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Psoriasis is a chronic skin disease affecting an estimated 125 million people worldwide. One of the key problems in the management of this condition is the objective measurement of lesion severity over time. Currently, severity is scored by clinicians using visual protocols leading to intra and inter observer variability that makes measurement of treatment efficacy subjective. In this paper, an automatic computer aided image analysis system is proposed that quantitatively assess the changes of erythema and scaling severity of psoriatic lesions in long-term treatment. We develop a method to segment psoriasis lesion in the early stage of diagnosis. In this stage region of interest is very clear that help the k-means clustering to achieve accuracy segmentation. This method has produced a mask which includes the region of interest as white color and background as black color. In the second diagnosis level (scan the region of interest), if the patient case has enhanced, the region of interest will disappear and that will affect the segmentation method and make it a difficult challenge. To avoid this problem we have used the mask of the early stage scans and applied on the second scan image to see the difference between the two regions scan. This process helps us to evaluate severity changes the patient case enhancement on erythema and scaling of lesions. The algorithm proposed in this paper works on 2D digital images by selecting features that can be used to accurately segment erythema and scaling in psoriasis lesions and assess their changes in severity, according to the popular psoriasis area and severity index (PASI). The algorithms are validated by developing objectives that correlate well with changes in severity scores given by dermatologists. To the best of our knowledge, no such computer assisted method for psoriasis severity assessment in a long-term treatment exists. Monitoring severity change psoriasis lesion measures are highly correlated with the dermatologist's decisions than PASI. This and the fact that the obtained measures are continuous indicate the proposed methods are a suitable tool to evaluate the lesion and to track the evolution of dermatological diseases. These systems were evaluated by a number of dermatologists with different experiences.

Keywords: scoring; PASI; the doctor scoring; psoriasis lesion disease; segmentation lesion.

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I. INTRODUCTION

Psoriasis is a chronic skin disease with no known cure and there are currently an estimated 125 million people worldwide suffering from this disease. A psoriatic lesion manifests as red inflamed skin (erythema) typically surrounding, or partially surrounding, scaly flaky skin (scaling). Pills, balms and radiation treatments are available to control the symptoms of psoriasis, but there is no generally accepted standard treatment for psoriasis. Different dermatologists will treat the same symptoms differently. Further, due to the chronic nature of psoriasis, treatments usually span long time frames. The symptoms may change

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with remission, relapse or rebound. To monitor psoriasis, lesions need to be evaluated over a time period [1]. Time-based evaluation will also aid research into psoriasis treatment and clinical practice by facilitating objective treatment comparisons to determine the most effective treatment methods. This paper presents a computer aided image analysis system that to the best of our knowledge is the first to automatically evaluate the changes in severity of erythema and scaling in a long-term psoriasis treatment. Existing methods either manually record the changes or are only applicable to a short-term change assessment. Currently, dermatologists monitor changes of psoriasis by recording psoriasis severity scores over time. A widely used severity scoring system is the PASI score, which requires estimates of the percentage of skin area covered by psoriatic lesions and grades the severity of erythema and scaling. PASI scores for erythema and scaling are currently estimated visually by dermatologists, however, doing this results is unavoidable inter and intra observer variation. The aim of this research is to develop a reliable change assessment system to quantitatively assess the changes of erythema and scaling severities of psoriatic lesions. Computer-aided analysis has been introduced into the area of psoriasis severity diagnosis for a number of decades, but only a very few systems have been implemented that focus on analysing the changes in psoriasis lesions. The only system so far is given in [2], where lesion changes are analysed through lesion image subtraction after registering images of the same lesion. The registration is implemented based on an assumption that in the treatment the psoriatic lesion boundaries do not change and the changes only happen inside the lesion. However, the assumption is only valid for a short term treatment. In long term treatments, psoriatic lesions do not only change within their boundaries, but also the boundary itself changes. Thus change analysis through image registration of the lesions is not suitable for comparisons in chronic treatment [3], [4]. In this paper, we propose a set of features for assessing changes in psoriasis severity for the long term. The features are based on our previous work on erythema and scaling segmentation of the lesion [5]. For comparison with the algorithms, the ground truth is chosen to be the difference in PASI severity scores and dermatologist's rankings between the two time points for the same lesion.

