MEAT COLOR RECOGNITION USING MACHINE VISION

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A project report submitted in partial fulfillment of the
requirement for the award of the degree
Master of Electrical Engineering

Faculty of Electric and Electronic Engineering
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JANUARY 2012

ABSTRACT

New technologies are being developed to give an ease to the human in a variety of different field each and every day. Food industry is the key of development that led to the rise of human civilization. The development of food industry dealt with the husbandry of domesticated animal and plants creating food surpluses that enabled the development of more densely populated and stratified societies. The study of food is very important that improves the quality of human's life. When it comes to classify and grade a meat, the color of fresh meat is a sensory indicator of which affects the consumers behavior, especially the consistency of meat color and musculature. Other factors that influence consumers purchasing include security, nutrition and taste. There has been no report that grades the meat freshness in the process of meat delivery. Most of the meat freshness is grading manually by using the human eyesight at the meat's color and quantity of fats. A parameter to show the freshness of meat has only been analyzed manually using a human's eyes. This is some kind of difficult method when making a right decision whether the meat is fresh or not. In order to overcome this problem, meat grading method has been studied to show the mathematical calculation on the change of color hue, saturation, and intensity (HSI) values. This study focuses on grading system design that helps to characterize the meat freshness according to its color. Using a MATLAB Graphical User Interface (GUI) program, it can analyzes the color of the meat that being inspected. The theory of this program includes the calculation of the mean values and histograms, and the final result. This system is capable of classifying meat freshness.

CHAPTER 1

INTRODUCTION

1.1 Project Background

Food industry is the key of development that led to the rise of human civilization. Meat industry is very important in the food industry as it contributes to the increase of consumers apply. This husbandry of domesticated animal and plants creates food surpluses that enabled the development of more densely populated and stratified societies. This field of food study is very important to improve the quality of human being. The color of fresh meat is a sensory indicator of which effects the consumers behavior, especially the consistency of meat color and musculature. Other factors that influence consumers to purchase include security, nutrition and taste.

Recently, there has been no report to grade the meat freshness in the process of meat delivery. Before this, most of the meats freshness is grading manually by using the human eyesight at the meat's color and quantity of fats. A parameter to show the freshness of meat has only been analyzed manually using a human's eyes. This is some kind of difficult method to make a right decision when choosing whether the meat is fresh or not. Meat grading is a method to show the mathematical calculation on the change of color and using online learning Neural Network in the process of meat classification. This study focus on designing a grading system based on time when selecting the fresh meat. This study had found that color changing significantly with the time, and this was proven after calculation. For the concentrations of bacteria, it can be known after image processing with a mathematical morphology method.

By doing a test on the selected number of samples using a photoelectric technology, an effectiveness method for grading system using a vision feature with an image processing may help in the selection of the fresh meat using the grading system. The results obtained using the proposed method were confirmed to agree well with the judgments of a grader.

1.2 Problem Statement

This project has become the interest to the researcher when system grading for meat detection is develop to ease human and also to improve their quality of life. The main objective of this project is to ease consumers how to choose a good quality of meat when buying or purchasing the fresh meat. The targeted users are huge, whether persons in charge at the restaurants, hotels or domestic consumers, which always use meat as their dishes. Meat freshness has become an issue when consumers purchase a meat while the color of fresh meat is acted as sensory indicator of which effect the consumer behavior, especially the consistency of meat color and musculature. The other factors that affected this kind of issue are various factors such as farm management, pre-slaughtering process, slaughtering, refrigeration and processing.

The purposes of grading meat and carcass classification are to set up a standard system to estimate the characteristics of carcasses and to determine the carcass value by these characteristics. A good standard and system classification not only reflect as the need of the market, but also will urge the meat producers to improve the quality of meat carcass and lastly it will become an approved design of meat quality grading based on the result investigated.

In this study, the image processing technique and color recognition method are used to analyze the samples images. A sample image is collected by photoelectric technology. Image processing method for recognition of the color is applied for grading the captured sample images and the data is compared with the grader in the system.

1.3 Project Objectives

The main objectives of this research constitute of:

1. To develop a grading system for selecting the fresh meat and show the quality of meat freshness based on meat color using unsupervised neural network.
2. To develop an online learning algorithms with the image processing and color recognition process.
3. To develop MATLAB Graphical User Interface (GUI) as the centerpiece in the recognizing colors system.

1.4 Scope of Project

This project consists of four main tasks which include:

1. The system grading is focused on detection of the meat freshness based on meat color.
2. Introducing a visual-based color classification using machine vision system for meat grading.
3. Designing the system grading for detection of the fresh meat using MATLAB Graphical User Interface (GUI).
4. Hardware and software in this project are consist of:
    - Camera: Logitech webcam, resolution 1600x1200@30fps, 8mm fixed focus, 2 Megapixel.
    - Personal Computer: windows operating system, processor Intel Core 2 Duo with 1.66Hz, 2GB memory, 160 hard disk and 384MB NVIDIA GeForce Go 7300 TurboChache.

- Other: Two lamp shelves, tripod for webcam and USB cable.

