Meat Color Recognition and Classification Based on Color using NIR/VIS Camera

V.Nai Chian[a,b*], F. S. A. Saad[a,b], M.F.Ibrahim[a,b] ,S. Sudin[a,b], A. Zakaria[a,b], ,A.Y.M. Shakaff[a,b]
[a]School of Mechatronics Engineering
[b]Centre of Excellence for Advanced Sensor Technology (CEASTech)
University Malaysia Perlis, Kampus Ulu Pauh, 02600 Arau, Perlis, MALAYSIA.
ceastech@unimap.edu.my

***Abstract t*—Food supplying industry is one of the role models of development areas which had led to the rise of human weal. The study of food is very challenging as it improves the quality of earthly life. To classifying and grading meat, then the color of the texture is a sensory indicator that affects the consumers' manner, especially the change of meat color and musculature. There has yet been any data reported on freshness grading in processed meat. To overcome with this problem, the meat classifies method has been studied based on the change of the color texture. This study is focussing in a grading system design that helps to classify the meat freshness using texture and the change of color space and histogram value. The support of the theory included in the calculation of color space from the Red, Green and Blue (RGB) and also Hue, Saturation and Intensity (HSI) value. This study focuses on grading system design that helps to classify the meat freshness according to its color. By using a Graphical User Interface(GUI) program, it can analyze the color of the meat that being inspected. The mathematical calculation of the mean values and histograms is capable of classifying meat freshness based on color.**

Keywords- Image Processing; Machine Vision System; NIR/VIS Camera; Fish.

I. INTRODUCTION

Recently, there has been no report to grade and analyze meat freshness of process of meat delivery. Before this, mostly meat is graded manual 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 of difficulty method to make a right selection when choose and select the fresh meat. Meat grading is a method to show the mathematical calculation on the change of color and using classification of the mean value in the process of meat freshness detection. This study focus on designing a grading system based on color changing to the texture when meat is selected and exposure with vinicity. This study had found that color changing significantly with the time, and this was proven after calculation of color changing in meat texture. By doing a test on the selected number of samples using a photoelectric technology, an effective 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.

The possession and consumption level of meat product is a measure of a state and important indicators of the quality of people. The quality of meat product is growing forward by grading it with the quality standards. The idea of changing in people, lifestyle, people has claimed about health is becoming stronger. The aim to choose or instance of fresh meat and green healthy food has become important.

The grading system for meat or carcass is by quantity of fat and a color. Currently a manual system is presented to a 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[1] 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 a 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 the image.

II. MEAT RECOGNITION AND IMAGE PROCESSING

The methods of detection in meat freshness degree include as following manner: the sensory detection, all kind of physiochemical detection, microorganism detection, and 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 [2][3].

The study of marbling score is a measure of the distribution density of fats in the rib-eye region. 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 grades 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.

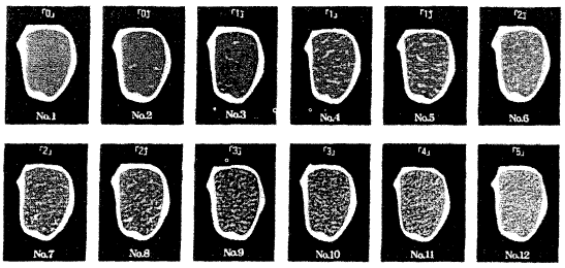

Fig. 2.1. Beef marbling standard[2]

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 the input given by a grader had been proposed and a multiple regression equation for the determination of the grade using the feature obtained by 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 the 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. The color of meat, then becomes more important judging with the grading system characteristic. Figure 2.2 shows the 4-bit monochromatic image of Hough transforms.

Fig 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 fresh. The author uses digital image processing technique to detect the plaque bacteria that taking Hough Transform to extract the complete outline of fat cell based on mathematical morphology method[4][5]. Sample image is collected for an image processing method to analyze the sample. As the sample is positioned in the glass, the specimen illuminates from the bottom to keep away the result which reflection and refraction from the glass effect image is captured.

