

**A COMPUTERIZED DESIGN OF PASI SCORING FOR REDNESS OF  
PSORIASIS SKIN DISEASE**

By

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**FINAL PROJECT REPORT**

Submitted to the Electrical & Electronics Engineering Programme  
in Partial Fulfillment of the Requirements  
for the Degree  
Bachelor of Engineering (Hons)  
(Electrical & Electronics Engineering)

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# CERTIFICATION OF APPROVAL

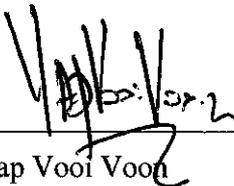
## A COMPUTERIZED DESIGN OF PASI SCORING FOR REDNESS OF PSORIASIS SKIN DISEASE

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A project dissertation submitted to the  
Electrical & Electronics Engineering Programme  
Universiti Teknologi PETRONAS  
in partial fulfilment of the requirement for the  
Bachelor of Engineering (Hons)  
(Electrical & Electronics Engineering)

Approved:



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Dr. Yap Vooi Voon  
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

July 2007

## 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.



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Atiqah Farhana Bte Zakaria

## ABSTRACT

Psoriasis is one type of skin disorder that is chronic inflammatory skin condition, characterized by localized, widespread well-demarcated red plaques often topped by silvery scales. Dermatologists are using Psoriasis Area and Severity Index (PASI) as a gold standard for evaluating level of psoriasis. Four basic characteristics of psoriasis lesion must be calculated for giving PASI score, one of them is lesion redness. The objective of this project is to design and build a computer-based system to enable system to detect lesion region and generate its PASI scoring for redness using image processing technique. The system would assist dermatologists to give the most suitable treatment to the different levels of psoriasis severity based on the redness score using PASI. The sample images are analyzed to classify the severity of the lesion based on color, area covered, shape, size and other features by applying engineering knowledge using the Digital Image Processing Tools in MATLAB7 software. Segmenting lesion from healthy skin is central part of this system. Several filtering and image processing techniques available in the MATLAB7 tools are applied to the sample images to produce their histograms and color distribution particularly in the region concerned. From the results, it shows that the technique used has potential to analyze the sample images. The accuracy of the system can be improved by applying different image processing technique. Result of this project can be analyzed further and served as identification of diagnosis to aid dermatologist in their work. The system is still open for further improvement to increase the accuracy and reliability.

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## LIST OF ABBREVIATIONS

|                      |  |
|----------------------|--|
| <b>A<sub>h</sub></b> | Area of involvement score on the head              |
| <b>A<sub>l</sub></b> | Area of involvement score on the lower extremities |
| <b>area</b>          | Area of Lesion                                     |
| <b>areah</b>         | Area of Healthy Skin                               |
| <b>A<sub>t</sub></b> | Area of involvement score on the trunk             |
| <b>A<sub>u</sub></b> | Area of involvement score on the upper extremities |
| <b>B</b>             | Blue   |
| <b>Bcomp</b>         | Comparison Value of B                              |
| <b>BSA</b>           | Body Surface Area                                  |
| <b>C</b>             | Cyan   |
| <b>EM</b>            | Electromagnetic                                    |
| <b>G</b>             | Green  |
| <b>Gcomp</b>         | Comparison Value of G                              |
| <b>GUI</b>           | Graphical User Interface                           |
| <b>GUIDE</b>         | Graphical User Interface Development Environment   |
| <b>h</b>             | Head   |
| <b>l</b>             | Lower Extremities                                  |
| <b>M</b>             | Magenta  |
| <b>MATLAB</b>        | Matrix Laboratory                                  |
| <b>PASI</b>          | Psoriasis Area and Severity Index                  |
| <b>R</b>             | Red  |
| <b>Rcomp</b>         | Comparison Value of R                              |
| <b>Rd</b>            | Redness  |
| <b>R<sub>h</sub></b> | Redness score on the head                          |
| <b>R<sub>l</sub></b> | Redness score on the lower extremities             |
| <b>R<sub>t</sub></b> | Redness score on the trunk                         |
| <b>R<sub>u</sub></b> | Redness score on the upper extremities             |
| <b>S</b>             | Scaliness  |
| <b>S<sub>h</sub></b> | Scaliness score on the head                        |
| <b>S<sub>l</sub></b> | Scaliness score on the lower extremities           |

|                      |  |
|----------------------|--|
| <b>S<sub>t</sub></b> | Scaliness score on the trunk             |
| <b>S<sub>u</sub></b> | Scaliness score on the upper extremities |
| <b>T</b>             | Thickness                                |
| <b>t</b>             | Trunk                                    |
| <b>T<sub>h</sub></b> | Thickness score on the head              |
| <b>T<sub>l</sub></b> | Thickness score on the lower extremities |
| <b>T<sub>t</sub></b> | Thickness score on the trunk             |
| <b>T<sub>u</sub></b> | Thickness score on the upper extremities |
| <b>u</b>             | Upper Extremities                        |
| <b>U.S</b>           | United State                             |
| <b>Xacc</b>          | RGB Accumulative Value for Lesion        |
| <b>Xacch</b>         | RGB Accumulative Value for Healthy Skin  |
| <b>Xcomp</b>         | Comparison Value of RGB                  |
| <b>Xmean</b>         | RGB Mean Value for Lesion                |
| <b>Xmeanh</b>        | RGB Mean Value for Healthy Skin          |
| <b>Y</b>             | Yellow                                   |

# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Study

Skin forms the largest organ of the body, accounting for about 16 per cent of a person's weight and obviously the most visible. It performs many vital roles as both a barrier and a regulating influence between the outside world and the controlled environment within our bodies. There are more known diseases of the skin than any other organ system. To make matters worse, one skin disease is likely to breed another. Some of the common skin diseases are acne, eczema, psoriasis, melanoma, and tinea [1].

Psoriasis is one type of disease that can be diagnosed using medical imaging process. The psoriasis patient are graded in terms of redness, thickness and scaliness on a 0 – 4 scale using PASI.

Digital image processing tools in MATLAB is used to determine the score of redness of psoriasis skin disease where the severity is rated for each index on a 0–4 scale. The fundamental concept of diagnosis the lesions are by looking at the skin lesion and analyze it in automatic and computerized system. This system is needed for better accuracy and efficiency diagnosis.

## **1.2 Problem Statement**

### ***1.2.1 Problem Identification***

Diagnostic data from the human skin is complex in nature and becomes difficult to analyze. Specialists use different techniques to get the clear picture of human skin, but due to complexity of texture and structure, it has been always difficult to interpret these images.

Dermatologist needs preliminary analysis of color and texture when diagnosis a skin lesion, but the human eye is not always sufficient to perform such analysis. Therefore, better true color digital imaging is required.

Processing of these images with computer has made more convenient to diagnose and analyze such data. Availability of the system will assist the doctors and scientist to analyze the data and diagnose the abnormality especially in the eye a more effective manner. In conjunction with that, it is important to use this computerized system to support early diagnosis.

### ***1.2.2 Significance of the Project***

Through the years, colleges and universities worldwide have played a crucial role in all aspects of biomedical education and research. It is envisaged that this project will contribute to the field of computer vision in dermatology for the follow up of skin lesions, it can also be served as the visual front end for developing a knowledge-based pre-diagnostics system to aid dermatologist in their work. It aids the dermatologist to better diagnose of psoriasis lesion.

## **1.3 Objectives and Scope of Study**

The main objective of this research-based and simulation-based project is to study on image processing field and design an intelligent algorithm that will determine the redness score of psoriasis skin disease. It is envisaged that the processing algorithms

will be implemented in MATLAB environment. The objectives, scopes and assumptions for this project are:

- To build an automated system capable of classifying the level of redness severity using PASI
- To apply engineering knowledge in the image processing techniques
- To do carry out image analysis and data validation utilizing the score of redness severity

The sample images and their respected clinical evaluation are taken from the hospital around Malaysia west midland region

### ***1.3.1 The Relevancy of the Project***

Psoriasis is reported to have the highest number of patients in Malaysia, consuming about 3% of the population [2; 3]. This chronic scaling disease belongs to the papulosquamos disease group of skin disorder [4]. Plaque was chosen in the designing of an automatic diagnosis model because of the highest percentage of occurrence among psoriasis patients. Hence this project is very relevant to treatment process of psoriasis disease.

### ***1.3.2 Feasibility of the Project within Scope and Time Frame***

The project starts with the study of several image-processing techniques focusing on the morphological operation method. Research is done as the methods are having their pros and cons. A program that will determine the redness score of psoriasis skin disease is created. In the first semester, simulation is done on the segmentation algorithm using MATLAB. Later in the second semester, the algorithm is enhanced to get the better result and GUI is applied for easy-to-use program for user. Finally, a thorough analysis is conducted on the result obtained based on the dermatologist's diagnosis. **Appendix A** shows the Gantt chart for the whole semester.

## **CHAPTER 2**

### **LITERATURE REVIEW**

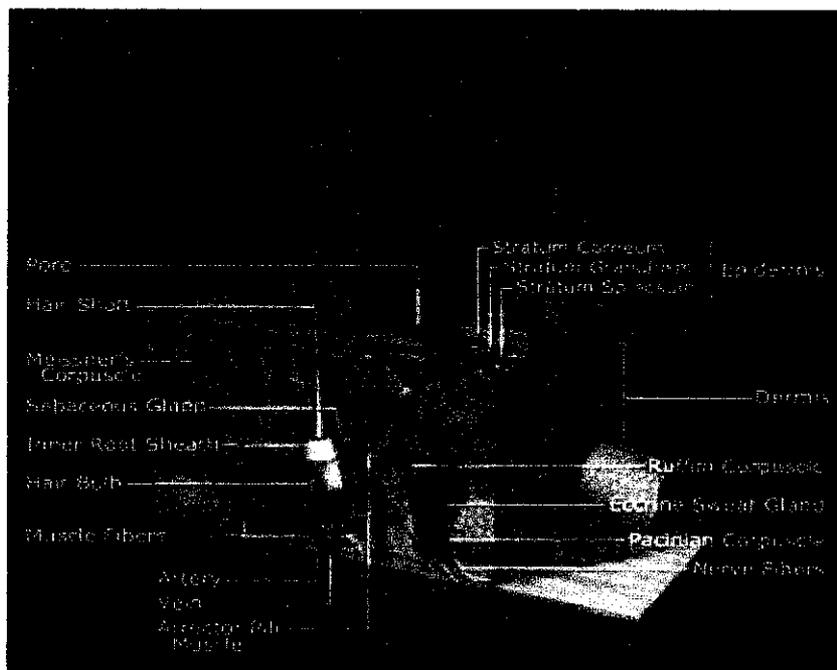
#### **2.1 Human Skin**

##### ***2.1.1 Skin structure***

In dermatology, skin is an organ of the integument system made up of multiple layers of epithelial tissues that guard underlying muscles and organs. As the interface with the surroundings, it plays the most important role in protecting against pathogens. Skin is considered one of the most important parts of the body.

Skin has pigmentation, or melanin, provided by melanocytes, which absorb some of the potentially dangerous ultraviolet radiation in sunlight. This has sometimes led to the classification of people(s) on the basis of skin color.

Skin is composed of three primary layers: the epidermis, which provides waterproofing and serves as a barrier to infection; the dermis, which serves as a location for the appendages of skin; and the hypodermis (subcutaneous adipose layer), which is called the basement membrane.



