FRUIT CATEGORIZATION TECHNIQUE BY USING FUZZY LOGIC AND NEURAL NETWORK

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15481

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CERTIFICATION OF APPROVAL

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Approved by,

_____

(A.P Dr. Zuhairi B. Hj Baharudin)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

SITI NOORATIQAH BT. MOHD NORDIN

ABSTRACT

Before fruits can be issued to the consumers, the fruits will be going through thorough processes and one of the processes is grading. The fruits will be graded according to the standard. The standard is based on the fruits' country of origin (Malaysian Standard, MS and FAMA Standard). This project is a Matlab simulation of fruits categorization (grading) using artificial intelligent (AI) technique (Fuzzy Logic and Artificial Neural Network) in order to overcome problems faced on the existing system or current method. It is also to ease, fasten the process of fruit grading, and produce consistent and accurate result. Since there are numerous types of fruits, this project will only be focusing on the grading of mangoes, papayas and starfruits or carambola. The input of the system will be the properties that needed to determine the grade of the fruits such as weight, color, shape and the exterior condition of the fruits (defect). Rather than using hardware such as scanner, camera to automatically detect or to give input to the system, the input of the system will be manually keyed in by user. The data of the input will be processed using Matlab Fuzzy logic (FL) and Neural Network (NN) toolbox. The system will process the input with the reference data programmed in the system. The output of the system will be the grade and size of the fruit.

ACKNOWLEDGEMENT

Given the opportunity to be working and completing the project under the supervision of my supervisor, A.P Dr. Zuhairi B. Hj Baharudin is a privilege to be grateful for. With his trust and guidance, I managed to complete this project within the time given, simultaneously experience and learned new things. Throughout completing the project, although sometimes it is quite hard and frustrating but I managed to overcome the problems faced.

I am also deeply indebted to FAMA RTC Gopeng, FAMA Chui Chak, Langkap and FAMA KLIA representatives especially Encik Abdul Rahim and Encik Sharudin (FAMA Gopeng), Tuan Haji Mat Zin and Puan Zainab (FAMA Langkap), Encik Roslan and Encik Sharani (FAMA KLIA) for the collaboration held and cooperation given to ease the process of data sampling, details information and explanation in commodities grading practiced in Malaysia.

As artificial intelligence is not part of Electrical and Electronic Engineering syllabus in UTP, it is necessary for me to have my own initiative to learn and discover about the topic. Sincere gratitude to my colleagues; Tareq and Nasih for their time spent and all the assistance given in helping me out to understand and learn about the Fuzzy Logic and Neural Network in Matlab.

Last but not least, thanks to my family and friends for being understanding, the continuous supports and companies that help me to keep going and stay motivated.

Above all, utmost appreciation to the Almighty God for the precious opportunity to allow me to complete this project. Alhamdulillah.

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INTRODUCTION

1.1 Project Background/Background study

1.1.1 Fruit grading/categorization

Fruits and vegetables are the important type of food which contains variety of nutrition that helps minimizing the possibility of diseases and become the alternative for better and healthy living. Other than dieting, it also use for cosmetic purposes. Since fruits and vegetables (commodities) are natural ingredients, it is preferable by the consumers rather than the product that uses chemical ingredient. Since fruits carry important role in human's life, the quality of the fruit used is also important. The quality of fruit is one of the factors to be considered in determining the price of the fruit. The quality of the fruit is determined by the grade of the fruit. Each fruit has its own standard that need to be followed in order to maintain the quality of fruits before it can be marketed to the consumers, especially the exported ones. The price of fruits is also based on the size. The bigger the size of the fruit and the better the quality (grade), the higher the price is. In Malaysia, the standard of the products must be according to the Malaysian Standard, MS. The agency responsible to monitor this activity is the Federal Agricultural Marketing Authority (FAMA) *[1] [2]*.

1.1.2 Artificial Intelligence (AI)

Artificial Intelligence (AI) is a modern technology of system that can make decisions and solve problems. It imitates human's behavior and 'intelligence'. The main objectives of AI research are to understand human cognition, to invent cost-effective automation to replace humans in intelligent tasks, general problem solving and to learn about the system on how to store and retrieve information. Acting like a human being, AI is a system that works automatically (sensors as input to provide data to be processed) and makes decision or reacts based on the reference data programmed in the system. AI is currently used in variety of industries, carrying out different functions and wide range of scope. AI is commonly related with robotics as

it is currently copying the human capability of walking, talking and "thinking". ASIMO is one of the famous applications of AI *[3, 4]*.

1.2 Problem statement

Several factors need to be considered in order to determine the grade or class of the fruits which are the weight, the smell and the appearance (color, texture, shape, defect and etc). Different fruit has different specification in determining the grade. Therefore, the same specification and range for all type of fruits cannot be used since the factors are also different. The categorization of fruit can be classified into three categories (depending on the type of fruit); Premium, Grade 1 and Grade 2. The color of the fruit represents the maturity of the fruit. The tone of the fruit's color is called Maturity Index. *[5]*.

1.2.1 Training and courses needed

In Malaysia, most of grading process is currently done manually by personnel who are known as Agricultural Commodity Grader (ACG). ACG is responsible in sorting the fruits according to its category based on the specification or standard. In order to do so, ACG must be very familiar with the product (in this case, the fruits). As mentioned earlier, different fruit has different standard and class. This job requires experience, good decision-making skill, alertness and knowledge about the fruit. The personnel need to be trained by attending courses, taking tests and go through probation phase for some time. Therefore, it takes quite some time to hire qualified personnel to do the task.

1.2.2 Human factor error

Since the current grading process is done manually by the ACG, it is a human dependent process. Hence, several factors might affect the judgment of the personnel in grading the fruit, which it is called as Human Factor Error. ACG needs to be in a good health and condition; physically and mentally. If the personnel are tired, the duration to grade the fruit taken might be longer. If the personnel is sick and absent,

the workload of the other personnel might increased. Personnel might overlook some features of the fruit in grading that can cause errors to occur. The grading might be various depending on the personnel who are grading the fruit although it is according to the standard as human tends to make mistake. The duration taken to grade certain amount of fruit may also inconsistent and the fruit's grade may not be accurate. A huge numbers of fruit has been graded and exported but all the data of graded fruit is not recorded. It is impossible to track (if error occurs) or to improve the quality if no data to refer to.

1.2.3 Limited source/function

For some commodities, the process can be done by machine instead of manually. Sorter or grading machine is the latest technology to increase the speed of fruit grading in large amount of fruits. Unfortunately in Malaysia, fruits that being sorted using the grading machine can only be done in certain places such as in Kedah and Cameron Highland. The grading machine is specified only for the particular type of commodities or fruits and normally it is available for small size of commodities. The one in Cameron Highland is only for tomatoes. In this case, if more type of commodities needs to use the grading machine, more machines needed which is inconvenient as it will cost more and require bigger space.

1.3 Objective

The objectives of executing this project are;

i. To utilize the Artificial Intelligent (AI) technique to categorize fruit according to its grade
ii. To contribute to the current development of agricultural industry in Malaysia
iii. To ease and fasten the process of fruit grading in Malaysia
iv. To be exposed with artificial intelligent system
v. To improve MATLab skill

1.4 Scope of study

1.4.1 Type of fruits chosen

Agricultural industry is one of the industries that affect Malaysia's economy. Exporting fruits internationally is one of the agricultural contributions. The quality and the quantity of fruits being exported or marketed to the consumer determine the price of the fruit. The better the quality and more quantity of fruits offered, the higher the price of the fruit can be sold and the better the profit to the country. Three fruits that are chosen as the main focus of this project are mango, papaya and starfruit or carambola. These three fruits were selected since the quality of these fruits help in contributing Malaysia's economy.

Malaysia is the main exporter of startruit or carambola in the world. Starfruit is the Malaysia's forth important commodity after papaya, watermelon and durian. The demand of this fruit is increasing from time to time. As mentioned earlier, papaya is one of the top Malaysia's four important commodities. Malaysia used to be the main exporter in papaya trade but the market of Malaysia's papaya has decreased. Therefore, it is important to help regaining Malaysia's place in global papaya trade *[1, 6]*.

1.4.2 The system

In any system, there are three main parts; the input, the processor and the output. In order to create an intelligent system, the system also must contain these three main parts. These three main parts of the system is depending on the system that wants to be constructed. Input can be fed to the processor via various methods; either automatically or manually inserted. There are several input methods that have been used in conducted researches such as an image captured by CCD (charge coupled device) camera, scanned image by scanner, the measured intensity of a light absorbed or reflected by spectrophotometer *[7-9]*. A processor of a system is the part where the input is being process to produce the output. This process can also be using various methods. An output of a system can be in any kind of form. For example, it can be in form of motorized (involve movement) or visual (a blinking LEDs or a monitor displaying the result).

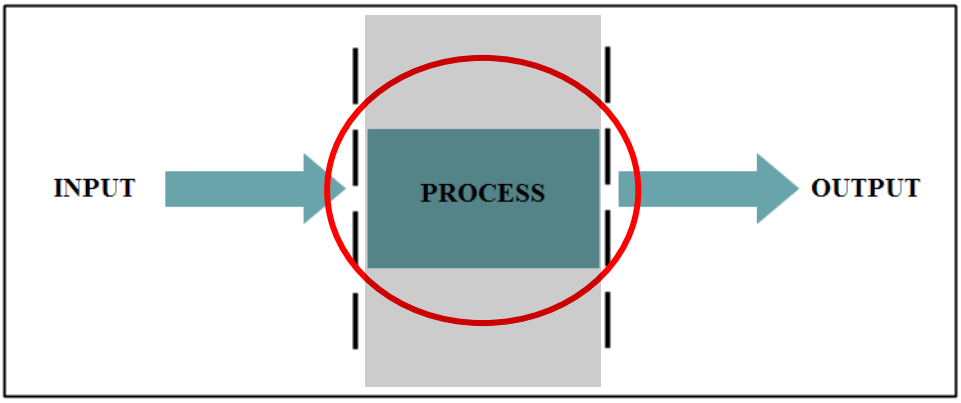

Figure 1: Basic block diagram of a system

Due to time constrain and the complexity of the project, this project will be only focusing on the processing part. In this project, the properties of fruit to be considered are the weight, the shape, the color and the exterior condition (defect) of the fruit. Since this project is only concentrated on the program or the system (simulation using MATLab), the input of the properties need to be keyed in by user manually since no hardware to sense or detect the input automatically. Moreover, there is no output such as a conveyor belt or sorter to sort the graded fruit (from the configured system).

CHAPTER 2
LITERATURE REVIEW

2.1 Artificial Intelligent (AI) Technique

AI can be programmed using expert system or learning program. An expert system is based on observation and the structure of programmed AI while learning program is based on experience, a program that needs to be trained. Fuzzy Logic (FL) is one of the expert system methods and Artificial Neural Network (ANN) is a learning program method.

2.1.1 Objectives of AI

AI is invented or created in a way to comprehend human cognition by discover how does human brain and mind works, why does it works in that kind of behavior and etcetera. Human cognition needs to be understood first prior programming AI since another purpose of AI is to go beyond human intelligence. AI is a cost-effective initiative for replacing human being in certain area and to amplify human intelligent. Since AI is a system, it can be enhanced to be more consistent, faster and better unlike human intelligent that is not programmable *[3, 4]*.

2.1.2 Turing Test

In order to verify whether the AI is working correctly or not, there are methods to test its function. One of the tests is a Turing Test. Turing test is to evaluate the AI by comparing the result for given problem between the programmed AI and a human being. Turing test can also be described as to trick the evaluator. If the result of the AI is the same as the result given by the human being, the evaluator may not able to determine which result or answer given by the AI or the human being. Thus, the objective of the AI is achieved which is to imitate the human intelligent. This project uses similar test to evaluate the programmed AI *[3]*.

2.2 Fuzzy Logic (FL)

Fuzzy Logic (FL) is a method where the AI is programmed based on experienced operator knowledge. It is a rule-based computer in making a decision. Since it is a programmed system, it is limited *[10]*. It cannot be adapted or easily change the condition. If the condition changes, the system needs to be reprogrammed. Nonetheless, this method is easy to construct and easy to understand. In order to construct the FL, there are three components involve in this method which are Fuzzy sets, Membership Function and If-Then Rules.

2.2.1 Fuzzy sets

Fuzzy sets of FL can be more than one (multiple). The sets are the input of FL. It provides the category that the data to be processed belongs to. This input will be fed to the next stage and help to determine the membership function.

2.2.2 Membership Function

A membership function is where the input can be categorized in the range that can be grouped into three categories and it lies between the Boolean binary of 0 and 1. Membership function can also be considered as where all the reference data are located. Each fuzzy set has its own membership function. Figure 2 below portrays how the membership function works *[11]*.

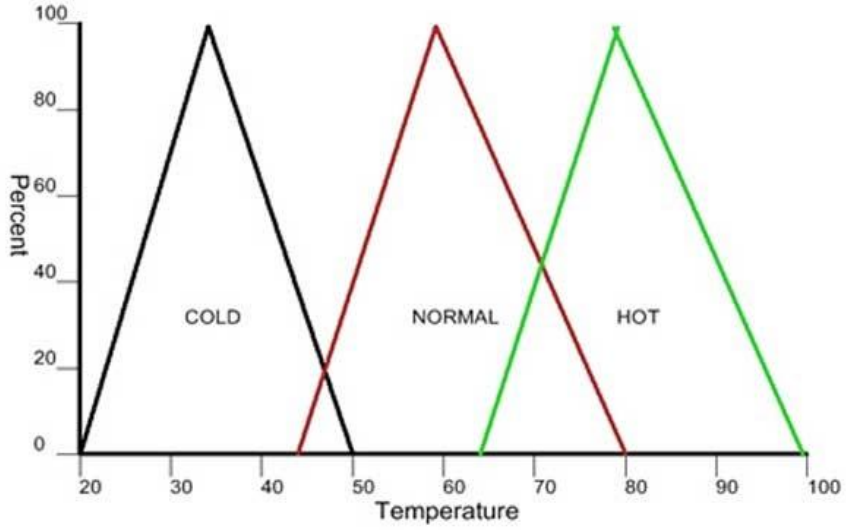

Figure 2: The example of FL membership function

The input (fuzzy sets) can be in any ranges and categories. Based on the example (figure 2), the category of the data belongs to is temperature. It is divided into three range; cold, normal and hot. The output-axis (percent-axis) is a number known as the membership value. The curve is known as a membership function. The membership function must really satisfy the condition that falls between 0 and 1. It is suitable for simplicity, convenience, speed, and efficiency of the system.

2.2.3 If-then rules

If-then rules are used to construct the correlation between the fuzzy sets (input) and the membership function. The rules will be determined by the user or programmer. The programmer decides how they want to relate the input with the membership function and what output they want from that relation. Using the functions of fuzzy logical operational AND, OR and NOT, the problem construction using fuzzy sets can be resolved *[10]*.

2.3 Artificial Neural Network (ANN)

ANN is a learning program which the system needs to be trained and more flexible compared to expert system. It consists of three layers; the input unit layer, the hidden layer and the output unit layer. Each layer connected to each other. This method works by recognizing the patterns based on the data sets. The layer has its weight; the weights specify the strength of the influence. Since the system is data dependable, the data used must be suitable and comes from very complex data set. Since it uses pattern recognition, the system needs to be trained and learnt. Thus, this method is time consuming but it is more suitable for uncertain type of problem.

2.3.1 Hidden Layer (Neurons)

Since AI is used to mimic human intelligent, the analogy of how human's brain works is being applied in ANN. ANN applies the same concept as brain's neuron structure. One of the important layers in ANN is the hidden layer. This hidden layer is consisting of neurons and this neuron interconnected to the other units to transfer the data or information *[11]*.

2.4 Existing system and current method

Site visits have been conducted to FAMA Chiu Chak, Perak and FAMA KLIA to observe the fruit grading process, gather information and interview the graders and managers. Based on the observation during the visit at Chiu Chak's farm, it can be concluded that the process of grading the fruits done manually by exporter. There is no weighing machine. The weight that determines the size of the fruit being graded is done based on the workers experience. The workers have been doing the sorting process minimum duration of one to six years and able to sort the 50 to 60 boxes of fruit a day (eight working hours, 30 minutes break), depending on the number of workers working. This process is not only inaccurate, it is inconsistent and a heavy workload for the workers since most of the time the work being done while the worker is standing.

Figure 3: Workers conducting the packaging and grading process at one of the exporters' farm

FAMA KLIA on the other hand, instead of checking all the fruits sent by exporters, they only check few random samples from the whole amount of the boxes. Refer to Table 1 for the number of boxes that need to be checked depending on the total number of boxes to be exported. This is to shorten the duration of grading process by FAMA grader. Instead of checking the whole box of fruit, an assumption has been made that the sample boxes represents the rest of the boxes. If the exporters are one of the companies listed as the Self-Regulated by Regulated Entities (SRBRE), FAMA does not have to grade the fruit. They just need to approve the boxes of fruits that are going to be exported by checking the E-grading system.