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 structure of the image capturing system is shown in Figure 2.3 below.

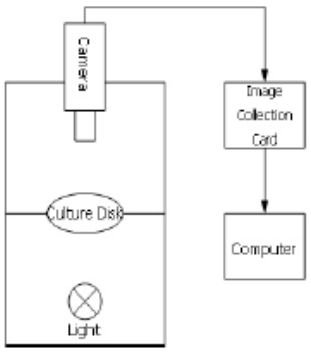

Fig. 2.3. Image Acquisition System

III. 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 knowing description or class model to implement the recognition task. It is useful to easier a monochrome problem by improving contrast or segregation.

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 manufacturing industry, as it can reduce dependence on human power and highly production. Basically, machine vision system is performing a four basic procedure. The image is captured and acquisition and image are processed in the computer center. Then the image is analyzed to get the information and will be interpreted to the image processing. The elements include in a vision system consist of a camera or sensor, lighting, a computer and software. The camera is used to capture an image of the object being inspected. Lighting is needed to shine 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 programming is used to create and execute, processing input image data and providing a conclusive result[6].

A. Graphical User Interface (Gui)

GUI software development is needed in this color detection and grading system. The MATLAB GUI is used in this study as the centerpiece of the system in detection colors and show the results. The main idea of the program advanced here is to measure the histogram of RGB and HSI colors in the captured image and calculate its mean values.

B. Color Image Processing

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[7]. The intensity is represented by the average grey level normalized to 1:

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

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

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

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:

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

IV. EXPERIMENTAL DESIGN

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 6 This design is for capturing images and collecting data into a personal computer. This data then will be analyzed using image processing methods.

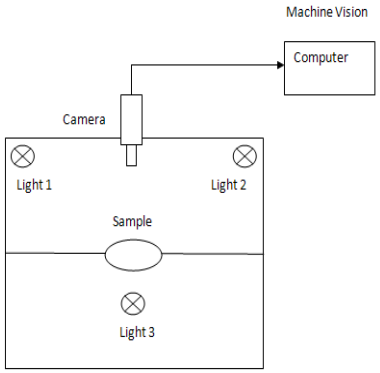

Fig. 6. Block diagram of an image acquisition system

A. Image Capturing

VIS/NIR camera will be used in acquisition image and also to capture the meat data. The images of the meat were first acquired using VIS/NIR 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 in color. Figure 6.1 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.

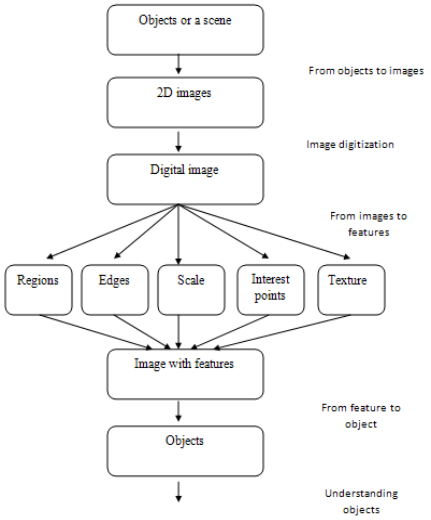

Fig. 6.1. Image representation and image analysis

The raw images of meat are collected per days and the time periods are 24, 48 and 72hours. This means that there are a 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 much 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.

B. Sample Selection

Meat sample is purchased at Parit Raja market area and has been cut into slices and each weighed 10mg. As the sample is lighted from two light bulbs is placed in glass to prevent the reflection and refraction that will affect the image acquisition. The size of the image acquisition is 640 x 480 pixels. 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.

C. Image Processing

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

During the meat stored, its color and shine will change with the freshness level of meat. Meat freshness is red in color compared to the hypo-fresh meat which is gray. Defective meat is henna and no shining. The change of color and shine of meat can be reflected through the change in the gray level. The change of freshness level than can be identified through the change of the gray level. From this gray level, the characteristic of the freshness is designed according to the class of gray level.

