



RECOGNITION OF PSORIASIS FEATURES VIA DAUBECHIES D8 WAVELET TECHNIQUE

H. Hashim¹, S. Ramli¹, N. Wahid², M. S. Sulaiman², N. Hassan²

Faculty of Electrical Engineering

¹Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

²Universiti Teknologi MARA Terengganu, 23000 Dungun, Terengganu, Malaysia.

Emails: hadzli120@salam.uitm.edu.my, nurbaiti@tganu.uitm.edu.my,
suhaimisulaiman_2003@yahoo.com, nurhaffizah@tganu.uitm.edu.my,

Submitted: Jan. 15, 2013

Accepted: Mar. 28, 2013

Published: Apr. 10, 2013

Abstract- This paper presents a study in an efficient methodology for analysis and characterization of digital images psoriasis lesions using Daubechies D8 wavelet technique. The methodology is based on the transformation of 2D Discrete Wavelet Transform (DWT) algorithm for Daubechies D8 at first level to obtain the coefficients of the approximations and details sub-images. For classification method, statistical approach analysis is applied to identify significance difference between each groups of psoriasis in terms of mean and standard deviation parameter. Results performances are concluded by observing the error plots with 95% confidence interval and applied independent T-test. The test outcomes have shown that approximate mean and standard deviation parameter can be used to distinctively classify erythroderma from the other groups in consistent with visual observations of the

error plots. Whilst, in order to discriminate guttate from the other groups, standard deviation parameters for horizontal, vertical and diagonal can be utilized. Based on the results, plaque is distinguishable with guttate and erythroderma by using standard deviation vertical sub-images parameter. Results of Daubechies D8 is compared with study done previously by using Daubechies D4 and Daubechies D12 in order to observe the reliability of the results in Daubechies families. The resultant parameters can be used to design computer-aided system in diagnosis the skin lesion of psoriasis.

Index terms: Discrete Wavelet Transform (DWT), DWT algorithm, doubechies, t-test, psoriasis, plaque, guttate, erythroderma

I. INTRODUCTION

Dermatologists have based the diagnosis of skin lesions on the visual assessment of pathological skin and the evaluation of microscopic features. Therefore, the diagnosis has been highly dependent on the observer's experience and on his visual acuity. However, the human vision lacks accuracy, reproducibility and quantification in gathering information from an image thus, systems that are able to evaluate images in objective manner are obviously needed [1]. There are many people who suffer because of many various types of skin diseases [2], [3], [4], [5] and [6]. Psoriasis is an inflammatory skin disorder with a strong genetic basis [7]. The psoriasis lesions are distinctive. They can conveniently be distinguished from the ordinary normal skin. Psoriasis begin as red scaling papules that coalesce to form the round to oval plaques. The diagnosis of psoriasis is usually apparent clinically but sometimes it may resemble other skin disorders in a typical cases, such as lichen simplex chronicus, nummular eczema, seborrheic dermatitis and tinea corporis. The extent and duration of the disease is highly variable from patient to patient. Acute flares or relapses of plaque psoriasis may also evolve into more severe disease, such as pustular or erythrodermic psoriasis [8].

Psoriasis cannot be cured, nevertheless, there are treatments available to help control the disease [9]. Dermatologist will monitor the extent of psoriasis continuously during treatment to ascertain the treatment efficacy [10]. Recently, there is an analyzing image technique that has been proposed for classifying the features of psoriasis. Several clinical psoriasis lesion groups [11], were been studied for digital RGB colors features extraction. Plaque lesion was experimented

with other types of psoriasis. Quantification of data images through the normal/direct and differential of the reflectance method was considered. The statistical tests outcomes had shown that the component for conventional differential method could be distinctively classify plaque from the other groups. This method produced some promising results, but only for discriminating plaque lesion with the other groups of psoriasis.

Initial work on identification of psoriasis features by using Wavelet as the main analyzing tool was done by Zafran [12]. Coefficient parameters of plaque were compared with guttate and erythroderma, where they are represented in terms of error plots. The coefficient of the approximation, detail sub-images and images of the lesions are transforms using two dimensional (2D) Discrete Wavelete Transform (DWT) Daubechies D4 algorithm at first level. Nidhal *et al* [8] developed and tested a skin diagnosis system used for diagnosis of psoriasis skin disease. The system used to evaluate the ability of the proposed skin texture recognition algorithm to discriminate between healthy and infected skin. Feed-forward and neural networks is used to classify input images for psoriasis infected or non psoriasis infected. The neural network training give the encouraging results in generalization face.

In [13] a multiresolution-resolution based signature subspace classifier (MSSC) for the segmentation of color images to psoriasis images has been proposed. The fuzzy texture spectrum and two-dimensional fuzzy color histogram are adopted to locate homogeneous regions in the image. From the research, the proposed algorithm can effectively segment psoriasis image. Meriem *et al* [14] used discrete wavelet for multifractal characterization of skin cancer in ultrasound image. The proposed method establishes a multifractal analysis framework based on a new multiresolution indicator, called the maximum wavelet coefficient. Guyot [15] studied the mathematical correlation between a fractional Brownian motion and speckle patterns, in optical imaging and used successfully the diffusion equation to characterize skin psoriasis infections.

Meanwhile, according to [16] 3D imaging method has been proposed to assess Psoriasis Area Severity Index scaliness parameter of psoriasis lesions. The polynomial surface fitting is applied to the lesion surface to extract the estimated waviness from the actual lesion surface. Surface roughness is measured and the algorithm has been validated against 328 lesion models on a medical mannequin. The result shows that the proposed algorithm giving an accuracy of 89.30%. Since psoriasis is a chronic disease [13], it is important to track the condition of the patient to select a proper treatment. This paper proposed to further extend the studies on wavelet as an

analyzing tool in recognition of psoriasis features by using Daubechies D8 wavelet technique at level one. Coefficients parameters for psoriasis are compared with each other in terms of mean and standard deviation. The results performances are concluded by observing the error plots with 95% confidence interval and outcomes of the independent t-test applied. Then, the results is compared with study done previously by using Daubechies D4 and D12 wavelet technique.

