

Comparison of Phase Only Correlation and Neural Network for Iris Recognition

Yogendra Kumar Jain¹ and Manoj Kumar Verma²
¹Department of Computer Science and Engineering, SATI
Vidisha, M.P. 464001, India

²Department of Computer Science and Engineering, SATI
Vidisha, M.P. 464001, India

Abstract

This paper compares two different techniques of iris recognition and explains the steps of extracting iris from eye image palette formation and conditioning of palette for matching. The focus of the paper is in finding the suitable method for iris recognition on the basis of recognition time, false detection rate, conditioning time, algorithm complexity, bulk detection, database handling. In this paper comparison has been performed two methods POC (Phase Only Correlation) and Neural Network. Although both methods are practically proven by many researchers, still a comprehensive comparison is missing, we hope that the results drawn in this paper will be helpful for the peoples working in same field; the complete algorithm is developed in Matlab.

Keywords: *Iris recognition, POC (Phase Only Correlation), Neural Network.*

1. Introduction

Iris recognition [1] is a method of biometric authentication that uses pattern-recognition techniques based on high-resolution images of the irises of an individual's eyes. Iris recognition uses camera technology, with subtle infrared illumination reducing specular reflection from the convex cornea, to create images of the detail-rich, intricate structures of the iris. Converted into digital templates, these images provide mathematical representations of the iris that yield unambiguous positive identification of an individual [2].

Iris recognition [7] efficacy is rarely impeded by glasses or contact lenses. Iris technology has the smallest outlier (those who cannot use/enroll) group of all biometric technologies. Because of its speed of comparison, iris recognition is the only biometric technology well-suited for one-to-many identification. A key advantage of iris recognition is its stability.

The human iris is the annular part between the dark pupil and the white sclera; it is unique and stable throughout life. In an iris recognition system, iris localization is one of the most important steps, and has great influence on the subsequent feature extraction and classification. It aims to find the parameters, the centers and radii, for both the iris inner and outer boundaries. There are many iris localization methods; more algorithms were developed to improve the performance of iris localization. More recently, other algorithms have been presented by many researchers. However, these methods have promising performance; they need to search the iris boundaries over large parameter space exhaustively, which takes more computational time. Moreover, they may result in circle detection failure, because some chosen threshold values used for edge detection cause critical edge points being removed. In this paper, we compare two algorithms for iris recognition from iris template images. The paper also explains the iris extraction from eye image. The paper is arranged in following way, section 2 explains the method of iris extraction by using Hough circle method, and then the conversion of circular iris image into rectangular template, section 2.3 explains the methods of iris recognition then after section 4 shows the simulated results and conclusion on the basis of results.

Most of the researchers in the field of iris recognition use iris images from the following databases, which are available freely online:

- The Chinese Academy of Sciences database (CASIA)[16]
- The Bath database, produced by the university of Bath[17]

2. PRE PROCESSING FOR IRIS RECOGNITION

2.1 Iris Boundaries Detection

Iris is the area between pupil and white section of eyes, as shown in figures 2.1 the area between two white circles.

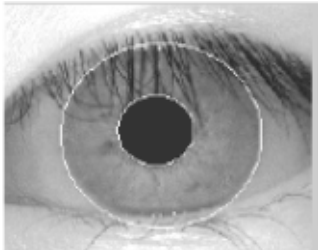


Figure 2.1 Eye and iris

It is clear the iris is a circular strip hence both iris boundaries are circular. Therefore most of the techniques [3][4][5][6] utilizes the shades of pupil, iris and other sections, but in proposed technique we preferred Hough circle[3][4] and threshold technique method for detection of correct iris boundaries. Following are the steps used in this paper for detection of correct iris boundaries.

1. Perform the histogram equalization in the iris image.
2. Convert it into edge image using sobel filter.
3. From each point of edge image draw a circle of diameter greater than 10 percentage of image height up to 90 percent of height.
4. Counts the edge travelled by each periphery of each circle and find normalized edge density of each periphery using the formula.
$$D_n = \text{edges}/\text{total points}$$
5. Now find out the best circle with highest edge density with diameter from 10 to 30 percent, this will denote the inner boundary of the iris, repeat same for diameter range 50 to 90 percent this will denote the outer boundary.
6. Now crop the image between these circles is the required iris.