No. of Box/Lot	No. of sample (Primary)
< 100 Boxes	5 Boxes
101 – 250	7 Boxes
251 – 350	9 Boxes
351 – 500	11 Boxes
501 – 750	13 Boxes
751 – 1000	15 Boxes
> 1000 Boxes	20 Boxes

Table 1: Method of sampling (papaya/starfruit/mango)

At least two graders are needed to perform the task. One of the grader will perform the inspection while the other one operate the e-grading system. FAMA grader needs to check the fruits manually by visually inspect the shape and the condition of the fruits. The fruit needs to be taken out from the box and to be checked one by one. As for the weight and size, a weighing machine is required. The reading from the weighing machine will be keyed in to the system, same as the shape and condition of the fruit.

Figure 4: FAMA graders are grading the fruits by manual inspection

2.4.1 Self-Regulated By Regulated Entities (SRBRE)

SRBRE is a program or system where exporter is given the right to grade their own fruits according to Malaysian Standard (MS) or FAMA. Exporters' company needs to apply for the permit from FAMA. However, only the authorized personnel by FAMA whom attending full courses of grading, passed the probation and auditing phase are allowed to do the grading for the exporters. All the details of the graded fruits will be uploaded to E-grading. The details will be checked and monitored by FAMA certified grader. If the grading is fine, it will be approved and proceed to the next process which is exporting.

Figure 5: Graded mango ready to be exported (Premium – left and Grade 2 – right)

2.4.2 E-grading

E-grading is a system used to help grader determine the grade of the fruits. It has been configured according to Malaysian Standard (MS) and FAMA specifications. It is a system that allows FAMA to monitor, approve and check all the details of other exporters, graded information done by SRBRE. If FAMA personnel want to approve the graded fruit by SRBRE, they just need to view the waiting list of Approval Application and approve them accordingly. If the FAMA personnel want to grade a fruit, they need to key in the information of the fruit manually based on the name of exporter (Refer to Appendix 2 for the sample of e-grading system).

The method is similar to this project but e-grading is fixed and it is not owned by FAMA. It is a paid system prepared by Dagang.net. Hence, it cannot be upgraded or reconfigured. Unlike this project, this project is basically focus on the system which can be adjusted, reconfigured and enhanced depending on the function, the inputs and outputs.

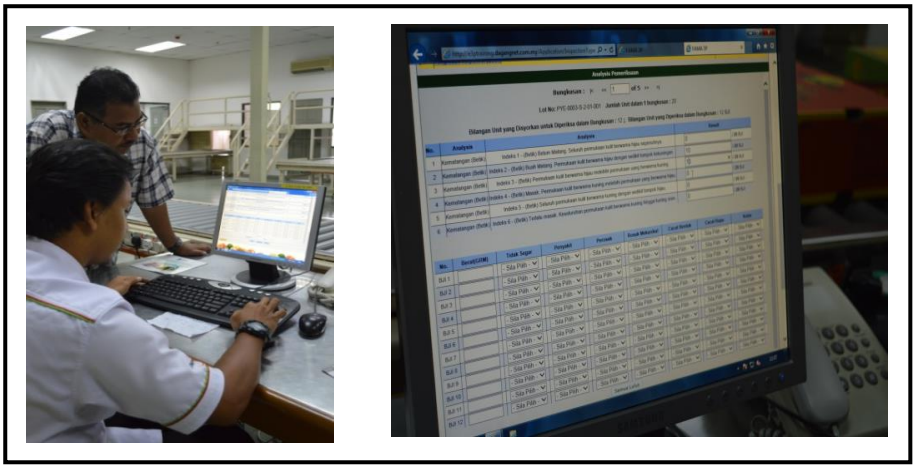

Figure 6: FAMA is currently using e-grading as their grading system

CHAPTER 3
METHODOLOGY

3.1 Gantt Chart

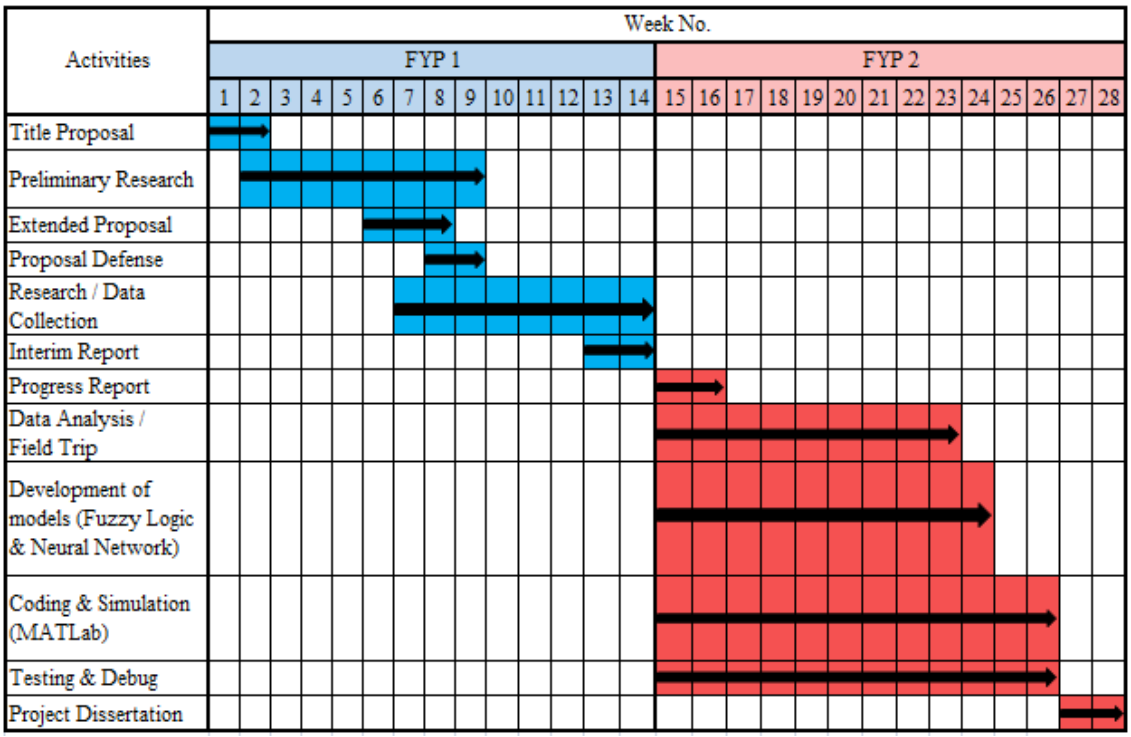

Table 2: Gantt chart of the project (FYP1 and FYP2)

Based on Table 2, the Gantt chart of the project is divided into two phases; FYP1 and FYP2. During the first phase of the project (FYP1), most of the activities done are basically involve with research and data collection. A firm understanding of the project is important before the project can be carried out. The collection of the data for the project is also crucial in order to program the system and to get satisfactory result. All data should have been collected and the system is being tested and troubleshoots until accurate result is obtained.

3.2 Project Key milestone

Activities	Week No.																										
	FYP 1														FYP 2												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Approved Title Proposal by FYP Committee		♦																										
Submission of Extended Proposal								♦																				
Completion of the Preliminary Research									♦																			
Execution of Proposal Defense									♦																			
Completion of Interim Report Documentation														♦														
Completion of Data Collecting & Analysis																♦												
Completion of models development (MATLab-Fuzzy Logic)																	♦											
Completion of models development (MATLab-Neural Network)																			♦									
Completion of Project(Simulation) Testing & Troubleshooting																										♦		
Completion of Project Dissertation																											♦	

Table 3: Key milestone of the project (FYP1 and FYP2)

Table 3 explains the key milestone of the project throughout both of the semesters and phases (FYP1 and FYP2). All the due dates and the targets of the milestone should be met for smooth execution of the project and to complete the project successfully on time.

3.3 Flowchart of the project

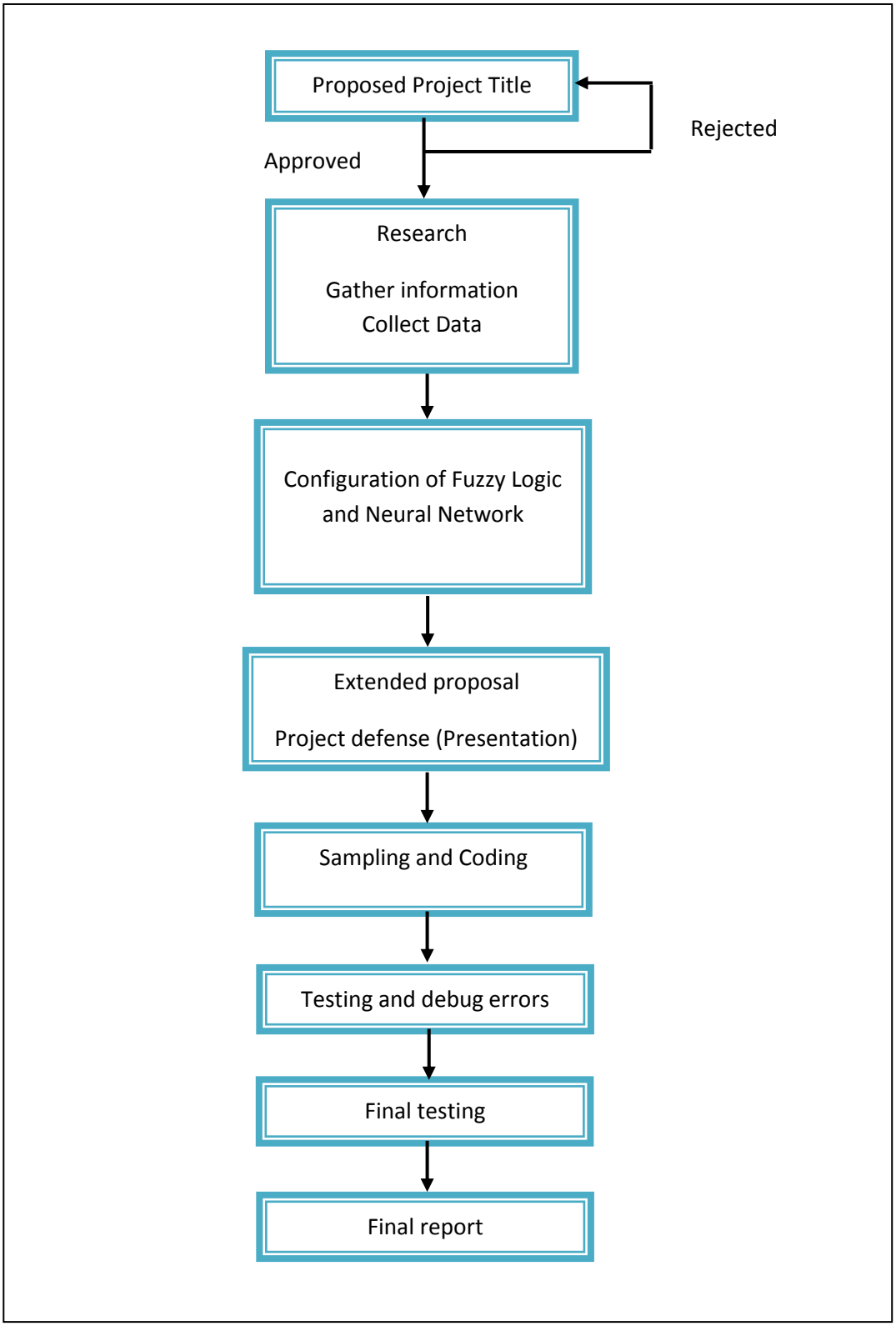

Figure 7: Flowchart of the project

3.4 Flowchart of the system/program

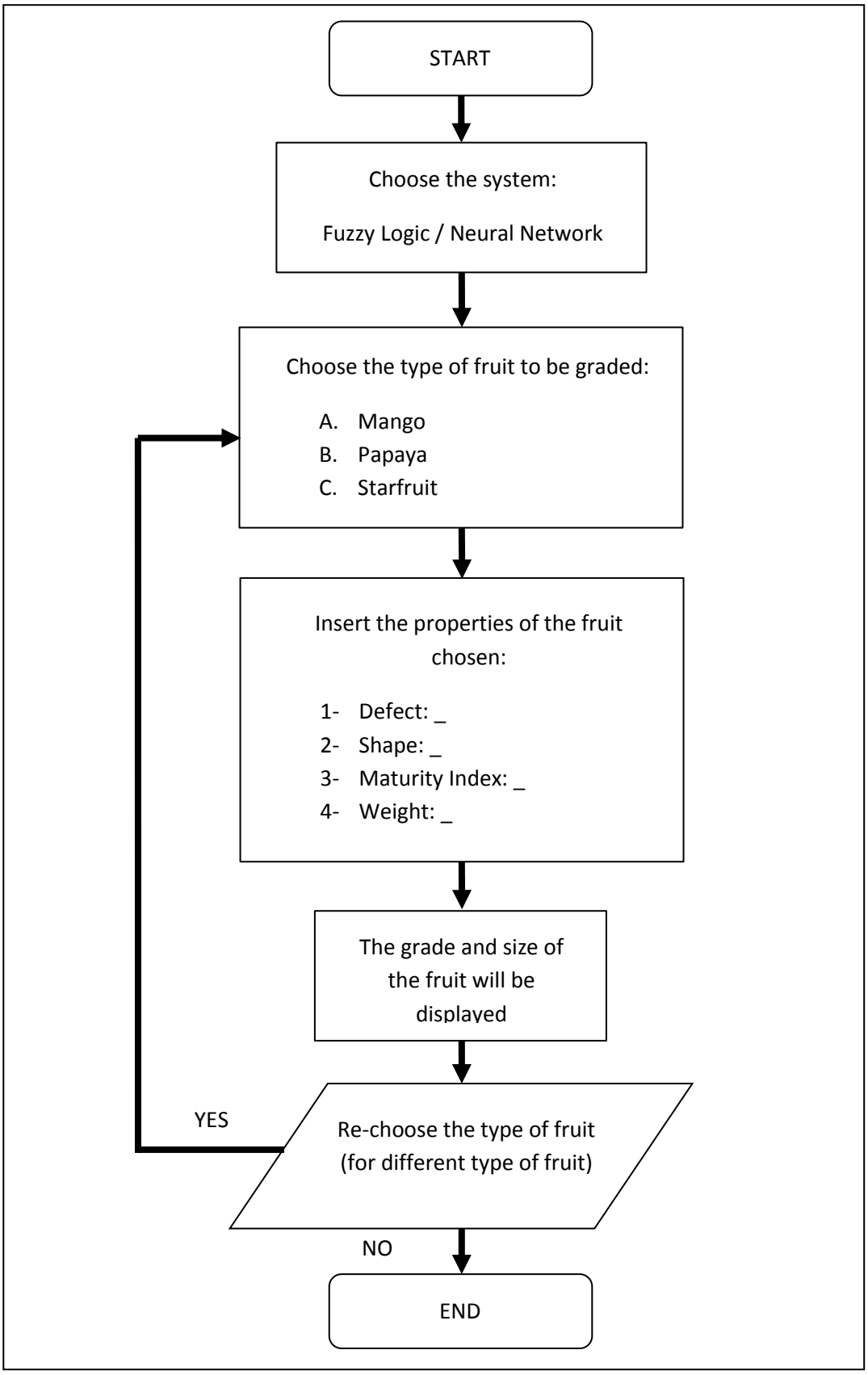

Figure 8: Flowchart of the system/program

3.5 System Configuration

3.5.1 MATLab (ver. 2009)

In order to code the program involving the Fuzzy Logic and the Neural Network technique, M-file is used. Code to do the command of the program will be using C and MATLab commands. The M-file will be the main part of the program as it will call the Fuzzy Logic and Neural Network functions *[12] [13]*. The program to combine both of the techniques (fuzzy logic and neural network) for all the three type of fruits (mango, papaya and starfruit or carambola). For each type of fruit, one Fuzzy Logic and one Neural Network are needed. Therefore, there are six fuzzy logic and neural network functions prepared for the project.

3.5.2 Fuzzy Logic Toolbox

MATLab Fuzzy Logic Toolbox eases the process of processing the data. The input of the program will be the properties of the fruit. Membership function plays an important role in order to determine the grade of fruit. This is where the reference data or information from the FAMA guidelines is stored. It processes the variables from the input according to the data of the membership function program and compares it using the configured if-then rules.

