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Vitiligo detection techniques: A Survey

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Abstract- Vitiligo is one kind of skin disorder in which white patches are appearing in different parts of our body. It is a one kind of autoimmune disease. Our skin color concentration is mainly depending upon two components: Melanin and Hemoglobin. In vitiligo, your immune system may kill the melanocytes cell which is responsible for melanin pigment in the skin. So, as a result skin loses the melanin causes skin color so this situation is generally define as vitiligo. In this situation your skin pigment is lose. The national vitiligo foundation has calculated around that 0.5 to 1% of general people have vitiligo. Generally the treatment of this disease called as a re-pigmentation and it will take long time. It is complicated to determine the therapeutic changes visually because it is too time-consuming procedure and does not provide accuracy. Recently, image processing plays an important role in many field and has widely used for detection of skin disease. This paper presents the survey of various vitiligo detection techniques that is based on image processing and comprehensive study of these techniques is also carried out.

Keywords –Re-pigmentation, Digital Image Processing, Melanin, Vitiligo.

I. INTRODUCTION

Research has justification that our skin colors are due to the pigment components: melanin and hemoglobin. Whenever this pigment is lose it will causes different kind of skin disease. Vitiligo is a one kind of epidermal skin disease which is rising due to lack of melanin pigment. Generally, melanin is generated by melanocytes cells. Whenever, your immune system wrongly attack on your own body it will kill that melanocytes cells. So, your skin loses the melanin pigment and white patches are generated on different parts of your body. This situation is generally called as Vitiligo. Vitiligo treatment has two aims, to control disease succession and re-pigment the vitiligo affected area. Treatment of this disease is called as re-pigmentation. Visually to determine treatment efficiency is difficult because this re-pigmentation process is time consuming and we are not able to determine the therapeutic changes accuracy. Physician's Global Assessment (PGA) scale is the traditional scoring system to evaluate the progression report of the treatment [4].

Table 1- Physician's Global Assessment Scale [4]

Re-pigmentation	Scale
0-25%	Mild
26-50%	Moderate
51-75%	Good
76-100%	Excellent to complete

Here the limitation of PGA scale is variation in inter and intra observer [4]. So, to detect this therapeutic response of vitiligo some image processing based techniques are developed. This technique is able to detect vitiligo affected area. So, it will able to detect the shape variation after the treatment. So, using image processing based technique therapeutic response evaluation is possible and it also provides some kind of accuracy.
Rest of the paper organized as follows: Section 2 provides a basic overview of existing method available for the diagnosis of vitiligo. In section 3 image processing based vitiligo detection approaches are to be discussed. Then in section 4 the parametric comparison of this all approaches are to be carried out. Last section briefly concludes the paper.

II. RELATED WORK

There are so many techniques are available to estimates the therapeutic response of vitiligo. In 2012, Alghamadi et.al[9] classify the technique available for diagnosis and assessment of pigmentary disorder of the skin.

1. Subjective methods[9]
2. Semi-objective methods[9]
3. Objective methods[9]

Subjective methods: Subjective methods contain clinical assessment by dermatologist and visual comparison of the skin before and after treatment [9]. This method also provide vitiligo disease activity score (VIDA).This subjective methods are depend upon the judgment of the dermatologist. In this method images are captured at different times of treatment. Yet here it needed adequate scoring system. This standard scoring system will enable accurate and sufficient data collection that can be used for two purposes: Direct comparison, and the collection of results of treatments from different clinical trials. This class of techniques includes visible light and digital photography, Ultraviolet light photography, Vitiligo disease activity score.

Semi-objective methods: It consists of the vitiligo area scoring index (VASI) and point counting, diffuse reflectance spectroscopy [9].In this class two scoring system is used: VASI and VIDA.

VASI is the standard method to measure the value of re-pigmentation. In VASI body of the patients divided into 5 regions: hands, upper extremities, trunk, lower extremities, and the feet [9]. In VASI one formula is used for whole body given as below:

$$VASI = \sum(\text{all body size})(\text{hand} \quad \ldots(1)[9]$$

VASI is a subjective method because it needs the help of physician to determine the quantity of pigmentation and the region of involvement. Another method that is point counting is used to approximate the irregularity shaped surface regions to obtain the volumes of structures. Last one diffuse reflectance spectroscopy (DRS) that is based on different types of analysis of light reflected from the skin. DRS provide the quantitative information about the reflectance of light by the hemoglobin and melanin.

Objective methods: It consists of software based image evaluation, spectrophotometry, and confocal laser microscopy (CLM).

III. EXISTING APPROACH

A. Determination of Skin Repigmentation Progression[4]:

In 2007, hermawan et.al[ ] developed an image processing based technique to determine the area of skin that have undergone re-pigmentation. This approach use Tsumura et.al[4], for the spatial distribution of the melanin and hemoglobin. In this technique the analysis is based on skin color model with three suppositions: First the linearity is assumed in optical density domain of RGB channel. Second is spatial variation in skin color is caused by hemoglobin and melanin. The third one is the quantity of these both components (i.e hemoglobin and melanin) are mutually independent. After using this model PCA is applied for the dimension reduction purpose. So, as a result two dimensional subspaces can be representing by its first and second principle component and it is denoted by s1(x, y) and s2(x, y) represent the quantities of two color pigments on image coordinates,(x, y). After that two color vector of two pigments per unit quantity is calculated and it is denoted as a1 and a2 respectively. This process is generally called as independent component analysis. After that the segmentation is applied. In this approach they used median cut segmentation on the melanin extraction portion of skin color image to separate the normal skin lesion and vitiligo affected skin lesion. In median cut segmentation Euclidian distance is measure to map each pixel to its nearby segments. Finally percentage of re-pigmentation in each vitiligo lesion is calculated and generally this process is called as re-pigmentation measurement.