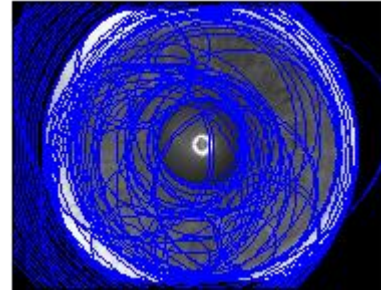


Figure 2.2 Circles drawn all over the image.

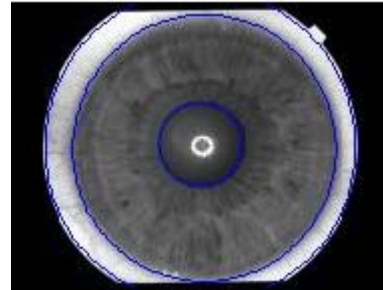


Figure 2.3 Selected circles.

2.2. Circular to rectangular conversion

From figure 2.2 we can easily crop iris but for recognition of iris it's much better to deal with Cartesian coordinates than circular, hence a conversion from circular to rectangular is performed, since the image is digital hence inner edge having lower number of points than upper edge. Now the conversion is performed by using formula,

$$\begin{aligned}x &= r \cos \theta \\y &= r \sin \theta\end{aligned}\quad (1)$$

Where θ varies from 0 to 360 degree and r varies from inner circle radius to outer circle radius.

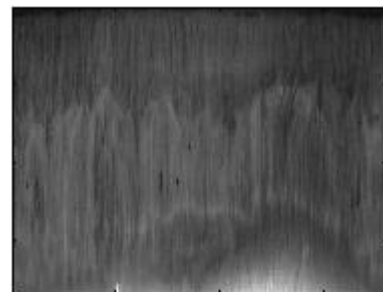


Figure 2.4 Rectangular iris image.

Figure 2.4 shows the rectangular converted image from of iris, since not all image content have important information,

therefore we can filter out some unwanted components figure 2.5 shows the filtered image [8].

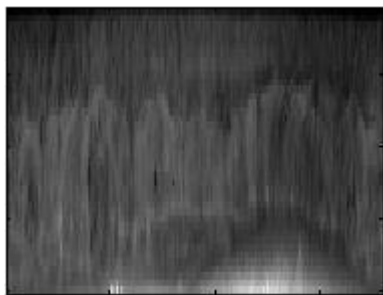


Figure 2.5 Rectangular filtered iris image.

Now this is called the standard template can be used for matching by any method.

2.3. Iris Matching Methods

2.3.1. Hamming distance

The Hamming distance gives a measure of how many bits are the same between two bit patterns. Using the Hamming distance of two bit patterns, a decision can be made as to whether the two patterns were generated from different irises or from the same one. In comparing the bit patterns X and Y, the Hamming distance, HD, is defined as the sum of disagreeing bits (sum of the exclusive-OR between X and Y) over N, the total number of bits in the bit pattern [19][15].

$$HD = 1/N \sum_{i=1}^N X_i (XOR) Y_i \quad (2)$$

If two bits patterns are completely independent, such as iris templates generated from different irises, the Hamming distance between the two patterns should equal 0.5. If two patterns are derived from the same iris, the Hamming distance between them will be close to 0.0.

2.3.2. Weighted Euclidean Distance

The weighted Euclidean distance (WED) can be used to compare two templates, especially if the template is composed of integer values. The weighting Euclidean distance gives a measure of how similar a collection of values are between two templates. This metric is specified as

$$WED(k) = \sum_{i=1}^N [(f_i - f_i^{(k)})^2 / (\partial_i^{(k)})^2] \quad (3)$$

Where f_i is the i^{th} feature of the unknown iris, and is the i^{th} feature of iris template, k, and $\partial_i^{(k)}$ is the standard deviation of the i^{th} feature in iris template k. The unknown iris template is found to match iris template k, when WED is a minimum at k.

