AUTOMATIC SEGMENTATION OF U-ZONE AREA ON FACIAL IMAGES USING FUZZY EDGE DETECTION, HOUGH TRANSFORMATION, AND VIOLA-JONES ALGORITHM

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Abstract— Each person has different types of facial skin. Knowing the type of skin that we have is very important for skin care because different skin types require different treatments. The face area commonly used for examining skin types includes the right cheek, left cheek, and chin, commonly referred as the U-zone area. However, determining the U-zone area manually gives subjective results and requires a long time. Currently there is very few research on determining the U-zone area using the aid of computer. In this research a new scheme for detecting the U-zone area automatically was proposed by combining Fuzzy edge detection, Hough transformation, and Viola Jones algorithm. Fuzzy edge detection and Hough transformation are used to detect face locations, while the Viola-Jones algorithm is used to detect the location of eyes and mouth which is the basis for detecting cheeks and chin. Based on the research that has been done, it is proven that Fuzzy edge detection and Hough transformation can be used to detect the location of the elliptical face even though the range of facial rotation values must be between 80-100 degrees. The method of determining the U-zone area proposed by combining with the Viola-Jones Algorithm can provide a fairly accurate U-area result with the accuracy of 89.90%.

Keywords— Segmentation, U-zone, Fuzzy edge detection, Hough Transformation, Viola-Jones Algorithm

1. INTRODUCTION

Sulastomo (2013) explains that “Skin is the outermost organ of the body that lines the human body. Skin weight is estimated at 7% of total body weight. On the outer surface of the skin there are pores (cavities) that become the place of sweat. The skin is an organ that has many functions, including the protection of the body from various things that can be dangerous, as a means of sense of touch, body temperature regulator, etc.” The face is an important part of the body for a person, both for men and women. The skin is an elastic wrap that protects the body from environmental influences. The skin is also the heaviest and widest body size, which is 15% of the body weight and the width of 1.50-1.75 m2 Average 1-2mm skin thickness. The thickest (6 mm) is on the palms and feet and the thinnest (0.5 mm) is in the penis. The skin is divided into three main layers, namely the epidermis, dermis or corium, and subcutaneous or subcutaneous tissue (Harahap,

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2000). The face or face is the front of the head, in humans it covers the area from the forehead to the chin, including hair, forehead, eyebrows, eyes, nose, cheeks, mouth, lips, teeth, skin, and chin. The face is mainly used for facial expressions, appearance, and identity. There is no single face that is absolutely identical, even in identical twin humans. Every person certainly craves a face that is white, clean, and not dull. Therefore, intense care is needed for it, in a natural and appropriate way.

Each person has different types of facial skin. Knowing the type of skin that we have is very important for skin care because different skin types require different treatments. Rostamailis (2005) describes that the type of facial skin is divided into 4 types, namely normal, dry, oily, and combination skin. The use of skin care products that are not suitable for the skin type will cause damage to the skin. Healthy, fresh, and smooth skin is the dream of all of us, men and women. Unfortunately, many people ignore or even do not understand the condition of their own skin. Skin health problems are often allowed to drag on and people just consult the doctor after being the problem becomes severe and disturbing.

The face area commonly used for examining skin types includes the right cheek, left cheek, and chin, commonly referred as the U-zone area. However, determining the U-zone area manually gives subjective results and requires a long time. Currently there is very few research on determining the U-zone area using the aid of computer. Digital image processing is a field that is developing very rapidly in line with technological advances in the industry today. Digital image processing is used to process data obtained in machine perceptions, which are procedures used to extract information from images in a form suitable for computer processing.

Image segmentation is part of the digital image processing. The process of image segmentation is more a preprocessing in the object recognition system of the image. Image segmentation means dividing an image into homogeneous regions based on certain similarity criteria between the gray level of a pixel with the gray level of neighboring pixels. The results of this segmentation process will be used for further high-level processes that can be done on an image, for example the image classification and object identification. In the image segmentation process there are several algorithms that can be used, one of which is Viola-Jones Algorithm.