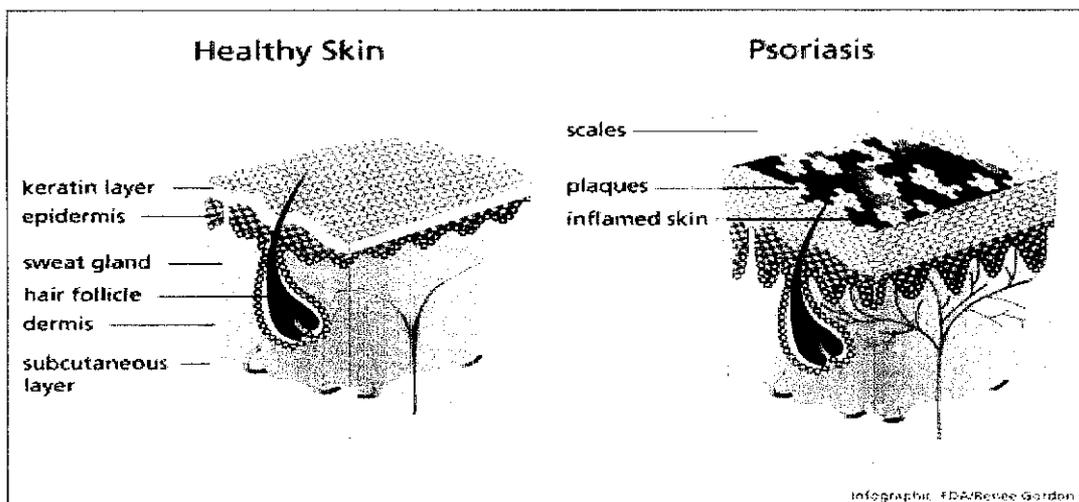
**Figure 1** Diagram of the layers of human skin

(Source taken from Wikipedia, the free encyclopedia)

## 2.2 Psoriasis

### 2.2.1 Psoriasis

Psoriasis is a chronic (long-lasting) skin disease characterized by scaling and inflammation. Scaling occurs when new skin cells (melanocyte cells) in the epidermis layer of skin reproduce about eight times faster than normal in few days instead of a month and the abnormality rate of these cells to replace the old ones at the outer layer of skin. When psoriasis develops, patches of skin thicken, redden, and become covered with silvery scales. These patches can be itchy and are sometimes referred to as plaques. These scaly plaques most often found on the elbows, knees, legs, scalp, lower back, face, palms, nails and soles of the feet.



**Figure 2** Skin structure for both healthy skin and psoriasis skin

(Source taken from the U.S. Food and Drug Administration,  
Department of Health and Human Services)

### **2.2.2 Type of psoriasis**

Dermatologists distinguish different forms of psoriasis according to what part of the body is affected, how severe symptoms are, how long they last, and the pattern formed by the scales [5].

#### **Plaque psoriasis**

Plaque psoriasis (*psoriasis vulgaris*), the most common form of the disease, is characterized by small, red bumps that enlarge, become inflamed, and form scales. The top scales flake off easily and often, but those beneath the surface of the skin clump together. Removing these scales exposes tender skin, which bleeds and causes the plaques (inflamed patches) to grow. Plaque psoriasis can develop on any part of the body, but most often occurs on the elbows, knees, scalp, and trunk.



**Figure 3** Plaque psoriasis on the knee

(Source taken from [14])

### **Scalp psoriasis**

Scale-capped plaques on the surface of the skull characterize this form of the disease. At least 50 of every 100 people who have any form of psoriasis have scalp psoriasis.

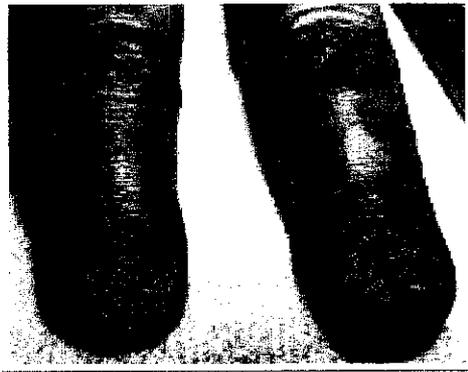


**Figure 4** Scalp psoriasis

(Source taken from [14])

### **Nail psoriasis**

The first sign of nail psoriasis is usually pitting of the fingernails or toenails. Size, shape, and depth of the marks vary, and affected nails may thicken, yellow, or crumble. The skin around an affected nail is sometimes inflamed, and the nail may peel away from the nail bed.

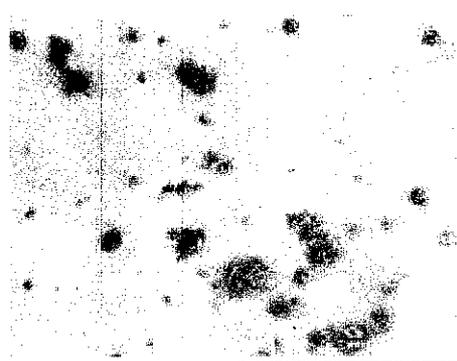


**Figure 5** Nail psoriasis

(Source taken from [14])

### **Guttate psoriasis**

Guttate psoriasis is characterized by small, red, drop-like dots that enlarge rapidly and may be somewhat scaly. Often found on the arms, legs, and trunk and sometimes in the scalp, guttate psoriasis can clear up without treatment or disappear and resurface in the form of plaque psoriasis.



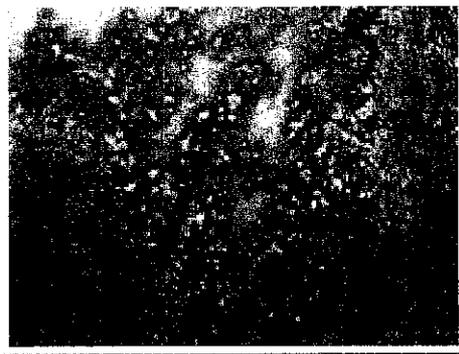
**Figure 6** Guttate psoriasis on the back

(Source taken from [14])

### **Pustular psoriasis**

Pustular psoriasis usually occurs in adults. It is characterized by blister-like lesions filled with non-infectious pus and surrounded by reddened skin. Pustular psoriasis,

which can be limited to one part of the body (localized) or can be widespread, may be the first symptom of psoriasis or develop in a patient with chronic plaque psoriasis.



**Figure 7** Pustular psoriasis on the knee

(Source taken from [14])

### **2.3 Psoriasis Area and Severity Index (PASI)**

A patient's Psoriasis Area and Severity Index (PASI) is a measure of overall psoriasis severity and coverage. It is a commonly used measure in clinical trials for psoriasis treatments. Typically, the PASI would be calculated before, during, and after a treatment period in order to determine how well psoriasis responds to the treatment under test (a lower PASI means less psoriasis, generally) [6]. The Psoriasis Area and Severity Index (PASI) is the most widely used tool to assess psoriasis disease severity in clinical trials. Fredriksson and Pettersson formulated the PASI in 1978 as a method to evaluate the clinical efficacy of a new treatment for psoriasis [7].

When using the PASI, psoriatic plaques are graded based on three criteria: redness (**Rd**), thickness (**T**), and scaliness (**S**). Severity is rated for each index on a 0-4 scale (0 for no involvement up to 4 for severe involvement). The body is divided into four regions comprising the head (**h**), which covered 10% of a human skin surface, upper extremities (**u**), which covered 20% of a human skin surface, trunk (**t**), which covered 30% of a human skin surface and lower extremities (**l**), which covered 40% of a human skin surface. In each of these areas, the fraction of total surface area affected is graded on a 0-6 scale (0 for no involvement; up to 6 for greater than 90 % involvement). The various body regions are weighted to reflect their respective proportion of body surface

area (BSA) [8].

### **2.3.1 Method used to assess severity of psoriasis using PASI**

The severity of psoriasis skin disease is measured based on three criteria: redness (**Rd**), thickness (**T**), and scaliness (**S**) of the lesions. Severity is rated for each index on 0 – 4 scale.

**Table 1** Severity of each score

| <b>Score</b> | <b>Severity</b> |
|--------------|-----------------|
| 0            | No involvement  |
| 1            | Slight and mild |
| 2            | Moderate        |
| 3            | Severe          |
| 4            | Most severe     |

The body is divided into four regions: -

- head (**h**)
- upper extremities (**u**)
- trunk (**t**)
- lower extremities(**l**)

In each of these areas, the fraction of total surface area affected ( $A_h$ ,  $A_u$ ,  $A_t$ ,  $A_l$ ) is graded on a 0-6 scale (0 for no involvement; up to 6 for greater than 90 % involvement)

**Table 2** Coverage area of each score

| Coverage | Score |
|----------|-------|
| 0%       | 0     |
| < 10%    | 1     |
| 10-29%   | 2     |
| 30-49%   | 3     |
| 50-69%   | 4     |
| 70-89%   | 5     |
| 90-100%  | 6     |

Scores of redness (**R**), thickness (**T**), and scaliness (**S**) for each area are calculated

- Head =  $R_h + T_h + S_h$
- Upper extremities =  $R_u + T_u + S_u$
- Trunk =  $R_t + T_t + S_t$
- Lower extremities =  $R_l + T_l + S_l$

The composite PASI score can then be calculated by multiplying the sum of the individual-severity scores for each region by the weighted area-of-involvement score for that respective region

- Head =  $0.1(R_h + T_h + S_h) A_h$
- Upper extremities =  $0.2(R_u + T_u + S_u) A_u$
- Trunk =  $0.3(R_t + T_t + S_t) A_t$
- Lower extremities =  $0.4(R_l + T_l + S_l) A_l$

Summing the four resulting quantities to get the PASI score

$$\text{PASI} = 0.1(R_h + T_h + S_h)A_h + 0.2(R_u + T_u + S_u)A_u + 0.3(R_t + T_t + S_t)A_t + 0.4(R_l + T_l + S_l)A_l$$

The highest potential PASI score is 72; the lowest is 0.

Highest PASI score:

$$\begin{aligned} &= 0.1 (4+4+4) 6 + 0.2 (4+4+4) 6 + 0.3 (4+4+4) 6 + 0.4 (4+4+4) 6 \\ &= 0.1 (72) + 0.2 (72) + 0.3 (72) + 0.4 (72) \end{aligned}$$

= 72

Lowest PASI score:

$$= 0.1 (0) + 0.2 (0) + 0.3 (0) + 0.4 (0)$$

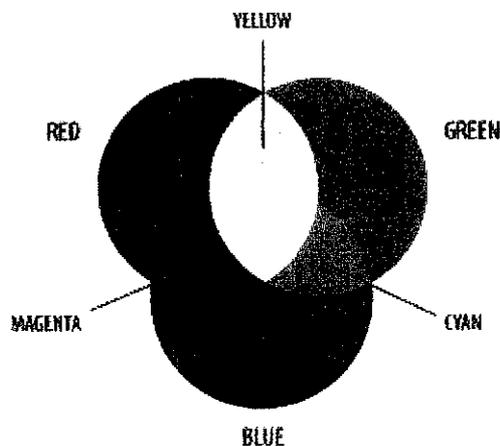
$$= 0$$

PASI is now well established that 75% improvement in PASI (PASI 75) is a clinically meaningful endpoint for clinical trials, and there is strong evidence demonstrating that 50% improvement in PASI (PASI 50) is also a clinically meaningful endpoint.

