

**AUTOMATED SCORING FOR SCALINESS
OF PSORIASIS LESIONS USING CLUSTER SEGMENTATION**

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

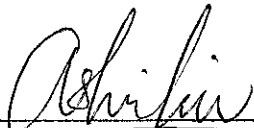
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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
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(Electrical & Electronics Engineering)

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CERTIFICATION OF ORIGINALITY

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



NADIRAH BINTI NORDIN

ABSTRACT

Psoriasis is a chronic skin disease and is a genetically determined inflammatory and proliferate disease, measure by three different parameter; Redness, Scaling and Thickness. Psoriasis is categorized as localized or generalized, based on the severity of the disease and its overall impact on the patient's quality of life and well-being. The most widely method used in clinical trials to evaluate psoriasis disease severity is Psoriasis Area and Severity Index (PASI).

The objective of this project is to generate a quantitative score of scaliness for psoriasis disease which to be used in PASI score calculation. The current PASI scoring system is complicated to be used for scaling evaluation. Moreover, psoriasis lesions are quite visible and therefore relatively hard to quantify with human vision.

The images used for the analysis are obtained from the dermatologist and psoriasis website, also from General Hospital Ipoh. Throughout this project, MATLAB 7 software is used in obtaining the results. The algorithm is developed together with a sub-system for image acquisition and processing, segmentation, texture analysis for scaliness scores and PASI scoring based on the scales.

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LIST OF ABBREVIATIONS

A	Area of real body image
A _h	Area involvement score on head
A _l	Area involvement score on lower extremities
A _t	Area involvement score on trunk
A _u	Area involvement score on upper extremities
b	Range of intensity
BSA	Body Surface Area
BSA _h	Body Surface Area on head
BSA _l	Body Surface Area on lower extremities
BSA _t	Body Surface Area on trunk
BSA _u	Body Surface Area on upper extremities
CAD	Computer-aided Diagnosis
cm	Centimeter
cm ²	Centimeter squared
e.g.	For the sake of example (Latin <i>exempli gratia</i>)
GUI	Graphical User Interface
GUIDE	Graphical User Interface Development Environment
h	Head
i.e.	That is (Latin <i>id est</i>)
kg	kilogram
l	lower extremities
M	Total pixels of lesion
m ²	Meter squared
Mean	Mean Intensity Value
N	Size of lesion
p	Ratio for size of lesion over total pixels of lesion
PASI	Psoriasis Area and Severity Index
PASI(s)	Psoriasis Area and Severity Index for Scaliness Score
PASI (s,h)	Psoriasis Area and Severity Index for Scaliness Score on head

PASI (s,u)	Psoriasis Area and Severity Index for Scaliness Score on upper extremities
PASI (s,t)	Psoriasis Area and Severity Index for Scaliness Score on trunk
PASI (s,l)	Psoriasis Area and Severity Index for Scaliness Score on lower extremities
R	Redness
R _h	Redness score on head
R _l	Redness score on lower extremities
R _t	Redness score on trunk
R _u	Redness score on upper extremities
S	Scale
S _h	Scaliness score on head
S _l	Scaliness score on lower extremities
S _t	Scaliness score on trunk
S _u	Scaliness score on upper extremities
T	Thickness
t	Trunk
T _h	Thickness score on head
T _l	Thickness score on lower extremities
T _t	Thickness score on trunk
T _u	Thickness score on upper extremities

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Skin is the largest organ of our bodies which gave us external protection from heat, injury, and infection. However there are some circumstances that might change the look of our healthy skins such as skin disease. A various number of common skin diseases can affect our skins condition. The most well-known skin diseases are Acne, Eczema, Psoriasis, Warts, Seborrhoeic Dermatitis, and Tinea [1].

There have been lots of medical researches and development in the area of skin diseases analysis. Medical imaging has become a very important technology in this medical diagnosis and treatment. Most of the diagnosis involves acquiring sample images of the suspicious areas in any part of human body which then analyzed from its shape or pattern, color and other aspects depending on types of diseases involved.

Psoriasis is a diverse skin disease that appears in a variety of forms. It is an autoimmune disease which frequently affects the skins and joints but can even cover the whole body including scalp and genital area. It is identified by the presence of a thickened red scaly elevated patch called plaques. The primary cause of psoriasis remains unknown but it is believed that psoriasis is genetic; one third of patients have family members who also suffer from this unsightly skin condition [2].

In [4], Psoriasis Area Severity Index (PASI) is the most commonly used measurement tools to evaluate the severity of this disease in clinical trials. The psoriasis severity is measured by three different parameters: **Erythema** (redness), **Scaling** and **Thickness** (psoriatic skin is thicker than normal skin).

In this paper, the main concern is on Scaling parameters for measuring the psoriasis severity. Digital Image Processing Tools in MATLAB software is used to generate an average score in classifying the severity of the scalp. Image segmentation approaches is applied to find the skin lesion border and to differentiate between normal and lesions skins. Moreover, this analysis includes the texture analysis and skin pattern which will then rate according to the PASI score.

1.2 Problem Statement

In the clinical trials, diagnoses on skin lesions done by dermatologists were based on visual assessment of its physical features and also the evaluation of the macroscopic features. Hence, validated requirements are required in order to properly analyze the lesions.

Unfortunately, human vision has lots of limitation in analyzing the lesions. Human vision lacks of accuracy, reproductability and quantification in gathering information from an image. Simple quantization of the lesions cannot be called a 'complete' assessment of the severity, as the impact of the lesions is experienced differently by different patients. Therefore, an algorithm is needed to enable accurate assessment of the lesion classification. The algorithm must take into consideration with known features such as boundary location, skin pattern and texture, also the lesion color.

In last few years, extensive researches into digital dermatoscopy have been in growth. Some of these digital processing techniques are contour detection and image segmentation. There are lots of methods of image processing that can be implemented, but the main challenge is the determination of the most accurate result to assess lesions. Besides, the algorithm developed must be reliable, valid, and accurate in identifying and diagnosing the lesion for better treatment.

1.3 Significant of the Project

The development of this automated algorithm system, would hopefully bring great advantages to the dermatologist. It would help them in providing faster identification

and diagnosis of the skin lesions. Moreover, this system will be a good tool for the dermatologist to obtain accurate and more reliable results compared to traditional method; visual assessment.

The algorithm developed will be applied for Psoriasis Area and Severity Index (PASI) because it is the most frequent used clinical psoriasis severity scale although it can be exceedingly cumbersome for use in daily clinical practice. Typically, the PASI would be calculated before, during, and after a treatment. This is to determine the responds of the lesion to the treatment given.

Current clinical trials are dependable on the PASI for inclusion criteria. Therefore by having an automated scoring system for the PASI score, it is hope that a better and accurate treatment could be given to the clinical patients.

1.4 Objective

The objective of this project is to:

1. Develop an algorithm that can automatically generate a quantitative score for scaliness of psoriasis disease which can be used in PASI score calculation.
2. Develop an automated system that is capable in classifying the level of severity of psoriasis lesions.
3. Provide a computer-aided diagnosis (CAD) system for enhancing the normal method used in identification and treatment of psoriasis lesions.

1.5 Scope of Study

This project takes into consideration the study of Biomedical Image Processing with MATLAB based application. Image processing is actually a vast area and this project covered only limited primarily to areas associated with medical imaging; image acquisition, image enhancement, segmentation and image analysis. All the areas cover the conventions used by MATLAB's Imaging Processing Toolbox.

At the end of this project, a computer-aided diagnosis (CAD) system will be developed that is capable in classifying the level of severity of psoriasis lesions. This project has exposed the author to MATLAB programming and Biomedical Image Processing. Moreover this project has provided a hands-on experience to complete the task on time.

CHAPTER 2

LITERATURE REVIEW

2.1 Psoriasis

Psoriasis is an autoimmune disease which frequently affects the skins and joints but could cover the whole body including scalp and genital area. It is identified by the presence of a thickened red scaly elevated patch called plaques. Psoriasis plaques are areas of inflammation and excessive skin cell production [5].

2.1.1 Overview of Psoriasis

This disease occurs due to the activation of T-cells (a type of white blood cell) which then affect the immune system as illustrated by Figure 1. It sent faulty messages that caused skin cells to reproduce and mature at an enhance rate, every three to six days whereas a normal skin cell matures in twenty-eight to forty-five days [5].

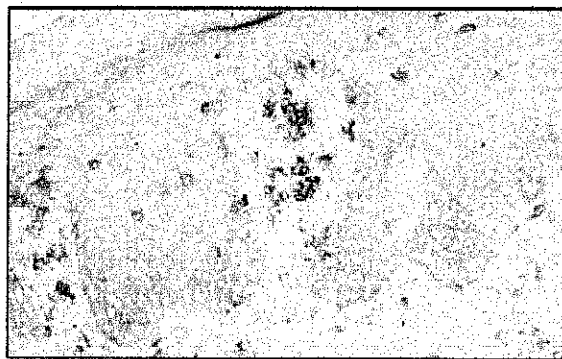


Figure 1 Immunohistology of psoriasis skin [5]

The lesions are usually symmetrically distributed and are characteristically located on the ears, elbows, knees and genitalia. Moreover, the joints, nails and scalp may also be affected by this disease.

Psoriasis may be caused by the skin being attacked by its own immune system [6], a phenomenon known as autoimmunity in response to an external stimulus. The result is an increased turnover of skin cells, inflammation and the formation of large clumps of cells on the skin surface producing characteristic scales.

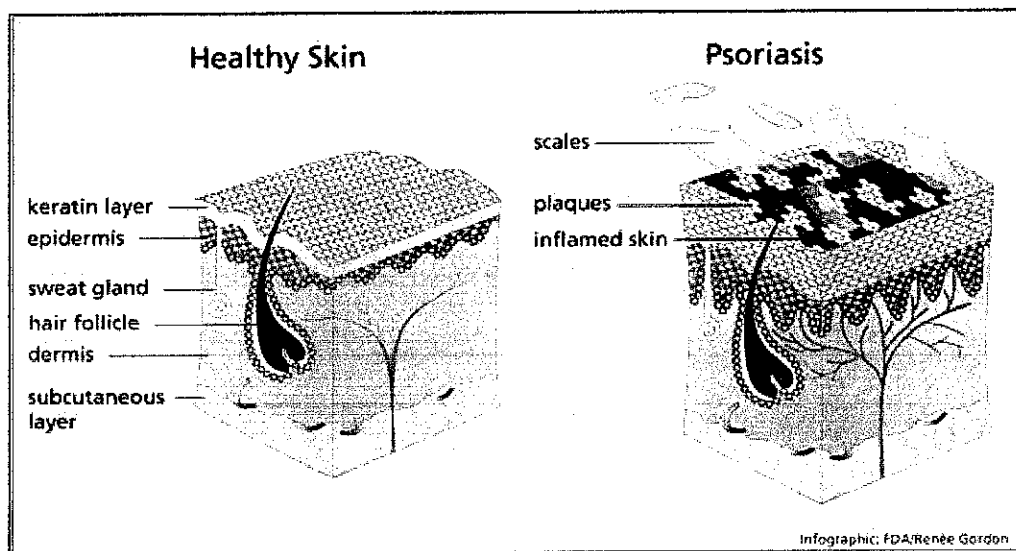


Figure 2 The difference between normal skin and skin covered by psoriasis lesion [17]

The cause of psoriasis is not fully understood. There are two main theories about the process that occurs in the development of the disease. The first considers psoriasis as primarily a disorder of excessive growth and reproduction of skin cells. Some also think that psoriasis is heritable and genetics [6].

2.1.2 *Types of Psoriasis*

In United States, Psoriasis has been classified as a chronic disease which affects approximately 5.5 million people [7]. There are several types of psoriasis that have been identified.

2.1.2.1 *Plaque Psoriasis*

It is the most common type of psoriasis. Approximately, 9 out of 10 people with psoriasis have plaque psoriasis [7]. Normally the skin is red and covered with silvery scales. Circular- to oval-shaped red plaques that sometimes itch or burn are typical of plaque psoriasis. The patches usually are found on the elbows, knees, trunk, or scalp but may be found on any part of the skin. Most plaques of psoriasis are persistent (they stay for years and do not tend to come and go) [7].



Figure 3 Picture of hips covered with plaque psoriasis [7]

2.1.2.2 *Guttate Psoriasis*

About 2% of those with psoriasis have the guttate type [7]. This type of psoriasis is more common in children and adults younger than 30 years [6]. Guttate psoriasis looks like small, salmon-pink (or red) drops on the skin. The word guttate is derived from the Latin word *gutta* which means drop. Guttate psoriasis usually occurs on the trunk, arms, or legs. However, it may cover a large portion of the body. The trigger to the disease is usually a

streptococcal (bacterial) infection. The rash of the lesions on the skin usually occurs at 2-3 weeks after the person has strep throat. This type of psoriasis often goes away without treatment in a few weeks.

