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Reducing Intra-class Variations of Deformed Iris Recognition System

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ABSTRACT

Based on previous researches, it has been demonstrated that different pupil dilation of same eye is one of the factors that lead to negative impact on iris recognition performance. This work proposes the use of three-different-database scheme for reducing intra-class variation of iris recognition system having different pupil dilation size. Experimental on the CASIA-Iris-Lamp database indicate performance improvement when three-different-database scheme is used for matching iris images with different pupil sizes.

Key words : Pupil dilation, deformed iris recognition system, decidability.

1. INTRODUCTION

Research on pattern recognition system has been actively conducted by researchers lately [1]-[5]. As any other security technology, iris recognition system also faces some challenges that influence its performance. Its challenges including capturing non-ideal iris images. The acquisition of human iris is quite difficult compared to other biometric traits because of its small size. The acquired images are seldom perfect even under a controlled environment due to various uncertainty factors. Reflections, defocus, motion blur, occlusion and pupil dilation are factors that cause to noisy iris images.

Among other factors that cause to noisy iris images, pupil dilation, or also known as iris deformation has become an active research topic in recent years. Several factors such as alcohol, drugs, age, disease, psychology and light intensity changes had been demonstrated to induce varying levels of pupil dilation. In the issue of light intensity changes, there are two muscle systems which consists of several radial dilator muscles and a sphincter muscle that function to adjust the amount of light entering the pupil by controlling the size of the iris. The dilator muscle fibers are radially arranged to widen pupil size whereas the sphincter muscle fibers are circumferentially arranged to constrict pupil size. [6].

Two eye images of the same person having different pupil size make the iris texture patterns dilate and contract according to the light intensity changes [7], and the visible features of the iris such as crypts, collarette and radial furrow change perceptibly [6]. The change of visible features of iris will increases the possibility of false non-matches, where the user is failed to be identified, hence lower the accuracy of the system [8],[9]. Figure 1 shows example of two iris images with different degree of pupil dilation values having different visible iris features.

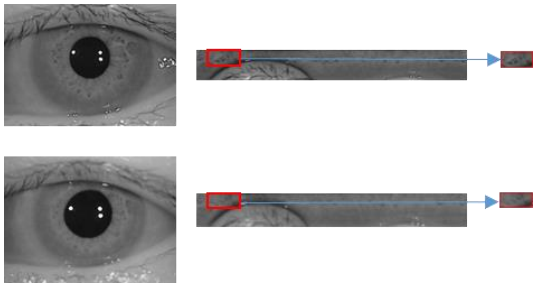


Figure 1: Different iris texture of two eye images of same person due to changes in pupil size

In this paper, we analyzed the effectiveness of proposed work on reducing intra-class variation of iris recognition system having different pupil dilation size.

2. RELATED WORK

Table 1 shows existing works on enhancing deformed iris recognition system. Some of researchers proposed nonlinear iris normalization scheme to reduce intra-class variations [6],[10] which in return got significant accuracy improvement. Some of them proposed selective matching scheme by using multiscale filter [8]. There is also previous work proposed feature extraction scheme that extract non-linear tensile properties of iris patterns [7].

Table 1: Existing works on enhancing deformed iris

Author /s	Countermeasure	Comments	Database (iris classes, images)
[6](Tomeo-reyes, Ross, & Chandran, 2016)	Normalization scheme	proposes the use of a biomechanical nonlinear iris normalization scheme along with key point-based feature matching for mitigating the impact of drug-induced pupil dilation on iris recognition	Iris Degradations Data Set (IDDS) (19/345)
[8](Pasula, 2016)	Matching scheme	propose selective matching scheme based on IrisCodes obtained using multiscale filter	OSIRIS_v4.1 SDK (52/2218)
[7](Jeong et al., 2015)	Feature extraction	extracting iris features by nonlinear and dynamic track allocation based on the nonlinear tensile properties of iris patterns	CASIA-Iris V3-Lamp database (819/16,213)
[10](Chen et al., 2010)	Normalization scheme	propose a fast and simple nonlinear normalization scheme	iris image database (DB1) (18/162)
[11](Wei, Tan, & Sun, 2007)	Nonlinear iris deformation correction scheme	Proposed nonlinear iris deformation correction algorithm based on Gaussian model to reduce nonlinear iris stretch	CASIA-Iris V3-Lamp (30/1800)

3. MOTIVATION AND CONTRIBUTION

In deformed iris recognition system, iris features can be extracted based on either linear or non-linear normalized iris. Generally, previous works based on non-linear normalized iris demonstrated better accuracy performance compared to linear normalized iris. It is obviously due to the deformed iris features were extracted in the form of non-linear positions of iris pattern, which is followed the characteristic of deformed iris tissue [7],[11],[12].

