Automatic Acne Detection for Medical Treatment

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***Abstract*—In this paper, an effective image processing technique has been studied to develop a system of acne detection. The focus is on binary thresholding applied to facial images with various types, shapes or amounts of acne. A typical image on a cheek has been usually used to take in the experiment which results are markings on acnes automatically, this method is more effective than manual counting by a typical dermatologist. An input image is first taken into gray and special color model from regular red-green-blue version, this work is for comparison and revelation of region of interest. The regions of interest are mostly acnes but it can contain some noise. Then binary threshold has been used to clearly show and can remove the noise easier from regions of acne. A box shape is constructed to mark the final result of acne detection, so that correct and incorrect detected acne can be displayed and calculated for a system efficiency. Experimental output can be summarized that accuracy, precision and sensitivity are quite fluctuated depending on color, shape and lighting condition of acnes in the image.**

Keywords—image processing, acne detection, binary threshold

I. INTRODUCTION

Having a beautiful skin is popular and influenced on the society nowadays as it is seen that beauty clinics have been increasing more and more. The face problem that is usually found is that having acnes. Most teenagers and adults are facing the problem of having acnes on their face and they later become cystic acnes which happen after inflammatory acnes. The cause of acne is changes in hormones in the body. It can also be because of other factors such as skin condition, stress, unhealthy food, hot and cold weather and medicines.

Skin analysis is one of the important procedures before getting any treatment. The most popular skin analysis is to manually count and mark acne on the patient's face but this is not reliable and inaccurate number of acnes can be retrieved. Also, it takes a lot of time and effort [1], [2], [3]. Thus, there is an evolution on creating computer-aided detection program in recent years [4]. Regular way to detect acnes is to use shape detection. It can be edge detection, blob detection, brightness with RGB detection features. Edge detection is the way to capture a sudden change in image intensity which is an edge of every object in image. Blob detection is like development of edge detection technique, this is worked by capture objects with edge of circle. For brightness and RGB detection, it utilizes intensity and color of image to specifically define facial acnes. But there are advantages and disadvantages for each method, so that we can improve a system.

Most skin analysis systems require manually outlining the regions of interest (ROIs) [5-6, 7]. However, manual ROI outlining is commonly known as a time-consuming and non-repeatable Process. In skin clinics, a widely used skin analysis system, VISIA, acquire images from various wave lengths to detect skin spots [7]. However, system still relies on manual ROI Outlining to obtain high-accurate results. Besides, it is very expensive.

For example of previous work, Phillips studied about polarized light photography to observe the comedo and acne to be used in counting. Polarized light comes from electric and magnetic fields vibrate in a single plane. Skin features, color, lighting and framing are enhanced in polarized photo, so acnes are easily found. [8] Hideaki Fuji uses a multispectral image (MSI) is an image data at wide range of the electromagnetic spectrum. The MSI is used to be able to differentiate several types of skin lesions such as comedo, reddish papule, pustule and scar. But there are limitations which is it still requires manual inspection. [9] Humaynn utilizes a template matching approach used for locating the correlated object and it is applied for localizing the acne lesion. This approach proved to be affective for counting and recognizing of lesions by letting a system learn the appearance of acne in advance to do matching. [10] Cula employed multispectral imaging and linear discriminant functions with a time varying component into acne detection and counting system. Gaussian mixture models have been used to detect and register facial acnes over multiple time points, so there must be an alignment technique to synchronize pictures from several times. [11]

In this proposed paper, an automatic detection and counting acnes on facial image is introduced. An input image can be any parts of face which have acnes and lesions. First, RGB image must be changed into gray-scale and HSV image, so that it can be easily calculated and brightness controllable. In order to calculate, gray data has to be normalized and subtract from HSV model to obtain ROI. Next step is making binary image to clearly see ROI, then we can apply a method of small spots and large region elimination to classify which is acne and which is not. These coordinates are used to mark

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constructed boxes onto locations of acnes, this is final step to take an output.