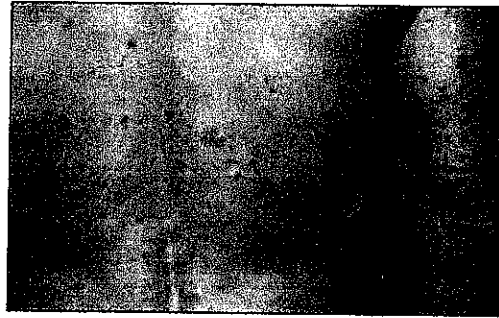


Figure 4 Red droplike lesions are found on the skin[7]

2.1.2.3 Pustular Psoriasis

Pustular psoriasis is an uncommon form of psoriasis [7]. People with pustular psoriasis have raised bumps on the skin that are filled with infections pus (pustules). The skin under and around these bumps is reddish. Pustular psoriasis may cause large portions of the skin to redden.

Pustular psoriasis is classified into several types, depending on the symptoms. Lesions may be sudden (*acute*), long term (*chronic*), or somewhere in between (*sub acute*).

- A generalized type with *acute symptoms* of fever, chills, nausea, headache, and joint pain is called the von Zumbusch type.
- Pustular psoriasis of the palms and soles is usually *chronic* and presents with red patches studded with white-to-yellow pustules.
- A ring-shaped (annular, or circinate) is usually *subacute or chronic*, and people with this type do not usually have symptoms aside from the skin symptoms.

- The least common type is the juvenile or infantile type, which occurs in children.



Figure 5 Pustular Psoriasis [7]

2.1.2.4 *Inverse Psoriasis*

This type of psoriasis is identified by bright red, smooth (not scaly), patches which are found in the folds of the skin. The most common areas are under the breasts, in the armpits, near the genitals, under the buttocks, or in abdominal folds. These irritated and inflamed areas are aggravated by the sweat and skin rubbing together in the folds. These moist irritated areas are prime areas for yeast and other fungal infections.

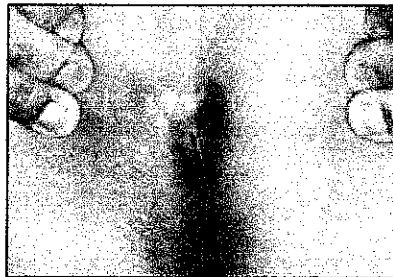


Figure 6 Inverse psoriasis under buttocks[7]

2.1.2.5 *Erythrodermic Psoriasis*

This is the least common type of psoriasis and can be quite serious [7]. A very large area of the body (not most of the body) is bright red and inflamed. The body can appear to be covered in a red, peeling rash that is usually itches or burns. Sometimes people with this type of psoriasis

become prone to dehydration, infection, and fever which require hospitalization.



Figure 7 Erythrodermic Psoriasis[7]

2.1.2.6 *Nail Psoriasis*

Most people who have psoriasis of the nails also have skin psoriasis, called cutaneous psoriasis. Nails psoriasis occurs in fewer than 5% of people [7] who do not have skin psoriasis. In people who have skin psoriasis, 10-55% has psoriasis of the nails [7], also called psoriatic nail disease.

People with nails psoriasis have clear yellow-red nail discoloring that looks like a drop of blood under the nail plate. Little pits may form in the nails. These pits develop when cells are lost from the nail's surface. Lines may develop going across the nails (side to side rather than root to tip). Areas of white on the nail plate may also be present. Psoriasis of the nails is not contagious [7].



Figure 8 Nail Psoriasis with pitting [7]

2.1.2.7 Scalp Psoriasis

The scalp may have fine dry scaly skin, or have heavily crusted plaque areas. The plaque can flake off or peel off in crusted clumps.



Figure 9 Scalp Psoriasis [7]

2.2 Psoriasis Area and Severity Index (PASI)

Psoriasis Area and Severity Index (PASI) is the current gold standard for assessment of psoriasis lesion [4]. The PASI is a measure of the average redness, thickness, and scaliness of the lesions (each graded on a 0–4 scale), weighted by the area of involvement.

2.2.1 Overview of Psoriasis Area and Severity Index (PASI)

Fredriksson and Pettersson created the PASI in 1978 [8] as a method to evaluate the clinical efficacy of a new treatment for psoriasis. When using the PASI, psoriatic plaques are graded based on three criteria: redness (R), 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).

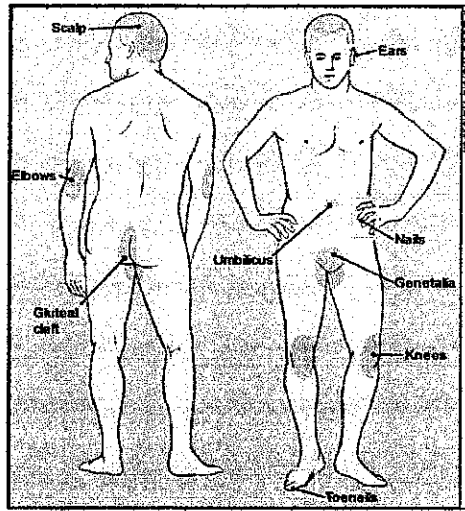


Figure 10 Common areas of psoriasis distribution[2]

2.2.2 Steps in generating PASI score

The body is divided into four regions consist of the head, upper extremities, trunk and lower extremities. Table 1 show an example of the elements consider in the PASI scoring.

Table 1 Elements of Psoriasis Area and Severity Index (PASI) [4]

		Head	Upper extremities	Trunk	Lower extremities
1	Redness				
2	Thickness				
3	Scale				
4	Sum of row 1, 2, and 3				
5	Area score				
6	Score of row 4 x row 5 x the area multiplier	row 4 X row 5 X 0.1	row 4 X row 5 X 0.2	row 4 X row 5 X 0.3	row 4 X row 5 X 0.4
7	Sum row 6 for each column for PASI score				

The steps in generating the PASI score;

- i. Divide body into four areas:
 - Head(h),
 - Arms or upper extremities(u),
 - Trunk to groin(t) and
 - Legs to top of buttocks or lower extremities (l).

- ii. Generate an average score for the erythematic, thickness, and scale for each of the 4 areas
 - 0 = clear or no involvement;
 - 1 = mild
 - 2 = moderate
 - 3 = severe
 - 4 = most severe

Table 2 The description of severity in the difference score [4]

Score	Redness	Thickness	Scaliness
0	No Redness	No Thickness	No Scale
1	Slight Pink	Feels Firm	Slight Scale
2	Pink	Raised	Scaly
3	Red	Thick	Flaky
4	Dark Red	Very Thick	Very Flaky

iii. Sum scores of erythema, thickness, and scale for each area.

- Head(h) = $R_h + T_h + S_h$, (2.1a)

- Arms or upper extremities(u) = $R_u + T_u + S_u$, (2.1b)

- Trunk to groin(t) = $R_t + T_t + S_t$ (2.1c)

- Legs to top of buttocks or lower extremities = $R_l + T_l + S_l$ (2.1d)

iv. Generate a percentage for skin covered with psoriasis for each area (A_h , A_u , A_t , A_l) and convert that to a 0–6 scale [4]

- 0 = 0%
- 1 = <10%
- 2 = 10–<30%
- 3 = 30–<50%
- 4 = 50–<70%
- 5 = 70–<90%
- 6 = 90–100%

v. Multiply all the sum of redness, thickness and scaliness for each area obtain in part iii. with the generate percentage obtain in part iv. After that multiply them by 0.1, 0.2, 0.3, and 0.4 for head, arms, trunk, and legs, respectively.

- Head(h) = $0.1(R_h + T_h + S_h)A_h$, (2.2a)

- Arms or upper extremities(u) = $0.2(R_u + T_u + S_u)A_u$, (2.2b)

- Trunk to groin(t) = $0.3(R_t + T_t + S_t)A_t$ (2.2c)

- Legs to top of buttocks or lower extremities = $0.4(R_l + T_l + S_l)A_l$ (2.2d)

vi. Add these scores to get the PASI score [4]

$$\text{PASI} = 0.1(R_h + T_h + S_h)A_h + 0.2(R_u + T_u + S_u)A_u + 0.3(R_t + T_t + S_t)A_t + 0.4(R_l + T_l + S_l)A_l \quad (2.3)$$

2.3 Image Processing

Image processing is a common term for a wide range of techniques that exist for manipulating and modifying images in various ways. This section covers theoretical aspects of processing techniques used in this project.

2.3.1 Image Acquisition

The first stage of any image processing is the image acquisition stage. It is the most important step in Digital Imaging Systems. After the image has been obtained, various methods of processing can be applied to the image to perform many different vision tasks required today. However, if the image has not been acquired satisfactorily then the intended tasks may not be achievable, even with the aid of some form of image enhancement. High quality images require a good microscope, a camera appropriate to the specimens, a frame grabber board, a computer and software to integrate the system.

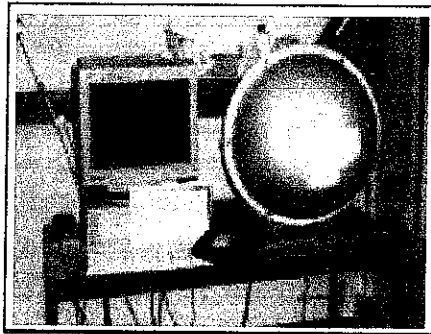


Figure 11 The equipment used in image acquisition [16]

2.3.2 Image Enhancement

This is also known as the low-level processing, which essentially serves the objective of preparing images for next higher-level processing (i.e. segmentation). This is important to improve the quality of images, which may be degraded due to noise, out-of-focus blur, motion effect, inappropriate illumination etc. These negative effects could be corrected by ‘enhancement’ and/or ‘restoration’ [3].

2.3.2.1 Histogram Equalization

Histogram equalization is a method in image processing of contrast adjustment using image's histogram. This method usually increases the local contrast of the images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast without affecting the global contrast.

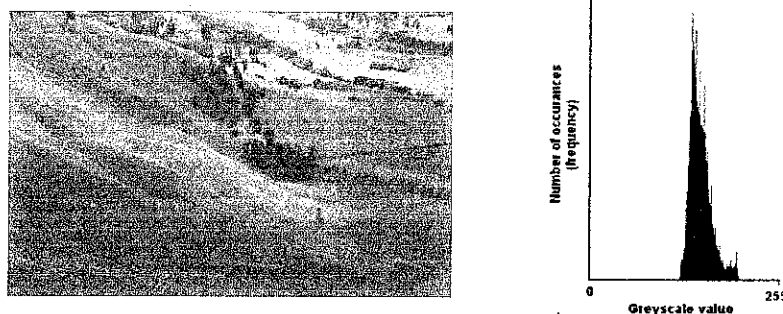


Figure 12 An image and its histogram [9]

This histogram equalization technique attempts to change the original histogram into a histogram that is constant for all brightness values. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.

Consider a grayscale image in Figure 12 and let n_i be the number of occurrences of gray level i . The probability of an occurrence of a pixel of level i in the image is

$$p(x_i) = \frac{n_i}{n}, i \in 0, \dots, L - 1 \quad (2.4)$$

L = total number of gray levels in the image

n = total number of pixels in the image

p = the image's histogram, normalized to 0..1

Then, the cumulative distribution function corresponding to p is defined by equation 2.5;

$$c(i) = \sum_{j=0}^i p(x_j) \quad (2.5)$$

Also known as the image's accumulated normalized histogram.

From equation 2.5, a transformation of the form $y = T(x)$ is created. This will produce a level y for each level x in the original image such that the cumulative probability function of y will be linearized across the value range. The transformation is defined by equation 2.6:

$$y_i = T(x_i) = c(i) \quad (2.6)$$

In equation 2.6, T maps the level into domain of $0 \dots 1$. In order to map the values back into their original domain, the following simple transformation needs to be applied on the result:

$$y'_i = y_i \cdot (\max - \min) + \min \quad (2.7)$$

The above method describes histogram equalization on a grayscale image.

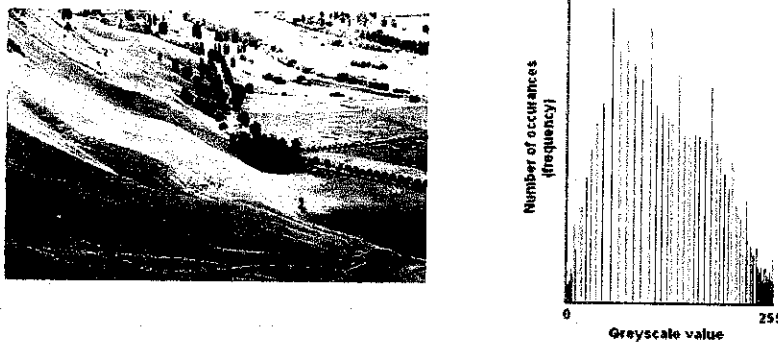


Figure 13 An image after apply histogram equalization and its histogram [9]

2.3.2.2 Contrast Stretching

Contrast stretching (often called normalization) is a simple image enhancement technique that attempts to improve the contrast in an image by 'stretching' the range of intensity values it contains to span a desired range of values. It differs from the more sophisticated method (i.e. histogram equalization) in that it can only apply a *linear* scaling function to the image pixel values. As a result the 'enhancement' is less harsh.

To perform the operation, it is required to specify the upper and lower pixel value limits over which the image is to be normalized. Often these limits will just be the minimum and maximum pixel values that the image type concerned allows. For example for 8-bit gray level images the lower and upper limits might be 0 and 255. Call the lower and the upper limits a and b respectively.