D. 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 6.4. The vertical axis of the tree specify 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 any 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.

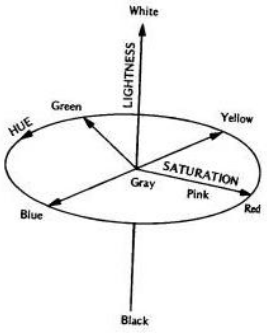

Fig. 6.4. Three dimensional color tree

E. 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 the area of Parit Raja and Batu Pahat, Johor. This image analysis has been carried out in two parts, which the first 240 images are used in the color analysis of meat based on histogram on 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 general classification of fresh meat is too simple to meet the producers practice requirement. More detailed according to the meat fresh and grading classification would play a significant guiding, or role model in the real

application. The system measures the change of value Hue, Saturation and Intensity during the idea of meat freshness classification.

This change of the meat color is measured through the image collection system based on camera and measured precisely the content of the gray level test. The value of H, S, and I are act toward as input signal. The system identification meat freshness is through GUI system. The flow chart of the system is shown in Figure 6.5 below.

Fig. 6.5. The system identification flow chart to the fresh degree classification

The purpose idea is that under a fixed or control heat 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 bring into the GUI system to analyze the mean values, from this method the freshness level of meat can be known.

F. Sample Analysis

The samples of meat A is selected and is categorized to three days, which the A1 is for the sample of the first day of images, were captured. A2 represented the data of images captured on the second day and the A3 is the data sample of images captured on the third. The sample of meat A, then analyze and the results of the experiment have been shown in the Figure 7.1. It represents the example of the images to the RGB after image processing and image extraction are done to get the information from the images.

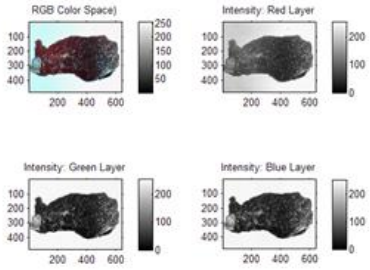

Fig. 7. RGB space color for sample A

Figure 7.1 shows that the image of the sample A is separated to the space color transform. From the figure, all the data of the 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 image results are shown as in the Figure 7.2 and Figure 7.3.

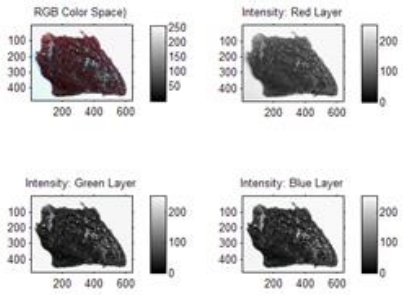

Fig. 7.2. RGB space color sample B

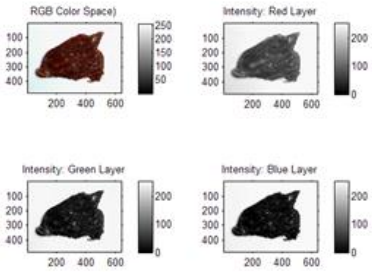

Fig. 7.3. RGB space color for sample C

As a conclusion, this experiment of the color space is done with all of the images and the data of the mean values are then stored into the file data. The data of mean value will be used in the analysis and the classification of meat grading in the last experiment. For the HSI color space for the sample A is represented in the Figure 7.4.

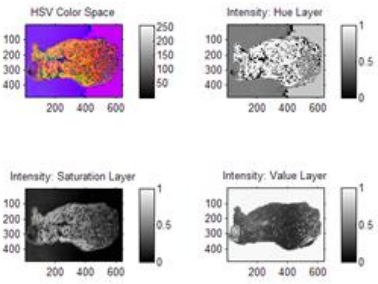

Fig. 7.4. HIS space color for sample A

V. MEAN INTERVAL VALUE RGB AND HSI

This experiment then calculates the value of the mean value and also the mean interval value to be used in classification meat degree. Experiment result obtained from fresh meat to the Sample A, are charted in the Figure 8.1, 8.2 and 8.3.