B. Assessment of Therapeutic Response in Skin Pigment Disorder Treatment[5]:

In 2008, ahmad et.al[5] developed other Image processing based technique in which first two phase is common and segmentation method is changed for getting better result. They use PCA for dimension reduction from 3(RGB) to 2 principle component. After that ICA is used to represent pure density vector of melanin and hemoglobin. As a result we get the images that shows the skin area due to melanin and hemoglobin. Then finally segmentation method is applied on the melanin images. Here they apply thresholding method that is based on Euclidian distance. This method segments foreground and background of skin images. At the end percentage of re-pigmentation in each vitiligo lesion is calculated.

C. Computerized image analysis of vitiligo lesion: evaluation using manually defined lesion areas[6]:

In 2011, hermawan et.al[6] developed approach which is also used PCA and ICA for getting separate component skin images (i.e hemoglobin and melanin). After that for getting better performance they use Region growing method for segmenting an image. Region growing is an image segmentation method process that cluster pixel based on predefined condition. In this method approach first set of seed points are calculated. From these seeds, segmentation regions grow by connecting to each seed those neighbouring pixels that have characteristics similar to seed point. In this first the intensity values for vitiligo affected area and for normal skin is calculated. After that using Euclidian distance Imax intensity is measured that maximize the separation between normal skin area and vitiligo affected area. In this approach they compare their results performance with manual segmentation and for this evaluation they considering parameters like Accuracy, Sensitivity, Specificity etc. This method provides better results than manual segmentation.

D. KL divergence based Agglomerative Clustering for Automated Vitiligo Grading[7]:

In 2015 Mithun et.al[7] develop an approach that is based on bottom up agglomerative clustering algorithm. They developed KL divergence agglomerative clustering algorithm for image segmentation This method is applied on the set of superpixel which is obtain by SLIC method proposed by Achanata et.al[7] which is able to provide convenient primitive from which local image feature can be evaluated. Vitiligo is one kind of epidermal skin disease leading to total or partial loss of skin color. This will results in higher reflection from affected skin area. They working on albedo and shading image for vitiligo region segmentation. In this method first they require RGB image then the number of final cluster Cf is generated. After that albedo and shading images are to be generated. From this generated images super pixels are to be obtain using SLIC method which is very fast and efficient. Finally the multidimensional feature set is generated. For performance evaluation they compare the results with other bottom up algorithm i.e MRF, SWAMNCut, Ground truth. So, ultimately they worked on accuracy parameter.

E. Development and clinical validation of a novel photography based skin pigmentation evaluation system: a comparison with the calculated consensus of dermatologists[8]:

In 2016 Cho et.al [8] developed a system for skin pigmentation evaluation and also compared their results with calculated consensus of dermatologist. It is a photography based technique in which in the photograph the region of interest (ROI) was manually selected by a user and the whole information about affected area including area, intensity and the number of pigmentation was produced. In this approach they work on luminance component. The original RGB image is converted into HSL space because they work on luminance component because it is used for effective pigmentation detection. So, they work on gray image. After that for removing noise from image they applied bilateral filtering. So, as a result noise reduced image is produced. Then for getting better results they develop one contrast enhanced technique that is discriminate equalization method. In this technique by creating a larger difference between the closed pixel and mean value of all pixels in the L space this method make possible the classification of pigmentation and ambiguous parts. After that this contrast enhanced image is passing through segmentation phase in which fuzzy entropy filtering is applied to extract the singularity in contrast image. Finally candidate area is generated on which the four level of classification is applied.

IV.PARAMETRIC EVALUATION

Table 2 - Comparison of various image processing based vitiligo detection techniques

Paper Title	Space Type	Advantages	Limitations	Segmentation Method	Performance Evaluation Parameters	Preprocessing Method	ROI

Determination of Skin Repigmentation Progression[4]:	RGB	Within short time it will able to determine re pigmentation progression objectively and treatment efficacy on shorter time cycle	Not provide good accuracy and images are not calibrated to standard size.	Median Cut segmentation	Accuracy	PCA,ICA	
Assessment of Therapeutic Response in Skin Pigment Disorder Treatment[5]:	RGB	It can be able to detect therapeutic changes in percentage whereas PGA provide in generalized terms.	This method is depend upon angle of incident and refractive index.	Thresholding Method	Accuracy	PCA,ICA	
Computerized image analysis of vitiligo lesion: evaluation using manually defined lesion areas[6]:	RGB	Provide more accurate result than in segmentation phase than the existing image processing based vitiligo detection technique	This method is depends upon angle of incident and refractive index.	Region Growing	Accuracy Sensitivity Specificity	PCA,ICA	
KL divergence based Agglomerative Clustering for Automated Vitiligo Grading[7]:	RGB	For better feature extraction they expose albedo and shading	This method is not able to identify stable regions	KL divergence agglomerative clustering algorithm	Accuracy Albedo Shading	SLIC	

Development and clinical validation of a novel photography based skin pigmentation evaluation system: a comparison with the calculated consensus of dermatologists[8]:	HSL	Able to provide morphometric changes accuracy	Not able to detect colorometric changes.	Fuzzy Entropy Filtering	Accuracy	Bilateral Filtering	✓

V. CONCLUSION

This paper gives a description of various vitiligo evaluation methods by using image processing from which researchers can get an idea for an efficient technique. This paper has made comparison of these existing method based on their advantage, limitation, their performance evaluation parameters, and the different kinds of segmentation techniques they applied for detection of vitiligo. In future, present methodologies can be expanded for detecting stable region of vitiligo, for variation of any skin color and variation in any intensity value of patches.

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