Skin Cancer Prognosis Based Pigment Processing

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Abstract

This paper develops a new computerized vision of skin cancer prognosis based on symmetry and color matching for lesion pigments. Initially, the lesion/tumor edge is detected and segmented. Then, the symmetrization is computed for all images to isolate benign (mole) tumor. The even symmetry parameter is introduced here to improve the symmetrization computations. The suspicious images would be nominated into one of three categories: melanoma, Basal Cell Carcinoma (BCC), or Squamous Cell Carcinoma (SCC) tumor depending on the symmetrization and pigment-color matching score table. Two matching procedures have been developed for nominating the suspicious images. First procedure matches pigment values with artificial spectrums of Reddish, Yellowish, Brownish, and Blackish. The second procedure matches pigment values with true malignancy/benign pigment database. The results of two procedures are compared over 40 pre-classified images. With Mean Squared Error (MSE) value equals to 0.003, procedure#1 satisfied 80% true classification while 92.5% for procedure#2. These results could be improved if lesion segmentation and/or spectrums/pigment-database are increased.

Keywords: Melanoma, SCC, BCC, Skin Cancer, Color Matching.

1. INTRODUCTION

Skin cancer is mainly divided into two types: melanoma or non-melanoma. The non-melanoma tumors have two sub-types: Squamous Cell Carcinoma (SCC or SqCC) and Basal Cell Carcinoma (BCC). So, computer-aided diagnosis software is essential in this case to assist the early detection of the malignant tumors. Skin as a large organ of the body it consists of three layers: Outer epidermis layer; dermis layer; and deep sub-cutis layer. The melanocyte which is located in the epidermis, synthesizes melanin that determines the pigment of the skin (skin color) [2, 3]. Studies results found that melanoma is responsible for 80% of skin cancer deaths and cases of non-melanoma skin cancer have been raised an average of 4.2% a year. The clinical criteria that pathologist applies them for tissue diagnosis includes: the type of cell that is proliferating, its histological grade, genetic abnormalities, and other features of the tumor relating to its pigments. Together, this information is useful to evaluate the prognosis of the patient and to choose the best treatment [4, 5, and 6]. The ABCD is a traditional diagnostic rule of dermatoscopy which is made by Stolz's [7], it is based on the four main criteria or lesion parameters: Asymmetry, Border, Colour and Diameter. The "E" in Elevation is added later to describe the uneven surface of tumour. ***This rule applies a semi-quantitative score system to make a decision*** [8, 9]. The ABCD method is improved by "ELM 7"; which is a computerized scanning method that based on polarized light surface microscopes. G. Di Leo, A. Paolillo, et al., developed "ELM 7 point checklist" diagnostic method in 2010. It provides same accuracy of traditional "ABCD" criteria where, it defines a set of seven features, based on colour and texture parameters that describe the lesion malignancy [10]. The comprehensive research that is made

by [11] in 2009, provides clear view about such tools that are mostly intended for assisting and supporting the decision systems at early stages. If a comparison is made between these tools and the medical experts in the field, even with the best diagnostic results, the system depicts relatively lower performance in terms of accuracy and confidence. However, the physicians admitted that the computerized diagnostic tools are very useful in producing quantified results, recording patient follow-ups, and monitoring the therapeutic and healing progress. These tools would not be in any case, used for replacing the physicians, but just to serve as early diagnostic adjuncts.

This work develops a new computerized vision of skin cancer diagnosis. It adopts spatial processing for pigment-color matching and symmetry computations to detect early the malignant tumor. This paper is organized as follows: the next section II, presents the three types of skin cancer and their signs; symptoms; and lesion pigments. Section III illustrates the lesion boundary detection (segmentation). Section IV and V illustrate the two matching procedures which they have been developed for approximating the lesion color values (pigments). One procedure uses color spectrums for matching operations, while second procedure applies pigment database for that matching. Section VI is a conclusion summarization for the two procedures results and evaluation that have been tabulated in eight tables.

2. SKIN CANCER TYPES

Skin cancer can be defined as an abnormal growth up of skin cells due to defective in the DNA. Oftenly, not necessarily it may be happened because of the sunshine, tanning beds, or genetic defective. This section presents three kinds of malignant tumor.

