

**Identifying Green Vegetables Using Machine Learning Approach**

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of  
Bachelor of Science in Computer Science and Engineering.

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## **APPROVAL**

The project titled “Identifying Green Vegetables Using Machine Learning Approach”, submitted by MAHIN MIAH ID: 172-15-1526, and MD SABBIR AHMED SHETOL ID: 172-15-1569 to the Department of Computer Science and Engineering, Daffodil International University has been acknowledged as agreeable for the incomplete satisfaction of the necessities for the level of Bachelor of Science in Computer Science and Engineering and affirmed concerning its style and substance.

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## **DECLARATION**

We, therefore, declare that this undertaking has been finished by us under the management of SM Aminul Haque Associate Professor, Department of CSE, Daffodil International University. We further announce that this venture or any piece of this task has not been submitted for any degree or certificate grant somewhere else.

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## ABSTRACT

This report portrays a strategy for making a system for distinguishing green vegetables utilizing an AI technique. The objective of the system is to lessen the quantity of human-PC cooperations, accelerate the identification cycle, and improve the convenience of graphical UIs contrasted with existing systems. To make a system to improve these highlights, an idea of executing AI to recognize the items delivered. Rather than appointing the duty to the client, who as a rule distinguishes the items physically, a PC is given this obligation.

Different intrusive neural organizations have been tried and retrained to group an article. Organizations have been retrained in informational indexes gathered from Imagenet. To improve precision, networks have been retrained in pictures that are like the verbally expressed climate in which organizations serve. The organizations tried in this report are Mobile Net and Inception.

Organizations have diverse advancement times and differ with exactness.

To additionally improve systems, ease of use tests are performed on existing system results and the system's graphical UI. To test the convenience, a heuristic evaluation was acted in a blend of the subsequent test created by the creators. The investigations inferred that the current system was easier to use than the current system.

Taking everything into account, the use of engineered neural organizations to order pictures and the improvement of another UI prompted a quicker discovery measure with fewer client mistakes.

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# CHAPTER ONE

## INTRODUCTION

### 1.1 Introduction

For decades, humankind has sought to reshape its technological equivalence when it comes to intelligence, feeling, and behavior. He has been able to create computers capable of performing different tasks than many individuals. Although a robot calculates the initial factorization in seconds, it takes weeks or even years for a human to perform the same task. However, thanks to our human intelligence when it comes to skills like understanding social codes and identifying things.

A single glance at an image is enough to gather the necessary information about what is in a person's photograph. In seconds, the human brain discovered different shapes and patterns outside of an image. Compared to a computer, visual data analysis and detection are like a human. To get a computer to detect an object in an image with sufficient accuracy. It must fed and trained with a few thousand or million specimens. Being able to identify objects as an image classifier is, therefore, a huge challenge.

The idea of implementing image classification in voluntary systems in the retail business was born out of the experience of misuse in existing systems. The idea of reducing human-computer interaction (HCI) time and giving a computer the task of identification has given the idea of implementing image recognition in self-service systems.

### 1.2 Motivation

At the present world, people used modern technology for every purpose to save their time and stamina. To consider this aspect we work for a project that's name "Identify green vegetables using machine learning approach". The project it's easy to identify and sorting the different types of vegetables as per as their types.

### **1.3 Objective of the Study**

To develop a system that can identify different types of vegetables from a combination of vegetables.

Shorten the time it takes to identify Green Vegetables

### **1.4 Rational of the study**

The reason for this undertaking is to improve the leafy foods distinguishing proof cycle performed without anyone else administration systems in the retail market. All the more explicitly, upgrades ought to incorporate a quicker processor and a more easy-to-understand system. Moreover, utilizing PC vision in self-administration systems can improve the way toward distinguishing objects by moving an interaction starting with one PC then onto the next. Hypothetically, this could accelerate the way toward recognizing items and decreasing the number of blunders by eliminating human parts.

Complex and tedious self-administration systems permit clients to pick another supermarket. Since clients are the explanation organizations endure, their fulfillment is the way to business achievement. The requirement for measures, which decrease handling time, exists due to the assumption for their consistent exertion to save clients time.

Besides, from a business viewpoint, a significant motivation to improve oneself assistance system is to keep up work misfortune. Since systems exist to decrease work, which prompts cost decrease, organizations profit by utilizing easy-to-use systems. If organizations utilize tedious systems, their clients won't utilize them by any stretch of the imagination, and time proficiency and occupation substitution vanish.

## **CHAPTER 2**

### **BACKGROUND**

Since the project is based on the idea of improving the usability of user interfaces in existing systems and reducing the number of human-computer interactions, knowledge of usability engineering in conjunction with programming insights is a priority. Some theories about mathematical operations, which are the basis of CNN training, need to be understood as a part of the image classification process. In this chapter, the theories and background information required to perform this project are presented.

#### **2.1 Literature Review**

Products of soil discovery are applied in various cases. The most well-known zones are recognized as retail and in places where it is not difficult to gather crops from a rural perspective.

As a rule, the distinguishing proof is done through a clerk or store's self-administration system.

In this part, various techniques for recognizing green vegetables will be introduced.

Products of soil discovery are applied in various cases. The most widely recognized zones in the retail business can be distinguished and for their situation to make it simpler to gather grain from a horticultural perspective, the ID is for the most part done through a clerk or store-inadministration system. Amazon 1 is an organization that has taken extraordinary steps in its innovative development regarding man-made consciousness, picture acknowledgment, and robotized actual work. Amazon has made an item considered Amazon Go that empowers a shopping experience with no clerk or self-administration checkout. The organization has made a store where the client's registration application utilizes a cell phone utilizing Amazon Pay. The store is set up with heaps of cameras and sensors. On account of PC vision and profound learning calculations, Amazon had the option to make a store where innovation distinguishes the items

clients pick. No checkout is required; Selected items are charged from the client's Amazon Pay account.

Solid Point is an association settled in Norway that gives mechanical answers for retail organizations. Solid Point as of late revealed a recognizable proof system called DG. The DG discovery measure has a UI set apart on the touch screen with picture acknowledgment and can measure up to existing pieces of the venture. DG is new to the market; So it isn't utilized in numerous stores. On account of ranchers, acknowledgment work has been done as demonstrated in Figures [3], [4], [5] to control plant and organic product yields and different developments. The innovation has been utilized to computerize yields with the assistance of mechanical yields. A few nearby CNNs have been utilized to gather or figure the outcomes. In any case, the improvement of a quick and dependable natural product identification system is as yet progressing. This is because of huge changes within the sight of natural product infiltration, including shading, shape, size, and surface attributes.

### 2.3 Book Review

For writing our paper, we study more than 10 papers to get idea about our thesis topic and writing paper. From that we here discuss summary about 10 papers below there:

SL	Review Factors	Review
1.	Paper title	<b>A comprehensive review of fruit and vegetable classification technique</b>
	Year published	2018
	Ranking (if any)	Not Given
	Goal/purpose of the paper	This paper contributes to a critical comparison of the various sophisticated computer vision methods proposed by researchers for the classification of fruits and vegetables.

	Related work & their goals	In the food industry, fruits and vegetables are a major part of fresh produce and their classification is an extension of material recognition. Traditionally fruits and vegetables are inspected visually by trained staff to determine quality as products or grains.
	Methodology proposed and its details	There is a prominent comparative study for the abandonment of sensors' notable features, feature descriptions, and classification algorithms. A comparison of the techniques used in fruit and vegetable classification is established to understand the current key challenges in this field. The study touches on the use of sensors currently available in different applications in the food industry and the main obstacles to the combination of multiple sensors.
	Input received (if the paper mentioned)	Not Given
	Output produced (if the paper mentioned)	Not Given
	Source & types of datasets used	Apple, Citrus, Tomato, Eggplant, Litchi, Papaya, Pomegarante.
	Major attributes on what the mining is performed	RGB images have been extensively studied to use the significant features of fruits and vegetables such as color and shape, texture and size for conventional computer viewing systems. One of the top applications in visual fruit and vegetable classification is disease detection and erosion analysis in robotics cut quality analysis.
	Tools/ platform used to experiment their work	Recognition, taxonomy, fruit, vegetable, taxonomy production, machine learning, computer vision.