Psoriasis Area and Severity Index (PASI) is one of the most widespread methods [7] in clinical treatment and research. In [8] *Naldi* reviewed 44 scoring systems used in 171 clinical trials of psoriasis therapies and observed that the PASI scoring was used in about half the trials. PASI scoring was proposed by *Fredricksson and Pettersson in 1978* for use in a single clinical trial, and subsequently became popular. PASI gives a single index that captures the severity in four different body regions: head (occupying 10% of total body surface), upper limbs (20%), trunk (40%), and lower limbs (30%), each of which is weighted based on the proportion to the whole body surface area. In every region, the affected area is graded on a 0-6 scale corresponding to the percentage of coverage. Additionally, the severest psoriasis lesion is picked out in each body part and is rated on a scale of 0-4 by assessing the three symptoms visually: redness, thickness and scaliness. The final score of psoriasis severity is the sum of the scores for the three symptoms, together with the area affected based on the weighting for each region. The equation of the PASI scoring is expressed below:

$$PASI = 0.1(R_h + T_h + S_h)A_h + 0.2(R_u + T_u + S_u)A_u + 0.3(R_t + T_t + S_t)A_t + 0.4(R_l + T_l + S_l)A_l$$

Where R_i, T_i, S_i and A_i are the redness, thickness, scaliness and area scores for different regions of the body, where the subscript $i \in$ {h, u, t, l} indicates the regions head (h), upper limbs (u), trunk (t) and lower limbs (l) respectively. The range of PASI score is from 0 to 72, and this score is discrete, with increments of 0.1 values [9].

Table 1 shows a description of stratification for erythema, scaliness and thickness [10,11,12].

Table 1: Description of stratification lesion for erythema, scaliness and thickness

Severity	Scores	Erythema condition	Scaliness condition	Thickness condition
Mild	1	Light red	Partial coverage of lesion with fine scales	Slight elevation
Moderate	2	Red between light red and dark red	Major coverage of lesion with fine to rough scales	Moderate elevation
Severe	3	Dark red	Major coverage of lesion with rough and thick scales	Deep elevation
Very severe	4	Very dark red	Complete coverage of lesion with very rough and very thick scales	Very Deep elevation

II. RELATED WORK

Many researchers have conducted many studies and researches in medical image segmentation to solve psoriasis disease based on many factors such as according to differences intensity and color. According to *David Delgado* [6], presented combined statistical and image analysis methods to automatically evaluate the severity of scaling and redness in psoriasis lesions. The method realises a hierarchical segmentation to isolate the different structures present in the image normal skin, red area and scales. Results showed that scores are highly correlated with scores made by physicians. *David Delgado Gomez et al* [2], presented a comparative study of the available change detection techniques applied to change visualization and quantification in bi-temporal psoriasis images. The chosen methods are evaluated at a time series of psoriasis images and results are compared with dermatologists' scores.

III. MATERIALS AND METHODS

3.1 Materials

In this research work, we have gathered colored imageries from the psoriasis section of Ramadi teaching Hospital, Ramadi, Anbar under the supervision of a dermatologist. The images were processed in Joint Photographic Expert Group (JPEG) format with color depth of 24 bits per pixel. For this work, a total of the images includes 44 psoriasis colour images that amounted in a total of 22 for the first period and 22 after six months of treatment for the same lesions. Fig 1 shows the diseased skin samples.

