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Video Sequence-Based Iris Recognition Inspired by Human Cognition Manner

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Abstract

In video sequence-based iris recognition system, the problem of making full use of relationship and correlation among frames still remains to be solved. A brand new template level multimodal fusion algorithm inspired by human cognition manner is proposed. In that a non-isolated geometrical manifold, named Hyper Sausage Chain due to its sausage shape, is trained using the frames from a pattern class for representing an iris class in feature space. We can classify any input iris by observing which manifold it locates in. This process is closer to the function of human being, which takes 'matter cognition' instead of 'matter classification' as its basic principle. The experiments on self-developed JLUBR-IRIS dataset with several video sequences per person demonstrate the effectiveness and usability of the proposed algorithm for video sequence-based iris recognition. Furthermore, the comparative experiments on public CASIA-I and CASIA-V4-Interval datasets show that our method can also achieve improved performance of image-based iris recognition system, provided enough samples are involved in training stage.

Keywords: iris recognition, video sequences, multi-modal fusion, bionic recognition, hyper sausage neuron

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1 Introduction

Iris recognition is devoted to distinguishing individuals by physical iris characteristic, which is considered more universal, distinctive and stable[1]. The state-of-the-art iris recognition system was proposed by Daugman in 1993[2,3]. 2D Gabor phase code and Hamming distance are applied to represent iris texture and make classification respectively. Wildes's iris recognition system is another important system[4,5]. Subsequently a large number of algorithms have been proposed to improve iris recognition performance with less control[6–8].

Previous literatures were concentrated on single image-based iris recognition. It suffers from some kinds of problems, for example, intra-class variations (*e.g.* iris texture affected by ageing), inter-class similarities (lead to false accepted), and noises in data (*e.g.* illumination effect to iris image pixels)[9]. Video sequence-based iris recognition may offer the opportunity to overcome these difficulties. First, more template modalities from video sequences can provide the correlation and effective representations of intra-class samples to help identification. Second, online iris video sequence-based recognition allows updating the template modalities by the current and past frames in a video sequence for a robust model. Lee *et al* introduced an effective methodology for a biometric system sensitivity analysis. They illustrated this methodology by application to a Video-Based Automated System for Iris Recognition (VASIR) system[10]. Du *et al*. proposed a video-based non-cooperative iris image segmentation scheme via a coarse-to-fine strategy[11]. Zhou *et al* employed a quick bad quality images selection method for video-based iris recognition[12]. These literatures focused on iris image quality assessment and selection for VASIR. However, the challenges of multimodal fusion and online learning still remain in VASIR. Multimodal fusion consolidates the connectivity and correlation among multiple modalities, for the purpose of addressing the problem of intra-class

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variations and noises. Latha and Thangasamy proposed a new person authentication based on five biometric traits including iris, ear, palm print, fingerprint and retina, whose matching scores would be combined using weighted sum fusion rule[13]. Monwar and Gavrilova presented a multimodal biometric system via utilizing face, iris, and ear biometric rank level fusion[14]. Kim *et al*. proposed a multimodal system with both face and iris based on score level fusion[15]. These multimodal fusion strategies were used for multimodal biometric traits, and much appeared at score level owing to the heterogeneity of multimodal biometric resources. In this case, less information can be included in making decision than fusion at early stage. To our best knowledge, seldom efficient multimodal method to fuse multiple frames to make iris classification has been proposed for VASIR in existed literatures. In this paper we provide the following contributions for video-based iris recognition.

(1) A multimodal fusion method at template level based on bionic recognition is proposed. Compared with other fusion strategy, this template level fusion method, whose principle is based on ‘matter cognition’ instead of ‘matter classification’[16], may introduce the connectivity and correlation among multiple frames in the videos from a pattern class to help recognition.

(2) A sausage shape like manifold named Hyper Sausage Chain (HSC) is introduced to represent a pattern class for the implementation of bionic recognition[17]. Its training process is incrementally learned using the prior generic model and successive frames from video sequences, to maintain high level of recognition performance and usability of video sequence-based iris recognition.

(3) To evaluate the efficiency of the proposed method to iris video sequences, a contrastive analysis of some popular iris recognition systems and ours is carried out on self-developed JLUBR-IRIS dataset with iris video sequences. Moreover, the comparisons with these systems on CASIA-I and CASIA-V4-Interval image-based datasets are also conducted. The experimental results demonstrate that our method is expected to facilitate video-based iris recognition and obtain more reliable performance on both video sequence-based and image-based iris recognition system.

The rest of this paper is organized as follows. Section **2** details bionic recognition and its basic principle. Section **3** describes the experimental setup and results on CASIA-I, CASIA-V4-Interval and JLUBR-IRIS with video sequences datasets. Section **4** gives the conclusion.

2 Method

2.1 Bionic recognition and its basic principle

There are two typical paradigms for implementing pattern recognition[18], whose essential difference can be observed from the view of geometrical analysis. One of them takes the partition of feature space in accordance with the boundaries of all pattern classes as its task. Its particular cases include distance classifiers, clustering methods, Back Propagation (BP) networks and the Radial Basis Function (RBF) networks. The core issues of them are seeking for the optimal division among pattern classes by distance measure, linear mapping or Gaussian fitting respectively. The second one called bionic recognition or biomimetic pattern recognition is inspired by human cognition manner[18]. When cognizing an object, we will quickly find and then strongly adsorb on its relation with known pattern-matched objects, in which case, the correlation among all samples in each known pattern is analyzed. This principle named homology continuity brings out that a gradually changing sequence must exist between two samples in a pattern class[16]. Let $\boldsymbol{A}$ denote a pattern class having any two samples x and y. When a minimum $\varepsilon>0$ is given, there must exist a subset $\boldsymbol{B}$ having samples b_j (j=1,2,…, N) as follows, whose number of samples is $\boldsymbol{N}$.

$$\begin{aligned}\boldsymbol{B} = \{x = b_1, b_2, \ldots, b_n \\ = y \,|\, \| b_m, b_{m+1} \| < \varepsilon, n-1 \geq m \geq 1, n \subset \boldsymbol{N}, m \subset \boldsymbol{N}\} \subset \boldsymbol{A}\end{aligned}$$

$\| \;\|$ denotes the distance between two points. All these continuous points from a pattern class compose a connected and non-isolated manifold, which can be trained to represent a certain pattern class. Hence the core issue of bionic recognition might be to ascertain a topological manifold for each pattern class and make decision under this circumstance.

2.2 Hyper sausage chain construction

In order to achieve an optimal topology for each pattern class, we get inspiration from dynamic programming. A whole manifold can be deemed optimal as long as any two nearest neighbor samples are appropri-