	Experimental evaluation methodology and results obtained	An epoch-making review of the fruit and vegetable classification based on the literature and the material processing of this material was granted and the previous shot was well recorded. Significant features, feature descriptions, and classification algorithms have been identified for data acquisition devices. Sensors used for data acquisition in the food industry are available as synthesized due to considerable limitations in various applications such as some applications have non-destructive, environmental consequences of nature, present inter and class similarities, and complex features. Another significant limitation in the use of multiple sensors in the same application of the same fruit					
		And the different nature of the data produced by them in the botanical analysis.					
	Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)	<table border="1"> <thead> <tr> <th data-bbox="760 940 1179 1003"><b>Strengths</b></th> <th data-bbox="1179 940 1432 1003"><b>Weaknesses</b></th> </tr> </thead> <tbody> <tr> <td data-bbox="760 1003 1179 1482">Important topics have been created on the need for preprocessing and segmentation for computer vision-based analysis in the food industry. The characterization of preprocessed and segmented images is discussed in detail with an emphasis on fruit and vegetable properties.</td> <td data-bbox="1179 1003 1432 1482">I can not find out weakness in this paper.</td> </tr> </tbody> </table>	<b>Strengths</b>	<b>Weaknesses</b>	Important topics have been created on the need for preprocessing and segmentation for computer vision-based analysis in the food industry. The characterization of preprocessed and segmented images is discussed in detail with an emphasis on fruit and vegetable properties.	I can not find out weakness in this paper.	
<b>Strengths</b>	<b>Weaknesses</b>						
Important topics have been created on the need for preprocessing and segmentation for computer vision-based analysis in the food industry. The characterization of preprocessed and segmented images is discussed in detail with an emphasis on fruit and vegetable properties.	I can not find out weakness in this paper.						

<b>SL</b>	<b>Review Factors</b>	<b>Review</b>
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2.	Paper title	Type of Tomato Classification Using Deep Learning	
	Year published	2019	
	Ranking (if any)		
	Goal/purpose of the paper	People can easily determine types of tomato accurately.	
	Related work & their goals		
	Methodology proposed and its details	Model takes raw images and used convolutional neural network, which is extract feature, in result the model, consist from feature extraction and it for full color approach and gray color approach, which consist of four convolutional layer with Rely activation function and each followed by Max pooling Layer.	
	Input received (if the paper mentioned)		
	Output produced (if the paper mentioned)		
	Source & types of datasets used	Kaggle dataset & 7 types	
	Major attributes on what the mining is performed	Using deep neural network shows classify tomato species. To develop a template which developers can create a app and identify tomato varities.	
	Tools/ platform used to experiment their work	Deeplearning,tomato,classification,discovery,CNN,Max pooling layer	
	Experimental evaluation methodology and results obtained	Accuracy was 99.99% and validation accuracy 93%.	
	Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its	<b>Strengths</b>	<b>Weaknesses</b>

	limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)		
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SL	Review Factors	Review
3.	Paper title	Fruit identification using deep learning methods
	Year published	2021
	Ranking (if any)	Not given
	Goal/purpose of the paper	To create an automated system for extracting features using CNN.
	Related work & their goals	
	Methodology proposed and its details	The paper introduces a system that develops one Autonomous identification of the fruits of self-service systems in supermarkets.
	Input received (if the paper mentioned)	Not given
	Output produced (if the paper mentioned)	Not given
	Source & types of datasets used	ImageNet & Five type

	Major attributes on what the mining is performed	The greatest accuracy of classification achieved on the data set.	
	Tools/ platform used to experiment their work	CNN	
	Experimental evaluation methodology and results obtained	Accuracy was 92.23%	
	Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)	<b>Strengths</b>	<b>Weaknesses</b>
			In the future, the model could be used to train more different types of fruit. It can also examine the effects of various parameters such as activation function, pooling function, and optimizer.

SL	Review Factors	Review
2.	Paper title	fruit and vegetable identification using machine learning for retail application
	Year published	2018
	Ranking (if any)	14th
	Goal/purpose of the paper	The ID interaction of foods grown from the ground by administration frameworks in the retail market. Another reason has been to make an easy-to-use framework as assessed by reasonableness examines.

Related work & their goals	Counting picture, acknowledgment has been done in the objective of controlling the vegetation and collect of products of the soil developments at fields of ranchers. A few CNNs have been utilized to limit the organic products with the objective of one or the other gathering or tallying.
Methodology proposed and its details	The task has two stages experimentation and execution. Experimentation tracks down the most appropriate organization and execution depicting how the product and equipment are coordinated structure a distinguishing proof framework. CNN has over as of late become incredible everywhere scale picture acknowledgment undertakings. Enormous scope picture acknowledgment has become conceivable as a result of more extensive crowd picture data sets like Imagenet.
Input received (if the paper mentioned)	Not Given
Output produced (if the paper mentioned)	Not Given
Source & types of datasets used	Retail market. Apple, Avocado, Banana, Bell Pepper, Clementine, Kiwi, Orange, Pear, Potato and Tomato. Ten different classes.
Major attributes on what the mining is performed	
Tools/ platform used to experiment their work	The equipment of the framework is set up by a Raspberry Pi, camera, show, load cell, and a case. A Raspberry Pi works in a manner same as an ordinary PC however on a negligible portion of the expense and size. the Raspberry Pi has a CSI and a DSI port for adding a Raspberry Pi camera module and a touchscreen show. It is an advanced stage for making models and attempting ideas. It depends on a 64bit QuadCore 1.2GHz CPU and has 1GB of RAM accessible. The camera cautioned for this venture is the RaspberryPi Camera Module v2 and is the authority item from the Raspberry Pi.
Experimental evaluation	

	methodology and results obtained		
	Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)	<b>Strengths</b>	<b>Weaknesses</b>

SL	Review Factors	Review
3.	Paper title	Potato Classification Using Deep Learning
	Year published	2019
	Ranking (if any)	
	Goal/purpose of the paper	
	Related work & their goals	Computer vision and machine learning technique have applied different kind of disease detection and classification different type of vegetables and fruits for example tomatoes,grapes,potatoes and cauliflower.
	Methodology proposed and its details	Deep learning is a machine learning technique that instruct computers to do what comes naturally to humans.
	Input received (if the paper mentioned)	
	Output produced (if the paper mentioned)	

	Source & types of datasets used	2400 images of potatoes.	
	Major attributes on what the mining is performed		
	Tools/ platform used to experiment their work	CNN	
	Experimental evaluation methodology and results obtained	Accuracy was 99.5%	
	Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)	<b>Strengths</b>	<b>Weaknesses</b>
		accuracy	Later on, The model can be utilized to prepare more assortment of organic products. It can likewise inspect the impacts of different boundaries like enactment work, pooling capacity, and analyzers.

