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Handshape Recognition Using Correlation Filter and Euclidean Distance

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Abstract: This paper proposes a handshape recognition based on correlation filter and Euclidean distance. Unlike biometric and face verification system, handshape is rarely used for verification of an individual. Therefore, handshape will be used as an alternative way for human identification and authentication for this system. The performance for the minimum average correlation energy (MACE) filter and Euclidean distance are evaluated using a new database.

Keywords: correlation filter, Euclidean distance, handshape recognition, minimum average correlation energy (MACE).

1. Introduction

Technology has been tremendously in a way to improve human being lifestyle and comfort. There are many occasions in which personal authentication is required, such as unlocking a smart phone and access to a restricted building. Personal authentication can be categorized into various methods, such as using fingerprint and personal identification number (PIN). The most common way for personal authentication is passwords and PIN. However, users might choose less secure passwords for their convenience and ease of memorization and passwords usually contain common words [1]. Furthermore, passwords are plagued by security problems [2] and openly hated by users [3].

Correlation filter is widely used in pattern recognition such as video surveillance [4], vehicle navigation [5] and automatic target recognition (ATR) [6]. There are several types of correlation filter such as matched spatial filter (MSF) [7], synthetic discriminant function (SDF) filter [8] and MACE [9]. The most common correlation filter is MSF which is also known as North filter, where the unknown signal is convolving with a conjugated time-reversed version of the template. However, it performs poorly when the reference image appears with distortions such as rotations and scale changes. Therefore, SDF filter is later introduced by Hester and Casasent [8] which is a linear combination of MSF. The correlation outputs would yield pre-specified values at the origin of the training images.

Face verification using MACE filter and individual eigenface subspace method are successfully performed by using three or five training images [10]. The results of using MACE filter yields a very high accuracy rate when only using three training images. Besides, a fingerprint verification system using correlation filter also successfully performed with 98% accuracy [11]. It required a total number of six training images to achieve the accuracy of the system.

Human hand does not significantly change after a certain age. Geometrical feature extraction [12] is used for recognition of human hand using Euclidean distance to measure the distances of centroid from the origin to detect the presence of hand and achieved an overall accuracy of 92.56%. However, his method consists of big number of parameters.

Handshape recognition using MACE filter and Euclidean distance (with less parameters) are introduced in this paper. Often note in literature, MACE filter is used for face and fingerprint verification where it yields a high accuracy rate. However, this paper present will implements on handshape. The Euclidean distances between points of interests will be measured and discussed. A new database of handshape will be tested by using the proposed method and the performances for the two proposed methods will be evaluated as shown in Figure 1.

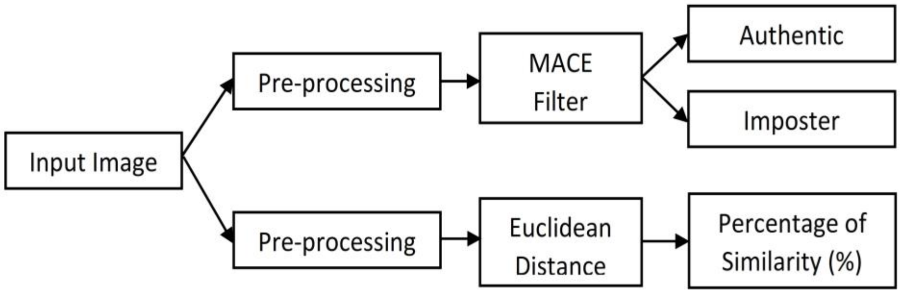

Figure 1. Overall block diagram

2. Proposed Handshape Recognition System

2.1 Database

The images obtained from this paper utilized a new handshape database collected by the author using Logitech HD Webcam C310. A slight rotation of the hand is acceptable by the system. The database consists of 4 persons where each person has 10 images of similar, varying handshape position or slight rotation. The size of the image captured is 1280 *x* 960 pixels using Logitech Webcam Software version 2.80.853.0a. Throughout the experiment, the same raw images will be used for both method and Matlab 2013a is used to evaluate the results. Sample images are shown in Figure 2.