1.5 Project Outline

The project is organized into five chapters. The outline is as follows:

First outline of the research is introduction. The introduction is describing what this project is all about. Aside from that, there are also definition of proposed objectives and scopes for this project, deciding the methods to conduct the study and developing the plan of the project.

Chapter II deals with the literature review of the project. It describes the definition, concepts, principles and tool used in this project. Literature review provides a background of this project and also gives guidelines and direction in this research.

Chapter III is a research methodology. This chapter will describe the detailed method that is used to conduct this research. There are also some explanations on how the image processing is process and collection of current data.

Chapter IV is for the result and discussion. This chapter will highlight the overall of the research outcomes with the results of the neural network. The results consist of histogram, mean value of RGB and HSI image. The mean value is calculated from the results of the RGB histogram. From this calculation, the meat grading system can be simplified. The meat freshness then can be classified using the histogram and mean value.

Chapter V consists of conclusion for this study. It also describe the problem arises and recommendations for the future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter is based on the reviews from the selected journal, articles, technical papers and website. It will focus on the machine vision and using the MATLAB Graphical User Interface (GUI) for classification and grading meat freshness.

2.2 Introduction

The possession and consumption level of meat product is a measure of a states and important indicators of the quality of people life. The quality of meat product is growing forward by grading it with the quality standards. Because of the change of idea to life, people claim about health is becoming stronger. The desire to choose or instance of fresh meat and green healthy food has become important.

Currently when buying a meat or carcass at a market, mostly freshness degree of meat is grading manually by looking at the color of meat or a fat include on it. The first impression consumers have on any meat product is its color thus color is the most important aspect. In Malaysia, meat or carcass is subjectively graded by certified inspectors from the government. The primary factor is to determine the quality of meat and carcass according to the consumers.

The grading system for meat or carcass is by quantity of fat and a color. Currently a manually system is presented to user or consumer when buying a meat or

carcass. This happens because of a practical system to inspect and grading a meat does not yet exist. In order to help the food industry analyze and object the subjective decisions of human testers, several devices had appeared and designed especially for that purpose. The disadvantage with this alternative type of testing is what human's interpretation such as tastes and smells, machines will interpret them in a more complicated and difficult way. The aim of this research is to devise a system such as image processing and neural network which capable of interpreting the analyses made by an electronic device and making the results of those analyses more easily understandable for human experts.

Topology of freshness meat levels is according to the color of the meat itself. System grading by rule algorithm is dividing the freshness level with pattern such as very fresh, fresh, semi fresh, half-fresh and defective meat by color intensity at a meat itself. The freshness level of meat is classified by a level of histogram and also a mean value of image.

2.3 Meat Recognition and Image Processing

The detection methods of meat fresh degree are includes as following method: the sensory detection, all kind of physiochemical detection, sanitation or microorganism detection etc. Several researches have been carried out by Japanese students on describing a method of determining meat quality using the concept of marbling score. A research based on describing a method to determine a meats quality using the concept of "marbling score" and texture analyses had been carried out before (Kazuhiko and his team mates, 2000).

The study of marbling score is a measure of the distribution density of fats in the rib-eye region. The system considered the marbling of meat as a texture pattern. They use a grey level occurrence matrix as a texture pattern and make a standard texture feature vector for each grade using it. In the grading by the marbling score, the comparison of the meat with the standard images is the fundamental step. The marbling score in the rib-eye standard was determined by calculating the percentage of fats in the

rib eye region. From figure 2.1 shown the design of marbling concept, 12 standard images which represent 12 grade of marbling. Professional graders decide the grade of actual meat by comparing it with the standard images. The disadvantage using "marbling score" or texture pattern recognition is when the grading is performed in a refrigerator at a low temperature, this will make it difficult for grader to make a decision.