The simplest sort of normalization then scans the image to find the lowest and highest pixel values currently present in the image, represents by c and d . Then each pixel P is scaled using the following function:

$$P_{out} = (P_{in} - c) \left(\frac{b - a}{d - c} \right) + a \quad (2.8)$$

Values below 0 are set to 0 and values about 255 are set to 255. Equation 2.8 however, can be somewhat sensitive to outliers and less sensitive.

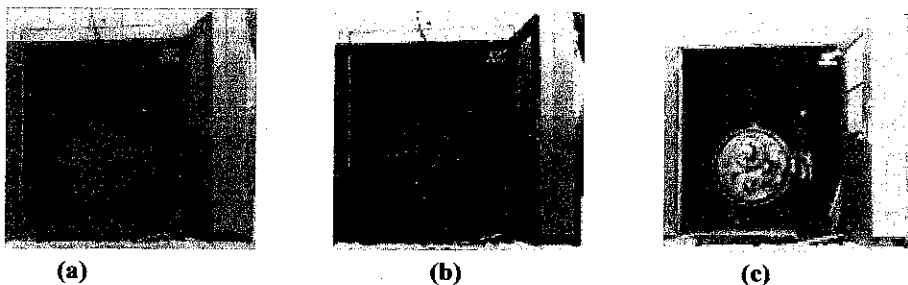


Figure 14 Comparison between histogram equalization and contrast stretching [18], (a) Original image, (b) After applied contrast stretching, (c) After applied histogram equalization

2.3.3 *Image Segmentation*

Segmentation involves separating an image into regions (or their contours) corresponding to objects. Typically, an image is segmented into regions by identifying its common properties. Or, similarly, identify contours by identifying *differences* between regions (edges). The simplest property that pixels in a region can share is intensity.

The role of segmentation is crucial in most tasks requiring image analysis. The success or failure of the task is often a direct consequence of the success or failure of the segmentation [14].

For image segmentation, there are lots of methods that can be used such as Graphical Gaussian shape models, Thresholding method, Edge-based methods, Region-based techniques, Watershed transform and K-Means Cluster. Image segmentation is essential in improving image analysis especially for image querying and retrieval [13].

2.3.3.1 *K-Means Clustering*

K-means [10] is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. It is known as a partitioning method since the user must first define number of clusters at the onset. K-Means clustering requires a specific number of clusters to be partitioned to quantify how close two objects are between one another.

The algorithm provides a simple and easy way to classify a given set of data through a certain number of clusters (e.g.: k clusters) such that some metric relative to the centroids of the clusters is minimized. The main idea is to define k centroids, one for each cluster. Various metrics to the centroids that can be minimized include;

- maximum distance to its centroid for any object
- sum of the average distance to the centroids over all clusters
- sum of the variance over all clusters
- total distance between all objects and their centroids

The metric to minimize and the choice of a distance measure will determine the shape of the optimum clusters. The algorithm iterates over two steps:

- compute the mean of each cluster
- compute the distance of each point from each cluster by computing its distance from the corresponding cluster mean. Assign each point to the cluster it is nearest to.

First, the algorithm makes a partition to the input points into k initial sets, either at random or using some heuristic data. It then calculates the mean point, or centroid, of each set. It constructs a new partition by associating each point with the closest centroid. Then the centroids are recalculated for the new clusters, and algorithm repeated by alternate application of these two steps until convergence, which is obtained when the centroids are no longer change. This algorithm has remained extremely popular because it converges extremely quickly in practice [9].

Finally, this algorithm aims at minimizing an *objective function*, in this case a squared error function. The objective function

$$J = \sum_{j=1}^k \sum_{i=1}^n \|x_i^{(j)} - c_j\|^2 \quad (2.9)$$

where $\|x_i^{(j)} - c_j\|^2$ is a chosen distance measure between a data point $x_i^{(j)}$ and the cluster centre c_j , is an indicator of the distance of the n data points from their respective cluster centres. In general, the algorithm does not achieve a global minimum of J over the assignments. In fact, since the algorithm uses discrete assignment rather than a set of continuous parameters, the minimum it reaches cannot even be properly called local minimum. Despite these

limitations, the algorithm is used fairly frequently as a result of its ease of implementation.

2.3.4 Feature Extraction

This operation aims to identify structures in the image that are useful for recognizing the objects being analyzed. The structures might include the pixels that constitute an area, or the straight boundaries between regions.

2.3.4.1 Feature Recognition

This process uses the features from extraction phase to assign a label or categories to the image or parts of the image by comparing the features against those derived from previously labeled objects.

2.4 Graphical User Interface (GUI)

In general, the steps to create a GUI are first constructing its layout (its appearance in terms of size, colour, placement of components etc.) and programming the callback functions for desired components (provide functions to GUI).

2.4.1 Creating GUI's Layout

To create GUI in MATLAB, several layout tools are essential for tasks' simplification. These tools are listed and defined as below:

2.4.1.1 Layout Editor [15]

- a. Enable placement of GUI components in the figure window
- b. These components are selected beforehand from Component Palette
- c. The Component Palette consists of *uicontrol*¹ objects

¹ Programmable objects to perform specified functions, e.g. push buttons, toggle buttons, sliders etc.

2.4.1.2 *Alignment Tool [15]*

- a. Enable positioning of objects with respect to each other, and also adjusting of the spacing between selected objects.
- b. Provides two types of alignment operations:
 - i) **Align** : aligning all selected components to a single reference line
 - ii) **Distribute** : spacing all selected components uniformly with respect to each other

2.4.1.3 *Property Inspector [15]*

- a. Enable the settling of components' properties in the layout
- b. Provide a list of settable properties, which are associated with editing devices.
 - Example: a colour picker to change the background colour, a text field to specify the Callback string etc.

2.4.1.4 *Object Browser [15]*

Displays a hierarchical list of the objects in the figure

2.4.1.5 *Menu Editor [15]*

There are two kinds of menu that could be created in MATLAB:

- a. Menubar objects: menu displayed on the figure menubar
- b. Context menu: menu that pop up when user right-clicks on graphics objects

2.4.2 *Programming GUI*

MATLAB generates the application M-file, which acts as a framework for the program that provides functions to the GUI [15]. The application M-file basically serves the two purposes of:

- i) **Initializing and launching GUI**
Initialization: 'In this step the graphical elements and data structures are created. For each objects we must specify its position and other

properties, especially callback functions. The callback of a *uicontrol* is the code that is executed when the control actuated. Other properties specify the style and appearance of the object' [15]

- ii) Containing the callback functions for all components in the GUI

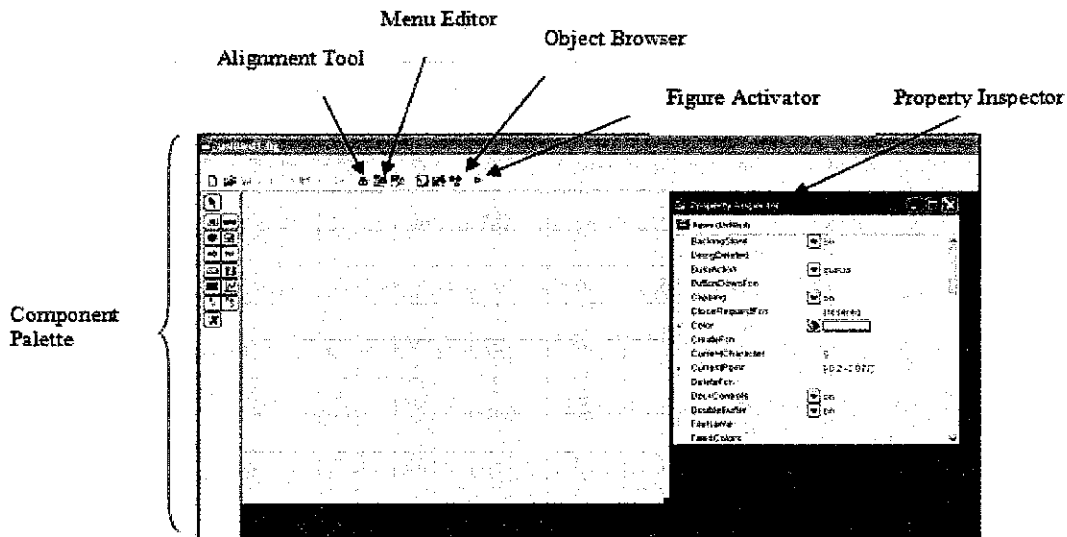


Figure 15 The GUIDE layout editor

A key feature in generated M-file is handles structure. The purposes of this structure are to;

- a. Store the handles of all controls, menu, and axes in GUI
- b. Store global data used in the program

Each object *handle* is stored in a field of the *handles* structure having the same name as the object's Tag [15]. For example,

`handles.data_popup`

contains the *handle* of a popup menu [15].

The data can then be stored and passed it to any callback, using the handle structure. This is done by first creating a new field in the *handles* structure. Then, this field is saved using the *guidata* function. For example, from the callback of the object which *handle* is h [15],

```
handles.x_data = X
guidata(h,handles)
```

saves the variable X in the x_data field of the *handles* structure. The *guidata* then writes the new version of *handles* to the figure's application data to save it. To obtain X in another callback, reference the correct field [15]:

```
X = handles.x_data
```

The primary mechanism for implementing a GUI is programming the callback of the *uicontrol* objects used to build the interface. Other properties that facilitate callbacks definition are;

- i. **ButtonDownFcn** – MATLAB executes this callback when users click the left mouse button and the cursor is over the object or within a five-pixel border around the object.
- ii. **CreateFcn** – MATLAB executes this callback when creating the object
- iii. **DeleteFcn** - MATLAB executes this callback just before deleting the object

Finally, the GUI Simulate and Store results button callback runs the model simulation and stores the results in the handles structure [15].

CHAPTER 3

METHODOLOGY

3.1 Procedure Identifications

There are six stages proposed for this project completion, starting from data gathering until submission of the final report and final presentation of the project. This project development is represented in details on a Gantt chart in Appendix A.

The author had developed system architecture for achieving the objectives of this project. The system architecture developed considers all the tasks needed in developing the PASI scoring system.

3.1.1 Project Methodology

This project is implemented into several stages to complete as shown in bring down Table 3;

Table 3 List of tasks for project development

TASK 1	Literature review and data gathering
TASK2	Learning and training of MATLAB 7.0 software (Image Processing Tools)
TASK 3	Design planning of the system architecture
TASK 4	Designing and develop the automated system
TASK 5	Testing and troubleshooting of the system develop
TASK 6	Final Report and Presentation

3.1.1.1 Literature review and data gathering

During this stage lot of information and data gathering will be done. This phase is the most crucial phase and provides the author all the useful and important knowledge for design progress. Books, Internet and Journals are the most practical sources for data gathering.

3.1.1.2 Learning and training of MATLAB 7.0 software (Image Processing Tools)

The software that is used in this project is MATLAB7 software. Therefore it is important to learn how to use the software especially on Image Processing Tools. The average score in classifying the scaliness severity is determined by using the Threshold Method obtained from the Image Processing Tools.

3.1.1.3 Design planning of the system architecture

Before the system is implemented, the system is sub-divided into several stages which are represented in Figure 16, the system architecture. Each sub-division represents a process related to image processing. This is to ensure the specification of the system is according to the user requirements and to ensure the progress of the design stage.

3.1.1.4 Designing and develop the automated system

The system is designed based on the user requirements. This phase is important in ensuring the development of the system.

3.1.1.5 Testing and troubleshooting of the system develop

Testing and troubleshooting guarantee that the system functions is successful without any flaws. Several test plans were implemented on a set of data to validate the accuracy of the system designed. A large set of data consisting of about 40 psoriasis images were used in this project.

3.1.1.6 Final Report and Presentation

The final report and presentation will be carried out as scheduled.

3.1.2 Project Architecture

The method that will be implemented in this project is shown in Figure 16;

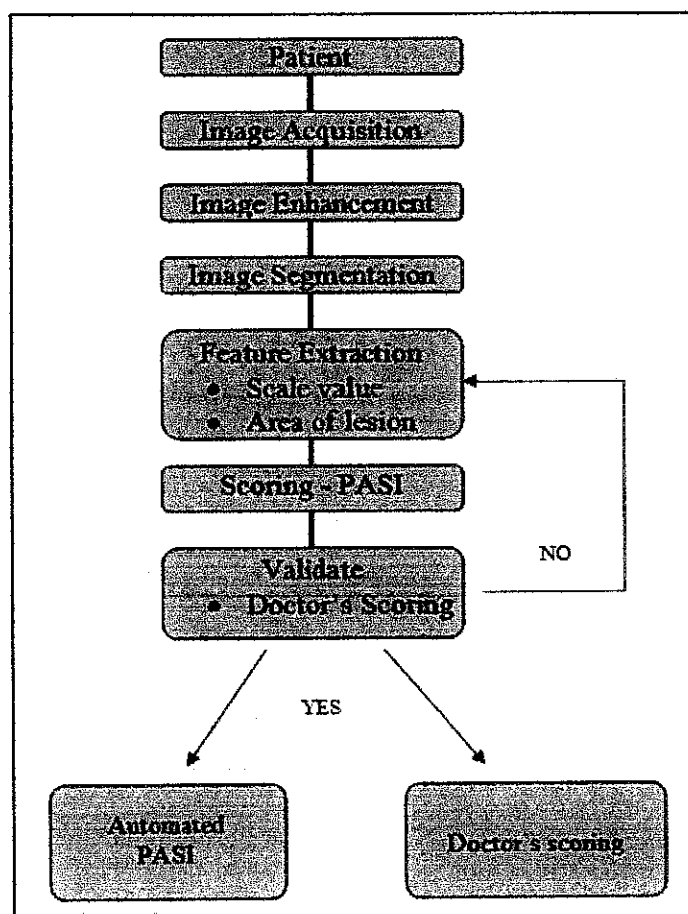


Figure 16 The proposed system architecture

3.1.2.1 Image Acquisition

The images of skin lesion used in this project analysis are acquired from psoriasis and dermatologist websites. The images then will be stored as a graphics file (i.e. in gif, jpg, bmp format), so that those images can be loaded and read in MATLAB software. The images that were used in this project are showed in Appendix B.