2.1 Melanoma

Melanoma is the least common type of skin cancer, but it is the most deadly one. It can be quickly spread to other body parts causing a secondary cancer. The signs and symptoms caused by this most dangerous disease are [12,13]:

- Appears as a mole, dark spot, or freckle anywhere on the body with changing in shape, color, and size
- The border is smudgy (blurred) and irregular
- Lesion pigment has more than one color like: red, brown, black, white and/or light grey

The most three common diagnostic rules are:

- ABCDE" which is based on semi-quantitative analysis
- The ELM 7-point checklist scoring diagnosis analysis which defining only seven standard ELM criteria.
- Pattern analysis, which is based on the "expert" qualitative assessment of numerous individual ELM criteria;

2.2 Squamous Cell Carcinoma

SCC is the second most common form of skin cancer. it is mainly caused by cumulative ultraviolet exposure over long time. It is less risk than melanoma, but more dangerous than BCC. The SCC signs and symptoms are:

- Typically occur everywhere on the body including the mucous membranes and genitals. The exposing body parts like ear, neck, arm, etc are the most common affected areas.

- It looks like tender scaly, scaly red patches, open sores or warts, ulcerated lump they may be crust or bleed easily.

- Usually it presents with one or more dry or crusted red or brown patches.

In 2002 almost all people with SCC were aged 40 years and over 1138,000 new cases of SCC were estimated to have been diagnosed in 2008 [13].

2.3 Basal Cell Carcinoma

BCC is by far the most common form of skin cancer. It grows from cells in the lower part of the upper layer of the skin, taking a period of months to years. The BCC signs and symptoms are:

- BCC is very difficult to recognized, only a specialist in diseases of the skin, can decide for sure. A persistent, non–healing sore is a very common sign of an early BCC.

- An open sore, reddish patch, pink growth, scars, or irritated area that commonly occurring on the face, chest, shoulders, arms, or legs.

- A shiny bump or nodule which is pearly and is often pink, red, or white. It can be confused with mole because of the rolled border. The bump can also be tan, black, or brown.

- A scar-like area that is white, yellow or waxy with poorly defined borders; the skin itself appears shiny and taut.

In 2002, 96% of people with BCC were aged 40 years or older. 1296,000 new cases of BCC were estimated to have been diagnosed in 2008. BCC is more easily treated in its early stages, but if it lefts untreated it can grows, erodes and destroys adjoining structures [12, 13, and14].

3. LESION BOUNDARY DETECTION

Lesion boundary can be detected and extracted by finding the orthogonal and perpendicular diagonal line values. These intersected values are used to find the symmetry, even symmetry, semi-symmetry, or asymmetry of lesion [15, 16, and 17]. See Fig. 1.

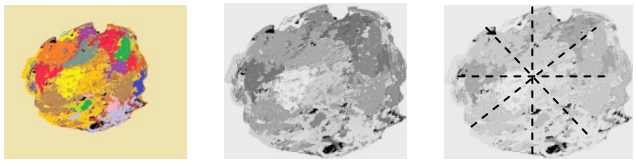

FIGURE 1: a) Example of Colored Lesion Image, b) Lesion Boundary Detection, c) Symmetry/Asymmetry Computations.

4. MATCHING PROCEDURE#1: PIGMENT vs. SPECTRUMS

This procedure attempts finding a true color approximation for all sub-image lesions, where the four new sub-images are segmented from the original one with size (m/2× n/2: where, m & n is the row and column respectively). Fig. 1 explains clearly the segmented operations. Matching operation starts finding the minimum Mean Squared Error (MSE) between sub-image pigments and the 140 artificial spectrums of reddish, brownish, yellowish, and blackish, see Fig. 2. The results of this procedure would be stored in image profile that contains score of matching events. The MSE between pigments and the artificial colors could be calculated as follows:

$$MSE = (m - \mu)^2 \quad (1)$$

The necessary procedure steps for matching operations can be detailed below:

Procedure #1 (suspicious pigments, spectrums)
for all suspicious images
for all artificial colors
error = (mean (sub-image pigment) - spectrum value)^ 2
if error ≤ threshold value (□)
matching is true; event=event+1
else matching is false
end if;
next spectrum; next suspicious image
end for; end for

Table 1, 2, 3, and 4 represent procedure#1 matching results that have been applied on 40 suspicious images. Those images were already classified, and the procedure is just succeeded reclassifying benign (80%), melanoma (90%), BCC (60%), and SCC (90%) with overall succeeded predicting equals to 80%. The MSE or threshold value (□) is chosen to be 0.003. Procedure#1 segments the suspicious image into four sub-images. So, each quarter tries matching it pigment mean value with 120 spectrum values. That means the total number of operations are:

