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Fusion of License Plate and Face Recognition for Secure Parking

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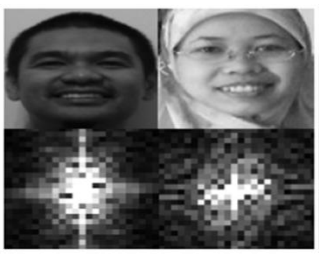
Graphical abstract



Abstract

Integration of multimodal biometrics is widely explored for the purpose of security enhancement. Hence, in this research we deemed further to evaluate the integration of car plate and face recognition as security enhancement in parking lot. Firstly, the acquired face and car plate that acted as database is encrypted based on Hill Cipher matrix manipulation using random numbers and Fast Fourier Transform (FFT) as encryption algorithm. Next, Unconstrained Minimum Average Correlation Energy (UMACE) was applied for car plate recognition process during parking entrance in identifying the intruder via Peak to Side lobe Ratio (PSR) value. During exit, UMACE is once again utilized for both plate and face recognition for verification of registered driver based on decision fusion of PSR value. Results attained specifically Total Success Rate (TSR) of 96% during parking entrance along with over 99% during exit at PSR value of 10, confirmed that the proposed method is apt as security in parking space.

Keywords: Decision fusion; Unconstrained Minimum Average Correlation Energy (UMACE); Peak to Side lobe Ratio (PSR); encryption; plate and face recognition

Abstrak

Integrasi multimodal biometrik diterokai secara meluas bagi penambahbaikan tahap keselamatan. Justeru, integrasi pengecaman plat kereta dan muka dijalankan bagi peningkatan keselamatan di ruang parkir kereta. Pertamanya, algoritma penyulitan pangkalan data imej plat kereta dan muka dibangunkan dengan memanipulasi secara rawak matriks Hill Cipher serta transformasi Fast Fourier (FFT). Bagi mengenal pasti penceroboh, penuras korelasi minimum purata tenaga tanpa kekangan (UMACE) digunakan bagi pengecaman plat kereta semasa memasuki kawasan parkir berdasarkan nilai Nisbah Puncak lobus sampingan (PSR) yang diperoleh. Seterusnya, sebelum keluar dari kawasan parkir, hasil gabungan pengecaman plat dan muka berdasarkan UMACE digunakan bagi pengesahan pemandu mengikut pendaftaran dalam pangkalan data berasaskan nilai gabungan PSR yang diperoleh. Dengan nilai PSR bersamaan 10, jumlah kadar sukses (TSR) memasuki kawasan parkir adalah 96% manakala TSR untuk keluar dari kawasan parkir pula adalah 99%. Maka, keputusan ini mengesahkan bahawa hasil kajian ini adalah amat sesuai sebagai meningkatkan keselamatan dalam ruang parkir.

Kata kunci: Pelakuran keputusan; penuras korelasi minimum purata tenaga tanpa kekangan (UMACE); nisbah puncak lobus sampingan (PSR); penyulitan; pengecaman plat dan pengecaman muka

1.0 INTRODUCTION

Biometric is an essential protection apparatus which can be used for public recognition as well as verification to offer an optimum degree of inviolability than traditional recognition approaches. Therefore, rapidly evolving biometric research is updated all the time for enhancement of more robust and rapid system. Many countries use biometric applications for tasks such as time attendance, door access, payroll and human resource management systems. The biometric recognition identifies an individual's face, fingerprint, eye, vein, palmprint, signature, gait and DNA. Biometrics can also be utilized for parking systems, law enforcement, surveillance, immigration, and airport security to ensure safety against terrorism.

Initially, most research only focused on one modality before upgrading to multimodal biometrics. With multimodal methodology, the likelihood of accepting an impostor is greatly reduced [1]. One of the multimodal approaches is based on fusion. In general, fusion is defined as a combination or integration of separate entities such as, fusion in faces and thumb print or fusion in face, fingerprint, and hand geometry. Hence, fusion produces better results at the output and achieves higher accuracy in the system [2]. For instance, unlike unimodal biometrics, fusion takes place with several biometrics, thereby enhancing the security and safety of the system. Since it is more difficult to forge multiple biometric characteristics than a single characteristic, a multimodal biometric system is generally more robust in protecting against fraudulent technologies [3].

Therefore, in this study, fusion of face and car plate is discussed for recognition purpose.

Recently, other researchers have also studied numerous methods of car plate and face recognition. In plate recognition, problems may also arise including plates that contain different characters, occlusion, illumination and distance [4]. These difficulties become more challenging in face recognition since it implicates gender, face impression, aging and hair styling [5]. To counteract these challenges, researchers have developed algorithms that improved system performance and usefulness.

This research proposed plate and face recognition in parking and retrieving process based on unconstrained correlation filters introduced by Mahalanobis *et al*. [6]. The study is only focused on recognition area based on feature extraction introduced by Mahalanobis which is not covering any detection or segmentation process. Mahalanobis introduced advanced correlation filter known as unconstrained minimum average correlation energy (UMACE). Main reason of using UMACE filters is because of advantages like shift invariance, capability to compromise in class image inconstancy, and closed form solutions [7]. Next, the study on parking and retrieving process is categorized into three stages; enrolment, parking, and exit. During parking, only plate recognition is concerned regardless who is a driver as long as the plate is registered, it also will reduce camera consume. Then, the decision fusion for matching plate and face are paired based on AND rule is applied during exit process. In addition, the template images are protected by cryptosystem algorithm based on Hill Cipher method. Further discussions are elaborated in proposed method and methodology section.