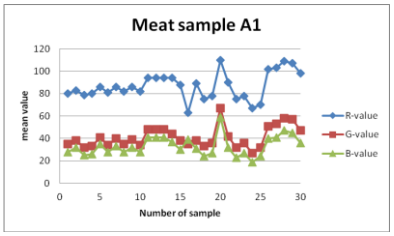

Fig. 8.1. Chart of RGB to the fresh meat for sample A1

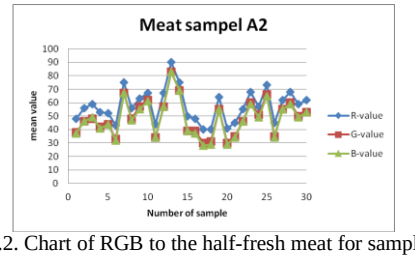

Fig. 8.2. Chart of RGB to the half-fresh meat for sample A2

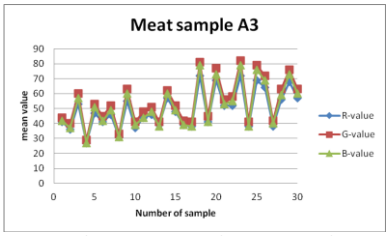

Fig. 8.3. Chart of RGB to the defective meat for sample A3

From the charts above show the mean value according to RGB of the sample A. This sample is calculated for mean value according to the day of captured image as A1 is for first day the image was captured, A2 is for second day the image was captured and A3 is for third day the image was captured.

This test for 240 samples of meat has been done for the mean color of RGB and HSI. This classification using a rule based has been used to identify a degree of freshness to the sample. The system processed the collected data, and using the model color values transforms to extract sample color value (R, G, B, H, S, I). The images tested with the rule based were created for identification to the degree of freshness. 30 samples of meat images were tested and this gave a positive response with 80% of the target is achieved.

VI. CONCLUSION

During the experiment of the mean value, classification of meat can be done with the value of the mean and also the histogram. From the experiment, the highest intensity value of the mean value to the RGB and HSI is proved that the grading meat is successful. The fresh meat is choosing from the interval value with the specific mean value and this also help the researcher to complete the meat grading processes.

The experiment results achieve have greatly helped in develop the entire study. Without the data, the performance of the system may not be successful. One of the purpose of this study is to dissipate meat into ‘fresh’, ‘half-fresh’ and ’defective’ meat.

References

[1] Thodberg, H. H. (1997). The automation of intuitive visual expertise: classification of beef carcasses using neural networks. Neural Networks for Industrial Applications (Digest No. 1997/014), IEE Colloquium, 1997, pp 4/1-4/2, Feb 1997.

[2] Shiranita, K., K. Hayashi, et al. (1999). Grading meat quality by texture analysis. Systems, Man, and Cybernetics, 1999. IEEE SMC '99 Conference Proceedings. IEEE International Conference 1999, pp 958-962, Oct 1999.

[3] Shiranita, K., K. Hayashi, et al. (2000). Determination of meat quality by image processing and neural network techniques. Fuzzy Systems, 2000. FUZZ IEEE. The Ninth IEEE International Conference on 2000, pp 989-992, .2000

[4] Guo, P., M. Bao, et al. (2007). Detection of Meat Fresh Degree Based on Neural Network. Mechatronics and Automation, 2007. ICMA. International Conference 2007., pp2726-2730, Aug 2007.

[5] Guo, P., S. Bi, et al. Pork freshness pattern recognition based on SOM neural network. Control Conference (CCC), 29th Chinese, 2010, pp 2338-2341, Jul 2010.

[6] Ling Mei Chan, Rodney Tan, Gilbert Thio (2007), Design of Visual-based Color Classification System.

[7] Digital Image Processing using MATLAB, R. C. Gonzalez et al., Prentice Hall, ISBN 0-13-008519-7.