4 (no. of quarters) × 40 (no. of images) ×120 (no. of spectrum) = 19, 200 matching operations

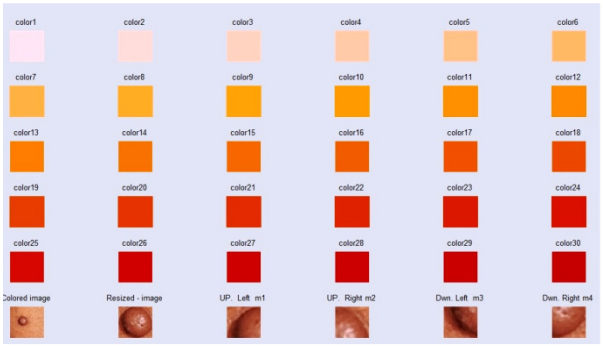

FIGURE 2.: Example of Matching Operations between Benign Image Pigment and Reddish Spectrums.

5. MATCHING PROCEDURE#2: PIGMENT vs. PIGMENT DATABASE

This procedure is similar to the first one except it matches the suspicious sub-image pigments with malignant pigment database. So, the procedure#2 necessary steps would be:

Procedure #2 (suspicious pigments, pigment database)
for all suspicious images
for all malignant image database
error = (mean (sub-image pigment) – malignant pigment)^ 2
if error ≤ threshold value (□)
matching is true; event=event+1
else matching is false
end if;
next malignant image; next suspicious image
end for; end for

Table 5, 6, 7 and 8 represent procedure#2 matching results that have been applied on the same 40 images. According to the results of these tables, procedure#2 succeeded re-classifying 90% of

benign images, melanoma (90%), BCC (90%), and SCC (100%). The same MSE value (0.003) is considered as a threshold value. The overall predicting result would be 92.5%. With this procedure, the suspicious image is segmented into four sub-images so, 4 quarters goes to full, 3 quarters, half, and quarter. Clearly, from two procedure results, procedure#2 satisfies better matching operations because of the true color values (lesion pigments) that have been used for matching process. Fig. 3 is an example of procedure#2 pigment matching operation.

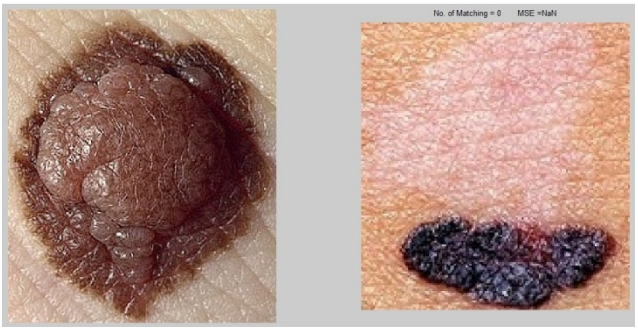

FIGURE 3.a: Example of Procedure#2 Matching Operation, MSE Equals to 0.003, No Matching Event.

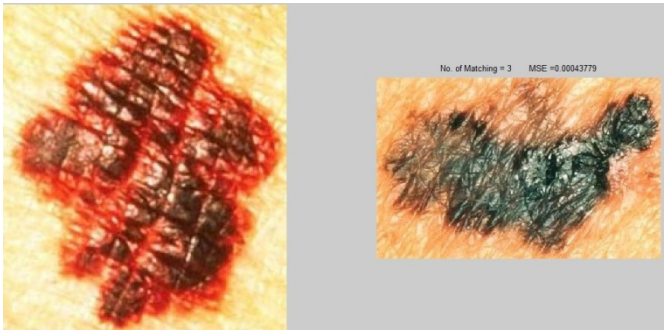

FIGURE 3.b: Example of Procedure#2 Matching Operation with MSE Equals to 0.003 and 3 Quarters Matching Events.