SL	Review Factors	Review
4.	Paper title	On Tree Detection, Counting & PostHarvest grading of fruits Based on Image Processing and Machine Learning Approach-A Review
	Year published	2017
	Ranking (if any)	

Goal/purpose of the paper	This paper has advanced another model of the mechanized reviewing framework for oil palm natural products that are created utilizing the RGB shading model and fake fluffy rationale.	
Related work & their goals	Machine vision and PC vision have been for the most part utilized for the qualifying examination and reviewing of leafy foods..	
Methodology proposed and its details	K methods grouping division is an effective technique for both development and youthful organic product discovery.	
Input received (if the paper mentioned)		
Output produced (if the paper mentioned)		
Source & types of datasets used	Two classes	
Major attributes on what the mining is performed	The greatest accuracy of classification achieved on the data set.	
Tools/ platform used to experiment their work	ANN	
Experimental evaluation methodology and results obtained	88.28%	
Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)	<b>Strengths</b>	<b>Weaknesses</b>

<b>SL</b>	<b>Review Factors</b>	<b>Review</b>	
5.	Paper title	Classification of Cape Gooseberry Fruit According to Its Level of Ripeness Using Machine Learning Techniques and Different Color Spaces	
	Year published	2019	
	Ranking (if any)		
	Goal/purpose of the paper	The goal of this paper was to develop a non-intrusive system for the classification of gooseberry fruit according to their degree of ripeness.	
	Related work & their goals		
	Methodology proposed and its details	Data first extracted from image samples to obtain feature vectors organized by each class and vector space.	
	Input received (if the paper mentioned)		
	Output produced (if the paper mentioned)		
	Source & types of datasets used	925 cape gooseberry and different level of ripeness	
	Major attributes on what the mining is performed		
	Tools/ platform used to experiment their work	KNN,ANN,SVM,DT	
	Experimental evaluation methodology and results obtained	89.85%,93.02%,89.97%,	
	Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes	<b>Strengths</b>	<b>Weaknesses</b>

	the authors mention the current drawbacks in the discussion/conclusions and future works sections)		Use different strategies to combine information from color spaces. Information fusion technique may be involve of the feature space, the fusion of scores or the decisions of classifiers.
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SL	Review Factors	Review
6.	Paper title	Machine vision based fruit classification and grading-A Review
	Year published	2017
	Ranking (if any)	
	Goal/purpose of the paper	This paper reviews basic process flow of fruits classification and grading.
	Related work & their goals	
	Methodology proposed and its details	Process of image and preprocessing, segmentation, feature extraction, knowledge base comparison and decision creating step are included.
	Input received (if the paper mentioned)	
	Output produced (if the paper mentioned)	
	Source & types of datasets used	ImageNet and 2000 categories
	Major attributes on what the mining is performed	Outside properties of fruits such as color, size, shape, texture and unlike defects are very important attribute fruits for classification and grading.
	Tools/ platform used to experiment their work	KNN, SVM

Experimental evaluation methodology and results obtained	92%, 96.55%	
Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)	<b>Strengths</b>	<b>Weaknesses</b>
		In future, we can work image classification for local fruits and vegetables and used for plants, leaves, flowers identification and classification.

SL	Review Factors	Review
7.	Paper title	<b>On Tree Detection, Counting &amp; Post Harvest grading of fruits Based on Image Processing and Machine Learning Approach-A Review .</b>
	Year published	April, 2017
	Ranking (if any)	Not Given
	Goal/purpose of the paper	This paper presents identification of develop and healthy fruits, flawless and unhealthy fruits, and furthermore foresee the heaviness of the natural product from its shape.

Related work & their goals	This paper presents machine vision and PC vision that has been utilized principally for quality investigation and reviewing of products of the soil. These incorporate the capacity to computerize manual evaluating measures and lessen assessment undertakings. More advanced mechanics and sensors have utilized for information robotization in this paper.
Methodology proposed and its details	There are at present a few existing natural product quality IDs and reviewing innovation abilities welcoming drawback significant expenses and intricacy stress so it is important to build up a quick speed and minimal effort natural product size ID and understanding framework. Here the connection between the Metatheory strategy and the system that investigates the outcomes is utilized for distinguishing proof counts and reviewing so every one of the fundamental fillers can recuperate the best appropriate strategies for its execution.
Input received (if the paper mentioned)	Not Given
Output produced (if the paper mentioned)	Not Given
Source & types of datasets used	This paper generates three types of fruit and vegetable classes such as: Extra class, Class 1st, Class 2nd.
Major attributes on what the mining is performed	RGB pictures have been widely concentrated to utilize the critical highlights of foods grown from the ground, like tone, shape, surface, and size, for regular PC vision frameworks. Mechanical quality examination through driving applications in the order of vision-situated products of the soil has been utilized to analyze illness and break down the harm.
Tools/ platform used to experiment their work	Acknowledgment, Classification, Fruit, tree, Produce grouping, Machine Learning, Computer vision, Machine vision.

	Experimental evaluation methodology and results obtained	This study presents the Great Survey after Identification Calculations and Fruit Harvesting on Trees. This study of its recent work in this field is very effective for researchers in this interesting area. K-man clustering color space partitioning RGB color recognized HSI techniques have been used in different ways for identification. Throughout the discussion we have come to the conclusion that K-Man clustering segmentation is very effective for identifying both mature and immature fruits.	
	Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)	<b>Strengths</b>	<b>Weaknesses</b>
		Important topics have been created on the need for practice and division for computer vision based analysis in the food industry. In this place more emphasis has been laid on determining the size of fruits and trees and on the characteristics of fruits and trees	I can not find out weakness in this paper.

SL	Review Factors	Review
8.	Paper title	Size Classification of Tomato Fruit Using Thresholding, Machine Learning and Deep Learning Techniques
	Year published	September 30, 2019

Ranking (if any)	Not Given
Goal/purpose of the paper	Tomato fruit size should be classified using throw holding and machine learning techniques so that the farmer takes less time to pick the tomatoes and benefits both the farmer and the buyer.
Related work & their goals	The part presents inside and out learning methodologies in arrangement dependent on pictures of single tomato organic product applied to little, medium, and open CV libraries and Python programming utilizing tomato string learning AI and profound learning procedures.
Methodology proposed and its details	The dataset was collected according to several tomato farms in Batangas, Philippines. There are three classifications of sizes: small-large-medium and each classification has 160 images distributed as training for 200 images and 40 tomato maturity grades for testing. System overview shows that capturing box using digital photo camera after input is captured from two closed images. The camera will be placed 15 inches from the part where the tomato will be located for which 5 slot tomatoes are separated by 4 inches.
Input received (if the paper mentioned)	Not Given
Output produced (if the paper mentioned)	Not Given
Source & types of datasets used	Sample tomato image (A) small, (B) medium, (C) large
Major attributes on what the mining is performed	To adapt to the use of machine learning algorithms introduced for this method. Machine learning models are used for various purposes and one of them is the three popular models for the classification of maps such as SVM, ANN and K-NN. Visual Geometry Group improves the architecture of Alexnet by increasing network structural and polling levels.
Tools/ platform used to experiment their work	Recognition, Classification, Tomatoes, Produce classification, Machine Learning, Deep-learning

	Experimental evaluation methodology and results obtained	The data set for this method is divided into 80% for training and 20% for testing. The total number of data sets is 600 which is 480 for training and 120 for testing. This data setting displays the scatter plots of the data set of the generated training data set and displays the threshold values generated for the region, perimeter and radius of the perimeter circle. These threshold values are generated	
		using a statistical tool called Minitab. The generated descriptive statistics represent small to medium margins for short to medium to large margins.	
	Main strengths and weakness of each approach/method discussed (identify the main strengths and weaknesses using different steps, including an understanding of the proposed method and its limitations, how other researches cited and criticized the paper, sometimes the authors mention the current drawbacks in the discussion/conclusions and future works sections)	<b>Strengths</b>	<b>Weaknesses</b>
		Significant points have been created on the requirement for pre-preparing and division for PC visionbased and investigation in the food business. Highlights of pre-handled and sorted pictures Description and audit of tomatoes	I cannot find out weakness in this paper.

## 2.2 Usability

### Heuristic Evaluation

These days, the recognizable proof of retail items is done physically with the assistance of a clerk or shopper self-administration framework. On the off chance that the discovery is performed physically, the human part can influence the outcome. Quite possibly the client may press some unacceptable fasten or misjudge the application. An assessment of existing frameworks can help improve existing GOIs. Of the four investigations created by Nielsen and Molich [1], they inferred that hypothetical assessment is troublesome however the significance of assessment cash

for the utilization test. Nielsen [1] said: "My fundamental guidance for training convenience designing is that this course ought to be immovably settled in the research facility. An essential piece of any ease of use designing course is to check the genuine number of clients. All the more significantly, it is the best way to accomplish the essential progressive change Way (p. IV).

Heuristic assessment is a casual technique for convenience examination for us. [15] [16]

Official assortments of rules are accessible when creating interfaces by taking a gander at an interface to accumulate criticism on what is positive and what is negative about the interface, yet it very well may be viable in thousands. [14] [20] This guide has been diminished to nine rules that catch genuine mistakes [14] and can be distinguished.