II. BACKGROUND OF WAVELET

Wavelet analysis is a method of analyzing visual data by taking into account scale information, allowing the exploration of texture on different scales [17]. The wavelet analysis procedure, called as analyzing wavelet or mother wavelet is used to adopt a wavelet prototype function [18]. The wavelet transform converts the image array into a series of wavelet coefficient, each of which represents information at a particular location within the array and for a particular spatial scale. To span the data domain at different resolutions, the analyzing wavelet is used in a scaling function.

$$W(x) = \sum_{k=-1}^{N-2} (-1)^k c_{k+1} \Phi(2x+k) \quad (1)$$

where $W(x)$ is the scaling function for the mother function $\Phi(x)$, and c_k are the wavelet coefficients. The relationship between spatial and frequency domain is expressed with basic functions.

$$\Phi_{(s,l)}(x) = 2^{1/2} \Phi(2^{-s} x - l) \quad (2)$$

The variables s and l are integers that scale and dilate the mother function $\Phi(x)$ to generate wavelets. The scale index s indicates the wavelet's width and the location index l gives its position. By scanning a function (or signal) with the translated and dilated wavelet functions, the function can be decomposed in its frequency parts, represented by the coefficient, c_k . The discrete wavelet transformation can be realized as matrix operation (WT)

$$C = WT (B) \quad (3)$$

By applying the inverse wavelet transformation, starting from a low level (coefficients in the low-frequency band) and moving to higher levels, recursively new information is introduced at each level and more details are added stepwise to the image. A wavelet transform of an image

generates four sub-image with a quarter area, one approximation image and three details image consist of horizontal, vertical, and diagonal details [17]. Figure 1 shows the transformation of the image into the sub-images. Approximation image is the sub-image compose of the low frequency parts in both row and column directions (LL), and details images are the remaining three images, containing high frequency components (LH, HL, and HH).

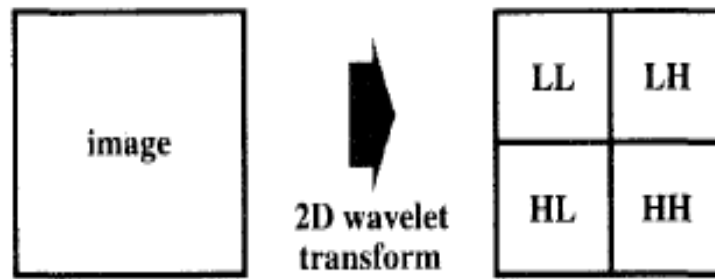


Figure 1. Transformation of the image into sub-images.

The inverse transformation is simply the transpose of the transform (WT^{-1}),

$$B = WT^{-1}(C) \quad (4)$$

where $C = (c(i,j))$ is the coefficient matrix and $B = (b(i,j))$ is the image matrix. In image analysis, it is usual to describe the wavelet transform as convolution of the image with a filter bank. The matrix structure is then determined by the wavelet filter coefficients, which are ordered using two dominant patterns that work as a smoothing filter and to bring out the data detail information. Therefore, a data vector is decomposed into parts containing smooth information and parts with detail information. Wavelet filters of the Daubechies class are often used in medical image processing, especially for image compression [19].

III. METHODOLOGY

a. Clinical data

The RGB color images were acquired using FinePix 6900 Zoom (Fujifilm) digital camera, with pixel resolution 1280 x 960. It was placed at a distance of one foot directly above the patient's skin. The light intensity was controlled by a standard low flash with default timing. Three sets of 30 major psoriasis images representing plaque, guttate and erythroderma group was used for this study. These images and their respected clinical evaluation were obtained from two local

hospitals in Malaysia which are Universiti Kebangsaan Malaysia Medical Centre (HUKM) and Melaka General Hospital (HM). Psoriasis patients involved in this work were initially identified through their medical records or clinically diagnosed by dermatologists at the clinic.

b. Pre-processing

Initially, 30 samples of psoriasis image through a pre-processing to prepared the images for further analysis. Once the area that includes normal skin and three samples of lesions were recognized the area were cropped out. During the pre-processing, 30 images of psoriasis were selected for each individual group. Then these images were crops at 64×64 pixels dimension inside the affected area of skin. After images were cropped, then it was catalogued and stored. The cropping was done at the effected region without considering the border or edge. This is due to the idea that the affected area will convey exact information about the psoriasis. Other information such as hair follicle and blood vessels will be considered as a noise to the images.

c. Processing

The test has been applied based on the 3 different groups of psoriasis which are plaque, guttate and erythroderma. From the test applied, it shows that different group of psoriasis is distinctively different from each others with a wavelet technique. The procedures is begin by decompose the image with Daubechies D8 (Level 1) DWT to obtain the coefficient of the approximation and details. The details coefficient can be described as a horizontal, vertical and diagonal coefficient. This coefficient was stored and transferred into the SPSS in-order to obtain the statistical measurement. The statistical data used are the mean coefficients value and standard deviation value. Thus, these means and standard deviations of the coefficient individually were plotted in form of error plots. A T-test was applied in order to find equality between the groups of psoriasis. The null hypothesis and the T-test used are shown below.

Null hypothesis, H_0 :

$$\mu_y - \mu_z = 0 \quad (5)$$

Alternative hypothesis, H_1 :

$$\mu_y - \mu_z \neq 0 \quad (6)$$

Sample variance:

$$s_p^2 = s_y^2 = s_z^2 \quad (7)$$

Sample standard error:

$$SE = \sqrt{s_p^2 \left(\frac{1}{n_y} + \frac{1}{n_z} \right)} \quad (8)$$

Test statistic:

$$t = \frac{(\bar{y} - \bar{z}) - (\mu_y - \mu_z)}{SE} \quad (9)$$

Interval estimator:

$$(\bar{y} - \bar{z}) \pm t_{\alpha/2, df} SE \quad (10)$$

where \bar{y}, \bar{z} is the sample mean

μ_y, μ_z is the population mean

$df = n_y + n_z - 1$ is the degrees of freedom

In order to distinguish a significant difference on plaque, guttate and erythoderma, the mean and standard deviation of coefficients is used in this differentiation because the value of coefficient from wavelet transform is represented by a real data [20]. The flow of the process for analyzing of the images is shown in Figure 1.