II. PROPOSED SYSTEM

This overall proposed system is processed by MATLAB program as an image processing module. For now, it can only detect acnes in side-facial image, left and right side separately. Exact positions of acne will be output in image marking form. Fig. 1 presents processes of the proposed approach, which includes convert RGB color input image to gray-scale image, Find maximum intensity, Retrieve HSV color image from RGB input image, Extract only brightness (V) image from HSV model, Subtract normalized gray-scale value out of brightness (V) image, Threshold in image, from image of threshold find the suitable of spots image, Labeling and counting objects, Drawing boxes on input image at location of acnes. Details of these processes are explain in the following Figure 1.

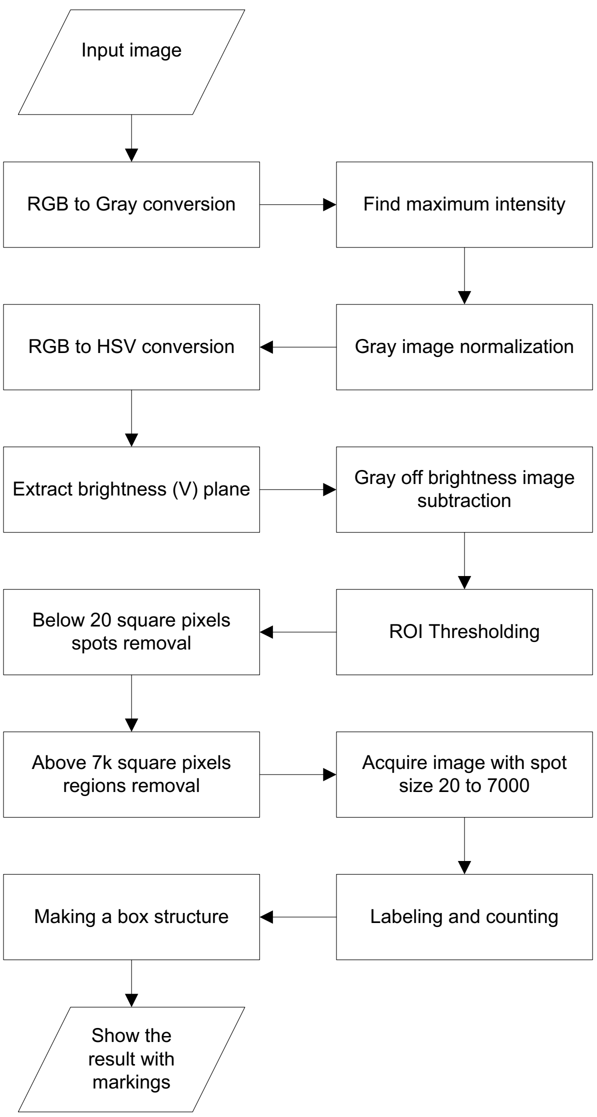

Figure 1. The flowchart of the proposed system.

III. METHODOLOGY

This section will clarify a function and work done by each step of the proposed system. They can be explained as following:

A. RGB to Gray-scale conversion

This step works in converting RGB color input image to gray-scale image with the equation of;

$$\text{Gray} = (0.2989 \times R) + (0.5870 \times G) + (0.1140 \times B)$$

Where R, G and B are red, green and blue colors, respectively. [12] The values multiplied in each color are obtained from experiment. RGB image must be processed to gray scale because it is simpler to calculate in program. The images in this step are visualized in Figure 2.

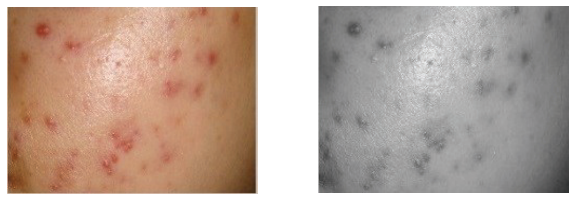
Figure 2. Color image (*left*), Gray-scale image (*right*)

B. Maximum Intensity

This is done by finding maximum intensity in gray-scale image by maximizing in X and Y coordinate. When image is taken into max function, it will first getting maximum value along x-axis in each y-column. By taking max function again, an absolute maximum value is obtained.

