Open Access

Research of Iris Recognition Algorithm Based on Fractal Geometry Theory

Yang Duan-li*, Zhao Yang and Wang Jun-hao

College of Information Science and Technology, Agricultural University of Hebei, Baoding 071001, China

Abstract: The rapid development of global economy and science and technology makes the modern society to the safety requirements more and more important. Personal identification system has been unable to meet the need of information security, people proposed biometric identification technology using biometric for human identification, such as fingerprints, iris and voice. The iris recognition technology with its non-invasive, high reliability advantages of rapid development is becoming the research focus in the field. Fractal geometry theory provides new ideas and methods to express nonlinear image information, the fractal dimension is an important parameter of fractal geometry, is a measure of complexity of irregular change, covering blanket dimension can better reflect the graphics changes in different resolution characteristics; missing is the fractal dimension and independent statistics, is a supplement to the fractal dimension, overcome the different texture characteristics may have the same fractal dimension of the problem. This paper presents a blanket and missing items based on the combination of texture feature extraction algorithm, can make full use of radiation in different resolution iris texture information and texture, classification ability make feature matrix has a better.

Keywords: Iris recognition, score fusion, iris location, image match, code matrix feature extraction, non-separable wavelet.

1. INTRODUCTION

The traditional identification methods cannot meet the need of information security, so people proposed biometric identification technology by using biometric identification, such as fingerprint, iris and voice. In modern society, traditional identification methods are usually identify some identification of personal identity based on things, including passwords, password, key, certificates etc.. Identification of these traditional methods: personal things easily lost or forged, personal password and password easily forgotten or mistaken [1]. Moreover, the traditional identification methods cannot distinguish between items the real owner and obtain identification things counterfeiters, once the counterfeiters get these things, can get real owner of the same power, great threat to the safety of life and property. These problems make the traditional identification methods are facing enormous challenges, the research and application of biometric identification technology has been the world's attention, to the rapid development and application [2, 3].

Iris recognition is subtle physiological structure based on iris recognition technology, iris recognition applied in the filaments, spots, wrinkles [4]. Before and after corneal lens, iris is located, is a layer of film disc containing pigments, composed of connective tissue cells and muscle fiber, which is the pupil. The iris and the pupil function are closely related, iris's role is to control the size of the pupil, iris color and most visible feature expansion and contraction of pupil and iris. Iris can be subdivided: surrounding the pupil area, is the ring can make the pupil dilation of the organization. Outside is a hair like fibers, is a peripheral annular region. The pupil contraction is the reflection of unconscious, not by the neural control. Iris details of feature rich, including spot, radial folds, circular fold, depression, projection [5].

Iris recognition system is mainly composed of several parts below: acquisition of iris image is the image acquisition system of iris image acquisition. The iris is a small organ, ca. 10 mm, there is a big difference between the different races of iris color. Iris color, white light, texture significantly. Iris yellow to dark brown, texture is not obvious. At present the main is to obtain iris image by CCD, CMOS and other optical sensors. Acquiring iris image collection device to usually includes not only the iris, often have the rest of the eye, but also in the high non aggressive, because the test is not required, the size and location of the iris in the image will be changed. Therefore, prior to the iris recognition, must be normalized image. In some cases, iris image illumination is not uniform, the size of the pupil will be different with light intensity bigger or smaller, it will make the iris image deformation, affect the accuracy of iris recognition [6, 7].

