Face Recognition using Modified Triangle Method

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Abstrak. Pengenalan wajah diperlukan untuk beberapa aplikasi seperti siatem keamanan. Pada penelitian ini, peneliti memberikan metode triangle yang baru untuk deteksi dan pengenalan wajah dari wajah seseorang yang diaplikasikan untuk sistem keamanan. Metode ini berdasarkan deteksi warna kulit untuk mendeteksi wajah manusia dan mengenali wajah tersebut menggunakan metode *modified triangle*. Yang dilakukan pertama kali adalah pemrosesan gambar dimana semua gambar dijadikan dalam resolusi yang sama. Kemudian, metode ini akan melakukan skin detection berdasarkan warna kulit dari gambar, non-face object akan dihapus oleh *morphological method* untuk mendapatkan hanya gambar wajah saja, segmentasi wajah, deteksi *features point* dari wajah (mata kanan, mata kiri, dan mulut) dan kemudia dihitung *Euclidean distance* diantara *features face*. Jarak antara *eatures face* akan dibandingkan dengan database untuk proses pengenalan wajah. Dari hasil penelitian menunjukkan bahwa metode ini dapat mencapai tingkat keberhasilan 90% dalam deteksi wajah dan 50% untuk pengenalan wajah.

Kata kunci: deteksi wajah, pengenalan wajah, *triangle method*

Abstract *Human face recognition is required for several applications such as security system. In this paper, we propose a new triangle method for detection and recognition of the human face which is applied for security system. We use the skin colour based detection to detect the human face and recognize the selected face by modified triangle method. First, we do image pre-processing which include change all picture in same resolution. Next, this method will do skin detection based skin colour from the image, non-face object removal by morphological method for getting the face of image only, face segmentation, detect features point of face (right eye, left eye, and mouth) and then compute Euclidean distance between features face. The distance between features face will be compared with database for face recognition. Experimental result shows that our method can achieve 90% success rate for face detection and 50% for face recognition.*

Keywords : *face detection, face recognition, triangle method*

1. Introduction

Face recognition, nowadays has become a very important technique for several applications namely computer vision, security system, surveillance, identification etc. Since every human has a different face characteristics, it makes face becomes the most suitable parameter for security system among other parts of the body. Face recognition, like another technique of image processing, has many challenges. The first challenge is face detecting itself. Face detecting is required before recognizing the face. There are some problems that make face detection becomes difficult, they are lightning condition or illumination, distance between object and camera, camera resolution, face orientation, facial expression and pose, and the background of the captured picture.

Low illumination or also high illumination makes face becomes more difficult to detect due to the degradation of the difference level between face and other objects around it. Distance between object and camera and camera resolution makes algorithm has to apply a treatment so different face sizes can be detected. Face orientation, facial expression and pose change the face shape and feature on it. Various backgrounds can make the algorithm detect false face because there can be a similar colour object in background with the human face.

There are several face detection algorithms, Those algorithms are based on four characteristics, namely skin colour based, geometry based, appearance based, edge based [Phimoltares, 2007]. Skin colour based is a simple method to locate face based on its skin colour component. This method is relatively simple but it's difficult to apply in a picture with low illumination and various colours of background especially when there is another object which has similar colour with skin. The geometry based uses the shape of the face which is similar with an ellipse, this method is relatively difficult due to the algorithm which we use to find the ellipse of face. The appearance based is a method which use some transformations to make the face appear, generally the gray component is the paramater for face detection. Edge based is a method which uses edge detection of the face.

In face recognition there are two kinds of technique namely traditional technique and 3-dimensional technique. The 3-D technique requires an advance sensor system to capture information about the 3-D geometry, surface and shape of face. The traditional technique only requires a picture or a video frame to extract the feature of the face. There are six algorithms of traditional technique [Harguess, 2009], namely Eigenfaces, Multilinear Principal Components Analysis (MPCA), MPCA with Linear Discriminant Analysis (MPCALDA), Fisherfaces or Linear Discriminant Analysis (LDA), Independent Component Analysis (ICA), Support Vector Machine (SVM). Eigenfaces contains a set of eigenvector in the form of human face which can represent various different human faces. Any human face is a combination of these eigenfaces. These eigenfaces (eigenvector-face) is generated by Principal Component Analysis (PCA) which is a statistical analysis of some sample faces [Turk, 1991]. MPCA is also a statistical analysis and it is a development algorithm of PCA. The difference between PCA and MPCA is MPCA can handle a multidimensional image by using multiple orthogonal transformations without converting it to a vector. Due to this process, MPCA can handle an image much faster than PCA [Plataniotis, 2006]. Fisherface is a method similar to eigenface but they are different in the variable modeling.

