CS663 Project Proposal

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Topic - Iris Recognition Using Phase-Based Image Matching

Paper -Kazuyuki Miyazawa, Koichi Ito, Takafumi Aoki Graduate School of Information Sciences, Tohoku University, Sendai 980–8579, Japan E-mail: miyazawa@aoki.ecei.tohoku.ac.jp Koji Kobayashi, Atsushi Katsumata Yamatake Corporation, Higashi-shinagawa 140-0002, Japan

Databases - CASIA iris image databases (versions 1.0 to 4.0), ICE 2005 iris database.

Data-Sets Link - CASIA Data-sets
For our project, we have used only the CASIA1 images.

Link - An Iris Recognition System Using Phase-Based Image Matching

1 Abstract

The chosen paper presents an implementation of iris recognition algorithm using phase-based image matching using the Phase Only Correlation Function of chosen image pairs. Through some experimentation, we have tried to see what parameters suite best for CASIA data-set and also given values for genuine detection accuracy and imposter detection accuracy.

We have implemented our algorithm as per Fig 1 of the paper. Thus the overall report is divided into two parts, the first dealing with Pre-processing Stage and second dealing with Matching Stage. As a secondary reference we will also use the paper **An Effective Approach for Iris Recognition Using Phase-Based Image Matching** which discusses the similar issue from a implementation point of view.

2 Pre-Processing Stage

This section will deal with removing the irrelevant parts from our image of the whole eye.

2.1 Iris Localization

This step involves locating the iris in the image of the eye. We can model the iris boundaries as ellipses as shown in Figure below. In this model, we consider following parameters.

- Corresponding to the inner boundary of the iris we have : $(l_1, l_2, c_1, c_2, \theta_1)$ where, (c_1, c_2) represents the center of the inner ellipse, l_1, l_2 are the lengths of the major and minor axes of the ellipse and θ_1 is the angle between the major axis with the horizontal
- Similarly, corresponding to the outer boundary of the iris we have $(l_3, l_4, c_3, c_4, \theta_2)$ where, (c_3, c_4) represents the center of the outer ellipse, l_3, l_4 are the lengths of the major and minor axes of the ellipse and θ_2 is the angle between the major axis with the horizontal.

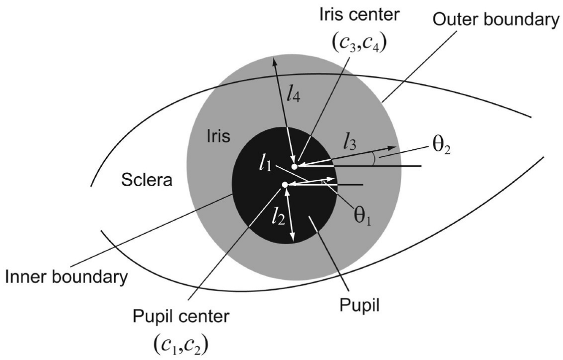


Figure 1: Deformable iris model

2.1.1 Finding Center

First, we start with the algorithm to detect the centre of the pupil in the CASIA images. This is done by first creating a binary image with dark pixels given value 1 and bright pixels 0. Then iteratively take center as:

$$c_1 = \frac{\sum_{(m_1,m_2)\epsilon W} m_1 f_{bin}(m_1, m_2)}{\sum_{(m_1,m_2)\epsilon W} f_{bin}(m_1, m_2)}$$

$$c_2 = \frac{\sum_{(m_1,m_2)\epsilon W} m_2 f_{bin}(m_1, m_2)}{\sum_{(m_1,m_2)\epsilon W} f_{bin}(m_1, m_2)}$$

Then, along the previous centre (c1,c2) we will take a circular mask and repeatedly reduce the area of the circle till the point (c1,c2) converges.