## 2.4 RGB Color Model

RGB and its subset CMY form the most basic and well-known color model. This model bears closest resemblance to how we perceive color. It also corresponds to the principles of additive and subtractive colors. Mixing spectral light in varying combinations creates additive colors. Subtractive colors are seen when pigments in an object absorb certain wavelengths of white light while reflecting the rest. Any colored object, whether natural or man-made, absorbs some wavelengths of light and reflects or transmits others; the wavelengths left in the reflected/transmitted light make up the color we see.

Red, green, and blue are the primary stimuli for human color perception and are the primary additive colors. The relationship between the colors can be seen in this illustration:



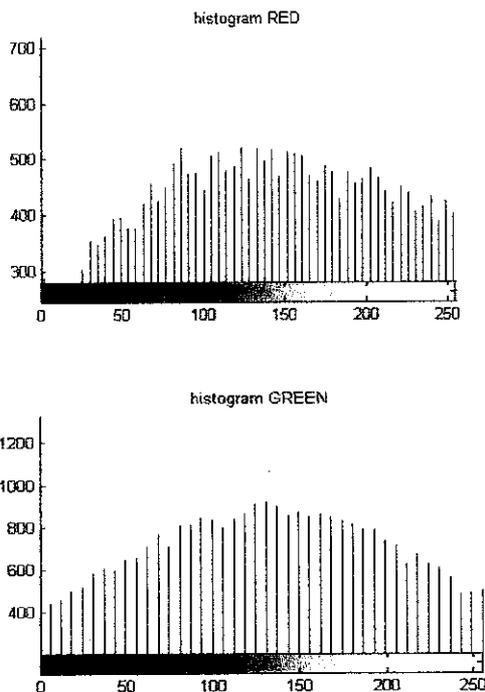
**Figure 8** Combination of additive and subtractive color

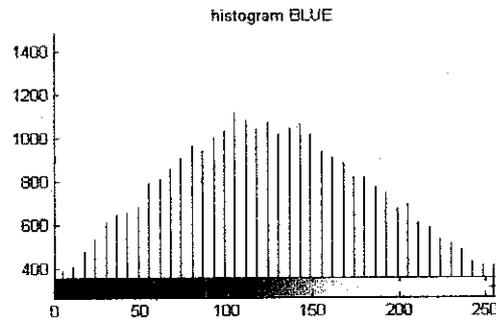
(Source taken from the U.S. Food and Drug Administration,  
Department of Health and Human Services)

The secondary colors of RGB, cyan, magenta, and yellow, are formed by the mixture of two of the primaries and the exclusion of the third. Red and green combine to make yellow, green and blue make cyan, and blue and red make magenta. The combination of red, green, and blue in full intensity makes white. White light is created when all colors of the EM spectrum converge in full intensity. The importance of RGB as a color model is that it relates very closely to the way we perceive color with the *r*, *g* and *b* receptors ( $\rho$   $\gamma$   $\beta$  receptors) in our retinas.

### 2.4.1 Color Histogram

For this project, Color Histogram serves as one of the most important techniques for content-based image retrieval [10] because of its efficiency and effectiveness. Work in progress includes studying one of the image processing tools; RGB Color Histogram focusing on how to read image files and transform them in terms of histogram.





**Figure 9** RGB Color Histogram

(Source taken from [15])

## 2.5 MATLAB

MATLAB stands for Matrix laboratory, powerful engineering software from Math Works that able to perform various technical and engineering computation including digital image processing, simulation, and to communicate to the outside world through various interface. MATLAB programming language is C, the most common programming used by application programmers.

*One of the most common practices of MATLAB software is digital signal processing that can lead to various applications in the electronics world. Digital signal processing may perform advancement in image processing, audio processing, data communication, signal pattern recognition, and many other mathematical operations [11].*

## 2.6 Component of computer based system

### 2.6.1 Image Segmentation

Segmentation is performed to select a group of pixels that have particular color space value to be selected and processed for further operation [12]. The segmentation in this work is interested in human skin color information since the study is to generate score of redness of human skin.

Color space chosen for the operation is RGB. Red, green, and blue are the primary stimuli for human color perception and are the primary additive colors. The segmentation is performed after the conversion from RGB to grayscale. Once the image is converted, each pixel value is checked to obtain the value of each component in RGB format. If the components of the pixel are within the range of lesion color properties, the pixel will retain its RGB original value otherwise the pixel will be changed into black by changing all layers component into zero. The outcome of the segmentation will show lesion of human color skin ranged pixel only where the other pixels are black.

The range of values of lesion on human skin color is based on the sample images. By taking statistics of pixel that represents the lesion, the lesion color range value for each plane of the color space can be obtained. The thresholding operation is also applied after converted the sample image in black and white in order to prepare for boundary tracing using *bwboundaries*.

## **2.7 Graphical User Interface (GUI)**

A graphical user interface (GUI) is a pictorial interface to a program. A good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth.

The three principal elements required to create a MATLAB Graphical User Interface are: -

### **Components**

Each item on a MATLAB GUI (pushbuttons, labels, edit boxes, etc.) is a graphical component. The types of components include graphical controls (pushbuttons, edit boxes, lists, sliders, etc.), static elements (frames and text strings), menus, and axes. Graphical controls and static elements are created by the function `uicontrol`, and menus are created by the functions `uimenu` and `uicontextmenu`. The function `axes` create axes, which are used to display graphical data.

## Figures

The components of a GUI must be arranged within a figure, which is a window on the computer screen. In the past, figures have been created automatically whenever we have plotted data. However, empty figures can be created with the function `figure` and can be used to hold any combination of components.

## Callbacks

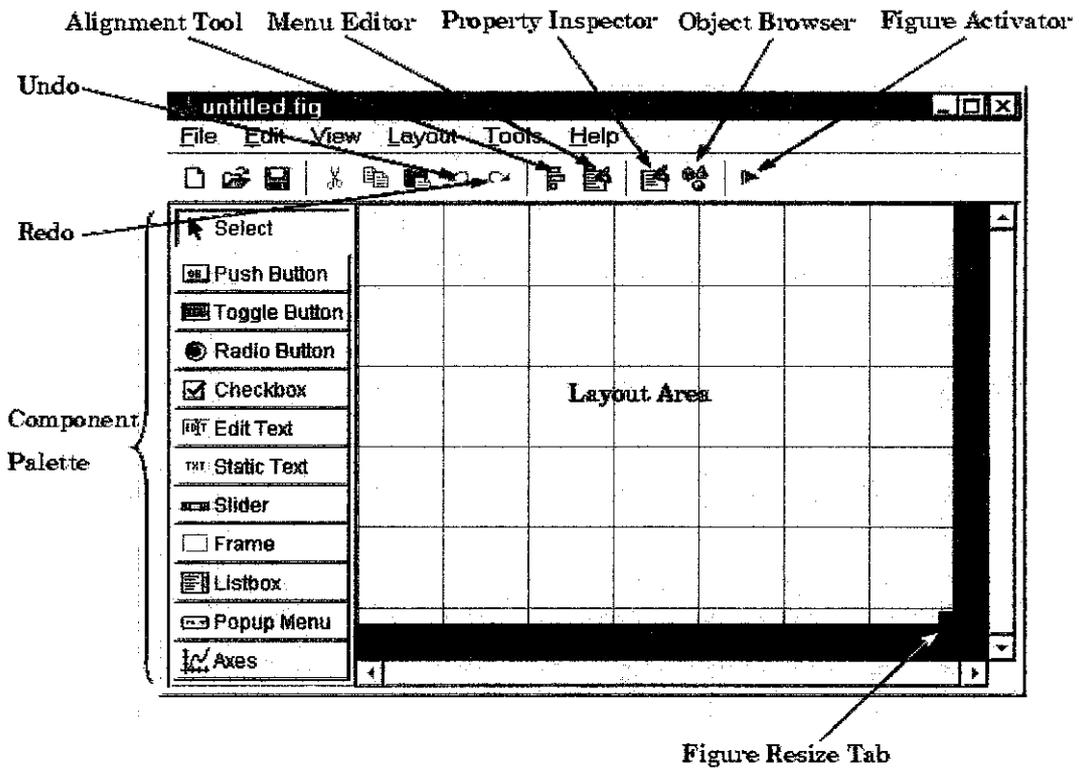
Finally, there must be some way to perform an action if a user clicks a mouse on button or types information on a keyboard. A mouse click or a key press is an event, and the MATLAB program must respond to each event if the program is to perform its function. For example, if a user clicks on a button, that event must cause the MATLAB code that implements the function of the button to be executed. The code executed in response to an event is known as a call back. There must be a callback to implement the function of each graphical component on the GUI.

The process of implementing a GUI involves two basic tasks:

- Laying out the GUI components
- Programming the GUI components

### 2.7.1 GUI Layout

MATLAB GUIs are created using a tool called GUIDE, the GUI Development Environment. This *tool* allows a programmer to layout the GUI, selecting and aligning the GUI components to be placed in it. Once the components are in place, the programmer can edit their properties: name, color, size, font, text to display, and so forth. When GUIDE saves the GUI, it creates working program including skeleton functions that can be modify to implement the behavior of the GUI. When GUIDE is executed, it creates the Layout Editor, shown in **Figure 10**.



**Figure 10** The guide tool window

(Source taken from [16])

### 2.7.2 GUI Programming

After laying out the GUI, the next step is to program it. This section explains how to do so. The section covers: -

- Setting properties for the GUI components
- The GUI M-file
- The opening function
- Sharing data between callbacks
- Adding code to the opening function
- Adding code to the callbacks
- Using the Object Browser to identify callbacks

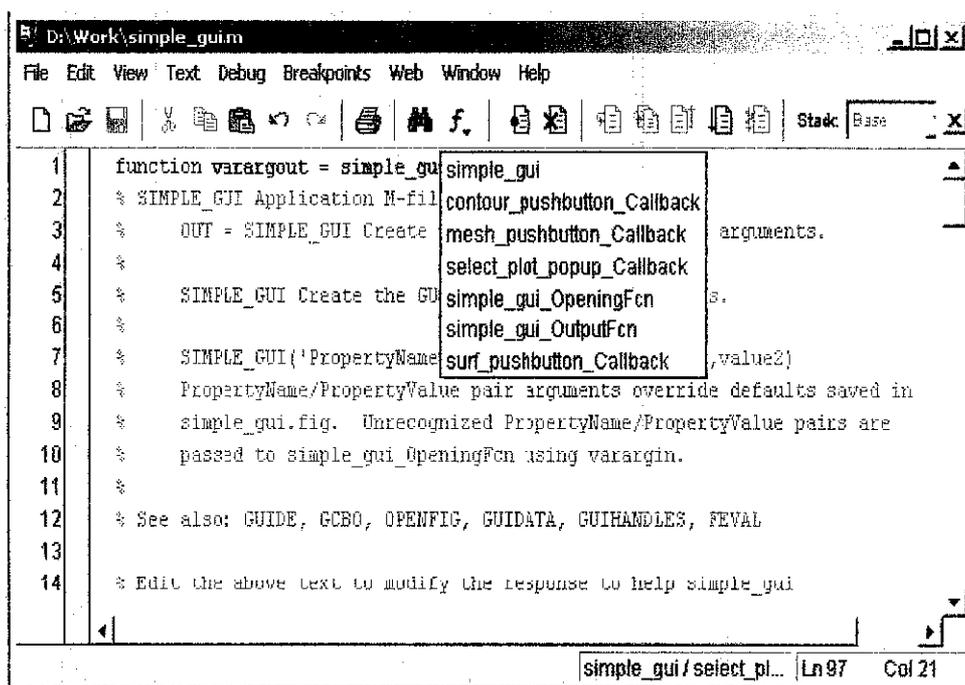
GUIDE stores GUIs in two files, which are generated the first time you save or run the GUI:

- **FIG-file**

A file with extension .fig that contains a complete description of the GUI figure layout and the components of the GUI: push buttons, menus, axes, and so on. When there are any changes to the GUI layout in the Layout Editor, the changes are saved in the FIG-file.