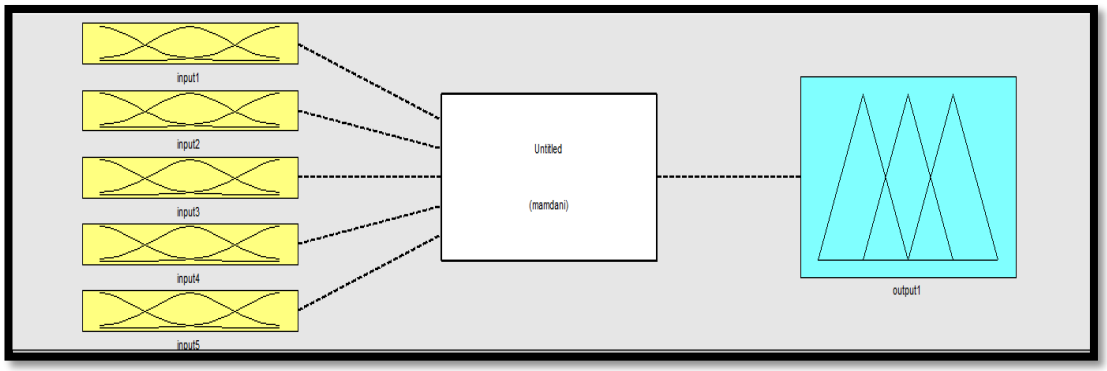

Figure 9: The overall structure of Fuzzy Logic (FIS Editor)

The variables are set together with the membership function according to the range for each of the properties; if-then rules compare the data from the input with the range set in membership function. Each fruits (mango, papaya or starfruit) are graded according to all these four characteristics;

Defect	Shape	Maturity Index**	Weight**
1 = Minimum (None/Perfect)	1 = Perfectly shape	Index 1: Premature	250 – 450
2 = Medium (Acceptable)	2 = Off shape	Index 2: Mature	451 – 650
3 = Maximum (Rotten)		Index 3: Half ripe	651 – 850
		Index 4: Ripe	851 - 1000
		Index 5: Perfectly ripe	
		Index 6: Over ripe	

Table 4: Fruits characteristics/properties being considered

**depending on the type of fruit

3.5.2.1 FIS Editor

Fuzzy Interface System (FIS) Editor is use to configure the fuzzy logic model. The Fuzzy Logic for mango, papaya and starfruit has been configured as figure 10 (below). Based on the figure 10 below, each Fuzzy Logic has four input properties (left side) and two outputs (right side).

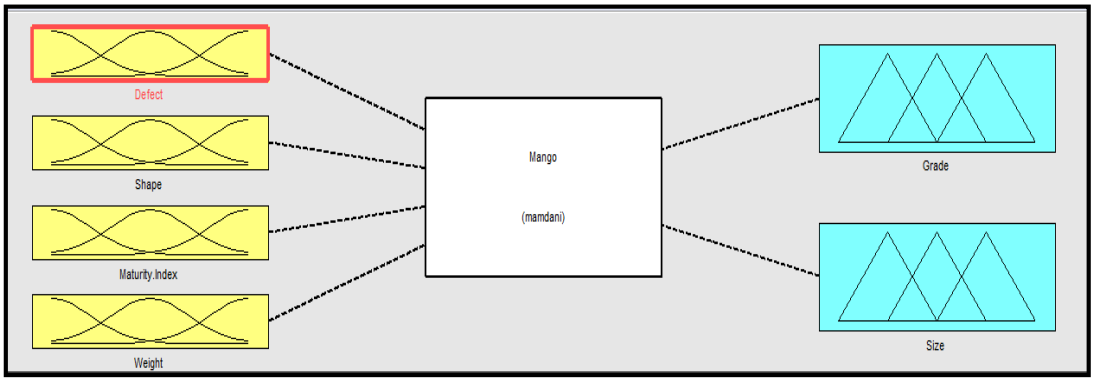

Figure 10: Overall structure of Mango FL

3.5.2.1.1 Input parameters (FIS Variables)

The inputs (FIS Variables) have been arranged according to the level of effectiveness of the input to the output (refer to figure 11). This is to shorten the time of the system to process the parameters and to minimize the if-then rules; to make it easier to troubleshoot (if any errors occur). The priority is given to the fruit's condition. The defect of the fruit is the first quality that needs to be considered in order to determine whether the fruit is acceptable or rejected. Based on FAMA and MS, the shape of the fruit is the second main characteristic. The maturity index is placed as the third important characteristic since only Index 2 to Index 5 is acceptable for international export. Index 1 and Index 6 are rejected. Since the weight of the fruit does not affect the fruit's grade, it is placed as the last characteristic. However, it is use to determine the second output which is the size of the fruit.

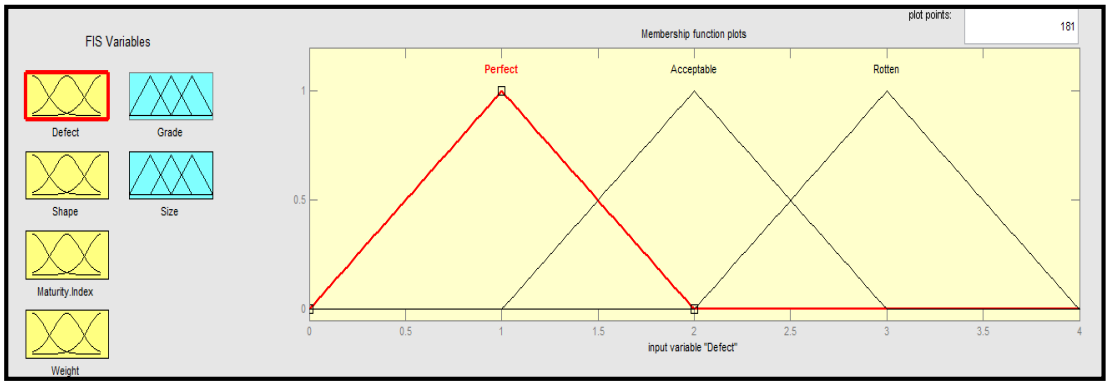

Figure 11: The membership function of mango's defect characteristic

3.5.2.1.2 FIS Membership function

Membership functions for all inputs (figure 11) and outputs are being configured one by one. The grade of the fruit is divided into four categories which are; Premium, Grade 1, Grade 2 and Reject (refer to figure 12). The size of the fruit is divided into four categories which are; S, M, L and XL. It is based on the weight. These two are the outputs of the system since these two properties determine the price of the fruit.

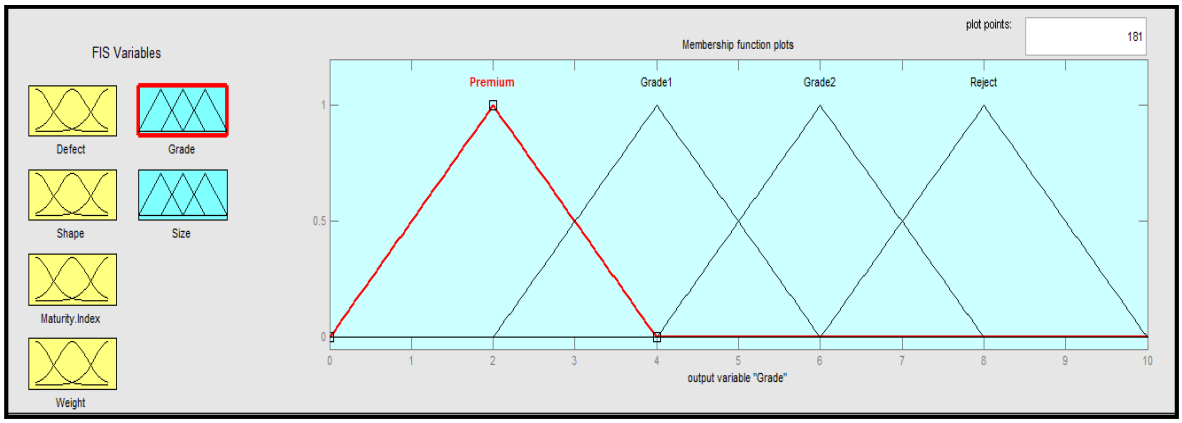

Figure 12: The membership function of the output (grade of the fruit)

The same configuration is done for both papaya and starfruit using the four characteristics; defect, shape, maturity index and weight. Only the range of the membership function will be difference as according to FAMA 36 Commodity Quality Guidelines. The range of membership function of size is as stated in the guidelines. As for the grade, the range of the membership function is self designate for the sake of project simplicity. Based on figure 11, if the result of the fuzzy falls in the range of 0-4; the grade is Premium. The Grade 1 is ranged 2-6 and Grade 2 is ranged 4-8. The range of 6-10 is for Reject.

3.5.2.1.3 If-then rules

In order to relate the input properties with the outputs, the specifications are configured based on if-then rules. Each property must satisfy the if-then rules in order to get the appointed output. Since the number of properties (or input) is four and each one of the properties contain 3 type of defects, 2 type of shapes, 6 type of maturity indexes and 4 range of weights (size), therefore the total number of complete if-then rules that need to be set is 3 x 2 x 6 x 4 = 144 *[12][14]*. The structure of the if-then rule is as below;

If (defect), (shape) and (maturity index) then (grade) and (size)

Input variables Output variables

	Input variables	Degree (level)		Output variables	Degree (level)
If			then		
	(defect)	(1/2/3),		(grade)	(Premium/Grade 1/Grade 2)
	(shape)	(1/2),			
and	(maturity index)	(Index1/Index2/ Index3/Index4/ Index5/Index6/ Index7),			
If			then		
	(weight)	(the specified range)		(size)	(S/M/L/XL)

Table 5: The If-then rules of the specifications

The if-then rule for Premium is:

If (defect) is (1 = none/perfect), (shape) is (1= perfectly shape), and (maturity index) is (Index2)/(Index3)/(Index4)/(Index5)

The if-then rule for Grade 1 is:

If (defect) is (1 = none/perfect), (shape) is (2 = off shape), and (maturity index) is (Index2)/(Index3)/(Index4)/(Index5)

If (defect) is (2= medium), (shape) is (1 = perfectly shape), and (maturity index) is (Index2)/(Index3)/(Index4)/(Index5)

The if-then rule for Grade 2 is:

If (defect) is (2= medium), (shape) is (2 = perfectly shape), and (maturity index) is (Index2)/(Index3)/(Index4)/(Index5)

The if-then rule for Reject is:

If (defect) is (3=Rotten)

If (maturity index) is (Index1)/(Index6)/(Index7)

3.5.3 Matlab Neural Network (NN) Toolbox

There are three important components are needed in order to used the Neural Network Toolbox which are the input, the number of the hidden neurons and the output which is the result of the system. Similar to Fuzzy Logic model, the Neural Network model also consists of four inputs (variables/properties) and two outputs. Neural Network model is configured using Neural Network Fitting Tool (nftool) and Neural Network Training (nntraintool).

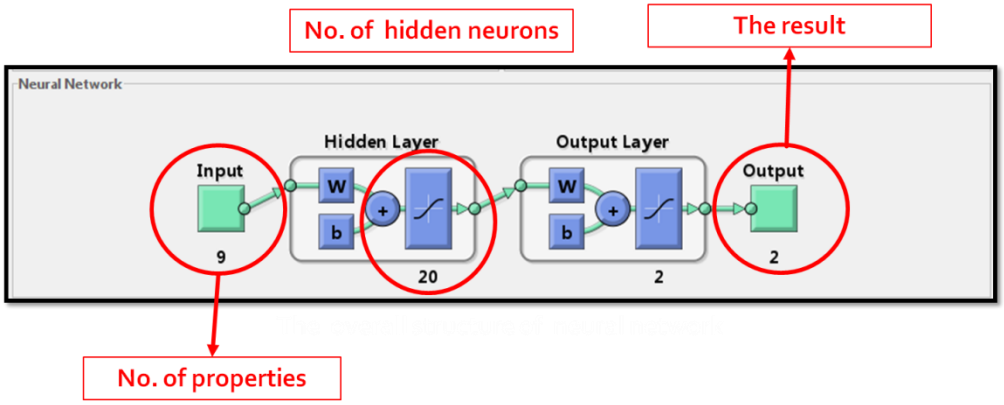

Figure 13: The whole structure of Neural Network Toolbox

3.5.3.1 Samples data

Since Artificial Neural Network is a learning program, it requires some set of data for the program to learn from. Therefore, samples data are prepared for mango, papaya and starfruit. The data contain of 100 random samples of four different elements or specifications (input variables). The samples of data are obtained from FAMA and have been graded by the FAMA authorized personnel. (Refer to Appendix 2 for mango, Appendix 3 for papaya and Appendix 4 for starfruit). Only

70 samples taken in order to train the Neural Network and the rest of 30 samples are for testing and validation purposes.

3.5.3.2 Number of hidden neurons

The number of hidden neurons plays important role as the accuracy of the result is depending on it. In order to know the correct number of hidden neurons for the output to generate an accurate result, the hidden neurons need to be "trained" by repetitive testing of try-and-error.

3.5.3.3 Neural Network Training

The training is done using Levenberg-Marquardt backpropagation algorithm. The samples data is uploaded into the Neural Network Fitting Tool (nftool). The suitable trained neural network is chosen based on the value of Mean Squared Error (MSE) and Regression R. The neural network is trained until the value of MSE obtain is as lower as possible and the value of Regression R is near to 1. Lower value of MSE determines low error of the trained network. The Regression R value represents the relationship of the samples. Value of 1 indicates a close relationship while 0 indicates a random relationship. The number of hidden neurons chosen can be changed depending on the result of the training process of the neural network. Once the best trained neural network is gained, it is saved in the Neural Network function as the network to be used in analyzing the inserted data by user *[13]*. The output of the neural network model is based on this trained neural network.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Result

4.1.1 Fuzzy Logic

4.1.1.1 Rules Viewer (FIS Editor)

As mentioned in the objectives of the project, the purpose of this project is to determine the grade of the fruit according to the input parameters that have been keyed in to the system. In order to do so, FIS (Fuzzy Interface System) Editor has been configured. To monitor and check for the fuzzy logic accuracy, the Rules Viewer is used (Figure 14). Based on Figure 14, the red line is the adjustable value of input for each characteristic (weight, maturity index, shape and defect). The small red box indicates the value of the input. The input can be either adjusted using the red line or keyed in the box. The other two sections on the right side of Figure 14 (red box) are the outputs (grade and size). Rule Viewer is also used to troubleshoot if the results are wrong by checking whether the configured if-then rules are wrong.

Figure 14: Rules Viewer of Mango properties

4.1.1.2 Surface Viewer (FIS Editor)

FIS Editor is not only used to configure the input, output parameters and the if-then rules but also as a tool to troubleshoot the correlation constructed between the input and output other than the Rules Viewer. The input-output correlations are shown in a graph form. Figure 15 and Figure 16 display the Surface Viewer of the starfruit. Since all fruits involved in this project (mango, papaya and starfruit) utilize the same method, only starfruit's Surface Viewer is shown as the example and representing the others.

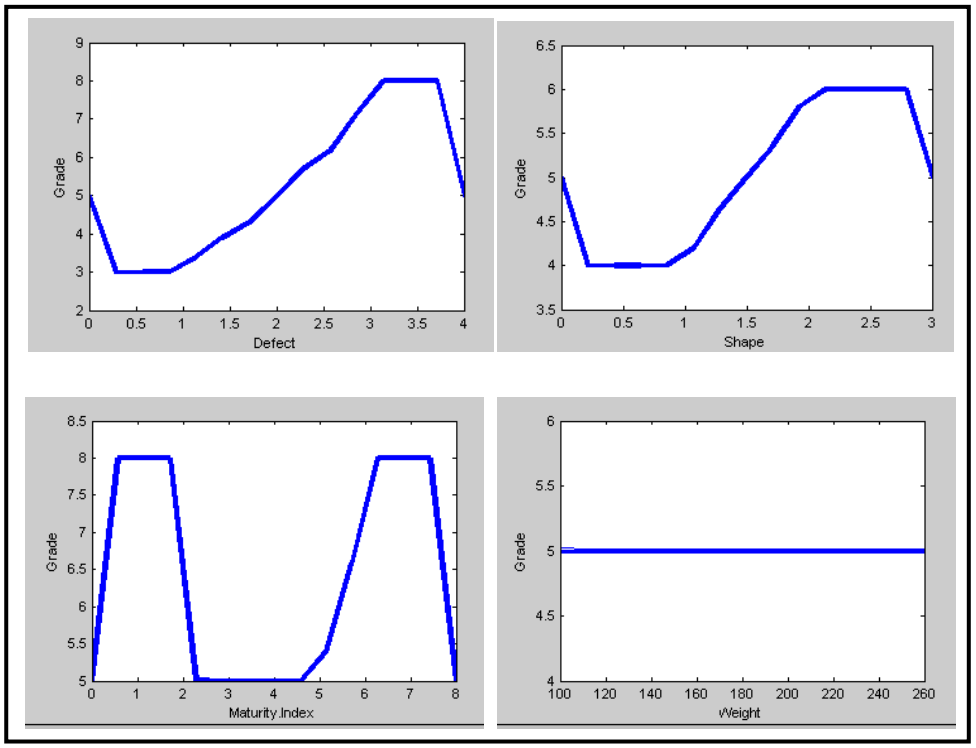

Figure 15: Surface Viewer of Starfruit properties for grade

As shown in Figure 15 above, the four graphs signify the correlation between the inputs (defect, shape, maturity index and weight) with the grade (output). It is obvious that the weight parameters do not affect or do not influence the result of the grade. Unlike the other three inputs (defect, shape and maturity index), these inputs influence or affect the result of the grade. The range of the X-axis (input) and Y-axis (output) are based on the membership function configured. According to these graphs, it can be concluded that the higher the value of grade, the lower the grade.