Viola-Jones algorithm is an algorithm that is most widely used to detect faces. Viola-Jones has introduced a face detection framework that is capable of processing images very quickly with a high detection rate. Viola-Jones applies Adaboost (adaptiveboosting) algorithms that can improve detection performance. The Adaboost algorithm plays a role in choosing suitable features to detect interesting objects. In this study a new U-zone area detection scheme was proposed by combining Fuzzy edge detection, Hough transformation, and Viola-Jones algorithm. Fuzzy edge detection and Hough transformation are used to detect face locations, while the Viola-Jones algorithm is used to detect the location of eyes and mouth which is the basis for detecting cheeks and chin.

2. RESEARCH METHODOLOGY

Fig. 1 The Proposed Methodology for Detecting the U-Zone Area

To detect and segment U-zone area on the face, three different methods are used, which are Fuzzy edge detection, Hough transformation, and Viola-Jones algorithm. Fuzzy edge detection is used in this research to produce edge images which will then be followed by oval detection. Fuzzy edge detection is used because it is considered more accurate in producing edge images so that edge detection becomes more optimal. After the edge image is obtained, the next step is detecting oval or ellipse using Hough transformation. The oval or ellipse on the edge image shows that the part is the face. Cropping the face part needs to be done to eliminate the background of the input image so that later it will not reduce the accuracy of U-zone area detection. After the face image is obtained, the next step is detecting the location of the eyes and mouth using Viola-Jones algorithm. The Viola-Jones algorithm was chosen because it has a high degree of accuracy and its computational time is 15 times faster than the Rowley Baluja-Kanade detector and is approximately 600 times faster than the Schneiderman-Kanade detector. Detection of eye in facial images is needed to get the coordinates of the right and left boundaries of the cheeks. The bottom boundary of the eye is used for the upper boundary of the cheek. The bottom coordinates for the cheeks boundary are used from the upper boundary of the mouth. The right, left and bottom boundary of the mouth is used as the right, left, and top boundary of the chin, respectively, while the bottom boundary of the chin is the lowest part of the face image. The details of the proposed methodology can be seen in Figure 1.

2.1. U-ZONE AREA

The U-zone area is the area of the face around the cheeks and chin that forms the letter U. This area usually looks more oily because it has more oil glands than other skin areas so that this area usually requires more attention and care. The U-zone area on the face is often used to classify facial skin types. The example of U-zone area on the face can be seen in Figure 2.

Fig. 2 U-Zone Area on Facial Images

2.2. IMAGE SEGMENTATION

Images captured by the camera and quantized in the form of discrete values are referred to as digital images. Printed photos from the printer cannot be called digital images, but photos stored in image files (bmp, jpg, png or other formats) on a computer can be called digital image (Basuki, 20015 & Destyningtias et al, 2010). Image segmentation is part of the image processing. The process of image segmentation is more a preprocessing in the object recognition system of the image. Image segmentation means dividing an image into homogeneous regions based on certain similarity criteria between the gray level of a pixel with the gray level of neighboring pixels. The results of this segmentation process will be used for further high-level processes that can be done on an image, for example the image classification and object identification. In the image segmentation process there are several algorithms, including: point detection, line detection, and side detection algorithms (based on Robert Operators and Sobel Operators).

Gonzalez and Wintz (1987) stated that segmentation is the process of dividing an image into a number of parts or objects. Segmentation is a very important part of automatic image analysis process, because in this procedure the desired object will be used for the next process, for example: on pattern recognition. The segmentation algorithm is based on two characteristics of the degree of image brightness, which are discontinuity and similarity. By using the discontinuity characteristics, the image is separated on the basis of striking changes in the degree of brightness. Common applications are for detection of points, lines, areas, and sides of the image. The similarity characteristics becomes the base of thresholding, region growing, region of splitting, and region merging algorithm. The principle of image segmentation can be applied to static or dynamic images. Image segmentation is dividing an image into homogeneous regions.

2.3. FUZZY EDGE DETECTION

Contours or edges are usually found at the boundary between two different regions of an image. The edges can be oriented in a direction, and this direction varies depending on changes in intensity (Putra, 2010 & Sutoyo et al., 2009). Fuzzy logic is used in many fields including edge detection. Fuzzy image processing is a collection of fuzzy approaches in the field of image processing to understand, present, and process images, image segments, and their parts as fuzzy sets. In fuzzy image processing there are three main steps, which are fuzzification process, membership value modification, and defuzzification. The most important step is the membership value modification (Tizhoosh, 2004). More details about fuzzy image processing is presented in Figure 3.

