AUTOMATIC ACNE DETECTION WITH FEATURED BAYESIAN CLASSIFIER
FOR MEDICAL TREATMENT

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Abstract

In this paper, several image processing technique has been studied to develop a system of acne detection. The focus is on blob detection applied to facial images to see circular shape of acne and amounts. Then this detection output is fed into feature extraction and classification to deeply separate real acne from mistake in previous step and improve performance. A typical image on a check has been usually used to take in the experiment which results are markings on acne automatically, this method is more effective than manual counting or blob detection alone. The results show that this proposed method reduce error of false positive/negative significantly, a system efficiency can be calculated afterward. Experimental output is summarized that accuracy, precision and sensitivity are quite constant but still depending on location, shape and lighting condition of acne in the image.

Keywords—Image processing, acne, blob detection, feature extraction, Bayesian classification

1. INTRODUCTION

Acne vulgaris is a common chronic skin disease involving blockage and/or inflammation of pilosebaceous units, those are hair follicles and their accompanying sebaceous gland (fatty gland). These glands are stimulated by male hormones produced by the adrenal glands which are included in both males and females. Acne can be a non-inflammatory lesions, inflammatory lesions, or a mixture of both, affecting mostly on the face but also on the back and chest are possible to occur. However, acne is not dangerous, but it is able to leave skin scars.

Skin analysis is one of the most important procedures before getting any treatment. The typical way of diagnosis is a marking sheet. A doctor has to manually and approximately mark the spot of acne on a sheet corresponding a location of acne seen on it. This method results in unreliability, inaccuracy, doctor’s excessive effort, and time wasting [1-3]. Thus, it is much better to have an automatic equipment to inspect these acne problems using computer-aided detection program developed in recent years [4]. Regular way to detect acne is to use shape detection, especially a blob detection. It is the way to capture a sudden change in image intensity to be considered an object in image as a circular closure.

For example of previous work, Chuan-Yu Chang (2010) used feature-based detection to locate ROI and pattern recognition to detect different type of defect with performance boosting by classifier. This method provides the highest chance of detection of all reviews and can detect several features at a time [5].

Manita Khongsuvan (2011) used UV fluorescence image for acne detection since bacteria in acne react to UV light. The image is applied to H-maxima transform to find regional maxima and segment acne. This method is good and quite robust with satisfied efficiency, but UV can damage a test skin for long period of exposure [6].

O. Cula (2011) used acne-like and non-acne regions detection by spatial-temporal features, which is acne condition changed over time provided by synchronization, with supervised-learning approach to separate features in image. This method is very useful for long period of diagnosis with acne-change tolerance, but it requires more time to process [7].

Jawad Hamayun (2012) used template matching technique with N-mean kernel. The template window is compared throughout whole image with chi-square matrix, the location of acne is where this matrix value goes lowest. This method is not quite good because it does not analyze image in details which it can ignore some important information, but it is easy and fast [8].

Biman Chandra Dey (2013) used digital color (RGB) image to detect acne with pixel-based method. The pixels are record by skin background and acne of interest separately. A knowledge cluster is made by pixels data arrangement, then acne are segmented by Mahalanobis Distance (MD) and Bayes’ method. Compared to ground
truth, the efficiency of MD is better than Bayes'. This method is good that it keeps data of both skin and acne with a fine pixel details with direct RGB input. [9]

In authors' previous project, an automatic detection and counting acne on facial image is introduced to make acne detection much easier. RGB inputs must be converted into gray-scale and HSV, so that it can be easily calculated and brightness controlled by normalization and subtraction between gray one and HSV one which made ROIs. Next step is binarization to do background separation from ROIs, then we can apply a method of small and large region elimination to detect acne coordinates.