This paper proposes adaptive iris preprocessing method. It can accurately segment the iris, iris images obtained by pretreatment of high quality. Traditional iris preprocessing method based on the iris boundary circle hypothesis, by two rounds will be separated from the eye image of iris. However, the boundary is not circular accurately separate the iris image database, we analyzed the domestic and abroad, found the iris boundary, especially the inner boundary is often not round. In order to solve this problem, this paper proposed an adaptive iris preprocessing method, it can segment the iris
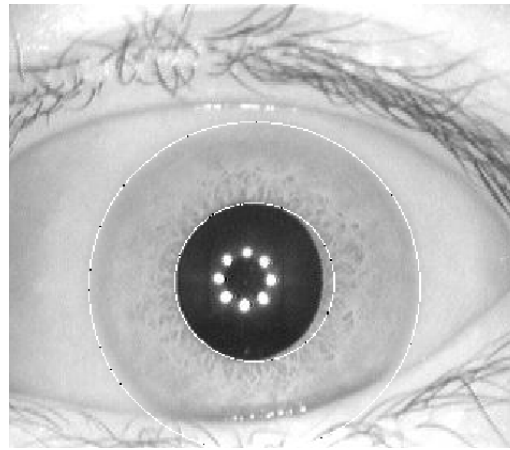
Fig. (1). Black pupil and iris is located between the white sclera, ring-shaped structure.
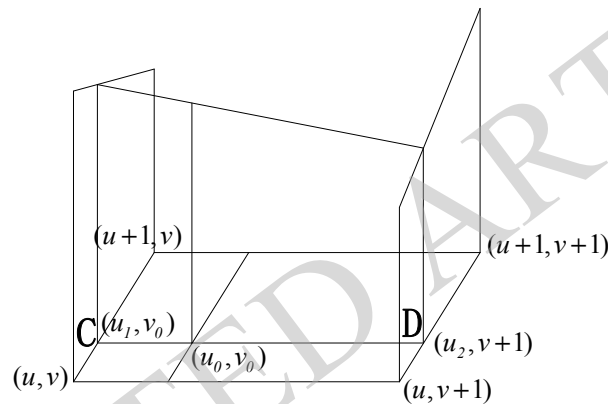

Fig. (2). The process of calculation.

region accurately, and get the image preprocessing of iris and high quality, the result is not affected by the iris boundary shape change.

2. RELATED THOERY AND ANALYSIS

2.1. The Physiological Structure of the Iris

The color of the iris is composed of iris tissue structure and the content of melanin, iris color can also be used for iris recognition [8]. Iris white almost does not contain melanin, the diffraction of light, if the iris structure dense and opaque, the iris is gray, if the organization structure is thin, iris is blue or green. Iris tissue black and brown dense thick, rich in thick dense black pigment, so the iris color yellow for the different shades of brown. Therefore, iris white people can capture iris texture clear under visible light, such as the UBIRIS iris image database [9]. Black pupil and iris is located between the white sclera, ring-shaped structure, as shown in Fig. (**1**). The look on the whole, the iris texture is in radial structure from the inside to the outside, which contains many fine structures, such as dot, filaments, coronary, stripes. In general, these structures was called the iris texture, the iris texture is rich in features, can be used for personal identity identification.

2.2. The Process of Iris Recognition

Bresenham proposed a fast algorithm for drawing straight lines using error correction method, Field linear interpolation Bresenham algorithm is applied to linear [10]. Bresenham algorithm analysis in two-dimensional plane, the error change of the linear approximation using equidistant, error estimation method will calculate all the points on a straight line from floating-point multiplication and division is integer addition and subtraction [11-12]. The bilinear interpolation algorithm is completed at the same time two Bresenham line drawing process, is also a kind of improvement to the nearest neighbor interpolation, according to (U0, V0) gray four points around the point values to estimate the (U0, V0) gray value of the point, the process of calculation see Fig. (**2**):