On paper [C. Lin, 2000], Lhin et al introduce Geometric Triangle Relationship as a method to detect a human face. This method utilizes the feature of the human face, eyes and mouth, to create a triangle between the relationship of these three points. This kind of method is used with some modification by Gao et al in paper [Gao, 2012] to recognize the face orientation. Based on the triangle method algorithm, this method can be used for face recognition since this method count the Euclidean distance between each of the human face features (right eye-left eye, right eye-mouth-left eye mouth) which has various value in different human face.

In this paper, we propose method for detection and recognition of the human face. We use the skin colour based detection to detect the human face and recognize the selected face by modified triangle method.

2. Theoretical Background

2.1 Proposed triangle Method

Face recognition identify the person in the image using a stored data base of faces, which depends on features of face The scheme of our system based on a triangle method that use eyes and mouth as features of face. Flowchart system of the purposed triangle method is shown in Fig. 1.

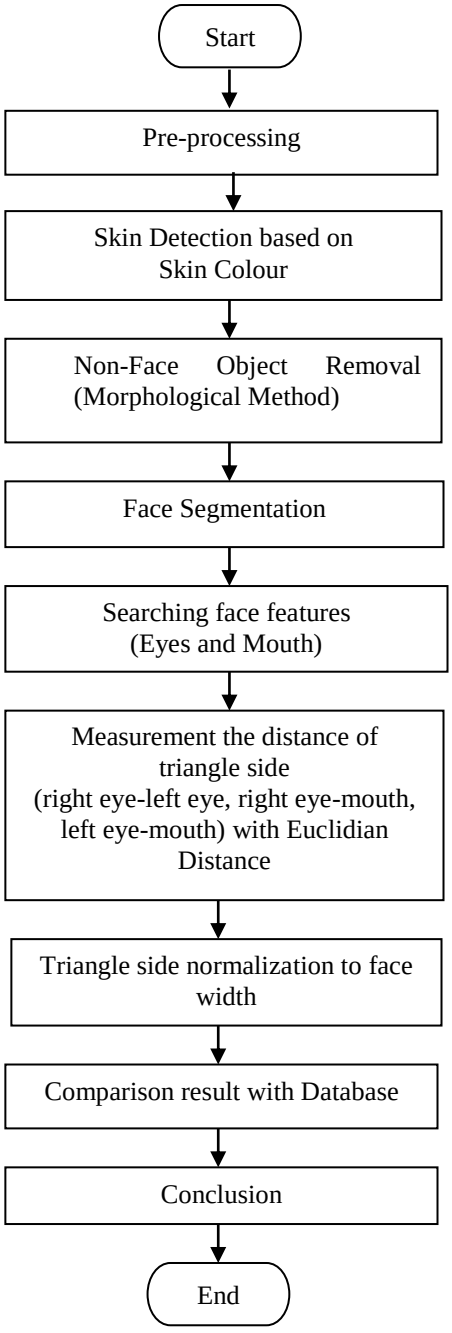


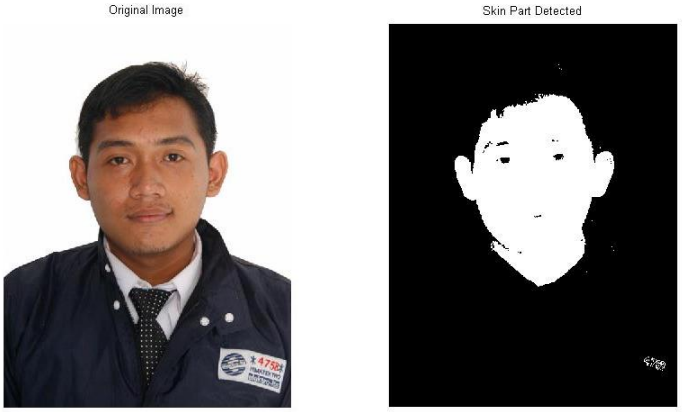
Figure 1. Flowchart of Purposed Triangle Method

a. Preprocessing

Before starting the face recognition, there is a process called preprocessing. All images assumed to have a ratio of 3:4 based on the camera resolution in general. Each image will have a resolution of 640x480 in order while the morphology process of all images to equal treatment. If an image has a resolution more than 640x480 then the resolution will be reduced to 640x480. In turn, if an image has a resolution less than 640x480 then the resolution will be enlarged to 640x480.

b. SkinColour Based for Face Detection

There are three colour models which is usually used to represent an image namely RGB, YcbCr and HSV. RGB is colour format in general picture. There are some works before that have classified the colour component value for human skin in these three models. In [Chen,2008], the RGB is normalized and used for the skin detection criteria. Zhang et al use the value of H and S as the criteria for skin detection in [Zhang, 2009]. Vranceanu et al use both HSV and YcbCr as the criteria [Vranceanu, 2011]. YcbCr also becomes a criteria in [Ming,2010]. From our experimental result in several sample pictures, Cr is the most suitable criteria for skin detection with value 10-45.