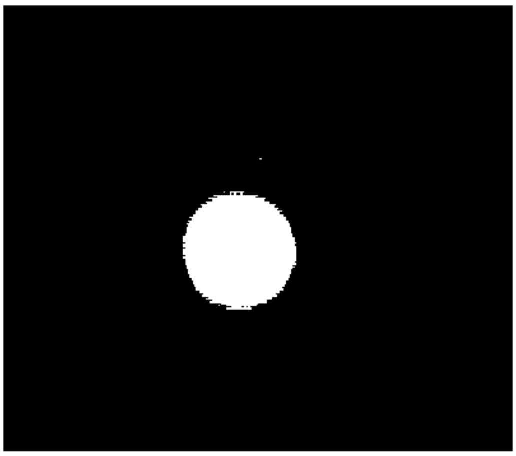


Figure 2

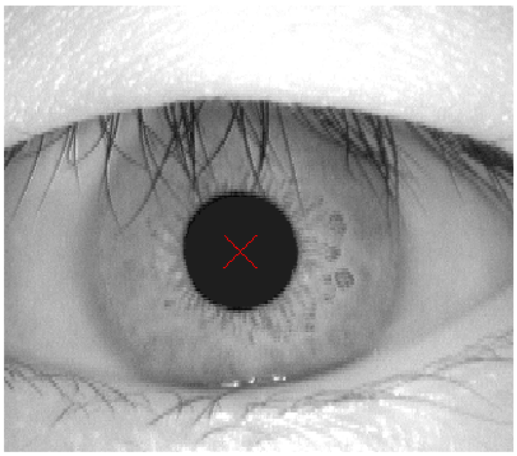


Figure 3

The above images shows the result of this step.

2.1.2 Detecting iris boundaries

In this step we detect the inner boundary (the boundary between the iris and the pupil) and the outer boundary (the boundary between the iris and the sclera) in the original gray-scale image. This involves finding optimal estimate $(l_1, l_2, c_1, c_2, \theta_1)$ for the inner boundary of iris. and optimal estimate $(l_3, l_4, c_3, c_4, \theta_2)$ for the outer boundary.

To achieve this, we maximize the following absolute difference:

$$\Delta S = |(l_1 + \Delta l_1, l_2 + \Delta l_2, c_1, c_2, \theta_1) - S(l_1, l_2, c_1, c_2, \theta_1)|$$

Here, l_1 and l_2 are small constant, and S denotes the N-point contour summation of pixel values along the ellipse and is defined as

$$S\left(l_1, l_2, c_1, c_2, \theta_1\right) = \sum_{n=0}^{N-1} f_{\mathrm{org}}\left(p_1(n), p_2(n)\right)$$

where,

$$p_1(n) = l_1 \cos\theta_1 \cdot \cos\left(\frac{2\pi}{N}n\right) - l_2 \sin\theta_1 \cdot \sin\left(\frac{2\pi}{N}n\right) + c_1$$

$$p_2(n) = l_1 \sin\theta_1 \cdot \cos\left(\frac{2\pi}{N}n\right) + l_2 \cos\theta_1 \cdot \sin\left(\frac{2\pi}{N}n\right) + c_2$$

Thus, by maximizing the absolute difference, we will detect the inner boundary as the ellipse on the image for which there will be a sudden change in luminance summed around its perimeter. In order to reduce the computation, θ_1 is set to 0 owing to the radial symmetry of the images and it causes no degradation in performance. Thus, we find those values of l_1 and l_2 which maximizes ΔS. This is achieved by considering ellipses centered at c_1 and c_2 and finding the values of ΔS for all possible l_1 and l_2 and then taking the maxima. The figure below shows the result of inner boundary detection.