Even though linear normalized iris always got low accuracy, there is still a room to enhance the accuracy without applying non-linear normalization scheme. Previous works based on linear normalized iris used same threshold value for matching process for all iris images of the same subject that have different degrees of dilation ratio. Different degrees of dilation ratio in iris image cause variation in iris texture which then generate different iris code. Therefore, using same threshold value for all degrees of dilation ratio will lead to increasing intra-class variation of iris recognition system, hence reducing accuracy of deformed iris recognition system.

To overcome this problem, a new scheme of deformed iris recognition system based on different threshold values need to be proposed. As been recommended by [13], each generated iris code can be associated with dilation ratio that functions as meta-data, which then allow system to classify an iris code based on the value of its dilation ratio, which is expected to improve accuracy of the system. Inspired by his suggestion, dilation ratio could be used as reference values in order to specify different threshold values for different degrees of dilation ratio.

4. MEASURING DILATION

Measuring pupil dilation size was the first step in this work in order to make sure that the database used consists of iris with varying pupil dilation sizes. Besides, its purpose is to determine how many of iris images for each type of dilation.

Both radii of iris and pupil are obtained from segmentation process. In order to measure pupil dilation, the pupil radius is divided by the iris radius. This dilation ratio value must be between 0 and 1 since the iris radius is always larger than the pupil radius [14]. In this work, all dilation ratios for 2250 iris images were between 0.21 and 0.62. The dilation ratio distribution is illustrated in Figure 2. There are three types of dilation ratio based on three different range of values. According to [15] the range of value for constricted dilation ratio is $0.28 < \Delta \leq 0.35$. The range of value for normal dilation ratio is $0.35 < \Delta < 0.48$ while for dilated dilation ratio is $\Delta \geq 0.48$.

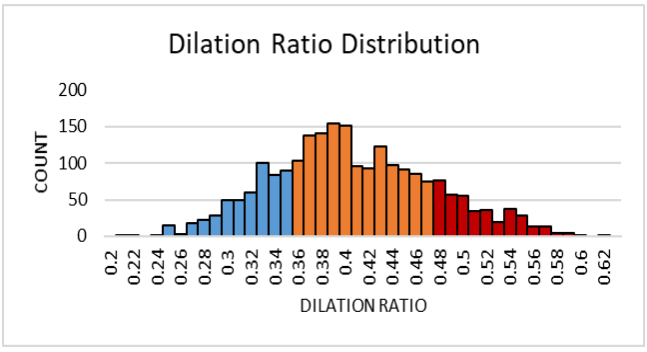


Figure 2: Dilation ratio distribution of CASIA-Iris-Lamp database

5. PROPOSED SCHEME

In this section, the proposed scheme of iris recognition system based on three different databases is explained, which is expected to reduce the intra-class variation of deformed iris recognition system. Figure 3 shows overall procedure of the proposed scheme while Figure 4 shows conventional scheme. The main difference between proposed and conventional scheme is that, the proposed scheme uses three different type of databases which are DB_constr, DB_norm and DB_dil instead of only one database used in conventional scheme. DB_constr is used to save iris templates of constricted pupil, while DB_norm and DB_dil are used to save iris templates of normal and dilated pupil, respectively. Dilation ratio values will be used as a reference value to classify which type of databases to save iris templates.