Section 2 will elaborate the method utilized in this study whilst methodology will be discussed in Section 3. Next, Section 4 will detail the experimental and results attained and finally in Section 5, we will conclude our findings.

2.0 OVERVIEW OF PROPOSED METHOD

2.1 Fourier Transform in Image Processing

Image taken by camera is categorized into time (spatial) domain which can be manipulated in two or three dimension. Analyzing, manipulating and synthesizing image in spatial domain will increase computational time. Therefore processing image in frequency domain is more convenient. The transformation of image from spatial domain into frequency domain is easier to process and evaluate using mathematical equation. The process is using fast Fourier transform (FFT) based on 2D discrete Fourier transform (DFT) equation. Here, the formulation of 2D FFT is given as follows:

$$F(u,v) = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n-0}^{N-1} I(m,n)e^{-j2\Pi(um/M+uv/N)} \tag{1}$$

Where, *F(u,v)* represents image in frequency domain while, *I(m,n)* represents image in time domain, and the size of *F* and *I* is MxN refer as row and column of image pixels. The complex number is represented by *e* which consists of sine and cosine function. Next, transformation of image from frequency domain to time domain is applicable by inverting the FFT formula. The equation of 2D IFFT is given as follows:

$$I(m,n) = \sum_{u=0}^{M-1}\sum_{v-0}^{N-1} F(u,v)e^{j2\Pi(um/M+uv/N)} \tag{2}$$

FFT is used in image processing to authentic test image with image stored in database, especially in discriminating genuine and impostor for image recognition application. As illustrated in Figure 2.0, both images were transformed using FFT have produced different images spectrum. These differences will provide the recognition outcome to identify owner or intruder of the vehicle. Thus, in this study FFT and IFFT was used as an image filter for feature extraction and also applied in cryptosystem algorithm.

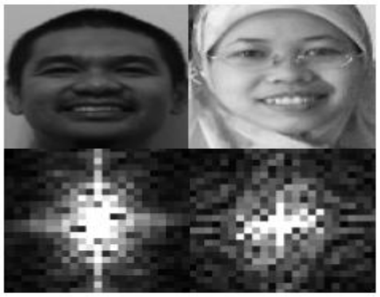


Figure 2.0 FFT results of two different face images

2.2 Correlation Filters

A benchmark designed for the correlation filters is served by synthetic discriminant function (SDF) [6]. SDF is designed to reconcile constraints in the optical systems. However, SDF does not fulfill some requirements as stated in [6], there are three essential points to consider for designing the correlation filters, first is the capability to restrict entropy and noise, second is the algorithm design to manage peak easily, and third is the design should be tolerated with distortions occurred. Therefore, from many designs of correlation filters, UMACE has fulfilled all three consideration points.

Unconstrained MACE (UMACE) filter is a variant of the original MACE filter. However, UMACE will maximize the average correlation values at the origin without constraining any values. Therefore, the original MACE filter is shown in equation (3). The following is a MACE filter equation in a vector form:

$$\boldsymbol{Hmace = D^{-1} X (X^{+} D^{-1} X)^{-1} u} \tag{3}$$

In equation (3), *X* is matrix from column vectors of d x N. Where, d is the number of pixels in each image of the *N* training images from the true class. Column vector *u* contains correlation peak values of the training images subject to the constraints value normally set to 1, and *D* is diagonal matrix in the form of average power spectrum. Superscript ‘+’ and ‘-1’ are denoted as transpose and inverse matrix form respectively.

While the equation for UMACE which subject to unconstraint values will make the peak correlation at origin is maximized is expressed as:

$$\boldsymbol{Humace = D^{-1}m} \tag{4}$$

where D is the average power spectrum and m is the Fourier transform of the average training image as formulated in (1) and (2).

The advanced correlation filter is enhanced and served to be robust in differentiating genuine and impostor as in [8-11] used the correlation filter in face recognition. Further, Tahir *et al*. [12] utilized the UMACE in posture recognition and Ghafar *et al*. [13] detected the abnormal changes in ECG based on UMACE. UMACE is applied in this research as feature extraction in plate and face recognition to distinguish between genuine and impostor as illustrated in Figure 2.1, is also shown in the block diagram of proposed method during exit process.

2.3 Peak to Sidelobe Ratio (PSR)

As mentioned before, UMACE filters will produce maximum correlation peak at the origin and minimize the average correlation energy. This peak value is responsive to changes of illumination in the test image. But the illumination variance can't be easily avoided in image processing. Thus, PSR is employed to reduce the illumination problems [14]. The peak sharpness is measured using peak to sidelobe ratio denoted as follows:

$$PSR = \frac{Peak_{correlation} - Mean_{sidelobe}}{Standard\ Deviation_{sidelobe}} \qquad (5)$$

