COLOR SEGMENTATION FOR SKIN LESIONS CLASSIFICATION

N. A. Masood [1], H. M. Mashali [2], Abdalla S. A. Mohamed [3]

[1]Department of Medical Engineering, Faculty of Engineering, Menia University
e-mail: nsreen_masood@yahoo.com
[2]Department of Dermatology, Faculty of Medicine, Cairo University
[3]Department of Systems &Biomedical Engineering, Faculty of Engineering, Cairo University

***Abstract*- Differential diagnosis of Erythemato-Squamos diseases is considered a real problem in dermatology. They all share the clinical features of erythematic and scaling, with very little differences. This paper introduces an unsupervised color segmentation procedure applied to one disease of this group named Atopic Dermatitis. Evaluation of different color models is done to select the most appropriate model for representing skin lesions. Two steps of color segmentation were done to detect skin lesions with less computation. First is coarse segmentation with optimal threshold of the CIE color model, and second is fine segmentation with K-means clustering technique. Results of the proposed algorithm prove its success as the manual segmentation with expertise.**

***Keywords*- image segmentation, color models, optimal threshold, K-means clustering, skin lesions.**

I. INTRODUCTION

The importance of the skin arises from its function where it covers the whole body and adjusts easily to remarkable variations in environment, as well as adapting to the needs of the underlying shelters [1]. There is a variety and great number of skin diseases than any other organ in the human body owing to the non-homogenous structure of the skin. Skin diseases are characterized by signs rather than symptoms [2]. A matter that makes it easier to be diagnosed is the surface of the skin may be visually examined by the physician. The difficulties that face the physician are the presence of a large number of skin diseases as well as the variations of their patterns that occur in different parts of the body. This makes the physician may get confused during the diagnosis of some diseases. In this paper we concern with Erythemato- Squamous diseases where their differential diagnoses are considered a real problem in dermatology. They all share the clinical features of erythematic and scaling, with very little differences. In this work, a special attention is given to one disease of this group namely, Atopic Dermatitis due to the abundance of its images and its frequent occurrence in our country [3].

One basic characteristic of this disease is redness or inflammation of dermal surface. Skin lesions can cover large areas of the body and have component of ulceration, either solitary or wide spread. The determination of the degree of infection has always been problematic for clinician who uses medications to prevent or decrease that degree in patients. Current methods for diagnosis are highly subjective and often do not detect disease in an early stage when treatment and preventive strategies are most effective.

This paper will introduce a procedure – as a preprocessing step- to determine states of dermal surface which can be used to diagnose lesions in a quantitative manner. A modified color image segmentation procedure is presented to discriminate between the lesions and normal skin in the field of view of imaging system. The accuracy of this procedure is calculated for the selected disease. Testing different color models for skin diseases to prove the selected model for image segmentation is outlined in section-2. Stages for coarse and fine segmentation are outlined in section-3. Results and discussions are given in section-4.

II. SELECTION OF SKIN IMAGE COLOR MODEL

By a naked eye a special attention is given to color variability; asymmetry; border irregularity; and dermoscopic structures as brown globules, black dots or pigment within the lesion. Also, low-contrast structure in visible-light may not be directly observed. Therefore, processing of digital colored images of skin lesions may improve diagnostic reliability by employing more information residing in such images that is not directly observable.

The use of color in image processing is motivated by two principal factors. First, in automated image analysis, color is a powerful descriptor that often simplifies object identification and extraction from scene. Second, in image analysis performed by human beings, the motivation for color is that the human eye can discern thousands of color shades and intensities, compared to about only two-dozen shades of gray [4]. Existing color imaging systems produce colored skin images in red-green-blue [RGB] as the three primary colors of light. They suffer from standardization with respect to spatially artifacts due to lighting and image exposure conditions. In addition, we do not know the camera settings.

Due to the complexity of human visual system, several different color models had been proposed to model the characteristics of color. Full details of these models are available in [4]. They are briefly called NTSC, CIE, HSI, C-Y, YIQ, CIE XYZ, UVW, uvw.

 978-1-4244-2695-9/08/$25.00

The different color models start with RGB color components and perform a new transformation into a new color coordinate system [6]. RGB color model treats a color image as a set of three independent grayscale images, each of which represents one of the red, green, and blue components of a color image. Transformations from real RGB color representation to other models are available with full details in [5, 6].