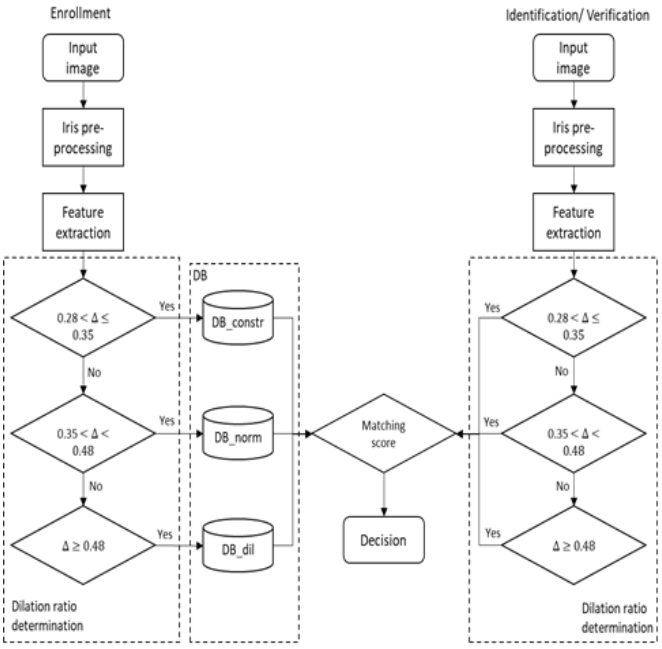


Figure 3: Overall procedure of the proposed scheme

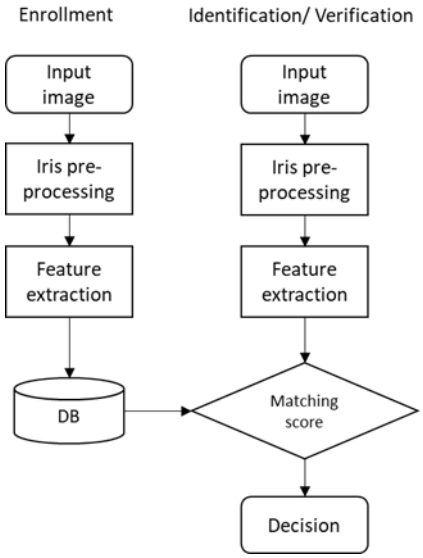


Figure 4: Conventional scheme

6. EXPERIMENTAL EVALUATIONS

Performance is evaluated in terms of decidability, d'. Decidability is a distance measured in standard deviations and is a function of the magnitude of difference between the mean of the intra-class distribution μ_S, and the mean of the inter-class distribution μ_D, and also the standard deviation of the intra-class and inter-class distributions, σ_S and σ_D respectively. According to [16], decidability is a better metric to measure separation of intra-class and inter-class distributions. The higher the decidability, the greater the separation of intra-class and inter-class distributions, which allows for more accurate recognition. The formula of decidability is as follow:

$$d' = \frac{|\mu_S - \mu_D|}{\sqrt{\frac{\sigma_S^2 + \sigma_D^2}{2}}} \quad (1)$$

6.1 Experimental Setup

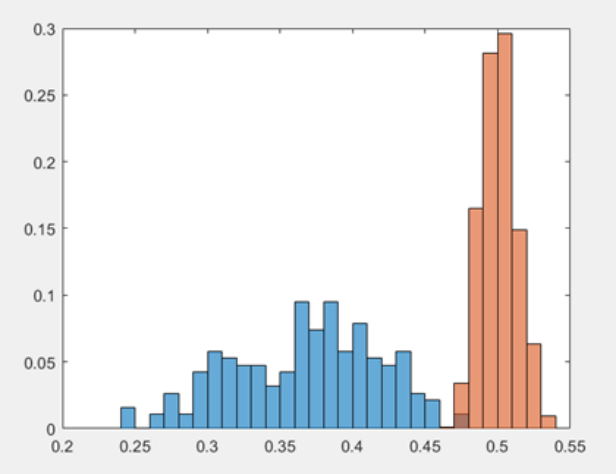
To evaluate the effectiveness of proposed work, CASIA-Iris-Lamp database are used to carry out experiments, which consist of 8 bit gray-level JPEG images. Those images are collected under near infrared illumination with 640 x 480-pixel resolution. The dataset comprises 16,212 iris images of left and right eyes of 411 subjects resulting in a total number of 819 different classes. In this work, only 53 classes were used, which comprises 1060 iris images. At pre-processing the iris of a given sample image is detected, un-wrapped to an enhanced rectangular texture of 480 × 40 pixel. Software of Iris system from [16] had been used to carry out the experiment.

6.2 Performance Evaluation

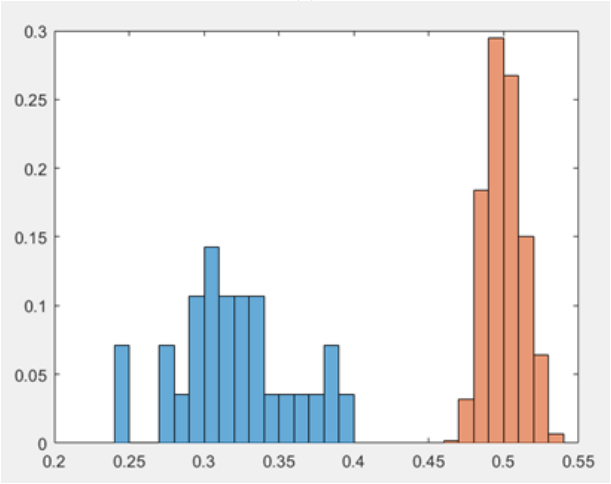
Table 2 shows comparison of decidability values between both proposed and conventional scheme. As expected, the proposed scheme shows better results for all eight iris images.