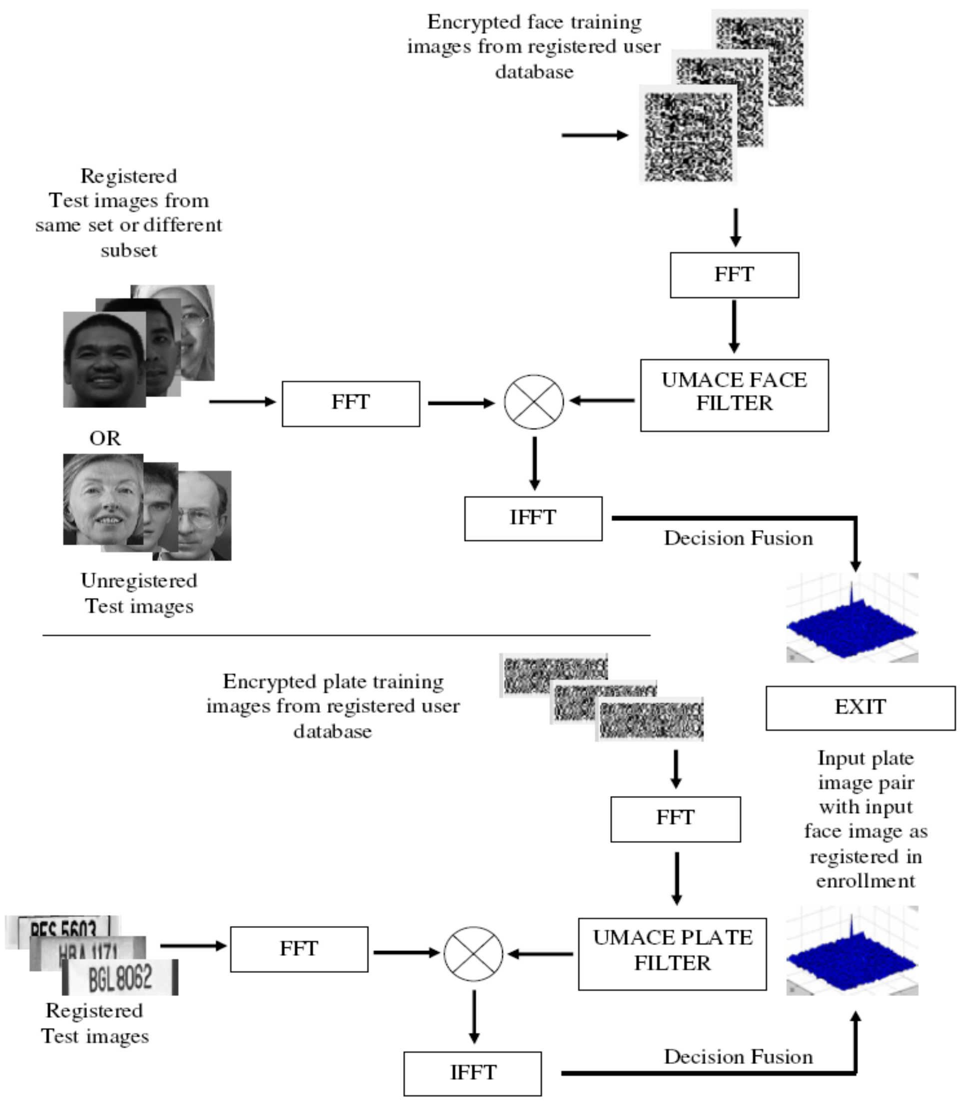
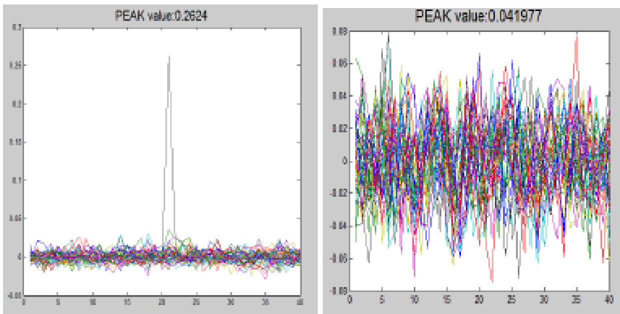


Figure 2.1 Block diagram of proposed method during exit

where *mean* and *standard deviation* are average value of sidelobe and *peak* is the maximum value in the correlation output.

The importance of correlation peak is to identify and determine the originality of test image. As depicted in Figure 2.2, (a) if a test image is genuine, correlation output will exhibit sharp with high peak. Otherwise, (b) if no high discernible peak, the test image will categorize as impostor.



(a) (b)

Figure 2.2 Correlation peak

2.4 Cryptosystem

This study proposes implementing a cryptosystem during parking and retrieving of vehicles for security enhancement. Recently, researchers have proposed numerous encryption and decryption techniques that are more beneficial than other method [15-18]. Generally, there are four properties that need to be fulfilled when designing a quality template protection scheme: diversity, revocability, security, and performance [19]. Hill Chiper matrix manipulation algorithm [20-21] is used in this research. Hill Cipher is a block cipher that has several advantages including its ability to disguise letter frequencies of the input image. In addition, its simplicity is a result of matrix multiplication and the inversion for enciphering and deciphering.

Hill Cipher is a polygraphist substitution cipher based on linear algebra. Hill Cipher use matrices and matrix multiplication to mix up the plaintext. The 'key' to a Hill Cipher is a matrix (i.e., matrix 3 by 3). However, it can be any size as long as it is a square matrix. Cryptosystem is applied in the enrollment process as shown in Figure 2.3. Face and plate of training image is multiplied with random number in matrix form. Size of the matrix must be the same to produce encrypted training images. Further, an image is transform into UMACE filter and resize as initial images.

Enrollment Phase:

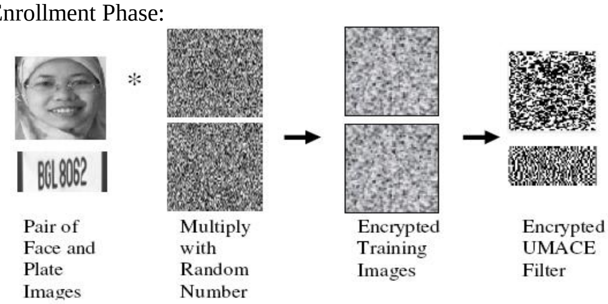


Figure 2.3 Proposed of encryption face and plate.