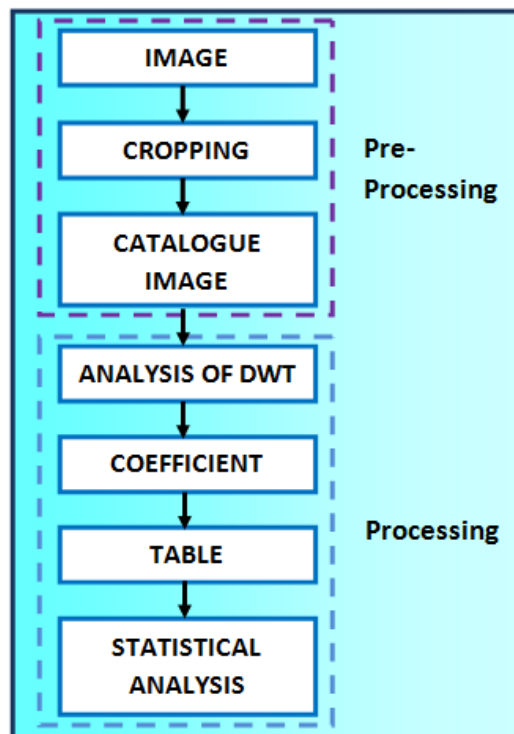


Figure 2. Flow process of method with wavelet and statistic

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The original psoriasis image of 64x64 pixels have been transformed into coefficient bases by using multistep decomposition and reconstruction of Daubechies D8 wavelet technique at level 1. This process yields 6084 coefficients, which represent approximation coefficients and details sub-images coefficients including horizontal, vertical, and diagonal. The coefficients can be visualized into 3D surfaces. By observation, different types of psoriasis will produce different types of 3D surfaces as illustrated in Figure 3, Figure 4 and Figure 5 respectively. In this work, two methods is used to produce the results and analysis, which are error plot and t-test.

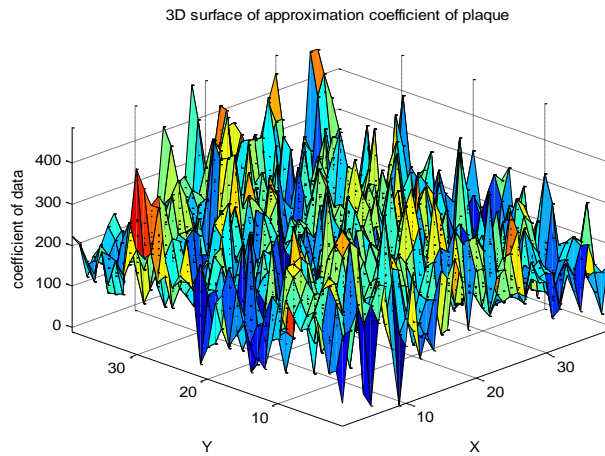


Figure 3. Coefficient for plaque in approximate sub-image

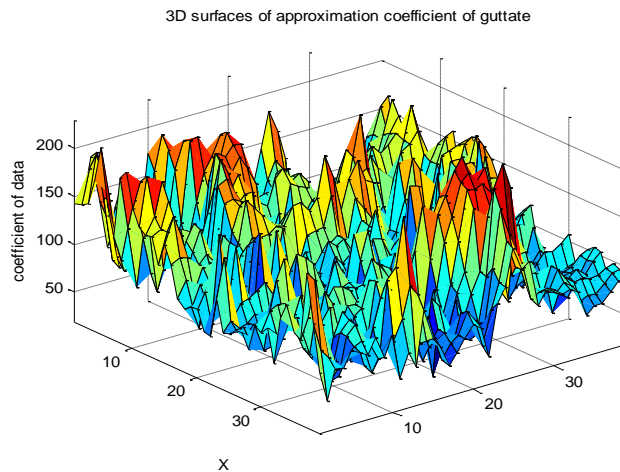


Figure 4. Coefficient for guttate in approximate sub-image

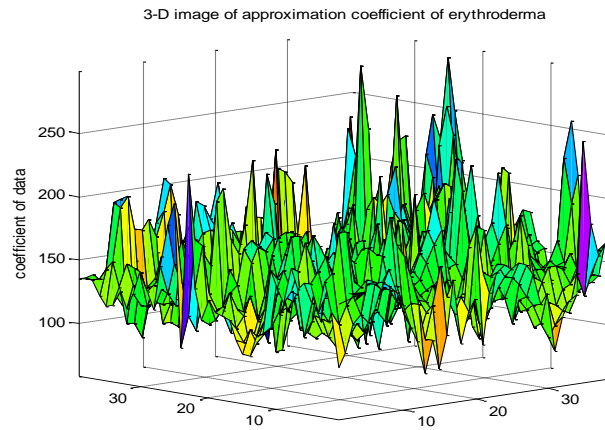


Figure 5. Coefficient for erythroderma in approximate sub-image

a. Error plot

In order to recognize the features between three groups of psoriasis, error plot was utilized as a first method of analysis. Error plot provides a range of values based on the sample mean and standard deviation.

a.i Approximation coefficients

Figure 6 and 7 shows the error plots for means and standard deviation of the approximation coefficients value. In approximation coefficient value for mean, erythroderma can be discriminated with guttate and plaque. However, plaque does not have distinct difference with guttate since its region falls in the same range of plaque. The same condition goes for standard deviation plot, which shows that erythroderma can be distinctively distinguished with guttate and plaque but guttate and plaque cannot be classify between each other.