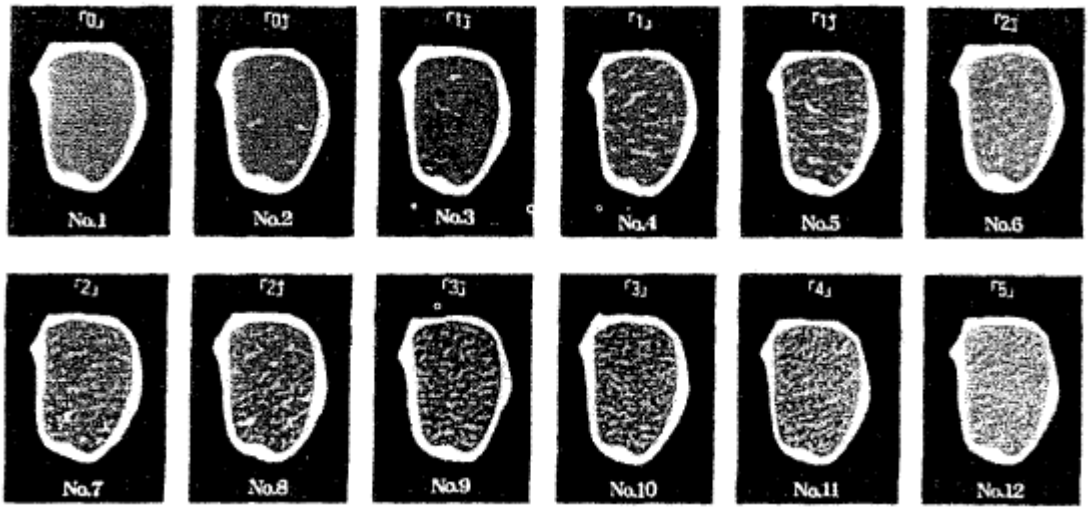

Figure 2.1: Beef marbling standard

According to this paper, the researchers have used the image processing with the neural network technique and multiple regression analysis to examine the kind of image input to the grading system and clarify that 4-bit monochromatic image that is sufficient for accurate grading. Besides that, a method of binarization of the 4-bit meat image using a three layer neural network developed on the basis of input given by a grader had been proposed and a multiple regression equation for the determination of the grade using the feature obtained with multiple regression analysis also had been formulated.

From the experiment result showed the proposed method to be effective and the application of texture analysis for grading meat quality is a suitable example of the application of texture analysis. The researchers also used a "fat-pixel" and the "muscle-pixel pattern" to find the density histogram for grading meat. From this method, fat and

muscle has become a problem to the meat grading without a fats. Color of meat then become more important judging with the grading system characteristic. Figure 2.2 shows the 4-bit monochromatic image of Hough transform.

Figure 2.2: An example of 4-bit monochromatic image

Pattern recognition is one of the image processing methods which may help the researches on finding the solution in grading the meat freshness. The author using digital image processing technique to detect the plaque bacteria that taking Hough Transform to extract complete outline of fat cell based on mathematical morphology method (Guo peiyuan, Xiao hongbing, 2010). Sample image is collected for image processing method to analyze the sample. As the sample is placed in the glass, the sample is lighted from the bottom to avoid the result which reflection and refraction from the glass effect image acquisition.

The Hough transformation is a kind of method that can feature point of the image onto the parameter space so that the image point can be gained. This method identifies the geometric figure from images and is widely used. If the shape of region beforehand is known, Hough transformation is used to get the border and connect the discontinuous point conveniently. The characteristic of Hough transform that the dish diameter is half of the height of the image. This is valid that the circle radius is 1/3 to ½

of the length of the entire image after Hough transform. Detection of the principle of the round is described by the equation $(x-x_0)^2+(y-y_0)^2=r$, which consists of three parameter x_n, y_n, and r. The structure of image acquisition system is shown in Figure 2.3 below.

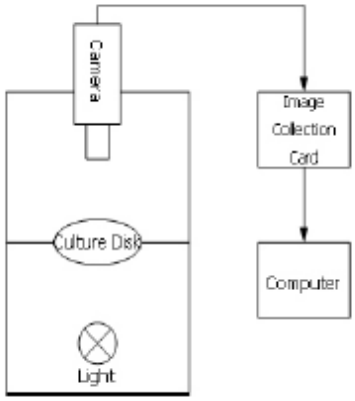

Figure 2.3: Image Acquisition System

2.4 Machine Vision

The process of color classification involves image extraction of useful information concerning the spectral properties of object surfaces and discovering the best match from a set of know description or class model to implement the recognition task (Ferhad Sahin,1997). It is useful to simplify a monochrome problem by improving contrast or separation. Color has been a great help in identifying objects for many years.

A visual-based color classification system is introduced to overcome the best match and color identifying objects. This system is used in the industrial manufacturing, as it can reduce dependency on manpower and hence increase production. Basically, machine vision system is performing a four basic procedure. The image is capturing and acquisition and image is processing in the computer centre. Then the image is analyzing to get the information and will be interpreting to the image processing. The physical elements in a vision system consist of a camera or sensor, lighting, a computer and software. A camera is used to take the picture of the object being inspected. Lighting is needed to illuminate the object, so that the image taken by the camera is adequately

exposed. The computer is a key element of the machine vision system; a fast computer will reduce the time needed for image processing. Machine vision software is used for creating and executing routines, processing incoming image data and providing a conclusive result (Ling Mei Chan and team, 2007).

2.5 Graphical User Interface (GUI)

Software development is highly important in this color classification system. The MATLAB Graphical User Interface (GUI) is used in this study as the centerpiece of the system in recognizing colors and displaying the results. The main function of the program developed here is to calculate the histogram of Red, Green, and Blue (RGB) colors in the captured image and calculate its mean values.

2.6 Color image processing

Color image processing is divided into two major areas: full-color and pseudocolor processing. For full-color, the color typically is acquired with a full-color sensor. Pseudocolor is one of assigning a color to a particular monochrome intensity or range of intensities lighting. Hues is a color attribute that describes a pure color (pure yellow, orange, or red), whereas saturation gives a measure of the degree to which a pure color is diluted by white light. Intensity (gray level) is a most useful descriptor if the images are monochromatic.