2.3.3. Normalized Correlation

Normalized correlation between the acquired and database representation for goodness of match. This is represented as

$$\sum_{i=1}^n \sum_{j=1}^m (p1[i,j] - \mu_1)(p2[i,j] - \mu_2) / nm \sigma_1 \sigma_2 \quad (4)$$

Where p1 and p2 are two images of size nxm, μ_1 and σ_1 are the mean and standard deviation of p1, and μ_2 and σ_2 are the mean and standard deviation of p2. Normalized correlation is advantageous over standard correlation, since it is able to account for local variations in image intensity that corrupt the standard correlation calculation.

2.3.4. POC (Phase Only Correlation)

POC is a method for finding the correlation between two different images in frequency domain; it gives much better results than normal time domain correlation [8] [14].

This section introduces the principle of phase based image matching using the Phase Only Correlation (POC) [1][13] function. Consider two $N_1 \times N_2$ images $f(n_1, n_2)$ and $g(n_1, n_2)$.

$$F(k_1, k_2) = \sum_{n_1=-M_1}^{M_1} \sum_{n_2=-M_2}^{M_2} f(n_1, n_2) W_{N_1}^{k_1 n_1} W_{N_2}^{k_2 n_2} \\ = A_F(k_1, k_2) e^{j\theta_F(k_1, k_2)} \quad (5)$$

$$G(k_1, k_2) = \sum_{n_1=-M_1}^{M_1} \sum_{n_2=-M_2}^{M_2} g(n_1, n_2) W_{N_1}^{k_1 n_1} W_{N_2}^{k_2 n_2} \\ = A_G(k_1, k_2) e^{j\theta_G(k_1, k_2)} \quad (6)$$

Here $F(k_1, k_2)$ and $G(k_1, k_2)$ are the 2D DCT transform of function F and g, now the cross-phase spectrum $R_{FG}(k_1; k_2)$ between $F(k_1; k_2)$ and $G(k_1; k_2)$ is given by

$$R_{FG}(k_1, k_2) = \frac{F(k_1, k_2) \overline{G(k_1, k_2)}}{|F(k_1, k_2) G(k_1, k_2)|} \\ = e^{j\{\theta_F(k_1, k_2) - \theta_G(k_1, k_2)\}} \quad (7)$$

Where $\overline{G(k_1; k_2)}$ denotes the complex conjugate of $G(k_1; k_2)$. The POC function $r_{fg}(n_1; n_2)$ is the 2D Inverse DFT (IDFT) of $R_{FG}(k_1; k_2)$ and is given by

$$r_{fg}(n_1, n_2) = \frac{1}{N_1 N_2} \sum_{k_1=-M_1}^{M_1} \sum_{k_2=-M_2}^{M_2} R_{FG}(k_1, k_2) W_{N_1}^{-k_1 n_1} W_{N_2}^{-k_2 n_2} \quad (8)$$

When two images are similar, their POC [13] function gives a distinct sharp peak. When $f(n_1, n_2) = g(n_1, n_2)$, the POC function $r_{fg}(n_1, n_2)$ becomes the Kronecker delta function $\delta(n_1, n_2)$. If two images are not similar, the peak value drops significantly. The height of the peak can be used as a good similarity measure for image matching and the location of the peak shows the translational displacement between the two images.

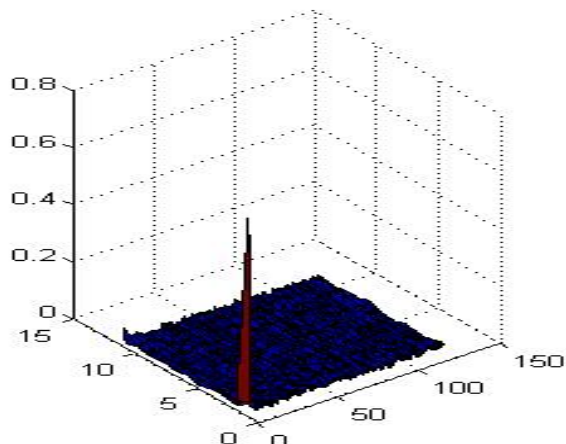


Figure 2.6 POC peak when iris image matched.