By using the above interpolation function, can be calculated (U0, V0) gray value of the point, specific calculation steps can compact representation by matrix:

$$f(u_0, v_0) = EFG \tag{1}$$

$$E = [c(1+u_0), c(u_0), c(1-u_0), c(2-u_0)] \tag{2}$$

$$F = \begin{bmatrix} f(u'-1,v'-1) & f(u'-1,v') & f(u'-1,v'+1) & f(u'-1,v'+2) \\ f(u',v'-1) & f(u',v') & f(u',v'+1) & f(u',v'+2) \\ f(u'+1,v'-1) & f(u'+1,v') & f(u'+1,v'+1) & f(u'+1,v'+2) \\ f(u'+2,v'-1) & f(u'+2,v') & f(u'+2,v'+1) & f(u'+2,v'+2) \end{bmatrix} \quad (3)$$

$$G = \begin{bmatrix} c(1+v_0) \\ c(v_0) \\ c(1-v_0) \\ c(2-v_0) \end{bmatrix} \quad (4)$$

By iris image capture device to capture iris images are often impossible to contain only the iris, there are often other parts of the eye, such as eyelids, eyelashes, whites.

$$\max_{(r,x_c,y_c)} \left| G(r) * \frac{\P}{\P_r}^{(r,x_c,y_c)} \frac{I(x,y)}{2\pi r} ds \right| \quad (5)$$

$$\text{Where} G(r) = 1/\sqrt{2\pi}\P e((r-r_o)^2/(2x^2)) \quad (6)$$

2.3. The Difficulty of Iris Recognition Research and Traditional Iris Segmentation Problem

Although researchers have made certain achievements in the research of iris recognition, but to further improve the performance of iris recognition, expanding its scope of application, will still face many difficulties, mainly in the following points:

A: Iris segmentation is the first step in iris preprocess, it performs the accuracy will directly affect the iris preprocessing results. The whole of iris recognition system depends largely on the quality of iris preprocessing. Although the traditional iris segmentation segment iris boundary imprecise, iris segmentation method is proposed for an adaptive, accurate segmentation of the iris, however, in the imperfect of iris image recognition system, there are some iris eyelash thick, eyelid sinking and other problems, caused the iris region occlusion seriously, that cannot be divided, but iris segmentation method and not through quality inspection system will be eliminated. Therefore, the low quality of iris robust iris segmentation algorithm needs further study.

B: Non-perfect iris recognition. Although the traditional iris recognition algorithm can achieve good effect in the recognition of the high quality of iris image, but the low quality of iris image is not perfect and the recognition error rate (especially the false rejection rate of increase in FRR). Therefore, how to not perfect in iris recognition, ensure the false acceptance rate of FAR to meet the requirements of the premise, to further reduce the false rejection rate is one of the difficult problems of FRR researchers concern.

C: The rotation invariance is always a difficult problem in iris recognition, iris recognition system of traditional problems in solving the problem on the rotation invariance. They can only perform extra computation in the matching stage to achieve rotation invariance approximation. This increases the computational identification of the complexity of the system, and it is only approximate the rotation invariant iris, when the rotation of iris beyond a certain range, the error rate of the system will increase. In order to solve this problem, some researchers use the iris to iris recognition with rotation invariance. However, their algorithm to extract only the statistical characteristic of iris, while ignoring the directions of iris texture, so their recognition rate is not high, compared with the algorithm of iris recognition of the latest, the FAR and FRR are not satisfactory.

3. IRIS PREPROCESSING METHOD ADAPTIVE

3.1. The Normalized and Calibration of Iris Image

Iris localization mainly includes the internal and external edge of iris. The other part of the iris section and the gray scale image section in the clear distinction between the existing positioning, segmentation algorithm based on image gray analysis mostly, and the inner and outer edge of iris setting for circular curve, from the eyes of the structure and the algorithm execution results, this assumption is reasonable. Iris location main segmentation methods are as follows: Daugman uses the circulation integral operator to determine the iris edge:

$$max_{(r,x_c,y_c)} \left| G(r) * \frac{\partial}{\partial r} \oint_{(r,x_c,y_c)} \frac{I(x,y)}{2\pi r} ds \right| \quad (7)$$

In the formula I (x, y) gray function eye image, the circular outline the iris with center point (x0, y0), radius parameter model representation of R.

$$G(r) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(r-r_0)^2}{2\sigma^2}} \quad (8)$$