The contribution of this paper is to propose model, The assesses the severity changes for long-term of treatment. We develop methods to assess the severity changes without registration of psoriatic lesion images automatically. As explained in the next sections, the previous work on the assessment of changes relies on the registration of lesions in different images. This is only available for short-term treatments, since the boundaries of psoriatic lesions are almost the same in the before/after psoriasis images photographed in short- term treatments. In long-term treatments, not only does the content of the lesion change, but also the boundaries of the same lesion can dramatically change. Therefore, it is hard to conduct lesion registration in this situation. See Fig 1 as an example of images of the same lesion taken different time apart. Physicians are visited by the patients several times to control the evolution of the disease. However, due to the fact that no objective methods to summarize the lesion exist, physicians make scoring and take notes to document the actual condition of the patient. A drawback of this method is the dependency on the individual physician. An experiment over a collection of psoriasis images is conducted to test the performance of the methods. Results show that the obtained scores are highly correlated with scores made by doctors. This and the fact that the obtained measures are continuous indicate that the proposed methods are a suitable tool to evaluate the lesion and to track the evolution of dermatological diseases. Different values are obtained from these areas and they are used to approximate the doctor scoring.

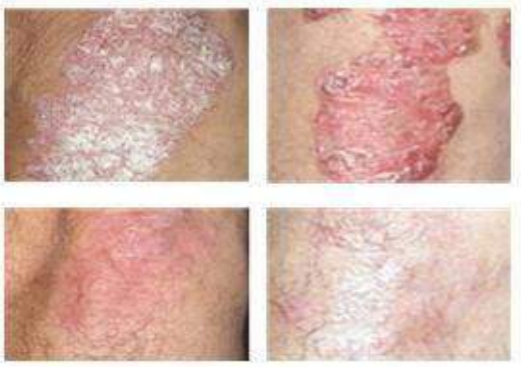


Fig. 1: An example of the before-after images taken in a psoriasis treatment. The first row photographed before treatment, the second row photographed after six months of treatment for the same lesion

Since the psoriasis is a chronic disease, it is important to track the condition of the patient to select a proper treatment and to track the condition improvement of the patient. Our proposed model reveal that the severity changes are assessed lesion image registration and without lesion image registration. This section begins with a presentation of these methods, including descriptions of the proposed severity change features. This is followed by an analysis of the consistency between the severity change models and severity scores evaluated by clinicians in the experiments. It is shown that using the proposed method to assess the severity changes is reliable.

3.2 Methods

3.2.1 The proposed framework

Observe from Fig 1 that the severity of erythema and scaling is closely related with the composition of the lesion, and consequently that changes in severity are also related to changes in the composition of the lesion. Given a 2D image of a psoriasis lesion, the first step is to segment the elements of the psoriasis lesion, and in particular, to segment erythema and scaling within a lesion. In our work this is done not separately. Segmenting out erythema and scaling allows the calculation of severity of erythema, scaling area and the whole lesion area.

Since the psoriasis is a chronic disease, it is important to track the condition of the patient to select a proper treatment and to track the condition improvement of the patient. Our proposed model reveal that the severity changes are assessed without lesion image registration. This section begins with a presentation of these methods, including descriptions of the proposed severity change features. This is followed by an analysis of the consistency between the severity change models and severity scores evaluated by clinicians in the experiments. It is shown that using the proposed method to assess the severity changes is reliable.

Determining the lesion area is the first step towards the assessment of severity changes. In our previous work [5], an algorithm for segmenting lesion from normal skin is given using a L*a*b color space followed by *k*-means clustering scheme with k value two clusters depending on skin components of the melanin and hemoglobin. *Segmentation Framework:* the chart shows the mechanism the monitoring the treatment for the long term, the segmentation process is applied on the lesion before the treatment, then utilized the segmented process as mask on an image after the treatment. *Monitoring Framework:* the lesion has extracted from the background by using color feature, then features are extracted of the lesion for monitoring severity change the lesion, assess the lesion by two factors: erythema and scaling. Shown in Fig 2.