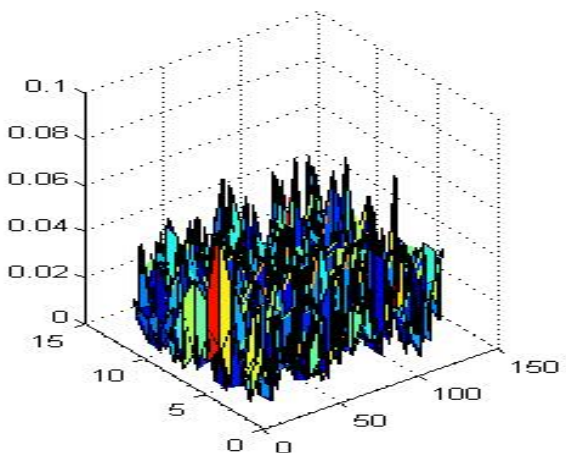


Figure 2.7 POC when iris image not matched.

2.3.5 Neural Network

The term **neural network** [15] was traditionally used to refer to a network or circuit of biological neurons. The modern usage of the term often refers to artificial neural networks, which are

composed of artificial neurons or nodes. Thus the term has two distinct usages:

1. Biological neural networks are made up of real biological neurons that are connected or functionally related in the peripheral nervous system or the central nervous system. In the field of neuroscience, they are often identified as groups of neurons that perform a specific physiological function in laboratory analysis.

2. Artificial neural networks are composed of interconnecting artificial neurons (programming constructs that mimic the properties of biological neurons). Artificial neural networks may either be used to gain an understanding of biological neural networks, or for solving artificial intelligence problems without necessarily creating a model of a real biological system. The real, biological nervous system is highly complex: artificial neural network algorithms attempt to abstract this complexity and focus on what may hypothetically matter most from an information processing point of view. Good performance (e.g. as measured by good predictive ability, low generalization error), or performance mimicking animal or human error patterns, can then be used as one source of evidence towards supporting the hypothesis that the abstraction really captured something important from the point of view of information processing in the brain. Another incentive for these abstractions is to reduce the amount of computation required to simulate artificial neural networks, so as to allow one to experiment with larger networks and train them on larger data sets.

An **artificial neural network (ANN)**, usually called **neural network (NN)** [15], is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. Modern neural networks are non-linear statistical data modeling tools. They are usually used to model complex relationships between inputs and outputs or to find patterns in data.

An iris-recognition algorithm first a discrete cosine transform is used in order to extract the spatial frequency range that contains the main abstract of iris image. The result is a set of complex numbers that carry local amplitude and phase information for the iris image which is used as training input for neural network.

In this paper the matrix of discrete cosine transform of Edge of iris images has been used for Iris Recognition using Probabilistic neural networks following figure shows the structure of Iris Recognition system that has been design in this paper. The output of neural network is the class of iris which is name of the person. This system can classify the noisy iris image very well. The sobel edge detection has been used in this paper. Neural network that has been used in this paper is LVQ. LVQ, or Learning Vector Quantization, is a prototype-based supervised classification algorithm.LVQ can be understood as a special case of an artificial neural network.LVQ is one of the competitive neural networks. Following figure shows the structure of neural network:

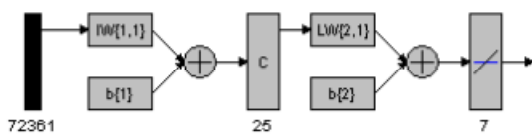


Fig. 2.8 Structure of Neural Network

2.3.6 Matching Score Calculation

In this step, we calculate the POC function r_{eff}^{fg} (n_1, n_2) between the aligned images $f(n_1, n_2)$ and $g(n_1, n_2)$ and we evaluate the matching score [19]. In the case of genuine matching, if the displacement between the two images is aligned, the correlation peak of the POC function should appear at the origin $n_1, n_2 = (0, 0)$. Thus, we calculate the matching score between the two images as the maximum peak value of the POC function within the small window O centered at the origin. The matching score is given by

$$\text{Matching score} = \text{Max}_{(n_1, n_2) \in O} \{r_{fg}^{K_1 K_2}(n_1, n_2)\} \quad (9)$$

