Thermal imaging method in the evaluation of psoriasis in upper limb region

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Abstract. Psoriasis is a dermatological disorder that most often causes scaling, itching and lesions on various regions of the skin. This study aims to focus on just the upper limb region affected by psoriasis and perform image acquisition using thermographic imaging. Each and every bodily disorder has a unique heat signature and respective temperature differences. Similarly, Psoriasis also has a typical heat signature that can be clearly observed on performing automated segmentation of the thermal images. The aim of this study includes automated segmentation and GLCM feature extraction in order to understand the nature of the disorder from the thermal images, and to characterize it in a more precise manner. The segmentation algorithm used for the purpose of this study is the Fuzzy C-Means algorithm. Segmentation is performed in order to clearly characterize the region of interest (ROI). The skin temperature differences in the ROI between normal and psoriasis affected hand are important to evaluate the latter. The segmented images’ features have to be extracted in order to clearly visualize the unique aspects of Psoriasis which may not be understandable upon just clinical trials. The GLCM features are extracted using the respective algorithms. The mean average temperature difference between the normal and psoriasis was found to be 2.91°C. The percentage difference between the normal and psoriasis in measurement of average temperature was found to be 9.57%. Thermographic imaging is a non-contact method of image acquisition and is being extensively used in present day for medical study. This study will help understand Psoriasis in a more elaborate and clarified manner and aims to be used as diagnostic tool in the future.

1. Introduction
Psoriasis vulgaris also known as plague psoriasis which is a chronic inflammatory skin disease with a strong genetic component, characterized by hyperkeratosis, dermal inflammatory infiltrate and increased angiogenesis [1]. In most cases Psoriasis is a genetic disorder. The gene variation causing it can stay dormant for invariantly long or express itself quite soon. In a study performed in 2007, it was observed that patients with history of skin disorders and skin infection carried the higher risk of developing psoriasis [2]. The usual indications of Psoriasis are scaling, skin lesions and redness. It can occur on the hands, legs, back, chest, nails, genitals etc. The most common form of Psoriasis is the plaque Psoriasis that causes the flaky skin lesions.
The prevalence of Psoriasis was understood in a study conducted in 2013. Three databases were searched in July 2011 during a survey. A total of 385 papers were critically appraised; 53 studies reported on the prevalence and incidence of psoriasis in the general population. The data indicated that the occurrence of psoriasis varied according to age and geographic region, being more frequent in countries more distant from the equator. In children, the incidence estimate reported (United States) was 40.8/100,000 person-years. In adults, it varied from 78.9/100,000 person-years (United States) to 230/100,000 person-years (Italy) [3]. According to this study and many more similar studies, approximately 2-3% of the world population are affected by Psoriasis. The prevalence of psoriasis in India ranges from 0.44% to 2.8% [4]. It has been increasing due to the modern stressful lifestyle, lack of adequate physical activities, and associated risk of metabolic syndrome. Studies have proved that there are more characteristic changes in adults compared to all other age groups.

The most common method of diagnosing Psoriasis is digital imaging and further clinical analysis of the nature of the skin lesions is done by a clinical biopsy. Various thermographic studies have been conducted in order to characterize psoriasis and its different forms. Psoriasis being a skin disorder, efficiently displays unique heat signatures which aids in the analysis. This study also uses a similar technique, a unique segmentation algorithm and GLCM feature extraction for specific characterization of the disease centralizing the same only in the upper limb region.

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According to recent studies, fuzzy C algorithm has shown a great promise in calculating and sorting of high end data. Various surveys are available which shows clustering and GLCM feature extraction techniques along with statistical data which proves for the efficiency of the techniques. Tanya et al performed accurate segmentation of psoriasis images using k-means algorithm based on (L*a*b) colour space and found that k means clustering exhibits great accuracy and there were effective results in segmentation [8]. Manoranjan et al implemented automated skin lesion segmentation using modified U-Net-based fully convolutional network in psoriasis patients [9].

The main aim of this study is to conduct a skin temperature analysis in Psoriasis patients by performing a comparative study between normal and Psoriasis patients using thermal image processing. The objectives of the study are a) To obtain skin temperature in Psoriasis patients using thermal image processing. b) To perform automated segmentation and feature extraction in the extracted thermal images obtained from the psoriasis and normal patients.

The most important function of image segmentation using the Fuzzy C-Means algorithm is to clearly segregate the ROI, in order to be clearly be able to see the difference between the normal and psoriasis affected hands. When furthering towards feature extraction, the important features such as temperature, entropy etc. are used as means to understand the abnormality.

2. Methodology

2.1. Image Acquisition

For the purpose of this study, 10 normal patients (unaffected by psoriasis) and 10 psoriasis patients have been taken into consideration. Image acquisition was performed using the thermographic imaging method. Thermographic imaging is a non-contact diagnostic and research tool used extensively recently. Due to its simplicity in usage technique and accuracy in displaying abnormality in temperature, it is being used in studies. In this study we captured thermal images of the palm and forearm regions of affected and unaffected people to observe temperature differences. The methodology is shown in figure 1.
2.2. **Image Pre-Processing**

Image Pre-Processing is basically a method used to make the image ready for further segmentation and other processing. For this purpose, the FLIR Tools software was used. The FLIR Tools software provides color palettes in order to choose the correct color composition of the thermal images. This is important in order to evidently be able to observe the temperature differences between the images. For this research, the Rainbow color palette has been used to observe specific redness in the regions that show skin lesions for psoriasis affected people; and an evenly spread out warm or cold temperature gradation in unaffected people.

