Now, the histogram was calculated for the given input images of apple. Figure 4.6 represents the tested apple and its color histogram.

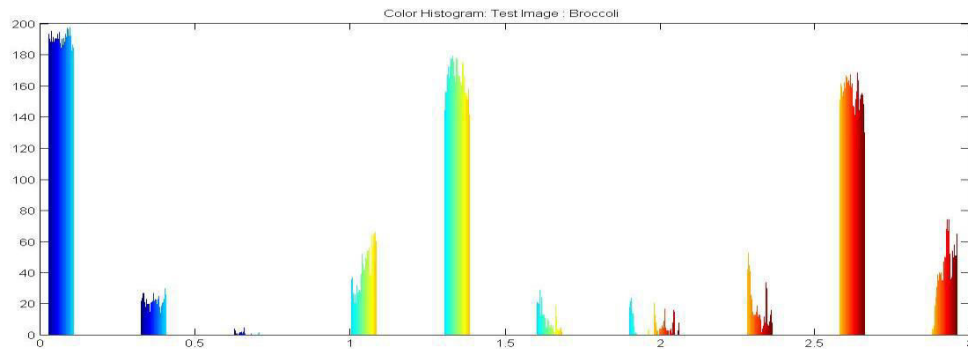


Fig 4.6: Tested Color Histogram of Apple

Chapter 5

METHODOLOGY

This section presents the technology inputs and processing steps needed in the vegetables identification and recognition. The key stages in the vehicle identification and tracking process. Each of these steps is described in detail below.

1. Select the fruit image.
2. Crop the area of fruit.
3. Calculate mean value for RGB component.
4. Calculate shape by threshold segmentation (remove noises, morphological operations).
5. Calculate the geometrical segmentation (Area and perimeter)
6. Calculate the roundness value.
7. Calculate entropy values.
8. Use nearest neighbor classification algorithm and their parameter to classify 3, 4, 5, 6, 7 of image.
9. Output is the result. [8][9]

5.1 K-Nearest Neighbors Algorithm

The k-nearest neighbor algorithm is the methodology that has been used to develop the fruit recognition system. KNN Algorithm perform fruit classification by using the distance between the feature value of unknown fruit with the feature value of stored fruit examples after that algorithm will find out the nearest examples to unknown fruit. KNN classifier classify to fruit mean color value; shape roundness value area and perimeter values. [10]

5.2 Mean of RGB color value

User crops the area of fruit in the fruit image because system will compute the mean values for each of red, green, blue Color component. Area calculating on the 3D matrices then stored all of the fruit pixels. Using the mean function computed by the RGB value for each fruit pixels.

5.3 Calculate area, perimeter and roundness value

The fruit shape roundness (metric) value can be computed after extract the area and perimeter of fruit by using equation as below.

$$\text{Metric} = 4\pi (\text{Area}/\text{perimeter}^2)$$

Table 1: Summarizes the recognition result of twelve test fruit images. The results are effect for whole testing fruit set the table listing the fruit name, computed feature value, such as mean RGB color values, shape roundness, values, area and perimeter values

Perimeter		Roundness		Entropy	
Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
1269	200.10	200.10	0.398239	0.3982	0
44	27.071	27.071	0.754487	0.7544	0
81088	1254	1254	0.6479946	0.6479	2.0
2437	468.46	468.46	0.1395422	0.1395	0
11928	1378	1378	0.7893672	0.7893	0
69878	2946.7	2946.7	0.1011288	0.1011	0
50505	904	904	0.776618	0.7766	0
50505	904	904	0.776618	0.7766	0

Figure: Result Table

303	104.12	104.12	0.351191	0.3511	0
42	23.313	23.313	0.971038	0.9710	0
71	38.627	38.627	0.597967	0.5979	0
34	24.142	24.142	0.733056	0.7330	0