Conversely, Figure 16 below indicates the correlation between the inputs (defect, shape, maturity index and weight) with the size (output). For size correlation with the inputs, only weight input affects or influences the result of the size. As for the other inputs (defect, shape and maturity index), no correlation can be observed.

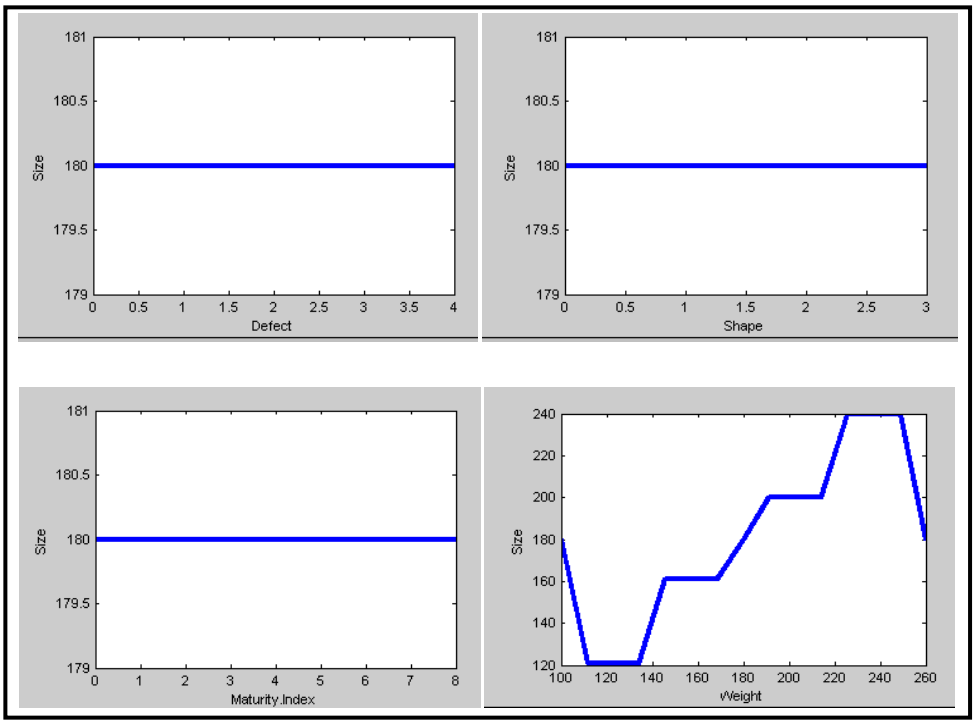

Figure 16: Surface Viewer of Starfruit properties for size

4.1.1.3 Percentage of error (FL)

In order to test the system for accuracy, the result generated by the Fuzzy Logic system is evaluated against the reference. The samples data obtained from FAMA (Appendix 2, 3 and 4) are used as the reference. All 300 samples (100 samples for each fruit) have been inserted to the system and the output of system from the inserted parameters of input is being compared one by one to check for error. Table 6 below signifies the percentage of error for each type of fruit tested.

Type of fruit	Percentage of error
Mango	0%
Papaya	0%
Starfruit/Carambola	0%

Table 6: Percentage of error for each fruit for Fuzzy Logic

4.1.2 Neural Network

4.1.2.1 Trained Neural Network (Neural Fitting tool, nft)

The neural network has been trained for each type of fruit. The suitable number of hidden neurons is determined by try-and-error process from 1 to 20 and observing the Regression value and MSE value of the training. The training is using 20 hidden neurons as it gives the best result. After several time of trainings, the best result of trained neural network obtained for mango is displayed as in Figure 17 and Figure 18 below.

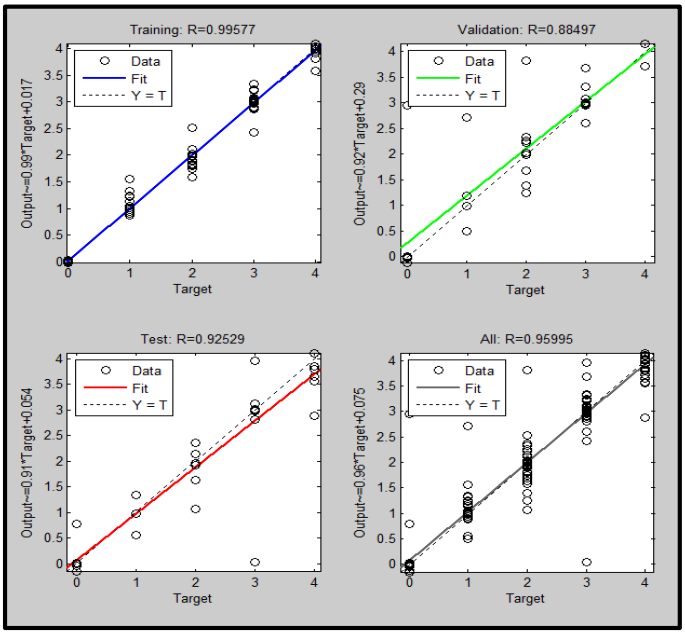

Figure 17: Mango regression neural network trained result

The best overall value of Regression, R gained for mango is 0.95995 which is near to the value of 1. Regression R value that is close to 1 indicate a good result of training. Therefore it has been chosen as the trained neural network result to be fed into the neural network system. An observable result can be seen in Figure 18 below as only a slight different between the predicted (NNgrade and NNsize) and the reference (Actualgrade and Actualsize).

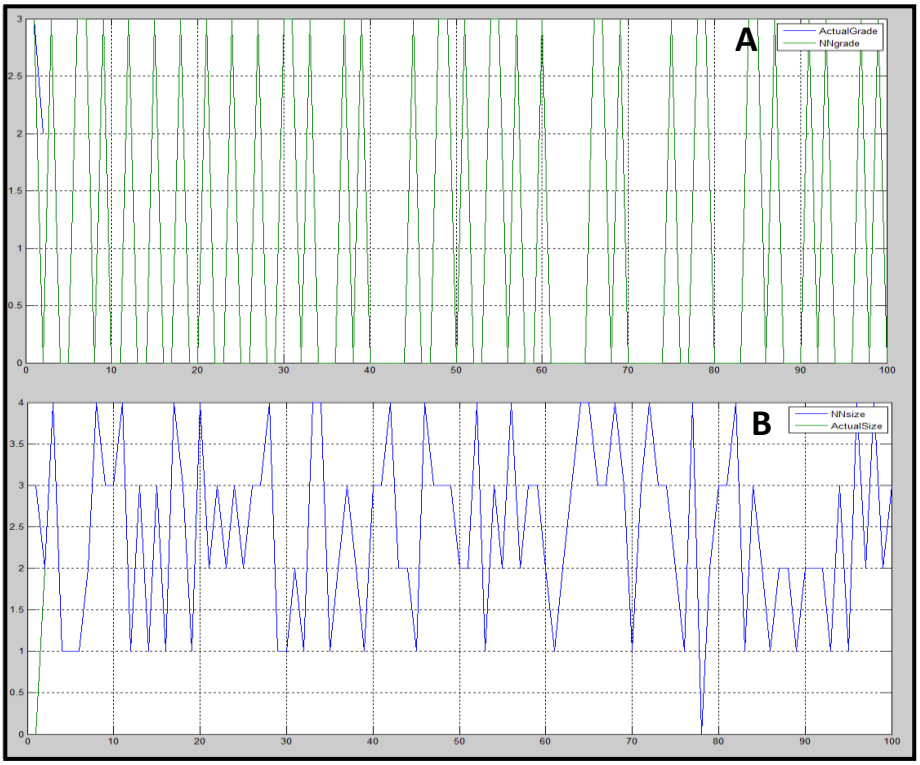

Figure 18: The graph of trained neural network for mango (A for Grade and B for Size)

As for papaya, the best result of trained neural network obtained is displayed as in Figure 19 and Figure 20 below.

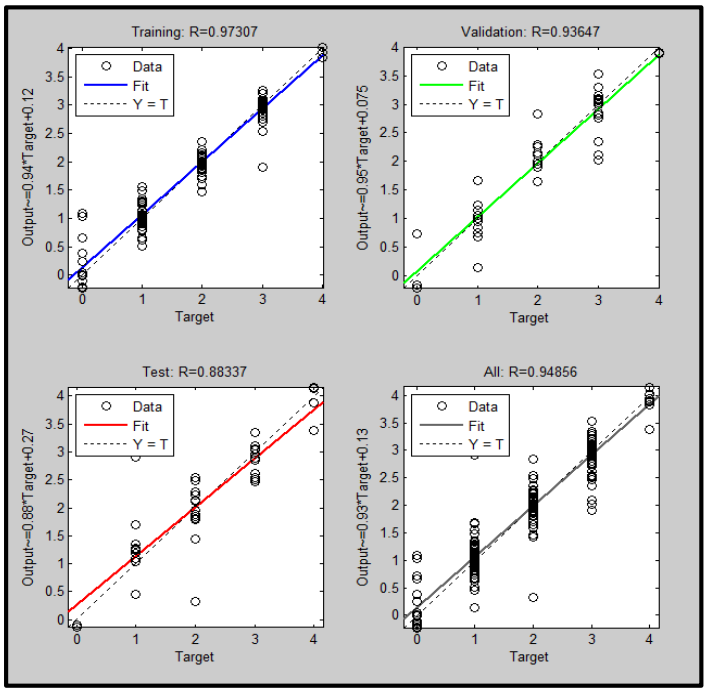

Figure 19: Papaya regression neural network trained result

The best overall value of Regression, R gained for papaya is 0.94856. Although it is not as high as Regression value of trained neural network for mango, but it is the best result obtained (using the same number of hidden neurons). Regression R value is still close to 1 and it still indicates a good result of training. Therefore it has been chosen as the trained neural network result to be fed into the neural network system. An observable result can be seen in Figure 20 below as only a slight different between the predicted (NNgrade and NNsize) and the reference (Actualgrade and Actualsize).

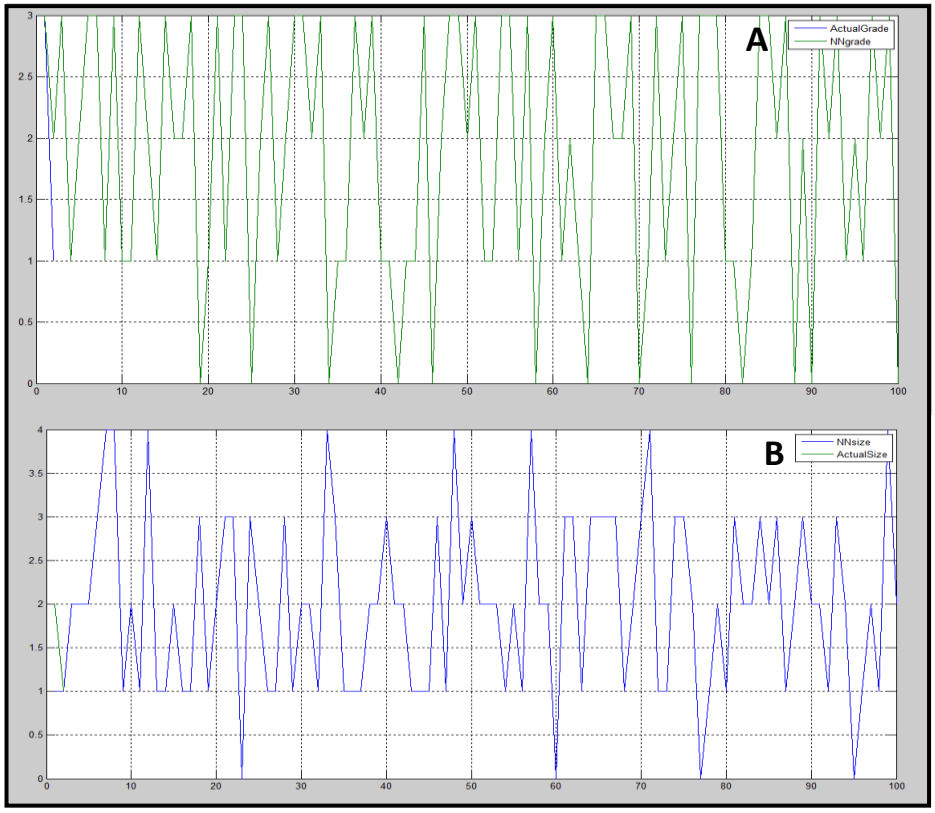

Figure 20: The graph of trained neural network for papaya (A for Grade and B for Size)

As for starfruit, the best result of trained neural network obtained is displayed as in Figure 21 and Figure 22 below.

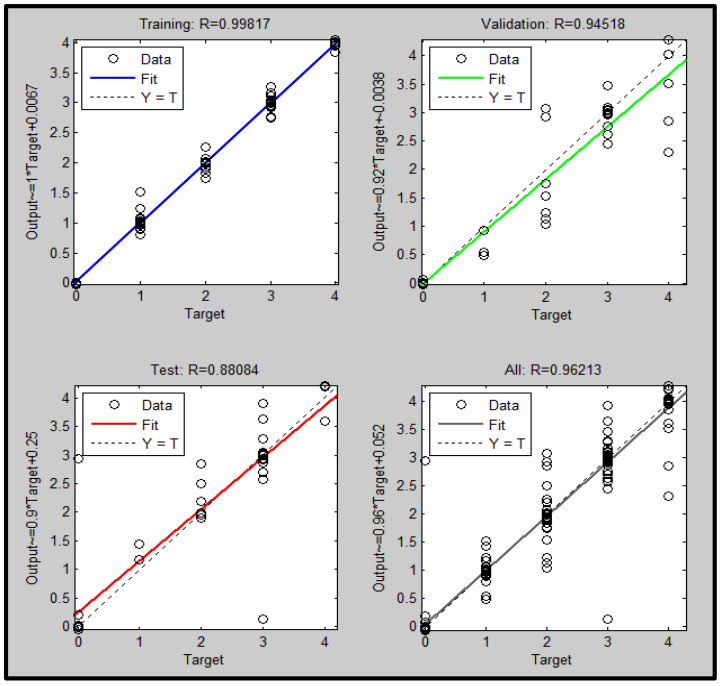

Figure 21: Starfruit regression neural network trained result

The best overall value of Regression, R gained for starfruit is 0.96213. It is the highest Regression value of trained neural network compared to mango and papaya. As the Regression R value is the closest to 1, it should give a good result. Therefore it has been chosen as the trained neural network result to be fed into the neural network system. An observable result can be seen in Figure 22 below as only a slight different between the predicted (NNgrade and NNsize) and the reference (Actualgrade and Actualsize).

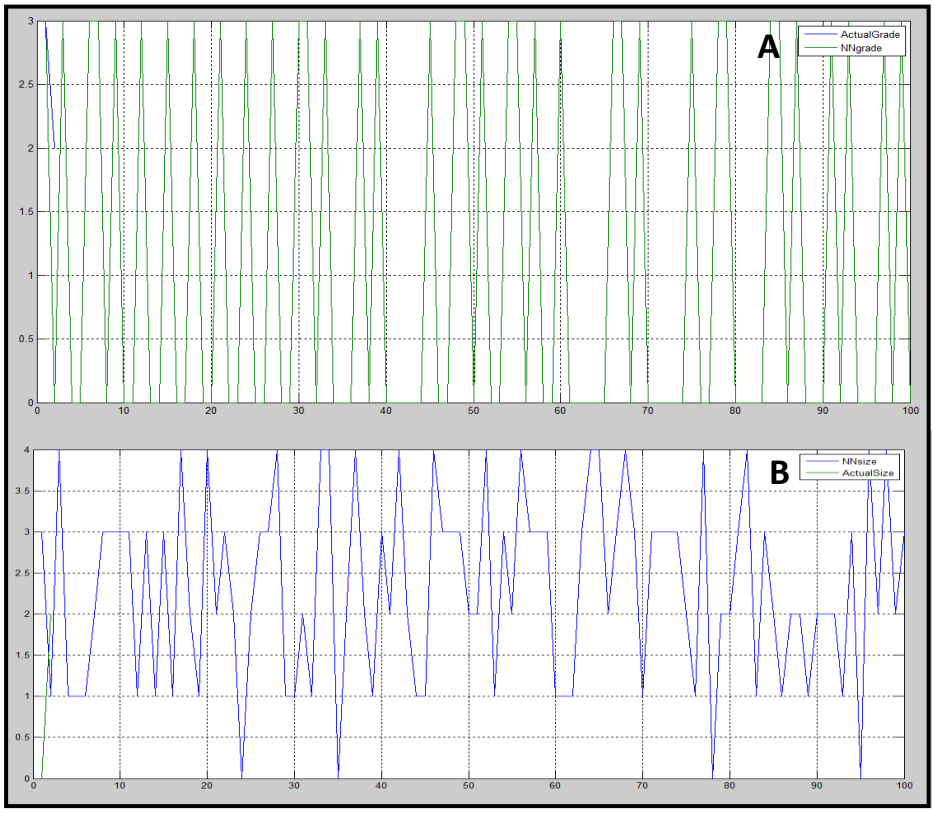

Figure 22: The graph of trained neural network for starfruit (A for Grade and B for Size)

4.1.2.2 Percentage of error (NN)

Similar with testing conducted for Fuzzy Logic; in order to test the system for accuracy, the result generated by the Neural Network system is evaluated against the reference. The samples data obtained from FAMA (Appendix 2, 3 and 4) are used as the reference. Only 70 out of 100 samples are used to train the Neural Network and the rest of 30 samples are used to test the trained system. The samples that need to be tested have been inserted to the system and the output of system from the inserted parameters of input is being compared one by one to check for error. Table 6 below signifies the percentage of error for each type of fruit tested.