Figure 17 Example of original image of psoriasis lesion

Figure 17 is an example of the original image of psoriasis lesion. The image was then converted into grayscale image for further analysis process. The grayscale image then will be enhanced to be used in segmentation process later.

3.1.2.2 Image Processing

Image processing is a common term for a wide range of techniques that exist for manipulating and modifying images in various ways. This section covers theoretical aspects of processing techniques used in this project.

3.1.2.2.1 Image Enhancement

Image enhancement is implemented for improving the image quality for further analysis. In [12] stated that a common method that used for image enhancement is by histogram equalization in the spatial domain or contrast stretching which then will uniformly redistribute gray levels. In this paper, the intensity of the image is enhanced by using the MATLAB command ***imadjust***.

imadjust adjusts the image intensity values or colormap to new values such that 1% of data is saturated at low and high intensities of the original image. This increases the contrast of the output image.

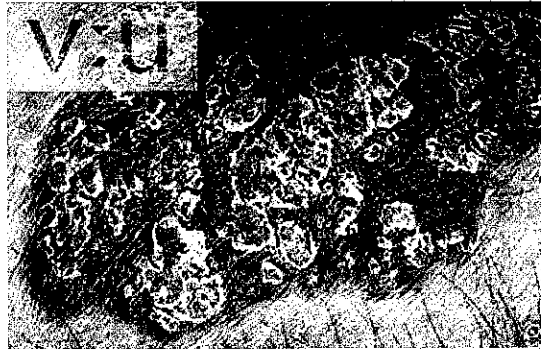


Figure 18 The enhance image of psoriasis lesion

3.1.2.2.2 Image Segmentation

This project must used clustering method for segmentation process in developing the automated scoring system. The chosen segmentation is K-Means Clustering method.

K-means clustering method segmented the enhanced image into k clusters. The number of cluster is actually defined by the programmer (i.e. the author). In this project, the author has chosen the cluster number to be three. In Figure 19, the lesion could be obtained in cluster 1.

In this stage, the user has to determine the specific cluster which shows the lesion image. The right image chose will ensure an accurate result.

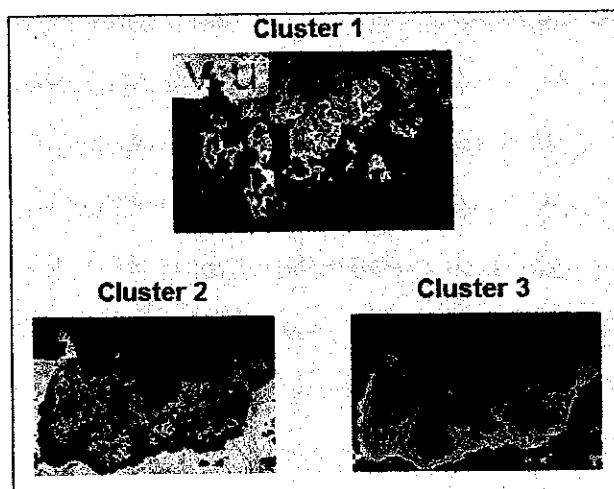


Figure 19 The different segmented images in different cluster

3.1.2.3 Image Analysis (Scaliness Values)

Both the segmented images are converted into grayscale image using MATLAB command *rgb2gray*. This command converts the color image to grayscale intensity image by eliminating hue and saturation information while retaining luminance.

Then from the grayscale image, the image intensity is displayed by a histogram using command *imhist*. This command displays the intensity image which number of bins specified by image type. The default value of bins is 256.

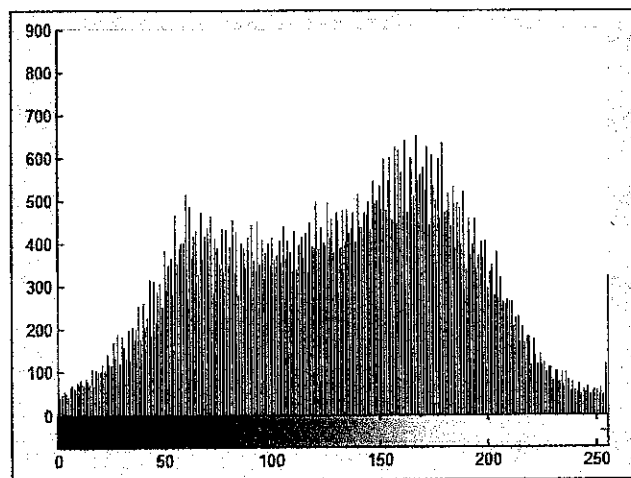


Figure 20 Histogram of the image data

From the histogram, the plot at $x = 0$ shows the background of the image while the others bins or plots represent the image lesions. Therefore to get the size of the lesion, N , the background will be excluded by obtaining only the value range of $(x > 0)$.

$$[y \ x] = \text{imhist}(g);$$

$$N = y(x > 0);$$

Then, the grayscale image is converted into binary image to obtain the total pixels of the lesion.

$$J = \text{roifilt2}(h, \text{lesion}, \text{bw}) \quad (3.1)$$

The command *roifilt2* will filter the region of interest. It returns an image that consists of filtered values for pixels in locations where binary image, *bw*, contains 1's, and unfiltered values for pixels in locations where *bw* contains 0's. *bw* is a binary image that is the same size as *lesion* (grayscale image) used as a mask for filtering.

The thresholding can be summarized as;

$$J = (g \geq \text{low}) \ \& \ (g \leq \text{high}) = 1 \quad (3.2)$$



Figure 21 The binary image with 0's outside the region and 1's inside

The total pixels of the lesion can be determined from the binary image which corresponds roughly to the value of 'on' pixels of the lesions. Different patterns of pixels (images) may not be exactly the same therefore they are weighted differently.

The total pixels of the lesion can be determined from the binary image.

$$\text{total} = \text{bwarea}(J)$$

NOTE: total = M = total pixels of the lesion

Thus, the value of mean intensity of the lesion can be calculated from the value obtained;

- N = size of lesions
- M = total pixels of the lesions

Both of the values have been obtained earlier. The image data, p , and the mean intensity, Mean , are calculated;

$$p = [N/M]; \quad (3.3)$$

$$\text{Mean} = b * p \quad (3.4)$$

The mean intensity values were obtained from few images to generate the scale values.

3.1.2.4 *Generated Score (PASI Scoring)*

There are two main components that need to be obtained in generating the PASI score:

1. Scale score
2. Area score

3.1.2.4.1 Scale Score

In generating different values of scaliness, five images with different scores are chosen. The values of scaliness for each image are obtained in image analysis stage.

- V_0 = scale value for lesion image score 0
- V_1 = scale value for lesion image score 1
- V_2 = scale value for lesion image score 2
- V_3 = scale value for lesion image score 3
- V_4 = scale value for lesion image score 4

Then, the threshold values are calculated by determining the average values between the higher and the lower score.

- $T1 = (V0 + V1)/2$ (3.5a)

- $T2 = (V1 + V2)/2$ (3.5b)

- $T3 = (V2 + V3)/2$ (3.5c)

- $T4 = (V3 + V4)/2$ (3.5d)

The generated score obtained by using threshold values for each;

<u>Score</u>	<u>Range</u>
0	Scale \geq T1
1	T1 > Scale \geq T2
2	T2 > Scale \geq T3
3	T3 > Scale \geq T4
4	Scale < T4

3.1.2.4.2 Area Covered by psoriasis lesion

The next step is to obtain the score for the area of psoriasis. The score generated will be based on the area covered by the lesions. The area of the lesions has been obtained in the image analysis stage where the total pixels of the lesion image, *total*, is divided by the area of the Region of Interest (ROI), the image, in terms of pixels.

Area percentage of the lesion could be calculated by the following formula:

$$\text{Area percentage} = \frac{\text{Area of lesion}}{\text{Area of ROI}} \times 100\% \quad (3.6)$$

From the equation 3.6, the percentage obtained will be used to get the score for the area covered by the psoriasis lesion which is based Table 4

Table 4 The range of percentage area for each score [4]

Score	Range
0	0% (clear)
1	< 10%
2	10 - < 30%
3	30% - < 50%
4	50% - < 70%
5	70% - < 90%
6	90 - < 100%

3.1.2.5 Validation of results

The results obtained from the developed algorithms will be verified for its accuracy by the expert dermatologist

3.2 Tools/Software

Through out this project, MATLAB software will be used to develop the algorithm especially the Digital Image Processing Tools. Moreover, the MATLAB Graphical User Interface (GUI) will be used for creating the database of the algorithm.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Overview of the project results

In developing the automated scoring system, the author has divided the project's results into four main components:

- i) Image processing
- ii) Image Analysis
- iii) PASI score

Five of psoriasis lesion images are chose randomly and shown for discussion. All the psoriasis images obtained from the dermatologists' website databases and General Hospital Ipoh are shown in Appendix B.

4.2 Image processing

This part is the most crucial and important part in ensuring the accuracy of the final results. Image processing includes image enhancement and image segmentation. The results of image processing are based on samples taken randomly from Appendix B.

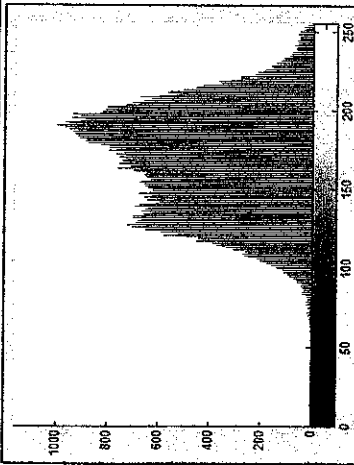

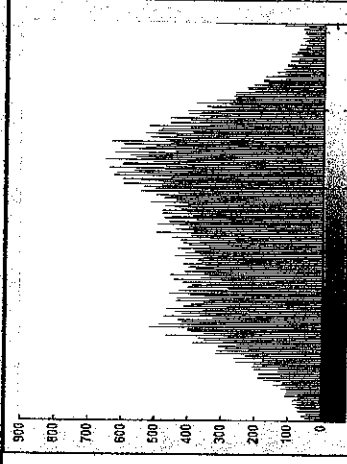
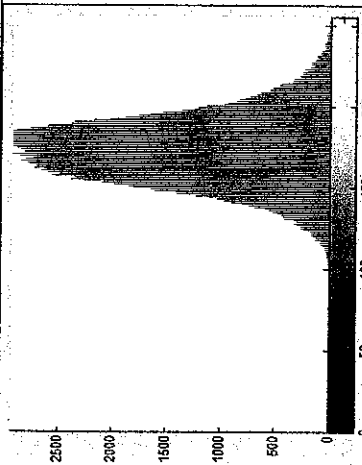

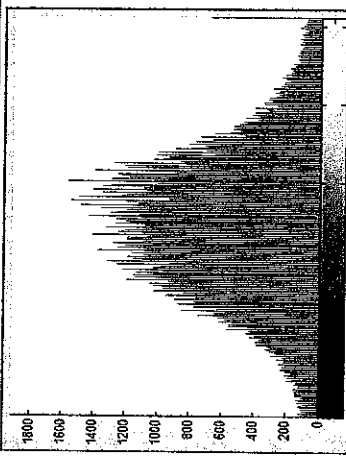
4.2.1 Image Enhancement

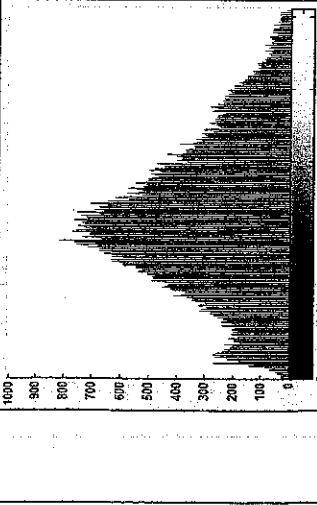

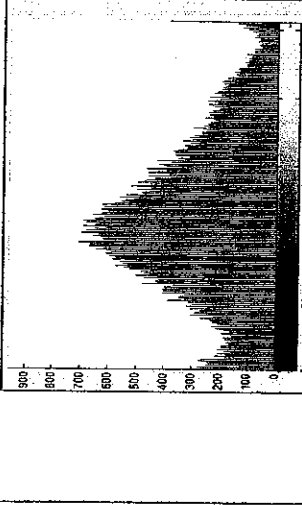
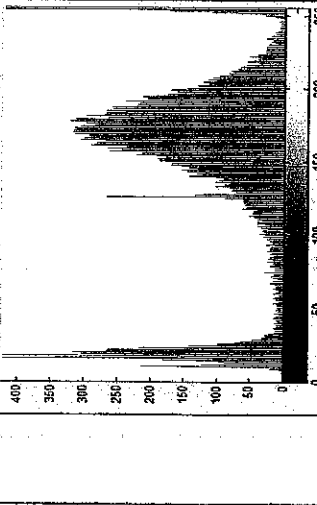

