Automatic wrinkles detection on face image

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Abstract. Image processing techniques are beneficial for reconstructing and processing an image in resulting different images. One of its benefits is it can be used for detecting wrinkles on a face. Line characteristic of wrinkles can be detected also with the support of the features that had been provided. The purpose of this research is to design a system that could detect the exact location of the line of wrinkles which occur from one face image. Generally, the step that required for this research is the HSV colour image segmentation step and K-Means Clustering for dividing skin object and non-skin object. The second step is phase image improvement step with Laplacian of Gaussian filter to sharpening line of wrinkles on image face, and the last step is feature extraction which used for taking wrinkles. After all the steps had been done, each of the wrinkle’s areas are detected with Canny filter and eliminated based on Area characteristic. From research experiment, the result validation data of system based on an expert are 40.6% for sensitivity, 96.9% for specificity, and 94.2% for accuracy, with the performance of the system 5,247 seconds.

1. Introduction

Human skin will change along with age. The most visible change is the appearance of wrinkles on the hands and face skin. Wrinkles can be a sign of premature aging. Generally, wrinkles can be seen clearly in some areas of the face and palms. Wrinkles are caused by a lack of elasticity of the skin, so the skin loses flexibility [1]. The most severe effect is it can disrupt a person's psychosocial aspects which someone will feel inferior and be ignored by their environment. Therefore, many people start to treat their skin especially for wrinkles. The treatment, however, is quite expensive, because it requires special instruments in the beauty clinic.

Some studies were conducted to identify wrinkle automatically. Batool and Chellappa in their study assumed about the geometrical characteristics and the wrinkles features. They said wrinkles appear in the arches form, continuous, and not intersecting with each other [2]. Wrinkles detection system of Nazre Batool and Rama Chellappa research was carried out using Gabor filters, image morphology, and geometric constraints to detect wrinkles lines on the face. The study can detect wrinkles lines only on the forehead with a deep wrinkles line, not in the whole face.

The second study is conducted by Nur Hayatin, which classifies age based on facial images using important features namely face anthropometric and wrinkles [3]. The wrinkle features calculated are width and depth of wrinkles. The accuracy of that system is 65%, but this study did not show the wrinkles features obtained.

According to the previous studies, wrinkles lines in the facial image can be detected by utilizing image processing techniques. Thus, this study attempts to create a prototype that can identify the presence of wrinkles through facial images automatically without the need to use special instruments owned only by beauty clinics. This study aims to detect the location of wrinkles lines on the face.
image. The system is expected to help users detect wrinkle lines on their face. Besides, this system can also be applied as one of the features in beauty product skin advisors and the analysis of this study can be used as a reference for further research.

This journal is described in several sections. Section I describes the introduction and benefits of the system. The methods and data used are explained in section II. The research methodology described in section III. The results and discussion of the research conducted are explained in section IV. Section V explains the conclusions and suggestions from research that has been done.

2. Data and methods

2.1. Wrinkle

Wrinkles are lines or folds which appear on the skin [1]. There are two factors that affect the aging process of the skin, namely intrinsic factors, and extrinsic factors. Intrinsic factors include heredity (genetic), racial, and hormonal. While extrinsic factors include environmental factors such as sunlight, humidity, and free radicals [4].

Wrinkles occur due to reduction of collagen in the skin. Collagen and elastin are the main components of the dermis layer. Loss of these collagen has a negative impact on moisture and elasticity skin which can cause wrinkles [5]. Skin that lacks collagen can be seen in Figure 1. Wrinkles can be seen clearly in some areas of face, such as forehead, outer corner of the eye, below eyes, cheeks, and between the cheeks and upper lip [6].

![Figure 1. Illustration of facial skin deficiency in collagen](image)

2.2. HSV colour model

HSV color model consists of three layers, Hue, Saturation, and Value. Hue defines true colors such as red, violet, and yellow. Saturation states the level of purity of a color, which indicates how much white is given to the color. Value is an attribute that states the amount of light received by the eye regardless of color [7].