Fig. 3 Basic Structure in Fuzzy Image Processing

FUZZIFICATION

Fuzzification is the conversion of all input or output variables to a fuzzy set. The value ranges of the input variables are grouped into several fuzzy sets and each set has a certain membership degree. The form of fuzzification used in this system is triangle and trapezoid, as shown in Figure 4. The form of fuzzification determines the degree of membership of an input or output range value. The degree of fuzzy set membership is calculated using the membership function formula of the fuzzification triangle.

Fig. 4 Fuzzy Sets for the Variable to Determine Color Threshold

$$\mu_{Black}[x1] \begin{cases} 1 & x1 \leq 0 \\ (127,5-x1) / (127,5-0) & 0 \leq x1 \leq 127,5 \\ 0 & x1 \geq 127,5 \end{cases} \dots\dots\dots(1)$$

$$\mu_{Gray}[x1] \begin{cases} 0 & x1 \leq 0 \text{ atau } x1 \geq 255 \\ (x1-0) / (127,5-0) & 0 \leq x1 \leq 127,5 \\ (255-x1) / (255-127,5) & 127,5 \leq x1 \leq 255 \end{cases} \dots\dots\dots(2)$$

$$\mu_{White}[x1] \begin{cases} 0 & x1 \leq 127,5 \\ (x1-127,5) / (255-127,5) & 127,5 \leq x1 \leq 255 \\ 1 & x1 \geq 255 \end{cases} \dots\dots\dots(3)$$

The μ_{Black} in Equation 1 is for the black boundary of fuzzy set. The μ_{Gray} in Equation 2 is for the gray boundary of fuzzy set. The μ_{White} in Equation 3 is for white boundary of fuzzy set.

MEMBERSHIP VALUE MODIFICATION

The original image used is a color image that is converted into an eight-bit grayscale image to simplify calculations, where the color image is represented by the same value on the three RGB components. This simplification will reduce the time needed to do image processing. After the image is converted into a grayscale image, edges are detected by comparing the gray value of a pixel to the neighboring pixels. The degree of edge membership is the difference between a pixels and its neighboring pixels. In this research, each pixel (Z5) has eight neighboring pixels which form a 3x3 matrix.

$$\mu_{edge}(i,j) = 127,5(\mu_{image}(k,l) - \mu_{image}(i,j) + 255).....(4)$$

where:

$\mu_{image}(i,j)$ = the pixels to be searched for its degree of edges

$\mu_{edge}(i,j)$ = degree of edge for pixel with coordinates i, j

$\mu_{image}(k,l)$ = pixels located around pixel i, j

The results of the operation of Equation 4 will produce a value of edge (i, j) between 0 and 255. The center of concentration is around the value of 127.5. To detect edges, eight simple fuzzy rules are used. The degree of edge of each point is calculated by looking for the minimum value of edge (i, j) between the three points around it which is located on the upper left, lower left, upper right, lower right, upper horizontal, lower horizontal, left vertical and right vertical. These rules can be stated as follows:

R1 = min($\mu_{edge}(2,1)$, $\mu_{edge}(3,1)$, $\mu_{edge}(3,2)$),
R2 = min($\mu_{edge}(1,1)$, $\mu_{edge}(1,2)$, $\mu_{edge}(2,1)$),
R3 = min($\mu_{edge}(2,3)$, $\mu_{edge}(3,1)$, $\mu_{edge}(3,3)$),
R4 = min($\mu_{edge}(1,2)$, $\mu_{edge}(1,3)$, $\mu_{edge}(2,3)$)
R5 = min($\mu_{edge}(1,1)$, $\mu_{edge}(2,1)$, $\mu_{edge}(3,1)$),
R6 = min($\mu_{edge}(1,3)$, $\mu_{edge}(2,3)$, $\mu_{edge}(3,3)$)
R7 = min($\mu_{edge}(3,1)$, $\mu_{edge}(3,2)$, $\mu_{edge}(3,3)$),
R8 = min($\mu_{edge}(1,1)$, $\mu_{edge}(1,2)$, $\mu_{edge}(1,3)$)

The visualization can be illustrated in Figure 5. After searching for the minimum value of the three points around it, an operation is performed to find the maximum value of the three surrounding points. Then an operation is performed to find the maximum value of the eight results above. This value is used as the value of fuzzification results.