Contour extraction, the gray value of the image projection to the X and Y directions. According to these data to remove some irrelevant point diagram, using the least square method to the rest of the point and circle. A curve equation of the circle to:

$$R^2 = (x-A)^2 + (y-B)^2 \quad (9)$$

Discrete point (x, y) where i ∈ (1, 2... m) to the center distance of:

$$d_i^2 = (X_i - A)^2 + (Y_i - B)^2 \quad (10)$$

The Q (a, b, c) on a, b, c derivative, the partial derivative is equal to 0.

$$\frac{\partial P(a,b,c)}{\partial a} = \sum 2(X_i^2 + Y_i^2 + aX_i + bY_i + c)X_i = 0$$

$$\frac{\partial P(a,b,c)}{\partial b} = \sum 2(X_i^2 + Y_i^2 + aX_i + bY_i + c)Y_i = 0 \quad (11)$$

$$\frac{\partial P(a,b,c)}{\partial c} = \sum 2(X_i^2 + Y_i^2 + aX_i + bY_i + c) = 0$$
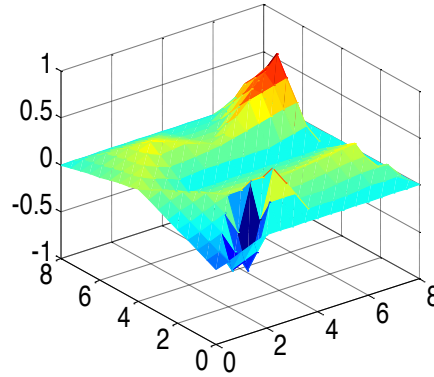
Fig. (3). Filter above non-separable wavelet image, using gives 3 dimensional coordinate.
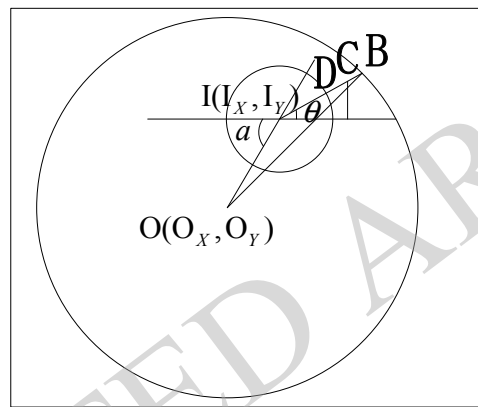

Fig. (4). Iris coordinate transformation diagram.

In order to express filter above non-separable wavelet image, using Fig. (**3**) gives three-dimensional coordinate their.

3.2. Location of the Iris Inner Edge

In locating the iris outer boundary, we still use the basic principles of the three point circle parameters of non collinear circle, but the need for the details of the algorithm is improved. Because the gray iris and sclera among mutant than iris and pupil are obvious, so the need to increase the detection template size, in order to enhance the edge contrast; smoothing the image using Gauss filter before detecting the edge, improve the ability to resist noise. In addition, outside edge of the iris by two horizontal edges easily by occlusion of eyelid and eyelash, therefore in the outer edge localization can be used in the left and right sides of the vertical edge points. Iris coordinate transformation diagram was shown in Fig. (**4**).

3.3. Calculation of Wavelet Function Modulus

In Mallat's work, they used the separable wavelet edge detection, image I (x, y) in L2 (R2) in scale s, defined the direction of 2D wavelet transform on the k:

$$N_s^k I(x,y) = I * \Psi_s^k(x,y), \ k = 1,2 \tag{12}$$

Two direction wavelet φ_s^k according to the following structure:

$$\psi^1(x,y) = \frac{\partial \theta(x,y)}{\partial x} \ and \psi^2(x,y) = \frac{\partial \theta(x,y)}{\partial y} \tag{13}$$

The θ (x, y) for B-spline scaling function. In this way, the 2D separable wavelet transform in scale is s, is the Gauss's function of θ (x, y) of original image is smoothed I (x, y) derivative.