2.5 Fusion at Decision Level

The final decision is made by accepting or rejecting result generated from the fusion of multiple classifiers. Since the evaluation stage only requires a single bit data, the process is simple and efficient. The decisions from various classifiers are then consolidated in order to obtain the final decision result [22]. [23-26] performed decision fusion in gait recognition, face verification, vehicle detection and car plate recognition respectively, which proved to be practical and effective. Further, [27] combined face and speech based on nearest neighbourhood (NN) classifier for security application which is implemented the fusion decision module to achieve optimum result in the verification system.

Generally, fusion at decision level uses the matching scores to either determine an identity or validate a claimed identity. By comparing the query image with the templates stored in the database, the matching scores of each classifier are generated. Then, the scores output from the multiple classifiers are combined using several fusion strategies to give a unique matching score. The final output will be either 'Accept' or 'Reject' as a results of multiple classifiers consolidated via techniques such as SUM rule, OR rule, AND rule or majority voting method.

Hereby, fusion of plate and face recognition were implemented at decision level using AND rule method. The probabilities of matching result are further evaluated as stated condition:

Parking process,
Recognize genuine plate.
[PQg] + [PR] = Registered (6)

Where, PQg is genuine query plate, '+' is match with and PR is registered plate.
Recognize impostor plate.
[PQi] + [PR] = Not registered (7)

Where, PQi is impostor query plate, '+' is match with and PR registered plate.
Exit process,
Recognize genuine face AND genuine plate AND both are paired as registered during enrolment.
[FQg + FR] * [PQg + PR] * [PE] = Matches (8)

Recognize genuine face AND genuine plate AND both are not paired as registered during enrolment.
[FQg + FR] * [PQg + PR] * [PEn] = Not matches (9)

Recognize impostor face AND genuine plate AND both are not paired as registered during enrolment.
[FQi + FR] * [PQg + PR] * [PEn] = Not matches (10)

Where PQg, PQi, PR and + are as defined earlier. FQg, FQi, and FR refer to genuine query face, impostor query face and registered face respectively. PE and PEn refer to paired and unpaired in enrolment respectively and finally the symbol '*' refers as the AND rule.

2.6 Car Plate Database

In this study, approximately 80 images of cars are randomly selected from the LPR database [28] based on several criteria such as type and color of plates, illumination conditions, and various angles of vision both indoor and outdoor images. In addition, more than 20 Malaysians and other country car images are captured in various conditions. All car plate images are resized to 51 x 151 pixels. On the whole, a total of over 100 car images are used as database.

2.7 Face Database

In the face recognition, AT&T face database [29] formerly known as ORL database from Cambridge laboratories is utilized as database in this study that contains face images of 40 subjects taken between April 1992 and April 1994. Also, 38 subjects are used from the extended Yale face database [30] and 22 of Malaysian faces. Some images are taken against dark homogenous background with the subject in an upright, frontal position and allowable for some side movement. The size of image is fixed as 92 x 112 pixels, with 100 face images utilized as the database.

2.8 Performance Measure

The validity of the result attained is measured using FRR, FAR, TSR, EER, specificity, and sensitivity. Typically, performance measures are false acceptance rate (FAR) and false rejection rate (FRR) as defined below:

$$FAR = \frac{\text{No. of impostor with PSR} > \text{threshold}}{\text{Total No. of impostor}} \, X\ 100 \qquad (11)$$

$$FRR = \frac{\text{No. of genuine with PSR} < \text{threshold}}{\text{Total No. of genuine}} \, X\ 100 \qquad (12)$$

For each face and plate, a PSR threshold is selected and if the query image resulted in a PSR is larger than the threshold it will be evaluated as genuine otherwise it will be evaluated as impostor. FAR refers to the percentage of impostors with PSR above 'threshold' and FRR refers to the percentage of genuine with PSRs below 'threshold'. The total measure can be obtained based on FRR and FAR into the Total Error Rate (TER) or Total Success Rate (TSR) defined as follows:

$$TSR = 1 - TER \qquad (13)$$

In general, sensitivity and specificity are measurements or indicators for accuracy performance of a system or method. In this research, sensitivity is referred as true positive rate to measure accuracy of genuine acceptance and specificity is referred as true negative rate to measure accuracy of impostor rejection.

$$Sensitivity = \frac{\text{Number of genuine} > PSR}{\text{Total number of genuine test image}} \ X\ 100 \qquad (14)$$

$$Specificity = \frac{\text{Number of impostor} < PSR}{\text{Total number of impostor test image}} \ X\ 100 \qquad (15)$$

3.0 THE METHODOLOGY IN ACTION

There are three processes involved in the proposed secure parking that will be based on fusion of face and plate recognition. The processes are enrolment, parking and exit as shown in Figure 3.0. In the enrolment process, the original image of plate and face are captured and stored as database. Next, each image is encrypted using matrix multiplication based on random number and fast Fourier transform. The cryptosystem algorithm is as outline:

START
• Acquire & resize image to 92 by 92
• load plate & face image;
*/*ENCRYPTION*/*
• Generate Random Number
• Multiply Image with random number and transform to frequency domain
*/*DECRYPTION*/*
• Attain encrypted image
• Invert image via FT & and transpose random matrix
• Obtain original image and authenticate with query image
END

Enrolment:

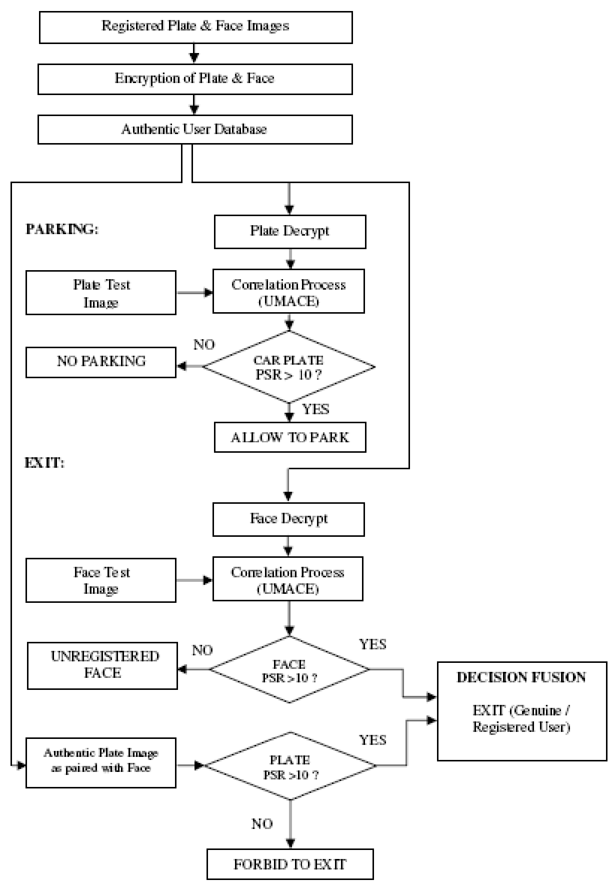


Figure 3.0 Overview of plate and face fusion method for secure parking.

The next stage is parking process. Based on UMACE classifier, the correlation between query image and decrypted images from database is measured by PSR value. The car will be allowed to enter and proceed to park only if PSR > threshold value attained. Finally, during exit, the UMACE classifier is applied once again for recognition purpose based on the PSR value. The exit of vehicle is allowed only if both face and plate is matched in pairs using AND rule decision fusion. In decision fusion, each classifier is based on PSR value. If matches score exceeded both PSR value, the matches are accepted, otherwise the matches are rejected. The decision process based on PSR of UMACE can be summarized as,

Fusion (face & plate) {
Matched - if PSR >threshold for both face and plate are correctly paired.
Unmatched - Otherwise

4.0 EXPERIMENTAL RESULT

This section will discuss the results attained. Upon completion of training, testing and validation of database, threshold value of 10 was identified as an acceptable and suitable threshold for PSR based on results attained as depicted in Figure 4.0. Threshold value is significant to determine between genuine and impostor. It is also observed that only one genuine plate is detected below PSR of 10 as circled and three of impostor faces obtained PSR of above10.

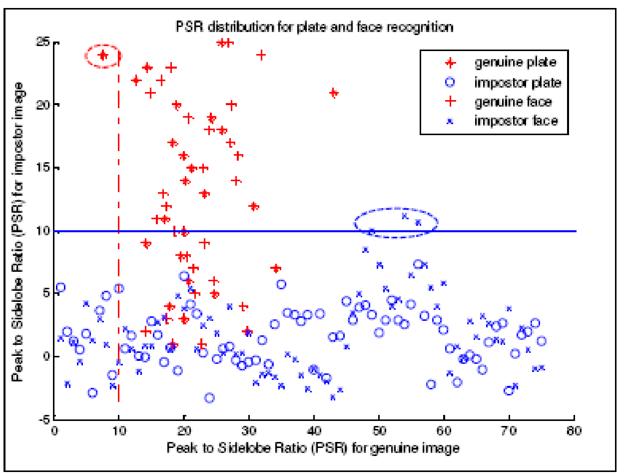


Figure 4.0 PSR distributions for face and plate database

For the performance measure, this proposed method is evaluated as tabulated in Table 1. FAR of 0% and FRR of 4% are attained during parking entrance with 100 plates as test database that comprised of 25 genuine plates and 75 imposter plates. During exit, implementation of fusion of face and plate for recognition purpose is evaluated. Here, 25 pairs (genuine face and plate) are utilized as genuine with 175 pairs (genuine plate but imposter face or vice versa) acted as imposter database attained FAR of 4% and FRR of 0.5% at PSR of 10 as the threshold value. In particular, this technique achieved total success rate (TSR) of 96% during parking entry and 99.5% during exit respectively. Hence, the decision fusion is proven to enhance accuracy with more than 99% success rate.

Additionally, the time consumption with and without encryption and decryption are tabulated as well in Table 1. It is observed that 9.2 second is required for parking and 13.8 second for exit in average for the system without encryption and decryption. However, the computational time is increased by 5.3 second for parking and 2.7 second for exit due to encryption and decryption implementation. This time consumption is tolerable for security purpose.

Further, the FRR, FAR and EER for plates and faces are discussed. Plots of false rejection rate (FRR) also known as type I error and false acceptance rate (FAR) also known as type II error versus PSR is plotted in Figure 4.1 and Figure 4.2 respectively. As we are aware, a good system with higher performance should have lower FAR and FRR. Refer to the FAR and FRR graph, it is analyzed that plate recognition achieved lower rate as compared to face recognition.

This is also supported by ROC curve in Figure 4.3 that showed the EER for plate recognition is low compared with face recognition. Thus, it seem that the error rate for plate is smaller than face due to complexity of face image compare to plate image.