Table 2: Comparison between conventional and proposed scheme

Iris Image	Decidability value	
	Conventional scheme	Proposed scheme
Img_1	3.6254	6.3037
Img_2	3.6271	6.3057
Img_3	3.6110	6.2910
Img_4	3.6113	6.2906
Img_5	3.6446	6.3425
Img_6	3.6472	6.3442
Img_7	3.5971	6.2618
Img_8	3.5866	6.2252

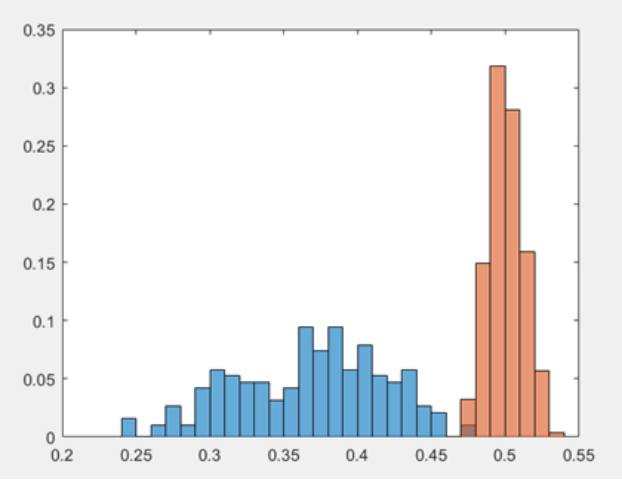


(a)

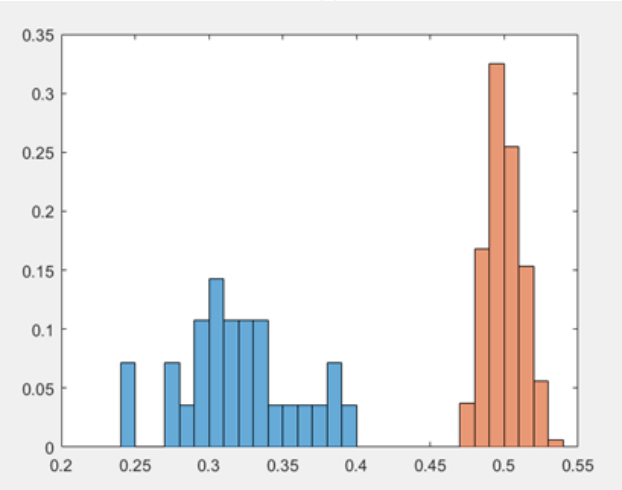


(b)

Figure 5: Intra-class and inter-class Hamming distances (HD) distribution of img_1 (a)-(b), graph (a) is distribution of conventional scheme while graph (b) is distribution of proposed scheme



(a)



(b)

Figure 6: Intra-class and inter-class Hamming distances (HD) distribution of img_2 (a)-(b), graph (a) is distribution of conventional scheme while graph (b) is distribution of proposed scheme

Both Figure 5 and Figure 6 show two distribution graphs generated from conventional scheme (a) and proposed scheme (b) from two different iris images, img_1 and img_2, respectively. From both figures, it can be observed that proposed scheme generated a better separation of intra-class and inter-class Hamming distance distribution compared to distribution generated from conventional scheme. It shows that proposed scheme is capable to reduce intra-class variations of deformed iris recognition system by separating iris templates having three different dilation ratio values into three different databases. It is because conventional scheme mixed up all types of iris template having different values of dilation ratio into one database only. Meanwhile in proposed scheme, iris templates having different values of dilation ratio are classified and saved into different databases according to its dilation ratio value, making those three databases contain templates of same dilation ratio value only.

7. CONCLUSION AND FUTURE WORK

In this paper, a new scheme for deformed iris recognition system using three different databases based on three different dilation ratio values was proposed. Based on result obtained, it is clearly proved that proposed scheme is capable to reduce intra-class variations of deformed iris recognition system by providing better decidability values compared to conventional scheme. Greater decidability values allow for more accurate recognition and better recognition system because it indicates a greater separation of intra-class and inter-class distributions. Future work would include the evaluation of proposed scheme on each types of iris dilation ratio. Besides, the effect of increasing sample size on intra-class variation also will be studied.

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