The module and phase gradient vector angle are as follows:

$$M_s I(x,y) = \sqrt{\left|W_s^1 I(x,y)\right|^2 + \left|W_s^2 I(x,y)\right|^2} \tag{14}$$

$$A_s I(x,y) = \arctan\left|\frac{W_s^1 I(x,y)}{W_s^2 I(x,y)}\right| \tag{15}$$

Due to the structural scheme, separable wavelet transform is anisotropic, it preference for a particular direction (vertical and horizontal and diagonal direction). As for the
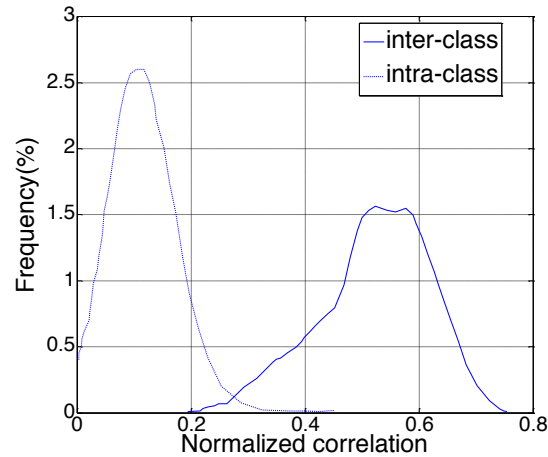
Fig. (5a). The DFBR fractal distribution of normalized correlation.
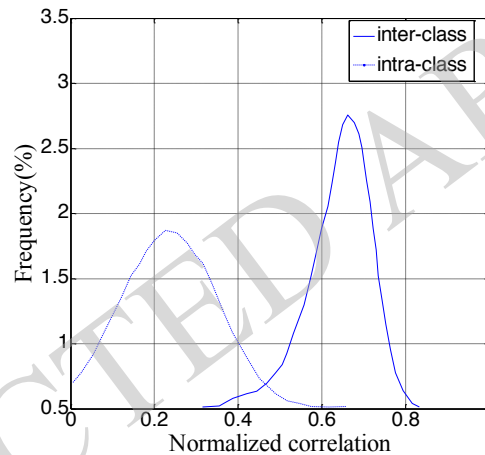

Fig. (5b). Correlation dimension distribution of normalized iris blanket.

iris segmentation, researchers must determine the annular iris boundary, requires the ability to detect each direction of edge. Therefore, separable wavelet is not suitable for edge detection in iris segmentation.

4. EXPERIMENTAL RESULTS

4.1. Analysis of the Recognition Results

Fig. (**5**) shows the iris blanket peacekeeping statistical distribution of normalized correlation between fractal dimension based on DFBR. As can be seen from the graph, the correlation and the within class iris asked the iris have obvious differences, so it can be normalized correlation fractal dimension as the iris classification basis.

In a variety of grid conditions, the longitudinal expansion blanket than ordinary blanket to obtain a better recognition effect. This also proves the longitudinal expansion blanket

dimension in the advantage of expression of iris texture alignment of radiation. At the same time, 5x5 grid is most suitable for iris texture changes the size, self similarity can reflect the iris texture, can get the best recognition results.

4.2. Analysis of Accuracy of the Iris

A: Segmentation. Traditional iris segmentation method can iris boundary localization correctly, but because the iris boundary (especially the boundary) are often non circular or non elliptic, which can not be accurate boundary of iris localization. Iris boundary localization inaccuracy will reduce the performance of the iris recognition system. In order to evaluate the accuracy of iris segmentation, select the 200 iris images from the CASIA-IrisV3 database, and test the iris segmentation method, this chapter, Monro is also used to iris segmentation method (assuming the iris boundary circular) method for iris segmentation and Miyazawa (assuming the iris boundary is an ellipse) do the same experiment.