The sensitivity for solely plates and faces is 96% and 80% respectively at PSR threshold or cut off value 10. The graph for the sensitivity versus PSR on the two modalities is plotted in Figure 4.4. Then, the graph for the specificity versus PSR is plotted in Figure 4.5.

From graph sensitivity and specificity versus PSR, it is observed that the plates attained high accuracy compared to faces. An ROC curve is a plot of specificity on the x-axis against sensitivity on the y-axis for different values of the PSR as showed in Figure 4.6.

5.0 CONCLUSION AND RECOMMENDATION

This paper concluded the research done based on the methodology implemented, algorithms developed, and findings attained upon validation and verification conducted to confirm that the proposed method and algorithms developed worked well. Significant findings in this research can be categorized into three. Firstly, algorithms developed with UMACE as feature extraction in plate and face recognition is succeeded based on 10 as PSR value as well as FRR at 0.5% and FAR at 1.71% in classifying between genuine and impostor. Next, encryption and decryption techniques implemented using Hill Cipher and random number is utilized to enhance the security of the plate and face database. Additionally, the performance measure for the cryptosystem is validated using correlation test and computational time taken. Thus, it was found that the time taken for encrypted and decrypted is 0.002s to 0.005s respectively and this time is indeed acceptable for security purpose. Third, decision level fusion employed that is based on AND rule during exit is verified with accuracy rate attained as 99.75%. Finally, the algorithms developed for plate and face recognition is also validated and verified based on genuine accept rate (GAR) for plate at 96%, face GAR as 80%, and impostor rejection rate (IRR) is 100%. Therefore, performance measures attained namely FRR, FAR, GAR and IRR confirmed that the selection of PSR as 10 is proven appropriate and suitable in this study.

Future work include enhancement of the proposed method for real time application which involved hardware and software integration. Finally, the plate and face recognition will become a necessity in the future, therefore, it is not mainly for parking and exit application, the system can be utilized in police surveillance database tracking system for trace stolen car, criminal car investigator and similar application.

Table 1 Performance measure of proposed method based on PSR

Item	Total test images	Recognition based on PSR	Average time consumption without encrypt and decrypt (second)	Average time consumption with encrypt and decrypt (second)	FRR (%)	FAR (%)	TER (%)	TSR (%)	Decision fusion (%)
Parking (plate)	100	99%	9.2	14.5	4.00	0.00	4.00	96.00	N/A (Plate only)
Exit (face & plate)	200	99%	13.8	16.5	0.50	1.71	0.005	99.45	99.75