Figure-1 represents a patient suffering from Atopic Dermatitis (AD) which is selected for evaluating these models. The resulting representations of this image with aforementioned models are illustrated in Fig. (2).

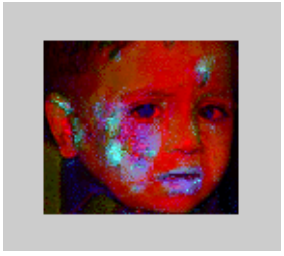
A. Transformation to the selected Model

The details of skin surface appearance depend on many variables namely body location, age, gender, health and imaging system. To investigate the visual appearance of the skin surface for computer vision, we have to consider both normal skin as well as skin affected by various disorders.

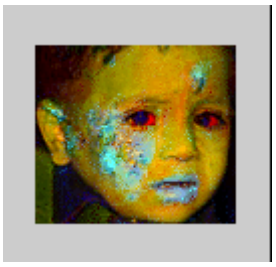
Starting with real colored image represented by RGB bands, CIE color representation is selected from the set of known color models [5] because it is a uniform color space in which equal perceived chromatic difference is available [6] and it also gives results similar to human visual perception of color. The CIE color components of red (R_{CIE}), green (G_{CIE}), and blue (B_{CIE}) are not monochromatic in order but contain a composition of several colors. The transformation from NTSC components to CIE components is controlled by the following equation:

$$\begin{bmatrix} R_{CIE} \\ G_{CIE} \\ B_{CIE} \end{bmatrix} = \begin{bmatrix} 1.167 & -0.146 & -0.151 \\ 0.114 & 0.753 & 0.159 \\ -0.001 & 0.059 & 1.128 \end{bmatrix} \begin{bmatrix} R_n \\ G_n \\ B_n \end{bmatrix} \quad (1)$$

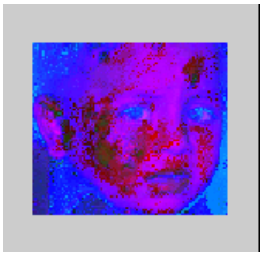
Fig.1. Original Image



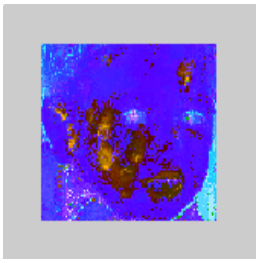
(a) NTSC Image



(b) CIE Image

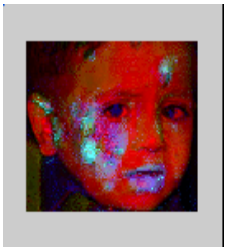


(c) HSI Image



(d) HLS Image

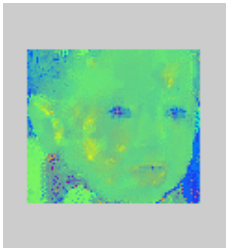
(e) C-Y Image



(f) YIQ Image

(g) CIE XYZ Image

(h) UVW Image



(i) uvw Image

Fig.2 Representation of original image with Color Models

III. SEGMENTATION OF SKIN LESIONS

It is necessary to achieve a compact-based description of the skin image by decomposing it into meaningful or spatial coherent regions sharing similar attributes. This low-level vision task is often the preliminary step for object localization or recognition. It is called image segmentation [7, 8]. Thus, the primary goal of skin lesions segmentation involves isolating lesions from healthy skin in an image for further analysis and making judgment. Such partitioning of the image into different regions is constrained with keeping similar characteristics for resulting regions such as intensity, color, texture, … etc.

978-1-4244-2695-9/08/$25.00 ©2008 IEEE

The main objective of this step is to improve the capability of dermatologist to obtain a numerically objective evaluation of skin lesions status through measurable attributes. Moreover, it monitors over time the evolution of skin lesion which is important for both clinical use and pharmaceutical research.