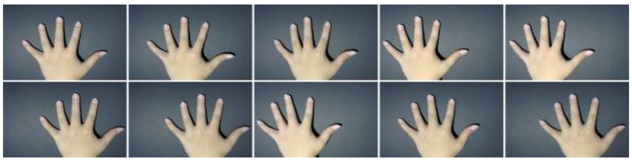

Figure 2. Sample images of the database

2.2 Minimum average correlation energy filter

MACE filter is used as it could reduce the large sidelobes from SDF filter [8] and produced high accuracy rate in face [10] and fingerprint verification system [11]. Because of the outstanding performance of MACE filter in face and fingerprint recognition, it will be utilized in this paper to investigate its performance on handshape. The correlation planes yield values which are close to zero everywhere except at the location of a trained object, where a strong peak is produced. Equation (1) is the MACE filter equation while Table 1 provides its description.

The overall system consists of two modules as shown in Figure 3, which are training module and testing module. During training module stage, the MACE filter template is created in the frequency domain array complex form. The correlation is computed by multiplying MACE filter template with one test image at the testing module stage. Figure 4 shows a typical correlation plane for an authentic image while Figure 5 shows a typical correlation plane for an imposter image. The peak to sidelobe ratio (PSR) is used to measure the peak sharpness and is shown in Equation (2). Large PSR indicated an image is authentic while a small PSR indicated imposters. The false acceptance rate (FAR) and false rejection rate (FRR) will be evaluated using equation (3) and equation (4).

$$H = D^{-1}X(X^{+}D^{-1}X)^{-1}u \qquad (1)$$

Table 1. Description of symbol for mace filter

Symbol / Matrix	Description
D	The *d x N* diagonal matrix contains along its diagonal and the average spectrum of the training images
X	2-D FFTs of the training images and convert the 2-D FFT arrays into 1-D column vectors by lexicographic ordering. These vectors are the column vectors of the *d x N* matrix.
u	Column vector with *N* element contains the pre-specified correlation peak value of the training images. It is normally set to 1 for all training images from the authentic class.
d	Numbers of pixel in a single training image.
N	Number of training image from the true class.
+	Complex conjugate transpose.
-1	Perform inverse of matrix.

$$PSR = \frac{peak - mean}{standard\ deviation}$$

$$FAR = \frac{Number\ of\ imposter\ images\ with\ PSR > Threshold}{Number\ of\ imposter\ images}$$

$$FRR = \frac{Number\ of\ authentic\ images\ with\ PSR > Threshold}{Number\ of\ authentic\ images}$$