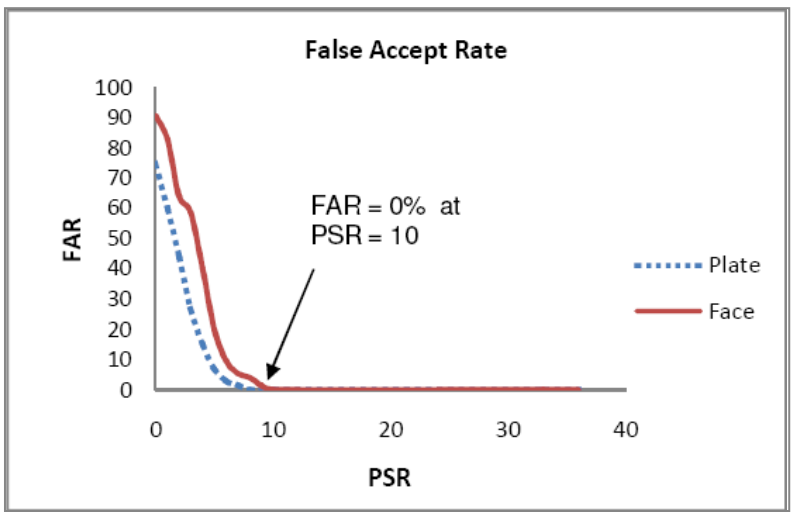


Figure 4.1 FAR versus PSR for plates and faces

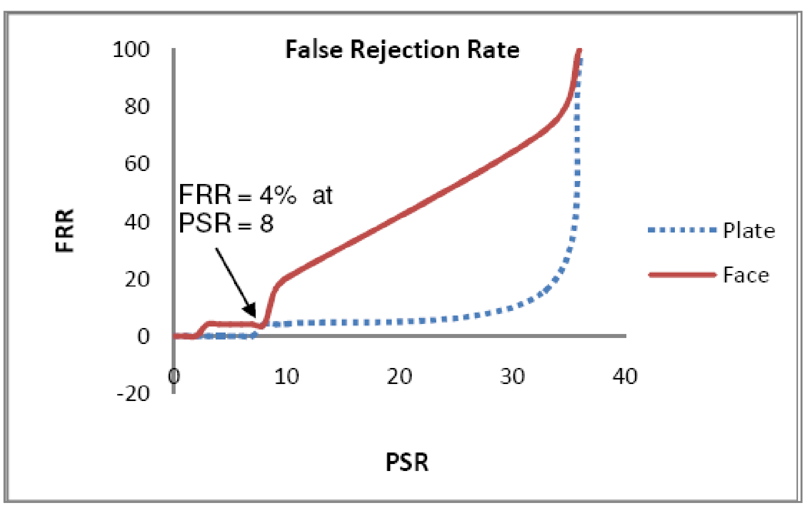


Figure 4.2 FRR versus PSR for plates and faces

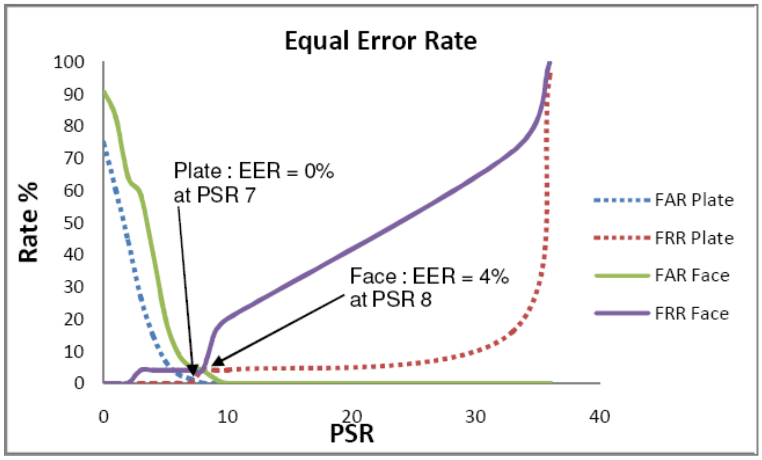


Figure 4.3 EER for plates and faces

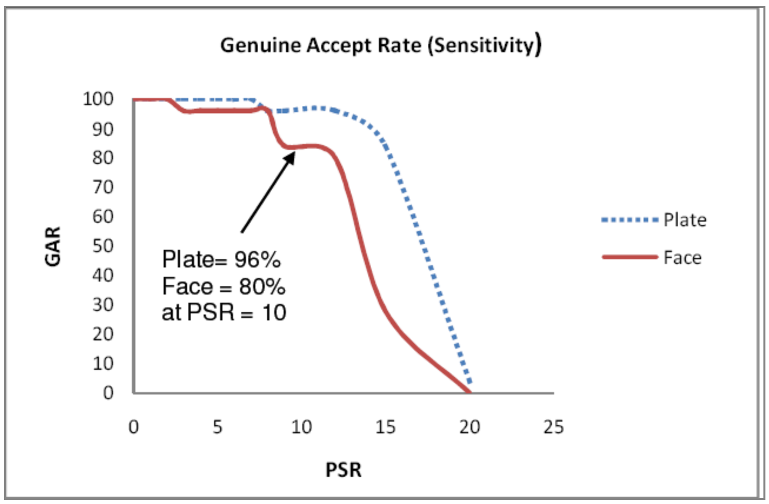


Figure 4.4 Sensitivity versus PSR for plates and faces

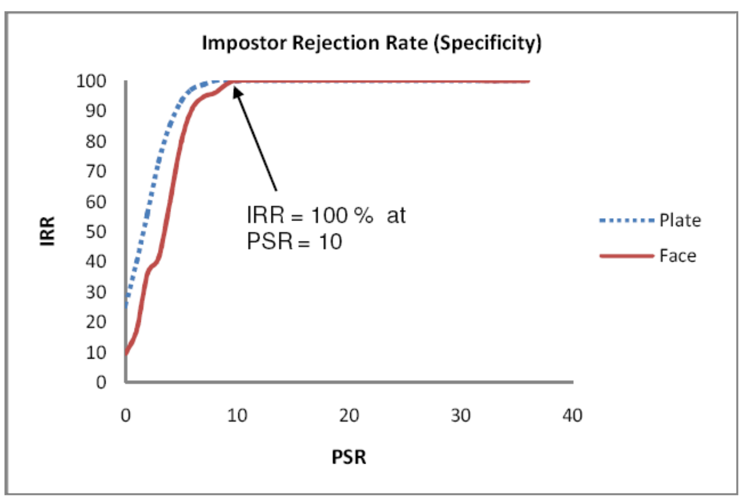


Figure 4.5 Specificity versus PSR for plates and faces

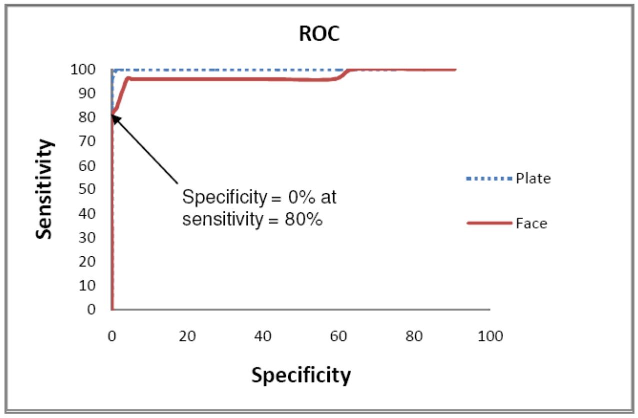


Figure 4.6 ROC curve sensitivity versus specificity for plates and faces

References

[1] R. N. Rodrigues, L. L. Ling, and V. Govindaraju. 2009. Robustness of Multimodal Biometric Fusion Methods Againts Spoof Attacks. *Journal of Visual and Computing*. doi:10.1016/j.jvlc.2009.01.010.

[2] A. Ross, and A. K. Jain. 2004. Multimodal Biometrics: An Overview. Proceeding of 12th European Signal Processing Conference. 1221–1224.

[3] L. Hong, and A. K. Jain. 2010. Multimodal Biometrics. http://www.cse.msu.edu/~cse891/Sect601/textbook116.pdf.

[4] C. N. E. Anagnostopoulos, I. E. Anagnostopoulos, I. D. Psoroulas, V. Loumos, and E. Kayafas. 2008. License plate recognition from still Images and Video Sequences: A Survey. *IEEE Transactions on Intelligent Transportation Systems*. 9: 3.

[5] M. Turk, and A. Pentland. 1991. Eigenfaces for Recognition. *Journal of Cognitive Neuroscience*. 3.