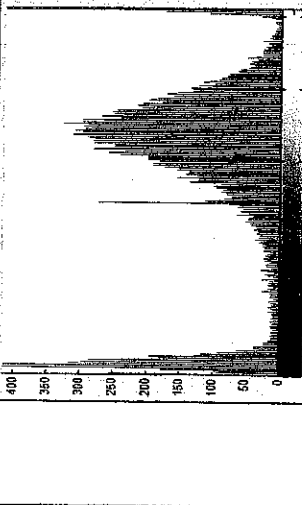
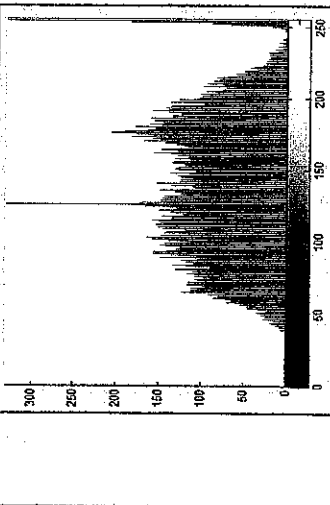

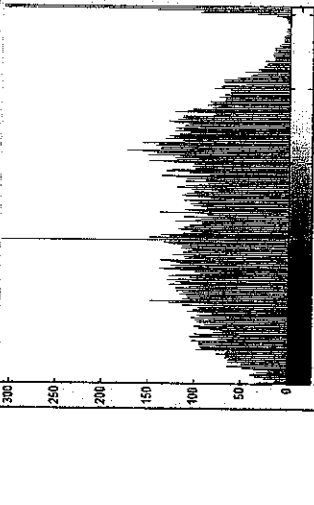
The purposed of image enhancement is to aid a better observation for higher-level processes. In this project, the enhancement technique chosen is *Contrast Stretching method*.

Contrast stretching is a technique which turns the dark feature of the original image to be increasingly darker, thus light feature to be lighter. The term contrast itself means 'increasing the differences between features, in terms of brightness' [9].

The results are summarized in Table 5 which shows the original images histogram, along with the enhancement images and their histogram respectively.

Table 5 Enhanced images and the histograms

Image no.	Histogram of original image	Enhanced image	Histogram of enhanced image
1	 <p>The histogram for the original image 1 shows a distribution of pixel intensities. The x-axis represents intensity from 0 to 255, and the y-axis represents frequency from 0 to 1000. The distribution is bimodal, with a primary peak around 100 and a secondary peak around 200.</p>	 <p>The enhanced image 1 shows a grayscale image of a textured surface with a small inset in the bottom-left corner containing the letters 'VU'.</p>	 <p>The histogram for the enhanced image 1 shows a distribution of pixel intensities. The x-axis represents intensity from 0 to 255, and the y-axis represents frequency from 0 to 900. The distribution is bimodal, with a primary peak around 100 and a secondary peak around 200.</p>
2	 <p>The histogram for the original image 2 shows a distribution of pixel intensities. The x-axis represents intensity from 0 to 255, and the y-axis represents frequency from 0 to 2500. The distribution is bimodal, with a primary peak around 100 and a secondary peak around 200.</p>	 <p>The enhanced image 2 shows a grayscale image of a textured surface.</p>	 <p>The histogram for the enhanced image 2 shows a distribution of pixel intensities. The x-axis represents intensity from 0 to 255, and the y-axis represents frequency from 0 to 1800. The distribution is bimodal, with a primary peak around 100 and a secondary peak around 200.</p>

6	 <p>A spectrogram showing frequency content over time. The vertical axis (frequency) ranges from 0 to 1000 Hz, and the horizontal axis (time) ranges from 0 to 250 seconds. The plot shows a complex, multi-band signal with significant energy across the frequency spectrum.</p>	 <p>A high-magnification micrograph showing a dense, granular surface texture with irregular, light-colored particles against a dark background.</p>	 <p>A spectrogram showing frequency content over time. The vertical axis (frequency) ranges from 0 to 900 Hz, and the horizontal axis (time) ranges from 0 to 250 seconds. The plot shows a complex, multi-band signal with significant energy across the frequency spectrum.</p>
12	 <p>A spectrogram showing frequency content over time. The vertical axis (frequency) ranges from 0 to 400 Hz, and the horizontal axis (time) ranges from 0 to 250 seconds. The plot shows a complex, multi-band signal with significant energy across the frequency spectrum.</p>	 <p>A high-magnification micrograph showing a granular surface texture with irregular, light-colored particles against a dark background.</p>	 <p>A spectrogram showing frequency content over time. The vertical axis (frequency) ranges from 0 to 400 Hz, and the horizontal axis (time) ranges from 0 to 250 seconds. The plot shows a complex, multi-band signal with significant energy across the frequency spectrum.</p>
16	 <p>A spectrogram showing frequency content over time. The vertical axis (frequency) ranges from 0 to 300 Hz, and the horizontal axis (time) ranges from 0 to 250 seconds. The plot shows a complex, multi-band signal with significant energy across the frequency spectrum.</p>	 <p>A high-magnification micrograph showing a granular surface texture with irregular, light-colored particles against a dark background.</p>	 <p>A spectrogram showing frequency content over time. The vertical axis (frequency) ranges from 0 to 300 Hz, and the horizontal axis (time) ranges from 0 to 250 seconds. The plot shows a complex, multi-band signal with significant energy across the frequency spectrum.</p>

From Table 5, it is observed that this technique produces image output of which their light and dark features are distinctly differentiated from each other. This technique provides distinct difference between objects of interest with their background. This is actually a useful criterion to ensure the effectiveness of segmentation in later stage.

Although after stretching the shape might be a little bit different, in essence, the output histogram still retains the same shape as the input histogram. Additionally, this method preserves the original shape of the histogram (only stretches it), none of the original information lost [12].

However, for images which the features do not distinctly differ from each other (in terms of brightness), contrast stretching will not distinguish them from each other, as images 6 and 12. This problem might effect the results for later process.







4.2.2 *Image Segmentation*

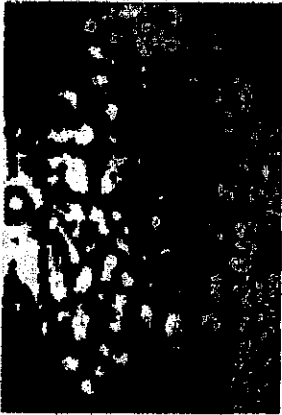
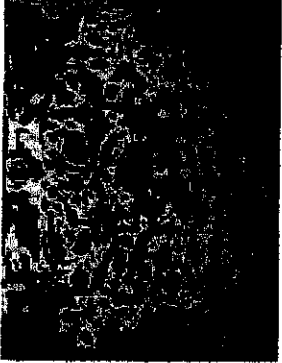

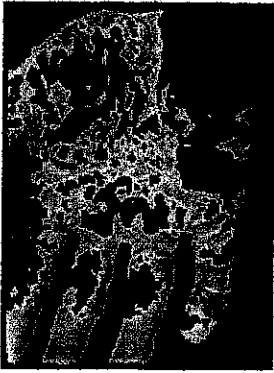
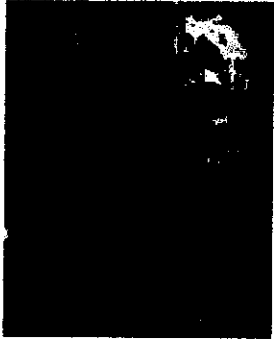




The purpose of this process is to isolate the objects of interest from the background, for further analysis purpose. The enhanced images are converted into grayscale image before being segment. In this project, the segmentation is done via K-Means Cluster Method.

K-Means clustering requires a specific number of clusters to be partition to quantify how close two objects are between one another. The number of cluster chose is three. This method however have a disadvantage, it could not operated automatically. It require user to choose a cluster which complied with the user requirement for further analysis.

However, this flaw will not affect the later processes, if the user chooses the right image which contained lesion. The results of the image segmentation are summarized in Table 6 for five images.

Table 6 Results of segmented image

Image no.	Cluster #1	Cluster #2	Cluster #3	Cluster with lesion
1				Cluster #1
2				Cluster #1

6				Cluster #1
12				Cluster #3
16				Cluster #3

From Table 6, it is observed that the binary image retain the majority details of the lesions. It is observed that most of the smaller details are omitted.

But from the Table also, there are also some of the images which could not be segment successfully (image 12 and 16). The required information on the objects of interest (i.e. lesions) is lost, and some incorrect information might be included in the output image. This is due to the lesions brightness feature is almost similar to the background brightness feature. Thus, they are indistinguishable from each other, in terms of brightness. For this type of images, other segmentation method should be used, such as edge detection, threshold method or watershed.

4.3 Image Analysis

During this stage, the analysis is divided into two parts: obtaining the scale score and the percentage of lesion's area. Both results will be used in calculating the PASI score later.

4.3.1 *Obtaining the scale score*

The scale score are obtained from the threshold value calculated by determined the average values of the lower and the higher score. The average value is actually obtained based on five images which have different scale values.

The score of each image as showed in Appendix B are summarized in Table 8. The score are with reference to PASI score:

Table 7 The description of scale severity in difference score [4]

Score	Scaliness
0	No Scale
1	Slight Scale
2	Scaly
3	Flaky
4	Very Flaky

Table 8 Scale Score of Images

Image no.	Scale Score	Image no.	Scale Score
1	3	21	2
2	3	22	3
3	3	23	2
4	1	24	2
5	2	25	0
6	1	26	1
7	3	27	1
8	2	28	1
9	2	29	1
10	2	30	2
11	4	31	2
12	1	32	2
13	0	33	1
14	1	34	0
15	3	35	0
16	2	36	1
17	1	37	4
18	3	38	2
19	0	39	2
20	1	40	4

From Table 8, all the images are with reference to Appendix B, the original image. Each score represents only one part of the body (i.e. the upper extremities or arm). The scores developed will be used in obtaining the level of severity of psoriasis lesion with references of PASI.

4.3.2 *Obtaining the percentage of lesion's area*

The area of the lesions is obtained based on the total pixels of the lesion divided by the region of interest. The region of interest is obtained by threshold method.

From the percentage calculated, the area score are obtained based on PASI score [4]:

- 0 = 0%
- 1 = <10%
- 2 = 10–<30%
- 3 = 30–<50%
- 4 = 50–<70%
- 5 = 70–<90%
- 6 = 90–100%

Table 9 Area Score of Images

Image no.	Area Score	Image no.	Area Score
1	2	21	2
2	4	22	1
3	1	23	1
4	1	24	1
5	6	25	2
6	2	26	2
7	2	27	1
8	1	28	4
9	4	29	2
10	5	30	2
11	1	31	2
12	1	32	2
13	2	33	2
14	2	34	3
15	2	35	1
16	1	36	3
17	2	37	5
18	1	38	2
19	1	39	2
20	2	40	2

All of the scores showed in Table 9 are with reference to Appendix B, the original images. The scores are generated based on the percentage of the lesion occur on the patient body. Each image only represents one part of the body area (i.e. upper extremities or arms). Most of the lesion occurs on the patient body parts about 10% to 30% which gives a score of 2. Each score generated is important in determine the accurate score of PASI.

4.4 PASI Score

The PASI Score is calculated based on Equation 4.1.

$$\begin{aligned} \text{PASI} = & \quad 0.1(R_b + T_h + S_h)A_h + 0.2(R_u + T_u + S_u)A_u + 0.3(R_t + T_t + S_t)A_t \\ & + 0.4(R_l + T_l + S_l)A_l \end{aligned} \quad (4.1)$$

The PASI score in equation 4.1 is evaluated from range 0 - 72. This equation only valid when all the elements of psoriasis is evaluated (i.e. Redness, Thickness and Scaliness). In this project, only scale score is evaluated, therefore equation 4.1 is omitted. The PASI score that will be used is:

$$\text{PASI (s)} = \quad 0.1(S_h)A_h + 0.2(S_u)A_u + 0.3(S_t)A_t + 0.4(S_l)A_l \quad (4.2)$$

However, each image represents only one part of the body therefore the value of PASI score are evaluated based on:

$$\text{PASI (s,h)} = \quad 0.1(S_h)A_h \quad (4.3a)$$

$$\text{PASI (s,u)} = \quad 0.2(S_u)A_u \quad (4.3b)$$

$$\text{PASI (s,t)} = \quad 0.3(S_t)A_t \quad (4.3c)$$

$$\text{PASI (s,l)} = \quad 0.4(S_l)A_l \quad (4.3d)$$

The overall results of the Scaliness Score based on PASI scoring are summarized in Table 10. The results are for all images which showed in Appendix B.