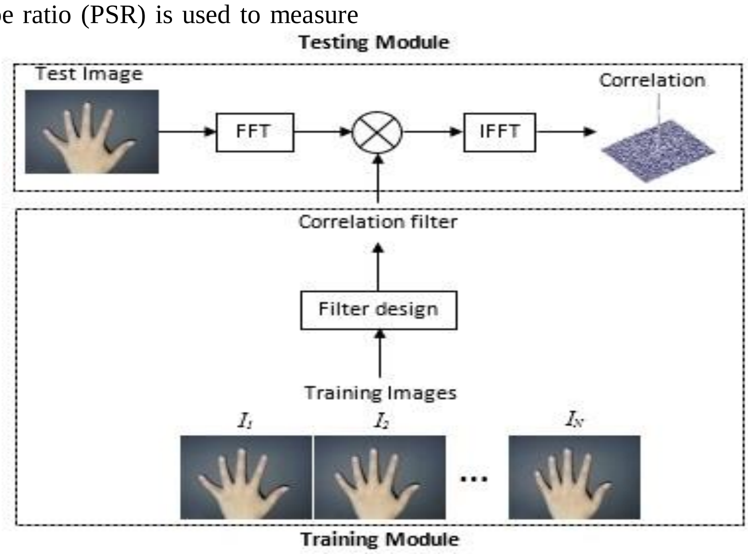

Figure 3. Block diagram for MACE

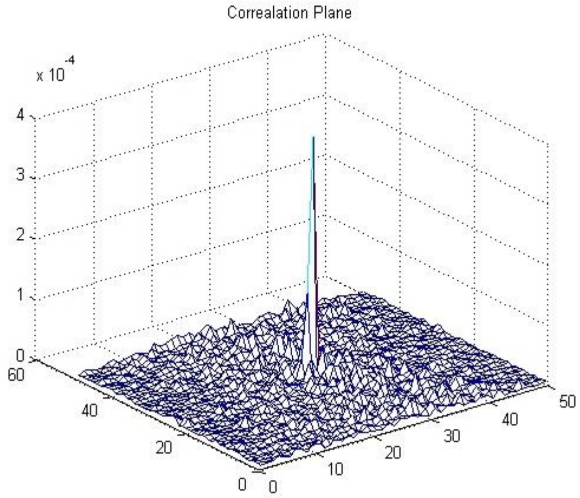

Figure 4. Sample correlation plane for authentic image

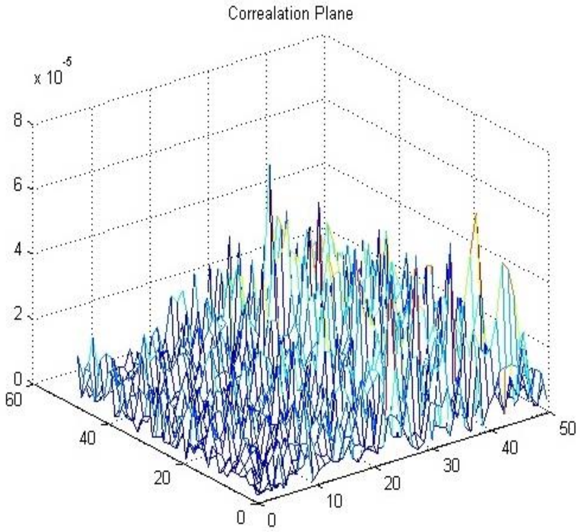

Figure 5. Sample correlation plane for imposter image

2.3 Euclidean distance

The overall system consists of 5 stages as shown in Figure 6. This method is chosen as it is easy to performed verification of the hand without a lots of parameters. One image is chosen by the user as an input image to the system. Image undergoes several processes such as image resize, binary and noise reduction before the features can be extracted. During feature extraction, several points of interest will be located, such as location of the thumb, middle finger, pinky finger, centroid and two reference points will be located.

$$Euclidean\ Distance = \sqrt{(x_2 - x_1) + (y_2 - y_1)} \tag{5}$$

Equation (5) is used to calculate the Euclidean distance between the points of interest. A tolerance value is set as there are definitely certain dissimilarities of the handshape during image acquisition and the percentage of similarity between the references and testing images is computed using Equation (6). The higher the similarities, the higher the percentages it is belongs to the same persons. A total of twelve (12) parameters will be used for matching and decision stages.

$$Percentage\ of\ similarity\ (\%) = \frac{Num\ of\ Parameter\ Pass}{Total\ Num\ of\ Parameters} \tag{6}$$

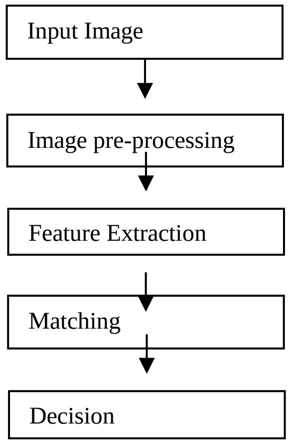

Figure 6. Components of Euclidean distance system

3. Experimental Design

Six (6) points of interests will be identified and shown in Figure 7. Twelve (12) parameters will be identified for Euclidean distance method. Table 2 shows the parameters used. Figure 8 shows the distances from parameter P1 to P5 while Figure 9 shows the distances from parameter P6 to P12.