There are many different HSI transformations, one of them is given below. The HSI color model represents a color in term of hue, saturation, and intensity. The RGB component of an image can be converted to the HSI (Gonzales and Woods). The intensity is represented by the average grey level normalized to 1:

$$I = \frac{1}{3}(R + G + B) \qquad (2.1)$$

The derivation of the formula for hue and saturation begins by removing intensity from the RGB values:

$$r = \frac{R}{R+G+B} \tag{2.2}$$

$$g = \frac{G}{R+G+B} \tag{2.3}$$

$$b = \frac{B}{R+G+B} \tag{2.4}$$

In order to have the value for hue in the range from 0 to 360 degrees, it is necessary to subtract H from 360 when B/I>G/I. It should be noticed that hue feature has an angular representation from 0 to 255 after normalization. The lower values near 0 or 255 represent red pixels, value near 85 represent green pixels while values near 170 represent blue pixels. It has the property of being relatively unaffected by shadow caused by the light source. The cosine of hue is:

$$\cos H = \frac{2R-G-B}{2(\sqrt{(R-G)^2+(R-B)(G-B)})} \tag{2.5}$$

The saturation is the ratio of the distances, d_p/d_q. Saturation also measures the degree of purity of Hue. The formula for saturation is:

$$S = 1 - \frac{3}{R+G+B}\min(R,G,B) \tag{2.6}$$

2.7 Conclusion

The literature review has shown that meat grading gives important benefit for consumers and users when purchase or buying a fresh meat with a good quality. Grading meat using image processing is focusing in color image processing method and using GUI system that recognizing color and display the result, it become a medium for grading a meat with an according specification. From this chapter, all the informations related with color recognition for meat grading system are defined.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will gives further explanation about the method and the designing procedure of this research.

3.2 Experimental Design

Figure 3.1 shows the flow chart that gives the overview of the grading meat freshness system. The general design of block diagram for image acquisition using a camera and computer as a machine vision with a light is shown in Figure 3.2. This design is for capturing image and collecting data into personal computer. This data then will be analyzed using image processing method.