- **M-file**

A file with extension .m that contains code to controls the GUI, including the callbacks for its components. This file is referred to as the *GUI M-file*. When first run or save a GUI from the Layout Editor, GUIDE generates the GUI M-file with blank stubs for each of the callbacks. The callbacks then can be program using the M-file editor. Below is the example of M-file editor window.



**Figure 11** The M-file editor window

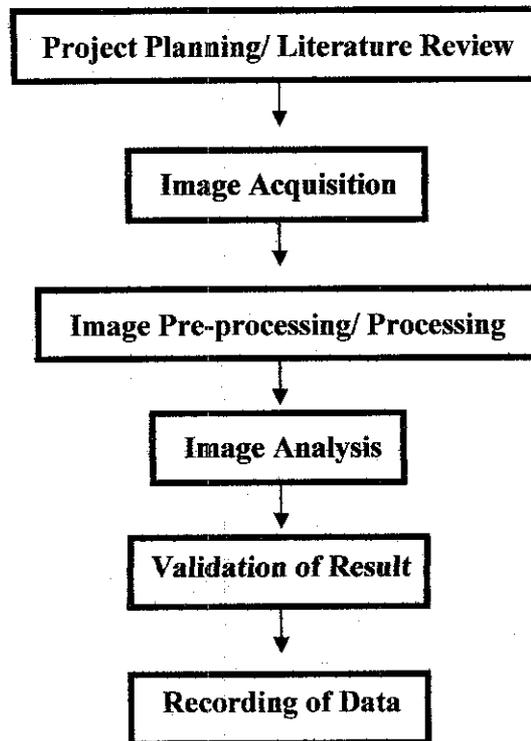
(Source taken from [16])

## CHAPTER 3

### METHODOLOGY / PROJECT WORK

#### 3.1 Procedure Identification

There were six tasks to be completed for the successful conclusion of the project. The following part will list and explain each of the tasks. The flowchart shown below is the basic procedures that have to be followed for conducting the case study: -



**Figure 12** Flow chart of project methodology

### ***3.1.1 Literature Review and Planning***

The scope of the literature review included the basic information of psoriasis skin disease, Psoriasis Area and Severity Index (PASI), RGB color model, the programming of the computerized system, design of GUI layout, and digital image processing technique. These literature studies enable to estimate the time process and the feasibility of the project. Perfect management of time scheduling and task breakdown ensured the success of the project.

### ***3.1.2 Image Acquisition/Image capturing***

Several options for image acquisition process have been identified throughout the end of FYP. Below are the options of image capturing method: -

- Get resources plaque image from internet
- Get resources plaque image from dermatologist
- Create my own catalogue with dermatologist assistance

Image is captured and classified into five (5) categories; no involvement, slight and mild, moderate, severe, and most severe with dermatologist assistant. The sample consist at least 30 samples per category to obtain accurate data. For this project, most of the images are obtained from psoriasis and dermatologist websites. In order to validate the accuracy of the system, the sample images get from dermatologist have been used.

### ***3.1.3 Image Pre-processing and Processing***

It is necessary to implement digital image restoration and enhancement algorithms in order to reduce both deformation and degradations. Below are the techniques used in the pre-processing and processing procedure: -

- **Filtering**

The procedure started with each image from the stored database was being filtered. In this case, a median filter technique was recommended to reduce "salt and pepper" noise. Median filtering is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges.

**Syntax:**  $B = \text{medfilt2}(A, [m\ n])$

Performs median filtering of the matrix A in two dimensions. Each output pixel contains the median value in the m-by-n neighborhood around the corresponding pixel in the input image. *Medfilt2* pads the image with 0's on the edges, so the median values for the points within  $[m\ n]/2$  of the edges might appear distorted.

- **Image Enhancement**

Maps the values in intensity image I to new values in J such that 1% of data is saturated at low and high intensities of I. This increases the contrast of the output image J.

**Syntax:**  $\text{imadjust}(I, \text{stretchlim}(I))$

- **Image Thresholding**

**Syntax:**  $\text{level} = \text{graythresh}(I)$

Graythresh computes a global threshold (level) that can be used to convert an intensity image to a binary image with *im2bw*. Level is a normalized intensity value that lies in the range [0, 1]. The graythresh function uses Otsu's method, which chooses the threshold to minimize the intraclass variance of the black and white pixels.

### 3.1.4 Image Analysis

Image analysis is done focusing on the score of redness using PASI with the application of image processing tools known as color histogram RGB Color Model with 0-255 gradations. Image histogram provides useful information of intensities of the image content.

Conventionally, a color image of size MxN can be defined as 3 sequences of pixel level:-

$$r(m,n), 1 < m < M; J < n < N \dots\dots\dots (1)$$

$$g(m,n), 1 < m < M; J < n < N \dots\dots\dots (2)$$

$$b(m,n), 1 < m < M; J < n < N \dots \dots \dots (3)$$

where each element pixel representing R, G and B component respectively [13]. The individual color components were typically represented by 8-bit which means that each element would be an integer in the interval [0,255]. In any processing of 8-bit images, the integer restriction is abandoned and the image is processed in a floating-point representation in order to minimize quantization effects.

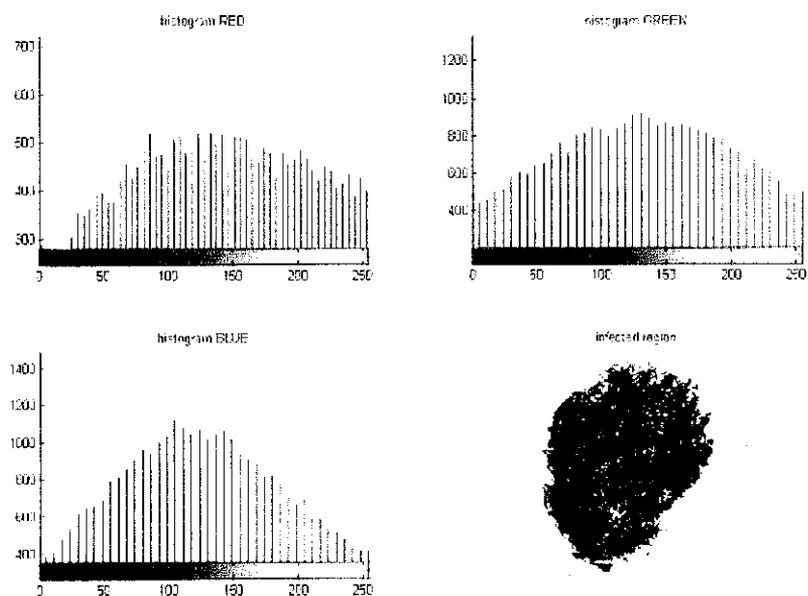
For image analysis, the sample RGB images will be converted to grayscale image by eliminating the hue and saturation information while retaining the luminance.

**Syntax: *rgb2gray (RGB)***

The image data from the grayscale image can be displayed by histogram using this: -

**Syntax: *imhist(I, n)***

It displays a histogram for the intensity image I above a grayscale colorbar. The image type specifies the number of bins in the histogram. If I is a grayscale image, imhist uses a default value of 256 bins.



**Figure 13** RGB Histogram of the sample image

The image will then be converted to a binary image, based on threshold for boundary tracing using *bwboundaries*.

**Syntax:**  $BW = im2bw(I, level)$

It converts the input image to grayscale format (if it is not already an intensity image), and then uses thresholding to convert this grayscale image to binary. The output binary image  $BW$  has values of 0 (black) for all pixels in the input image with luminance less than  $level$  and 1 (white) for all other pixels.

Only then the morphological operation is performed to analyze the sample image in order to obtain the redness score by determining the coordinates for pixel's boundary. This pixel's boundary is then been used to obtain mean value for R, G and B for both healthy skin and lesion.

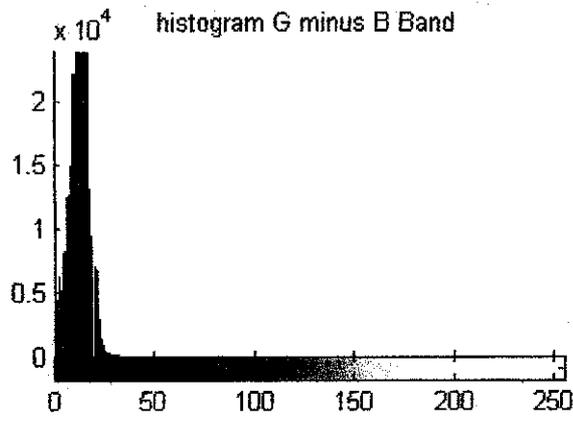
Redness is defined as contrast between lesion and healthy skin, in conclusion of that matter, the redness score can be generate by doing the comparison of mean value for both healthy skin and lesion specifically on G band.

From the analysis done throughout the two (2) semester of doing this project, found that subtraction of G from B give best result to discriminate lesion from healthy skin.

Removing B band

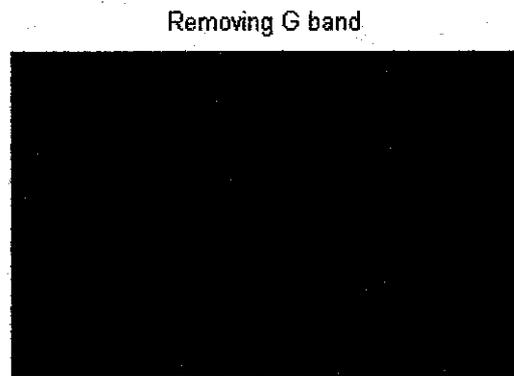


**Figure 14** Removing B band from G

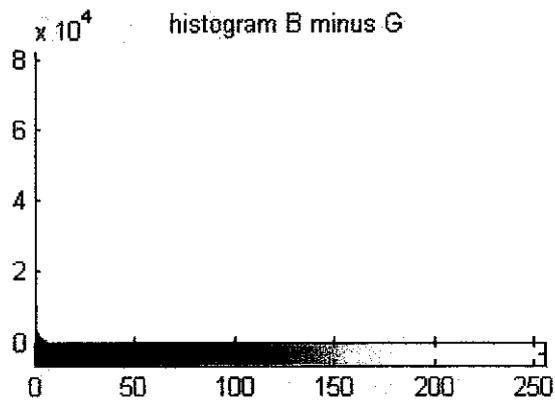


**Figure 15** Histogram of G minus B band of the sample image

Observed that the subtraction of B from G gives bad result of thresholding. This can be proving by the analysis done. Shown below are the rest of the analyses:-



**Figure 16** Removing G band from B



**Figure 17** Histogram of B minus G band of the sample image

Below are the syntax uses for generating score of redness: -

- The mean value for both healthy skin and lesion

$$X_{mean} = X_{acc}/area;$$

$$X_{meanh} = X_{acch}/areah;$$

- The comparison of mean value for both healthy skin and lesion.