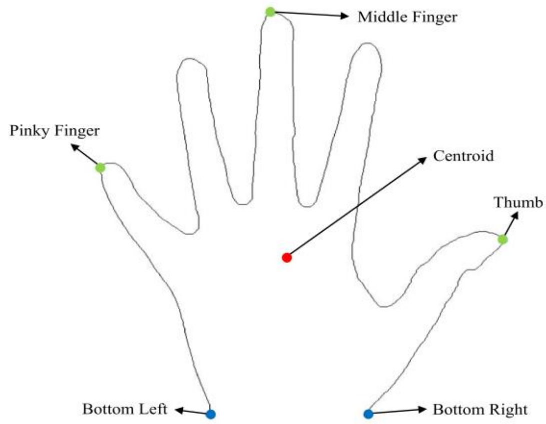

Figure 7. Image with identified points of interests

4. Results and Discussions

4.1 Minimum average correlation energy filter

Two tests are used to analyze the performance for MACE filter. The first test used only 3 training images to synthesis the template. PSR greater than 13 (>13) will be accepted as authentic image. Table 3 and Table 4 show the PSR by using 3 and 5 training images from person 1. Person 1 yields a large PSR as the MACE filter is designed for person 1.

In Table 5, person 1 exhibits the highest FAR while person 4 exhibits the highest FRR. The second test used five training images to synthesis the MACE template.

Table 2. Paramaters

Parameter	Measured Points
P1	Centroid to middle finger
P2	Centroid to bottom left
P3	Centroid to bottom right
P4	Centroid to pinky finger
P5	Centroid to thumb
P6	Bottom left to pinky finger
P7	Bottom left to middle finger
P8	Bottom left to thumb
P9	Bottom right to pinky finger
P10	Bottom right to middle finger
P11	Bottom right to thumb
P12	Bottom left to bottom right

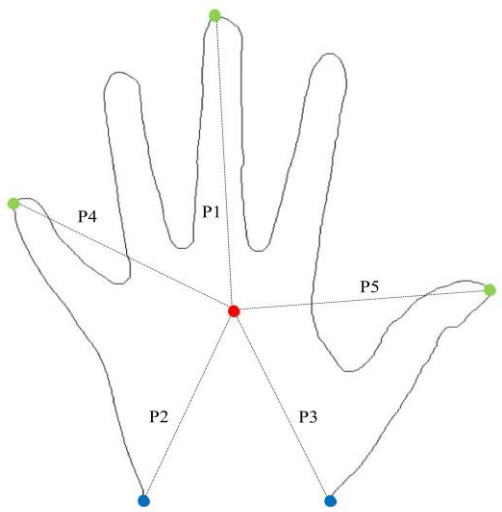

Figure 8. Image with identified parameter P1 to P5

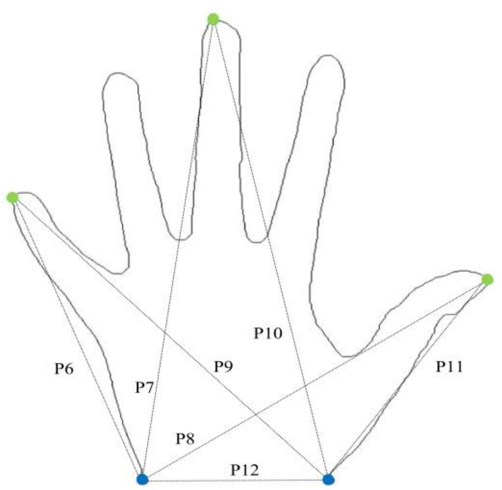

Figure 9. Image with identified parameter P6 to P12

Table 3. PSR using 3 training images from person 1

Testing Image	PSR			
	Person 1	Person 2	Person 3	Person 4
Image 1	72.31	15.94	6.38	11.52
Image 2	66.72	17.02	8.54	10.34
Image 3	68.60	15.69	11.23	7.38
Image 4	33.70	11.06	11.19	8.99
Image 5	30.77	15.35	7.30	8.35
Image 6	53.85	13.87	11.20	7.89
Image 7	24.14	14.47	9.91	13.17
Image 8	18.00	11.10	6.72	8.12
Image 9	28.62	13.12	6.72	6.52
Image 10	15.62	22.65	8.25	12.21