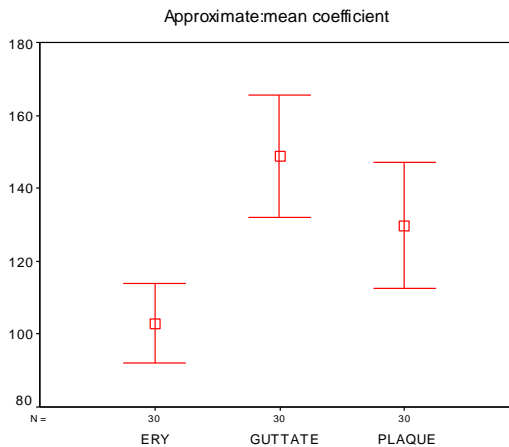


Figure 6. Error plot of mean coefficient for approximation sub-image

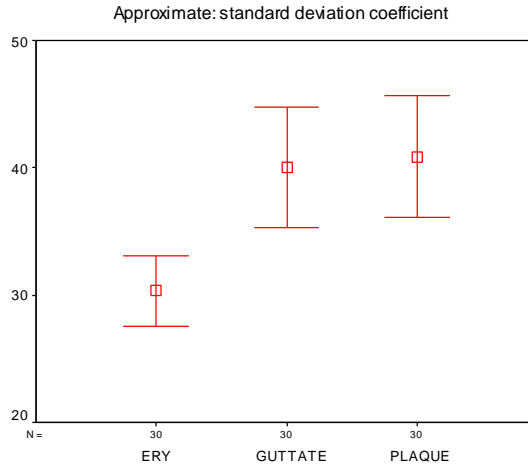


Figure 7. Error plot of standard deviation for approximation sub-image

a.ii Horizontal Coefficients

Figure 8 and 9 indicates the results of the horizontal coefficients value in term of mean and standard deviation. None of the lesions can be distinguished clearly in the horizontal mean plot coefficients because their ranges of regions were overlapped between each other. For standard deviation, it clearly shows that guttate can be differentiated with plaque and erythroderma. Nevertheless, plaque does not have distinct difference with guttate.

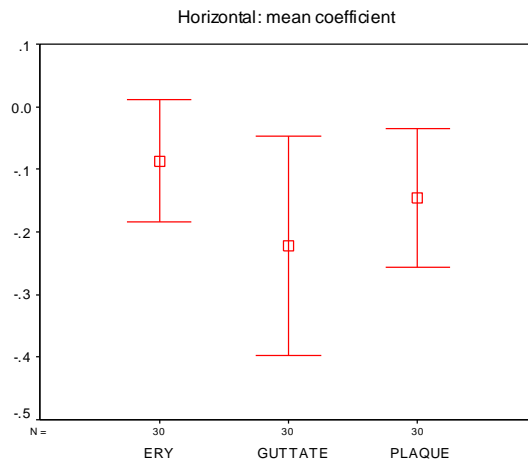


Figure 8. Error plot of mean coefficient for horizontal sub-image

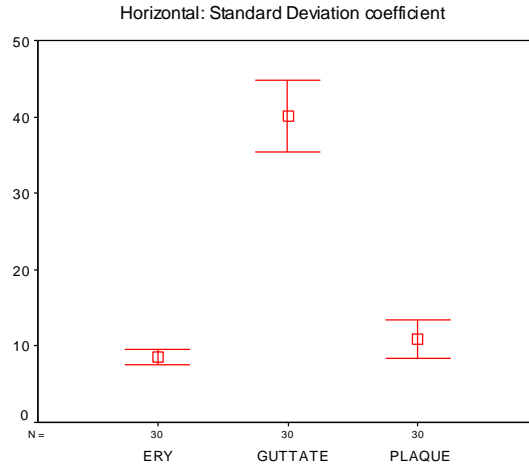


Figure 9. Error plot of standard deviation for horizontal sub-image

a.iii Vertical Coefficients

Mean and standard deviation plots of the vertical coefficients of three groups psoriasis is depicted in Figure 10 and Figure 11. In vertical coefficients, mean plot shows that both of the psoriasis unable to recognize because they fall in the same range of region. However, from Figure 11, standard deviation plot indicates that erythroderma can be distinguished with guttate, but it is not clearly discriminates itself with plaque. There is no distinct difference between guttate and plaque.

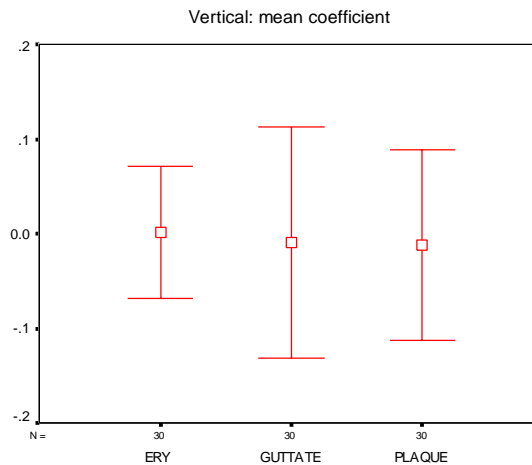


Figure 10: Error plot of mean coefficient for vertical sub-image

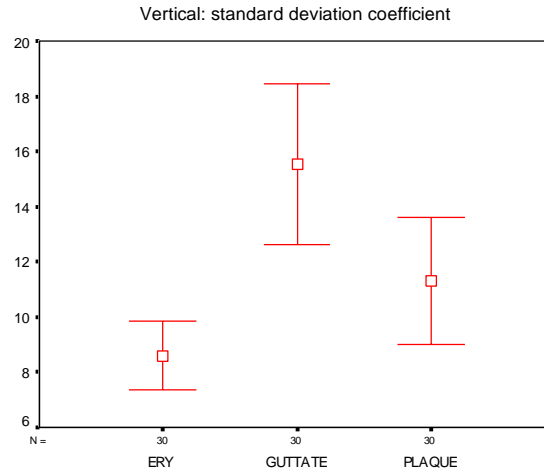


Figure 11: Error plot of standard deviation coefficient for vertical sub-image

a.iv Diagonal Coefficients

Based on diagonal coefficient in Figure 12, it is observed that the results implied that the groups cannot be discriminated. Therefore, the features between erythroderma, guttate and plaque are not able to recognize. Nevertheless, guttate can be distinctly distinguished with erythroderma and plaque by using standard deviation parameter.