Type of fruit	Percentage of error
Mango	15%
Papaya	10%
Starfruit/Carambola	23%

Table 7: Percentage of error for each fruit for Neural Network

4.1.3 The completed system

Once both of the systems (FL and ANN) configuration and programming are done, it is run to check whether the system is functioning or not. Several troubleshooting and debugging are done in order to make the system functioning correctly. When the system is running, the first thing that will come out is the dialog box asking to choose which system to use in grading the fruit. As stated in the flowchart of the program, the program executed as shown in Figure 22 below.

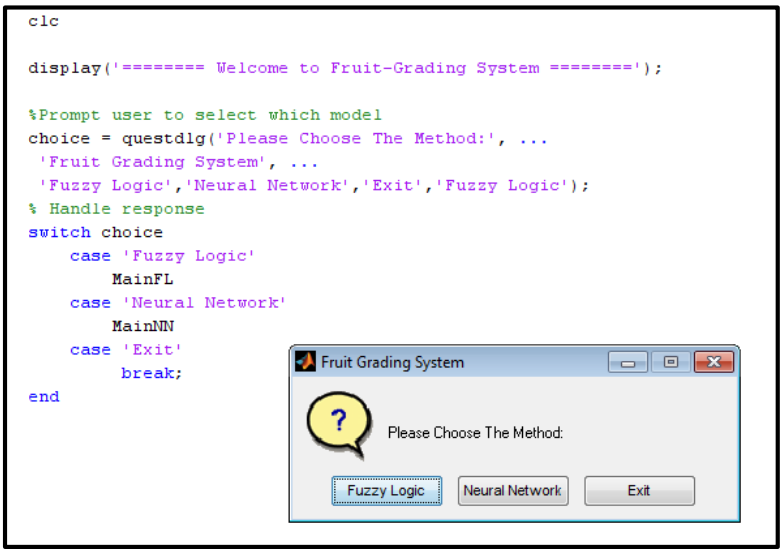

Figure 23: Fruit Grader Dialogue Box

Once the grading method is chose, second dialog box will appear. As stated in the flowchart of the system, the type of fruit to be graded need to be chooses. The dialog box is shown in Figure 23 below; it is depending on which grading method chose earlier.

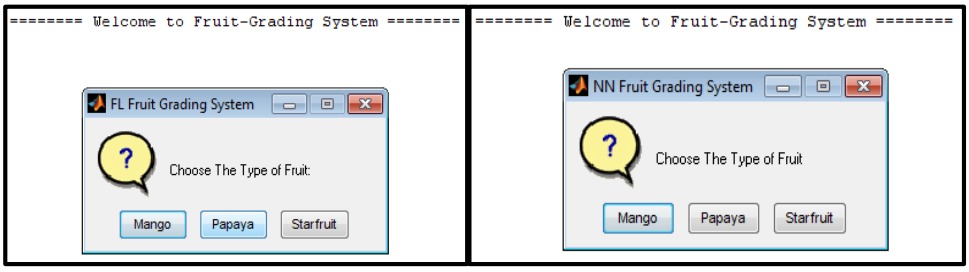

Figure 24: The dialog box where user needs to choose which type of fruit to grade

After the type of fruit is being chosen, the next dialog box will appear and ask for the value of parameters for each characteristic (defect, shape, maturity index and weight). A guideline is shown at the command window as reference (Figure 24).

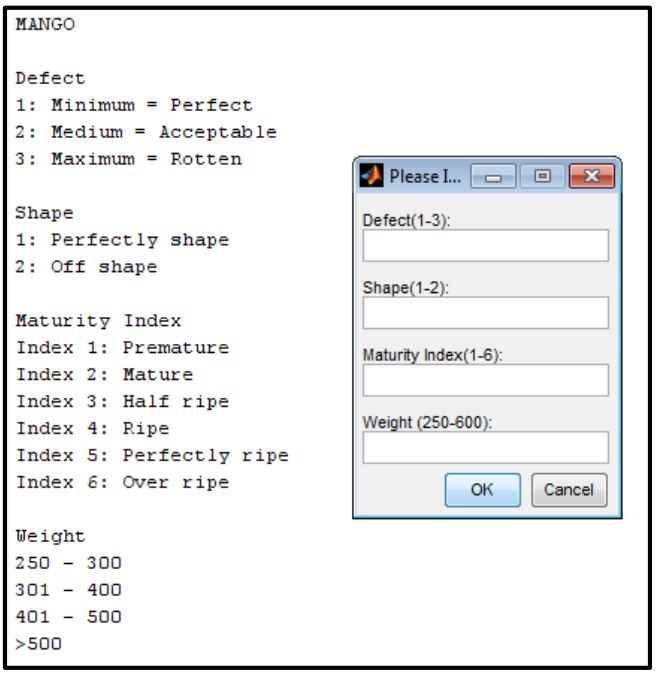

Figure 25: The dialogue box of the parameters (mango)

Once all the parameters being entered, the command window will show the grade and size of the fruit being graded. The next dialogue box will appear asking whether to proceed with next grading or not.

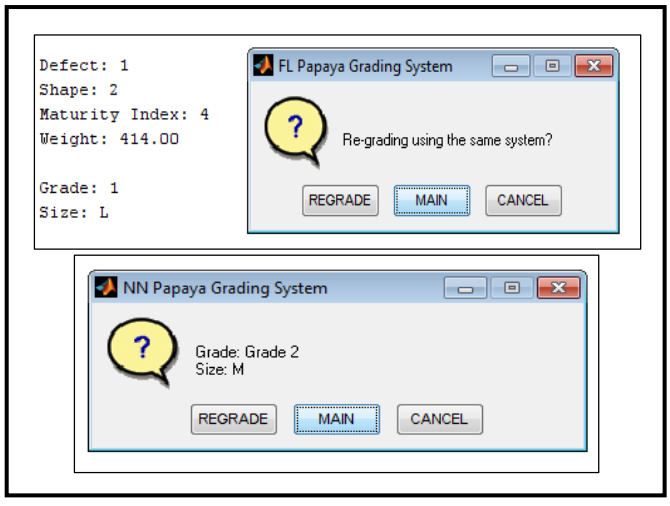

Figure 26: The output of the program (Fuzzy Logic – Upper, Neural Network - Lower)

4.2 Discussion

Similar with the Turning Test method, the result of this technique will be checked for accuracy by comparing the result from AI technique (Fuzzy Logic and Neural Network) with the manually graded fruit taken from FAMA (by ACG). The process of grading the same fruit using the AI technique being tested several times to ensure the result of the grading is the same and consistent. The result of the fuzzy logic is observed using the Rules Viewer and the output generated by the system. The grade of the fruit from the system is checked for accuracy based on the FAMA approved sample list (Appendix 2, 3 and 4).

Some of the results are not tally with the grade or size stated in FAMA sample list for both Fuzzy Logic and Neural Network. Based on the percentage of errors, the value of error for Neural Network is higher than Fuzzy Logic. By comparing the percentage of errors between the three types of fruit, starfruit result has the highest value of error and papaya result has the lowest value of error.

Type of fruit	Percentage of error (FL)	Percentage of error (NN)	Regression, R (NN)
Mango	0%	15%	0.95995
Papaya	0%	10%	0.94856
Starfruit/Carambola	0%	23%	0.96213

Table 8: Comparison of each fruit for both systems

Theoretically, the one with high value of Regression (nearest to 1) should give a good result as it indicates a good training result. Unfortunately, in this case, starfruit has the highest percentage of error compared to the other two even though it has the highest Regression value. The accuracy of the neural network model can be increased by retraining the neural network with different number of hidden neurons.

Since the samples data also affect the neural network performance, the number of samples data should be increased in order for the neural network to 'learn' more on the surrounding data. The neural network is trained using Levenberg-Marquardt backpropagation algorithm (Neural Network Fitting Tool) instead of scaled conjugate gradient backpropagation (Neural Network Pattern Recognition). Although Levenberg-Marquardt backpropagation algorithm method is the fastest neural network training method, it tends to have low competent for large networks that have thousands of weights. Due to that, it may not be suitable to be used for this project.

In this project, the samples are considered as a large network. Therefore, more memory and more computation time needed. As this project is a pattern recognition type, scaled conjugate gradient backpropagation (Neural Network Pattern Recognition) should be used or more suitable to perform the task for better result. Neural Network Fitting Tool is used as the alternative since the Matlab does not work properly for the Pattern Recognition Tool. Neural Network system need to be configured properly in order to achieve better result and higher accuracy. The samples data, number of hidden neurons and the method of training do affect the result performance.

The samples data obtained from FAMA grader need to be rechecked in case there are some mistakes for both Neural Network model and Fuzzy Logic. The samples data is every important and it needs to be accurate since it affects the accuracy of both systems. As for the Fuzzy Logic, the accuracy problem might be due to the assigned command in the programming. The fuzziness of the membership function and the if-then rules need to be checked and reconfigured. After the configured model being checked, the accuracy of the system improved. More testing and troubleshooting required. The duration of the grading process using the program for certain amount of fruit is shorter and easier compared to the manual grading and existing system.

CHAPTER 5
CONCLUSION

The project is completed within the duration planned. Although some of the results are not accurate but the system gives consistent output. If the samples data used to train the neural network is enhanced and the training is done using the suitable neural network training tool, the accuracy of the system can be improved. Cause of problems detected during completing the project has been discovered. For future improvement of this project, all the errors and mistakes can be corrected based on the solution that has been discussed. Hence, problems faced during executing this project can be overcome.

Based on the result, Fuzzy Logic is more suitable to be used in this grading system as it gives high accuracy and easier to configure. Since this grading system is not as complicated as other system, the use of Fuzzy Logic itself will able to solve the problem. Neural Network on the other hand can be used for more complicated and uncertain type of problem.

As conclusion, the system does help to ease the grading process. No additional knowledge, skills, training or experience needed to operate this system. Users can simply insert the parameters by referring to the reference specifications shown at the command window. Unlike the current system (e-grading), this system is more flexible and can be adjusted or reconfigured according to its function. Since grading is a repetitive process which consistent result and duration are very important, it is better and more suitable to let the system do the work instead of human being. Human energy and intelligence should be used to handle other or more important role that machine cannot do rather than performing the grading.

CHAPTER 6

RECOMMENDATION

For future recommendation of this project, rather than just designing the program or the software of this grading method, it is more efficient to connect the system with hardware for inputs (scanner, camera, sensor etc) and output (conveyor, sorter etc). The sensor can detect and automatically give input to the system rather than manually keyed in by user. Once the output is generated, the sorter or conveyor will act accordingly. It will become fully automatic grading machine.

Grading system is not crucial matter and it is an issue that people are less concern of. Using the same method, this technique can be used for other approach and purposes, which is more critical. The application of Neural Network (NN) can be utilized in various areas as long as the data to simulate the model is sufficient in order for the simulink to process it. Neural Network technique is usually used in forecasting something uncertain such as weather and raindrop. The grade of fruit for the tree to produce is also an uncertain scenario. Therefore, this technique (NN) can also be used if forecasting the grade of fruit produced by the tree is to be experimented.

Using nearly the same method of the grading technique, neural network (NN) and fuzzy logic (FL) can also be used for any other artificial intelligent applications. If this technique is used at the airport security system, it can help the detection of prohibited things or equipments going through the security before the passenger onboard the airplane. There are some cases where illegal things were managed to pass through the security system due to the carelessness and irresponsibility of the personnel in charge. This incident can be prevented if the same technique is applied.

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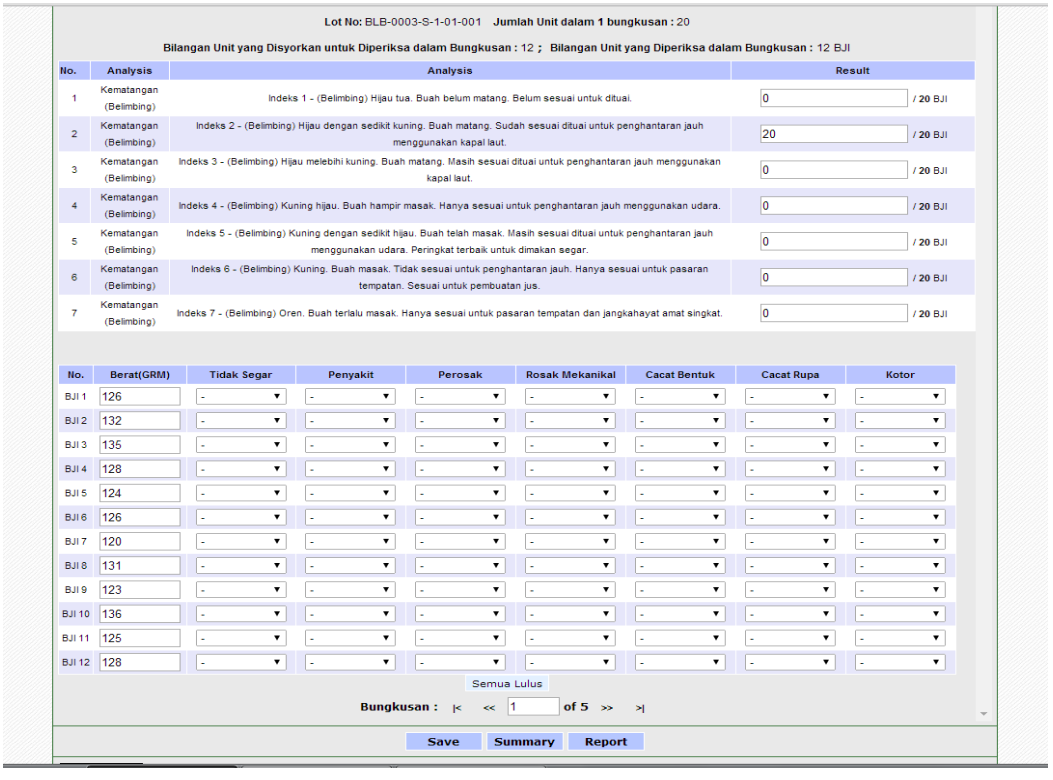
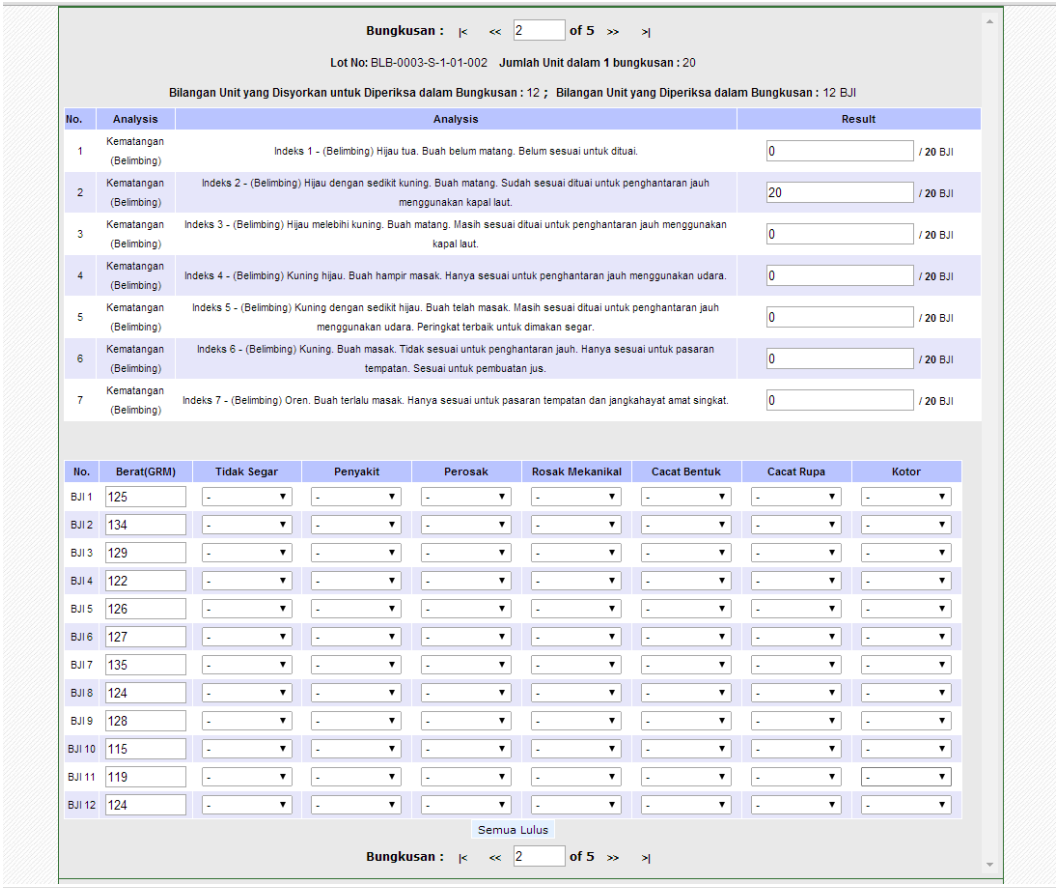
APPENDICES