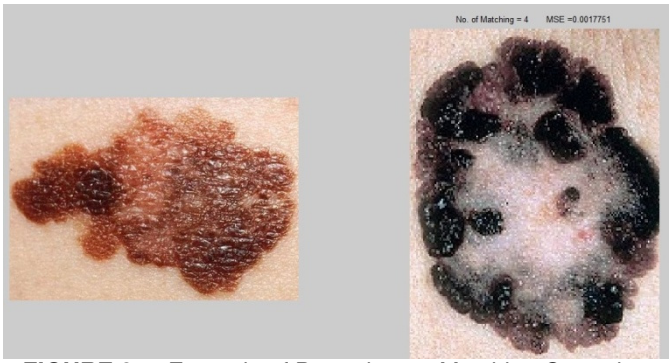

FIGURE 3.c: Example of Procedure#2 Matching Operation with MSE Equals to 0.003 and 4 Quarters (full) Matching Events.

Procedure#2 segments the suspicious image into 16 sub-images and only the interested lesion area is considered (the inner 4 sub-images). So, each quarter tries matching itself mostly once with pigment database. That means the no. of matching operations for each kind of malignant or benign image are less than:

4 (no. of quarters) × 10 (no. of suspicious images) × 40 (no. of sub-image database) = 1, 600 matching operations

Image No.	Symmetrisation		Matching spectrums				Predicted results
	Symmetry	Even Symmetry	Red	Yellow	Brown	Black	
Ben-1	semi	yes	√,√	-	√	-	-ve
Ben-2	semi	yes	√	-	-	√	-ve
Ben-3	semi	yes	√	-	-	√	-ve
Ben-4	semi	yes	-	-	-	-	-ve
Ben-5	no	yes	√	-	√	√	+ve
Ben-6	semi	yes	-	-	-	-	-ve
Ben-7	yes	yes	√, √	-	√, √, √	-	-ve
Ben-8	no	yes	√	-	√	-	-ve
Ben-9	no	yes	√, √	-	√,√	√, √	+ve
Ben10	yes	yes	√, √	-	-	√, √	-ve

TABLE 1: Procedure#1 Benign Matching Results.

Image No.	Symmetrisation		Matching spectrums				Predicted results
	Symmetry	Even Symmetry	Red	Yellow	Brown	Black	
Mel-1	no	yes	√,√,√	√	-	√	+ve
Mel-2	no	no	√,√	-	√	-	+ve
Mel-3	no	no	-	√,√	-	√	+ve
Mel-4	no	no	√	√	√,√,√	√	+ve
Mel-5	no	no	√	√,√	-	√,√	+ve
Mel-6	no	no	-	-	√	-	-ve
Mel-7	no	no	√	√	√,√	-	+ve
Mel-8	no	no	√	√,√	-	-	+ve
Mel-9	semi	no	√	√	√,√	√,√	+ve
Mel 10	no	no	√,√	√	√,√	-	+ve

TABLE 2: Procedure#1 Melanoma Matching Results.

Image No.	Symmetrisation		Matching spectrums				Predicted results
	Symmetry	Even Symmetry	Red	Yellow	Brown	Black	
BCC1	no	no	-	-	√,√	-	suspicious
BCC2	no	no	√,√,√	-	-	√,√	+ve
BCC3	no	no	√	-	-	√	+ve
BCC4	no	no	√	-	√	√	+ve
BCC5	no	no	√	-	-	-	suspicious
BCC6	yes	no	-	-	√,√	√	suspicious
BCC7	no	no	-	-	√	-	suspicious
BCC8	no	no	√	-	√,√	√,√	+ve
BCC9	no	no	√	-	√	-	+ve
BCC10	no	no	√,√,√	-	√,√	√	+ve

TABLE 3: Procedure#1 BCC Matching Results.

Image No.	Symmetrisation		Matching spectrums				Predicted results
	Symmetry	Even Symmetry	Red	Yellow	Brown	Black	
SCC1	no	no	-	√	√	√,√	+ve
SCC2	no	no	√,√	√,√	√	√	+ve
SCC3	no	no	√	-	-	√	+ve
SCC4	no	no	√	√,√	√,√	√,√	+ve
SCC5	no	no	-	√,√	-	√,√,√	+ve
SCC6	no	no	√	√	-	√	+ve
SCC7	no	yes	√	-	√	-	suspicious
SCC8	no	no	-	√,√	√,√,√	√,√	+ve
SCC9	no	no	-	√	√	√	+ve
SCC10	no	no	√,√	√,√	√	√	+ve

TABLE 4: Procedure#1 SCC Matching Results.