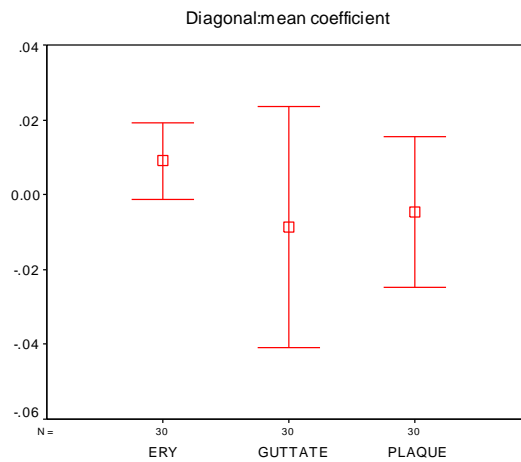


Figure 12. Error plot of mean coefficient for diagonal sub-image

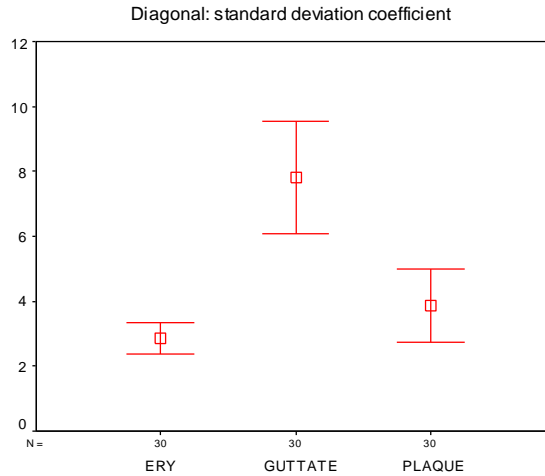


Figure 13. Error plot of standard deviation coefficient for diagonal sub-image

From the error plots analysis, the standard deviation of horizontal and diagonal coefficient can be utilized to detect guttates' features. Besides, the features between erythroderma with guttate and plaque can be recognized by using both mean and standard deviation of approximate sub-images.

b. T-test

The independent-samples T-test procedure is utilized for testing the equality of variances between erythroderma, guttate and plaque to determine significant values of psoriasis features recognition. Inferences about the P-value are determined by referring condition used in [21].

- If the P-Value is less than 0.01, there is overwhelming evidence to infer that the alternative hypothesis is true. The test is highly significant.
- If the P-value lies between 0.01 and 0.05, there is strong evidence to infer that the alternative hypothesis is true. The result is deemed to be significant.
- If the P-value is between 0.05 and 0.1, there is weak evidence to indicate that the hypothesis is true.
- When the P-value is greater than 0.1, the result is not statistically significant.

Table 1 and Figure 14 indicated the comparison of p-value for psoriasis lesion with various sub-image using wavelet Daubechies D8 coefficients in mean parameter. It can be observed that erythroderma is distinguishable with guttate and plaque by using approximate coefficient since its p-value is below significant value of 0.05.

Table1: P-value of psoriasis lesion with various sub-images by using mean coefficients.

	Erythroderma vs Plaque	Erythroderma vs Guttate	Guttate vs Plaque
Approximation	0.009	0.000	0.113
Horizontal	0.419	0.175	0.456
Vertical	0.869	0.869	0.976
Diagonal	0.220	0.289	0.830

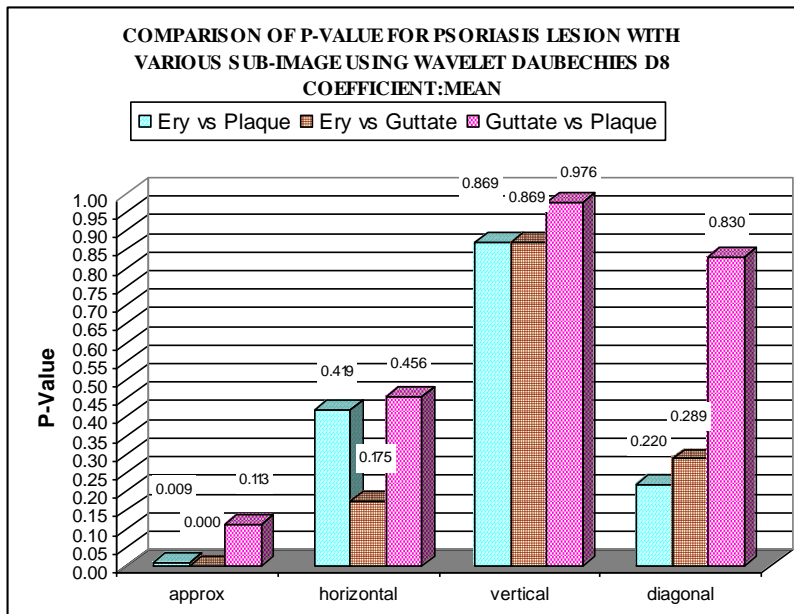


Figure 14. Comparison of p-value for psoriasis lesion with various sub-images (mean parameter)

Table 2 shows the comparison of p-value for psoriasis lesion with various sub-images using wavelets Daubechies D8 coefficient in standard deviation parameter. The results show that there is most significant difference in vertical coefficient to recognize the features of three groups of psoriasis since p-value are below 0.05. The results also indicated that erythroderma can be clearly distinguished with guttate by using both of the sub-images coefficients. Beside, erythroderma can be discriminated with plaque by using approximate and vertical coefficients.