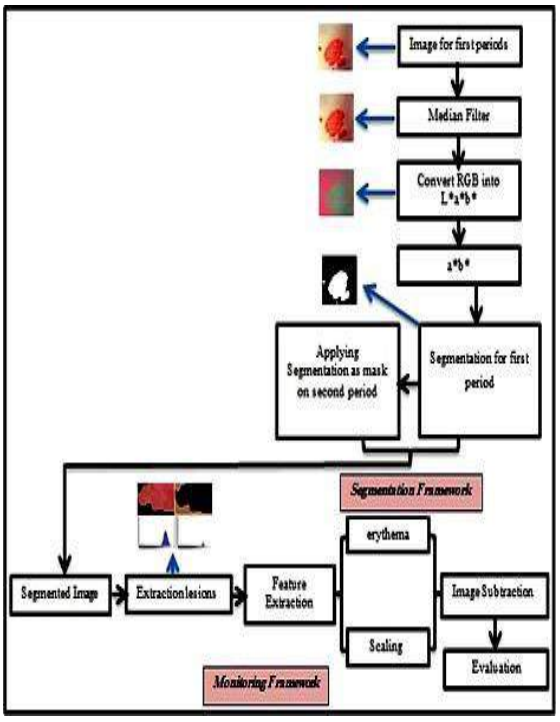


Fig. 2: The proposed system for monitoring the treatment efficiency

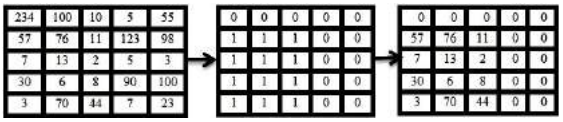
3.2.2 Erythema and Scaling Segmentation

We proposed *k*-means clustering algorithm for segmenting the lesion depending on color information as shown in [5], monitoring the lesion for long term did not find any sign of the registration the psoriasis lesion or when the color difference between the two objects is small. So, the segmentation with *k*-means method is not accurate because the improvement of lesion is very great, we faced a great challenge as shown in Fig 3.

(a) (b) (c) (d)

Fig. 3: (a) Original image. (b) Median filter. (c) L*a*b* color space. (d) Shows segmentation stage, difficult segmentation and not accuracy

So we proposed developing methods to solve this problem: applies *k*-means clustering algorithm on the psoriasis image before the treatment, then we take lesion segment and apply it as a mask on the image psoriasis after six months or more of treatment to discover severity change in the lesion. The development method gives wonderful results for monitoring the efficiency of treatment and to assess the severity changes without registration of psoriatic lesion images. See Fig 4 which shows a mask operation. The value 1 is a location segment lesion on image before treatment. The value 0 is a location of a normal skin.



(a) (b) (c)

Fig. 4: Shows mask operation. (a): Original image after treatment. (b) Segment lesion before treatment keep segment as a mask. (c) Applying a mask on the image after treatment

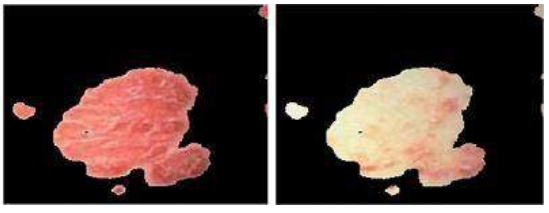
The algorithm 1 shows this developing method.

Algorithm 1: Segmentation Without Registration Lesion

Input: Image lesion
psoriasis Output: Image segmentation
Goal: Segmentation without the registration of lesions

Step1: We segmented psoriasis lesion before treatment
Step2: Saving locations lesion as a mask with value 1 and non-interesting object with value 0
Step3: After that we apply a mask on the psoriasis image after treatment
Step4: For each value equals to value1,
- We fetch pixels of origin image after treatment.

Step5: Then we return an image with the same area of segment before the treatment
Step6: Finally, we calculate redness and scaling features at two different time points



(a) (b)

Fig. 6: (a) Shows segment of the lesion psoriasis image before treatment. (b) Shows the application the same segment as a mask on the psoriasis image after 6 months of treatment

3.2.3 Severity Change Features of Erythema and Scaling

We use the features of the segmentation algorithm and the segmentation results to quantify the change in lesion severity and specifically on erythema and scaling as shown in [5].