These data are used to mark constructed boxes onto locations of acne as output result. This method has quite high efficiency but came with problem of fixed threshold, so that it may be unable to process different faces. [10]

2. PROPOSED SYSTEM

This overall proposed system is processed by MATLAB program as an image processing module. Refered from the previous project, a method of acne detection will be used as input step of this current project. A main process of this paper is feature extraction and filtering out wrong detected region. It will be separated into "Training" and "Testing" algorithm, and use each of them to compare performance with another one. Fig 1 presents processes of the proposed approach, acne detection technique is included in the first step of both training and testing algorithm. Then feature extraction method is applied to bring out regions in need by more deep and specific way. For training, the algorithm will give a knowledge to a system to know about acne features automatically. While testing, it feeds acne features input into "Bayesian Filter" to decide the regions whether they are in right detection or not. Details of these processes are explain in the following Figure 1.

3. METHODOLOGY

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

3.1 Blob Detection

This step is the same between training and testing process. It works as an algorithm to visualize and mark spots or regions those have a shape of circular closure that is called (blobs). Then an output of marking region of interest will be an input to next step afterward.

At first, RGB-to-gray scale and RGB-to-HSV conversion have to be implemented as separated output image. Gray-scale image must be used to calculate a normalized version of itself by using weighted-average and maximum intensity division. Then V-plane image from HSV model has to be utilized as brightness image with most regions of interest in bright area. Next, V-plane matrix is subtracted out by normalized gray-scale image to reveal region of interest clearer, followed by binary thresholding to segment out interested acnes as white object and a rest area as black background. Furthermore, blob analysis is applied to obtain visual marking at the
3.2 Feature Extraction

In this step, it is functional by using the detected region of interest to find their own characteristics in term of histogram analysis. These characteristic are called “state of the art” of histogram from the image. Feature extraction also works similarly in both training and testing process. First of all, an image intensity data has to be converted into histogram style, then probability density function can be acquired from this histogram. The feature values which we will consider, can be described in details as followings;

3.2.1 Mean Value

This value is simply an average measurement of intensity on region that we are interested in. An equation from MATLAB used to calculate is shown below:

\[ \text{Mean} = \text{sum} (\text{Prob} \times \text{Gray\_vector}) \]

This shows that mean is calculated by sum of each image pixel intensity multiply by its own probabilistic factor of occurrence compared to the whole region.

3.2.2 Variance Value

Variance is deeper value from mean. It is used to measure spread or wideness of intensity probabilistic data. Also from MATLAB, it can be expressed as a following equation:

\[ \text{Variance} = \text{sum} (\text{Prob} \times (\text{Gray\_vector} - \text{Mean})^2) \]

From above equation, weighted and squared on a subtraction between gray intensity of each pixel region mean is summed up to be the variance. So we must know the mean in region of interest prior.

3.2.3 Skewness

Skewness is a measure of symmetry or asymmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point which is the mean of overall probability density function of data. This value can be computed based on mean and variance:

\[ \text{Skewness} = \frac{\sum_{i=1}^{N} (Y_i - \bar{Y})^3 / N}{S^3} \]

Where, \( Y_i \) = gray intensity,
\( \bar{Y} \) = intensity mean,
\( S \) = standard deviation (root of variance)

But in this project, a probabilistic weight of each gray level is used, so sample number \( (N) \) is not necessary.

3.2.4 Kurtosis

Kurtosis is a measurement method to see if the data has a peak or flat relative to a normal distribution. This means, an intensity data which has a single distinct peak near its own mean tends to contain more value of kurtosis. Moreover, the high kurtosis data has a possibility to decline exponentially farer from mean area, and have heavy traffic of intensity at both tails of histogram. Data sets with low kurtosis will have opposite character of the high one. Kurtosis can be calculated by the below equation:

\[ \text{Kurtosis} = \frac{\sum_{i=1}^{N} (Y_i - \bar{Y})^4 / N}{\sigma^4} \]

As it can be seen, kurtosis equation is much like the one of skewness. Only it has the power of four instead of 3. Also, mean and variance are able to have a large impact on both skewness and kurtosis, though the visualized histogram is not clear enough to see symmetry or peak.

3.2.5 Energy

This term is utilized in several fields of study. But for image processing, it means the numerical contents presented in an image and how the intensities is distributed over whole image. This value is simply a mean-square of probabilistic function.

\[ \text{Energy} = \sum (\text{Prob} \times \text{Prob}) \]

Probability density value in each corresponding pixel intensity is multiplied together and summed out to be the energy of region of interest.