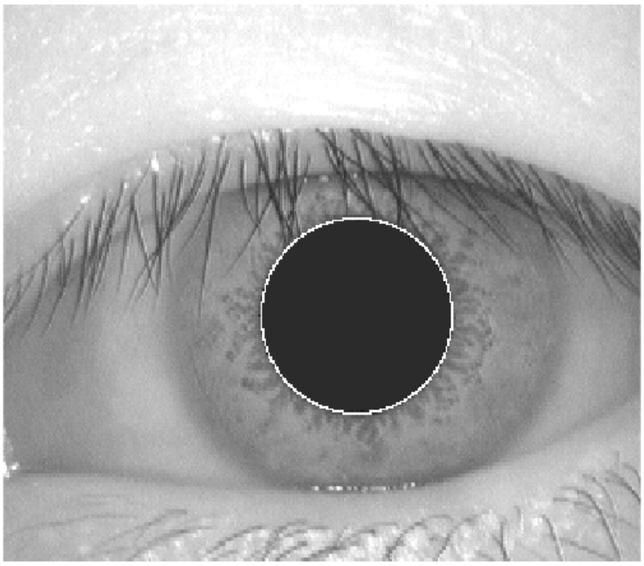


Figure 4: Inner boundary detection

The optimal estimate $(l_3, l_4, c_3, c_4, \theta_2)$ for the outer boundary, on the other hand, can be found in the similarly, with the path of contour summation simplified from an ellipse to a circle (that is, $l_3 = l_4$.) Figure below shows the result of outer boundary detection

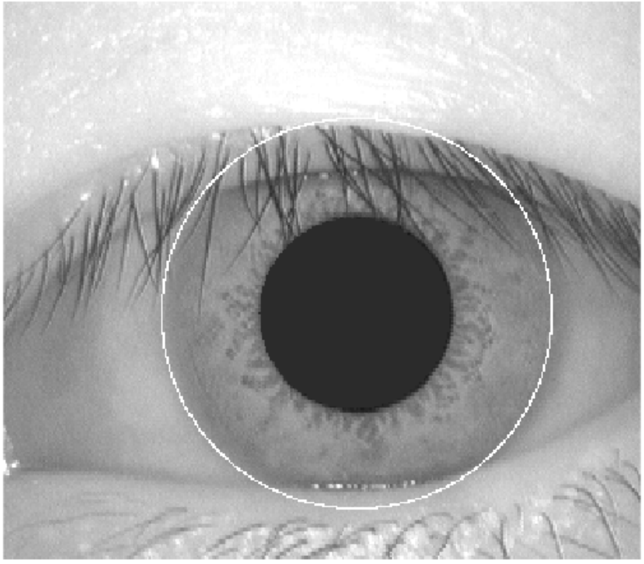
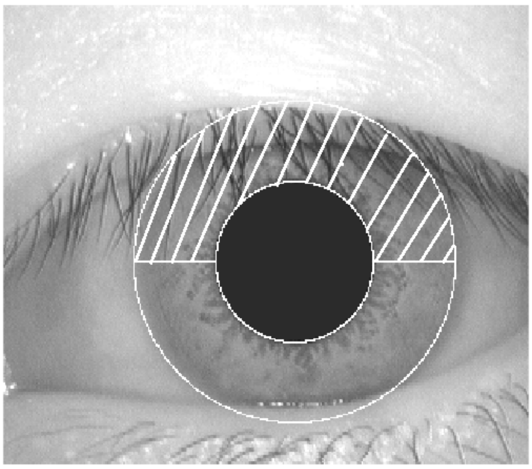


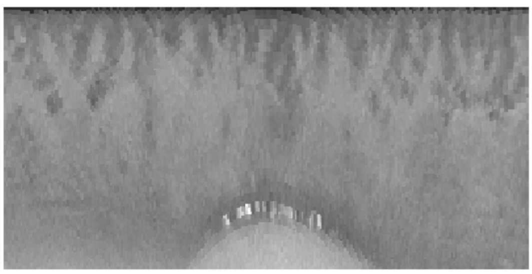
Figure 5: Outer boundary of iris

2.2 Iris Normalisation

In this step we noramlize the extracted iris region and to compensate for the elastic deformations in iris texture. The the iris region is unwrapped to a normalized rectangular block with a fixed size $256 \cdot 128$ pixels in this implementation. Also, the usually the upper part of the iris is occluded by the upper eyelid and eyelashes. Thus, we use only the lower half of the iris region. This iris region is transformed into the normalized image using the parameters$(l_1, l_2, l_3, c_1, c_2, c_3, c_4)$ which are found in the previous step. While transforming, the horizontal axis corresponds to the angle of the polar coordinate system and the vertical axis corresponds to the radius. The result image of size $256 \cdot 128$ obtained is as follows.