DEFUZZIFICATION

To improve the results obtained, a contrast operation is carried out. Contrast operation is carried out according to Equation 5 below.

$$C(i,j) = K * (\mu(i,j) - P) + P.....(5)$$

where:

$C(i,j)$ = grayscale on point i, j after contrast operation

K = a constant value

$\mu(i,j)$ = grayscale value results from fuzzy rules

P = grayscale value as a contrast center

After the contrast operation, to further clarify the results obtained, a thresholding process is carried out. The purpose of this thresholding process is to get binary image. The thresholding process is carried out according to Equation 6 below.

$$H(i,j) \begin{cases} 0, & \text{if } C(i,j) \leq K_1 \text{ or } C(i,j) \geq K_2 \\ 1, & \text{if } K_1 < C(i,j) < K_2 \end{cases} \dots\dots\dots(6)$$

where:

H(i,j)=the final value after the thresholding process is carried out

C(i,j)=the grayscale value after contrast operation

K1 and K2=thresholding constant

Fig. 5 Fuzzification Rules

2.4. HOUGH TRANSFORMATION

Hough transformation is a feature extraction technique used in image processing. The application of Hough transformation is an important part in the field of science and technology, such as segmentation of iris using Hough transformation from the patients with kidney disease (Tawas et al., 2010), processing of batik with machete patterns (Hapsari et al., 2015), detection of cataract eyes (Auliannisa et al., 2017), fingerprints matching (Qamal & Burhanuddin, 2012), detection of ceramic's angle and defects (Amelia, 2014), location detection based on vehicles' plate number (Setiawan & Asri, 2017), identification of cholesterol levels (Mubarak, 2015), detection of room door (Muharom, 2017), detection of pterygium disease (Tanazri et al., 2018), and detection of zebra cross (Indriani et al., 2017). Classical Hough transformation identifies lines in an image, then finally use it to identify positions in changing forms. Extraction of features

from digital image is very useful for finding straight, circular, and elliptical lines (Barrile et al., 2012). Hough transformation is based on feature points extracted from the original image, in which the edges are usually used as feature points. A variety of edge detection methods are used for different applications (Jain & Jain, 2012). The well-known methods for detecting circular or elliptical shapes are CHT (Circle Hough Transform) and EHT (Elliptical Hough Transform) (Smerka & Duleba, 2008). In this research, the EHT model was used to detect faces that usually have elliptical shapes.

2.5. VIOLA-JONES ALGORITHM

Nowadays there are many applications that use face detection features. Face detection can be done in various ways, one of which uses the Viola-Jones algorithm. Viola-Jones algorithm is an algorithm that is most widely used to detect faces. Viola-Jones has introduced a face detection framework that is capable of processing images very quickly with a high detection rate. Viola-Jones implements Adaboost (adaptive boosting) algorithms that can improve detection performance. The Adaboost algorithm plays a role in choosing suitable features to detect interesting objects. To simplify the process of calculating feature values, the Viola-Jones algorithm uses a medium in the form of Integral Image (Viola, 2001).

In the Viola-Jones framework, there are many libraries to carry out the feature selection process. Feature that is a basic function to improve the selection process known as the HaarLike feature. One proof of the accuracy of the Viola-Jones algorithm is found in the research conducted by Saeed-Syed and Kumar-Prasad (Saeed, 2010 & Kumar, 2011). The Viola-Jones algorithm is an object detection method with high accuracy of about 93.7% and a very high computational speed of around 0.067 seconds (Viola, 2001). Viola-Jones introduces a new image representation known as Integral Image that is inseparable. With this method, Haar-Like features can be calculated at any scale or location in a constant time.