Table 2: P-value of psoriasis lesion with various sub-images by using standard deviation coefficients

	Erythroderma vs Plaque	Erythroderma vs Guttate	Guttate vs Plaque
Approximation	0.000	0.001	0.803
Horizontal	0.069	0.000	0.000
Vertical	0.039	0.000	0.022
Diagonal	0.100	0.000	0.000

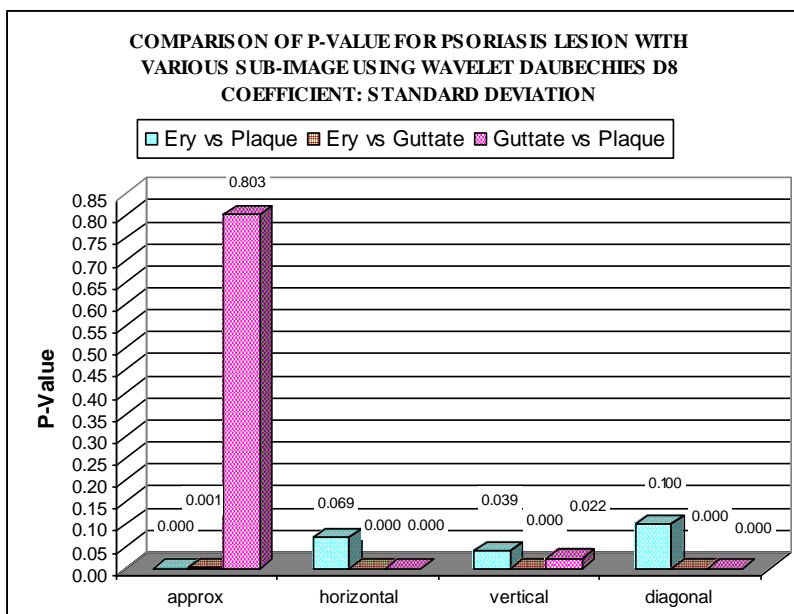


Figure 15: Comparison of p-value for psoriasis lesion with various sub-images (standard deviation parameter).

Referring to the Table 1, only erythroderma produced significant difference between guttate and plaque by using mean approximate sub-images coefficients. By consider to the results from Table 1, erythroderma is taken as a reference lesion for comparison between the other families of Daubechies which are DB4 and DB12. Table 3 shows the results of p-value compared with various types of Daubechies for mean approximate parameter. Both of the Daubechies families produced significant evidence to classify erythroderma with the others. From the three Daubechies family, DB12 gives the best indicators to recognize the features of erythroderma with the others by using mean approximate sub-images coefficient parameter.

Table 3: P-value of mean approximate coefficient for erythroderma versus others psoriasis compare with the families of Daubechies; DB4, DB8, DB12

	Erythroderma vs Plaque	Erythroderma vs Guttate
DB4	0.012	0.000
DB8	0.009	0.000
DB12	0.008	0.000

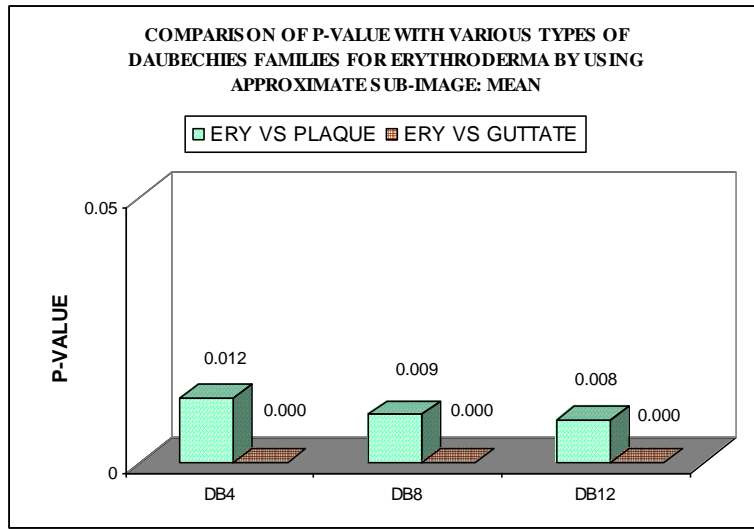


Figure 16. Comparison of P-value mean coefficients with various Daubechies families for erythroderma in approximate sub-images.

Comparison result of p-value with various types of Daubechies for psoriasis lesions by using standard deviation approximate parameter is depicted in Table 4 and Figure 17. Erythroderma is chosen as reference skin lesions and compared with the plaque and guttate. From the results, there is strong evidence that erythroderma is distinctively different from guttate and plaque by using the approximate sub-images coefficients. DB4 gives the best indicators to compare erythroderma with plaque and guttate where both of the p-value both are 0.000.

Table 4: P-value of standard deviation approximate coefficients for erythroderma versus other psoriasis compare with the families of Daubechies; DB4, DB8, and DB12

	Erythroderma vs Plaque	Erythroderma vs Guttate
DB4	0.000	0.000
DB8	0.000	0.001
DB12	0.001	0.000

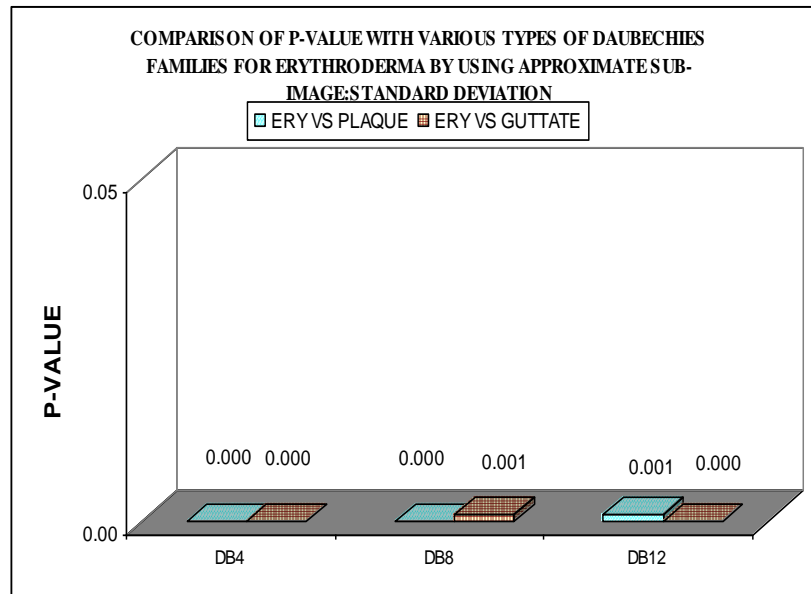


Figure 17. Comparison of p-value coefficients with various Daubechies families for psoriasis in approximate sub-images.