C. Gray-scale Normalization

This is a step for taking gray-scale image to be in range with brightness image by dividing it with its maximum to have a range of 0 to 1 intensity. Normalization means reduction of data into its simplest form to minimize redundancy. It is in range of zero to one to be able to compare with HSV model. The image is shown in Figure 3.

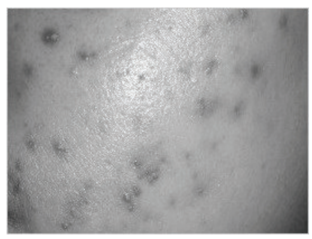
Figure 3. Normalization gray-scale image

D. RGB to HSV Conversion

Retrieve HSV color image from RGB input image. H is hue, it is a circle plate of color with zero degree of red color. As increasing degree, color is changed in gradient into green and blue respectively. S is saturation, it is value of color strength. V is brightness, it is value of illumination which is light or dark. This model is important to deal with exposure problem in picture.

E. Brightness Extraction

Brightness (V) image from HSV model is only taken out to utilize which has a range of 0 to 1. This luminance image shows how each region is acted with lighting. Areas with strong light are represented as white color tone (value of 1), while darker color tone (value of 0) is assigned to shadowing area as shown in Figure 4. Also, the brightness plane is normalized value.

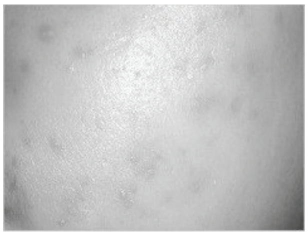

Figure 4. Brightness plane image

F. Image Subtraction for Region of Interest

Subtraction of normalized gray-scale value out of brightness (V) image is performed to reveal the interested areas. Both brightness and normalized gray-scale image are in the same range, so that it can be compared. Brightness has more intensity if it is subtracted by gray-scale image, it will provide region of interest at area of the strongest light. Figure 5 expresses acnes as ROI image

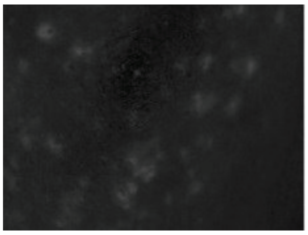

Figure 5. Region of interest image

G. Binary Threshold

By indicating threshold value referred from previous step, if any pixels have value below 0.2 which is defined from near black pixels have value around 0 to 0.2 known from trial-and-error experiment. They will be set to 1 and vice versa to emphasize ROI. This produces a binary image. The pixels with value of 0.2 are area that we do not interest in darker lighting. In this process, the image is flipped to negative binary color which can be seen in Figure 6.

Figure 6. Binary threshold image

H. Spot and Region Removal

(1) This step is the most important in the system which used to eliminate unwanted features. By Complementing binary image from previous step and removing spots with area less than 20 which is defined from user experiment that represents small noise, so very tiny dots will be erased. We have to change to negative color again to show region of interest of acnes at its clearest form. Afterward, very small dot noises have to be removed because they are not in a correct size of acne by setting threshold of area 20 square pixels (e.g. 4*5, 3*6 areas will be deleted).

(2) Then the recently processed image is taken into removing regions if they have area below 7000 which is user-defined value from average trial that represents large connecting area in most facial image, it results in a very large regions remaining. The very large region of above 7000 square pixels can be any skin inflammation, freckle or blemish those are not in project's focus. As it can be seen for this sample, there is no white region left in the image. It means that no large region exists in this image.