Table 4. PSR using 5 training images from person 1

Testing Image	PSR			
	Person 1	Person 2	Person 3	Person 4
Image 1	22.87	10.75	5.35	7.46
Image 2	24.94	11.07	6.51	6.22
Image 3	22.69	9.42	6.00	6.79
Image 4	24.67	6.67	7.09	6.98
Image 5	17.87	9.20	5.20	5.91
Image 6	21.51	8.36	6.91	5.76
Image 7	12.64	8.21	6.84	9.57
Image 8	9.10	7.74	-	6.88
Image 9	13.09	8.59	5.35	5.36
Image 10	9.50	13.74	6.56	7.95

Table 5. FAR & FRR using 3 training images

Person	1	2	3	4
FAR	0.3	0.0	0.17	0.10
FRR	0.0	0.2	0.0	0.2

In Table 6, person 1 exhibits the highest FAR while person 4 exhibits the highest FRR. In comparison, FAR is greatly reduced for all person as compare to using only 3 training images. Although it yield a low FAR, it may not ideal to have a system that yields a high FRR for authentic person. Among the two tests, using 3 training images produces high FAR but yield a low FRR. In contrast, using 5 training images produced low FAR but yield a high FRR. Overall, the FRR is greatly increased if 5 training images is used.

Table 6. FAR & FRR using 5 training images

Person	1	2	3	4
FAR	0.03	0.03	0.0	0.0
FRR	0.3	0.3	0.2	0.4

Based on this method, it can be seen that increasing the training images did not improve the accuracy for our system.

It may not appropriate to use correlation filter for handshape recognition.

4.2 Euclidean Distance

Several tolerance values are evaluated for this system, such as 2%, 5% and 10%. The results of using person 1 as references image is shown throughout this paper. In Table 7, the highest similarity for a false class is person 3 with 16.67%. For true class, the lowest similarity is 58.33% for Image 8. Although it provide an acceptable level of accuracy, it may not ideal to implement this system by using 2% tolerance as a slight rotation of the hand is unavoidable.

Table 7. Percentage of similarity using person 1 as training image with 2% tolerance

Testing Image	Percentage of Similarity (%)			
	Person 1	Person 2	Person 3	Person 4
Image 1	100	8.33	8.33	0
Image 2	75	8.33	8.33	8.33
Image 3	91.67	0	8.33	0
Image 4	75	0	8.33	0
Image 5	75	0	8.33	0
Image 6	91.67	0	0	0
Image 7	83.33	0	0	0
Image 8	58.33	0	16.67	8.33
Image 9	66.67	0	8.33	0
Image 10	75	8.33	0	8.33

In Table 8, the tolerance is increased to 5%. The highest similarity for person 3 is increased from 16.67% to 66.67%. Meanwhile, person 2 and person 4 yield a maximum similarity of 8.33% and 25%. For true class, the lowest similarity is 83.33%. In the experiment, person 1 yields more than 80% similarity throughout the 10 testing images.

In Table 9, 10% tolerance is used. The percentage of similarity for person 3 yields a very high similarity of 91.67%. It is not desired to obtain a high similarity for a false class. One noticeable results is observed for person 3, where most of the testing images yield more than 80% similarity. For person 2 and person 4, the highest similarity is 66.67% and 58.33%. Relatively, person 1 yields 100% similarity due to a larger tolerance is used.

Throughout the three test performed, using 5% tolerance is most suitable for this system. All images for person 1 yields more than 80% similarity while person 2 and person 4 yield a low similarity. However, person 3 yields more than 50% similarity for most of the images.

This could be due to the handshape is very similar in term of size. Hence, more parameters can be included to increase the accuracy of the system.