In our experiments, the size of the window O is 11×11 pixels. When multiple sub regions are extracted at the “Effective region extraction” process, as shown in figure 4.4b, the matching score is calculated by taking an average of matching scores for six sub regions.

3. Results

For result analysis in this paper, we are considering some parameters shown in table. Average segmentation time refer to average time taken by algorithm to partitioning a iris image into multiple segment of pixel. Segments accuracy rate refer as percentage of images correctly segmented by algorithm. Recognition accuracy means the probability that an authorized person is correctly recognized. It is the

percentage of how much time a true iris image is recognized correctly.

Recognition time in our algorithm is referring as time taken by the algorithm to match the captured image with true imaged stored in database. A parameter we are considering for analysis is bulk detection. These parameters reveal the strength of LVQ Based algorithm. This tells us how our algorithm will response in heavy load in term of high capturing rate and rich database. The reason behind good performance in heavy load is basic characteristic of neural network that is after a proper training it will response quickly. Last parameter we are considering here is algorithm complexity. Because of neural network LVQ Based algorithm is little bit complex.

Table 1:1 Result analysis

Parameters	POC Based	LVQ Based	Improvement with LVQ
Avg. Segmentation time	0.18 Sec.	0.14 Sec.	22 %
Segmentation Accuracy Rates	98.01	98.62	0.62 %
Recognition Accuracy	98.88	99.25	0.37 %
Recognition time	0.17 Sec.	0.07 Sec.	58 %
Algorithm Complexity	Low	Moderate	
Bulk Detection	Low	Best Suitable	

Experiment result analysis is shown in table 1.1.It is very clear with result that LVQ based algorithm has better performance than POC based method. Average segmentation time is reduced by 22 percent with LVQ based method. Similarly LVQ based iris recognition give better Segmentation Accuracy Rates and Recognition time. LVQ is best suitable where bulk detection is required. Because Learning Vector Quantization is a prototype-based supervised classification algorithm based on artificial neural network so once it is trained, it provides accurate and fast result. This is clearly shown by experiment. In figure 3.2, It is shown that the performance of ANN (LVQ) based algorithm is independent of input image load (number of iris need to process). Means LVQ based algorithm gives much better result in bulk detection. On the other hand performance is exponentially decrease as input image load is increase in POC based method. Similarly result can be found in figure 3.3 where matching time in LVQ based

method is considerable lower than POC based method (approximate 58% better than POC based method). The simulation results of the implemented algorithm, all the simulation is performed with Intel P4 1.4 GHz processors with 1 GB of RAM, the OS is windows and simulation software is MATLAB 7.5(R2007b).