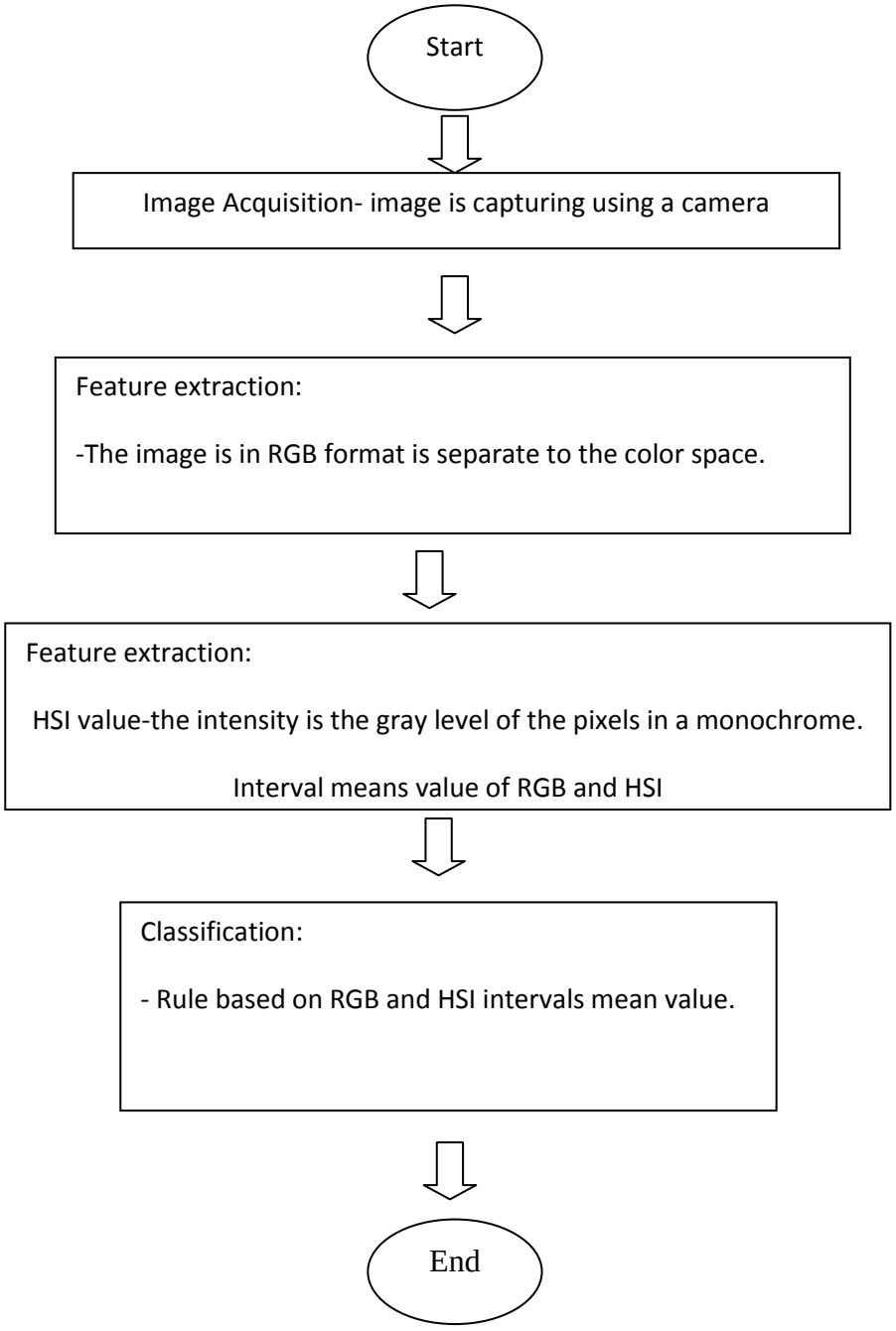

Figure 3.1: Flow chart of system grading meat freshness overview

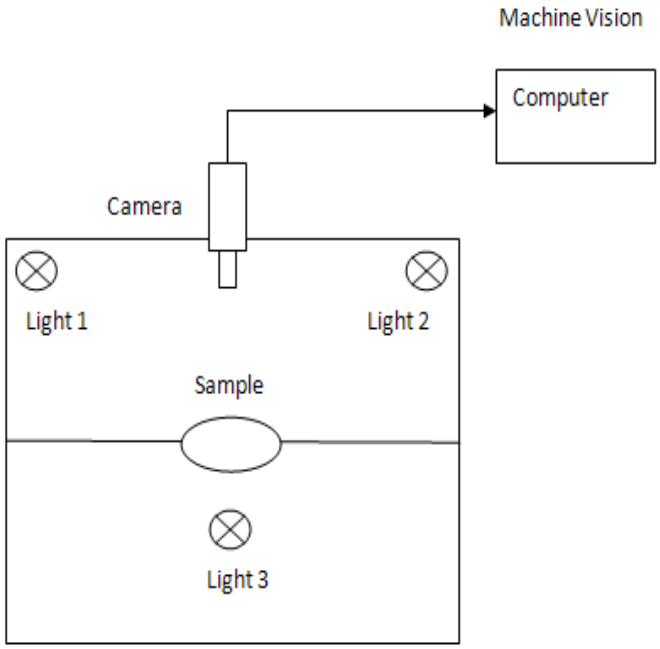

Figure 3.2: Block diagram of image acquisition system

3.3 Image Capturing

Webcam camera will be used in acquisition image and also to capture the meat data. The images of the meat were first acquired using Webcam camera and saved in the lab using a personal computer equipped with USB (Universal Serial Bus). CMOS camera is used to capture the image which is detailed and consists of useful data. For this project the sample is fixed and with additional time to capture an image, it gave benefits for improving resolution and color accuracy of three shot color. Figure 3.3 below shows when an image is captured with the image data, it will then be digitized first and sample is extracted and used in computer processing.

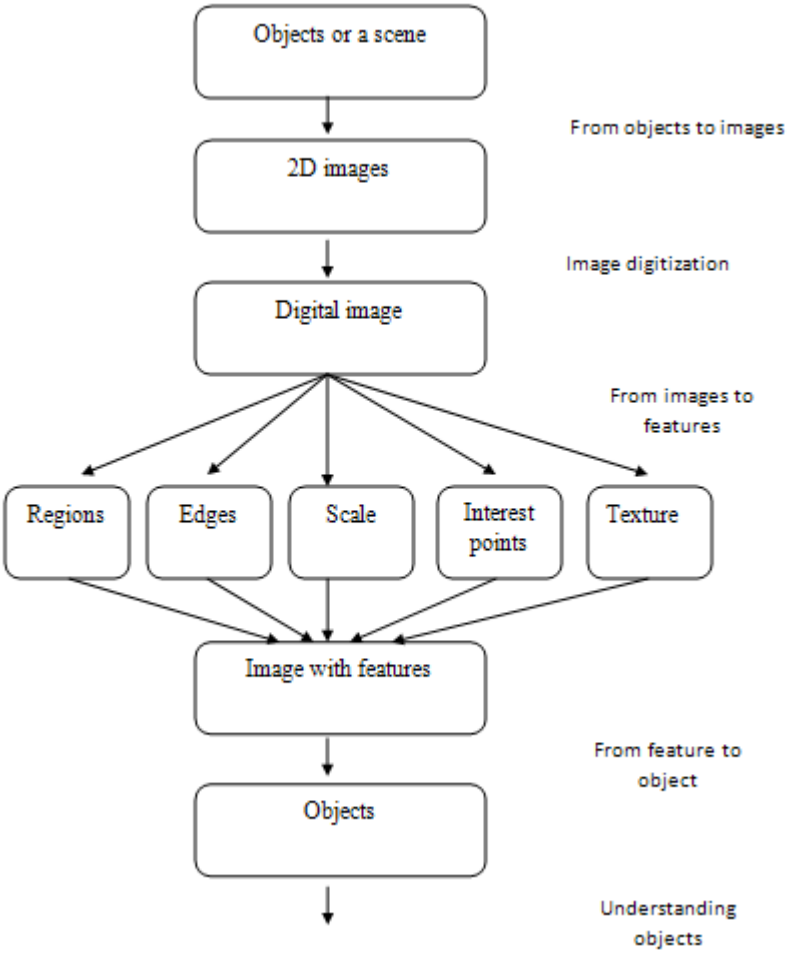

Figure 3.3: Image representation and image analysis

The raw images of meat are collected per days and the time periods are 24, 48 and 72hours. This means that there are total of 30 inputs per sample. Since there were 3 samples, the final data collections will be 270. Data are encouraged to be collected as many as possible in order to make this recognition system more accurate. The raw images are taken under different condition like the lighting and shadowing conditions and from different angles. The size of the image taken is 640x480 pixels. The images are then saved into the computer and will be used in the data analysis for meat classification.