Erythema of psoriasis lesion is related to the degree of skin inflammation and it reflects the severity of redness in psoriasis lesions. Features recognizing and classifying the redness of skin could be considered as good features for psoriasis lesion which can contribute to the whole system of psoriasis image classification. Keeping this in mind, three features can be extracted which indicate the redness of the skin i.e., aggressiveness of red to green, aggressiveness of red to blue, and redness as the ratios of mean values of the R, G and B, where μR, μG and μB represent the mean values of R, G, and B color component of RGB color space. We proposed using the R-band feature in the RGB color space is considered for the erythema severity scoring. By the color histogram feature of RGB color space, then the mean R μR of red channel is calculated applying the following function.

$$Erythema = \frac{\sum density\ red\ pixels\ of\ the\ lesion}{No.\ pixel\ classified\ as\ redness} \quad (1)$$

The scale feature in lesions represents white (brightness) colors and notices the variations intimate to lesions, thereby the anticipated procedure appropriates the grouping of image bands to be a principal constituent towards independent histogram and convert to grayscale images by means. The threshold employed with uppermost threshold values of histograms, every pixel with values between (240-255) of the density has been estimated, see Fig 7. Subsequently, by calculating the number of pixels classify as scaling, by using the function to calculate ratio scaling of the lesion. The algorithm 2 describes the process. The steps of the algorithm are as follows:

Algorithm 2: Extracting Scaling of The Lesion

Input: Color image
Output: Scales feature
Goal: Calculating scales in the lesion

Step1: Converting the image into 2-D a grayscale image.
Step2: Counting No. Pixel classification as scale (brightness) between 240-255 scale of the density
Step3: Calculate the scale area as calculated by ***Gomez et al, in 2007***:

$$Areascaling = \frac{No.pixel\ classified\ as\ scale}{Area\ of\ the\ lesion} \quad (2)$$

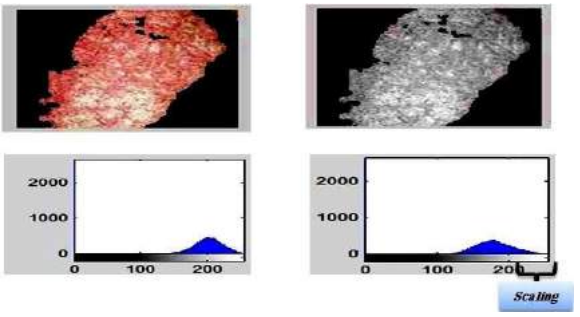


Fig. 7: Column (a) shows red channel and a histogram. Column (b)shows a grayscale image and histogram Changes in lesion severity are described by a subtraction between the severity features of a lesion at one time point and the features of the same lesion at another time point. A general severity change function D(X) is expressed as:

$$\Delta D(E,S) = X2(E,S) - X1(E,S) \quad (3)$$

Where $X2$ is the severity features at the second time point, and $X1$ is the severity features at the first time point. the change in erythema severity within a lesion can now be defined by the redness severity change feature set, which is related to changes of the relative quantities of redness of histogram for the red channel. E S the change in scales severity within a lesion can now be defined by the scales severity change feature set, which is related to changes of the relative quantities of white pixels in a grayscale image.

IV. EXPERIMENTAL VALIDATION

Psoriasis skin images are collected from a number of sources the imaging environment is carefully set to ensure controlled illumination. The set of images was chosen to include various skin types. The images for a specific lesion were collected at two different time points and given PASI scores and dermatologist's rankings by a dermatologist. Only those images that were given identical PASI scores and dermatologist's rankings by the dermatologist for both time points were selected. For comparison with the algorithms, the ground truth is chosen to be the difference in PASI severity scores and dermatologist's rankings between the two time points for each lesion. We note that a straight subtraction of severity scores between two time points may yield a negative value indicating a decrease in severity, or a positive value indicating an increase in severity. The situation is symmetrical for our analysis. In this case, only severity decrease is considered in the experiment. Additionally, when zero is given by subtraction of severity scores, it may imply that the severity change could not be recognized by dermatologists. Table 1 shows the results for 22 images with erythema severity changes and Table 2 shows the results for 22 images with scaling severity changes for the long term.