Investigations have shown that by following these nine rules, single members are once in a while ready to distinguish over half of the ease of use issues [17] However, in blend with various issues recognized by members, the hypothetical assessment strategy performs very well. Simply three to five members had the option to distinguish over 70% convenience issues by and large. [1]

Table 2.1: The Nine Guidelines

• Simple and Natural Dialogue	• Provide Feedback
• Speak the User's Language	• Provide Clearly Marked Exits
• Minimize the User's Memory Load	• Provide Shortcuts
• Be consistent	• Provide Good Error Messages
	• Error Prevention

Convolutional neural organizations (CNN) have gotten incredible at perceiving enormous pictures as of late [11]. Bigger public picture data sets, for example, ImageNet make it conceivable to perceive huge pictures. CNN is an organization comprised of neurons like the human mind [12] [31]. Figure 2.3 shows an illustration of a CNN. These neurons comprise loads and inclination that structure layers and fire in a particular request for conclusive yield end. Organizations can be prepared to distinguish explicit examples by taking care of them a lot of information. Figure 2.4 shows an illustration of a CNN looking for highlights to identify a

motorbike. This is valuable for PC vision since it implies that the PC can be prepared to perceive various things. CNN ordinarily comprises three kinds of layers, not including info and yield layers. These kinds of layers are the convection layer, the pooling layer, and the completely associated layer. Each level performs various sorts of tasks. These tasks ultimately yield a worth toward the finish of the organization. In the accompanying portrayal of the layers, a picture goes about as the info and the yield predicts what the picture is albeit this isn't generally the case it is identified with the task.

## **2.4 Convolutional Neural Networks**

### **Convolutional Layer**

Taking an image as an input, each convolutional layer performs a different mathematical operation over the pixels. The goal is to extract different kinds of features in the image. These features can be corners, edges or end-points. However, not all pixels in an image are part of the operation. Instead a square, referred to as kernel or filter, divides the pixels into a subset and performs the mathematical operation on this subset. The kernel is then reapplied all over the image performing the same operation. The notation of how much the kernel is offset from the previous mathematical operation is called stride. Furthermore, multiple mathematical operations can be performed in a single layer in purpose to extract more features. As the network progress through the layers the features extracted are then combined by the higher layers to form feature maps. Feature maps are a new image where every pixel is the result of the mathematical operation performed by the kernel. Figure 2.5 displays an example of a convolutional layer.

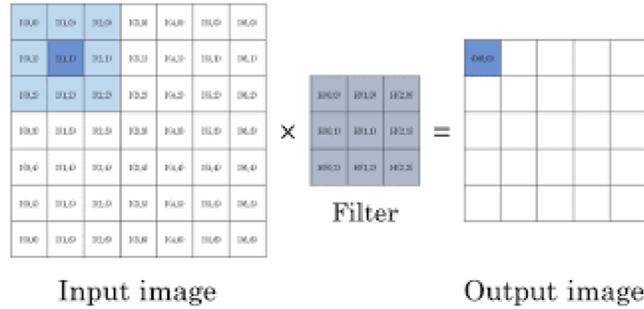


Figure 2.3: A more in depth view of a CNN with neurons, weights and biases.



Figure 2.4: An overview of how a CNN works.

### Pooling Layer

The pooling layer[5][13] combines the output of multiple neurons to one single neuron. The function deciding what the value of the new combined neuron is called pooling function. Popular pooling functions are called max, average and stochastic. The purpose of this layer is to scale down the resolution of the feature maps and thus reducing the sensitivity of the output to shifts and distortions. Figure 2.6 displays an example of a max-pooling layer.

### Fully Connected Layer

The fully connected layer is located at the end of the network. It takes the output of the previous layer and produces an N-dimensional vector where N is

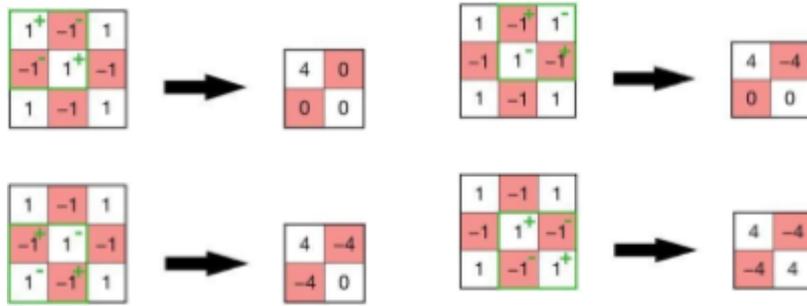


Figure 2.5: Example of a convolutional layer performing on an input image with a kernel size of  $2 \times 2$  and a stride of 1.

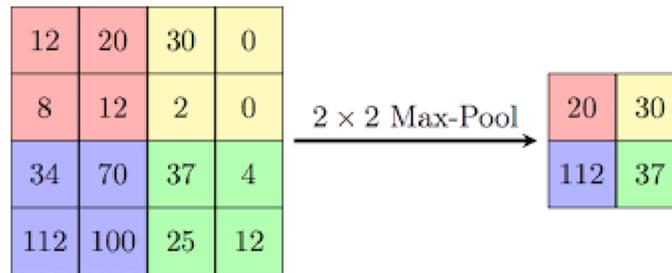


Figure 2.6: Example of a max-pooling layer with a kernel size of  $2 \times 2$  and a stride of 2.

the number of classes the network tries to identify. The vector contains values of how high the probability of each class is. This is again done by performing a mathematical operation on all connected neurons. A visualization of a fully connected layer can be found in Figure 2.7

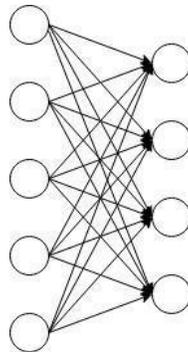


Figure 2.7: Visualization of a fully connected layer.

## 2.5 Transfer Learning

Transfer learning is the process of preserving knowledge gained from a particular problem and applying it to a new problem [19]. For example, the knowledge gained while learning to identify vegetables can be applied when trying to identify cauliflower. In many real-world applications, retrieving the necessary training data and rebuilding models is costly or impossible. [19]

### Loss Function

Loss function is a mathematical function used when training networks. It measures how far the estimated value is from the true value. This also allows the network to change its weights and biases to more accurately create an estimate next iteration by minimizing the loss function. The loss function is minimized by computing the gradient descent (GD).

$$\omega_{t+1} = \omega_t - \gamma \nabla Q(\omega_t) \quad (2.1)$$

The gradient  $\nabla Q(\omega_t)$  is a vector pointing in the direction of steepest ascent. Gradient descent learning attempts to find a point  $\omega$  in some parameter space that minimizes a loss function  $Q(\omega)$ [28]. It is computed by taking the partial derivatives for each dimension in the loss function. The following is an example of computing the gradient from a function  $f$  with three dimensions:

$$\nabla f = \text{grad}^f = \frac{\partial f}{\partial x} \mathbf{i} + \frac{\partial f}{\partial y} \mathbf{j} + \frac{\partial f}{\partial z} \mathbf{k} \quad (2.2)$$

The chosen gain  $\gamma$ , referring to equation 2.1, is a measurement of how large steps the network should take in the direction of the gradient. By subtracting the  $\gamma \nabla Q(\omega_t)$  from the current iteration  $t$  from the parameters  $\omega$ , a descending step in the direction of the gradient is made. This process is repeated for each iteration during the training procedure. However, a more practical real world example is to compute the gradient from a batch of samples. This is called batch gradient descent (BGD).

$$\omega_{t+1} = \omega_t - \frac{\gamma}{n} \sum_{i=1}^n \nabla Q(\omega_t), \quad (2.3)$$

Although it is discussed to be less efficient than regular gradient descent[28], it reduces the overall number of computations needed.