Table 10 Scaling score of Psoriasis Lesions and the PASI score

Image no.	Scale Score	Area Score	PASI Score
1	3	2	1.2
2	3	4	2.4
3	3	1	0.9
4	1	1	0.3
5	2	6	3.6
6	1	2	0.6
7	3	2	1.8
8	2	1	0.4
9	2	4	2.4
10	2	5	3.0
11	4	1	1.6
12	1	1	0.2
13	0	2	0.0
14	1	2	0.6
15	3	2	1.8
16	2	1	0.8
17	1	2	0.6
18	3	1	0.6
19	0	1	0.0
20	1	2	0.6
21	2	2	1.2
22	3	1	0.9
23	2	1	0.8
24	2	1	0.8
25	0	2	0.0
26	1	2	0.0
27	1	1	0.3
28	1	4	1.6
29	1	2	0.6
30	2	2	1.2
31	2	2	0.8
32	2	2	1.6
33	1	2	0.6
34	0	3	0.0
35	0	1	0.0
36	1	3	0.9
37	4	5	8.0
38	2	2	1.2
39	2	2	0.8
40	4	2	3.2

Each scores showed in Table 10 represents only one part of the patient body (i.e. upper extremities). All the 40 images tested on the system, are from a different source (i.e. different patients). Therefore, the PASI scores generated in Table 10 could not be used as reference for giving treatment to patient.

In order to give an accurate treatment to the patient with psoriasis lesion, the whole body of that patient has to be considered. The respective doctor should take pictures of the lesions from the patient overall body. Then each images should be tested under the system developed and generate the PASI score.

After, each of the images have been tested and obtained the scores, used equation 4.2 to obtain the overall score of the PASI. But equation 4.2 only represents the score for the scale severity. If the respective doctor want to evaluate all the three parameters of the psoriasis (i.e. thickness, redness, and scale), the doctor has to use equation 4.1.

The accurate generation of the PASI score will determine the accurate treatment to be given to the patient.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this project, an automated scoring system to determine the severity of scaliness of psoriasis lesion has been developed. From this image based system project, the level of scale for psoriasis lesion and the area covered by the lesion can be scored using the Image Processing Toolbox in MATLAB software. The generated results from the system will be used in the PASI scoring calculation which is the most widely used calculating system for psoriatic lesions.

The image processing applications used are for pre-processing (enhancement) and segmentation. Image enhancement is important to improve image quality which maybe negatively affected by factors of noise or inappropriate illumination. While segmentation is important to isolate object of interest from the background of the image, which is important in order to enable analysis. In this project, the techniques used are contrast stretching for image enhancement and K-Means clustering for image segmentation.

The system has been tested on 40 images and will continuously be tested on larger samples for accuracy purpose. The images are obtained from selected dermatologists' website and also from General Hospital Ipoh.

To further enhance reader's understanding on the imaging tasks done, a Graphical User Interface (GUI) is developed, which shows the applications of all tasks in the step-by-step flow.

For final conclusion, this project is able to achieve its main objectives in the specified time period.

5.2 Recommendation

Although the system developed has achieved its objectives, but more modifications and improvements are needed in ensuring the accuracy of the diagnostics. The system could be improved by proposed other method of image processing during pre-processing stage, which could give a better and accurate results especially in segmentation process.

Validation of the system is the major issue in this project. The automated psoriasis system generated must be verified against the evaluation done by several dermatologists. Hence, a collaboration work must be developed between the author and dermatologists.

The accuracy and reliability of the system can also be improved by using larger sets of psoriasis image databases. Other image processing methods should also be used and compare the results of psoriasis scoring.

Research on various techniques which related to skin disease could be conducted in order to develop a more flexible, faster and more user friendly system in the future. In this project, the system developed only is able to analyze the lesion after selecting the lesion image from segmentation stage. It is possible to have a system which can straight away scoring the severity level of the lesion after the image acquirement.

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APPENDICES

APPENDIX A
GANTT CHART

GANTT CHART for Final Year Project - 1st Semester (July 2006)

No.	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Selection of Project Topic - Assignment of the topics to students															
2	Preliminary Research Work - Introduction & Objective - List of references/literature - Project Planning															
3	Submission of Preliminary Report			•												
4	Project Work - Reference/Literature - Obtaining data - Obtaining information on image processing tools (MATLAB)															
5	Submission of Progress Report							•								
6	Project work continue - Processing images - Continue research															
7	Submission of Final Draft Report												•			
8	Submission of Interim Report															
9	Oral Presentation														•	•

Process
 Milestone

GANTT CHART for Final Year Project - 2nd Semester (January 2007)

No.	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Project Work Continue - Image Processing																				
2	Submission of Progress Report 1		•																		
3	Project Work Continue - Processing images																				
4	Submission of Progress Report 2							•													
5	Project work continue - Score skin lesion - Obtain the lesion area - Graphical User Interface																				
6	Submission of Draft Report																				
7	Submission of Dissertation Final Draft																				
8	Submission of Technical Report																				
9	Oral Presentation																				•
10	Submission of Project Dissertation																				•