2.3. **Image Segmentation**

Image segmentation is done in order to clearly isolate just the ROI so that, the other unwanted regions of the images do not interfere in the process of further characterization. For this study, the Fuzzy C-Means algorithm has been employed for segmentation [10, 11]. Fuzzy C Means algorithm works on assigning a data point in accordance with center of the cluster such that nearer the data point more is the probability of the data point belonging to that cluster.

The chosen algorithm is expressed in the below mentioned manner:

i. Choose suitable cluster centre.

ii. Compute the fuzzy membership function

\[
\mu_j = \frac{1}{\sum_{i=1}^{K} \left( \frac{d_i}{d_j} \right)^{2^{(m-1)}}} 
\]

iii. Calculate the fuzzy centre. The centroid of the cluster that is the mean point of all data points is given by:

\[
\mathbf{v}_j = \frac{\sum_{i=1}^{n} \left( \mu_j \right)^m \mathbf{x}_i}{\sum_{i=1}^{n} \left( \mu_j \right)^m}, \forall j = 1, 2, \ldots, \phi 
\]

Where, \( k \) is the iteration step

iv. Repeat the steps ii and iii, so that objective function is satisfied.
2.4. Feature Extraction (GLCM Features)
Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. The Gray Level Cooccurrence Matrix (GLCM) method is a way of extracting second order statistical texture features. The approach has been used in a number of applications. Third and higher order textures consider the relationships among three or more pixels. These are theoretically possible but not commonly implemented due to calculation time and interpretation difficulty.
(a) Energy is the square of the pixel values present in the feature extracted image in a square inch of the image is called as the energy or magnitude of feature extraction.
(b) Entropy is the measure of randomness and non uniformity exists in the image grey levels.
(c) Contrast is the element difference moment of order 2, which has a relatively low value when the high values of C are near the main diagonal.
(d) The homogeneity of a region of an image is related to the changes of intensity that appear in that region.
(e) Correlation is the relationship between the first processed image and the next processed image in order is called correlation between images.

3. Results and Discussion
In this study, two groups of 10 individuals were analysed. The first group was normal patients and the latter is psoriasis patients. Hand regions of all the individuals were imaged using FLIR thermal camera. The thermal images were acquired and segmented using fuzzy c-means algorithm and feature are extracted using GLCM method. Figure 2 represents the skin temperature measurement at normal hand and Figure 3 indicates the skin temperature measurement at psoriasis affected hand.

![Figure 2. Temperature difference for Normal.](image-url)
Table 1. Maximum temperature, minimum temperature and average temperature for normal and Psoriasis hand images.

| Temperature parameters | Normal hand       | Psoriasis hand  |
|------------------------|-------------------|-----------------|
| Maximum Temperature    | 34.32±0.9         | 37.62±0.9       |
| Minimum temperature    | 26.44±1.2         | 28.96±1.09      |
| Average temperature    | 30.38±1.3         | 33.29±0.7       |

Table 1 indicates the skin temperature measured at normal hand region and psoriasis affected hand indicating inflammation. The mean average temperature difference between the normal and psoriasis was found to be 2.91 °C. The percentage difference between the normal and psoriasis in measurement of average temperature was found to be 9.57%. Figure 4a indicates the normal hand image and figure 4b depicts the segmented hand image using Fuzzy c-means algorithm. Similarly, Figure 5a represents the psoriasis affected image and figure 5b indicates the segmented psoriasis affected image indicating the inflammation. After segmentation, feature extraction were performed and the features such as energy, entropy, contrast, homogeneity and correlation were extracted from the segmented image in table 2.

Figure 4 (a). Input image (Normal). (b). Segmented image (Normal).
4. Conclusion

Through the means of this study, the significant temperature differences between unaffected hands and psoriasis hands were clearly identified. Furthermore, the segmentation and feature extraction processes have distinctly characterized the abnormality and differentiated it from the normal cases. This imaging can be helpful to find out the affected person without any invasive techniques on real time. The mean values and standard deviation values for a psoriasis hand image and a normal image clearly shows the difference between the two variants as mentioned below respectively 0.781±0.12 and 0.68±0.18.

As mentioned before, each abnormality in the body emits a different heat signature. Thus, heat signature is captured by the thermographic camera. In the case of psoriasis, when the GLCM features of the thermal images are extracted, the corresponding features are unique to Psoriasis. Psoriasis occurs due to inflammation in the skin; hence the temperature was elevated due to inflammation in psoriasis affected hand compared to normal. Moreover, in a lot of cases, the lesions and scaling are also visible under the thermal camera. The thermographic imaging technique has been specifically used since it's a non-contact method and that on a first scale basis detects an abnormality in the heat signature. This imaging sometimes also detects scaling of the skin which is a unique feature to psoriasis.

5. Future Scope

Diagnosis and classification of psoriasis involved both invasive and non-invasive techniques. The imaging technique can be used a complimentary technique in the detection of psoriatic disorders. The accuracy for psoriasis lesions characterization verifies that these distinctive features are robust and gives insight into the improved segmentation approach which is used for detecting the affected region.

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