(a) (b)

Figure 2. (a) Original Image (b) Skin Part Detection

c. Non-Face Object Removal

After detecting skin, sometimes there are other objects which are also detected as skin because of the similarity Cr value with the skin/face. Each of these objects usually has a little size. To reduce the existence of the non-face object, in this paper we use one of the mathematical morphology operators, that is erosion. At the end of this step the picture is already cropped to form a bounding box of the face and neck.

(a) (b)

Figure 3. (a) Skin after eroded (b) Face Skin

d. Face Mapping

In this step the face has been detected and cropped. The face picture is then needed a transformation so its features (eyes and mouth) can be differed among other picture parts. We again utilize the mathematical morphology operator, but this time two kinds of the

morphological, erosion and dilation, are applied. The Y value of the picture is dilated and eroded using equation defined as :

$$\frac{Y(x,y) \oplus g_{\sigma}(x,y)}{Y(x,y) \otimes g_{\sigma}(x,y) + 1} \quad (1)$$

(a) **(b)**

Figure 4. (a) Cropped Figure (b) Figure after dilated and eroded

e. Eyes and Mouth Searching Algorithm

The mapped picture is then transformed into a binary image. The position of both right and left eyes are assumed in the range of 0.2-0.5 part of the face from the center of the face in the x-axis and 0.17-0.45 part of the face in the y-axis. In this region, eyes are recognized as the mean of the existing white pixels. The mouth is recognized as the mean of the white pixels in the region of 0.55-0.77 part of the face in the y-axis.

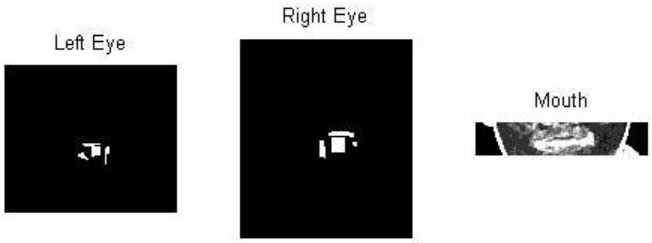


Figure 5. Left eye, Right eye, and Mouth detected

f. The Distance Calculaton of Face Feature

Distance between each of the face features is calculated using the Euclidean Distance Equation.

$$d_{12} = \sqrt{(dx^2 + dy^2)} \quad (2)$$

where

$dx = x_2 - x_1$

$dy = y_2 - y_1$

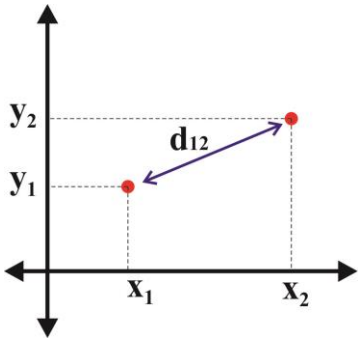


Figure 6. Euclidean distance (d_{12}) for two points in 2D

The three lines which connect the eyes to each other and to the mouth will form a triangle with the side sizes of the triangles are the Euclidean distance of face feature. After getting the Euclidean distance of the features, the distance is divided by the width of the face. This step is purposed to get a relative triangle size so whenever there is another same person's picture with different pixels or with various distances to the camera, the algorithm still has the ability to recognize the person. The last step is comparing between the calculated relative triangle size to the one in database. To handle probability of error, the database has a range of ± 5% tolerance.

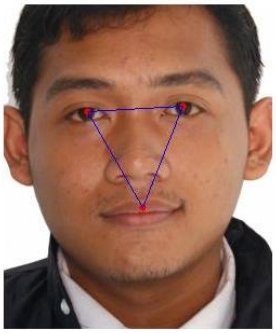


Figure 7. Features Face Detected

3. Experiments

In this paper, fifteen pictures with ten different persons as shown in Figure 6 and Figure 7, one pose (neutral pose, no variation of pose,facial expression and facial orientation) and no lightning of variation, are tested in four schemes of tested. The first test is the face detection through ten pictures of different person. The second test is the feature detection, the feature detection is successful if the three triangle corners are successfully located in right eye, left eye and mouth. The third test is variation of face size or the distance between camera to the face. The last test is face recognition itself.

Figure 6. Experimental Images

4. Result and discussion

A. Face Detection

The algorithm successfully detects the human face in the picture 1 to 9 but fail to classify the skin in picture 10. It could happen because the algorithm just classify the skin based on the Cr value, furthermore the human face in picture 10 has the Cr value of the skin outside the range of 10 to 45. The erosion function which is purposed to remove the non-face object makes the detected face becomes disappear. Based on this test, the algorithm could detect the human face up to 90% in accuracy.