■ Process
• Milestone

APPENDIX B
ORIGINAL IMAGES

IMAGE 1



IMAGE 2

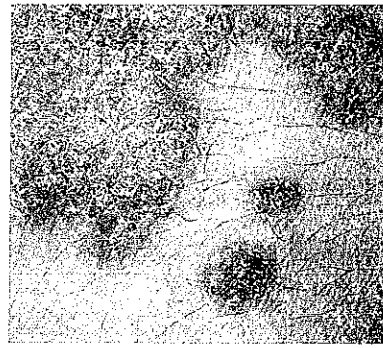


IMAGE 3

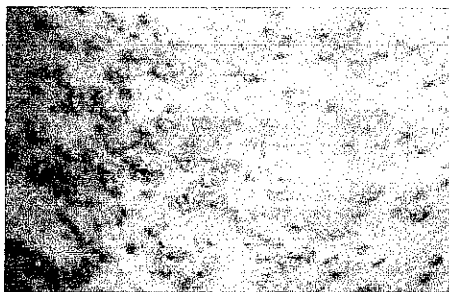


IMAGE 4

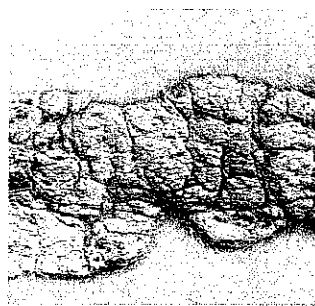


IMAGE 5

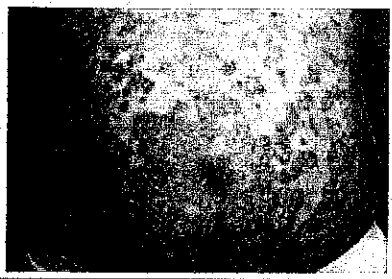


IMAGE 6

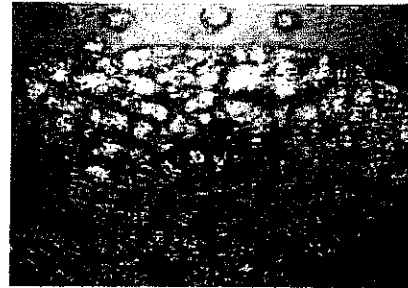


IMAGE 7



IMAGE 8

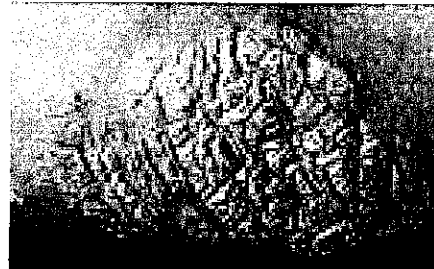


IMAGE 9



IMAGE 10

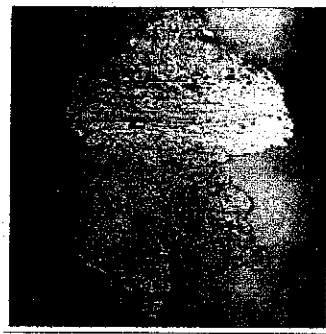


IMAGE 11



IMAGE 12



IMAGE 13



IMAGE 14

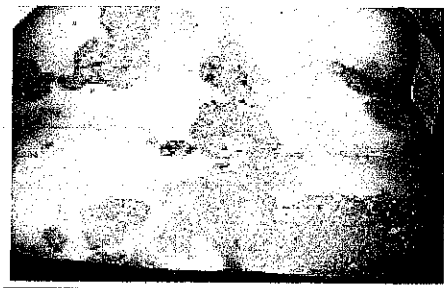


IMAGE 15

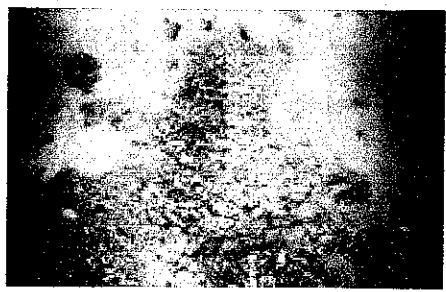


IMAGE 16



IMAGE 17

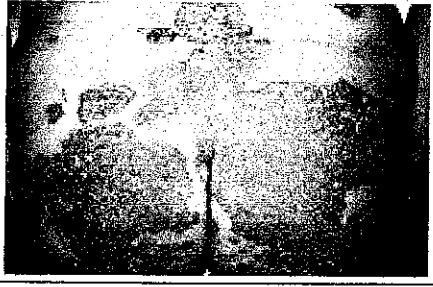


IMAGE 18



IMAGE 19



IMAGE 20



IMAGE 21

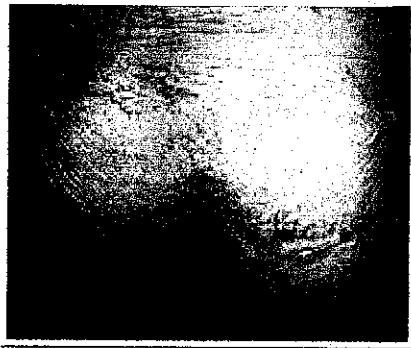


IMAGE 22



IMAGE 23



IMAGE 24

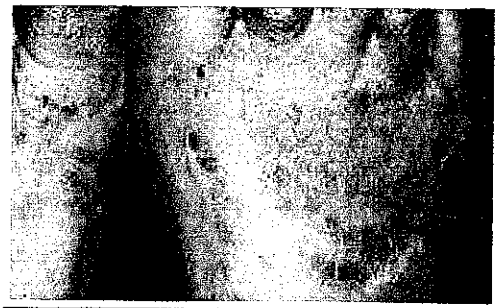


IMAGE 25



IMAGE 26

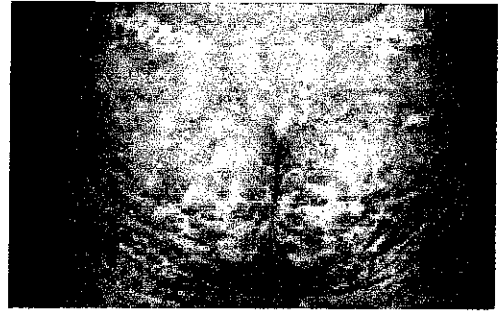


IMAGE 27

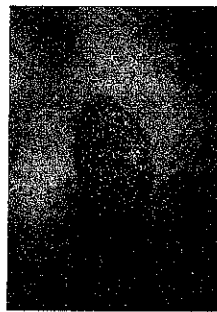


IMAGE 28



IMAGE 29

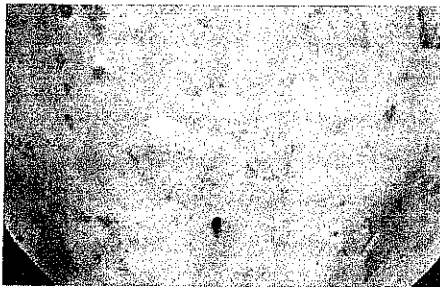


IMAGE 30

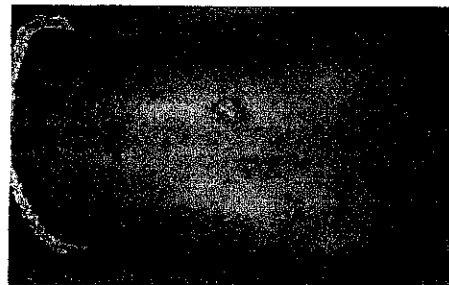


IMAGE 31

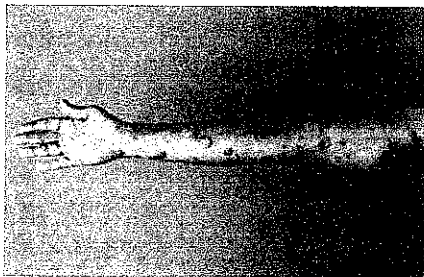


IMAGE 32

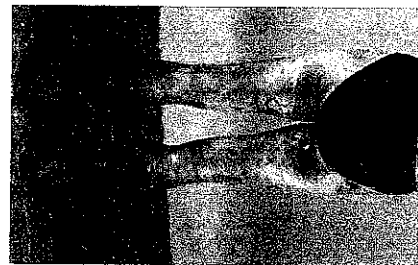


IMAGE 33



IMAGE 34

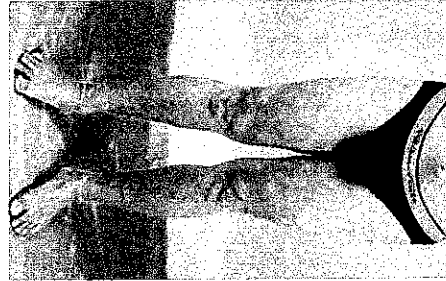


IMAGE 35

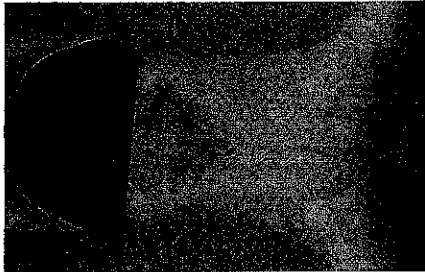


IMAGE 36

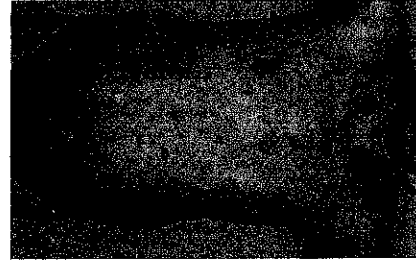


IMAGE 37

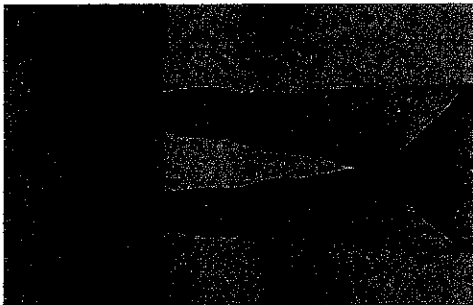


IMAGE 38

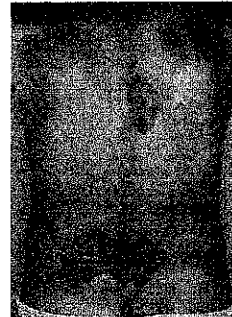


IMAGE 39

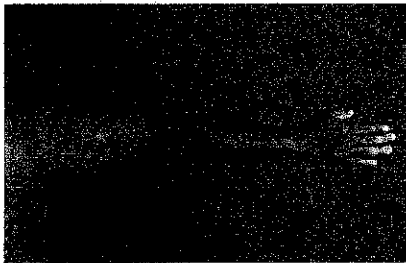
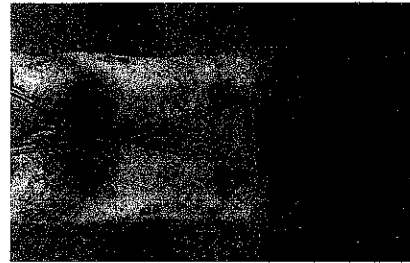


IMAGE 40



APPENDIX B
EXAMPLE OF PASI SCORING

Table 1. Sample Psoriasis Area and Severity Index (PASI) scoring sheet

Erythema/induration/scale Area percentage	PASI scoring system					
	0	1	2	3	4	5
None	None	Mild 1-9%	Moderate 10-29%	Severe 30-49%	Very severe 50-69%	-
PASI results: for each body area, record score for signs of psoriasis and area score. Half scores may be used for psoriasis signs (e.g. 2.5)						
	Head	Trunk	Lower limbs	Upper limbs		
Erythema	4	4	4	4		
Induration	4	4	4	4		
Scaling	4	4	4	4		
Sum	12	12	12	12		
Percentage involvement	10%	10%	10%	10%		
Area score	2	2	2	2		
Sum x area score	24	24	24	24		
x weighted average	0.1	0.3	0.4	0.2		
PASI score	2.4	7.2	9.6	4.8		
Total PASI score = sum of body area PASIs = 24		Total BSA involvement = 10%				

BSA, Body surface area.

APPENDIX D
COMMON QUESTIONS ON PSORIASIS LESIONS

About psoriasis Frequently asked questions

Posted on Nov. 18, 2004

These are answers to the questions most frequently asked of the National Psoriasis Foundation.

What is psoriasis?

Psoriasis is an immune-mediated, genetic disease manifesting in the skin and/or the joints. It affects more than 4.5 million people in the United States. In plaque psoriasis, the most common type, patches of skin called "lesions" become inflamed and are covered by silvery white scale. Psoriasis can be limited to a few lesions or can involve moderate to large areas of skin. The severity of psoriasis can vary from person to person; however, for most people, psoriasis tends to be mild.

Is psoriasis contagious?

No, psoriasis is not contagious. It is not something you can "catch" or "pass on." The psoriatic lesions may not look good, but they are not infections or open wounds. People with psoriasis pose no threat to the health or safety of others.

What causes psoriasis?

No one knows exactly what causes psoriasis, but it is believed to have a genetic component. Most researchers agree that the immune system is somehow mistakenly triggered, which speeds up the growth cycle of skin cells. A normal skin cell matures and falls off the body's surface in 28 to 30 days. But a psoriatic skin cell takes only three to four days to mature and move to the surface. Instead of falling off (shedding), the cells pile up and form the lesions.

How is psoriasis diagnosed?

No special blood tests or diagnostic tools exist to diagnose psoriasis. The physician or other health care provider usually examines the affected skin and decides if it is from psoriasis. Less often, the physician examines a piece of skin (biopsy) under the microscope.

Is there a cure for psoriasis?

There is no cure, but many different treatments, both topical (on the skin) and systemic (throughout the body), can clear psoriasis for periods of time. People often need to try out different treatments before they find one that works for them.

What treatments are the best for me?

The unpredictable nature of psoriasis makes treatment challenging for many people. A wide range of treatments is available. No single psoriasis treatment works for everyone, but something will work for most people. It is hard to predict what will work for a particular individual; however, it is important to be open-minded and willing to work with your doctor to find a treatment that will work for you.

Is all psoriasis alike?

No. There are various forms of psoriasis. Plaque psoriasis is the most common. Other forms are:

- Guttate [GUH-tate], characterized by small dot-like lesions
- Pustular [PUHS-choo-ler], characterized by weeping lesions and intense scaling
- Inverse, characterized by intense inflammation
- Erythrodermic [eh-REETH-ro-der-mik], characterized by intense shedding and redness of the skin

Psoriasis can range from mild to moderate to very severe and disabling.

Can psoriasis affect all parts of the body?

Psoriasis most commonly appears on the scalp, knees, elbows and torso. But psoriasis can develop anywhere, including the nails, palms, soles, genitals and face (which is rare). Often the lesions appear symmetrically, which means in the same place on the right and left sides of the body.

Can psoriasis occur at any age?

Psoriasis often appears between the ages of 15 and 35, but it can develop at any age. Approximately 10 percent to 15 percent of those with psoriasis get it before age 10. Some

infants have psoriasis, although this is considered rare.

Is psoriasis more prevalent in men or women, or in different ethnic groups?

Psoriasis occurs nearly equally in men and women across all socioeconomic groups. It is also present in all racial groups, but in varying rates.

What health complications are associated with psoriasis?

The skin, the largest organ in the body, plays an important role. It controls body temperature and serves as a barrier to infection. Large areas of psoriasis can lead to infection, fluid loss and poor blood flow (circulation).

Is psoriasis linked to other diseases?

Psoriatic arthritis is a specific type of arthritis that has been diagnosed in approximately 23 percent of people who have psoriasis, according to the Psoriasis Foundation's 2001 Benchmark Survey. Psoriatic arthritis is similar to rheumatoid arthritis but generally milder. In psoriatic arthritis, the joints and the soft tissue around them become inflamed and stiff. Psoriatic arthritis can affect the fingers and toes and may involve the neck, lower back, knees and ankles. In severe cases, psoriatic arthritis can be disabling and cause irreversible damage to joints.

If I have psoriasis does that mean I will develop psoriatic arthritis?

Approximately 10 percent to 30 percent of people with psoriasis will develop psoriatic arthritis, although it often may go undiagnosed, particularly in its milder forms. It can develop at any time, but for most people it appears between the ages of 30 and 50. Having psoriasis does not guarantee that you will eventually develop psoriatic arthritis.

How severe can my psoriasis become?

Psoriasis can be mild, moderate or severe. Three percent to 10 percent of the body affected by psoriasis is considered to be a moderate case. More than 10 percent is considered severe. The palm of the hand equals 1 percent of the skin. However, the severity of psoriasis is also measured by how psoriasis affects a person's quality of life.

Psoriasis can have a serious impact even if it involves a small area, such as the palms of the hands or soles of the feet.

What are psoriasis triggers?

Triggers can include emotional stress, injury to the skin, some types of infection and reactions to certain drugs. Stress can cause psoriasis to flare for the first time or aggravate existing psoriasis. Psoriasis can also be triggered in areas of the skin that have been injured or traumatized. This is known as the "Koebner phenomenon." Vaccinations, sunburns and scratches can all trigger a Koebner response. The Koebner response can be treated if it is caught early enough. Certain medications, like antimalarial drugs, lithium and certain beta-blockers, are also known to cause people's psoriasis to flare. Other triggers may include weather, diet and allergies. Triggers will vary from person to person and what may cause one person's psoriasis to flare may produce no reaction in another individual.

Why does my psoriasis itch, and how do I control the itching?

Itching that is associated with psoriasis arises when certain chemicals stimulate nerve fibers just below the outer layer of the skin. Itch messages travel to the brain along the same pathways in the nervous system that carry pain messages. Itch messages trigger the urge to scratch.

One of the simplest ways for people with psoriasis to control itch is by keeping the skin moisturized. Dry skin can induce and aggravate itch. Many people also rely on simple, inexpensive measures, such as pressing a wet towel against the itchy spot. Others find cold showers and cold packs offer relief. Other treatments for itch include antihistamines, steroids, capsaicin, topical anesthetics, topical immunomodulators, antidepressants and aspirin.

Will having psoriasis affect my lifestyle or quality of life?

For the most part, people with psoriasis function normally. Sometimes people experience low self-esteem because of the psoriasis. Psoriasis is often misunderstood by the public, which can make social interactions difficult. This may lead to emotional reactions such as anxiety, anger, embarrassment and depression. Psoriasis can affect the type of work people do if it is visible.

What is the financial impact of psoriasis?

Psoriasis is a chronic (life-long) illness. Most people need ongoing treatments and visits to the doctor. In severe cases, people may need to be hospitalized. About 56 million hours of work are lost each year by people who suffer from psoriasis, and between \$1.6 billion and \$3.2 billion is spent per year to treat psoriasis.

Is there hope for a cure?

Yes. Researchers are studying psoriasis more than ever before. They understand much more about its genetic causes and how it involves the immune system. The National Psoriasis Foundation and the federal government are promoting and funding research to find the cause and cure for psoriasis.

APPENDIX E
SOURCE CODE

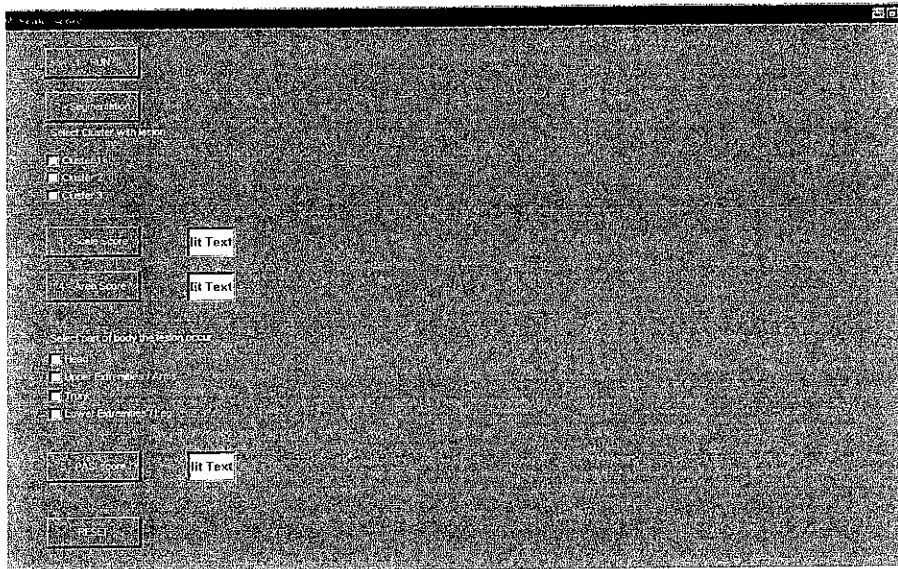


Figure A: The layout of GUI

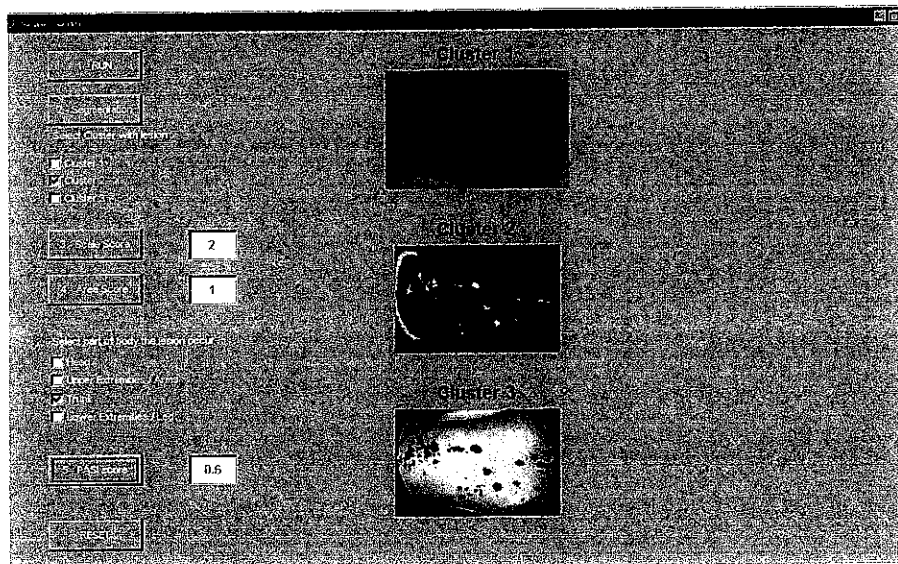


Figure B: The score of PASI obtained

Dear Project

ated scoring for scaliness of psoriasis lesions using Cluster
station"

otion
rogram will develop a scoring system for scaliness of psoriasis lesion.
ring will be based on the PASI score which will be classified accordingly.
em also is capable of classifying the level of severity of skin
; and retrieving the similar images stored in a skin database.