2.3. K-means Clustering

K-Means Clustering is an algorithm for grouping data [8]. The number of groups or clusters based on the value $k$ given by user. Data’s attributes become a space vector line. The clustering process starts by calculating the distance between each data and each cluster center. The data will be a member of the cluster $k_i$ when the distance of data to center of the cluster $k_i$ has the smallest value compared to the distance to the center of the other clusters. After the distance of all data to all cluster center calculated, the cluster center will be calculated again. Those process will be repeated until there is no change in cluster center.

2.4. Region Filling

Region filling is one of image reconstruction using morphological algorithm [7]. Region filling will remove the holes of an object in the image by filling the hole pixels with the same color to the pixels around the hole.
2.5. Laplacian
Laplacian is one of algorithm for enhancing image. Laplacian filter is used two-dimensional Laplacian operator for sharpening [7]. The filter will be convoluted to the image.

2.6. Canny edge detection
The Canny algorithm approach is carried out by convolution of image functions with Gaussian operators and their derivatives [7]. Canny combine method of smoothness and edge detection into a convolution in one dimension in two different directions, vertical and horizontal. Canny mark all existing edges in accordance with the convolution parameter criteria performed, can give very high flexibility to decide the desired edge thickness, able to localize well, and give a clear response to each edge.

2.7. Validation
System validation test is carried out using the Single Decision Threshold method. This method basically has information used to compare the detection results by the system (predictive value) with the detection results by experts (true value). The true value is generated by experts, skin and genital specialist. There are four terms used, namely:

1. True Positive (TP) is if the true value and predictive value produce positive results, such as, if the true value is "wrinkles lines", then the system decides "wrinkles lines".
2. True Negative (TN) is if the true value and predictive value produce negative results, such as, if the true value is "not a wrinkles line", then the system decides "not a wrinkles line".
3. False Positive (FP) is if the true value is negative, but the system produces positive results. For example, if the true value is "not a wrinkles line", but the system decides "wrinkles lines".
4. False Negative (FN) is if the real value is positive, but the system produces negative results. For example, if the real value is "wrinkles lines", but the system decides "not a wrinkles line".

Sensitivity and specificity can be calculated after the values of TP, TN, FP, and FN are obtained. Sensitivity is a parameter to measure the percentage of positive data that is correctly identified (wrinkles lines detected by the system are the same as experts). Specificity is a parameter to measure the percentage of negative data correctly identified (the system does not detect objects not wrinkles lines of candidates) [9]. The formula of value sensitivity and specificity can be seen in Equations 1 and 2, respectively. Accuracy is a value that describes how accurately the system can detect data correctly [10]. The formula for accuracy can be seen in Equation 3.

\[
\text{Sensitivity} = \frac{TP}{TP + FN}\]  
\[
\text{Specificity} = \frac{TN}{TN + FP}\]  
\[
\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN}\]

2.8. Data
The facial image data used in this study were obtained randomly from internet. The image should be color images (RGB), close-up, and front facing face. The facial image should have wrinkles. The image format used is JPG, PNG, and JPEG. The image should have evenly distributed lighting. There are 39 facial images. Three images were used as training data. Training data are used to identify the facial area and wrinkles features. The results of this identification process would be used as reference data to test other images. Three other images were used as testing data.

3. Methodology
The stages to develop prototype of automatic wrinkles detection on face image are shown in Figure 2.
Because the image data are taken from internet randomly, these images have different characteristics and sizes. In order for images to have similar characteristics which are close-up images, the image is cropped manually first. Thus, the largest object in the image is face object. The prototype begins by resizing the image size to 580x580 pixels. Resizing is carried out to equalize the size of the input image in order each process can be implemented for all images.

Second stage is image conversion. The original image is a color image in the Red, Green, and Blue color space (RGB). In segmentation process later, image objects will be separated into skin object and non-skin objects. To recognize the skin color object well, the original image in the RGB color space is converted to the HSV color space (Hue, Saturation, and Value) [11]. The range value on the HSV color model used to recognize the skin object in this study is 0.0-0.25 for \( H \) (hue), and 0.15-0.9 for \( S \) (Saturation) [12].