APPENDIX 1: E-GRADING SAMPLE





Bungkusan : |< << 2 of 5 >> >|

Lot No: BLB-0003-S-1-01-002 Jumlah Unit dalam 1 bungkusan : 20

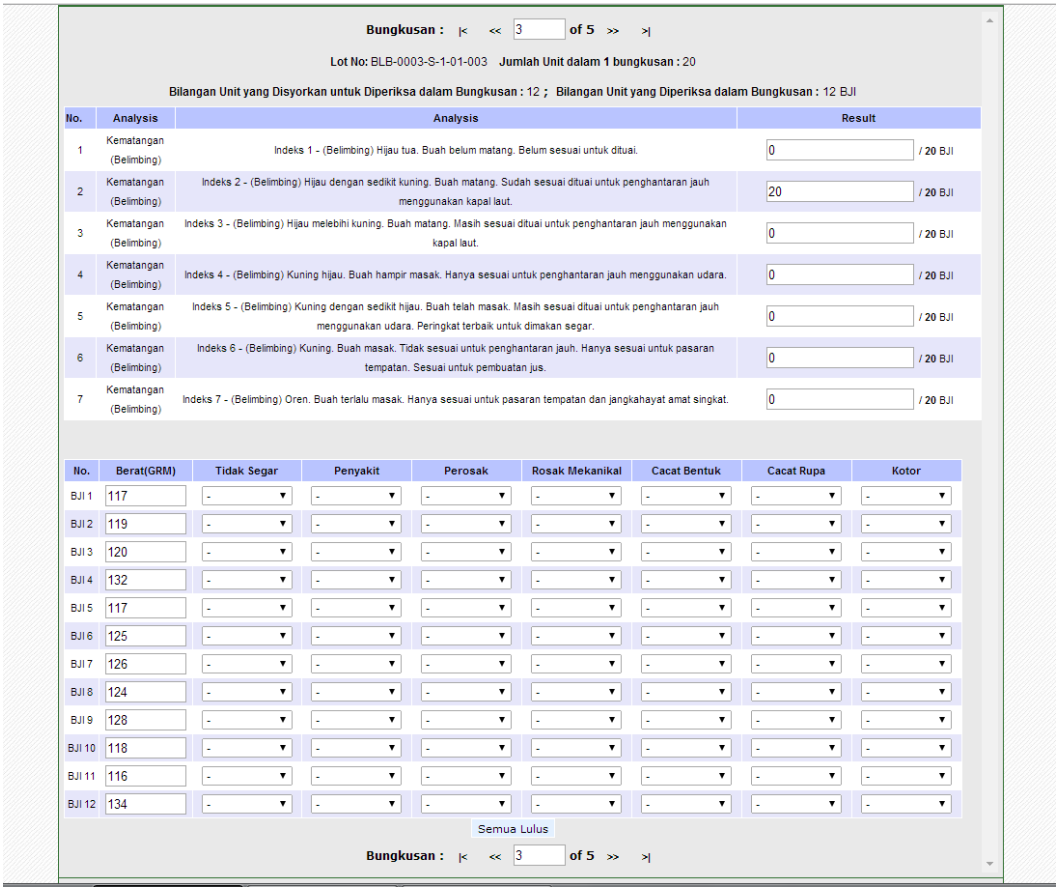
Bilangan Unit yang Disyorkan untuk Diperiksa dalam Bungkusan : 12 ; Bilangan Unit yang Diperiksa dalam Bungkusan : 12 BJI

No.	Analysis	Analysis	Result
1	Kematangan (Belimbing)	Indeks 1 - (Belimbing) Hijau tua. Buah belum matang. Belum sesuai untuk dituai.	0 / 20 BJI
2	Kematangan (Belimbing)	Indeks 2 - (Belimbing) Hijau dengan sedikit kuning. Buah matang. Sudah sesuai dituai untuk penghantaran jauh menggunakan kapal laut.	20 / 20 BJI
3	Kematangan (Belimbing)	Indeks 3 - (Belimbing) Hijau melebihi kuning. Buah matang. Masih sesuai dituai untuk penghantaran jauh menggunakan kapal laut.	0 / 20 BJI
4	Kematangan (Belimbing)	Indeks 4 - (Belimbing) Kuning hijau. Buah hampir masak. Hanya sesuai untuk penghantaran jauh menggunakan udara.	0 / 20 BJI
5	Kematangan (Belimbing)	Indeks 5 - (Belimbing) Kuning dengan sedikit hijau. Buah telah masak. Masih sesuai dituai untuk penghantaran jauh menggunakan udara. Peringkat terbaik untuk dimakan segar.	0 / 20 BJI
6	Kematangan (Belimbing)	Indeks 6 - (Belimbing) Kuning. Buah masak. Tidak sesuai untuk penghantaran jauh. Hanya sesuai untuk pasaran tempatan. Sesuai untuk pembuatan jus.	0 / 20 BJI
7	Kematangan (Belimbing)	Indeks 7 - (Belimbing) Oren. Buah terlalu masak. Hanya sesuai untuk pasaran tempatan dan jangkahayat amat singkat.	0 / 20 BJI

No.	Berat(GRM)	Tidak Segar	Penyakit	Perosak	Rosak Mekanikal	Cacat Bentuk	Cacat Rupa	Kotor
BJI 1	125	-	-	-	-	-	-	-
BJI 2	134	-	-	-	-	-	-	-
BJI 3	129	-	-	-	-	-	-	-
BJI 4	122	-	-	-	-	-	-	-
BJI 5	126	-	-	-	-	-	-	-
BJI 6	127	-	-	-	-	-	-	-
BJI 7	135	-	-	-	-	-	-	-
BJI 8	124	-	-	-	-	-	-	-
BJI 9	128	-	-	-	-	-	-	-
BJI 10	115	-	-	-	-	-	-	-
BJI 11	119	-	-	-	-	-	-	-
BJI 12	124	-	-	-	-	-	-	-

Semua Lulus

Bungkusan : |< << 2 of 5 >> >|



Bungkusan : |< << 3 of 5 >> >|

Lot No: BLB-0003-S-1-01-003 Jumlah Unit dalam 1 bungkusan : 20

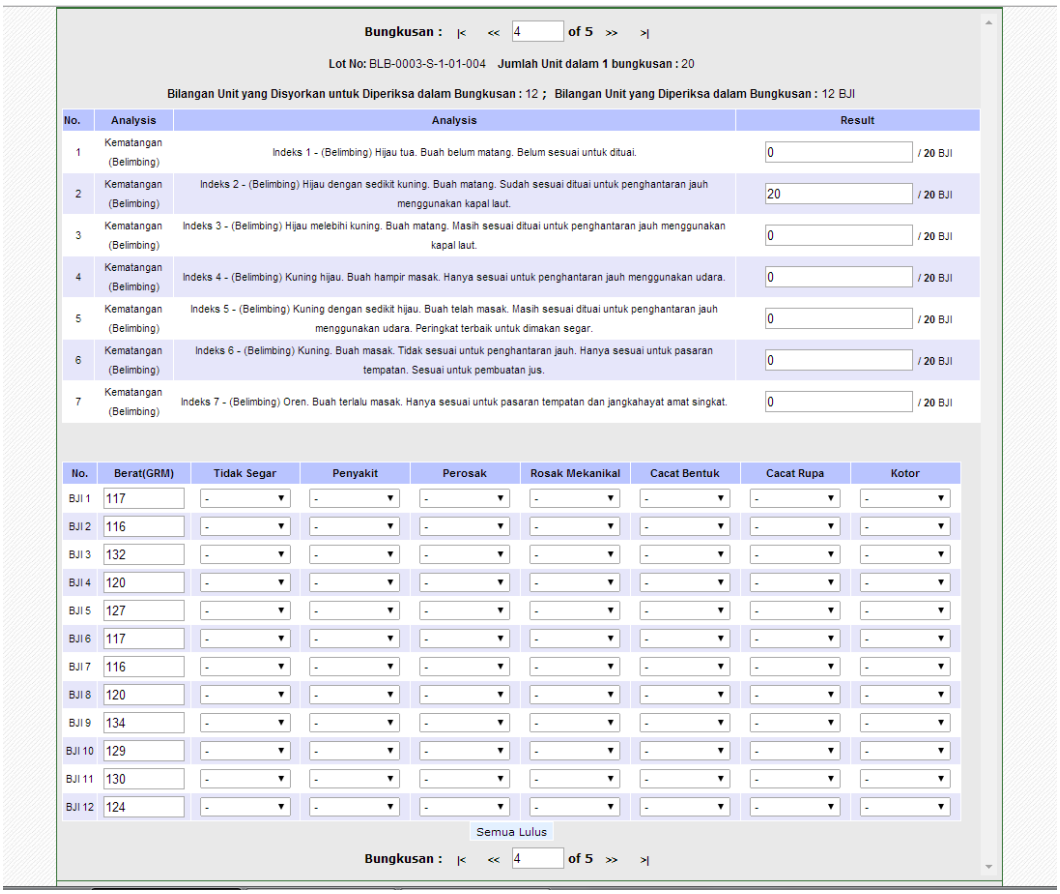
Bilangan Unit yang Disyorkan untuk Diperiksa dalam Bungkusan : 12 ; Bilangan Unit yang Diperiksa dalam Bungkusan : 12 BJI

No.	Analysis	Analysis	Result
1	Kematangan (Belimbing)	Indeks 1 - (Belimbing) Hijau tua. Buah belum matang. Belum sesuai untuk dituai.	0 / 20 BJI
2	Kematangan (Belimbing)	Indeks 2 - (Belimbing) Hijau dengan sedikit kuning. Buah matang. Sudah sesuai dituai untuk penghantaran jauh menggunakan kapal laut.	20 / 20 BJI
3	Kematangan (Belimbing)	Indeks 3 - (Belimbing) Hijau melebihi kuning. Buah matang. Masih sesuai dituai untuk penghantaran jauh menggunakan kapal laut.	0 / 20 BJI
4	Kematangan (Belimbing)	Indeks 4 - (Belimbing) Kuning hijau. Buah hampir masak. Hanya sesuai untuk penghantaran jauh menggunakan udara.	0 / 20 BJI
5	Kematangan (Belimbing)	Indeks 5 - (Belimbing) Kuning dengan sedikit hijau. Buah telah masak. Masih sesuai dituai untuk penghantaran jauh menggunakan udara. Peringkat terbaik untuk dimakan segar.	0 / 20 BJI
6	Kematangan (Belimbing)	Indeks 6 - (Belimbing) Kuning. Buah masak. Tidak sesuai untuk penghantaran jauh. Hanya sesuai untuk pasaran tempatan. Sesuai untuk pembuatan jus.	0 / 20 BJI
7	Kematangan (Belimbing)	Indeks 7 - (Belimbing) Oren. Buah terlalu masak. Hanya sesuai untuk pasaran tempatan dan jangkahayat amat singkat.	0 / 20 BJI

No.	Berat(GRM)	Tidak Segar	Penyakit	Perosak	Rosak Mekanikal	Cacat Bentuk	Cacat Rupa	Kotor
BJI 1	117	-	-	-	-	-	-	-
BJI 2	119	-	-	-	-	-	-	-
BJI 3	120	-	-	-	-	-	-	-
BJI 4	132	-	-	-	-	-	-	-
BJI 5	117	-	-	-	-	-	-	-
BJI 6	125	-	-	-	-	-	-	-
BJI 7	126	-	-	-	-	-	-	-
BJI 8	124	-	-	-	-	-	-	-
BJI 9	128	-	-	-	-	-	-	-
BJI 10	118	-	-	-	-	-	-	-
BJI 11	116	-	-	-	-	-	-	-
BJI 12	134	-	-	-	-	-	-	-

Semua Lulus

Bungkusan : |< << 3 of 5 >> >|



Bungkusan : |< << 4 **of 5** >> >|

Lot No: BLB-0003-S-1-01-004 **Jumlah Unit dalam 1 bungkusan :** 20

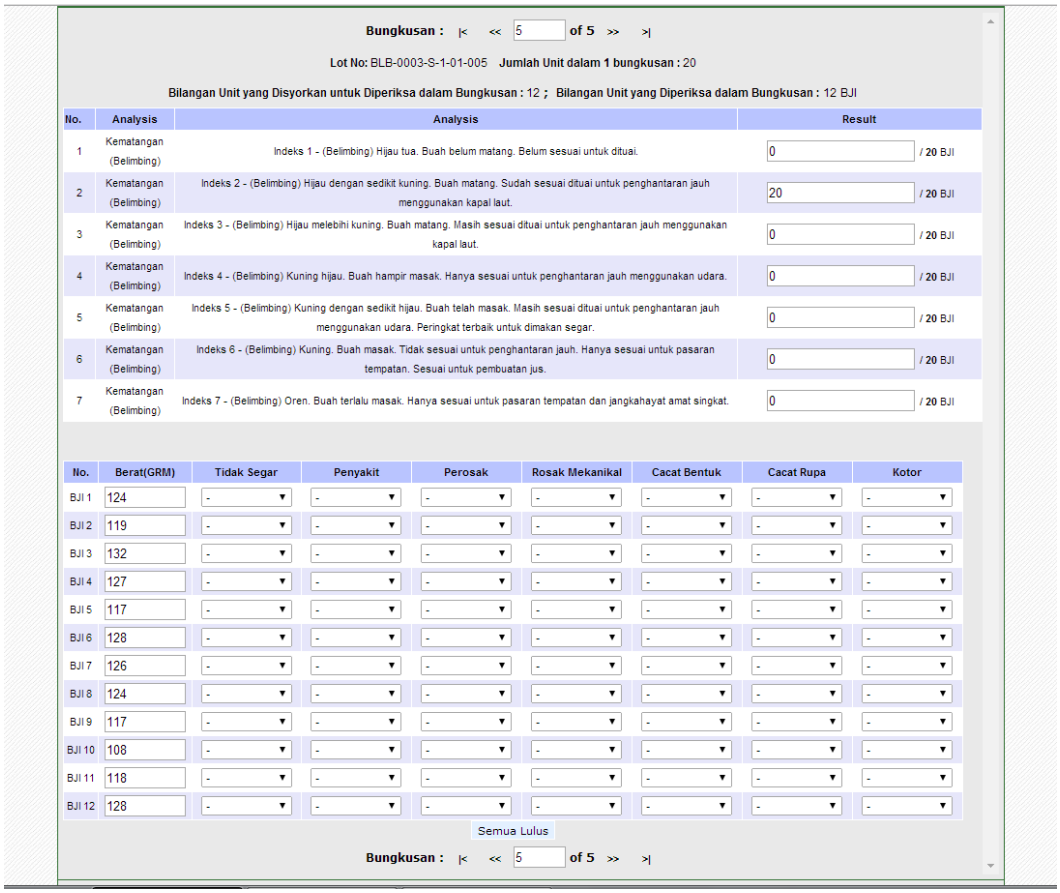
Bilangan Unit yang Disyorkan untuk Diperiksa dalam Bungkusan : 12 ; **Bilangan Unit yang Diperiksa dalam Bungkusan :** 12 BJI

No.	Analysis	Analysis	Result
1	Kematangan (Belimbing)	Indeks 1 - (Belimbing) Hijau tua. Buah belum matang. Belum sesuai untuk dituai.	0 / 20 BJI
2	Kematangan (Belimbing)	Indeks 2 - (Belimbing) Hijau dengan sedikit kuning. Buah matang. Sudah sesuai dituai untuk penghantaran jauh menggunakan kapal laut.	20 / 20 BJI
3	Kematangan (Belimbing)	Indeks 3 - (Belimbing) Hijau melebihi kuning. Buah matang. Masih sesuai dituai untuk penghantaran jauh menggunakan kapal laut.	0 / 20 BJI
4	Kematangan (Belimbing)	Indeks 4 - (Belimbing) Kuning hijau. Buah hampir masak. Hanya sesuai untuk penghantaran jauh menggunakan udara.	0 / 20 BJI
5	Kematangan (Belimbing)	Indeks 5 - (Belimbing) Kuning dengan sedikit hijau. Buah telah masak. Masih sesuai dituai untuk penghantaran jauh menggunakan udara. Peringkat terbaik untuk dimakan segar.	0 / 20 BJI
6	Kematangan (Belimbing)	Indeks 6 - (Belimbing) Kuning. Buah masak. Tidak sesuai untuk penghantaran jauh. Hanya sesuai untuk pasaran tempatan. Sesuai untuk pembuatan jus.	0 / 20 BJI
7	Kematangan (Belimbing)	Indeks 7 - (Belimbing) Oren. Buah terlalu masak. Hanya sesuai untuk pasaran tempatan dan jangkahayat amat singkat.	0 / 20 BJI