[6] A. Mahalanobis, B. V. K. Vijaya Kumar, S. Song, S. R. F. Sims, and J. F. Epperson. 1994. Unconstrained Correlation Filters. *Applied Optics*. 33: 17.

[7] B. V. K. Vijaya Kumar, M. Savvides, K. Venkataramani, and C. Xie. 2002. Spatial Frequency Domain Image Processing for Biometric Recognition. IEEE, ICIP, 0-7803-7622-6102.

[8] Marios Savvides, B. V. K. Vijaya Kumar, & Pradeep Khosla. 2002. Face Verification using Correlation Filter. Proc. Of Third IEEE Automatic Identification Advanced Technologies. Tarytown NY. 56–61.

[9] M. Savvides, B. V. K Vijaya Kumar, and P. K. Khosla. 2004. "Corefaces"-Robust Shift Invariant PCA based Correlation Filter for Illumination Tolerant Face Recognition.IEEE, CVPR'04, 1063–6919/04.

[10] P. K. Banerjee, J. K. Chandra, and A. K. Datta. 2009. Classifier for Face Recognition Based on Unconstrained Correlation Filter. IEEE International Conference on Signal and Image Processing Applications. 978-1-4244-5561-4/09.

[11] Chee Kiat Ng. Marios Savvides, & Pradeep K. Khosla. 2005. Real-Time Face Verification System On a Cell Phone Using Advanced Correlation Filters. Fourth IEEE Workshop on Automatic Identification Advanced Technologies (AutoID'05). 57–62.

[12] Kyu-Hwa Jeong, & Jose C. Principe. 2006. The Correntropy MACE Filter for Image Recognition. IEEE, 1-4244-0657-9/06.

[13] Nooritawati Md Tahir, Aini Hussain, Salina Abdul Samad, & Hafizah Hussain. 2008. Posture Recognition using Correlation Filter Classifier. *Journal of Theoretical and Applied Information Technology*.

[14] Rosniwati Ghafar, Aini Hussain, Salina Abdul Samad, & Nooritawati Md Tahir. 2008. UMACE Filter for Detection of Abnormal Changes In Eeg: A report of 6 cases. *World Applied Science Journal*. 5(3): 295–3011, ISSN 1818- 4952.

[15] B. S. Chandana, and S. Anuradha. 2010. A New Visual Cryptography Scheme for Color Images. *International Journal of Engineering Science and Technology*. 2(6).

[16] R. Krishnamoorthi, and P. D. S. K. Malarchelvi. 2005. Selective Combinational Encryption of Gray Scale Images using Orthogonal Polynomials based Transformation. *IJCSNS International Journal of Computer Science and Network Security*. 8(5).

[17] M. A. B. Younes, and A. Jantan. 2008. A New Steganography Approach for Image Encryption Exchange by using Least Significant Bit Insertion. *IJCSNS International Journal of Computer Science and Network Security*. 8(6).

[18] K. Gupta, and S. Silakari, 2009. Choase Based Image Encryption using Block Based Transformation Algorithm. *IJCNS International Journal of Computer and Network Security*. 1(3).

[19] K. Jain, K. Nandakumar, and A. Nagar. 2008. Biometric Template Security. Hindawi Publishing Corporation. *EURASIP Journal on Advances in Signal Processing*. Article ID 579416, 17 pages.

[20] S. K. Panigrahy, B. Acharya, and D. Jena. 2008. Image Encryption using Self-Invertible Key Matrix of Hill Cipher Algorithm. 1st International Conference on Advance in Computing, Chikli, India.

[21] R. S. Mangrulkar, and P. V. Chavan. 2009. Encrypting Informative Image by Key Image using Hill Cipher Technique. *International Journal of Recent Trends in Engineering*. 1.

[22] K. Veeramachaneni, L. Osadciw, A. Ross, and N. Srinivas. 2008. Decision-Level Fusion Strategies for Correlated Biometric Classifiers. Proc. of IEEE Computer Society Workshop on Biometrics at the Computer Vision and Pattern Recognition Conference.

[23] L. Wang, H. Ning, T. Tan, and W. Hu. 2004. Fusion of Static and Dynamic Body Biometrics for Gait Recognition. *IEEE Transactions on Circuits and Systems for Video Technology*. 14(2).

[24] Q. Tao, and R. Veldhuis. 2007. Optimal Decision Fusion for a Face Verification System. Proceedings of the 2nd International Conference on Biometrics,Seoul, Korea. 958–967.

[25] Z. Sun, G. Bebis, and N. Bourbakis. 2007. Decision Level Fusion for Vehicle Detection. Proceedings of the 11th WSEAS International Conference on Computers, Anglos Nikolaos, Crete Island, Greece.

[26] C. Molder, M. Boscoianu, I. C. Vizitiu, and M. I. Stanciu. 2009. Decision Fusion for Improved Automatic License Plate Recognition. *WSEAS Transaction on Information Science and Application*. 2(6).

[27] A. Teoh, S. A. Samad, and A. Hussain. 2004. Nearest Neighbourhood Classifiers in Biometric Fusion. International Journal of the Computer, the Internet and Management. Vol. 12#1. 23–36.

[28] LPR database, http://www.medialab.ntua.gr/research/LPRdatabase.htm

[29] AT&Tdatabase,http:www.cl.cam.ac.uk/Research/DTG/attarchive:pub/ data/att_face.zi p, AT&T Laboratories Cambridge.

[30] Yale database B. vision.ucsd.edu/~leekc/ExtYaleDatabase/ExtYaleB.html