3.4 Sample Selection

The database consists of 3sample of meat, where 30 images are captured from them for 24, 48 and 72hour period of time. The total of data 3x30x3 is 270 images. Meat sample is purchased at Parit Raja market area and has been cut into slices and each weighed 10mg. As the sample is placed in the sample glass, it is lighted from two light bulbs to avoid the reflection and refraction from the glass that will affect the image acquisition. The size of the image acquisition is 640 x 480 pixels.

3.5 Image Processing

All the images were transferred to a computer workstation for further processing. The value of gray degree can be collected through this system during the course of meat classification. The color and luster are determined by the quantity of muscle-red protein and also the color of the meat itself because color is the meat's first impression for customers. It is best that the meat is Cerise and luster. The color of meat can well manifest its characters.

During the store of meat, its color and luster will change easily with the freshness level of meat. Fresh meat is red in color compared to the hypo-fresh meat which is gray. Degenerative meat is henna and no luster. The change of color and luster of meat can be reflected through the change of the gray level. The change of freshness level then can be identified through the change of the gray level. From this gray level, the characteristic of the freshness is design according to the class of gray level.

3.6 Hue, Saturation and Intensity (HSI) Transform

The hue, saturation and brightness of a light beam are often specified using a three-dimensional color tree, as shown in Figure 3.4. The vertical axis of the tree specifies the intensity of the beam, from nothing at the bottom (that is, black) through gray to some maximum value at the top corresponding to the brightest possible white.

At each level of the tree (which corresponds to a given lightness or brightness), by drawing a circle whose circumference shows the various pure, fully saturated, monochromatic colors of the rainbow in wavelength order from red to violet. The points on a radius line from the center of the tree to some point on the circumference represent different unsaturated colors formed by mixing some amount of white from the center of the tree with some amount of the color at the end point of the line. From this three dimensional, the calculation of value HSI is used to convert the value of RGB.

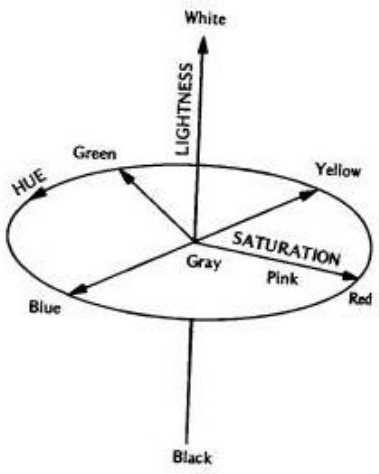

Figure 3.4: Three dimensional color tree

3.7 Meat Classifications

About 270 samples of meat for image analysis were prepared and have been bought from the market and slaughtered. The test is carried out at area of Parit Raja and Batu Pahat, Johor. This image analysis has been carried out with two parts, which the first 240 images are used in the color analysis of meat based on histogram of classification of meat freshness. The second group with the remaining 30 of the images was used for validation testing to the freshness level using GUI to identify meat freshness.

The generally classification of fresh meat is too simple to meet the producers practice requirement. More detailed according to the meat freshness grade classification would play a significant guiding or role model in the real application. The system measures the change of value H, S and I during the idea of meat freshness classification.

This change of the meat color is measured through the picture collection system based on camera and measured accurately the content of gray level test. The value of H, S, and I are treated as input signal. The identification of meat freshness is through GUI system. The flow chart of system is shown in Figure 3.5 below.

Figure 3.5: The identification flow chart of the fresh degree classification

The idea is that under a fixed or control temperature for instance room temperature. The data is collected once at every half an hour. The experiment is done repeatedly until the data is complete. The data is imported into GUI system to analyze the mean values, from this method the freshness level of meat can be known.

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

This chapter shows result and analysis from the experiment conducted using the image processing and machine vision system. There is also a detailed explanation on how the result was gained. In this research, the database consists of 3 samples of meat, where 30 images are captured from them for 24, 48 and 72 hours period of time. The total of data 3x30x3 is 270 images. Meat sample is purchased at Parit Raja market area and has been cut into slices and each weighed 10mg. As the sample is placed in the sample glass, it is lighted from two light bulbs to avoid the reflection and refraction from the glass that will affect the image acquisition. The size of the image acquisition is 640 x 480 pixels. The camera is used to acquire sample image with the number of monitoring and the need of all the features, such as stable performance, variable bit rate, and frame size variable compression.

The data is divided into two parts, experiment part and test part. In experiment part, the data will be analyzed using GUI procedure and the data is saved into the data file. While in image analysis and image classification part, the image sample will be transform in to histogram.

Using MATLAB vR2009a with GUI interface, the simulation of the image sample is analyzed and the value of mean to the RGB and HSI is calculated.