$$X_{comp} = X_{mean}/X_{meanh};$$

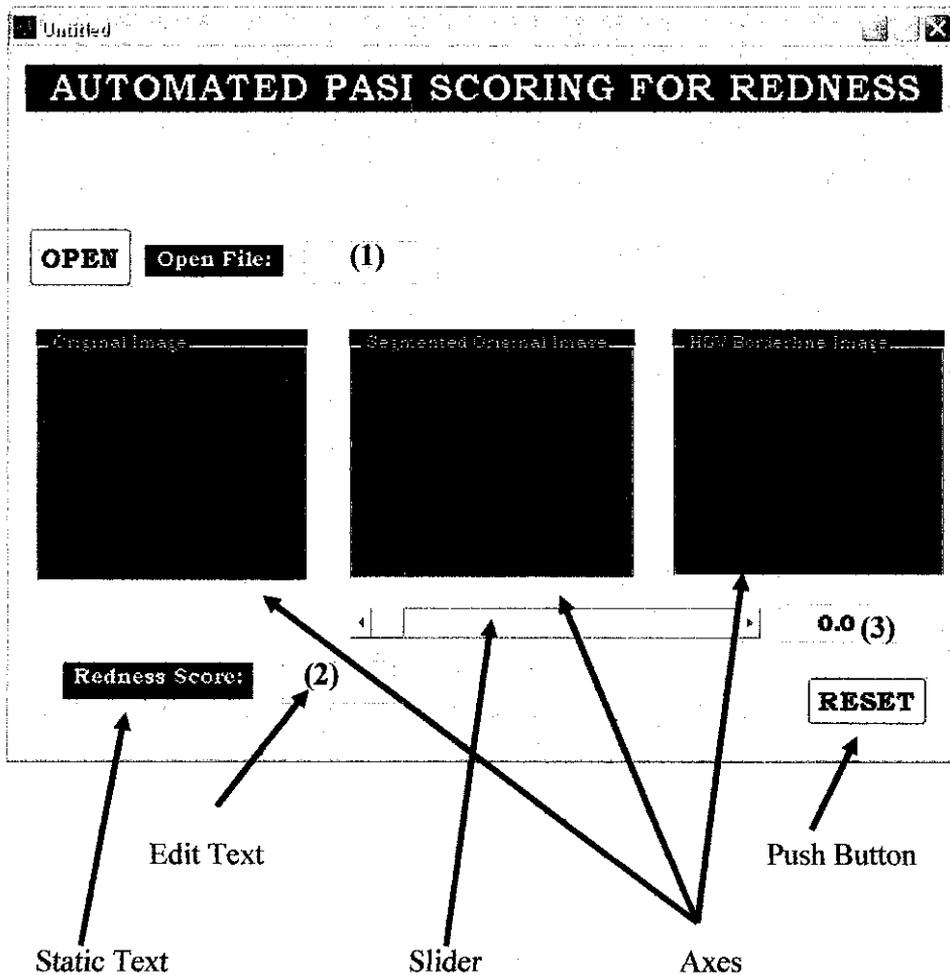
Due to the analysis done, the comparison of G band value for both healthy skin and lesion have been used to generate the score of redness using PASI. **Table 3** is the range values for each score.

**Table 3** Range of Rcomp, Gcomp and Bcomp for the system

| SCORE | RANGE OF REDNESS VALUE |             |             |
|-------|------------------------|-------------|-------------|
|       | Rcomp                  | Gcomp       | Bcomp       |
| 0     | < 0.5                  | < 0.5       | < 0.5       |
| 1     | 0.75 – 0.85            | 0.5 – 0.74  | 0.60 – 0.68 |
| 2     | 0.86 – 0.97            | 0.75 – 0.77 | 0.69 – 0.82 |
| 3     | 0.98 – 1.00            | 0.78 – 0.84 | 0.83 – 1.00 |
| 4     | >1.00                  | > 0.84      | >1.00       |

### 3.1.5 GUI Application

A Graphical User Interface (GUI) of the system is developed to facilitate the redness score of psoriasis skin disease.



**Figure 18** The GUI layout of the system

Table 4 is the components used in the GUI and its function.

**Table 4** The function of the components used in the GUI

| Components  | Strings   | Functions   |
|-------------|-----------|---|
| Push Button | OPEN      | Load psoriasis image from graphics file, read the loaded image and display the original image |
| Push Button | RESET     | Reset the filename and the redness score  |
| Edit Text   | Label (1) | Display the filename  |
| Edit Text   | Label (2) | Display the redness score   |
| Edit Text   | Label (3) | Display the value of fudge factor   |
| Static Text | Open File | Label the loaded filename   |

|             |               |   |
|-------------|---------------|---|
| Static Text | Redness Score | Label the value of redness score        |
| Slider      | Fudge Factor  | Control the range 0 - 1 of fudge factor |

### ***3.1.6 Validation of Result***

The result is then been compared with dermatologist in assuring the accuracy of the system.

### ***3.1.7 Data Recording***

The entire capture image is recorded and stored in personal computer. There is a good opportunity to store information with diagnostic information in order to use it for further investigations or creation of new methods of diagnosis.

### ***3.1.8 Final Report and Presentation***

The final report and presentation was carried out as scheduled.

## **3.2 Tools Required**

Throughout this project, the simulation is done using mathematics software called MATLAB. Therefore, knowledge in that software is essential in order to developed programs for this project. MATLAB is a powerful mathematical tool that allows matrix computation, calculation and plotting data. It consists of several toolboxes including image-processing toolbox. **Table 5** lists name of the programs have been developed using MATLAB for this project.

**Table 5** Matlab Program File

| <b>M-file Name</b> | <b>Functions</b>   |
|--------------------|--|
| RGBhistogram.m     | Display RGB Histogram of segmented image shown in <b>Appendix B.</b>   |
| Red.m              | Perform image segmentation and image analysis operation using RGB Color Model, calculate the score of redness of the sample image shown in <b>Appendix C</b> |
| REDMAIN.m          | Display GUI for the computerized-based system shown in <b>Appendix D</b>   |

## **CHAPTER 4**

### **RESULTS AND DISCUSSION**

#### **4.1 RGB Color Model**

The RGB Color Model that is selected for this project is one of the image processing tools to study on how to read image files and transform them in term of histograms for easy to see data. A color in the RGB color model can be described by indicating how much of red, green and blue color is included.

#### **4.2 Redness Score**

The redness' score (0-4) is categorized into five (5) categories; no involvement, slight and mild, moderate, severe, and most severe. Set of at least 30 real-world images have been used as reference images in order to get the comparison value of each R, G and B to generate the redness score. This procedure of finding the most accurate range of redness is repeated until the highest accuracy is achieved.

The redness values of the lesions for five (5) reference images which have been scored from 0 – 4 are obtained in the analysis stage.