Stochastic gradient descent (SGD) is an optimization technique applied to the learning process. Instead of computing the gradient exactly, the gradient is estimated each iteration from a single sample  $z_t$ [3].

$$\omega_{t+1} = \omega_t - \gamma \nabla Q(z_t, \omega_t) \quad (2.4)$$

The single example is arbitrarily picked with the expectation that the conduct will look like condition 2.1. The union of stochastic inclination drop has been concentrated broadly in the stochastic estimate literature[2] and is with the right methods quite often sure to intermingling under gentle conditions[4].

### Batch Normalization

Imagine two inputs of different scale. The first input is cauliflower. For the sake of the argument, let's limit the values to a range from 0 to 100. The second input node is an age of a person, typically in the range of 0 to 100. Since the distribution of these two inputs differ in such large amounts, the network will have problems adapting its trainable parameters[9] during the training process. The network experiences something known as *covariate shift*[24]. Furthermore, the large variations will cascade through the network leading to imbalance in the gradient. This is known as the *exploding gradient problem* [20]. To minimize the covariate shift and solving the exploding gradient problem, batch normalization (BN) is introduced. The purpose of BN is to minimize the covariate shift and thus removing the need of the network to adapt to a new distribution [9]. BN takes the batch of samples and calculating the mean as shown in equation 2.5.

$$\mu_\beta = \frac{1}{m} \sum_{i=1}^n x_i \quad (2.5)$$

Where  $\mu_\beta$  is the batch mean and  $x_i$  is an sample from the batch  $\beta$  of size  $m$ . From the batch mean, the batch variance  $\sigma_\beta^2$  is then determined as in equation 2.6.

$$\sigma_\beta^2 = \frac{1}{m} \sum_{i=1}^n (x_i - \mu_\beta)^2 \quad (2.6)$$

The normalization of the input is then done as in 2.7. Here, parameter  $\epsilon$  is introduced which is a trainable value that the network will adjust over the training period.

$$\hat{x}_i = \frac{x_i - \mu_\beta}{\sqrt{\sigma_\beta^2 + \epsilon}} \quad (2.7)$$

## Chapter 3

### Methodology

The venture is isolated into two stages, the testing stage, and the execution stage. The objective of the test stage is to track down the most reasonable organization for this venture. It establishes the framework for how the system will eventually function. The execution stage depicts how programming and equipment are incorporated into an ID system.

### 3.1 Software

#### Python

Python is a loosely typed language and emphasizes code readability. The language has access to enormous open source libraries created by the Python community and companies. The greatest reason why Python was chosen was the code readability, as mentioned above. Using a language that emphasize this property enables developers to ease into a subject without having to struggle with syntax. Additionally, Python was chosen because of access to complex mathematical libraries. Matrices and vectors are widely used in image classification. keras is a Python library that provides an easy way of creating large N-dimensional arrays and matrices along with mathematical functions to operate on these. Furthermore, Python is a commonly used programming language to use within machine learning software's such as Tensor flow, Caffe and PyTorch.

#### Google Coolab

Collaborative or "Collab" for short is an item gotten from Google Research. The club permits anybody to compose and execute self-assertive Python code through a program and is especially appropriate for AI, information investigation, and learning. All the more actually, Club is a facilitated Jupiter note pad administration that requires no arrangement to use to give free admittance to PC assets, including the GPU.

Ecolab assets are ensured and not limitless and the constraints of utilization vary now and then. It is important to give free assets to collab

Clients are keen on more dependable admittance to better assets. Jupiter is an open-source project dependent on the collab. Collab permits you to utilize and share Jupiter journals without downloading, introduce or run anything.

Google Drive forces different cutoff points, including per-client and per-record activity estimations and data transfer capacity standards. Surpassing this breaking point will trigger info/yield mistakes as above and show a warning in the CULB UI. A typical explanation is to get to a famous common document or to get to numerous individual records excessively fast. Zones of work include:

Duplicate the record utilizing Drive.google.com and don't share it a lot with the goal that different clients don't abuse it.

Try not to avoid such a large number of little I/O messages, rather duplicate the information from the drive in a chronicle design (eg .compress or.tar.gz record) to the information club VM and store the information locally in the VM rather than the mounted drive index.

Stand by a day to reset as far as possible. **Kaggle**

kaggle is an Airbnb for information researchers - from where they go through their evenings and ends of the week. It is a group satisfying stage for drawing in, supporting, preparing, and provoking information researchers to settle information science, AI, and prescient examination issues around the planet. It has more than 536,000 dynamic individuals from 194 nations and contributes around 150,000 every month. Beginning in Melbourne, Australia Cagle moved to Silicon Valley in 2011, raising almost 11 million from Hal Varian (Google's central market analyst), Max Levchin (PayPal), Index, and Khosla Ventures, and later obtained Google in March 2013. Kegel is the main stop for information science fans around the planet that goes after prizes and energizes their Kagle rankings. There are just 94 Kaggle Grandmasters on the planet to date.

Did you realize that most information researchers infrequently get an opportunity to rehearse before being utilized distinctly in the hypothetical and genuine world? Kegel tackles this issue with a stage for information science fans to interconnect and content to take care of genuine issues. The experience you have acquired at Kegel is priceless in setting you up to comprehend what potential answers for huge paper can discover.

Cagle empowers information researchers and different designers to run AI rivalries, compose and share code, and take part in have datasets. The information posted on Kaggle can be anything from looking at the patient's record of the sort of issue by dissecting the sensation of being stirred by a film audit and attempting to anticipate the frequency of malignancy by what it means for the crowd's reaction.

Different sources post activities on this exploring stage. Some are only for instructive purposes and fun cerebrum practices yet others are genuine issues that organizations are attempting to settle to make the climate serious by giving prizes and rankings to Kegel champs and members. Prizes can incorporate monetary as well as alluring prizes, for example, occupations in the facilitating organization of the opposition or free items.

Cash costs are alluring to most Keglars. For instance, Home Depot is offering a 40,000 winning prize looking for a calculation to improve indexed lists. Prize For most data science lovers, this inventive site isn't just a monetary asset, however, a fundamental learning instrument to improve the experience, acquire information, Helps to improve and upgrade abilities and gain from botches by re-presenting the code. This is the ideal stage to rehearse reliably.

The Kaggle people group is developing quickly. There are right now more than 1,000,000 Kagglers. This information local area has submitted 4,000,000 learning models in different rivalries. Cagle clients have shared more than 1,000 informational indexes, above 170,000 discussion posts, and an excess of 250 parts. As per the organizer, this amazingly quick development can be ascribed to excellent substance, information, and code-sharing coddlers.

Most Kaggle clients are submitted and dynamic so submit 4,000 gathering posts and more than 3,500 challenges each month. The stage is home to information researchers and AI engineers from around the globe.

### **Kaggles Work process:**

The host of the opposition is liable for setting up the information and setting up the subtleties of the current issue. To make it more advantageous for has, Kaggle gives an extra counseling administration that gets ready information and portrays the issue in the most ideal arrangement. Serious members presented their models with various procedures for the undertakings. All the paper has been shared on the stage through nitty-gritty paper contents to move groundbreaking plans to accomplish improved guidelines. In most Kegel rivalries, stores are scored right away and summed up freely straightforwardly on the live pioneer board.

Contenders are not given a solitary opportunity to tackle any issue. Before the cutoff time terminates, challengers are permitted to change their entries as they see fit. This fuel persuades contenders to be all the more reliably imaginative, to be innovative, and clean their abilities to deliver better, exquisite and powerful arrangements. Permitting reexamination additionally improves the degree of significance and precision.

At the point when a challenge lapses, the host pays the champ the prize cash. The host has sole ownership and a sovereignty-free permit to utilize the triumphant passage in any capacity, including all protected innovation.