ght 2006/07

rah Nordin

```
varargout = Scale_score(varargin)
SCORE M-file for Scale_score.fig
SCALE_SCORE, by itself, creates a new SCALE_SCORE or raises the existing
singleton*.
```

```
l = SCALE_SCORE returns the handle to a new SCALE_SCORE or the handle to
the existing singleton*.
```

```
SCALE_SCORE('CALLBACK', hObject, eventData, handles,...) calls the local
function named CALLBACK in SCALE_SCORE.M with the given input arguments.
```

```
SCALE_SCORE('Property','Value',...) creates a new SCALE_SCORE or raises the
existing singleton*. Starting from the left, property value pairs are
applied to the GUI before Scale_score_OpeningFunction gets called. An
unrecognized property name or invalid value makes property application
stop. All inputs are passed to Scale_score_OpeningFcn via varargin.
```

See GUI Options on GUIDE's Tools menu. Choose "GUI allows only one
instance to run (singleton)".

so: GUIDE, GUIDATA, GUIHANDLES

ght 2002-2003 The MathWorks, Inc.

he above text to modify the response to help Scale_score

odified by GUIDE v2.5 05-Jun-2007 13:28:51

initialization code - DO NOT EDIT

```
leton = 1;
e = struct('gui_Name',      mfilename, ...
          'gui_Singleton', gui_Singleton, ...
          'gui_OpeningFcn', @Scale_score_OpeningFcn, ...
          'gui_OutputFcn', @Scale_score_OutputFcn, ...
          'gui_LayoutFcn', [], ...
          'gui_Callback',  []);
```

```
n && ischar(varargin{1})
State.gui_Callback = str2func(varargin{1});
```

ut

```
argout{1:nargout}} = gui_mainfcn(gui_State, varargin{:});
```

```
mainfcn(gui_State, varargin{:});
```

```
Initialization code - DO NOT EDIT
```

```
executes just before Scale_score is made visible.
```

```
Scale_score_OpeningFcn(hObject, eventdata, handles, varargin)  
function has no output args, see OutputFcn.
```

```
hObject handle to figure
```

```
 GUIDATA reserved - to be defined in a future version of MATLAB
```

```
 GUIDATA structure with handles and user data (see GUIDATA)
```

```
 varargin command line arguments to Scale_score (see VARARGIN)
```

```
Default command line output for Scale_score
```

```
output = hObject;
```

```
handles structure
```

```
hObject, handles);
```

```
makes Scale_score wait for user response (see UIRESUME)
```

```
(handles.figure1);
```

```
Inputs from this function are returned to the command line.
```

```
varargout = Scale_score_OutputFcn(hObject, eventdata, handles)
```

```
function cell array for returning output args (see VARARGOUT);
```

```
hObject handle to figure
```

```
 GUIDATA reserved - to be defined in a future version of MATLAB
```

```
 GUIDATA structure with handles and user data (see GUIDATA)
```

```
Default command line output from handles structure
```

```
argout{1} = handles.output;
```

```
*****
```

```
ORIGINAL IMAGE
```

```
*****
```

```
executes on button press in run.
```

```
run_Callback(hObject, eventdata, handles)
```

```
hObject handle to run (see GCBO)
```

```
 GUIDATA reserved - to be defined in a future version of MATLAB
```

```
 GUIDATA structure with handles and user data (see GUIDATA)
```

```
Opens image from graphics file
```

```
[filename, pathname] = uigetfile( ...
```

```
'*.jpg', 'JPEG image (*.jpg)';
```

```
'*.gif', 'GIF image (*.gif)'; ...
```

```
'*.bmp', 'BMP image (*.bmp)'; ...
```

```
'*.*', 'All Files (*.*)'}, ...
```

```
'Pick a file');
```

```
filename = [filename];
```

```
img = imread(filename);
```

```
Shows the original image
```

```
subplot(2,1,1), imshow(x), title('Original Image', 'fontSize', 15, ...
```

```

'fontweight', 'bold', 'Color', 'b');

page chose
metricdata.x = x;
(hObject,handles);

*****
ENHANCEMENT
*****
recutes on button press in segment.
segment_Callback(hObject, eventdata, handles)
t handle to segment (see GCBO)
ata reserved - to be defined in a future version of MATLAB
s structure with handles and user data (see GUIDATA)

e saved image
les.metricdata.x;

the image intensity using contrast stretchng
e1 = imadjust(X,stretchlim(X),[]);

*****
SEGMENTATION
*****
color transformation structure
makecform('srgb2lab');

olor transformation structure
applycform(img_enhcel,cform);
contrast(img_enhcel);
ple(lab_p(:,:,2:3)); %convert image into double precision
size(ab,1); %size of array
size(ab,2); %size of array
ape(ab,nrows*ncols,2); %change the image size
= 3; %number of clusters

the cluster 3 times
_idx cluster_center] = kmeans(ab,nSegment,'distance',...
iclidean', 'Replicates',3);
vels = reshape(cluster_idx,nrows,ncols);
l_images = cell(1,3);
= repmat(pixel_labels,[1 1 3]);

c = 1:nSegment
cale = img_enhcel;
cale(rgb_label ~= k) = 0;
egmented_images {k} = scale;

,1,1), imshow(segmented_images{1}), title ('Cluster 1',...
',15,'fontweight','bold','Color','r');
,1,2), imshow(segmented_images{2}), title ('Cluster 2',...
',15,'fontweight','bold','Color','r');
,1,3), imshow(segmented_images{3}), title ('Cluster 3',...
',15,'fontweight','bold','Color','r');

= segmented_images{1};
= segmented_images{2};

```



```
3 = segmented_images{3};
```

images according to cluster

```
.metricdata.cluster1 = cluster1;
```

```
.metricdata.cluster2 = cluster2;
```

```
.metricdata.cluster3 = cluster3;
```

```
(hObject,handles);
```

```
*****
```

```
ANALYSIS
```

```
*****
```

```
ITERATE SCORE FOR SCALINESS*****
```

executes on button press in cluster1.

```
cluster1_Callback(hObject, eventdata, handles)
```

```
% handle to cluster1 (see GCBO)
```

```
% data reserved - to be defined in a future version of MATLAB
```

```
% s structure with handles and user data (see GUIDATA)
```

```
get(hObject,'Value') returns toggle state of cluster1
```

```
handles.metricdata.cluster1;
```

```
image
```

```
(3,1,1), imshow(scale);
```

display lesion image

```
metricdata.lesion = scale;
```

```
imshow(hObject,handles);
```

executes on button press in cluster2.

```
cluster2_Callback(hObject, eventdata, handles)
```

```
% handle to cluster2 (see GCBO)
```

```
% data reserved - to be defined in a future version of MATLAB
```

```
% s structure with handles and user data (see GUIDATA)
```

```
get(hObject,'Value') returns toggle state of cluster2
```

```
handles.metricdata.cluster2;
```

```
image
```

```
(3,1,1), imshow(scale);
```

display lesion image

```
metricdata.lesion = scale;
```

```
imshow(hObject,handles);
```

executes on button press in cluster3.

```
cluster3_Callback(hObject, eventdata, handles)
```

```
% handle to cluster3 (see GCBO)
```

```
% data reserved - to be defined in a future version of MATLAB
```

```
% s structure with handles and user data (see GUIDATA)
```

```
get(hObject,'Value') returns toggle state of cluster3
```

```
handles.metricdata.cluster3;
```

```

image
[3,1,1), imshow(scale);

% lesion image
metricdata.lesion = scale;
(hObject,handles);

-----
-----

% updates on button press in scale_score.
scale_score_Callback(hObject, eventdata, handles)
% handle to scale_score (see GCBO)
% data reserved - to be defined in a future version of MATLAB
% structure with handles and user data (see GUIDATA)

% saved lesion image
handles.metricdata.lesion;

% rgb2gray(image); %convert image into greyscale
% lesion)
% the lesion severity from histogram
% imhist(lesion);
% ); %identify the size of the image
% e(lesion,'canny' );
% dial('unsharp');
% imt2(h,lesion,bw); %filter region of interest
% ea(J); %total pixel of the lesion image
% 5); %set range of intensity

% the mean of the image
% = N;
% = M;
% [N/M];
% = b*p;

% reference value of 5 scores
171.8154; %reference value for score 0
166.5227; %reference value for score 1
134.7151; %reference value for score 2
129.0788; %reference value for score 3
98.8714; %reference value for score 4

% threshold value
(v0+v1)/2; %169.16905
(v1+v2)/2; %150.6189
(v2+v3)/2; %131.89695
(v3+v4)/2; %113.9751

% the scale score
mean >= T1)
scale_score = 0;
set(handles.score1,'string','0');
if (mean < T1 && mean >= T2)
    scale_score = 1;
    set(handles.score1,'string','1');
else if (mean < T2 && mean >= T3)
    scale_score = 2;
    set(handles.score1,'string','2');
else if (mean < T3 && mean >= T4)

```

```

        scale_score = 3;
        set(handles.score1,'string','3');
    else if (mean < T4)
        scale_score = 4;
        set(handles.score1,'string','4');
    end
end
end
end

e score for scale
metricdata.scale_score = scale_score;
hObject,handles);

-----
-----

GENERATE SCORE FOR THE LESION AREA*****
ecutes on button press in area_score.
    area_score_Callback(hObject, eventdata, handles)
t    handle to area_score (see GCBO)
ata reserved - to be defined in a future version of MATLAB
s    structure with handles and user data (see GUIDATA)

e saved lesion image
= handles.metricdata.lesion;

    rgb2gray(image_2); %convert image into greyscale
    the lesion severity from histogram
    imhist(lesion);
0); %identify the size of the image
e(lesion,'canny');
cial('unsharp');
ilt2(h,lesion,bw); %filter region of interest
bwarea(J); %total pixel of the lesion image
icolor(lesion,20,120);
wmorph(BW,'close');
    bwarea(bw2);
336 * 223;
ion = total/image; %in terms of pixels
= area_lesion * 100;

area score
_lesion == 0)
area_score = 0;
set(handles.score2,'string','0');
    if (area_lesion > 0 && area_lesion <= 10)
        area_score = 1;
        set(handles.score2,'string','1');
    else if (area_lesion > 10 && area_lesion <= 30)
        area_score = 2;
        set(handles.score2,'string','2');
    else if (area_lesion > 30 && area_lesion <= 50)
        area_score = 3;
        set(handles.score2,'string','3');
    else if (area_lesion > 50 && area_lesion <= 70)
        area_score = 4;
        set(handles.score2,'string','4');
    else if (area_lesion > 70 && area_lesion <= 90)

```



```
score = 0.3 * handles.metricdata.scale_score * handles.metricdata.area_score;
handles.metricdata.pasi_score = pasi_score;
set(handles,handles);
```

Executes on button press in leg.

```
function leg_Callback(hObject, eventdata, handles)
% hObject handle to leg (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)
```

```
get(hObject,'Value') returns toggle state of leg
```

Update and save the pasi score

```
score = 0.4 * handles.metricdata.scale_score * handles.metricdata.area_score;
handles.metricdata.pasi_score = pasi_score;
set(handles,handles);
```

Executes on button press in PASI.

```
function PASI_Callback(hObject, eventdata, handles)
% hObject handle to PASI (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)
```

Update the pasi score

```
handles.score3 = handles.metricdata.pasi_score;
set(handles.score3,'string',pasi_score);
```

Executes on button press in reset.

```
function reset_Callback(hObject, eventdata, handles)
% hObject handle to reset (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)
```

```
set(handles,handles,true);
```

```
function initialize_gui(fig_handle,handles,isreset)
```

metricdata field is present and the reset flag is false, it means just re-initializing a GUI by calling it from the cmd line while running. So, bail out as we do not want to reset the data

```
if (isfield(handles,'metricdata') && ~isreset)
return;
end
```

```
handles.score1,'string','');
handles.score2,'string','');
handles.score3,'string','');
```