No.	Berat(GRM)	Tidak Segar	Penyakit	Perosak	Rosak Mekanikal	Cacat Bentuk	Cacat Rupa	Kotor
BJI 1	117	-	-	-	-	-	-	-
BJI 2	116	-	-	-	-	-	-	-
BJI 3	132	-	-	-	-	-	-	-
BJI 4	120	-	-	-	-	-	-	-
BJI 5	127	-	-	-	-	-	-	-
BJI 6	117	-	-	-	-	-	-	-
BJI 7	116	-	-	-	-	-	-	-
BJI 8	120	-	-	-	-	-	-	-
BJI 9	134	-	-	-	-	-	-	-
BJI 10	129	-	-	-	-	-	-	-
BJI 11	130	-	-	-	-	-	-	-
BJI 12	124	-	-	-	-	-	-	-

Semua Lulus

Bungkusan : |< << 4 **of 5** >> >|



Bungkusan : |< << 5 **of 5** >> >|

Lot No: BLB-0003-S-1-01-005 **Jumlah Unit dalam 1 bungkusan :** 20

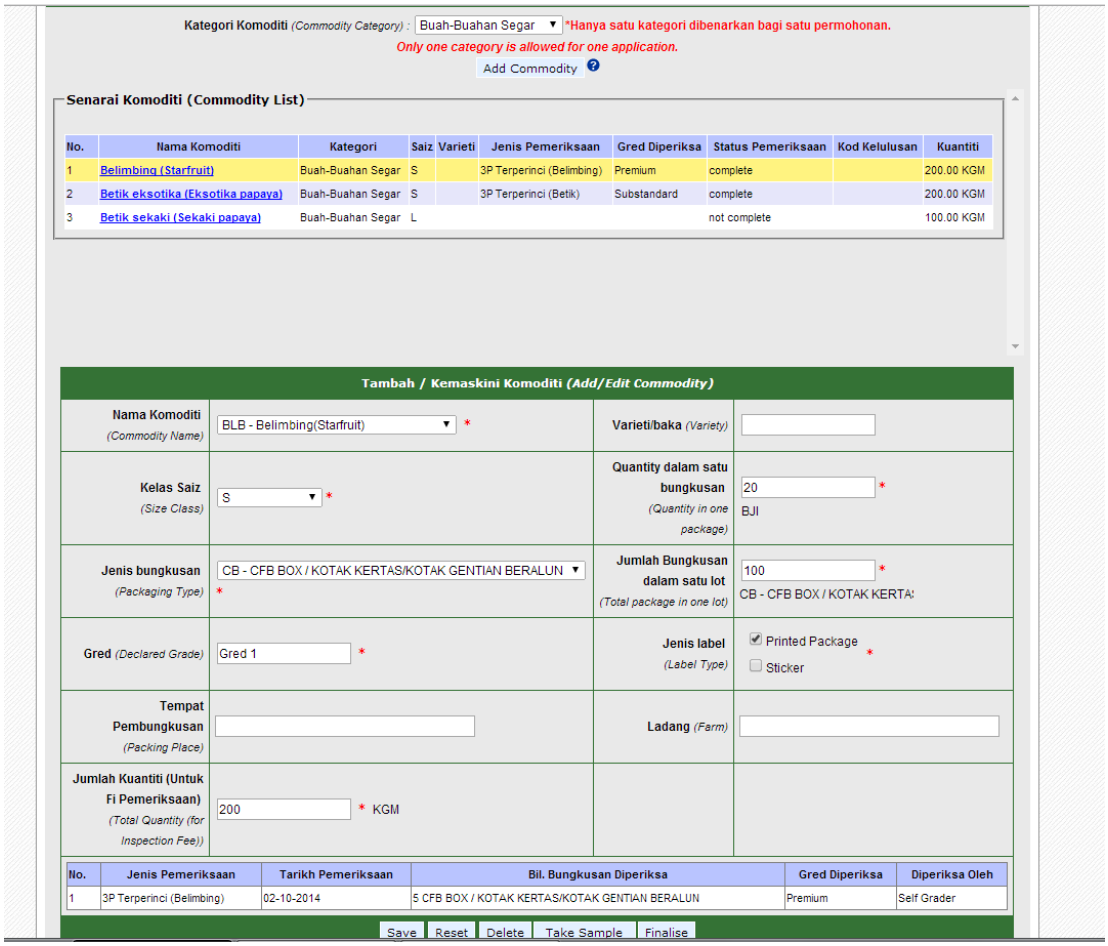
Bilangan Unit yang Disyorkan untuk Diperiksa dalam Bungkusan : 12 ; **Bilangan Unit yang Diperiksa dalam Bungkusan :** 12 BJI

No.	Analysis	Analysis	Result
1	Kematangan (Belimbing)	Indeks 1 - (Belimbing) Hijau tua. Buah belum matang. Belum sesuai untuk dituai.	0 / 20 BJI
2	Kematangan (Belimbing)	Indeks 2 - (Belimbing) Hijau dengan sedikit kuning. Buah matang. Sudah sesuai dituai untuk penghantaran jauh menggunakan kapal laut.	20 / 20 BJI
3	Kematangan (Belimbing)	Indeks 3 - (Belimbing) Hijau melebihi kuning. Buah matang. Masih sesuai dituai untuk penghantaran jauh menggunakan kapal laut.	0 / 20 BJI
4	Kematangan (Belimbing)	Indeks 4 - (Belimbing) Kuning hijau. Buah hampir masak. Hanya sesuai untuk penghantaran jauh menggunakan udara.	0 / 20 BJI
5	Kematangan (Belimbing)	Indeks 5 - (Belimbing) Kuning dengan sedikit hijau. Buah telah masak. Masih sesuai dituai untuk penghantaran jauh menggunakan udara. Peringkat terbaik untuk dimakan segar.	0 / 20 BJI
6	Kematangan (Belimbing)	Indeks 6 - (Belimbing) Kuning. Buah masak. Tidak sesuai untuk penghantaran jauh. Hanya sesuai untuk pasaran tempatan. Sesuai untuk pembuatan jus.	0 / 20 BJI
7	Kematangan (Belimbing)	Indeks 7 - (Belimbing) Oren. Buah terlalu masak. Hanya sesuai untuk pasaran tempatan dan jangkahayat amat singkat.	0 / 20 BJI

No.	Berat(GRM)	Tidak Segar	Penyakit	Perosak	Rosak Mekanikal	Cacat Bentuk	Cacat Rupa	Kotor
BJI 1	124	-	-	-	-	-	-	-
BJI 2	119	-	-	-	-	-	-	-
BJI 3	132	-	-	-	-	-	-	-
BJI 4	127	-	-	-	-	-	-	-
BJI 5	117	-	-	-	-	-	-	-
BJI 6	128	-	-	-	-	-	-	-
BJI 7	126	-	-	-	-	-	-	-
BJI 8	124	-	-	-	-	-	-	-
BJI 9	117	-	-	-	-	-	-	-
BJI 10	108	-	-	-	-	-	-	-
BJI 11	118	-	-	-	-	-	-	-
BJI 12	128	-	-	-	-	-	-	-

Semua Lulus

Bungkusan : |< << 5 **of 5** >> >|


Kategori Komoditi (Commodity Category) : Buah-Buahan Segar *Hanya satu kategori dibenarkan bagi satu permohonan.
Only one category is allowed for one application.
Add Commodity
Senarai Komoditi (Commodity List)
No. Nama Komoditi Kategori Saiz Varieti Jenis Pemeriksaan Gred Diperiksa Status Pemeriksaan Kod Kelulusan Kuantiti
1 Belimbing (Starfruit) Buah-Buahan Segar S 3P Terperinci (Belimbing) Premium complete 200.00 KGM
2 Betik eksotika (Eksotika papaya) Buah-Buahan Segar S 3P Terperinci (Betik) Substandard complete 200.00 KGM
3 Betik sekaki (Sekaki papaya) Buah-Buahan Segar L not complete 100.00 KGM
Tambah / Kemaskini Komoditi (Add/Edit Commodity)
Nama Komoditi (Commodity Name) BLB - Belimbing(Starfruit) *
Varieti/baka (Variety)
Kelas Saiz (Size Class) S *
Quantity dalam satu bungkusan (Quantity in one package) 20 *
BJI
Jenis bungkusan (Packaging Type) CB - CFB BOX / KOTAK KERTAS/KOTAK GENTIAN BERALUN *
Jumlah Bungkusan dalam satu lot (Total package in one lot) 100 *
CB - CFB BOX / KOTAK KERTA
Gred (Declared Grade) Gred 1 *
Jenis label (Label Type) Printed Package Sticker *
Tempat Pembungkusan (Packing Place)
Ladang (Farm)
Jumlah Kuantiti (Untuk Fi Pemeriksaan) (Total Quantity (for Inspection Fee)) 200 * KGM
No. Jenis Pemeriksaan Tarikh Pemeriksaan Bil. Bungkusan Diperiksa Gred Diperiksa Diperiksa Oleh
1 3P Terperinci (Belimbing) 02-10-2014 5 CFB BOX / KOTAK KERTAS/KOTAK GENTIAN BERALUN Premium Self Grader
Save Reset Delete Take Sample Finalise

APPENDIX 2: FAMA APPROVED SAMPLE (MANGO)

Universiti Teknologi Petronas

Fruit Grading System

Mango | Papaya | Starfruit

Fruit Grader: Mohd Sharani Mat Saad

No.	Defect		Maturity index	Weight	Grade	Size
1	Minimum	Perfectly shape	Index 1	280	Reject	S
2	Medium	Off shape	Index 2	341	Grade 2	M
3	Maximum	Perfectly shape	Index 3	572	Reject	XL
4	Minimum	Off shape	Index 4	414	Grade 1	L
5	Medium	Off shape	Index 5	303	Grade 2	M
6	Maximum	Perfectly shape	Index 3	421	Reject	L
7	Minimum	Off shape	Index 1	266	Reject	S
8	Medium	Perfectly shape	Index 2	500	Grade 1	L
9	Maximum	Perfectly shape	Index 3	268	Reject	S
10	Minimum	Off shape	Index 4	498	Grade 1	L
11	Medium	Perfectly shape	Index 5	441	Grade 1	L
12	Maximum	Off shape	Index 3	288	Reject	S
13	Minimum	Off shape	Index 4	292	Grade 2	S
14	Medium	Perfectly shape	Index 2	439	Grade 1	L
15	Maximum	Off shape	Index 3	394	Reject	M
16	Minimum	Off shape	Index 4	333	Grade 1	M
17	Medium	Perfectly shape	Index 5	269	Grade 1	S
18	Maximum	Off shape	Index 6	297	Reject	S
19	Minimum	Perfectly shape	Index 5	398	Premium	M
20	Medium	Perfectly shape	Index 2	456	Grade 1	L
21	Maximum	Perfectly shape	Index 3	361	Reject	M
22	Minimum	Off shape	Index 4	301	Grade 1	M
23	Medium	Off shape	Index 5	267	Grade 2	S
24	Maximum	Off shape	Index 6	377	Reject	M
25	Minimum	Perfectly shape	Index 4	564	Premium	XL
26	Medium	Off shape	Index 2	403	Grade 2	L
27	Maximum	Perfectly shape	Index 3	489	Reject	L
28	Minimum	Off shape	Index 4	275	Grade 1	S
29	Medium	Off shape	Index 3	450	Grade 2	S
30	Maximum	Perfectly shape	Index 6	332	Reject	M
31	Minimum	Off shape	Index 1	259	Reject	S
32	Medium	Off shape	Index 2	409	Grade 2	L
33	Maximum	Perfectly shape	Index 3	600	Reject	XL
34	Minimum	Perfectly shape	Index 4	346	Premium	M
35	Medium	Perfectly shape	Index 5	300	Grade 1	S
36	Minimum	Perfectly shape	Index 4	276	Premium	S
37	Minimum	Perfectly shape	Index 1	449	Reject	L
38	Medium	Off shape	Index 2	469	Grade 2	L
39	Maximum	Off shape	Index 3	312	Reject	M
40	Minimum	Off shape	Index 4	286	Grade 1	S
41	Medium	Perfectly shape	Index 5	299	Grade 1	S
42	Minimum	Perfectly shape	Index 6	430	Grade 2	L
43	Minimum	Perfectly shape	Index 4	328	Premium	M
44	Medium	Perfectly shape	Index 2	456	Grade 1	L
45	Maximum	Off shape	Index 3	400	Reject	M
46	Minimum	Perfectly shape	Index 4	525	Premium	XL
47	Medium	Off shape	Index 5	415	Grade 2	L
48	Maximum	Off shape	Index 3	418	Reject	L
49	Minimum	Perfectly shape	Index 1	377	Reject	M
50	Medium	Off shape	Index 2	253	Grade 2	S

S = 250 - 300
M = 301 - 400
L = 401 - 500
XL = > 500

Maturity Index
Index 1: Premature (Dark green)
Index 2: Mature (Light green)
Index 3: Half ripe (Green yellowish)
Index 4: Ripe (Yellow greenish)
Index 5: Perfectly ripe (Yellow)
Index 6: Over ripe (Dark yellow/orange)

Shape
1= Perfectly shape
2 = Off shape

Defect
1 = Minimum/None/Perfect
2 = Medium/Acceptable
3 = Maximum/Rotten

Grade
Premium
Grade 1
Grade 2
Reject

51	Maximum	Perfectly shape	Index 3	459	Reject	L			
52	Minimum	Off shape	Index 4	543	Grade 2	XL			
53	Medium	Perfectly shape	Index 5	428	Grade 1	L			
54	Maximum	Perfectly shape	Index 4	390	Reject	M			
55	Minimum	Perfectly shape	Index 1	426	Reject	L			
56	Medium	Perfectly shape	Index 2	352	Grade 1	M			
57	Maximum	Off shape	Index 3	484	Reject	L			
58	Minimum	Perfectly shape	Index 4	587	Premium	XL			
59	Medium	Off shape	Index 5	611	Grade 2	M			
60	Maximum	Perfectly shape	Index 6	399	Reject	M			
61	Minimum	Off shape	Index 4	437	Grade 1	L			
62	Medium	Off shape	Index 2	340	Grade 2	M			
63	Minimum	Perfectly shape	Index 3	301	Premium	M			
64	Minimum	Perfectly shape	Index 4	259	Premium	S			
65	Medium	Out of shape	Index 5	284	Reject	S			
66	Maximum	Off shape	Index 6	366	Reject	M			
67	Minimum	Perfectly shape	Index 1	411	Reject	L			
68	Medium	Off shape	Index 2	279	Grade 2	S			
69	Maximum	Off shape	Index 3	534	Reject	XL			
70	Minimum	Perfectly shape	Index 4	444	Premium	L			
71	Medium	Perfectly shape	Index 5	312	Grade 1	M			
72	Minimum	Off shape	Index 6	257	Reject	S			
73	Minimum	Perfectly shape	Index 3	441	Premium	L			
74	Medium	Off shape	Index 2	304	Grade 2	M			
75	Maximum	Off shape	Index 3	273	Reject	S			
76	Minimum	Perfectly shape	Index 4	522	Premium	XL			
77	Medium	Off shape	Index 5	222	Reject	Not in range			
78	Maximum	Off shape	Index 6	357	Reject	M			
79	Minimum	Perfectly shape	Index 1	478	Reject	L			
80	Medium	Perfectly shape	Index 2	293	Grade 1	S			
81	Minimum	Off shape	Index 3	300	Grade 1	S			
82	Minimum	Perfectly shape	Index 4	348	Premium	M			
83	Medium	Perfectly shape	Index 5	430	Grade 1	L			
84	Maximum	Off shape	Index 5	419	Reject	L			
85	Minimum	Off shape	Index 1	366	Reject	M			
86	Medium	Off shape	Index 2	511	Grade 2	XL			
87	Maximum	Off shape	Index 3	437	Reject	L			
88	Minimum	Perfectly shape	Index 4	350	Premium	M			
89	Medium	Off shape	Index 3	412	Grade 2	L			
90	Minimum	Perfectly shape	Index 6	492	Premium	L			
91	Minimum	Perfectly shape	Index 1	339	Reject	M			
92	Medium	Off shape	Index 2	250	Grade 2	S			
93	Maximum	Perfectly shape	Index 3	533	Reject	XL			
94	Minimum	Out of shape	Index 4	560	Grade 2	XL			
95	Medium	Perfectly shape	Index 5	209	Reject	Not in range			
96	Minimum	Perfectly shape	Index 3	243	Reject	Not in range			
97	Minimum	Perfectly shape	Index 1	555	Reject	XL			
98	Medium	Off shape	Index 2	341	Grade 2	M			
99	Maximum	Off shape	Index 3	298	Reject	S			
100	Minimum	Perfectly shape	Index 4	479	Premium	L			