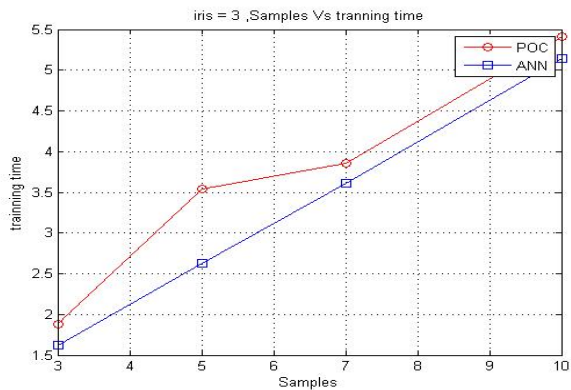


Figure 3.1 Samples vs. Training Time

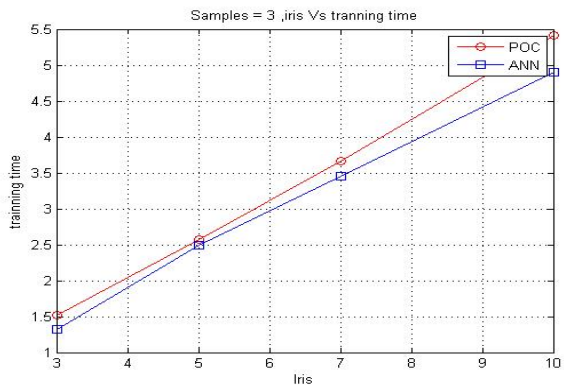


Figure 3.2 Number of Iris vs. Training Time

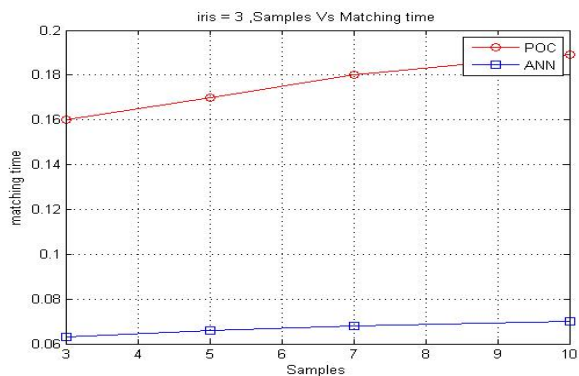


Figure 3.3 Samples vs. matching time

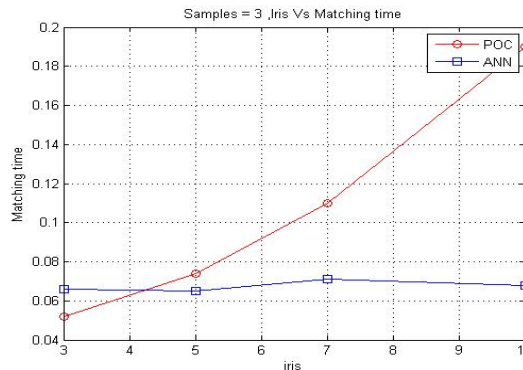


Figure 3.4 number of iris vs. matching time

4. Conclusions

Using neural networks a personal iris recognition system is presented in this paper. A fast iris matching method is proposed. Using this method, iris segmentation is performed in short time. Average time for iris segmentation is obtained to be 0.14 sec. Accuracy rate of iris segmentation 98.62% is achieved. The located iris after pre-processing is represented by a feature vector. Using this vector as input signal the neural network is used to recognize the iris patterns. The recognition accuracy for trained patterns is 99.25%. Matching time in LVQ based method is considerable lower than POC based method (approximate 58% better than POC based method). Proposed method also works considerable well for blurred or noisy images because of improved training method of Learning Vector Quantization (LVQ) neural network. This training makes learning process in such a way that it recognized correct images with lower error ratio. Once a system is proper trained then it improve recognition speed by 58%. So LVQ based method is responsible for both making system more robust (work well with noisy data) and improve accuracy. These characteristic make this system more appropriate for those application where bulk detection is required.

References

- [1] C. L. Tisse, L. Martin, L. Torres, M.Robert, "Person identification technique using human iris recognition" ST Journal of System Research Current Issue 2003.
- [2] R.Plemmons, M.Horvatha, E.Leonhardta, P. Paucaa, S. Prasadb, "Computational Imaging Systems for Iris Recognition", Processing of Spie 2004
- [3] L. Ma, U. Wang, T. Tan, "Iris Recognition Based on Multichannel Gabor Filtering", The 5th Asian Conference on Computer Vision, 23-- 25 January 2002, Melbourne, Australia