Table 8. Percentage of similarity using person 1 as training image with 5% tolerance

Testing Image	Percentage of Similarity (%)			
	Person 1	Person 2	Person 3	Person 4
Image 1	100	8.33	50	8.33
Image 2	83.33	8.33	33.33	8.33
Image 3	100	0	50	8.33
Image 4	83.33	8.33	50	0
Image 5	100	8.33	33.33	0
Image 6	100	0	41.67	8.33
Image 7	100	0	66.67	0
Image 8	83.33	8.33	66.67	25
Image 9	91.67	0	41.67	0
Image 10	91.67	0	50	8.33

Table 9. Percentage of similarity using person 1 as training image with 10% tolerance

Testing Image	Percentage of Similarity (%)			
	Person 1	Person 2	Person 3	Person 4
Image 1	100	50	83.33	33.33
Image 2	100	50	75	33.33
Image 3	100	41.67	75	33.33
Image 4	100	50	83.33	25
Image 5	100	50	83.33	8.33
Image 6	100	66.67	83.33	25
Image 7	100	75	83.33	25
Image 8	100	25	91.67	58.33
Image 9	100	41.67	75	25
Image 10	100	33.33	83.33	50

5. Conclusions

MACE filter and Euclidean distance is proposed in this paper. The results showed that Euclidean distance performed with a greater accuracy than MACE filter. Besides, Euclidean distance required 1 training image while MACE filter required 3 training images. Furthermore, more parameters can be included into the proposed method to improve the accuracy of the results.

References

[1] C. Yang, J. L. Hung, Z. X. Lin, "Loose Password Security in Chinese Cyber World Left the Front Door Wide Open to Hackers", in *14th Annual International Conference on Electronic Commerce*, pp. 121-126, 2012.

[2] R. Morris, K. Thompson, "Password Security: A Case History", *Communication of the ACM*, vol. 22, no. 11, pp. 594-597, 1979.

[3] A. Adams, M. A. Sasse, "Users Are Not The Enemy", *Communication of the ACM*, vol.42, no. 12, pp. 41-46, 1999.

[4] E. O. Omidiora, S. O. Olabiyisi, J. A. Ojo, A. Abayomi-Ali, A. Y. Akingboye, F. Izilein, P. I. Ezomo, “MACE Correlation Filter Algorithm for Face Verification in Surveillance Scenerio”, *Journal of Computer Science and Engineering*, vol.18, no. 1, pp. 6-15, 2013.

[5] R. Szeliski, *Computer vision: algorithms and applications*, 1st ed. Springer Science & Business Media, 2010.

[6] A. Mahalanobis, D. W. Carlson, B. V. K. Kumar, “Evaluation of MACH and DCCF correlation filters for SAR ATR using MSTAR Public Database”, *Algorithms for Synthetic Aperture Radar Imagery V*, vol. 3370, pp. 460-468, 1998.

[7] A. V. Lugt, “Signal Detected by Complex Spatial Filtering”, *IEEE Transactions on Information Theory*, vol. 10, no. 2, pp. 139-145, 1964.

[8] C. F. Hester, D. Casasent, “Multivariant Technique for Multiclass Pattern Recognition”, *Applied Optics*, vol. 19, no. 11, pp. 1758-1761, 1980.

[9] A. Mahalanobis, B. V. K. Kumar, D. Casasent, “Minimum Average Correlation Energy Filters”, *Applied Optics*, vol. 26, no. 17, pp. 3633-3640, 1987.

[10] M. Savvides, B. V. K. Kumar, P. Khosla, “Face Verification using Correlation Filters”, in *3rd IEEE Automatic Identification Advanced Technologies*, pp. 56-61, 2002.

[11] S. Joshi, A. Kumar, “Correlation Filter based on Fingerprint Verification System”, in *International Conference on VLSI, Communication and Instrumentation*, pp. 19-22, 2011.

[12] F. Mohammed, W. Mohammad, A. S. M. Kayes, “Geometrical Feature Extraction of Human Hand”, *International Journal of Computer and Information Technology*, vol. 2, no. 4, pp. 780-784, 2013.