Table 5 and Figure 18 show the results of p-value comparison with various types of Daubechies for psoriasis lesions by using standard deviation horizontal parameter. Guttate is chosen as a reference skin lesion and compared with the erythroderma and plaque. From the result, it can be observed that DB8 produced the best promising results which less than 0.01 and there is overwhelming evidence to recognize guttate with the other psoriasis.

Table 5: P-value of standard deviation horizontal coefficients for guttate versus others psoriasis compare within the families of Daubechies; DB4, DB8, and DB12

	Guttate vs Erythroderma	Guttate vs Plaque
DB4	0.000	0.035
DB8	0.000	0.000
DB12	0.096	0.016

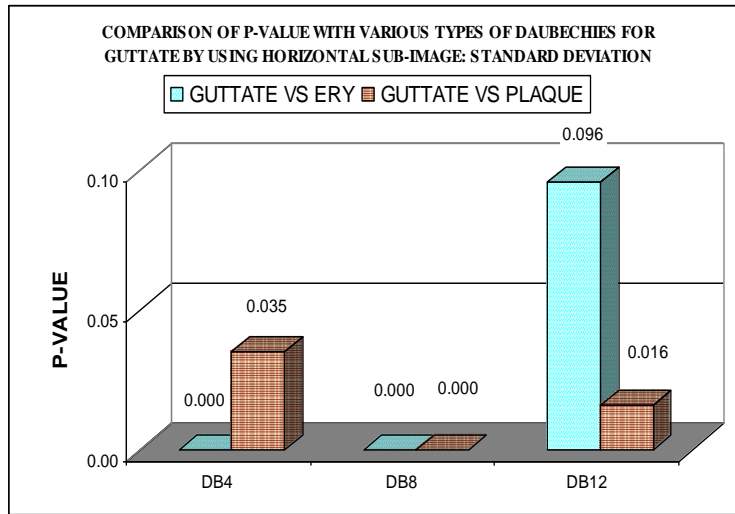


Figure 18. Comparison of P-value coefficients with various Daubechies families for guttate versus others in horizontal sub-images.

The results in Table 6 and Figure 19 show that, DB12 cannot recognize guttate with erythroderma since the value are greater than 0.1 but there is overwhelming evidence for recognition guttate and plaque. The results also indicated that DB4 distinctively can be distinguished guttate with the others. However, DB8 produced the best promising results for classify the features between themselves which is 0.000 for both guttate with erythroderma and guttate with plaque .

Table 6: P-value of standard deviation diagonal coefficients for guttate versus others compare within the families of Daubechies; DB4, DB8, and DB12

	Guttate vs Erythroderma	Guttate vs plaque
DB4	0.000	0.001
DB8	0.000	0.000
DB12	0.189	0.000

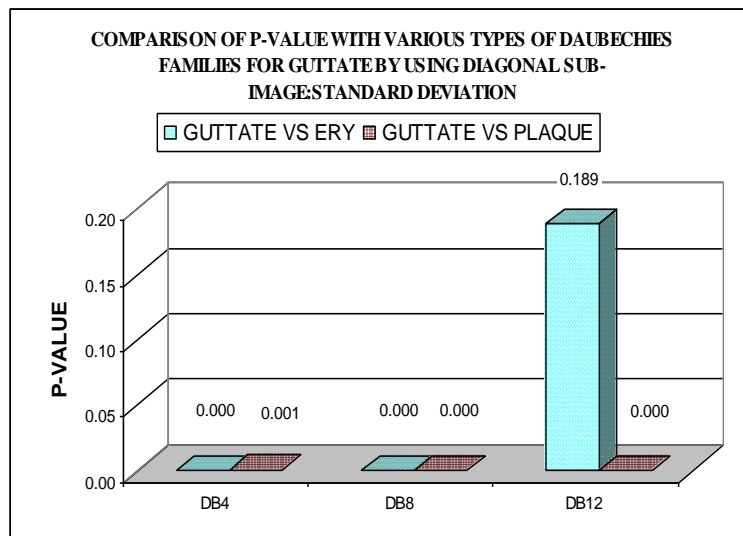


Figure 19. Comparison of P-value coefficients with various Daubechies Families for guttate versus others in vertical sub-images.

Table 7 and Figure 20 indicated the result of p-value compared with various types of Daubechies for psoriasis lesions by using standard deviation of vertical coefficients. From the previous results as shown in Table 2, standard deviation for vertical sub-images has a strong evidence to discriminate both groups of psoriasis by using DB8. DB4 also indicates that both of the psoriasis can be distinguished. However, DB12 showed that there is no significant evidence to discriminate erythroderma with guttate.

Table 7: P-value of standard deviation vertical coefficients for psoriasis lesions compare within the families of Daubechies

	Erythroderma vs Plaque	Erythroderma vs Guttate	Guttate vs Plaque
DB4	0.048	0.000	0.029
DB8	0.039	0.000	0.022
DB12	0.000	0.101	0.010

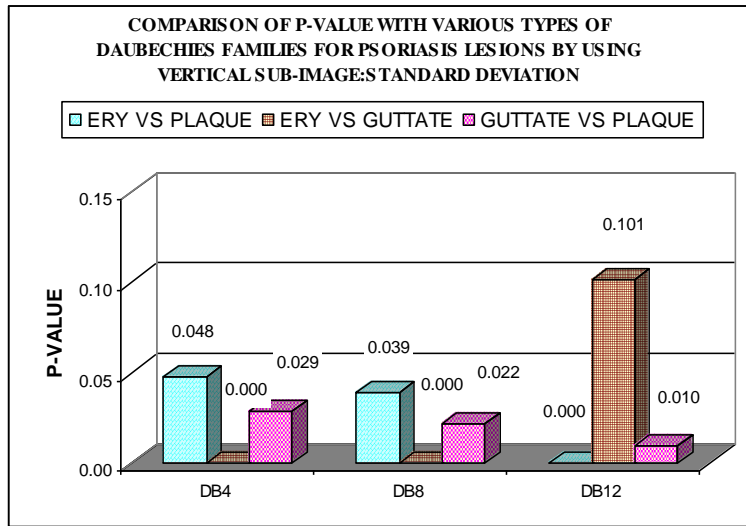


Figure 20. Comparison of P-value coefficients with various Daubechies Families for psoriasis lesions in vertical sub-images.