- [4] R. Narayan Swamy, P. E. X. Silveir, "Extended Depth-of-Field Iris Recognition System for a Workstation Environment" Proceedings of the Spied Biometric Technology for Human Identification II, Vol. 5779, pp. 41-50, Orlando, FL, 2005.
- [5] Z. Wei, T. Tan and Z. Sun, "Synthesis of Large Realistic Iris Databases Using Patch-based Sampling", IEEE 2008.
- [6] Czajka, A. Pacut, "Replay Attack Prevention for Iris Biometrics" ICCST 2008, IEEE.
- [7] R. Wildes, "Iris Recognition: An Emerging Biometric Technology," Proc. IEEE, vol. 85, no. 9, pp.348- 1363, Sept. 1997.
- [8] B.V.K. Vijaya Kumar, C. Xie, and J. Thornton, "Iris Verification Using Correlation Filters," Proc. Fourth Int'l Conf. Audio- and Video- Based Biometric Person Authentication, pp. 697-705, 2003.
- [9] Z. Sun, T. Tan, and X. Qiu, "Graph Matching Iris Image Blocks with Local Binary Pattern," Advances in Biometrics, vol. 3832, pp. 366-372.
- [10] C.D. Kuglin and D.C. Hines, "The Phase Correlation Alignment Method," Proc. Int'l Conf. cybernetics and Soc. '75, pp. 163 - 165, 1975.
- [11] K. Takita, T. Aoki, Y. Sasaki, T. Higuchi, and K. Kobayashi, "High- Accuracy Subpixel Image Registration Based on Phase- Only Correlation," IEICE Trans. Fundamentals, vol. E86-A, no. 8, pp. 1925-1934, Aug. 2003.
- [12] K. Takita, M.A. Muquit, T. Aoki, and T. Higuchi, "A Sub-Pixel Correspondence Search Technique for computer Vision Applications," IEICE Trans. Fundamentals, vol. 87-A, no. 8, pp. 1913-1923, Aug. 2004.
- [13] Kazuyuki Miyazawa and Takafumi Aoki, An Effective Approach for Iris Recognition Using Phase-Based Image Matching. IEEE transactions on pattern analysis and machine intelligence, vol. 30, no. 10, October 2008.
- [14] K. Ito, A. Morita, T. Aoki, T. Higuchi, H. Nakajima, and K. Kobayashi, "A Fingerprint Recognition Algorithm Using Phase- Based Image Matching for Low-Quality Fingerprints," Proc. 12th IEEE Int'l Conf. Image Processing, vol. 2, pp. 33-36, Sept. 2005.
- [15] Zhou Zhiping, Hui Maomao, Sun Ziwen, "An Iris Recognition Based on 2DWPCA and Neural Network", 978 1-4244-2723- 9/09/\$25.00© 2009 IEEE.
- [16]CBSR,2005.Center for biometrics and security research.
<http://www.cbsr.ia.ac.cn/english/Databases.asp>
- [17] CASIA Iris Image Database, Inst. Automation, Chinese Academy of Sciences, <http://www.sinobiometrics.com/>, 2008.
- [18]Univ. of Bath Iris Image Database, 2007, <http://www.bath.ac.uk/elec-eng/research/sipg/irisweb>.
- [19] J. Daugman, "Biometric Personal Identification System Based on Iris Analysis", U.S. Patent No. 5,291,560, 1994.

Dr. Yogendra Kumar Jain presently working as Head of the Department, Computer Science & Engineering at Samrat Ashok Technological Institute Vidisha M.P India. The degree of B.E. (Hons) secured in E&I from SATI Vidisha in 1991, M.E. (Hons) in Digital Tech. & Instrumentation from SGSITS, DAVV Indore (M.P), India in 1999. The Ph. D. degree has been awarded from Rajiv Gandhi Technical University, Bhopal (M.P.) India in 2010. Research Interest includes Image Processing, Image compression, Network Security, Watermarking, Data Mining. Published more than 50 Research papers in various Journals/Conferences, which include 30 research papers in International Journals.

Manoj Kumar Verma received the B.E. Degree in Computer Science and Engineering from MITS, Gwalior in 2001.He obtained M.Tech. Degree in Computer Science and Engineering from SATI, Vidisha, Rajeev Gandhi Technical University, Bhopal, India in 2011. Research interest includes Pattern recognition, Image Processing, Biometrics, Multimedia applications and Web Designing. He is working as a PGT (Computer Science) in KV, Trivandrum, India.