From previous sub-steps, logical subtracting is applied between those two images (1-2), the output contains objects with size between 20 and 7000. Logical subtraction must be used because binary images are operated at this step with only binary value 0 or 1. Image from (1) contains everything except small dots but image from (2) contains only large region in concept, which is not appeared in this sample image. So the subtraction of them contains only interested features. All of each sub-step image are illustrated in Figure 7.

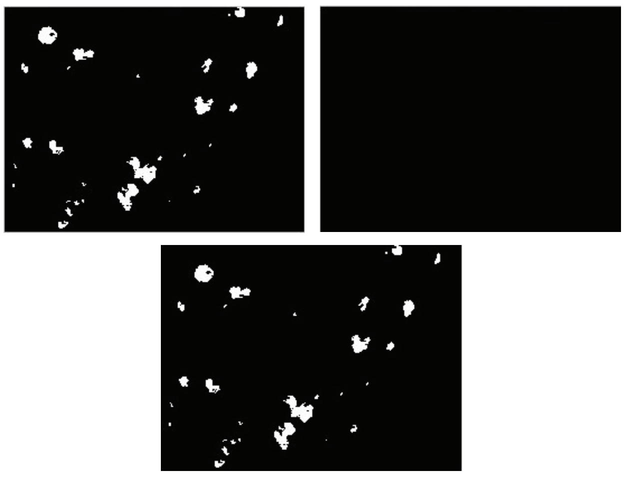

Figure 7. Spot removal image (*left* - (1)),
Large region image (*right* - (2)),
Image with clear region of interest (*bottom* = (1) – (2))

I. *Labeling and Structuring a Mark*

First, the image is being labeled and counted for the objects found in prior step, using function which output the coordinates and amount of acnes. They give the array of x and y at acne location and the length of array is acne's number.

Then by making a box structure at every single object referred to their size, by using function 'region props' which declared from MATLAB default module. This function have to be fed in with object coordinates which are received from array and type of marking that is 'Bounding Box' to make a structure array before boxes can be drawn.

J. *Marking Acnes on Image*

Drawing boxes on input image at location of acnes using 'rectangle' function also already in MATLAB module. This function can draw a rectangular shape by given in coordinates from step 12, line color and line width. As the result shown, it can mark and detect acnes on facial image properly with accurate location and size. The image is marked as shown in Figure 8.

Figure 8. Output with acne marking

IV. EXPERIMENTAL RESULTS

For experiments, 3 images were used to see results of this program. As they can be seen in the pictures, there are 3 sets of picture separated by acne image we used. Each set provides nine sub-images representing steps of program algorithm.

