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Evaluation of Periocular over Face Biometric: A Case Study

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Abstract

Recognition of a person through his face is the primitive mean of human identification. Identifying a person through face biometric have grown its importance through the last decade and researchers have attempted to find unique facial feature-points. Facial data also contains change with expression and age, which makes recognition through face difficult. And there has developed a stringent necessity to identify a person on partial facial data. These motives led researchers derive auxiliary biometric traits from facial image, viz. ear, lip and periocular region. In particular, periocular region has been exploited to examine the existence of uniqueness as there are many nodal points in periocular region. Classification and recognition is achieved through periocular region which shows significant accuracy, given the fact that periocular biometric uses only 25% of a complete face data.

Keywords: Face; Periocular biometric; Recognition; Classification.

1. Introduction

This paper investigates the evolution of research on biometric system concentrating from face towards a subset of it: periocular region. Periocular (peripheral area of ocular) region refers to the immediate vicinity of the eye, including eyebrow and lower eye-fold as depicted in Fig. 1. Face recognition had been main attention of biometric researchers due to its ease of unconstrained acquisition, and the uniqueness. Face is proven to have approximately 80 feature-points that can comprise in formation of a unique template for authentication. The major challenges in face detection faced by the researchers were change of human face with age, change of facial expression [1] etc. With the advent of low-cost hardware to fuse multiple biometrics in real-time, the emphasis began to extract a subset of face which can partially resolve the aforementioned issues. Hence the investigation towards ear [2], lip [3], and periocular started gaining priority. Furthermore, capturing eye or face image automatically acquires periocular image. This gives the flexibility of recognizing an individual using the periocular data along with iris data without extra storage or acquisition cost. Moreover periocular features can be used when an iris image does not contain subtle

details, which mostly occurs due to poor image quality. Periocular biometric also comes into play as a candidate for fusion with face image for better recognition accuracy. A comparative analysis of pros and cons of different partial-face biometrics are given in the Table 1, which self-justifies reason of using periocular over others.

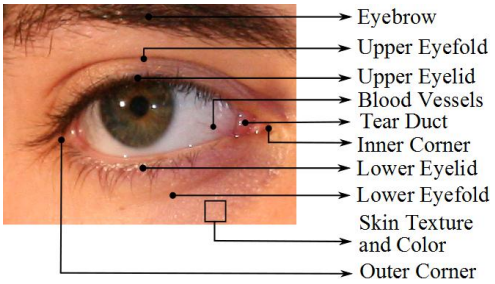

Fig. 1: Important features from a periocular image

2. From Face to Periocular

Face image is the most significant part of a human body carrying features that are unique to a person. Face image also gives information about a person's gender, ethnicity, age. Hence face biometric has been widely used by the researchers for personal authentication, as well as for ethnicity, gender, and age classification. However large template size makes facial recognition/classification system slow in practical large-database scenario. Hence to cater for the need of real-time application, periocular region: a potential subset of face has gained its importance rather than using the full face image. Both recognition and classification systems employing periocular image are proposed by various researchers. While recognition or classification through periocular region, approximately 25% of the whole face image is used. It signifies that most of the significant facial features of face are condensed into periocular region, which further emphasizes the importance of considering periocular region for classification/recognition. Hence periocular biometric can also be used as added information to face data used for classification [4], costing no added separate time and effort for acquisition, and no extra for storage space. However, if periocular region is deployed in an independent biometric system, then the each template size will be reduced to approximately 25% of the existing face template size. This fastens the identification mode of recognition, when the database size is as large a nation.

Table 1: Comparative analysis of partial-face biometric traits

Partially-face Biometrics	Advantages	Possible Challenges
Ear	Easy segmentation due to presence of contrast in the vicinity	Difficult to acquire Can be partially occluded by hair Use of ear-rings
Lip	Existence of global and local features	Difficult to acquire Less acceptable Shape of lip changes with human expression Possible partial occlusion due to moustache Pattern may not be visible due to lipstick
Periocular	Can be captured with face / iris without extra acquisition cost	Can be occluded by spectacle Can contain less feature in case of infants

3. Evaluation of Existing Periocular Biometric Techniques

Research in the domain of periocular biometric is basically sub-divided into two categories, viz. classification and recognition of an individual, to fulfill the need of database indexing and developing partial face-recognition respectively. Classification approaches includes extraction of various features in an attempt to classify a periocular region based on left or right eye-region, gender, or ethnicity, whereas recognition includes identification/verification of an individual.

The researchers have first experimented with the classification of periocular regions into left or right regions as proposed by [5] as listed in Table 2. Subsequently authors in [6,7] experimented classification on periocular regions based on gender and ethnicity. Gender classification has become more stringent due to the reason that gender classification partitions the search database into two moderately-equal halves. The researchers have mainly worked with local features extracted from periocular regions employing Gabor features, Local Binary Patterns (LBP), Gradient Orientation (GO), and Scale Invariant Feature Transform (SIFT). Support Vector Machine (SVM), and Linear Discriminant Analysis (LDA) are mainly used for classification.