### **Data Set**

The informational index is partitioned into 10 unique classes. Each class addresses one sort of leafy food. The picked classes are cabbage, carrot, cauliflower, cucumber, radish, spinach, and tomato. These classes are picked because some Green vegetables have comparable appearances and are as often as possible purchased in retail advertisements. Impediments to the informational index have been never really make the undertaking excessively broad. These restrictions are that a wide range of organic products or vegetables dwells under a similar class. This implies a wide range of apples dwell under the apple class and comparable for each natural product. Pictures for the informational index are gathered from ImageNet. Each class comprises roughly 400 pictures. This subset of pictures makes a base informational collection to prepare the organizations. Past

utilizing a solitary informational index brought from ImageNet, pictures taken in a climate like a retail location have been added to the subset to make a subsequent informational index. The extra pictures comprise every one of the 10 classes and 30 pictures for each class. The designers of Tensorflow prescribe retraining networks with pictures like the workplace. The extra pictures address around 7-8 % of the absolute informational collection. For retraining the organizations, the subsequent informational collection was utilized. For this venture, pictures of vegetables have been taken without being set in plastic sacks.

## **3.2 Implementation**

This section will go deeper into the steps the system takes to display a result. The image capture and classification will be referred to the back end, they build the backbone of the system. The graphical user interface is referred to as the front end, it is what the user will interact with. The work flow is described from back end to front end and starts with the activation mechanism and ends at the graphical user interface.

### **Workflow**

The system is started by launching the individual modules separately. Each module works independently from the other and will keep on running regardless if any of the other modules are unavailable. The back end is launched by starting a python script from the command line tool using the 'python' command. The Node.js middleware and React front end are launched in a similar way using the 'node' and 'npm' command respectively. Once all modules in the system are started, the back end waits for an activation mechanism to start. As the back end receives the starting signal, from the activation mechanism, an image is captured from the connected camera. This image is passed to the convolutional neural network for classification. The result from the classification is sent to the middleware using an HTTP post request. Once the middleware receives the post request, it redirects the data to the front end. The front end is constantly waiting for a response from the server. When the front end receives the data, an automatically push to the Result-page where the data from the image classification is presented.

### **Activation Mechanism**

The activation mechanism to the system is a 5 kg double bending beam load cell. The load cell is connected to a HX711 amplifier which in turn is connected to the pins of the Raspberry Pi. From the amplifier, the ports DT and SCK are connected to GPIO 5 and GPIO 6 on the Raspberry Pi respectively. The system is activated by placing an object on the load cell. If the measured weight of the object exceeds 200 grams, the system will proceed to capture an image.

## **Image Capture**

The camera is placed on top of the system and tilted forward towards a flat surface in front of the system. The purpose of this is to minimize the interference from other objects in the surroundings that otherwise could affect the results of the classification. The interference are objects, patterns and colours not relevant in the task of classifying the main object. In other words, not everything part of the vegetable or the fruit. To further decrease, the interference in the image a resolution of 640 by 480 was chosen. This resolution gives a user some leeway for where the object is placed in the image as well as cutting away interference in the surroundings. Once the camera is active, it waits for the activation mechanism to trigger. When the system is triggered, an image from the camera is captured and saved to a numPy array with a size equal to the resolution. The numPy array is then passed to the classifier.

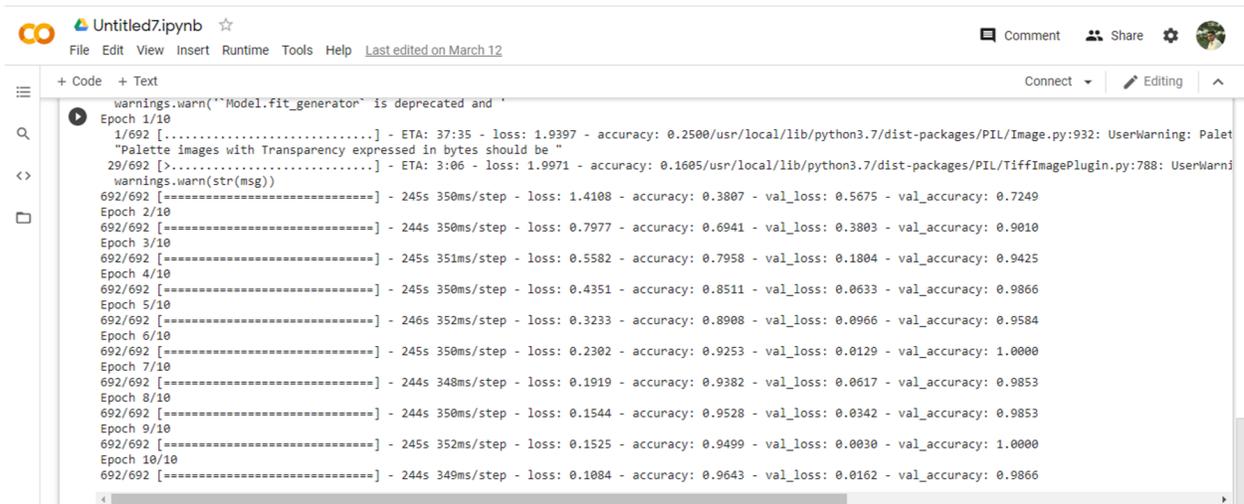
## **Classification**

When the classifier is initializing, it loads the pretrained model specified as an argument. This is by far the most computational heavy operation and is only done once every initialization. Furthermore, the classifier also defines image-preprocessing operations in the initialization phase. This will prevent an issue where these operations are recreated for every image and thus creating a memory leak. Once the initialization is complete, the classifier is ready to receive images one at a time. The image is provided to the classifier as a numPy array in a function argument. Before any processing of the image takes place, an HTTP post request is sent to Node.js. The purpose of the request is to inform the front end that a classification process is about to begin. After the request is issued, the image is transformed into a Tensorflow object called tensor. The tensor applies the image preprocessing operations before propagating it through the network. The image preprocessing involves subtracting the image mean to every pixel and resizing the image to fit the

input layer of the network. After the image is propagated through the network, an array is extracted from the output layer. This array contains the probabilities of the object in the picture for each of the classes the network is trained to recognize. The top five values are extracted from the array and staged to be transferred to the user interface.

## HTTP post

During the staging process, the array containing the results from the classifier is encoded into a JSON object. The JSON object is then added to the HTTP post request and sent to kaggle. Once the respond is sent, the returning status code is evaluated. Should anything else other than a status code 200 return, a second post request is sent. If the second post request does not receive a status code 200, the system assumes something is wrong on the other end and returns to the waiting state to capture an image.



The screenshot shows a Jupyter Notebook window titled 'Untitled7.ipynb'. The code cell contains the following output:

```
warnings.warn("`Model.fit_generator` is deprecated and
Epoch 1/10
1/692 [.....] - ETA: 37:35 - loss: 1.9397 - accuracy: 0.2500/usr/local/lib/python3.7/dist-packages/PIL/Image.py:932: UserWarning: Palet
"Palette images with Transparency expressed in bytes should be
29/692 [>.....] - ETA: 3:06 - loss: 1.9971 - accuracy: 0.1605/usr/local/lib/python3.7/dist-packages/PIL/TiffImagePlugin.py:788: UserWarni
warnings.warn(str(msg))
692/692 [=====] - 245s 350ms/step - loss: 1.4108 - accuracy: 0.3807 - val_loss: 0.5675 - val_accuracy: 0.7249
Epoch 2/10
692/692 [=====] - 244s 350ms/step - loss: 0.7977 - accuracy: 0.6941 - val_loss: 0.3803 - val_accuracy: 0.9010
Epoch 3/10
692/692 [=====] - 245s 351ms/step - loss: 0.5582 - accuracy: 0.7958 - val_loss: 0.1804 - val_accuracy: 0.9425
Epoch 4/10
692/692 [=====] - 245s 350ms/step - loss: 0.4351 - accuracy: 0.8511 - val_loss: 0.0633 - val_accuracy: 0.9866
Epoch 5/10
692/692 [=====] - 246s 352ms/step - loss: 0.3233 - accuracy: 0.8908 - val_loss: 0.0966 - val_accuracy: 0.9584
Epoch 6/10
692/692 [=====] - 245s 350ms/step - loss: 0.2302 - accuracy: 0.9253 - val_loss: 0.0129 - val_accuracy: 1.0000
Epoch 7/10
692/692 [=====] - 244s 348ms/step - loss: 0.1919 - accuracy: 0.9382 - val_loss: 0.0617 - val_accuracy: 0.9853
Epoch 8/10
692/692 [=====] - 244s 350ms/step - loss: 0.1544 - accuracy: 0.9528 - val_loss: 0.0342 - val_accuracy: 0.9853
Epoch 9/10
692/692 [=====] - 245s 352ms/step - loss: 0.1525 - accuracy: 0.9499 - val_loss: 0.0030 - val_accuracy: 1.0000
Epoch 10/10
692/692 [=====] - 244s 349ms/step - loss: 0.1084 - accuracy: 0.9643 - val_loss: 0.0162 - val_accuracy: 0.9866
```

Listing 3.1: Example of a object sent to google colab.