In Tables 1 and 2 the "PASI Score before" and "PASI Score after" are the severity scores given by a dermatologist at the first time point and the second time point respectively. The "D. Score " is the severity change scores given by a dermatologist if -1 decrease severity, if +1 increase severity and if 0 refers not changes in severity of psoriasis lesions. It is used by *Gomez et al, in 2007*. The results will match the doctors scores. Different values are obtained from these features and they are used to approximate the doctor scoring.

$$f(x) = \begin{cases} -1, & if\ x < 0 \\ 0, if\ 0 \le x < 0.012 \\ +1, & if\ x \ge 0.012 \end{cases} \quad (4)$$

The purpose of this comparison was to assess the involved change of psoriasis lesion before and after different anti-psoriasis treatments using the Computer Image Analysis (CIA) system and human eye for doctors scores and PASI.

In columns 2 and 4 of tables 1 and 2 refer feature extracted (erythema and scaling for long term) by proposing algorithms at the first time point and the second time point respectively. In column 7 of tables 1 and 2 refer to severity change features of the subtraction image process of severity scores. Table 1 shows the experimental results for severity change redness of the lesion.

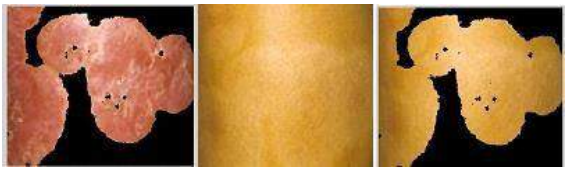


Fig. 8: Shows segmented as mask process

Table 2: Erythema severity change scores with the severity change features and the before-after treatment for a long time

Index	Severity Redness Lesion before	PASI Score before Redness (0-4)	Severity Redness Lesion after	PASI Score after Redness (0-4)	Change PASI Score	Change severity	D. Score
1	156.1731	2	158.9142	1	-1	2.7411	-1
2	212.9120	3	172.7055	0	-3	-40.2066	-1
3	227.5433	3	0	0	-3	-227.5433	-1
4	225.4975	2	81.3333	1	-1	-144.1642	-1
5	213.9814	2	168.3043	0	-2	-45.6771	-1
6	193.1651	3	170.5469	0	-3	-22.6182	-1
7	203.2937	3	181.7252	0	-3	-21.5684	-1

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8	215.0190	3	147.8519	0	-3	-67.1671	-1
9	217.7194	3	127.2400	0	-3	-90.4794	-1
10	204.5251	3	167.3625	1	-2	-37.1627	-1
11	203.5606	3	161.7486	1	-2	-41.8120	-1
12	216.8542	3	185.9413	0	-3	-30.9128	-1
13	183.7717	3	169.3432	0	-3	-14.4285	-1
14	208.3042	2	193.7579	1	-1	-14.5463	-1
15	212.9171	3	192.6316	1	-2	-20.2855	-1
16	194.6578	1	164.0204	1	-0	-30.6374	-1
17	153.4264	3	147.3454	1	-2	-6.0810	-1
18	187.9873	2	182.0964	0	-2	-5.8909	-1
19	195.8928	3	174.6143	0	-3	-21.2785	-1
20	223.1629	2	192.9419	1	-1	-30.2209	-1
21	164.7064	1	154.3671	0	-1	-103393	-1
22	176.2479	1	166.2686	1	-0	-9.9792	-1

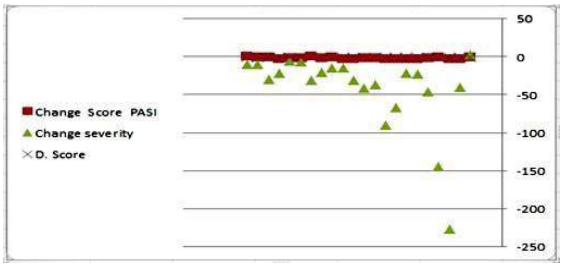

Fig. 9: Distribution of redness severity change features in Table 1 and the severity change Score

The results will match the PASI scores exactly, except for the difference index 16 and 22. This means The redness measurement is more accurate for the assessment of small severity changes which PASI is not able to measure them while the results will match the doctors scores exactly, except for the difference index 1. Table 2 shows the experimental results for severity change scaling of the lesion.