Approved by;

Mohd Sharani Mat Saad

Index 1	Reject
Out of shape	
Not in range	
Index 2-5	Acceptable

Shape	Defect	Gred
Perfectly shape	Minimum	Premium
Perfectly shape	Medium	Grade 1
Perfectly shape	Maximum	Reject

Shape	Defect	Gred
Off shape	Minimum	Grade 1
Off shape	Medium	Grade 2
Off shape	Maximum	Reject

APPENDIX 3: FAMA APPROVED SAMPLE (PAPAYA)

Universiti Teknologi Petronas

Fruit Grading System

Mango | **Papaya** | Starfruit

Fruit Grader: Mohd Sharani Mat Saad

No.	Defect		Maturity index	Weight	Grade	Size
1	Minimum	Perfectly shape	Index 1	280	Reject	S
2	Medium	Off shape	Index 2	341	Grade 2	S
3	Maximum	Perfectly shape	Index 3	572	Reject	M
4	Minimum	Off shape	Index 4	614	Grade 1	M
5	Medium	Off shape	Index 5	703	Grade 2	L
6	Maximum	Perfectly shape	Index 3	821	Reject	L
7	Minimum	Off shape	Index 1	866	Reject	XL
8	Medium	Perfectly shape	Index 2	900	Grade 1	XL
9	Maximum	Perfectly shape	Index 3	268	Reject	S
10	Minimum	Off shape	Index 4	498	Grade 1	M
11	Medium	Perfectly shape	Index 5	441	Grade 1	S
12	Maximum	Off shape	Index 3	888	Reject	XL
13	Minimum	Off shape	Index 4	292	Grade 2	S
14	Medium	Perfectly shape	Index 2	439	Grade 1	S
15	Maximum	Off shape	Index 3	594	Reject	M
16	Minimum	Off shape	Index 4	333	Grade 1	S
17	Medium	Perfectly shape	Index 5	269	Grade 1	S
18	Maximum	Off shape	Index 6	697	Reject	L
19	Minimum	Perfectly shape	Index 5	398	Premium	S
20	Medium	Perfectly shape	Index 2	456	Grade 1	M
21	Maximum	Perfectly shape	Index 3	761	Reject	L
22	Minimum	Off shape	Index 4	801	Grade 1	L
23	Medium	Off shape	Index 5	267	Grade 2	S
24	Maximum	Off shape	Index 6	777	Reject	L
25	Minimum	Perfectly shape	Index 4	564	Premium	M
26	Medium	Off shape	Index 2	403	Grade 2	S
27	Maximum	Perfectly shape	Index 3	289	Reject	S
28	Minimum	Off shape	Index 4	675	Grade 1	L
29	Medium	Off shape	Index 3	450	Grade 2	S
30	Maximum	Perfectly shape	Index 6	632	Reject	M
31	Minimum	Off shape	Index 1	559	Reject	M
32	Medium	Off shape	Index 2	409	Grade 2	S
33	Maximum	Perfectly shape	Index 3	900	Reject	XL
34	Minimum	Perfectly shape	Index 4	846	Premium	L
35	Medium	Perfectly shape	Index 5	300	Grade 1	S
36	Minimum	Perfectly shape	Index 4	276	Premium	S
37	Minimum	Perfectly shape	Index 1	409	Reject	S
38	Medium	Off shape	Index 2	649	Grade 2	M
39	Maximum	Off shape	Index 3	512	Reject	M
40	Minimum	Off shape	Index 4	786	Grade 1	L
41	Medium	Perfectly shape	Index 5	599	Grade 1	M
42	Minimum	Perfectly shape	Index 6	430	Grade 2	S
43	Minimum	Perfectly shape	Index 4	298	Premium	S
44	Medium	Perfectly shape	Index 2	346	Grade 1	S
45	Maximum	Off shape	Index 3	400	Reject	S
46	Minimum	Perfectly shape	Index 4	825	Premium	L
47	Medium	Off shape	Index 5	415	Grade 2	S
48	Maximum	Off shape	Index 3	918	Reject	XL
49	Minimum	Perfectly shape	Index 1	677	Reject	L
50	Medium	Off shape	Index 2	853	Grade 2	XL

Size & Weight
S = 250 - 450
M = 451 - 650
L = 651 - 850
XL = > 850

Maturity Index
Index 1: Premature (Green)
Index 2: Mature (A little yellowish)
Index 3: Half ripe (Green yellowish)
Index 4: Ripe (Yellowish)
Index 5: Perfectly ripe (A little greenish)
Index 6: Over ripe (Dark yellow/orange)

Shape
1 = Perfectly shape
2 = Off shape

Defect
1 = Minimum/None/Perfect
2 = Medium/Acceptable
3 = Maximum/Rotten

Grade
Premium
Grade 1
Grade 2
Reject

51	Maximum	Perfectly shape	Index 3	459	Reject	M			
52	Minimum	Off shape	Index 4	543	Grade 2	M			
53	Medium	Perfectly shape	Index 5	668	Grade 1	M			
54	Maximum	Perfectly shape	Index 4	390	Reject	S			
55	Minimum	Perfectly shape	Index 1	626	Reject	M			
56	Medium	Perfectly shape	Index 2	352	Grade 1	S			
57	Maximum	Off shape	Index 3	984	Reject	XL			
58	Minimum	Perfectly shape	Index 4	587	Premium	M			
59	Medium	Off shape	Index 5	611	Grade 2	M			
60	Maximum	Perfectly shape	Index 6	399	Reject	S			
61	Minimum	Off shape	Index 4	626	Grade 1	M			
62	Medium	Off shape	Index 2	740	Grade 2	L			
63	Minimum	Perfectly shape	Index 3	301	Premium	S			
64	Minimum	Perfectly shape	Index 4	745	Premium	L			
65	Medium	Out of shape	Index 5	844	Reject	L			
66	Maximum	Off shape	Index 6	666	Reject	L			
67	Minimum	Perfectly shape	Index 1	911	Reject	S			
68	Medium	Off shape	Index 2	279	Grade 2	S			
69	Maximum	Off shape	Index 3	534	Reject	M			
70	Minimum	Perfectly shape	Index 4	834	Premium	L			
71	Medium	Perfectly shape	Index 5	912	Grade 1	XL			
72	Minimum	Off shape	Index 6	257	Reject	S			
73	Minimum	Perfectly shape	Index 3	341	Premium	S			
74	Medium	Off shape	Index 2	804	Grade 2	L			
75	Maximum	Off shape	Index 3	673	Reject	L			
76	Minimum	Perfectly shape	Index 4	532	Premium	M			
77	Medium	Off shape	Index 5	222	Reject	Not in range			
78	Maximum	Off shape	Index 6	357	Reject	S			
79	Minimum	Perfectly shape	Index 1	758	Reject	L			
80	Medium	Perfectly shape	Index 2	359	Grade 1	S			
81	Minimum	Off shape	Index 3	800	Grade 1	L			
82	Minimum	Perfectly shape	Index 4	458	Premium	M			
83	Medium	Perfectly shape	Index 5	630	Grade 1	M			
84	Maximum	Off shape	Index 5	719	Reject	L			
85	Minimum	Off shape	Index 1	566	Reject	M			
86	Medium	Off shape	Index 2	811	Grade 2	L			
87	Maximum	Off shape	Index 3	347	Reject	S			
88	Minimum	Perfectly shape	Index 4	500	Premium	M			
89	Medium	Off shape	Index 3	712	Grade 2	L			
90	Minimum	Perfectly shape	Index 6	492	Premium	M			
91	Minimum	Perfectly shape	Index 1	639	Reject	M			
92	Medium	Off shape	Index 2	450	Grade 2	S			
93	Maximum	Perfectly shape	Index 3	733	Reject	L			
94	Minimum	Out of shape	Index 4	560	Grade 2	M			
95	Medium	Perfectly shape	Index 5	209	Reject	Not in range			
96	Minimum	Perfectly shape	Index 3	243	Reject	Not in range			
97	Minimum	Perfectly shape	Index 1	555	Reject	M			
98	Medium	Off shape	Index 2	341	Grade 2	S			
99	Maximum	Off shape	Index 3	898	Reject	XL			
100	Minimum	Perfectly shape	Index 4	579	Premium	M			

	Approved by;		Date:						
	Mohd Sharani Mat Saad								

	Index 1		Reject						
	Out of shape								
	Not in range								
	Index 2-5		Acceptable						

	Shape		**Defect**	**Gred**					
	Perfectly shape		Minimum	Premium					
	Perfectly shape		Medium	Grade 1					
	Perfectly shape		Maximum	Reject					

	Shape		**Defect**	**Gred**					
	Off shape		Minimum	Grade 1					
	Off shape		Medium	Grade 2					
	Off shape		Maximum	Reject					

APPENDIX 4: FAMA APPROVED SAMPLE (STARFRUIT)

Universiti Teknologi P

Fruit Grading Syst

Mango | Papaya

Fruit Grader: Mohd Sharani Mat Saad

No.	Defect	Shape	Maturity index	Weight	Grade	Size	
1	Minimum	Perfectly shape	Index 1	180	Reject	M	
2	Medium	Off shape	Index 2	141	Grade 2	M	
3	Maximum	Perfectly shape	Index 3	222	Reject	XL	
4	Minimum	Off shape	Index 4	114	Grade 1	S	
5	Medium	Off shape	Index 5	103	Grade 2	S	
6	Maximum	Perfectly shape	Index 3	121	Reject	S	
7	Minimum	Off shape	Index 1	166	Reject	M	
8	Medium	Perfectly shape	Index 2	200	Grade 1	L	
9	Maximum	Perfectly shape	Index 3	188	Reject	L	
10	Minimum	Off shape	Index 4	198	Grade 1	L	
11	Medium	Perfectly shape	Index 5	241	Grade 1	XL	
12	Maximum	Off shape	Index 3	128	Reject	S	
13	Minimum	Off shape	Index 4	192	Grade 1	L	
14	Medium	Perfectly shape	Index 2	139	Grade 1	S	
15	Maximum	Off shape	Index 3	194	Reject	M	
16	Minimum	Off shape	Index 4	133	Grade 1	S	
17	Medium	Perfectly shape	Index 5	259	Grade 1	XL	
18	Maximum	Off shape	Index 6	197	Reject	L	
19	Minimum	Perfectly shape	Index 5	118	Premium	S	
20	Medium	Perfectly shape	Index 2	256	Grade 1	XL	
21	Maximum	Perfectly shape	Index 3	161	Reject	M	
22	Minimum	Off shape	Index 4	201	Grade 1	L	
23	Medium	Off shape	Index 5	167	Grade 2	M	
24	Maximum	Off shape	Index 6	117	Reject	S	
25	Minimum	Perfectly shape	Index 4	164	Premium	M	
26	Medium	Off shape	Index 2	203	Grade 2	L	
27	Maximum	Perfectly shape	Index 3	189	Reject	L	
28	Minimum	Off shape	Index 4	265	Grade 1	XL	
29	Medium	Off shape	Index 3	150	Grade 2	M	
30	Maximum	Perfectly shape	Index 6	132	Reject	S	
31	Minimum	Off shape	Index 1	159	Reject	M	
32	Medium	Off shape	Index 2	109	Grade 2	S	
33	Maximum	Perfectly shape	Index 3	210	Reject	L	
34	Minimum	Perfectly shape	Index 4	246	Premium	XL	
35	Medium	Perfectly shape	Index 5	100	Grade 1	S	
36	Minimum	Perfectly shape	Index 4	176	Premium	M	
37	Minimum	Perfectly shape	Index 1	209	Reject	L	
38	Medium	Off shape	Index 2	149	Gred 2	M	
39	Maximum	Off shape	Index 3	112	Reject	S	
40	Minimum	Off shape	Index 4	186	Grade 1	L	
41	Medium	Perfectly shape	Index 5	199	Grade 1	L	
42	Minimum	Perfectly shape	Index 6	230	Premium	XL	
43	Minimum	Perfectly shape	Index 4	168	Premium	M	
44	Medium	Perfectly shape	Index 2	146	Grade 1	M	
45	Maximum	Off shape	Index 3	104	Reject	S	
46	Minimum	Perfectly shape	Index 4	225	Premium	XL	
47	Medium	Off shape	Index 5	215	Grade 2	L	
48	Maximum	Off shape	Index 3	218	Reject	L	
49	Minimum	Perfectly shape	Index 1	177	Reject	M	
50	Medium	Off shape	Index 2	153	Grade 2	M	

Size & Weight
S = 100 - 140
M = 141 - 180
L = 181 - 220
XL = > 220

Maturity Index
Index 1: Premature (Dark green)
Index 2: Mature (A little yellowish)
Index 3: Half ripe (More green than yellow)
Index 4: Almost ripe (Yellow greenish)
Index 5: Ripe (A little green)
Index 6: Perfectly ripe (Yellow)
Index 7: Over ripe (Orange)

Shape
1 = Perfectly shape
2 = Off shape

Defect
1 = Minimum/None/Perfect
2 = Medium/Acceptable
3 = Maximum = Rotten

Grade
Premium
Grade 1
Grade 2
Reject

51	Maximum	Perfectly shape	Index 3	159	Reject	M			
52	Minimum	Off shape	Index 4	243	Grade 1	XL			
53	Medium	Perfectly shape	Index 5	128	Grade 1	S			
54	Maximum	Perfectly shape	Index 4	190	Reject	L			
55	Minimum	Perfectly shape	Index 1	626	Reject	M			
56	Medium	Perfectly shape	Index 2	252	Grade 1	XL			
57	Maximum	Off shape	Index 3	184	Reject	L			
58	Minimum	Perfectly shape	Index 4	187	Premium	L			
59	Medium	Off shape	Index 5	211	Grade 2	L			
60	Maximum	Perfectly shape	Index 6	143	Reject	M			
61	Minimum	Off shape	Index 4	126	Grade 1	S			
62	Medium	Off shape	Index 2	140	Grade 2	S			
63	Minimum	Perfectly shape	Index 3	201	Premium	L			
64	Minimum	Perfectly shape	Index 4	245	Premium	XL			
65	Medium	Off shape	Index 5	224	Grade 2	XL			
66	Maximum	Off shape	Index 6	156	Reject	L			
67	Minimum	Perfectly shape	Index 1	191	Reject	L			
68	Medium	Off shape	Index 2	249	Grade 2	XL			
69	Maximum	Off shape	Index 3	234	Reject	XL			
70	Minimum	Perfectly shape	Index 4	134	Premium	S			
71	Medium	Perfectly shape	Index 5	212	Grade 1	L			
72	Minimum	Off shape	Index 6	257	Grade 1	XL			
73	Minimum	Perfectly shape	Index 3	194	Premium	L			
74	Medium	Off shape	Index 2	204	Grade 2	L			
75	Maximum	Off shape	Index 3	173	Reject	M			
76	Minimum	Perfectly shape	Index 4	132	Premium	S			
77	Medium	Off shape	Index 5	222	Grade 2	XL			
78	Maximum	Off shape	Index 6	357	Reject	Not in range			
79	Minimum	Perfectly shape	Index 1	158	Reject	M			
80	Medium	Perfectly shape	Index 2	179	Grade 1	M			
81	Minimum	Off shape	Index 3	220	Grade 1	L			
82	Minimum	Perfectly shape	Index 4	258	Premium	XL			
83	Medium	Perfectly shape	Index 5	130	Grade 1	S			
84	Maximum	Off shape	Index 5	219	Reject	L			
85	Minimum	Off shape	Index 1	166	Reject	M			
86	Medium	Off shape	Index 2	131	Grade 2	S			
87	Maximum	Off shape	Index 3	147	Reject	M			
88	Minimum	Perfectly shape	Index 4	170	Premium	M			
89	Medium	Off shape	Index 3	129	Grade 2	S			
90	Minimum	Perfectly shape	Index 6	492	Premium	M			
91	Minimum	Perfectly shape	Index 1	639	Reject	M			
92	Medium	Off shape	Index 2	150	Grade 2	M			
93	Maximum	Perfectly shape	Index 3	133	Reject	S			
94	Minimum	Off shape	Index 4	186	Grade 1	L			
95	Medium	Perfectly shape	Index 5	94	Reject	Not in range			
96	Minimum	Perfectly shape	Index 3	243	Premium	XL			
97	Minimum	Perfectly shape	Index 1	155	Premium	M			
98	Medium	Off shape	Index 2	241	Grade 2	XL			
99	Maximum	Off shape	Index 3	148	Reject	M			
100	Minimum	Perfectly shape	Index 4	192	Premium	L			

	Approved by;		Date:						
	Mohd Sharani Mat Saad		11/27/2014						

	Index 1		Reject						
	Out of shape								
	Not in range								
	Index 2-5		Acceptable						

	Shape		**Defect**	**Gred**					
	Perfectly shape		Minimum	Premium					
	Perfectly shape		Medium	Grade 1					
	Perfectly shape		Maximum	Reject					

	Shape		**Defect**	**Gred**					
	Off shape		Minimum	Grade 1					
	Off shape		Medium	Grade 2					
	Off shape		Maximum	Reject					