4.2 GUI Interface and Simulation

Matlab is chosen for the software development, as it provides a suitable GUI. Users can choose the image and the meat acquisition as the input type. The image is taken from the directory and is then digitized as Red, Green and Blue (RGB) data at resolution of 640x480. Data is then processed and analyzed. The main function of the program developed here is to calculate the histogram of the RGB of the captured image and calculate its mean values. The program displays the mean values of the RGB. The system overview of this visual-based color classification system is as figure 4.1. The block diagram has show the process of classification.

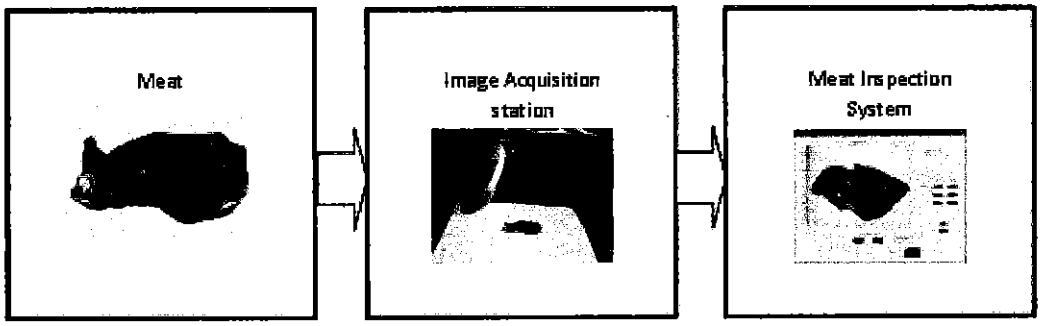

Figure 4.1: Block diagram of the system overview

According to the proposed method of experiment and analysis using a computer, simulation from MatLab Graphical Users Interface (GUI) has been carried out to analyze the classification of meat. The GUI has shown the function and analysis of the meat. The main interface of GUI to meat classification has shown in the figure 4.2. GUI interface consist of the button "Grab Image", RGB and HSV space color button and also mean color which display the result of the image.

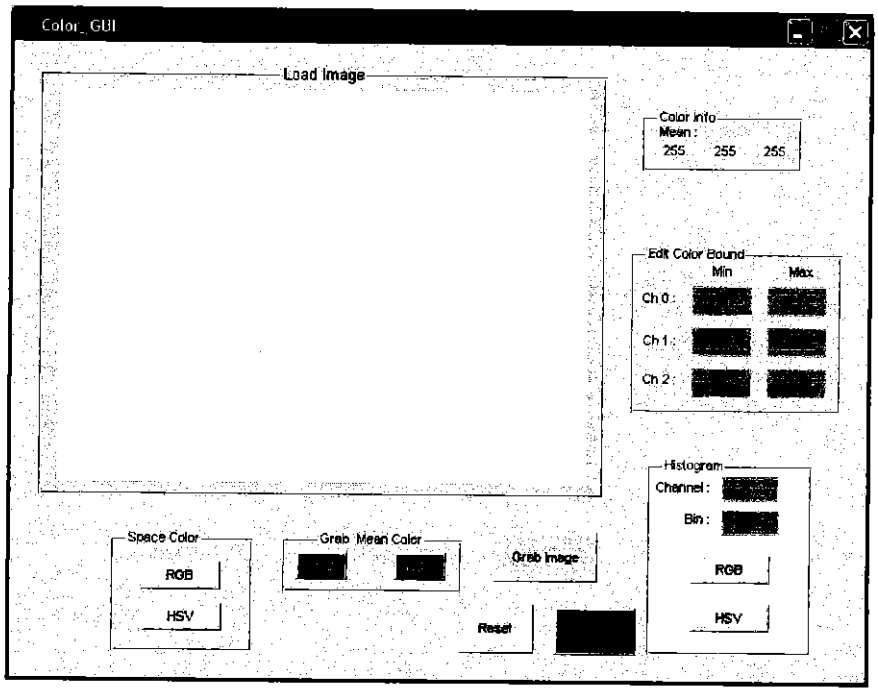

Figure 4.2: The main GUI interface of meat classification system

The image of meat is captured and stored in the directory. First, image of meat is selected to analyze from the directory where the image from acquisition is stored. By using the GUI interface, the button "Grab image" is clicked and the software needed a user to select the image to be analyzed. This operation is represented in the figure 4.3. From the GUI interface the data of the image is analyzed using the command which was set and the data will be saved as the data testing. The GUI interface is also consists of buttons which analyzed the image such as space color button, which the mean analysis will show the color info for RGB and HSI mean in the "Color info" button. All the samples of image will go through the operation of analysis in GUI interface as shown in figure 4.3.