3.2.6 Entropy

Entropy is quite similar to energy and also was in widespread utility in various branches of science. It can be called randomness of contents in image processing. For example, image with high density of contents such as city landscape, will contain a high value of entropy. On the other hand, image of a white plain wall is going to have lower entropy value. Its equation is quite resemble to the energy, with additional logarithm function:

\[ \text{Entropy} = -\sum (\text{Prob} \times \log (\text{Prob})) \]

From these six characteristic variable of histogram, we can train or test the system further to be able to know the features that is in needed in more accurate way.
3.3 Bayesian Classification

Typical classification is a way of decision making theoretically approaches to identify images feature. All classification algorithms are based on the assumption that the image contains one or more features like geometric shapes, color or gray-level. Each of these features will be assigned to one of several different classes. The classes may be specified a priori by an analyst or automatically clustered into sets of prototype classes, where the analyst merely specifies the number of desired categories. Classification and segmentation is quite similar in objectives, as the former is the form of component labeling that can result in segmentation in an image.

For Bayesian method, it is highly scalable, requiring several of number of features to be working in learning process. This type of classification can be done by evaluating a closed-form expression rather than iterative approximation as used for many other types of classifiers, so it is better to use to save computation time and resource. The Bayesian method is usually implemented to minimize the possibility of misclassification.

3.4 Training Process (Supervised)

This is the first branch of process to let the system know and remember which acne area is right or wrong detected. An algorithm to teach the system starts by having a window of pixels slide through until it covers all area in the image. Users have to manually input if area of interest that the window is on, is an acne or not. Then this vector of right and wrong detection will be implemented into blob detection image to filter out unnecessary area that has been in misunderstanding to be an acne and make a result more reliable.

Next, the naïve Bayesian classifier is applied into the training data set, comparing with original blob detection image. The basic equation of this classifier is shown as following:

\[ p(x = v | c) = \frac{1}{\sqrt{2\pi \sigma^2}} e^{-\frac{(x - \mu)^2}{2\sigma^2}} \]

According to Gaussian distribution, the equation supposes that the training data contain a continuous variable, \( x \). The intensity data from training class is computed out its mean and variance in each class. Let \( \mu_c \) be the mean of the values in \( x \) associated with class \( c \), and let \( \sigma^2 \) be the variance of the values in \( x \) associated with class \( c \). Then, the probability distribution can be computed by plugging \( \mu \) into the equation to make a normal distribution of parameter by \( \mu_c \) and \( \sigma^2 \).

Lastly, all of trained data and Bayes’ classification data are saved into original detected acne image to show more precise location of real acne that users have defined it into the core system.

3.5 Testing Process (Unsupervised)

This is the second phase process to let the system test and decide automatically whether a specific area is acne or not. First, we must create a window to observe parts of image, then it will slide throughout entire image. This is much like training except that a prediction function in MATLAB will be used to automatically classify. This function is shown in below statement:

\[ l = \text{predict}(Y, X) \]

Where, \( l \) = vector of class label for intensity data,
\( Y \) = discriminant classifier,
\( X \) = matrix of observation in row, predictor in column

After the prediction step, the area that passes criteria will be kept. While the one that fails, will be deleted. Then the whole image is marked on the right location of acne with centroid of coordinate and area referred from each acne component.

4. EXPERIMENTAL RESULTS

For experiments, two sample images were used to see results of this program. Figure 2 shows an image with quite high number of acnes. The result is well-defined and almost accurate, but there still be wrong detected and overlapped which it is all near the true acnes.

For Figure 3, it contains very few acne lesions. As it can be seen, a classification is very effective and almost no mistake is presented. Compared to only blob detection, this proposed method boosts an efficiency of system as it can detect blobs more perfectly.

Figure 2. Sample image output with many acnes
Figure 3. Sample image output with fewer acnes

For measuring effect and performance of proposed system, we use ten images of the acne from different patients’ face to test the proposed method based on the MATLAB program.