The fourth stage is image segmentation. Skin object and non-skin objects is separated using K-means clustering [13]. K-means clustering algorithm will group pixels that have the same color in the image accordance with HSV color model. The \( K \) value used in this study for K-means is two that's mean the colors in the image will be grouped into two groups. Group that has the greatest number of pixels will be considered as skin group and vice versa, group that has the least number of pixels will be considered as non-skin group. Therefore, the RGB intensity value of the skin group pixels in the original image will be retained, while the RGB intensity value of the non-skin group pixels will be changed to black. Images that only contain facial skin are obtained. However, in some images, the facial skin image has several holes. Therefore, Region Filling algorithm is implemented in this stage so that the holes in the skin are closed.

The fifth stage is image sharpening. The facial skin image is sharpened using Laplacian filter. Laplacian filter is used to sharpen the face line and wrinkle lines. The Laplacian filter used in this study is 3-by-3 filter and 0.2 for alpha value.

The sixth stage is to take areas of the skin where wrinkles often appear, namely the forehead, the middle-area between the two eyes, the left-side area of the left eye, the right-side area of the right eye, the left eye bag area, and the right eye bag area. In the facial skin image, the entire face skin area is given a percentage value of 100%. The index of initial row, end row, initial column, and end column of the facial skin area are taken. The position of the forehead area is obtained by taking an index value of 20-30% of the rows of facial skin area and 25-70% of columns of the facial skin. The position of the middle area between the two eyes is obtained by taking an index value of 34-43% of the rows of facial skin area and 44-55% of columns of the facial skin. The position of the right-side area of the right eye is obtained by taking an index value of 38-44% of the rows of facial skin area and 15-25% of columns of the facial skin. The position of the left-side area of the left eye is obtained by taking an index value of 38-44% of the rows of facial skin area and 75-85% of columns of the facial skin. The position of the right eye bag area is obtained by taking an index value of 45-44% of the rows of facial skin area and 15-25% of columns of the facial skin. The position of the left side-area of the left eye is obtained by taking an index value of 38-44% of the rows of facial skin area and 75-85% of columns of the facial skin. The position of the right eye bag area is obtained by taking an index value of 45-55% of the rows of facial skin area and 20-43% of columns of the facial skin. The position of the left eye bag area is obtained by taking an index value of 45-55% of the rows of facial skin area and 55-80% of columns of the facial skin.

After the wrinkles area is obtained, Canny edge detection algorithm is applied in each wrinkle area. In Canny edge detection, there is threshold values used to determine which lines are preserved. The smaller the threshold value is given, the more the edges are detected and vice-versa. Each wrinkle area
has their own threshold value because each area has a different edge line characteristic. Threshold value for forehead and the middle-area between the two eyes is 0.08. Threshold value for the left-side area of the left eye and the right-side area of the right eye is 0.06. Threshold value for the left and right eye bag area is 0.1.

The last stage is elimination. Lines detected in each wrinkle area are checked whether they are wrinkled or not. Area information from each line is extracted. In forehead area, lines which area is more than 100 pixels and less than 200 pixels are considered as wrinkles. In the middle-area between the two eyes, the left-side area of the left eye, and the right-side area of the right eyelines, lines which area is more than 50 pixel, or less than 30 pixels are considered as wrinkles. In the left and right eye bag area, lines which area is more than 35 pixels and less than 90 pixels are considered as wrinkles. After wrinkles lines are detected, the Marking process of wrinkle pixel position is carried out on the original image so that the results can be seen by the user.

### 4. Result and discussion

The results of each step according to Figure 2 are shown in Figure 3. Figure 3.(a) is original image that obtained from internet randomly. Because the largest object in the image is not a face object, the original image should be cropped manually before inputted to system. Figure 3.(b) shows cropped image of original image. The cropped images have different sizes, so that the image is resized to 580x580 pixels. The size is chosen in order the image size is not too large which will cause the detection process run too long. Besides, if the size of the image is too small, the wrinkle lines are not clearly visible, thus become difficult to be detected.