			Red	Green	Blue	Area		
Group	Fruit name	Minimum	Maximum	Minimum	Minimum	Maximum	Minimum	Maximum
1	Red Apple	138	227	34	103	29	73	1269
1	Red Apple	76	255	26	255	29	255	44
2	Banana	5	255	5	255	0	255	81088
2	Banana	41	255	25	255	0	255	2437
3	Guava	85	255	99	255	0	248	119280
3	Guava	84	255	93	255	16	255	69878
4	Green melon	0	226	55	255	0	127	50505
4	Green melon	0	229	38	255	0	212	50505
5	Orange	79	255	34	235	0	205	303
5	Orange	158	255	86	255	0	255	42
5	Orange	118	231	62	157	0	53	71
5	Orange	146	253	108	255	0	255	34

5.4 Calculate entropy value

Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. We have provided in mat lab function. For pixels on the borders of I, entropyfilt uses symmetric padding. In symmetric padding, the values of padding pixels are a mirror reflection of the border pixels in I.

$$I = \text{mat2gray}(A, [\text{min}, \text{max}])$$

$I = \text{mat2gray}(A)$ sets the values of a min and a max to the minimum and maximum values provided in mat lab function. [11][12]

5.5 Training and classification

After training data system, ready to use. KNN find out the shortest distance between the feature values of test fruit Images with feature value training fruit images. While KNN algorithm finds out the closest example to input fruit then allocate the input fruit to the class where majoring of 'K' closest example is form. 'K' is 1 that means classification of test fruit

image is based on stored fruit image.

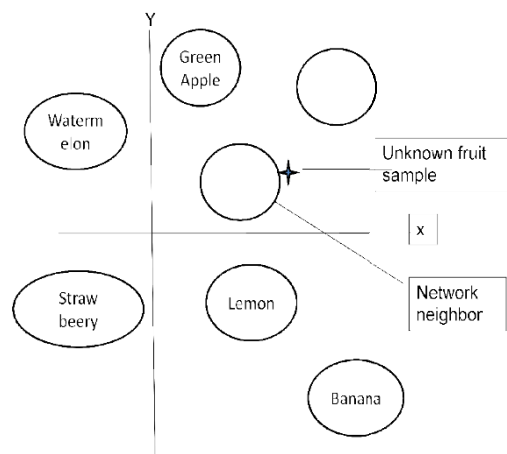


Fig 5.1: Classification processes of unknown fruit sample and stored fruit sample

The following function to classify the input fruit sample by using the fruit recognition system:-

Class=Knnclassify (sample, training, group)

This function will classify the attributes of input fruit sample with attributes of all other training fruit examples and Find-out the 'K' example then classify the unknown fruit image to the class or group where majoring of the 'K' nearest neighbors is form.[13][14][15]

Chapter 6

DISCUSSION

6.1 Future work

The proposed classification pipeline satisfies all the essential requirements for the live classification of the fresh fruits and vegetables in the self-checkout environment. The main future challenges are to increase robustness of the classifier and to improve the classification of the bagged items. Currently, the methods rely on the static background, which can be usually satisfied, but there can be situations in which an unexpected object appears in the field of view. This can be a hand of a shopper, or the next product, which is prepared to be scanned next. This would be confusing for the current classifier mainly in the colour clustering of the segmentation stage. As there is a very limited pool of features which can be used for the bagged items classification an additional feature might be beneficial. One such feature could be the weight of the items from the scale. This can be compared to the estimated size of the items and could help distinguish lighter items such as garlic which, thanks to its colour, is a challenging item, from heavier ones. The current classifier is very good in predicting the correct label in the top three. One reason for this is that there are no

groups greater than tree classes which are expected to have similar colour. If only the first prediction is considered, bananas and lemons get confused easily. This might be addressed by the item's specific features. For the un-bagged items texture can improve classification significantly and for the bagged items it remains an open question. The deep convolutional neural networks are performing very well in the computer vision classification tasks when a large amount of training data is available. This data should ideally be collected in the supermarket over a period of time. An alternative to training the full convolutional network from scratch is to use a pre-trained neural network for the object recognition. The hidden layer of the pre-trained network can be used as feature extractors and only the last layer would be trained to fine tune the fruit and vegetable recognition. This approach is called transfer learning.