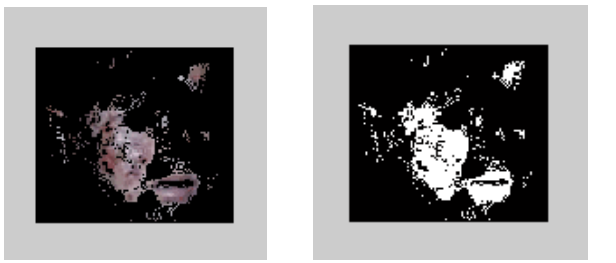
Based on segmentation, computer-based analysis of the position, size, shape, color, and other features becomes possible. Image segmentation algorithms are based on one of two basic properties of the attributes of images: discontinuity and similarity. Using the property of discontinuity, one approach is to partition an image based on abrupt changes such as edges. Determining histogram threshold as coarse segmentation becomes computationally inexpensive and fast where image brightness can be divided into two or more levels [9].

A. Coarse Segmentation

During this stage, we get background color of the image. It is done by selecting four windows of 4X4 pixels from four corners of the image. We choose the median color of pixels as the background color. Following to it, the thresholds and number of regions are determined automatically by applying scale-space filtering to histograms of the color components using optimal threshold [10]. Finally, a median filtering with 5X5 neighborhood and hole-filling were used. The advantage of median filtering is that it preserves the edges of color image while smoothing the image. All regions included within the segmented regions having number of pixels less than a selected threshold are filled with the surrounding color. The results of these steps are illustrated in Fig.3.

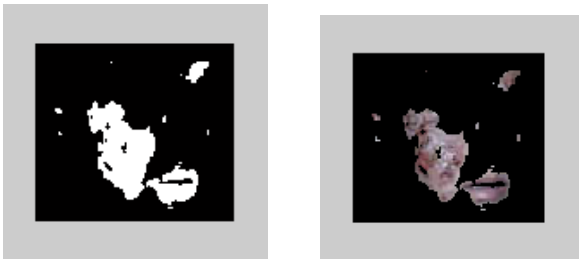
B. Fine Segmentation

In the second stage- fine segmentation- K-means clustering technique is used to segment those pixels that are not segmented in the first stage –coarse segmentation- and included in the predetermined regions (Fig.3-d) [11]. It is an intuitive way of classifying image pixels into classes or groups (provided the number of classes is known a priori). It depends on using Euclidean distance between the pixel and class means based on the nearest neighbor approach for classification. The basic idea behind the nearest neighbor rule is that pixels, which fall, close together are likely to belong to the same class [12]. The sum of the squared distance between the pixel vector and the class mean vectors is used as a method of distance comparison. The results of fine segments are shown in Fig.4. The main benefit of fine segmentation is to determine the degree of infection within the segment lesions. Moreover, it can be used to follow the effect of treatment.



(a) Primary segmented image with background removal

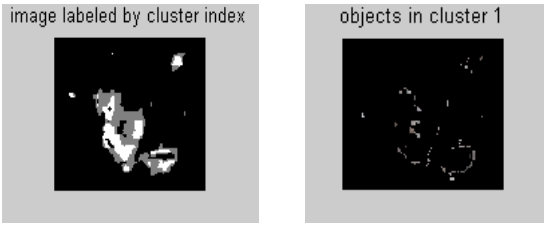
(b) Resulting image with Optimal Threshold



(c) Median Filtered Image

(d) Final Borders Detection

Fig.3 Results of Coarse Segmentation



(a) Regions within segmented Image

(b) ROI in cluster 1

(c) ROI in cluster 2

(d) ROI in cluster 3

Fig**.4.** Details of fine segmented skin lesions

IV. RESULTS AND DISCUSSIONS

In order to test the correctness of the proposed procedure, it was applied on a (50) images from a data base. The selection of the AD images was done by an expertise in dermatology. Such selection includes images with various sizes, and variable colors, lesions have clear and blur borders, dark and light, with and without hair, and other types of noise, etc. Experiments were carried out to test the agreement between the results of the proposed procedure and human perception. Five medical students participated in the experiment and independently reviewed the images before seeing the results and determined manually the infected regions.