B. Feature Detection/ Triangle Construction

On this test, not all of the result of nine successful face detected picture yields good triangle construction. Picture 10 which fails in the first test, certainly can't construct triangle of the face feature. Picture 1, 2, 6, 8 and 9 result perfect triangle construction since their feature can be detected correctly. In picture 3, 4 and 7 algorithm make the same mistake. The algorithm is designed to handle the human face image which the neck part is also included, the face segmentation in picture 3, 4 and 7 doesn't include the neck part due to the clothes type. Picture

5 is another example of a special case where triangle feature is not well constructed. The feature search in the left eye and mouth is perfectly found, but the right eye is not. This can happen because while right eye's segmentation and the eye mean calculation, the hair edge coordinate is also included. So,in this case the failure of triangle construction happens because the human hairstyle.

C. Human Face Size Variation

In this section, we perform experiments with human face size variation by difference of face to camera. Figure 7 below is tested for face recognition which is compared with database. The goal of this experiments is program can recognize the image as a same person although distance between face and camera is different.

(a) (b) (c)

Figure 7. Experimental Images with Face Size Variation

The database is filled with only one person "Edo" and its relative triangle size ranges are :

right-left eye : 0.2506-0.2768

right eye-mouth : 0.3571-0.3947

left eye-mouth : 0.3961-0.4159

Table 1.Triangle Relative Size Data From The Measurement of Same Picture but Different Size

	right-left eye	**right eye-mouth**	**left eye-mouth**	**Recognition Decision**
Database range	0.2506-0.2768	0.3571-0.3947	0.3961-0.4159	_
Picture 7(a)	0.2637	0.3759	0.3961	Recognized as "Edo"
Picture 7(b)	0.2681	0.3860	0.4030	Recognized as "Edo"
Picture 7(c)	0.2749	0.3736	0.3965	Recognized as "Edo"

5. Conclusion

This paper has presented a new triangle method to detect and recognize face. Our method extracts features of face point such as right eye, left eye, and mouth and count the Euclidean distance. There are several step before detect features face such as pre-processing, skin detection based on skin colour, non-face object removal (morphological method), face segmentation, and search features face (eyes and mouth). We have done 2 experiments. First, we use 10 images for detection and recognition image. The result show that our method can

achieve 90% success rate for face detection and 50% for face recognition. The second experiment is human face size variation. In this experiment, we use same face but different distance between face and camera which is causing face size difference. In database, the face in image is recognized as "Edo". The result of this second experiment is distance face to camera is different, that face is still recognized as "Edo".

References

H. Y. Chen, C. M. Fu, and C. L. Huang. 2008. Hybrid-Boost Learning for Multi-Pose Face Detection and Facial Expression Recognition, Pattern Recognition, pp. 1173–1185

L. Gao and Y. Xu. 2012. Face orientation recognition based on multiple facial feature triangles, International Conference on Control Engineering and Communication Technology

J. Harguess and J. K. Aggarwal. 2009. A Case for the Average-Half-Face in 2D and 3D for Face Recognition, Computer Vision and Pattern Recognition Workshops. CVPR Workshops 2009. IEEE Computer Society Conference on Pattern Recognition

Y. Z. Jie Yang, Xufeng Ling and Z. Zheng. 2008. A Face Detection and Recognition System in Color Image Series, Mathematics and Computers in Simulation, pp. 531–539

H. Lu, K.N. Plataniotis and A.N. Venetsanopoulos. 2006. MPCA: Multilinear Principal Component Analysis of Tensor Objects, IEEE 2006 Biometrics Symposium ,Sept.

C. Lin, K.-C. Fan. 2000. Human Face Detection Using Geometric Triangle Relationship, Proceedings 15 Th International Conference On Pattern Recognition, Sept.

C. Ming and C. Yisong. 2010. A hardware/software co-design of a face detection algorithm based on FPGA, International Conference on Measuring Technology and Mechatronics Automation, pp. 109–112

S. Phimoltares, C. Lursinsap, and K. Chamnongthai. 2007. FaceDetection and Facial Feature Localization without Considering the Appearance of Image Context, Image and Vision Computing,pp. 741–753

J. Tang and J. Zhang. 2009. Eye Tracking Based on Grey Prediction, First International Workshop on Education Technology and Computer Science, pp. 861–864

M. Turk and A.Pentland. 1991. Face Recognition using Eigen Faces, Computer Vision and Pattern Recognition, pp. 586–591

R. Vranceanu, R. Condorovici, C. Patrascu, F. Coleca, and L. Florea. 2011. Robust Detection and Tracking of Salient Face Features in Color Video Frames, 10th International Symposium on Signals, Circuits and Systems (ISSCS), 2011.

X. Wu Zhang, D. Duan, Ling-yan Liang, and W. liang Xia. 2009. A Novel Method of Face Detection Based on Fusing YCbCr and HIS Color Space, Proceedings of the IEEE International Conference on Automation and Logistics, pp. 831–835.