6.2 Limitation

1. This project can't recognize vegetable when the vegetables are surrounded by dirt.
2. When the vegetables are in polyethylene bag it can't detect vegetables.
3. Re-train system takes too much time.
4. Can't detect rotten vegetables.

6.3 Conclusion

Fruit and vegetable classification pipeline from the images was developed in this report. The task is motivated by the practical application at the self-checkout terminal in supermarkets to ease buying the fresh produce sold by weight. The pipeline consist of three main stages, namely segmentation, feature extraction, and classification. Each stage was addressed and optimised in order to obtain the best overall classification performance. The major challenge presented is the classification of the fresh produce items placed into the pixel. The usually effective segmentation technique background subtraction is not sufficient to separate the items and the background overlaid by the see-through pixel. This challenge was addressed by segmentation thought colour clustering, combining it with usual segmentation techniques, and the supervised support vector machine classifier to distinguish whether a cluster contains background or foreground pixels. The pixel reduces or completely removes characteristic features of the fruits and vegetables, mainly the texture. As it is not possible to distinguish separate items placed into the pixel the shape feature, which might have discriminate between

oval and elongated items is not usable. The features are based on the colour of the segmented pixels. Three colour spaces were compared.

Even though the position, the number of the items presence of the pixel was varied across the images, the conditions of the dataset creation were relatively controlled in terms of light and the background. Varying these conditions in the real environment may decrease the performance of the classifier (or some stage of the processing pipeline). The normalised RG colour space should be invariant to changes in lightness, and thus perform well even under different light condition. Nonetheless, all images in the second dataset contain a reference colour sticker if an additional colour correction would be required.

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APPENDIX

APPENDIX 1: TRAINING IMAGES



Fig: Different Position of Red Apple

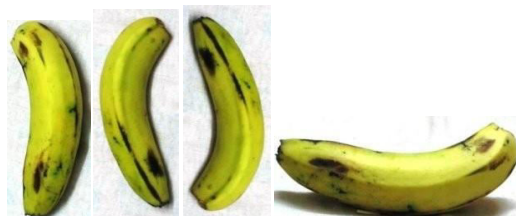


Fig: Different Position of Green Banana



Fig: Different Position of Green Guava

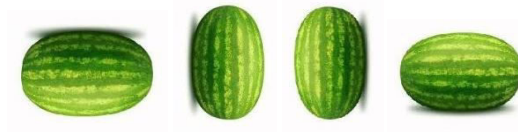


Fig: Different Position of Green Melon



Fig: Different Position of Orange



Fig: Different Position of Green Water Melon

APPENDIX 2: TESTED IMAGES

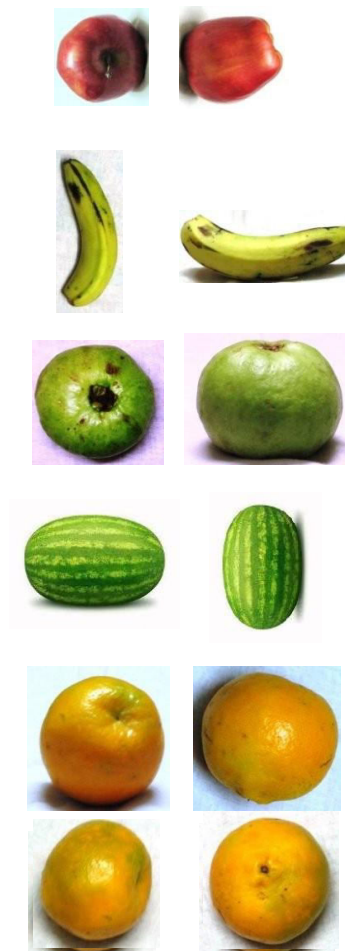


Fig: Different fruit images & different Position of tested images

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