Figure 3.(c) shows the result of segmentation process using the K-Means Clustering based on Hue and Saturation value. HSV colour model used in this process because it is the best colour model for detecting skin colour in normal lighting conditions [11]. HSV colour model separates luminance from the colour components while RGB colour model cannot. It must do because there is different lighting condition when the picture is taken.

K-Means Clustering algorithm group pixels according to their colour. Two clusters are selected to separate the pixels of skin colour from pixels of non-skin colours, such as hair colour and background. The pixels in the cluster which has the greatest number of pixels is determined as skin pixels. K-Means clustering algorithm was chosen because it has an accuracy score better than the Decision Tree method [14]. As shown in Figure 3.(c), the segmented image has some holes in skin object. Thus, Region Filling algorithm is needed in this process to fill the holes in skin object. The image result of region filling process is shown in Figure 3.(d).

Figure 3.(e) shows the results of sharpening process using Laplacian filter. Laplacian filter algorithm can enhance the image detail properly without any significant noise interference. The sharpened images can help the wrinkle detection process which wrinkles can be seen more clearly.

Figure 3.(f) and (g) shows results from the process of taking areas where wrinkles often appear, namely the forehead, the middle-area between the two eyes, the left-side area of the left eye, the right-side area of the right eye, the left eye bag area, and the right eye bag area. The method used to get these areas are percentage method. Another method that has been carried out before is Active Contour method. This method can take the wrinkled area but is not perfect because the edge of the wrinkled area is not neat.

Figure 3.(h)-(m) show results of edge detection in forehead, the middle-area between the two eyes, the left-side area of the left eye, the right-side area of the right eye, the left eye bag area, and the right eye bag area using Canny edge detection. Canny edge detection algorithm was chosen because this method is able to detect detail facial lines well compared to other edge detection methods. Canny can localize properly and provide a clear response to fine lines of wrinkles. The next elimination process is carried out based on the area of line. The lines detected in the Canny process image results will be eliminated according to the area of each line. The image result of line elimination based on area is shown in Figure 3.(n).
The evaluation of experiment results was carried out using the Single Decision Threshold method. Test validation is calculated by comparing the results obtained by the system with the doctor's marking results. The experiment is carried out using 36 testing images. From these testing image, the average value of the sensitivity, specificity, and accuracy of the system obtained are 40.6%, 96.9%, and 92.4%, respectively. The low scores of sensitivity are got due to there are the difference in location and length of the wrinkles marking by expert and system. However, based on the specificity scores, the results obtained are very good because system errors in detecting not-wrinkle objects as wrinkle object are rarely found.

When compared with previous studies, this research is quite effective. This study can achieve accuracy score up to more than 90%. Some of the advantages of this study compared to previous study is that the system is able to do segmentation well for Asian and European skin tones. Moreover, the system is able to detect wrinkles lines in the overall facial image in 5.247 seconds for an image.

![Figure 3](image) The examples of image result in each process

Not all test images can be processed well by the system, even though the image used is an ideal image that has fulfilled the requirements as an input image. This is caused by several things. First, the system fails to detect facial skin due to the colour similarity between skin objects and non-skin objects. The lighting factor that is too bright on the photo also causes the face to be undetectable. Second, the system fails in the process of taking the wrinkles area appropriately. This is due to the factor for taking an area is still static so that the size of area cannot adapt flexibly. Thus, it causes...
errors in detecting wrinkle lines. Lastly, the system fails to detect wrinkles lines in the area that has been taken. This is caused the area size limit used is also static.

5. Conclusion

From all the processes that have been carried out, the conclusions obtained from this study are in general testing, the program can achieve a high success rate for images with ideal conditions. The ideal conditions are RGB images contain close-up front facing faces and have a good lighting. The validation is tested

Test validation is calculated by comparing the results obtained by the system with the doctor's marking results. From the test results obtained sensitivity value is 40.6%, the specificity value is 96.9%, and the accuracy value is 94.2%. System performance is quite fast, 5.247 seconds, for the entire process.

For further research, it is better to use images taken by researchers themselves in order the initial characteristic of wrinkles can extract correctly. Parameters for area size are determined more flexible based on facial characteristics. Other characteristics of wrinkles can be proposed to increase the specificity score.

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