(a) Upper part removed

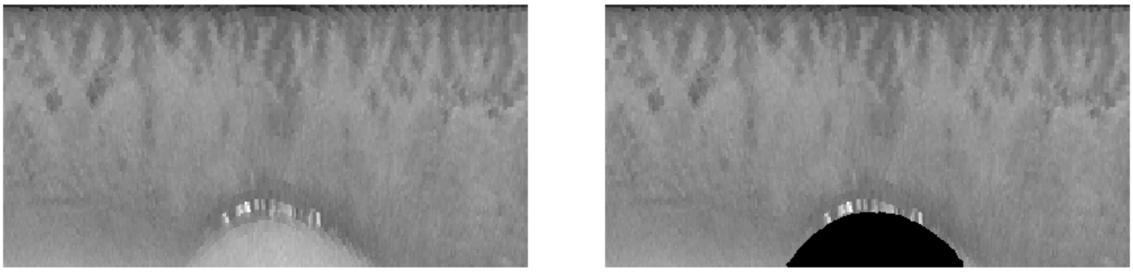


(b) Normalized iris

Figure 6

2.3 Eyelid masking

This step masks the irrelevant eyelid region in the normalized iris image. This is done by masking values higher than a threshold as the eyelid is much brighter. The result obtained is as follows.



(a) Normalized iris (b) Masked eyelid

Figure 7

3 Matching Stage

After removing the irrelevant data from the eye image, we are left with f_{norm} and g_{norm}. Our next steps will involve deciding if these two images belong to the same iris scan or not.

3.1 Phase Only Correlation Function(POC)

For two images f,g and DFTs F and G, we define:

$$R_{FG}(k_1, k_2) = e^{j\{\Theta_F(k_1,k_2) - \Theta_G(k_1,k_2)\}};$$

Where Θ_F and Θ_G represents the phase of F and G. Then the inverse DFT of R_{FG} is the POC fuction $r_{fg}(x, y)$. Band-limitting R_{FG} to certain values gives us the BLPOC. The matching score will finally be the maximum of absolute value of $r_{fg}(x, y)$.

3.2 Effective Region Extraction

Here our aim is to eliminate the masked eyelid region. To achieve this, we remove some of the last rows in the normalized image such that the common region between two images is selected finally. For the eyelid masked image shown above, we would get our effective region extracted to be:

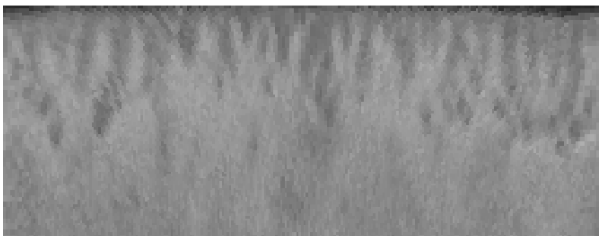


Figure 8

3.3 Displacement Alignment

This step is required in the case where the two images to be compared are translated w.r.t each-other. Then we judge the shift from maximum value of $r_{fg}(x, y)$ and do the appropriate shift.

Finally we take the common area between them obtained after shifting.