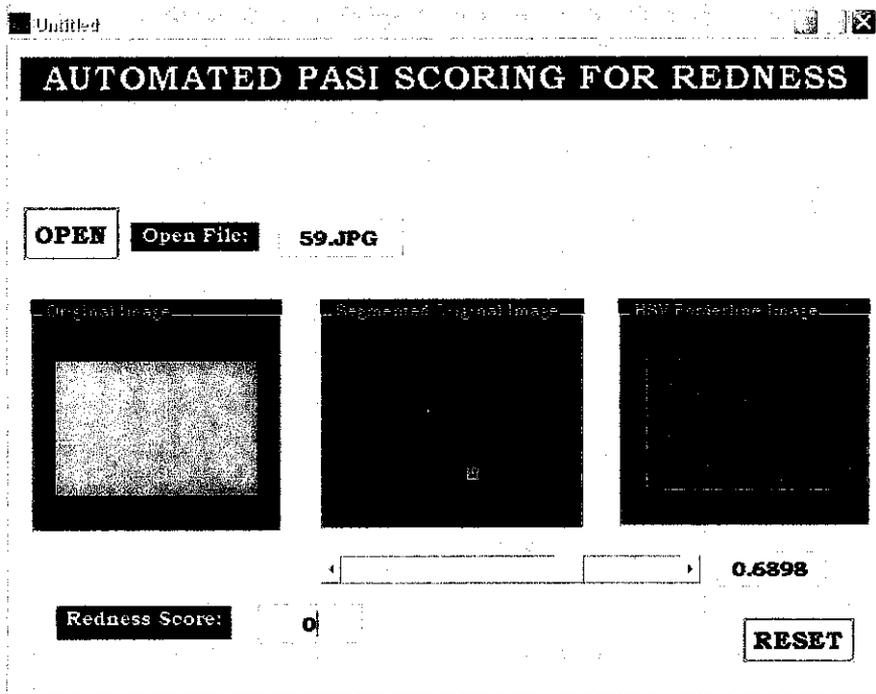


Figure 19 The reference image for redness score = 0

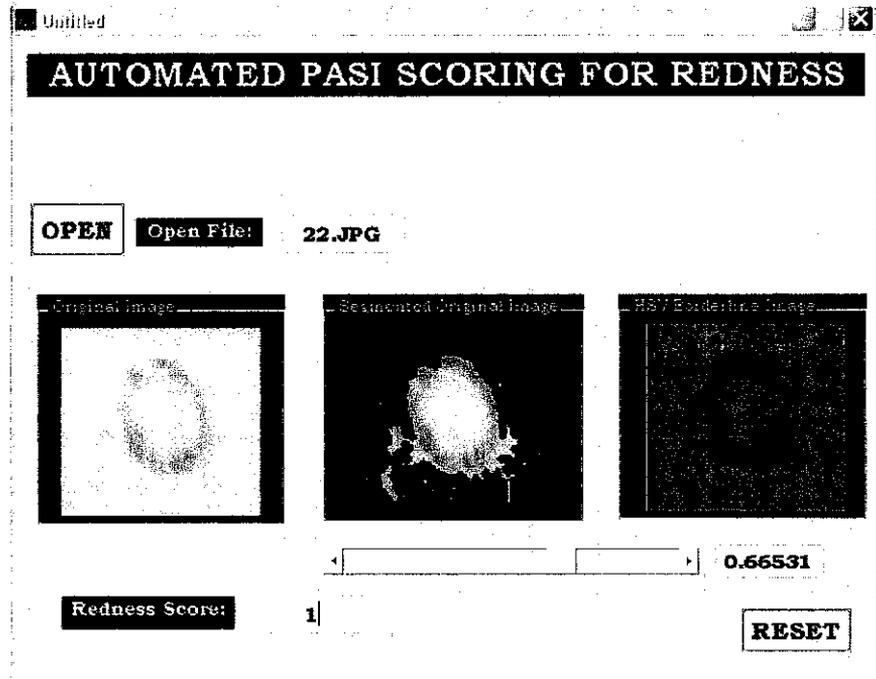


Figure 20 The reference image for redness score = 1

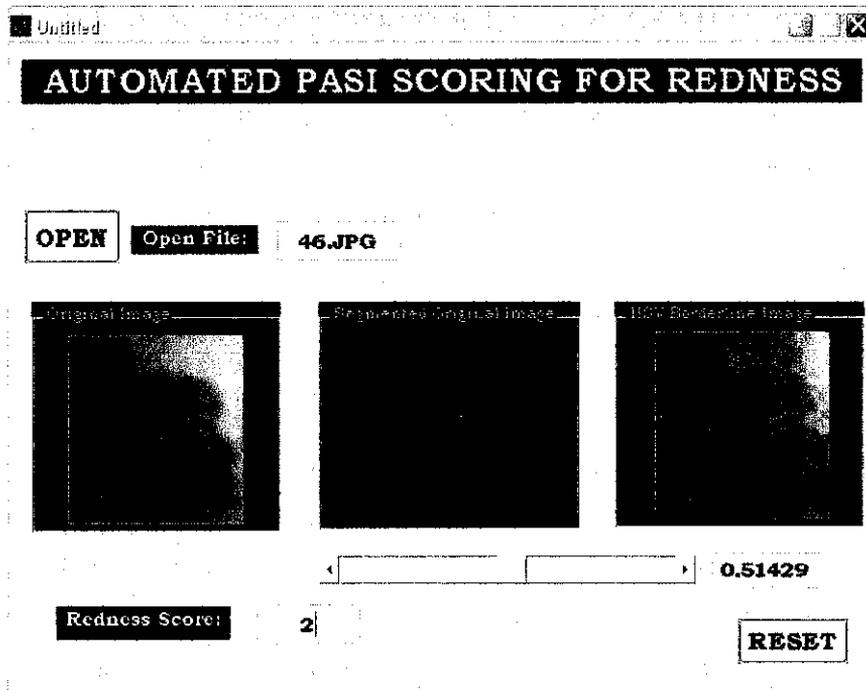


Figure 21 The reference image for redness score = 2

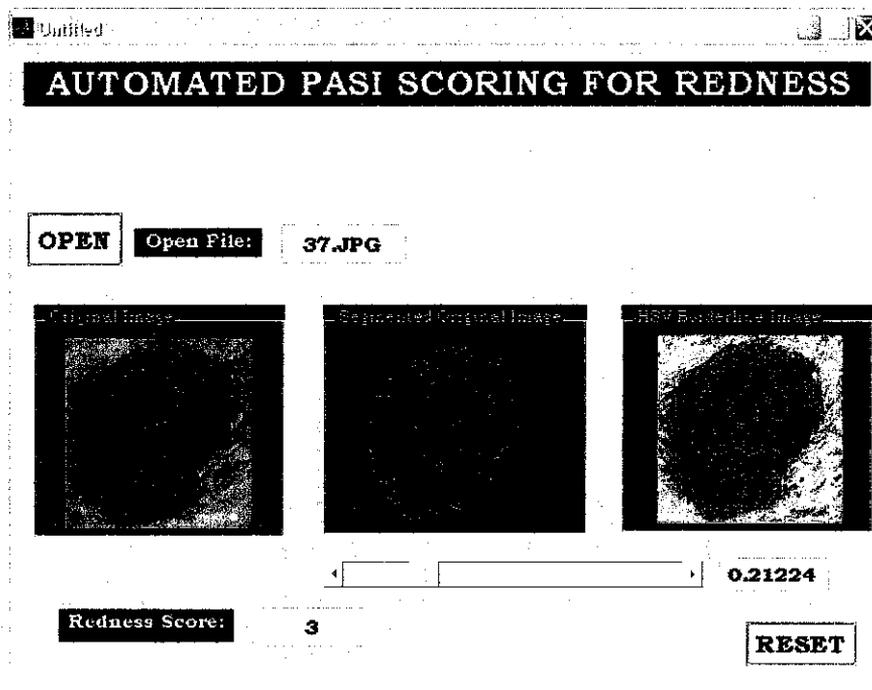
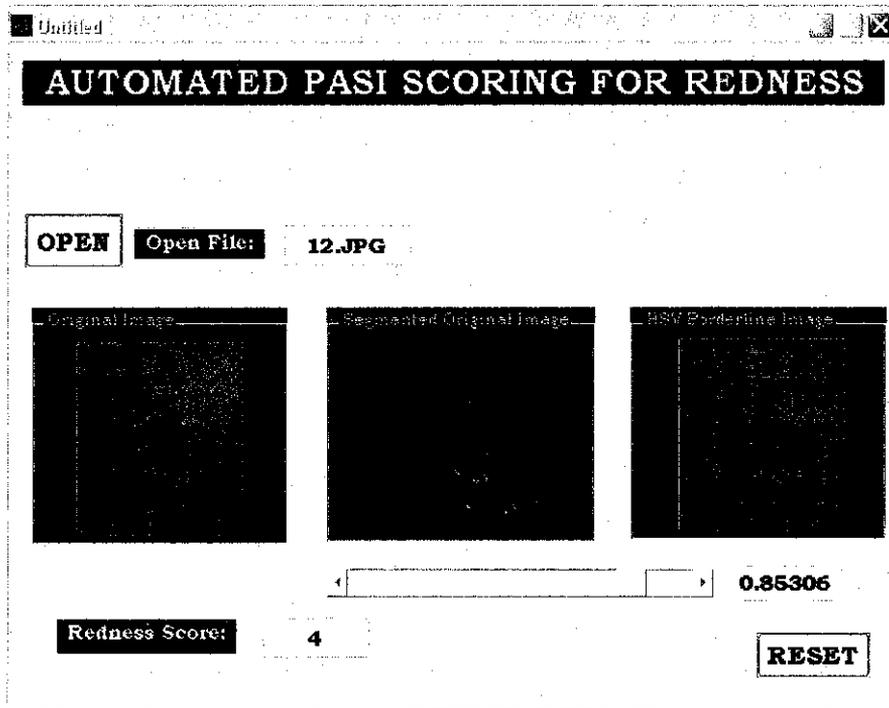


Figure 22 The reference image for redness score = 3



**Figure 23** The reference image for redness score = 4

Below is the range of redness values for the system: -

**Table 6** The range of redness values for the system

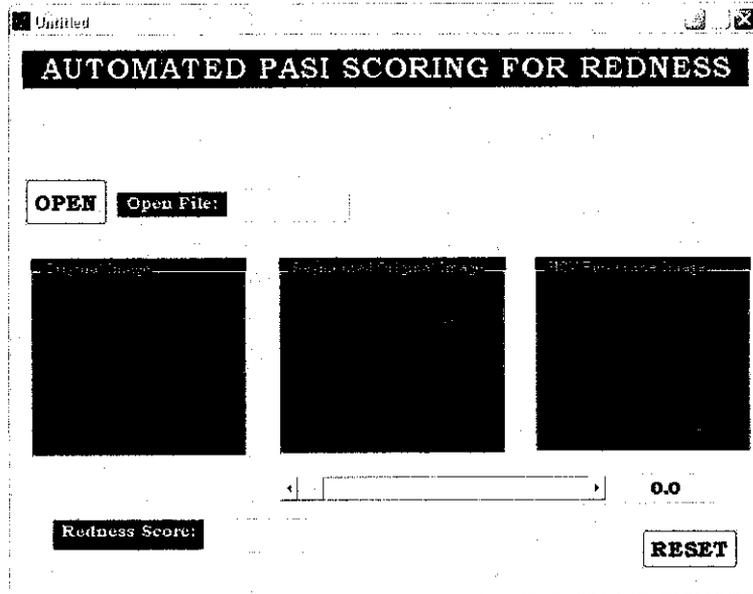
| SCORE | RANGE OF REDNESS VALUE |             |             |
|-------|------------------------|-------------|-------------|
|       | Rcomp                  | Gcomp       | Bcomp       |
| 0     | > 1.00                 | > 1.00      | > 1.00      |
| 1     | 0.98 – 1.00            | 0.88 – 1.00 | 0.83 – 1.00 |
| 2     | 0.86 – 0.97            | 0.70 – 0.87 | 0.69 – 0.82 |
| 3     | 0.75 – 0.85            | 0.66 – 0.69 | 0.60 – 0.68 |
| 4     | < 0.74                 | < 0.65      | < 0.59      |

Sets of five (5) images from each score (0 - 4) are used as the reference images in order to generate the redness score. The accuracy of the system is determined from the results of the test. The set of images will be replaced with the new set of images if a low accuracy is obtained from the test. This procedure is repeated until the highest accuracy is achieved. The finalize redness values with the highest accuracy is used to generate the redness score. **Table 6** above shows the finalize range of redness value for the

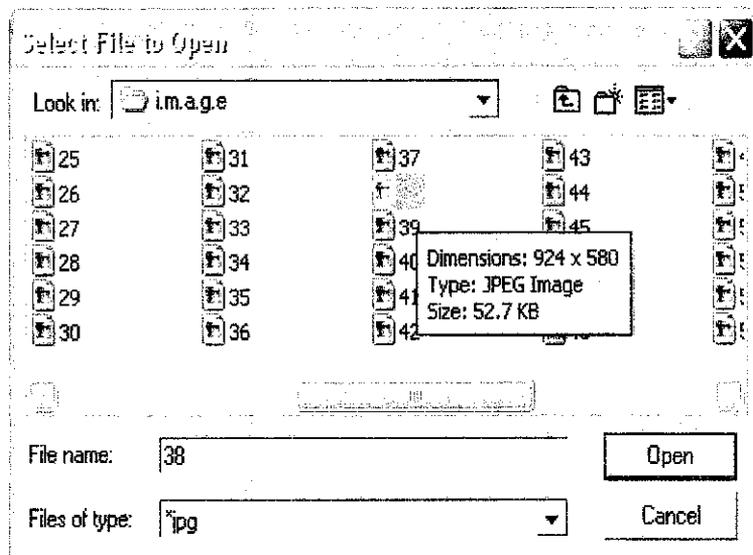
system.

The steps involved in GUI layout of the system are as follows: -

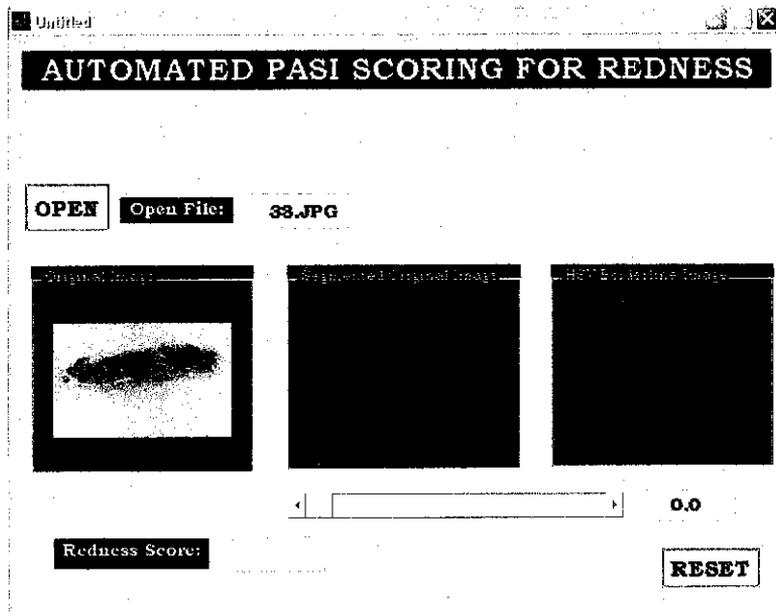
1. Click OPEN pushbutton. The OPEN push button represents the original sample image. By clicking the OPEN push button, the system will automatically display a standard dialog box for user to select and load any sample images available in the computer database