Table 1. Pupil coverage percentage of three iris segmentation method.

Method	Over Coverage Area (%)			Uncovered Region (%)			Error Coverage Area (%)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Monro	2.36	0.43	7.32	2.73	0.56	6.12	3.24	0.78	8.97
Miyazawa	0.82	0.24	1.96	0.77	0.19	1.67	1.03	0.34	2.45
Our method	0.16	0.15	0.26	0.18	0.15	0.23	0.21	0.18	0.28

ROC curve of iris recognition system
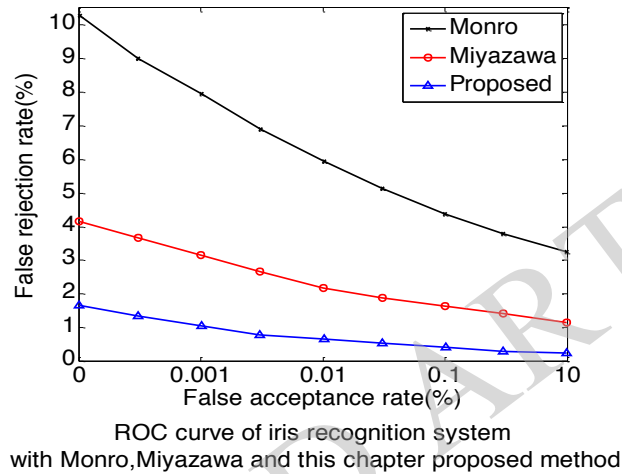with Monro,Miyazawa and this chapter proposed method

Fig. (6). The ROC curves of different pretreatment result of iris recognition system.

In order to locate the boundary of quantitative evaluation results, compared with actual pupil region after region segmentation. In Table **1**, gives three kinds of segmentation methods pupil coverage percentage.

In the spatial domain, people can obtain information of an image in a certain direction and scale for some special filters, such as wavelet filter. Due to the structural scheme, separable wavelet transform is anisotropic, it preference for a particular direction (vertical and horizontal and diagonal direction). In this chapter, to extract the iris features invariant to rotation, it requires to get the image texture information in different directions. Therefore, separable wavelet is not suitable for iris feature extraction and rotation invariant, the need for a new wavelet to overcome this limitation. Fig. (**6**) shows the ROC curves of different pretreatment result of iris recognition system.

In the CASIA-IrisV3 database, the image quality is higher, be collector's eyes are looking straight at the camera. However, in the iris recognition system in actual, be gatherers may not always look the cameras. The probability of the occurrence of non-circular iris boundary will be higher than the database. Therefore, in the actual application of iris recognition, this chapter preprocessing algorithm performance than traditional preprocessing algorithm is more excellent.

B: The recognition results. In the experiment, 1600 iris images are selected from the CASIA-IrisV3 database, are used to test the performance of different iris recognition system of the pretreatment results. The iris image is divided into two iris subsets, each subset of 200*4 images, each with 4 images of iris. The choice of two images of the same iris was a group of iris. In the experiment, the minimum joint classification is used for classification matching. Experiments show that, non separable wavelet and image histogram boundary of iris image can be very good with generalized Gauss distribution, as shown in Fig. (**7**).

CONCLUSION

This paper describes the whole process of iris recognition algorithm and implementation steps. Mainly includes the positioning of iris image, iris segmentation, normalization and enhancement, feature extraction and matching. In the classical learning algorithm of iris recognition at the same time, also made some improvement, improve the efficiency of the algorithm, experiments show the effectiveness of the proposed algorithm. This paper analyzes the iris image database at home and abroad, found the iris boundary, especially the inner boundary is usually not round. In order to solve this problem, this paper proposes adaptive methods of iris preprocessing, segmentation of the iris region which can
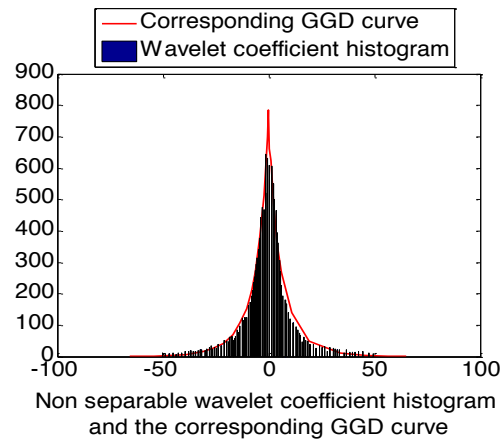
Fig. (7). Non separable wavelet and image histogram boundary of iris image.