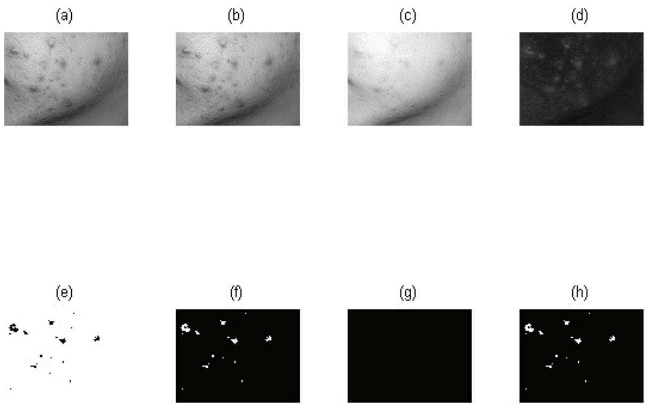

Figure 9. First image processing

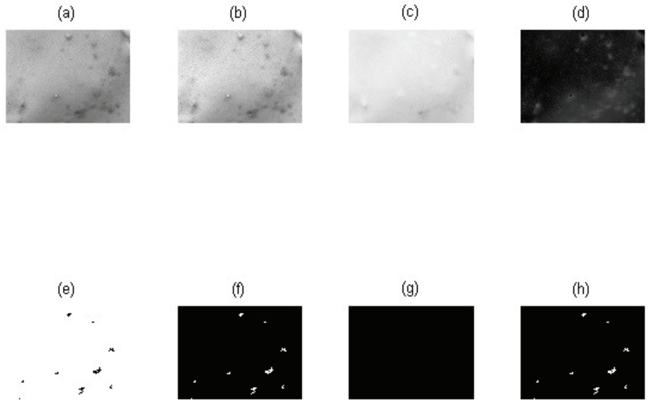

Figure 10. Second image processing

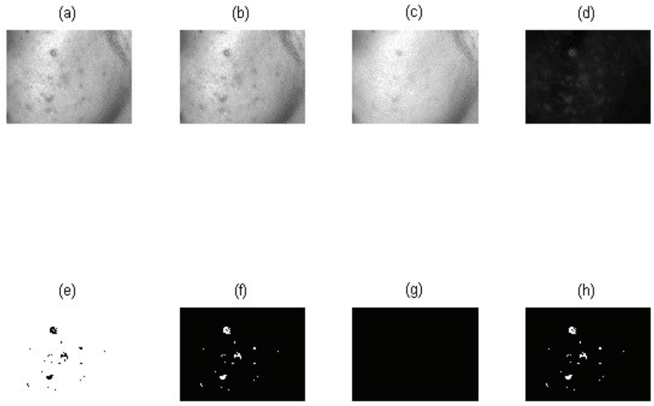

Figure 11. Third image processing

From Figure 9, in the first image, acnes on this face are considerably numerous and there are many areas those have quite large inflammatory acne. In (a) it is a pure gray input converted from original RGB image, then (b) is a normalized (a) image which convert range of gray from 0-255 to 0-1. It can be seen that (b) is a little bit clearer and brighter than previous one. Next, HSV image is obtained from RGB-to-HSV conversion directly from original one, this is needed because we want V-plane or brightness image that is image (c) to be able to compare value with the normalized gray one. Next, normalized gray image (b) is taken to subtract from V-plane image results in image (d) which is a consequence of lighting that is usually shine onto its own region of interest, we have ROI result. Image (e) is negative binary version of image (d), this step uses threshold to separate ROI and background completely. Then again, (e) image is inverted and taken into small-area filter as it can be seen on image (f), trivial dots passed from threshold method are no longer in the image. Afterward, (g) image is large-area pass filter image, so it must maintain only a very large area on an image. But some image may not contain large area of interest, so this step may result in whole black image. Further step is logical subtraction between (f) and (g) image to have a purely interested objects on the image (h) those are acnes as close as possible.

For the second image as shown in Figure 10, the result is a little bit different than the first one. There are acnes around edges of image which is not quite in an interested zone. So the result at binary threshold can be severely damaged by large area detect at bottom-right which is not totally acne. However, this problem is solved at step (g) and (h) that remove large area. Lastly, the third image from Figure 11 has quite low number of acne with low-contrast and faded acne around the center. This image produces an error of undetected low-contrast ROI, it can be seen that step (e) detects only very clear and round acnes.

A reference number of actual acnes is displayed as 'Ground Truth' which is counted manually. So the following evaluation process is blob-based since we consider only at interested shape of acne, not a whole pixels. We can evaluate detected acnes on image by using sensitivity, precision and accuracy. They can be described as following:

1) Sensitivity = it can be called 'true positive rate', it is a ratio between correctly detected acnes (true positive) and total real acnes that they must have been detected (true positive + false negative).

2) Precision = a ratio of objects which are precisely detected as an acne (true positive) compared to total positive results (true positive + false positive).

3) Accuracy = it is a measurement of how close of value measured at the time compared to its actual value. This value is ratio of total true results (true positive + true negative) compared with all population in the experiment (positive + negative).