Image No.	Symmetrisation		Matching Database (pigments)				Predicted results
	Symmetry	Even Symmetry	Full	3quarters	half	quarter	
Ben-1	semi	yes	√√	√√	√	√√	+ve
Ben-2	semi	yes	√√√√	√	√	√√	+ve
Ben-3	semi	yes	√√√√√	√	-	√	+ve
Ben-4	semi	yes	√√	√√	-	√	+ve
Ben-5	no	yes	√√√	√ √	√	√√	+ve
Ben-6	semi	yes	√√√	-	√√	√√	+ve
Ben-7	yes	yes	√	√	√√√	√	Suspicious
Ben-8	no	yes	√√√√	-	√	-	+ve
Ben-9	no	yes	√√	√√√	√√√	√√	+ve
Ben10	yes	yes	√√√	√√	√√	√	+ve

TABLE 5: Procedure#2 Benign Matching Results.

Image No.	Symmetrisation		Matching Database (pigments)				Predicted results
	Symmetry	Even Symmetry	Full	3quarters	half	quarter	
Mel-1	no	yes	√	-	√√	√√√√√*	-ve
Mel-2	no	no	√√	-	√√√√√*	-	-ve
Mel-3	no	no	√	-	√	-	+ve
Mel-4	no	no	√√√√	√√√√√	-	-	-ve
Mel-5	no	no	√√√√√*	-	√√	-	-ve
Mel-6	no	no	√√√	√√	√	√√√	-ve
Mel-7	no	no	√√√√√	√√√√	-	-	-ve
Mel-8	no	no	√√√√	√√√√	√	-	-ve
Mel-9	semi	no	√√√√	√	√√	√	-ve
Mel 10	no	no	√√√√√	√√	√	√	-ve

TABLE 6: Procedure#2 Melanoma Matching Results.

Image No.	Symmetrisation		Matching Database (pigments)				Predicted results
	Symmetry	Even Symmetry	Full	3quarters	half	quarter	
BCC1	no	no	√√√	√√√√	√	-	+ve
BCC2	no	no	√√√√√*	-	√√	-	+ve
BCC3	no	no	√√	√√√√√	√	√	+ve
BCC4	no	no	√√	√√√√	√√	-	+ve
BCC5	no	no	√√√	-	-	-	+ve
BCC6	yes	no	√√√	√√√	-	√√√	+ve
BCC7	no	no	√	-	-	√	-ve
BCC8	no	no	√√√√	√√√	√√	√	+ve
BCC9	no	no	√√	√√√√√	-	-	+ve
BCC10	no	no	√√√√√*	√√	-	-	+ve

TABLE 7: Procedure#2 BCC Matching Results.

Image No.	Symmetrisation		Matching Database (pigments)				Predicted results
	Symmetry	Even Symmetry	Full	3quarters	half	quarter	
SCC1	no	no	√√√	√√√√√	√	-	+ve
SCC2	no	no	√√	-	√√√	√√	+ve
SCC3	no	no	√	√√√	√√	√√	+ve
SCC4	no	no	√√	√	√√√	-	+ve
SCC5	no	no	√√	√√√√	√√	√	+ve
SCC6	no	no	√√√√√	√√√	√√	-	+ve
SCC7	no	yes	√√√√	√	√√	√	+ve
SCC8	no	no	√	√	√	√√√√	+ve
SCC9	no	no	√√√√√	√√	√	√	+ve
SCC10	no	no	√√√√√	√√	√	√	+ve

TABLE 8: Procedure#2 SCC Matching Results.

6. CONCLUSION

This research develops new computerized vision for early detection of most three dangerous kind of skin cancer where, the spatial processing of lesion pigment is applied to find the features like "**A**" in Asymmetric and "**C**" in Color instead of using mathematical rules of the "**ABCD**" which is relatively more complicated comparing with this approach. The even symmetry has been added in symmetry computations as an extra parameter to improve the calculations. The prognosis approach depends completely on score table which is completely depending on the constructed image profile. The precise evaluation of this work requires comparing it with "ABCD" and/or "ELM-7" by running these three methods on the same suspicious images and comparing the results. However, such comparison is planning to take a place in future research, especially when the three color planes (red, green, blue) of lesion pigment are considered for pigment matching operations instead of the equivalent gray-scaled value. For this work, the two matching procedures have been implemented to re-classify 40 suspicious images. These 40 images are already classified into mole/benign, melanoma, BCC, and SCC image. Procedure#1 uses 120 spectrum of reddish, yellowish, brownish, and blackish to match lesion pigment with these spectrums. While procedure#2 apply pigment vs. pigment as it uses the stored database for matching operations. For MSE value equals to 0.003, procedure#1 succeeded re-classifying 80% of suspicious images with 19,200 matching operations, while procedure#2 improved this result when it re-classified 92.5% of them with matching operations were less than 6,400.