Table 3: Scales severity change scores with the severity change features and the before-after treatment for a long time

Index	Ratio Scaling Lesion before	PASI Score before Scales (0-4)	Ratio Scaling Lesion after	PASI Score after Scales (0-4)	Change PASI Score	Change ratio	D. Score
1	4.7072e-05	3	4.7072e-05	1	-2	0	-1
2	0.0695	2	4.0683e-05	0	-2	-0.0695	-1
3	1.3016e-04	2	1.3016e-04	0	-2	0	-1
4	7.0502e-05	2	7.0502e-05	0	-2	0	-1
5	0.0904	3	2.0994e-04	1	-2	-0.0902	-1
6	3.8310e-05	2	3.8310e-05	0	-2	0	-1
7	7.5592e-05	2	7.5592e-05	0	-2	0	-1
8	6.1275e-05	3	6.1275e-05	0	-3	0	-1

9	5.8048e-05	2	5.8048e-5	0	-2	0	-1
10	3.6929e-05	3	3.6929e-05	0	-3	0	-1
11	4.8558e-05	2	4.8558e-05	0	-2	0	-1
12	3.8542e-05	2	3.8542e-05	0	-2	0	-1
13	3.9939e-05	3	3.9939e-05	0	-3	0	-1
14	4.0399e-05	2	4.0399e-05	0	-2	-0.0085	-1
15	0.0085	3	5.5797e-05	0	-3	-0.0010	-1
16	0.0011	2	3.4528e-05	1	-2	0	-1
17	5.7127e-05	1	5.7127e-05	0	-1	0	-1
18	8.2142e-05	1	8.2142e-05	0	-1	0	-1
19	9.2764e-05	2	9.2764e-05	0	-2	0	-1
20	7.8771e-05	1	7.8771e-05	0	-1	0	-1
21	7.5131e-05	2	7.5131e-05	0	-2	0	-1
22	5.1096e-05	2	5.1096e-05	1	-1	0	-1

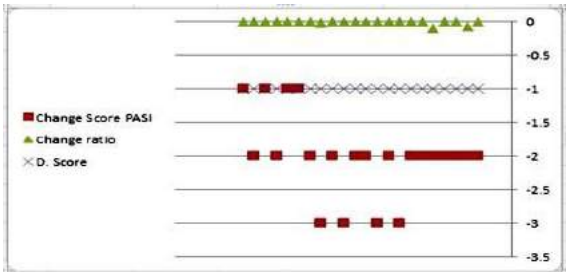

Fig. 10: Distribution of scale severity change features in Table 2 and the severity change score

The results of the subtraction process of extracting features are equal to zero, this didn't mean it do not occur any improvement in the lesion, because the skin didn't come back normal again. Even if the highest improvement in the lesion where the skin becomes more white than other normal skin. So when we calculate the scaling severity change in the long term, the results were negative and zero which means decrease severity. So the results will match the PASI score and the doctors score exactly. When evaluating the monitor system proposed with two ground truth PASI and doctor's score, the results of the system match the doctor's score exactly except for some cases.

Table 4: Shows accuracy of the monitoring severity change system

Features	Long term model
Area	--------
Redness	95.45%
Scaling	100%
Average accuracy of all features	97.72%

V. CONCLUSIONS

In this paper, a procedure to quantify the changes of erythema severity and scaling severity is presented. The erythema severity change features and the scaling severity change features are developed according to PASI severity scoring instructions. Severity change features determined by the algorithms are strongly correlated with the PASI severity scores given by dermatologists. Moreover, the algorithm shows promise for automatically quantifying severity changes in psoriasis lesions. In the future, we will further

investigate the severity change features, especially the roughness features in scaling, as well as collecting more lesion samples to explore relationships between the severity features resulting and PASI severity scores, and to improve the result of the severity change quantification.

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