## Graphical User Interface

The graphical user interface is coded to work as a browser application. It includes several components to make it easy for any developer to understand. The GUI is written in the text editor Atom including formatters and packages to ease the coding and auto indent the code, specifically

to use with React. The code is kept simple and clear and follows programming "rules of thumb". Names are adjusted and chosen for the purpose of the component. The maximum length of any component is 200 rows to keep the code airy and avoid mistakes leading to bugs or possible flaws. The user interface is written in JavaScript with the React library. It is styled with classes created with Cascading Style Sheets (CSS) combined with inline styling.

The content of the application is rendered every time the code is saved which enables updates in real time. Possible errors and warnings are printed in the terminal of the computer where the application runs. More specific errors and warnings are printed in the console of the web browser and displays every time the content is saved. This property provides effective development and since almost every change is saved and updated, errors and mistakes are easily noticed.

### **3.3 Network Evaluation**

This segment depicts the strategy and setup for how the organizations are assessed and tried. The organizations are assessed by two properties. Engendering time, which is the time it takes for a picture to be characterized, and exactness, which is the way precise the expectation is.

#### **Accuracy**

To appropriately assess the exactness of the organizations, a setting near the workplace of the result must be made.

Since the camera was at that point shifted forward, as referenced, a level and moderately similarly shaded surface must be set up. When the climate was set, pictures of Green vegetables caught by the mounted camera were spread through the organization. The aftereffects of every order were signed into a book document and later arranged. A sum of 10 tests was directed to each organization. Each test yielded 10 examples of exactness on natural products or vegetables from various points and in different sums. This brought about 100 examples of precision for each organization.

#### **Propagation Time**

To assess the engendering season of the organizations, the arrangement of 100 pictures was caught and grouped. The proliferation time is the time between the beginning and end of the characterization. Each trial of an organization was run multiple times and yielded 700 examples of time proliferation per network. The substance of each picture was not of importance and in this way not saved since it didn't influence the result of the deliberate time. Also, just one organization was stacked per test to forestall filling the working memory and influencing the result of the proliferation time. Each example was kept in touch with a log document and later assembled.

### 3.4 System Testing

#### Usability Evaluation

Three heuristic evaluations has been performed, one on the existing systems in the retail store, and two on the produced system:

**Heuristic Evaluation 1:** Test performed on *existing systems* in the retail market. The system uses manual identification of the vegetable.

**Heuristic Evaluation 2:** Test performed on *progressing system* to discover flaws during the development

**Heuristic Evaluation 3:** Test performed on *finished system*.

The tests has been performed on five test persons since the method only requires 3-5 persons to find 70% of the usability flaws. The heuristic evaluation has following steps to be completed:

1. Recording of the procedure starts
2. The individual is asked to identify a vegetable
3. The recorded material is analyzed

The usability tests are performed without any information given to the user. The user is simply requested to identify a vegetable with the goal of printing a label. No information is given which

could lead to any clues or guidance. The result has been analyzed by following the interactions between the individual and the computer to find any possible flaws.

Furthermore, another kind of usability test of the system has been performed with the help of fifteen individuals. The individuals are of different age, gender and background to get as many insights as possible. The test was created by the project members and is called the "Prelaunch Test". The test was performed when the project members felt the graphical user interface was finished. Since the project members is the creators of the system, the procedure of identifying a product is clearly precieved, hence there is no experienced usability flaws according to the creators. To find possible flaws not detected by the creators and to get inputs from the users, the Prelaunch Test was performed.

The Prelaunch Test included following questions and tasks:

1. First impression evaluation by the user
2. The user is requested to find the specific vegetable he or she has chosen. No description is given. The user can either search for the product.

## CHAPTER 4

### RESULTS & DISCUSSION

#### 4.1 Network Architectures

The networks are evaluated in terms of accuracy and propagation time. Data for evaluating these networks was collected by performing the two types of tests. The results presented in this section are from the final versions of kaggle and Inception after three iterations of retraining.

##### Accuracy

The disarray frameworks introduced beneath show what the classifier generally confuses an organic product or vegetable for. Four kinds of shading markings are utilized. Green, which are classes where the organization performs with precision higher than 90%. Blue, classes are anticipated to be right the greater part of the time yet not practical enough to get a green stamping. Red, classes the organization neglects to anticipate. At last, yellow is utilized to check classes that the organization confounds a sort of natural product. An organization's main 1 precision can be determined by isolating the amount of the slanting by the number of tests performed. This disarray framework shows the best 1 precision for the organization. Furthermore, a disarray framework for the best 3 forecasts is likewise shown to show great the organization is at setting the right name among the main three positions. To additionally research the precision of the organizations for certain classes, an aggregate lattice bend, CMC, to the related class will be introduced. The CMC shows how great the organization is at setting the right natural product in the best 1 to 5 position individually. The x-pivot shows a position from 1 to 5 and the y-hub shows the exactness for that position.

##### Discussion

In the beginning, we were satisfied with the results of this project and the experience we had. The project was at a stage with the expected degree, but more extensive than expected.

The goal of this project is to make a system more user-friendly than existing systems. It is almost impossible to classify the graphical user interface as user-friendly. Everyone has to do it himself or herself but there is a way to find some usage errors in the graphical user interface.

Comparing the usability of two systems gives its objectives if one of the systems is more user friendly than the other. The idea of creating a system with applied image classification arose when using existing systems. We as their experience:

- Then more complicated than necessary

- Many many options are available

- Natural No natural flow

- An unnecessary amount of interaction

We wanted to create a system that we liked to use on top of existing systems and where other people shared our opinions.

## Chapter 5

### Result & Discussion

#### 5.1 Results

##### Usability Evaluation

Compared with the existing system, the theoretical evaluation indicated a positive result. Users liked the design and felt that attendance had improved compared to existing ones. The first plan was to make an evaluation of the existing system and another evaluation of the created system. But we didn't know if our finished system was easy for anyone else to understand. Therefore, we decided to conduct a prelaunch test and a second theoretical evaluation to see if the system needed to be improved. We've done tests, made some changes, and considered the system finished.

The prelaunch test and heuristic assessment 2 were shown to be very useful. Our system lacked some functions and had some valuable input from the user which changed our design. The most common comment about the system was that the display was too small. The result of a small display limits the font size and the size of the product item. Implementing larger displays is a part of further development. Prelaunch tests and heuristic assessments have made us realize that the system has several usage errors.

However, according to the prelaunch test, 86% indicated that they would use our system instead of existing ones in the retail business.

The heuristic assessment 2 concluded that the number of guidelines was lower than the existing system. However, the manufactured system included usability errors that were not found in the existing system. This is probably because we have focused on solving problems in the existing system and by doing this we have created a new one.

The minimum guideline was discovered that the user's memory load was broken on the existing system due to this comment "Users should not remember whether the result is environmental". However, since the system produced does not have the ability to distinguish between any ecological vegetables or regular vegetables, as a result, the system will also violate this guideline.

In conclusion, there is no user error as indicated by the heuristic assessment 3. Nevertheless, usability testing helps GUI builders find about 70% of usability errors. This means there is a risk that the system includes usability errors that cannot be detected by testing. As Nielsen puts it in her research on testing the interfaces of several users: [1]

“So in the best case even half of the problem was found, and the general case was very bad. In fact, these numbers are not so bad either. Even finding some problems is certainly much better than solving any problem, and the heuristic method can be complemented with another usability engineering method to increase the total number of problems found.”