**Figure 19** GUI layout of the computerized-based system

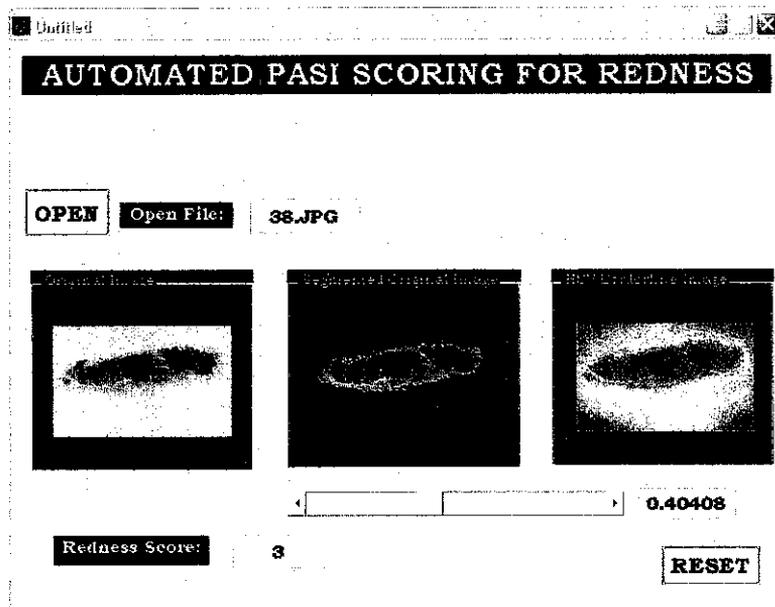


**Figure 20** Standard dialog box of the program



**Figure 21** GUI layout when OPEN push button is clicked

2. Click the mouse on the arrow button or on the slider trough only then the system is run. The system will automatically run its callback to execute the system by displaying the segmented sample image. The slider represents value of fudge factor for image thresholding range from 0 – 1
3. Observe the redness value of the sample image



**Figure 22** GUI layout when the callback is executed

4. The final step is to click the RESET push button to erase all the value of edit text

The slider represents the fudge factor of the thresholding technique used range from (0 – 1). The original image will be enhanced, filtered and segmented by moving the slider trough. The image enhancement gives the better results in segmentation. Besides, the greater the redness values obtained from the enhanced images, which contribute to the wider range of redness value of each score. It is important to have a wider range of redness values to avoid misclassifying the severity of lesion images.

Result of this project will be used for assisting dermatologist in giving PASI score and for monitoring purposes.

### 4.3 Validation Data

The front-end system has been successful developed using MATLAB incorporating image processing toolbox. The results get are then been compared with dermatologist in assuring the accuracy of the system. **Table 7** represents the comparison score between the system and the dermatologist diagnosis.

**Table 7** The comparison score between system and dermatologist diagnosis

| Image | PASI (MATLAB) | Dermatologist | Percentage Error (%) |
|-------|---------------|---------------|----------------------|
| L1    | 4             | 4             | 0                    |
| L2    | 3             | 2             | 50                   |
| L3    | 4             | 4             | 0                    |
| L4    | 4             | 4             | 0                    |
| L5    | 4             | 3             | 33.333               |
| L6    | 4             | 3             | 33.333               |
| L7    | 4             | 3             | 33.333               |
| L8    | 4             | 3             | 33.333               |
| L9    | 4             | 2             | 100.000              |
| L10   | 4             | 4             | 0.000                |

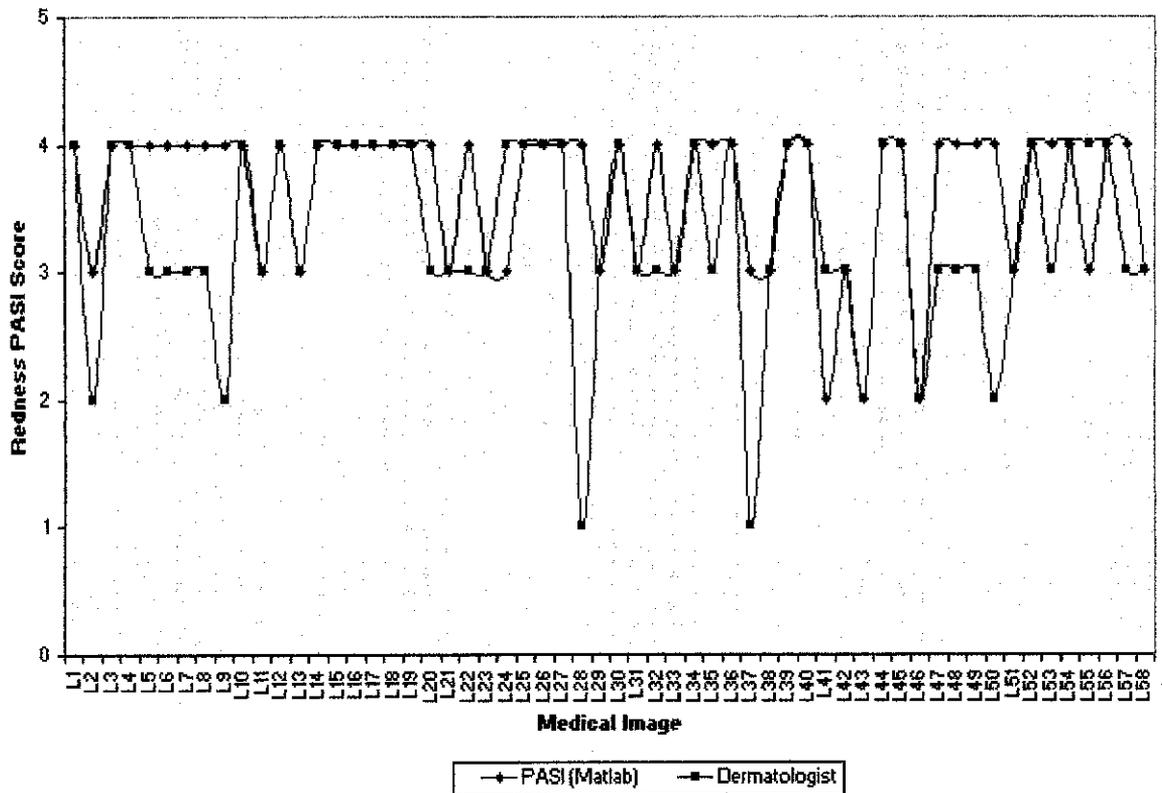
|     |   |   |         |
|-----|---|---|---------|
| L11 | 3 | 3 | 0.000   |
| L12 | 4 | 4 | 0.000   |
| L13 | 3 | 3 | 0.000   |
| L14 | 4 | 4 | 0.000   |
| L15 | 4 | 4 | 0.000   |
| L16 | 4 | 4 | 0.000   |
| L17 | 4 | 4 | 0.000   |
| L18 | 4 | 4 | 0.000   |
| L19 | 4 | 4 | 0.000   |
| L20 | 4 | 3 | 33.333  |
| L21 | 3 | 3 | 0.000   |
| L22 | 4 | 3 | 33.333  |
| L23 | 3 | 3 | 0.000   |
| L24 | 3 | 4 | 25.000  |
| L25 | 4 | 4 | 0.000   |
| L26 | 4 | 4 | 0.000   |
| L27 | 4 | 4 | 0.000   |
| L28 | 4 | 1 | 300.000 |
| L29 | 3 | 3 | 0.000   |
| L30 | 4 | 4 | 0.000   |
| L31 | 3 | 3 | 0.000   |
| L32 | 4 | 3 | 33.333  |
| L33 | 3 | 3 | 0.000   |
| L34 | 4 | 4 | 0.000   |
| L35 | 4 | 3 | 33.333  |
| L36 | 4 | 4 | 0.000   |
| L37 | 3 | 1 | 200.000 |
| L38 | 3 | 3 | 0.000   |
| L39 | 4 | 4 | 0.000   |
| L40 | 4 | 4 | 0.000   |
| L41 | 2 | 3 | 33.333  |

|              |            |            |               |
|--------------|------------|------------|---------------|
| L42          | 3          | 3          | 0.000         |
| L43          | 2          | 2          | 0.000         |
| L44          | 4          | 4          | 0.000         |
| L45          | 4          | 4          | 0.000         |
| L46          | 2          | 2          | 0.000         |
| L47          | 4          | 3          | 33.333        |
| L48          | 4          | 3          | 33.333        |
| L49          | 4          | 3          | 33.333        |
| L50          | 4          | 2          | 100.000       |
| L51          | 3          | 3          | 0.000         |
| L52          | 4          | 4          | 0.000         |
| L53          | 4          | 3          | 33.333        |
| L54          | 4          | 4          | 0.000         |
| L55          | 3          | 4          | 25.000        |
| L56          | 4          | 4          | 0.000         |
| L57          | 4          | 3          | 33.333        |
| L58          | 3          | 3          | 0.000         |
| <b>TOTAL</b> | <b>211</b> | <b>191</b> | <b>10.471</b> |

The percentage error of the system:

$$\text{Percentage Error (\%)} = \frac{\text{PASI (Matlab)} - \text{Dermatologist}}{\text{Dermatologist}} \times 100\%$$

**Figure 23** shows the plotted graph represent the difference of scoring for the medical images.



**Figure 23** Graph PASI (Matlab) vs. Dermatologist

As observed above in the plotted graph, the dermatologist diagnosis and the computerized-based system give the same redness score for image L16 that is 4.

From the results shows in **Table 7** and **Figure 23**, it is shows that the result get from the computerized-based system are slightly different with the score given by dermatologist. These results are different due to the quality of medical image during the image acquisition stage.

The capability of this system in classifying the redness severity is quite high with the percentage of accuracy up to 90%

The accuracy of the system:

$$\text{Accuracy Percentage} = 100\% - \text{Total Percentage Error (\%)}$$

## **CHAPTER 5**

### **CONCLUSION AND RECOMMENDATION**

#### **5.1 Conclusion**

The main objective of this project is to design and build a computer-based system to enable system to detect lesion region and generate its PASI scoring for redness using image-processing technique. This objective has been achieved. A system has been designed and then operated to generate redness score using PASI for psoriasis skin disease.

From the design done, image processing tools in MATLAB can be use to generate the score of redness for psoriasis lesion using a few algorithms and through MATLAB, application of GUI can be practice. During this process, the Image Processing will continue calculating the comparison value for each R, G and B. Once the program is finished, MATLAB will display the segmented lesion and generate the redness score. The capability of this system in classifying the redness severity is quite good with 90% accuracy. But the improvements and modifications are still needed to increase the system performance. The results from Chapter 4 show that the system has been validated by the dermatologist to better diagnose of psoriasis lesion.

Having a quantitative measure of disease severity has facilitated clinical trials of new agents for psoriasis. PASI has led to new treatments that have advanced the dermatologists' ability to care for patients with severe disease. The development of these agents, some of which set new standards of high cost of dermatological treatment, has led to new challenges as well.

## **5.2 Recommendation**

Although this system have achieved a high accuracy in classifying the level of redness severity for psoriasis skin disease, some modifications and improvements is still needed in development of this image computer-based system project. This system can be improve in terms of image processing technique used to give better results especially in the image processing stage.

Research work on the various techniques that are related to skin disease can be conducted in order to develop a flexible, faster and user-friendlier system in the future. For now, the system is only capable to analyze the sample image after being segmented, it is possible to have a system which can straight away scoring the severity of the redness level from the acquired sample image.