There are some definitions that have to be introduced attaching to this section:

- True positive (TP): Acne correctly detected as acne
- False positive (FP): Scar and normal skin incorrectly detected as acne
- True negative (TN): Scar and normal skin correctly detected as scar and normal skin
- False Negative (FN): Acne incorrectly detected as scar and normal skin.
- Sensitivity = Number of TP / (TP + FN)
- Precision = Number of TP/ (TP+FP)
- Accuracy = (TP + TN)/(TP + TN+FP+FN)

TABLE I. RESULT OF ACNE DETECTION

Sample image	Ground truth	Detected	TP	FP	TN	FN
1	5	4	4	0	1	1
2	28	31	27	4	1	0
3	21	15	12	3	1	6
4	18	22	16	6	1	2
5	18	27	18	9	1	0
6	25	29	21	8	1	0
7	16	23	13	10	1	2
8	22	27	18	4	1	4
9	9	7	7	0	1	2
10	33	35	27	8	1	6

As it can be seen from Table I, there are ten images in total those have been used to test the detection algorithm. Each of them has particular amount of acnes as the patients have more or less symptom. A ground truth is an amount of acne investigated by mere human eyes, so that the value can be result in some missing targets. Image processing value is number of detected region using proposed algorithm, but there can be errors among this results also. The results obtained from program can be separated into 4 categories, i.e. true positive, true negative, false positive, false negative as they are described earlier. Each sample image contains different view of facial acne such as, zoomed, whole, men's, women's. From the results, it can be told that less number of acne provides higher chance of it to be correctly detected as in sample 1 and 9 only false negative of 1 and 2 occur respectively. The more acnes found in image, they cause more errors and most of errors are false positive which is the area that is not acnes but be detected. They are like the inflammatory area which has shape and properties very like acnes in a very close neighborhood with acnes. Sample 3 has more false negative than false positive, this can be caused from spreading of acnes and its own irregular shape.

TABLE II. SYSTEM EFFICIENCY EVALUATION

Sample image	Sensitivity (%)	Precision (%)	Accuracy (%)
1	80.00%	100.00%	80.00%
2	100.00%	87.10%	87.10%
3	66.67%	80.00%	57.14%
4	88.89%	72.73%	66.67%
5	100.00%	66.67%	66.67%
6	100.00%	72.41%	72.41%
7	86.67%	56.52%	52.00%
8	81.82%	81.82%	69.23%
9	77.78%	100.00%	77.78%
10	81.82%	77.14%	65.85%
Average	86.37%	80.00%	70.00%

In table II, it contains values which are used to evaluate efficiency of the proposed system. First, sensitivity is a system detection rate that is how tendency the system is able to correctly diagnose objects. Which from the table, it provides acceptable value for all samples except sample 3 at 66.67 that is quite low because of acne position and shape. For precision, it is positive prediction value which is used to evaluate how much chance it can correctly identified objects throughout its own all identified objects. This value is quite low in image sample 5 and 7 because of unclear region of acne. The last thing is accuracy which is overall rate of correct results compared to all objects in both positive and negative, this value can tell a pure efficiency of this system which is still quite undesirable.

V. CONCLUSIONS

To conclude overall project, this paper has been separated into major part of three which are introduction to medical dermatology technology and traditional diagnosis method by regular dermatologist proposed method to automatically detect and separate acnes from other facial problems with developed algorithm, experimental results on sample facial image with different amount of acnes and efficiency evaluation of the system. The proposed algorithm consists of RGB input to gray conversion to be easily processed, gray-scale normalization, HSV input conversion to use V image compare with gray one, ROI extraction, binary threshold, Non-ROI features elimination, marking results and overlaying onto original image. About efficiency measurement, it is shown that false positive has a high chance of appearance due to some other facial problems can have quite similar properties compared to acnes. At last, sensitivity, precision and accuracy are calculated. It can be seen that all values are quite high except for accuracy which need to be improved very soon. Some small mistakes can occur caused from human errors, threshold level definition and various shape of inflammatory facial features.

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