Our interface may contain usability issues. However the problems have been reduced and as per Nielsen’s proposal, we have created one more usability test. For the final product, other types of usability tests will be applied.

### **Dataset**

The set was very acceptable even in the wake of getting a little level of data from the kaggle. The burden of the organizations for recognizing clematis and orange is that they are fundamentally the same as in appearance to the two natural products. Adding more pictures to this classification will probably not improve precision. Rather than extra contribution as weight, these two organic products can be considered independently. Like radish, precision can be improved by making another arrangement of pictures for this class. Right now, the majority of the pictures show the kiwis open cut and their green inside. These pictures don't portray what resembles a kiwi in a biological climate and the organization doesn't perceive the natural product.

### **Sustainability and Policy**

As engineers of the future, we have a responsibility to create and develop to be as sustainable as possible. To contribute to sustainable development, we must have the skills to design and operate the product considering the conditions and needs of the people. Besides, follow the goals of the social and economic guidelines of the society. Following these guidelines for sustainable development, the following points will be part of the policy and responsibility.

## **5.2 Ecological Sustainability**

Product footprints will be calculated and compared with existing products. Footprints calculate what impact an organization will have on the environment and its guidelines if a business uses more resources than the world's resources. In our case, it includes hardware manufacturing, hardware operation and transportation, and the energy used to maintain and develop systems. The goal is to run the business with the minimum possible steps and compensation for the business's gas emissions.

Moreover, the retail business has an impact on the vegetable environment when supplying or selling goods. Alternative fuel vehicles will be chosen with less contribution to gas emissions. Environmental liability includes waste recycling, renewable energy use and systematic work to follow and develop energy use. Further, taking a step towards selecting environmentally targeted manufacturers and factories rather than selecting affordable suppliers.

## **5.3 Social Sustainability**

To perform the business endeavor with social responsibility, the relationship between the customer, other businesses, manufacturers, and individuals within the organization must be supportive and collaborative. Those we contact will be treated similarly regardless of their origin, sexual orientation, gender, skin color, religion, or opinion.

## **5.4 Economic Sustainability**

Product development will be conducted following economic stability. Managing materials and human resources are most important for long-term settlement. The development will be driven to achieve continuous growth but social or environmental assessment should not be spent.

## **CHAPTER 6 CONCLUSION**

## **6.1 Conclusion**

The use of convolutional neural network to improve the process of identifying green vegetables by self-service systems in the retail market is a success. Quick detection results with accurate predictions. Some green vegetables were harder to label than others were and the reason for this can be found in the data set used during network retraining. The graphical user interface has fixed some usability issues on existing systems but has created new ones. Overall, the number of usage problems has decreased. The system still needs further development towards the back end and front to cover performance and usability issues. The project group would have done this development if more time was available. However, considering the scale of the project, the project has come a long way unexpectedly and the project group had almost no experience at the beginning.

The rest of this chapter will be devoted to answering questions on the issue and assessing goals and functional requirements.

## **6.2 Further Development**

### **User Interface**

Since three to five test subjects find usability issues with a heuristic evaluation of the user interface, more tests need to be performed. After five test subjects, the theoretical assessment reaches the stage of declining returns [14].

### **Optimize the Network**

Retraining networks in informational indexes from their genuine climate can get the organization more awesome. Utilizing informational collections from ImageNet, pictures of leafy foods in various conditions are accessible. Since it should work in any of the characterized retail locations, it is never accessible as a woods for instance. In this manner, preparing pictures that vary from the workplace may befuddle the grouping of the qualities of any vegetable that are essential for the picture. Preparing on informational indexes from the real climate will upgrade the organization

and is suggested in certain instructional exercises and establishment guides for TensorFlow and OpenView. The distributed work portrayed in Section 2.1 just uses pictures taken in the workplace during network retraining [1] [23]. Notwithstanding, the exchange learning strategy is as yet applied to diminish the number of pictures that should be contained. There is additionally the chance of retraining an organization without any preparation without applying move learning, however, this appears to improve just the smallest exactness [30].

On the off chance that we gather pictures from a climate where the framework should be served, we can likely build the precision. Besides, if more pictures are gathered, the classes can be isolated into various kinds of green vegetable subclasses. For instance, the apple class can be separated into subclasses like Granny Smith, Pink Lady, and Royal Gala which are a wide range of apples. Notwithstanding, there is a danger that partitioning a class into subclasses for each sort of natural product or vegetable is exceptionally trying for network arrangement. Although a large number of preparing tests have been given, it is practically difficult to anticipate the result of retraining. More unsurprising conduct can be accomplished by applying numerous organizations. The primary organization just chooses what sort of result it is. The undertaking of grouping the vegetable subset is left among the numerous effective organizations of single natural product elite advantages. Such techniques examine the vegetable location in the nursery [1] and vegetable. A vegetable location framework utilizing profound neural organizations [23] shows sensible subjective execution for a framework with comparable usefulness.

Another approach to build exactness is to take numerous pictures and characterize each. A type of democratic framework is then applied after the arrangement of each picture. The class that has the best positioning among every one of the orders will be the last answer. An option in contrast to this strategy is to take a solitary picture and apply a different preprocessing method for each picture and afterward execute the democratic. An undeniable disadvantage to this methodology is that the necessary expanded calculation change builds an opportunity to utilize the extra calculation framework contrasted with the characterization of a solitary picture, which can just give a helpless client experience.

At last, more mind-boggling strategies for organic product distinguishing proof exist. Quick district-based CNN (R-CNN) has been appeared to give exact outcomes in gardens [1] [23] and perhaps a superior option in contrast to CNN

### **Data Transfer**

One of the nine guidelines when developing an interface is to keep the user informed of what's always happening. If the system fails to complete some process or simply crashes, the user should be notified of this event. On the system, there is no way to notify the user of errors that occur on the back end. This is because the back end is sending data to Google Collab. By transmitting data via HTTP request, no communication channel is established in which both parties are aware of each other. Node.js simply redirects the received data. If by any means the rear end is not able to send data to the node.js, it is impossible to say that the rear end is wrong. From the point of view of Node.js, middlewares are easily unaware that they have tried to issue HTTP requests. Google Colab is not able to easily inform the user that something has gone wrong.

The problem can be solved by redesigning the back end by sending data to Google Collab. The implementation of a socket completed between the node.js and the front end enables the possibility of disconnection at both ends of the channel. If disconnected, both the rear edge and node.j can be aware of the event and disconnect.

### **Database**

The project was supposed to include a database to fetch fruits and vegetables from. However, since the project was bigger than expected, the database became the least priority due to its low importance. The database is a part of further development and will be integrated in the future.

### **Hardware and Physical Appearance**

According to the usability tests, a bigger display was desirable. Due to the strict budget of this project, a small touch screen was chosen. Using a 13-inch screen instead, would give the user an

interface displaying larger buttons and bigger font size. However, a larger display may affect the processing time.

The case used for the screen and Raspberry Pi lacks some obvious security. At the back of the system, there is visible cables between the display and the Raspberry Pi. Furthermore, the cable between the camera and the processor is visible and easy to remove if wanted. The camera is attached to the case with a small pressure and removed with low traction.

## **Policies, Laws and Regulations**

### **Laws and Regulations**

To get this item into a business, a few concerns ought to be thought of. Probably the main concerns are laws and guidelines. In May 2018, the General Data Protection Regulations (GDPR) will come into power and the old guidelines will supplant Paul. Huge changes partner the organization with delicate information, for example, individual code numbers, names, bank subtleties, photographs, or email addresses. Since this item incorporates a camera for taking pictures, there might be a danger of getting an individual's face in the image.

The purpose of following the rules for the use of cameras in any organization is to protect the integrity of the people. This product will not be placed in an environment of public access; It will be placed inside a store. The Swedish authorities in Sweden have demanded a report on the surveillance of Lansterlin cameras and the product will be acceptable in the market. Whether it is the product owner or the store owner, is responsible for future investigations.

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