V. CONCLUSION

The statistical T-test outcomes have reinforced the findings from the error plots. Based on the results, it shows clearly significant difference between each groups of psoriasis. Results show that, erythroderma has distinct difference compared to guttate and plaque by using approximate sub-images coefficient in both mean and standard deviation parameter. In order to recognize guttate features, standard deviation parameter in horizontal, vertical and diagonal sub-images coefficients can be utilized. On the other hand, standard deviation of vertical sub-images has been found clearly to identify both of the psoriasis. Therefore, it is indicates that plaque also can be recognized from the other groups of psoriasis. From the previous analysis by using error plot,

there is no significant result to distinguish plaque with the other groups of psoriasis. It proves that t-test is an effective method to produce significant outcomes for recognition the features between groups of psoriasis. Besides, psoriasis features are compared with the other families of Daubechies which are DB4 and DB12. In comparison, DB8 gives the most significant evidence in recognized psoriasis features by chosen standard deviation of vertical sub-images and produces the best promising results in recognition of guttate from the others by using standard deviation of horizontal and diagonal parameter. This study also attempted to analyze which parameter will be most effective results in order to recognize the difference between psoriasis. Conclusively, Daubechies D8 at level 1 can be used to recognize the features of the psoriasis.

REFERENCES

- [1] I.G. Maglogianis, E.P. Zafiroopoulos, "Characterization of Digital Medical Images Utilizing Support Vector Machines", *BMC Medical Informatics and Decision Making*, 4:4, 2004.
- [2] "Evaluation of Fingerprint Recognition Technologies-Bio-Finger," Public Final Report, Version 1.1, Bundesamt für Sicherheit in der Informationstechnik, pp. 122, 2004.
- [3] A. K. Jain, P. Flynn, and A. A. Ross, "Handbook of Biometrics", Springer, New York, 2008.
- [4] R. M. Bolle, J. H. Connell, S. Pankanti, N. K. Ratha, and A. W. Senior, "Guide to Biometrics", Springer, New York, 2004.
- [5] W. D. James, T. G. Berger, and D. M. Elston, "Andrew's Diseases of the Skin-Clinical Dermatology", Elsevier Saunders, 10th edition, 2006.
- [6] T. P. Habif, "Clinical Dermatology", Mosby, Hong Kong, 4th Edition, 2004.
- [7] Giardina, E.C. Sinibaldi and G. Novelli, "The Psoriasis Genetics as a Model of Complex Disease", *Current Drug Targets-Inflammation and Allergy*, 3(2): pp129-136, 2004.
- [8] Nidhal K. Al Abbadi, Nizar Saadi Dahir, Muhsin A. Al-Dhalimi and Hind Restom, "Psoriasis Detection Using Skin Color and Texture Features", *Journal of Computer Science* 6 (6): pp648-652, 2010.
- [9] T. Morrow, "Evaluating New Therapies for Psoriasis", *Managed Care*, Vol. 13, pp. 34-40, 2004.
- [10] D. M. Pariser, "Management of Moderate to Severe Plaque Psoriasis With Biologic Therapy", *Managed Care*, Vol. 12, pp. 36-44, 2003.

- [11] H. Hashim, M.T. Ali, and N.A. Talib, "Skin Lesions Color Analysis Based on RGB Reflectance Indices", International Conference on New Techniques in Pharmaceutical and Biomedical Research, Malaysia 2005.
- [12] M. Zafran, H. Hashim, Robbaiyah, Yuslindawati, "Identification of Psoriasis Lesion Features Using Daubechies D4 Wavelet Technique", Recent Researches in Communications, Electronics, Signal Processing and Automatic Control, 2012.
- [13] J. S. Taur, G. H. Lee, C. W. Tao, C. C. Chen, and C. W. Yang, " Segmentation of Psoriasis Vulgaris Images Using Multiresolution-Based Orthogonal Subspace Techniques", IEEE Transaction on Systems, Man and Cybernatics - Part B: Cybernatics, Vol. 36, No. 2, 2006.
- [14] Djeddi Meriem, Ouahabi Abdeldjalil, Batatia Hadj, Basarab Adrian and Kouamé Denis, "Discrete Wavelet for Multifractal Texture Classification: Application to Medical Ultrasound Imaging", 2010 IEEE 17th International Conference on Imaging Processing, Hong Kong, 2010.
- [15] S. Guyot, M-C. Peron and E. Deléchéle, "Spatial Speckle Characterization by Brownian Motion Analysis," Physical Review E, Statistical, Nonlinear, and Soft Matter Physics, Vol. 70, Issue 4, pp.046618.1-046618.8, 2004.
- [16] Ahmad Fadzil M Hani, Esa Prakasa, Hurriyatul Fitriyah, Hermawan Nugroho, Azura Mohd Affandi and Suraiya Hani Hussein, "High Order Polynominal Surface Fitting for Measuring Roughness of Psoriasis Lesion", Visual Informatics: Sustaining Research and Innovation, pp 341-351, 2011.
- [17] W. Marco, G. Armin, W. Christian, B. Patrick, S. Josef, "Discrimination of Benign Common Nevi from Malignant Malonoma Lesion by Use of Features Based on Spectral Properties of the Wavelet Transform", Analytical and Quantitative Cytology and Historlogy, pp243-253, 2003.
- [18] E.M. Fomitchev, "An Introduction to Wavelets and Wavelet Transform", Systems and Programming Resources Inc, Tulsa, USA, 1998.
- [19] C.M. Thoms, S.M. Dunn, C.F. Nodine, H.L. Kundel, "An analysis of Perceptual Errors in Reading Mammograms Using Quasi-local Spatial Frequency Spectra", Journal of Digit Imaging, Vol.4, pp117-123, 2001.
- [20] Kaiser, "The Fast Haar Transform Potentials", IEEE Transaction, Volume 17, Issue 2 pp34-37, 1998.
- [21] G. Keller and B. Warrack, "Statistical for Measurement and Economics", Fifth Edition, 2001.