In the eighth EECCIS journal, it is stated that the Viola-Jones algorithm is an object detection method that has a high level of accuracy, which is around 93.7%, with computational speed 15 times faster than the Rowley Baluja-Kanade detector and approximately 600 times faster than Schneiderman-Kanade detector. The Viola-Jones method combines four main keys, which are Haar-Like feature, Integral Image, Adaboost and Cascade classifier.

3. RESULTS AND ANALYSIS

a. Dataset

The experiments on the segmentation of U-zone area on facial images uses a total of 22 data. The data used are photos of the faces of Indonesian people from Sifra Skin Care (Pati, Central Java), Griya Ayu Clarista (Sidoarjo, East Java), Rossi Skin Care & Spa (Denpasar, Bali), Rumah Cantik Assyva (Kediri, Java East) using cell phone's camera and DSLR camera. The ground truth of U-zone area that will be used for comparison is selected manually by experts.

b. U-Zone Area Detection

The first step to detect U-zone area on facial images is by doing edge detection using the fuzzy method. Edge detection using the fuzzy algorithm is chosen because it is optimal in images that have a large variation in contrast or non-uniform lighting as contained in most facial images. The binary image from edge detection is then used as input to the EHT (Elliptical Hough Transform) method. The EHT method is used to detect oval shapes found in binary images from edge detection results. The selection of

ovals is done because most human faces have an oval face shape. After the oval area is found, cropping is done on the face. The detailed steps that have been systemized can be seen in Figure 6.

Fig. 6 Implementation of Fuzzy and Hough Transformation

After the face is cropped, the next step is to detect the position of the eyes and mouth using the Viola-Jones algorithm method. The Viola-Jones method combines four main keys namely Haar-Like feature, Integral Image, Adaboost, and Cascade classifier. In the Viola-Jones framework, there are many libraries to carry out the feature selection process. The process of eye and mouth detection using the Viola-Jones algorithm that has been implemented can be seen in Figure 7.

Fig. 7 Implementation of Viola-Jones Algorithm

The final step in detecting the U-area is to get the right and left boundary coordinates of the eye that can be used as the right and left boundaries of the cheeks. The upper cheek border is the lower limit of the eye and the upper border of the mouth is used as the lower limit of the cheek. The right, left and bottom boundary of the mouth is used as the right, left, and top boundary of the chin, respectively, while the bottom boundary of the chin is the lowest part of the face image. The results of the segmentation can be seen in Figure 8.

Fig. 8 U-Zone Area on Facial Image

c. Accuracy

Equation 7 is used to calculate the accuracy of the segmentation of the U-zone area on facial images using Fuzzy edge detection, Hough transformation and Viola-Jones algorithm [2].

$$Accuracy = \sum_{i=1}^c \frac{A_i \cap C_i}{\sum_{j=1}^c C_j} \times 100\% \dots\dots\dots(7)$$

where A is the segmentation result, C is the ground truth image. The accuracy measurement on fifteen different images is shown in Table I.

Table II. The Experiment Results

No	Images	Accuracy %
1	1-2.png	88.23
2	1-5.png	89.45
3	1-9.png	90.36
4	1-10.png	92.64
5	2-9.png	87.54
6	2-11.png	89.56
7	2-12.png	90.45
8	3-5.png	91.67
9	3-6.png	89.65
10	3-8.png	88.56
11	3-14.png	89.67
12	4-3.png	90.56
13	4-4.png	92.67
14	4-7.png	90.78
15	4-8.png	86.67
Average		89.90

4. CONCLUSION

Fuzzy edge detection and Hough transformation can be used to detect elliptical faces even though the range of facial rotation values must be between 80-100 degrees. The proposed method is used to determine the U-zone area by combining the Fuzzy edge detection, Hough transformation, and Viola-Jones Algorithm. The proposed method can provide an accurate segmentation of U-zone area with the average accuracy of 89.90%

even though the system is difficult to obtain accurate forehead U-area images when the patient is wearing an eye patch. Based on the experimental results, there are several suggestions that can be useful for future studies, such as automating the determination of Hough transformation parameters for detecting the face location and improving the image enhancement process because the images used often have uneven illumination.

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