3.4 Matching Score Calculation

After covering all the above stages, we finally find the matching score using max of the BLPOC of the final two images. A surface plot of the BLPOC function of like images is shown below:

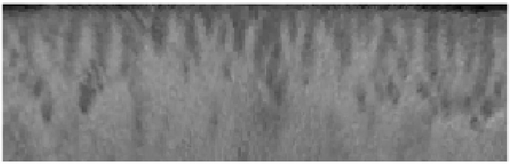


Figure 9: Image 1

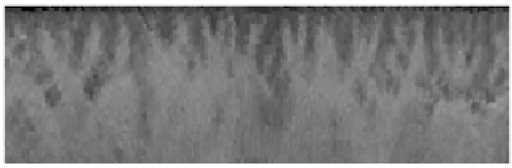


Figure 10: Image 2

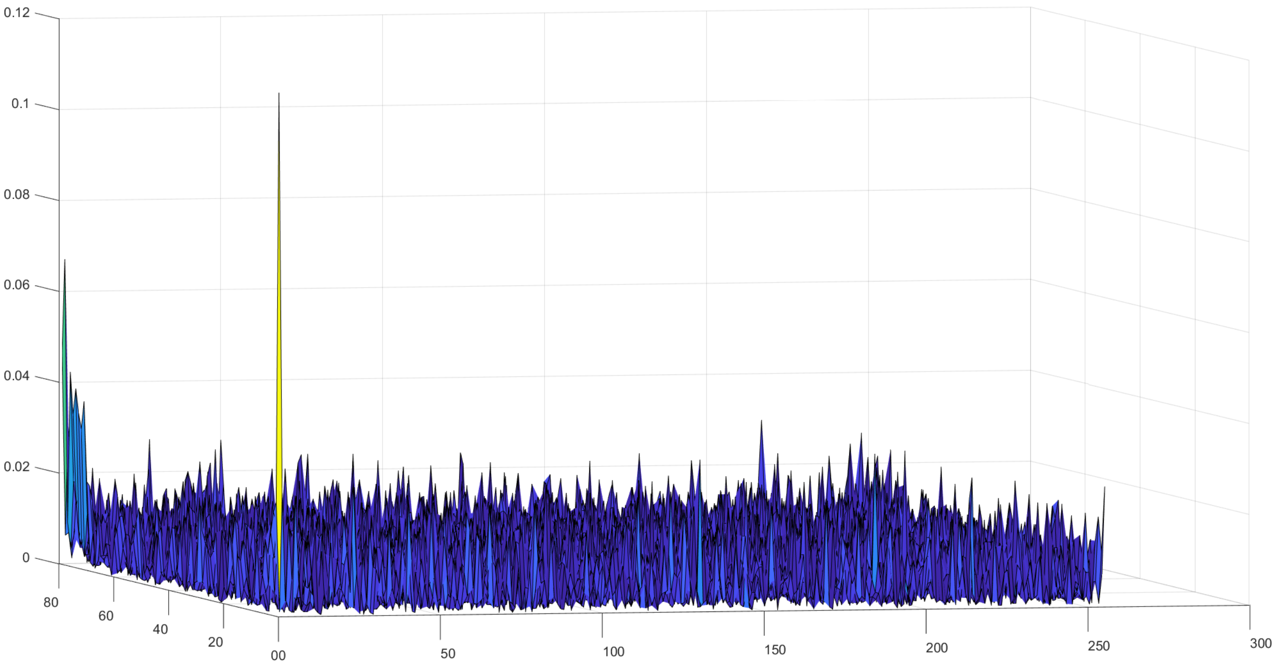


Figure 11

And for unlike images the BLPOC comes out to be:

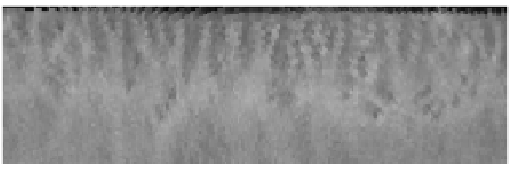


Figure 12: Image 1

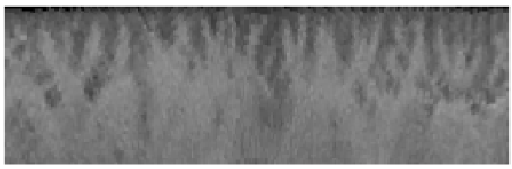


Figure 13: Image 2

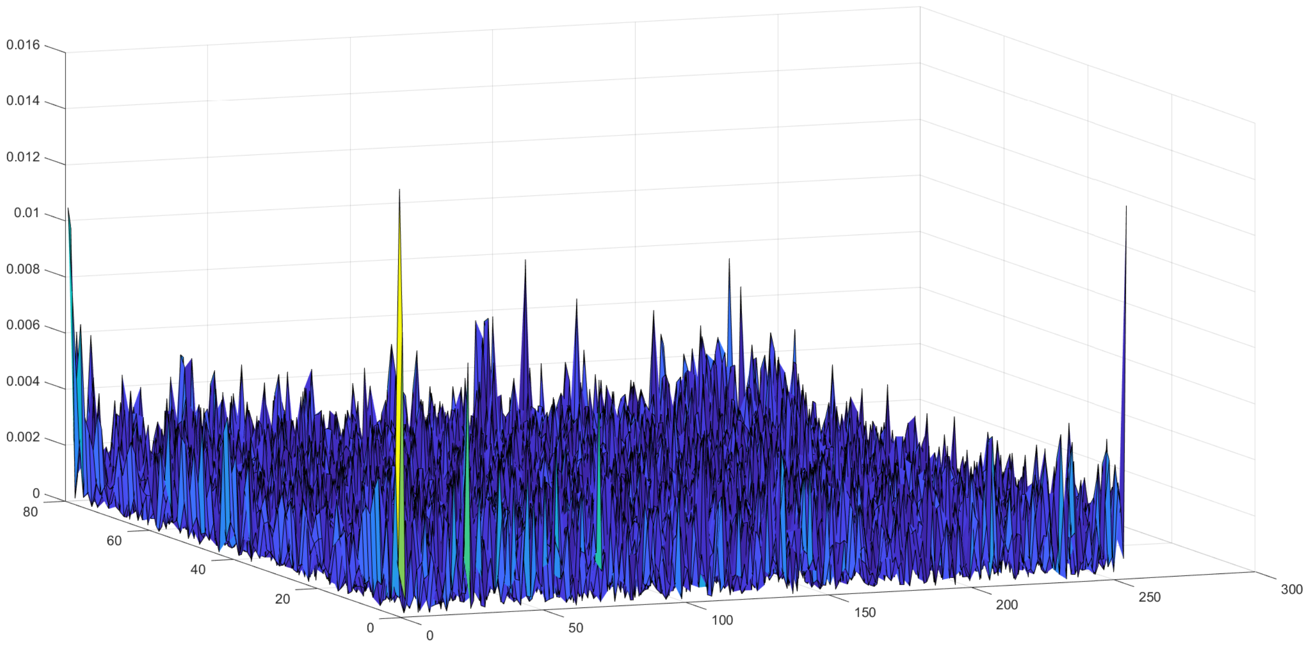


Figure 14

Note the point (0,0) is at the corner as per our convention. Hence for like images the BLPOC and POC both tend to become a delta function centred at origin.

4 Evaluation/Validation

The paper discussed a method of phase based image matching using the Phase Only Correlation(POC) and Band Limited Phase Only Correlation(BLPOC). We will use this method to calculate the maximum correlation peak value and match it with a suitable threshold to separate genuine and impostor cases.

Taking the parameters $(K_1/M_1) = 0.55$ and $(K_2/M_2) = 0.2$ as proposed in the paper, for a total of 180 genuine trials and 210 imposter trials using the persons 011 to 040: Total number of correct genuine = 139; false imposter = 41; correct imposter = 188; false genuine = 22.

Thus, the genuine detection accuracy = 77.22% and imposter detection accuracy = 89.52%. The parameters (K_1/M_1) and (K_2/M_2) can be tuned to obtained trade-off between the genuine detection accuracy and imposter detection accuracy.