7. REFERENCES

[1] M. H. Hamd and L. M. Mohammad. "Skin Cancer Prognosis Based Color Matching and Segmentation of Pigmented Skin Lesion." *journal of engineering and technology*, submitted, 2012

[2] P. Shetty. “Melanoma Decision Support System for Dermatologist,” International Conference on Recent Trends in Information Technology and Computer Science (IRCTITCS),2011, pp.101-105.

[3] L. DANIEL. “American Family Physician.” volume 70, No. 8, October 15 2004, www.aafp.org/afp.

[4] S. L. Phung and A. Bouzerdoum. “Skin segmentation using color pixel classification: analysis and comparison.” *IEEE Transactions on Pattern Analysis and Machine Intelligence ,* Vol. 27, No. 1, Jan. 2005.

[5] R. G. Gonzalez and E. R. Woods, “Digital Image Processing Using MATLAB.” A John Wiley & Sons, Inc., Publication 4th Edition , 2004, pp. 220-222.

[6] G. Blanchet and C Maurice “Digital Signal and Image Processing using MATLAB.”, ISBN 10: 1-905209-13-4, 2006, pp. 43-46.

[7] M. Thorsten. “Functional Infrared Imaging for Skin-Cancer Screenin,” Proceedings of the 28th IEEE EMBS Annual International Conference New York City, USA, Aug 30-Sept 3, 2006.

[8] W. Stolz, D. Hölzel, A. Riemann. “Multivariate analysis of criteria given by dermatoscopy for recognition of melanocytic lesions.” Book of Abstracts, Fiftieth Meeting of the American Academy of Dermatology, Dallas, Texas, December 1991.

[9] R. A. Fiorini, G. Dacquino and G. Laguteta. “A New Melanoma Diagnosis Active Support System,” Proceedings of the 26th Annual International Conference of the IEEE EMBS San Francisco, CA, September 1-5, 2004, 3206-3209.

[10] G. Di. Leo and A. P. Sommella. “Automatic Diagnosis of Melanoma: a Software System based on the 7-Point Check-List,” Proceedings of the 43rd Hawaii International Conference on System Sciences, 2010.

[11] M. Ilias and C. N. Doukas, “Overview of Advanced Computer Vision Systems for Skin Lesions Characterization.”, *IEEE Transaction on Information Technology in Biomedicine*, Vol. 13, NO. 5, September 2009.

[12] M. M. Rahman and B. C. Desai , “Image Retrieval-Based Decision Support System for Dermatoscopic Images,” Proceedings of the 19th IEEE, Symposium on Computer-Based Medical Systems, 0-7695-2517-1/06, 2006.

[13] C. Fatichah, “Skin Lesion Detection using Fuzzy Region Growing and ABCD Feature Extraction for Melanoma Skin Cancer Diagnosis.” *Journal of computing and informatics technology*, 2010, www.cs.ui.ac.id/files/icacsis2009/pdf/43.pdf.

[14] X. Yuan. “SVM-based Texture Classification and Application to Early Melanoma Detection,” Proceedings of the 28th IEEE EMBS Annual, International Conference New York City, USA, Aug 30-Sept 3, 2006.

[15] Y. Zhoul and M. Smith. “Segmentation of Clinical Lesion Images Using Normalized Cut “, IEEE conference, 978-1-4244-3610-1/09/, 2009.

[16] R. Cláudio and R. Jung. “Sharpening Dermatological Color Images in the Wavelet Domain.” *IEEE journal of Selected Topics in Signal Processing*, Vol. 3, No.1, February 2009.

[17] M. Sadeghi. “Automated Detection and Analysis of Dermoscopic Structures on Dermoscopy Images,” Congress on Image and Signal Processing, 2008.

[18] H. Yu-Chen. International Journal of Image Processing, Book, 2009, Vol. 3, Issue 5, ISSN(online):1985-2304, pp.229-245.