It is quite normal in medical research that people need to measure and test the agreement between observers when they rate or evaluate a group of persons independently [14]. The resulting segmented images were grouped into two groups:

Group (A) includes the images where the segmented regions manually include fully those regions segmented by the proposed algorithm; and Group (B) contains images where the segmented regions by the proposed algorithm include fully the predetermined regions manually. Group-A contains (29) images where $B \subset A$ while group-B contains (21) images, and $A \subset B$. The results of mean relative errors [MRE] calculated by equations (2, and 3) for both groups are depicted in Table-1

$$MRE_A = \sum_{r_i \varepsilon R} (N_{Ai} - N_{Bi}) / \sum N_A \quad (2)$$

$$MRE_B = \sum_{r_i \varepsilon R} (N_{Bi} - N_{Ai}) / \sum N_B \quad (3)$$

where N_A, and N_B are the total number of pixels of infected regions in both group (A) and group (B) respectively. N_{Ai} and N_{Bi} are the number of pixels in the i-the region (r_i) of group (A), and group (B) respectively. R includes all infected regions.

Table-1

MRE for group A and B

Group Type	Number of Images	MRE±SD
A	29	0.54±0.29
B	21	0.42±0.27

V. CONCLUSIONS

The color image segmentation procedure introduced in the above section is used to segment the images of Atopic Dermatitis diseases where it proved its success in the segmentation of the selected images of this disease. There are some aspects that make the proposed approach differs from others: a) It focuses on color regions recognition. Its objective is different from recent researchers such as transformation [15] of color image to enhance lesion borders to improve accuracy of the lesion boundary detection.

b) It does not stop at recognition of lesions but goes inside lesions for recognition of sub- regions within lesions as close to human perception as possible.

c) Color analysis implemented in this work is unsupervised.

ACKNOWLEDGMENT

The authors wish to express their deep appreciation to reviewers of this manuscript for their valuable comments that let to the successful completion of this work

REFERENCES

[1] Wm. D. Stewart, J. L. Danto, and S. Maddin, "Dermatology diagnosis and treatment of Cutaneous disorders". Fourth Edition, The C.V. Mosby Company-Saint Louis (1978).

[2] Sir R. B. Scott, "Price's textbook of the practice of medicine", English Language Book Society and Oxford Press, 12-th Edition (1978).

[3] D. Reinhardt, et.al. "Caesarean section and gastrointestinal symptoms, atopic dermatitis and sensitization during first year of life", Archives of Disease in Childhood, vol. 89, pp.993- 997, (2004).

[4] C. R. Gonzalez, and R. E. Woods, "Digital image processing", second edition, Addison- Wesley Publishing Company, (2002).

[5] R. Arthur, and Jr. Weeks, "Fundamentals of electronic image processing ", SPIE/ IEEE series on imaging science & engineering, IEEE Press (1998)

[6] W. K. Pratt, "Digital image processing ", second edition, John Wiley & Sons, New York, (1991)

[7] A. P. Dhawan, and A. Sicsu, "Segmentation of images of skin lesions using color and texture information of surface pigmentation", Computerized Medical Imaging and Graphics, Vol.16, pp.163-177, (1992)

[8] L. Xu, and M. Jackowski, " Segmentation of skin cancer images", Image Vision Computing, vol. 17, pp. 65-74, (1999).

[9] M. Sonka, V. Hlavac, and R. Boyle, "Image processing, analysis, and machine vision". Second Edition (1999)

[10] C. K. Chow, and T. Kaneko, "Automatic boundary detection of left ventricle from cineangiograms", Comp. and Biomed. Res., vol. 5, pp388-410, (1972).

[11] R. Duda, and P. E. Hart, "Pattern classification and scene analysis", John Wiley & Sons, (1973)

[12] D. Huawu, A. C. David, "Unsupervised image segmentation using simple MRF model with a new implementation scheme", Pattern Recognition, Vol.37, pp.2323-2335, (2004).

[13] R. F. Woolson, "Statistical methods for the analysis of biomedical data", John Wiley & Sons, (1987)

[14] J. Cohen, "A coefficient for nominal scales", Educational and Psychological Measurements, vol. 20, No.1,(1960).

[15] G. A. Hance, S. E. Umbaugh ,R. H. Moss, and W. V. Stoecker, "Unsupervised color image processing With application to skin tumor borders", IEEE Engineering in Medicine and Biology Magazine. January/ February (1996)