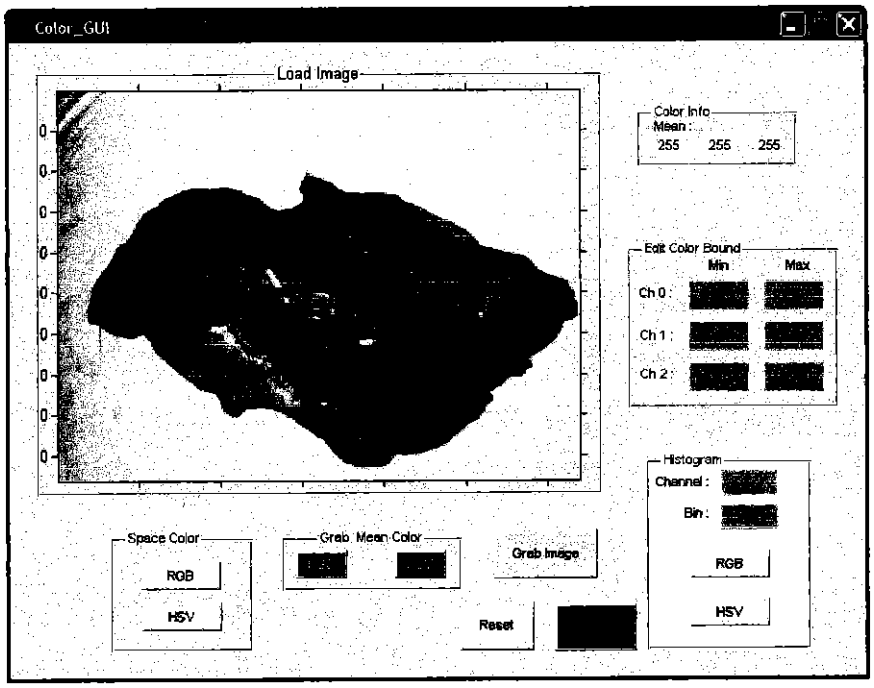

Figure 4.3: The main GUI with the image grabbed from the directory storage.

Figure 4.3 shows the main GUI with the image that was grabbed from the directory storage. For an example, the meat for sample A1 is selected and displayed in the GUI interface. The image then will be analyzed according to the buttons operation in the GUI interface, which consists of "space color", "Histogram", "Grab mean color" and the result of mean value later displayed in the "color info" button. The overall image is tested using GUI interface and the result is saved in the data file for analysis.

4.3 Experiment Setup

The sample of image is divided into 3 groups of sample which include of the sample A, B and C. This samples are represented the images consist of the RGB image and also the HSI value which calculated the mean value of RGB and HSI to be used in the system of classification meat freshness. To show the intensity of the sample, histogram is selected for the percentage of the contrast to the sample image and this will be used for freshness classification.

4.3.1 Sample analysis.

The samples of meat A is selected and is categorized to three days, which the A1 is for the sample to the first day of images, were captured. A2 represented the data of images captured on second day and A3 is the data sample for images captured on the third. The sample of meat A, then analyze and the results of the experiment have been shown in the figure 4.4. The figure 4.4, represents the example of the images to the RGB after image processing and image extraction is done to get the information from the images.

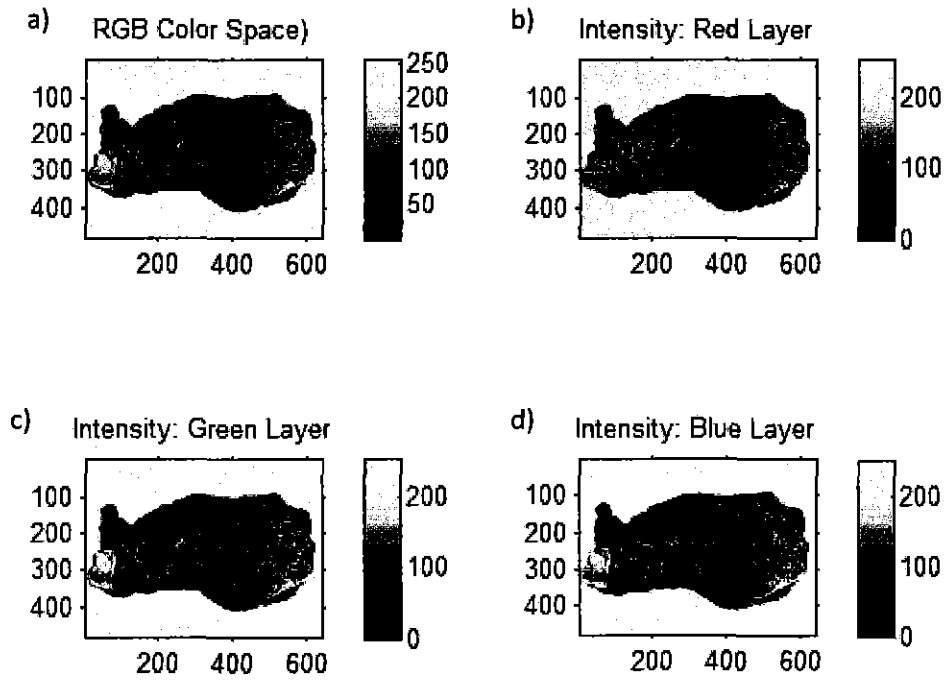

Figure 4.4: RGB space color for sample A

Figure 4.4 shows that the image of the sample A is separated to the space color transform. From the figure, all the data of image are calculated and known as: a) RGB color space, b) the intensity of Red layer, c) the intensity of Green layer and d) the intensity of Blue layer. The same experiment is repeated to the sample B and C, and the images results are shown as in the Figure 4.5 and Figure 4.6.

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