accurately, and get the image preprocessing of iris of high quality, the result is not affected by the iris boundary shape change effect. The classical method to solve the iris rotation invariance problems in iris recognition are analyzed, discussed the effect and efficiency of these methods, and indicates their rotation problem solving iris defects.

REFERENCES

[1]   J.M. Xin, and A. Sane, "Linear prediction approach to direction estimation of cyclostationary signals in multipath environment", *IEEE Transactions on Signal Processing*, vol. 49, no. 4, pp. 710-720, 2001.

[2]   E. Grosicki, K. Abed-Meraim, and K.Y. Hua, "A weighted linear prediction method for near-field source localization ", *IEEE Transactions on Signal Processing*, vol. 53, no.10, pp. 3651-3660, 2005 .

[3]   T.B. Lavate, V.K. Kokate and A.M. Sapkal, "Performance analysis of MUSIC and ESPRIT DOA estimation algorithms for adaptive array smart antenna in mobile communication", *International Journal of Computer Networks*, vol. 2, no. 3, pp. 152-158, 2010.

[4]   A. Hirata, T. Morimoto and Z. Kawasaki, "DOA estimation of ulta-wideband EM waves with MUSIC and interferometry", *IEEE Antennas and Wireless Propagation Letters*, vol. 2, no. 1, pp. 190-193, 2003.

[5]   F.Taga, "Smart Music algorithm for DOA estimation", *Electronics Letters*, vol. 33, no. 3, pp. 190-191, 1997.

[6]   W. Sun, J.L. Bai and K. Wang, "Novel method of ordinal bearing estimation for more sources based on obique projector", *Journal of Systems Engineering and Electronics*, vol. 20, no. 3, pp. 445-449, 2009.

[7]   Steve. Lu, R. Ostrovsky, A. Sahai, H. Shacham, and B. Waters. "*Sequential Aggregate Signatures and Multisignatures Without Random Oracles*, In: Eurocrypt 2008, LNCS 4004, Springer, Berlin, pp. 465-485, 2006.

[8]   B. Waters. "Effcient identity-based encryption without random oracles," In*: Proceedings of Eurocrypt,* LNCS *3494*, Springer, Berlin, pp.14-27, 2005.

[9]   J. Stern, D. Pointcheval, J. Malone-Lee, N. P. Smart, *Flaws in Applying Proof Methodologies to Signature Schemes*, In: CRYPTO 2002, LNCS 2442, Springer, Berlin, pp. 93-110, 2002.

[10] S. Goldwasser, S. Micali, and R. Rivest, "A digital signature scheme secure against adaptive chosen-message attacks," *SIAM Journal of Computing*, vol. 17, no. 2, pp. 281-308, 1988,.

[11] A. Lysyanskaya, S. Micali, L. Reyzin, and H. Shacham, *Sequential Aggregate Signatures from Trapdoor Permutations*, In: *Eurocrypt, LNCS 3027*, Springer, Berlin, pp. 74-90, 2004.

[12] F. Satoh, H. Yanagisawa, H. Takahashi and T. Kushida, (Eds.), "Total energy management system for cloud computing", In: *Proceedings of the IEEE International Conference of the Cloud Engineering (IC2E)*, Redwood City, CA, 2013.