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## APPENDICES

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| Appendix B..... | RGBhistogram.m |
| Appendix C..... | Red.m          |
| Appendix D..... | REDMAIN.m      |

# APPENDIX A

## Gantt Chart

First Semester of 2 Semester Final Year Project

| No. | Detail/Week   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|-----|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|
| 1   | Selection of Project Topic<br>-Topic assigned to students   | █ |   |   |   |   |   |   |   |   |    |    |    |    |    |
| 2   | Preliminary Research Work<br>-Study on Psoriasis Skin Disease                                     |   | █ |   |   |   |   |   |   |   |    |    |    |    |    |
| 3   | Submission of Preliminary Report  |   |   | ● |   |   |   |   |   |   |    |    |    |    |    |
| 4   | Project Work<br>-Design decision criteria<br>-Analysis Done<br>- Start on programming in MATLAB   |   |   |   | █ |   |   |   |   |   |    |    |    |    |    |
| 5   | Submission of Progress Report   |   |   |   |   |   |   |   | ● |   |    |    |    |    |    |
| 6   | Project work continue<br>-Continue with the MATLAB<br>-Analyze and compare the result performance |   |   |   |   |   |   |   |   | █ |    |    |    |    |    |
| 7   | Submission of Interim Report  |   |   |   |   |   |   |   |   |   |    |    |    | ●  |    |
| 8   | Oral Presentation   |   |   |   |   |   |   |   |   |   |    |    |    |    | ●  |

● Suggested milestone      █ Process

**Second Semester of 2 Semester Final Year Project**

| No. | Detail/ Week   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|-----|--|---|---|---|---|---|---|---|---|---|----|----|----|----|----|
| 1   | Project Work Continue<br>-Research and study on Early Termination                      |   |   |   |   |   |   |   |   |   |    |    |    |    |    |
| 2   | Submission of Progress Report 1  |   |   | ● |   |   |   |   |   |   |    |    |    |    |    |
| 3   | Project Work Continue<br>-Set the design criterion<br>-Continue programming in MATLAB  |   |   |   |   |   |   |   |   |   |    |    |    |    |    |
| 4   | Submission of Progress Report 2  |   |   |   |   |   |   | ● |   |   |    |    |    |    |    |
| 5   | Project work continue<br>-Continue with the MATLAB<br>- Analyze and compare the result |   |   |   |   |   |   |   |   |   |    |    |    |    |    |
| 6   | Submission of Dissertation Final Draft   |   |   |   |   |   |   |   |   | ● |    |    |    |    |    |
| 7   | Submission of Final Report   |   |   |   |   |   |   |   |   |   |    | ●  |    |    |    |
| 8   | Oral Presentation  |   |   |   |   |   |   |   |   |   |    |    |    | ●  |    |
| 9   | Submission of Project Dissertation   |   |   |   |   |   |   |   |   |   |    |    |    |    | ●  |

● Suggested milestone      ■ Process

## Appendix B

### RGBhistogram.m

```
clc
close all
sample = imread('lesion.jpg');
colmin = 0;
rowmin = 0;
colmax = (size(sample,2))-1;
colmax = (size(sample,1))-1;

for i=1:size(sample,1) %read the row of the image
    for j=1:size(sample,2) %read the column of the image
        if (sample(i,j,1)<204 && sample(i,j,2)<171 && sample(i,j,3)<140) %set
selectivity by RGB space
            sample(i,j,1)=sample(i,j,1);
            sample(i,j,2)=sample(i,j,2);
            sample(i,j,3)=sample(i,j,3);
        else
            sample(i,j,1) = 255;
            sample(i,j,2) = 255;
            sample(i,j,3) = 255;
        end
    end
end

figure(1)
%figure(1),imshow(sample),title('infected region')
subplot(2,2,4),imshow(sample),title('infected region')
subplot(2,2,1),imhist(sample(:,:,1)),title('histogram RED')
subplot(2,2,2),imhist(sample(:,:,2)),title('histogram GREEN')
subplot(2,2,3),imhist(sample(:,:,3)),title('histogram BLUE')
```

## APPENDIX C

### RED.M

```
function [redness,second, Segout1] = red (filename, fudgeFactor)

first = [filename];
second = imread(first);
zero = second;

% H = fspecial('unsharp');
% second = imfilter(infinity,H,'replicate');
% figure(2),imshow(second); title('Sharpened Image')

%convert color image to grayscale
third = rgb2gray(second);
%figure(2),imshow(third),title('Grayscale Image')
%third = medfilt2(zero,[3 3]);
%figure(3),imshow(third),title('Filtered grayscale')
%third = imadjust(third);

%convert the image to black and white in order to prepare for boundary
%tracing using bwboundaries
fourth = graythresh(third);
fifth = im2bw (third,fourth);
%figure(3),imshow(fifth),title('Threshold Image')

%detect entire lesion
[junk threshold] = edge(fifth,'sobel');
%fudgeFactor = .5;
sixth = edge (fifth,'sobel',threshold*fudgeFactor);
%figure(4),imshow(sixth),title('Binary Gradient Mask')

%dilate the image
se90 = strel('line',3,90);
se0 = strel('line',3,0);
seventh = imdilate(sixth,[se90 se0]);
%figure(5),imshow(seventh),title('Dilated Gradient Mask')

%fill interior gaps
eighth = imfill(seventh,'holes');
%figure(6),imshow(eighth),title('Binary Image With Filled Holes')
```

```

%remove connected objects on border
ninth = imclearborder(eighth,4);
%figure(7),imshow(ninth),title('Cleared Border Image')

%smoothen the lesion
seD = strel('diamond',1);
tenth = imerode(ninth,seD);
tenth = imerode(tenth,seD);

% figure(8),imshow(tenth),title('Segmented Image')

%Display segmented image by outline
BWoutline = bwperim(tenth);
Segout = second;
Segout(BWoutline) = 255;
%figure(9),imshow(Segout),title('Outlined Original Image')

BWoutline = bwperim(tenth);
Segout1 = third;
Segout1(BWoutline) = 255;
%figure(15),imshow(Segout1),title('Outlined Original Image')

% racc = 0;
% bacc = 0;
gacc = 0;
area = 0;

for i=1:size(second,1) %read the row of the image
    for j=1:size(second,2) %read the column of the image
        if (tenth(i,j) == 1) %if the object is represented by 1
%           rval = second(i,j,1);
%           racc = racc+double(rval);
            gval = second(i,j,2);
            gacc = gacc+double(gval);
%           bval = second(i,j,3);
%           bacc = bacc+double(bval);
            area = area+1;
        end
    end
end
end
end

```

```

% rmean = racc/area;
gmean = gacc/area;
% bmean = bacc/area;

% racch = 0;
% bacch = 0;
gacch = 0;
areah = 0;

for i=1:size(second,1) %read the row of the image
    for j=1:size(second,2) %read the column of the image
        if (tenth(i,j) == 0) %if the object is represented by 1
%           rvalh = second(i,j,1);
%           racch = racch+double(rvalh);
            gvalh = second(i,j,2);
            gacch = gacch+double(gvalh);
%           bvalh = second(i,j,3);
%           bacch = bacch+double(bvalh);
            areah = areah+1;
        end
    end
end

%rmeanh = racch/areah;
gmeanh = gacch/areah;
%bmeanh = bacch/areah;

fprintf ('This is the mean value for lesion skin');
%fprintf ('\n Mean value for red band : %3.2f',rmean);
fprintf ('\n Mean value for green band : %3.2f',gmean);
%fprintf ('\n Mean value for blue band : %3.2f \n',bmean);

fprintf ('\nThis is the mean value for healthy skin');
%fprintf ('\n Mean value for red band : %3.2f',rmeanh);
fprintf ('\n Mean value for green band : %3.2f',gmeanh);
%fprintf ('\n Mean value for blue band : %3.2f \n',bmeanh);

%rcomp = rmean/rmeanh;
gcomp = gmean/gmeanh;
%bcomp = bmean/bmeanh;

fprintf ('\nComparison value between lesion and healthy skin');
% fprintf ('\n Comparison value for red band : %3.2f',rcomp);

```

```

fprintf ('\n Comparison value for green band : %3.2f',gcomp);
% fprintf ('\n Comparison value for blue band : %3.2f\n',bcomp);

for i=1:size(second,1) %read the row of the image
    for j=1:size(second,2) %read the column of the image
        if (tenth(i,j) == 1) %if the object is represented by 1
            second(i,j,1)=second(i,j,1);
            second(i,j,2)=second(i,j,2);
            second(i,j,3)=second(i,j,3);
        else
            second(i,j,1) = 0;
            second(i,j,2) = 0;
            second(i,j,3) = 0;
        end
    end
end

end

%figure(9),imshow(second),title('Segmented Original Image')

%figure(10)
%subplot(2,2,1),imshow(zero),title('Original Image')
%subplot(2,2,2),imshow(tenth),title('Segmented Image')
%subplot(2,2,3),imshow(second),title('Segmented Original Image')

if (gcomp<0.5)
    redness = 0;
    %fprintf('\n');
    %fprintf('\nThe redness score for the image is 0')
end

if (0.5<gcomp<=0.74)
    redness = 1;
    %fprintf('\n');
    %fprintf('\nThe redness score for the image is 1')
end

if (0.74<gcomp<=0.77)
    redness = 2;
    %fprintf('\n');
    %fprintf('\nThe redness score for the image is 2')
end

if (0.77<gcomp<=0.84)

```

```
redness = 3;

fprintf('\n');
fprintf('\nThe redness score for the image is 3')
end

if (gcomp>0.84)
    redness = 4;
    fprintf('\n');
    fprintf('\nThe redness score for the image is 4')
end
```

## APPENDIX D

### REDMAIN.M

```
function varargout = REDMAIN(varargin)
% REDMAIN M-file for REDMAIN.fig
%     REDMAIN, by itself, creates a new REDMAIN or raises the existing
%     singleton*.
%
%     H = REDMAIN returns the handle to a new REDMAIN or the handle to
%     the existing singleton*.
%
%     REDMAIN('CALLBACK',hObject,eventData,handles,...) calls the
local
%     function named CALLBACK in REDMAIN.M with the given input
arguments.
%
%     REDMAIN('Property','Value',...) creates a new REDMAIN or raises
the
%     existing singleton*. Starting from the left, property value
pairs are
%     applied to the GUI before REDMAIN_OpeningFunction gets called.
An
%     unrecognized property name or invalid value makes property
application
%     stop. All inputs are passed to REDMAIN_OpeningFcn via varargin.
%
%     *See GUI Options on GUIDE's Tools menu. Choose "GUI allows only
one
%     instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Copyright 2002-2003 The MathWorks, Inc.

% Edit the above text to modify the response to help REDMAIN

% Last Modified by GUIDE v2.5 04-Feb-2007 07:33:02

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',      mfilename, ...
```

```

        'gui_Singleton', gui_Singleton, ...
        'gui_OpeningFcn', @REDMAIN_OpeningFcn, ...
        'gui_OutputFcn', @REDMAIN_OutputFcn, ...
        'gui_LayoutFcn', [] , ...
        'gui_Callback', []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT

% --- Executes just before REDMAIN is made visible.
function REDMAIN_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to REDMAIN (see VARARGIN)

% Choose default command line output for REDMAIN
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes REDMAIN wait for user response (see UIRESUME)
% uiwait(handles.figure1);

% --- Outputs from this function are returned to the command line.
function varargout = REDMAIN_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

```

\*\*\*THE REST OF THE CODING IS CONFIDENTIAL