Recognition through periocular region has emerged subsequent to classification as listed in Table 3. The authors in [8,9] have concentrated on recognition by eye regions of periocular images. Along with local features, the authors have also proposed several algorithms that use skin information available in the periocular region. In all these papers, the authors have mainly worked with the local features available in the periocular regions like SIFT, LBP, city block distance, color histogram of periocular images. Authors in [10] have achieved 99.75% accuracy testing on periocular region from FRGC face dataset [11].

Table 2: Survey on classification through periocular biometric

Year	Author	Classification type	Algorithm	Classifier	Database	Accuracy
2008	Abiantum et al.[5]	Left vs right eye	Adaboost, Haar, Gabor features	LDA SVM	ICE	89.95%
2008	Bhat et al.[12]	Left vs right eye	ASM	SVM	ICE, LG	Left eye 91% Right eye 89%
2010	Merkow et al. [6]	Gender	LBP	LDA, SVM, PCA	Downloaded from web	84.9%
2010	Lyle et al.[7]	Gender and ethnicity	LBP	SVM	FRGC	Gender 93% Ethnic 91%

As there is no dedicated database solely available for research and testing on periocular biometric, the researchers have mainly worked with localizing periocular region from existing face databases or directly used iris databases to fetch periocular information. The most widely used database for periocular biometric is Face Recognition Grand Challenge (FRGC) database [11], containing high-resolution face images of size 1200×1400. It also contains images of different sessions and variable expressions.

Table 3: Survey on recognition through periocular biometric

Year	Authors	Algorithm	Features	Database	Performance Results	
2009	Park et al. [8]	GO, LBP, SIFT	Eye region	899 VS images of 30 subjects	Maximum Rank – 1 RR 80.8%	
2010	Hollingsworth et al. [9]	Human analysis	Eye region	NIR images of 120 subjects	Accuracy of 92%	
2010	Woodard et al. [13]	LBP fused with iris matching	Skin	MBGC NIR images from 88 subjects	Left eye Rank – 1 RR:	Iris 13.8%
						Periocular 92.5%
						Both 96.5%
					Right eye Rank – 1 RR:	Iris 10.1%
						Periocular 88.7%
						Both 92.4%
2010	Miller et al. [10]	LBP	Color information, Skin Texture	FRGC Neutral expression, different session Alternate expression, same session Alternate expression, different session	Rank – 1 RR for Exp 1:	Periocular 94.10%
						Face 94.38%
					Rank – 1 RR for Exp 2:	Periocular 99.50%
						Face 99.75%
					Rank – 1 RR for Exp 3:	Periocular 94.90%
						Face 90.37%
2010	Miller et al. [14]	LBP, City Block Distance	Skin	FRGC VS images from 410 subjects FERET VS images from 54 subjects	Rank – 1 RR on FRGC:	Left eye 84.39%
						Right eye 83.90%
						Both eyes 89.76%
					Rank – 1 RR on FERET:	Left eye 72.22%
						Right eye 70.37%
						Both eyes 74.07%
2010	Adams et al. [15]	LBP, GE to select features	Skin	FRGC VS images from 410 subjects FERET VS images from 54 subjects	Rank – 1 RR on FRGC:	Left eye 86.85%
						Right eye 86.26%
						Both eyes 92.16%
					Rank – 1 RR on FERET:	Left eye 80.25%
						Right eye 80.80%
						Both eyes 85.06%
2011	Woodard et al. [16]	LBP, Color Histograms	Skin Texture + Color	FRCG -1 (neutral expression, different session) FRCG – 2 (alternate expression, same session) FRCG – 3 (alternate expression, different session)	Rank – 1 RR on FRCG – 1:	Left eye 87.1%
						Right eye 88.3%
						Both eye 91.0%
					Rank – 1 RR on FRCG – 2:	Left eye 96.8%
						Right eye 96.8%
						Both eye 98.3%
					Rank – 1 RR on FRCG – 3:	Left eye 87.1%
						Right eye 87.1%
						Both eye 91.2%

4. Conclusions

Periocular and other auxiliary biometric traits are recently developed by the researchers, and there is still a long way to judge the potential of them. Initial investigation done in this paper behind evaluation of periocular biometric from face leads to few conclusions: 1. There is a generalized requirement of short-template auxiliary biometrics to support real-time operation of existing biometric systems; 2. Periocular biometric has grown its importance and will be more important than other partial-face-biometrics like lip or ear because of existence of more modal points in the region; 3. Local feature analysis with different existing methods by different author assures existence of rich feature in periocular region; 4. Periocular region is capable to give gender information besides recognition; 5. Periocular biometric can be captured along with iris, or face. Hence current researches aims to verify whether poor quality periocular image cropped from a face image can be useful for recognition.

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