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:

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

<table>
<thead>
<tr>
<th>Sample image</th>
<th>Ground truth</th>
<th>Detected</th>
<th>TP</th>
<th>FP</th>
<th>TN</th>
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<td>25</td>
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<td>33</td>
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<td>26</td>
<td>10</td>
<td>1</td>
<td>7</td>
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</table>

TABLE I. RESULT OF ACNE DETECTION
TABLE II. SYSTEM EFFICIENCY EVALUATION

<table>
<thead>
<tr>
<th>Sample Image</th>
<th>Sensitivity (%)</th>
<th>Precision (%)</th>
<th>Accuracy (%)</th>
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<tr>
<td>1</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>75.76%</td>
<td>89.29%</td>
<td>70.23%</td>
</tr>
<tr>
<td>3</td>
<td>74.07%</td>
<td>80.00%</td>
<td>63.64%</td>
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<tr>
<td>4</td>
<td>87.55%</td>
<td>80.76%</td>
<td>73.33%</td>
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<tr>
<td>5</td>
<td>76.92%</td>
<td>76.92%</td>
<td>66.71%</td>
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<tr>
<td>6</td>
<td>84.85%</td>
<td>82.35%</td>
<td>72.50%</td>
</tr>
<tr>
<td>7</td>
<td>92.00%</td>
<td>54.76%</td>
<td>53.33%</td>
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<tr>
<td>8</td>
<td>81.82%</td>
<td>75.00%</td>
<td>65.52%</td>
</tr>
<tr>
<td>9</td>
<td>80.00%</td>
<td>100%</td>
<td>81.82%</td>
</tr>
<tr>
<td>10</td>
<td>78.79%</td>
<td>72.22%</td>
<td>61.36%</td>
</tr>
<tr>
<td>Average</td>
<td>83.17%</td>
<td>81.13%</td>
<td>70.65%</td>
</tr>
</tbody>
</table>

As it can be seen from Table I, there are ten images in total; all have been used to test this detection algorithm. Each of them has different amount of acne, various symptoms of lesion among these ten patients' face. A ground truth is an amount of acne investigated by expert human eye, so that the value can be result in some missing targets. Consequently, the value produced by Bayesian classification is number of detected region using train-and-test algorithm, but there can be errors among these results also. The output obtained from program can be separated into 4 kinds, i.e. true positive, true negative, false positive, false negative as they are described from before. Each sample image contains different view of facial acne such as, zoomed, whole, men’s, women’s. From this 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 0 and 2 occur respectively. The more acne found in image, they cause more errors and most of errors are false positive which is the area that is not acne but be detected. They are like the lesion of colored area which has 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 except in sample 1 and 9.

5. CONCLUSIONS

To conclude overall project, this paper has many parts. It is starting by introduction to acne, traditional diagnosis method by regular dermatologist, and literature reviews before the project has been implemented. Proposed method presented in this paper, is to automatically detect acne with developed algorithm, then features extraction and classification have been used additionally. Experimental results on sample facial image with different amount of acne and efficiency evaluation of the system has been shown on the last part. The proposed algorithm consists of blob detection technique which is the author’s preliminary work. It has been implemented to separate acne blobs from skin background, but this method alone still produces high amount of errors. Therefore, feature extraction extracts out histogram characteristics of acne image to see distinctiveness among themselves. At last, Bayesian classifier with train-and-test algorithm are introduced to furtherly see and classify true acne out of misunderstanding or overlapped errors. 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 acne. As the results shown in tables, sensitivity, precision and accuracy are calculated. It can be seen that all values are quite high except for accuracy which need to be improved more. Some small mistakes can occur caused shape and properties very similar to acne in a very close neighborhood with acne. Sample 7 has the most false positive as it contains high amount of non-acne circular blobs, while the others has false positive value around eight. On the other hand, false negative is the highest at sample 10. This can be caused from spreading of acne and its own irregular shape of blob.
from human errors and various shape of inflammatory facial features.

6. ACKNOWLEDGEMENT

This research is financially supported by Thailand Advanced Institute of Science and Technology (TAIST), National Science and Technology Development Agency (NSTDA), Tokyo Institute of Technology, Sirindhorn International Institute of Technology (SIIT), Thammasat University (TU) under the TAIST Tokyo Tech Program.

7. REFERENCES


