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Multimodal biometrics: Weighted score level fusion based on non-ideal iris and face images

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ABSTRACT

The iris and face are among the most promising biometric traits that can accurately identify a person because their unique textures can be swiftly extracted during the recognition process. However, unimodal biometrics have limited usage since no single biometric is sufficiently robust and accurate in real-world applications. Iris and face biometric authentication often deals with non-ideal scenarios such as off-angles, reflections, expression changes, variations in posing, or blurred images. These limitations imposed by unimodal biometrics can be overcome by incorporating multimodal biometrics. Therefore, this paper presents a method that combines face and iris biometric traits with the weighted score level fusion technique to flexibly fuse the matching scores from these two modalities based on their weight availability. The dataset use for the experiment is self established dataset named Universiti Teknologi Malaysia Iris and Face Multimodal Datasets (UTMIFM), UBIRIS version 2.0 (UBIRIS v.2) and ORL face databases. The proposed framework achieve high accuracy, and had a high decidability index which significantly separate the distance between intra and inter distance.

1. Introduction

Biometrics is about measuring the personal features such as iris, face, fingerprints, retina, hand geometry, voice or signatures and recently drawn extensive concerns in the current security technologies. Biometrics has been the subject of widespread concern in modern society due to its widespread applications, making accuracy an important goal. In recent years, face and iris biometrics have become more popular than other modalities such as the fingerprint, retina, hand geometry, voice or signature (Jain & Kumar, 2011; Yunhong, Tieniu, & Anil, 2003). However, for systems that use unimodal biometrics, the recognition accuracy is sometimes questionable and is often affected by small sample size, noisy sensor data, low error rate, poor robustness, and spoofing attacks (Cui & Yang, 2011). A multimodal biometric system can alleviate some of these problems by utilizing and fusing two or more biometric modalities. Dass, Nandakumar, and Jain (2005) stated that a multimodal biometric system based on different biometric traits performs better and thus, can fulfill tighter real-world requirements. In the study reported in this paper, two biometrics were chosen to perform the fusion, namely, the face and iris biometrics.

Iris pattern is absolutely unique (Daugman, 2002). The chance of finding two randomly formed identical irises is almost astronomical order. Iris is formed since embryonic stage until age of 1 (Daugman, 2002). It will become constant after that till the end of the human life unless there are accidents or surgery. This is one of the main advantage of choosing iris biometric since almost every other biometric template would change significantly over certain time. In the past, iris recognition systems managed to authenticate accurately in cooperative environment. However, it is strictly in a constraint where the iris acquisition is in an ideal condition and imaginary setup (Farouk, 2011). Iris recognition performance may be in a very low accuracy especially when it faces a non-cooperative environment. In addition, probability of obtaining non ideal iris image is very high (Roy & Bhattacharya, 2010). Non-ideal iris image is defined as dealing the acquired iris images with off angle, occluded, blurred, reflection and noisy images captured in non-cooperative environment. Comparing different noise factors, the focus for this study is the off-angle iris. Off-angle iris is due to the rotation of the subjects head and eyes where iris images is capture with the iris not properly aligned with the imaging direction. These off-angle iris images have the elliptical shape for the region corresponding to the iris (Proenca & Alexandre, 2006).

Face recognition is the problem of verifying or identifying a face from its image. It has received substantial attention over the last

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three decades as well as in addressing many challenging real-world applications, identity documents (e.g. passport, driver license, access control, and video surveillance. It is an automated technique that human implicitly use their visual and cognitive capabilities to recognize a person (Modi, 2011) and also one of the nonintrusive modalities in biometrics. The most stable and distinctive information contained in the face is focused on the region that is unlikely to change such as eyes, nose and mouth. Although face recognition in controlled conditions (frontal face of cooperative users and controlled indoor illumination) has already achieved impressive performance, there still exist many challenges for face recognition in uncontrolled environments, such as partial occlusions, large pose variations, and extreme ambient illumination. Uncontrolled environment in face recognition is a very complex problem, where faces appear in different position and orientation, make up, facial hair, and a face can even be partially occluded.

Multi-biometric is an emerging technologies which attracts increasing attention of researcher. The multi-biometric main purpose is to overcome the shortcoming of the unimodal biometric system. Generally, there are five types of multi-biometric system which includes multi-sample (Poh, Bengio, & Korczak, 2002), multi-instance (Yuille et al., 2007), multi-sensor (Kisku, Sing, Tistarelli, & Gupta, 2009), multi-algorithm (Burge, Bowyer, Connaughton, & Flynn, 2012) and multi-modal (Lee et al., 2007). As reported in the literature of the biometric system, results provided by multimodal biometrics is much more accurate due to the availability of richer information (Rattani, Kisku, Bicego, & Tistarelli, 2007). Therefore, in this study, we propose the multimodal biometric system of iris and face biometrics. Combining the biometric information obtained from different modalities using an effective fusion scheme can significantly improve the overall accuracy of the biometric system. Multimodal approach proposes a fusion of different biometric traits and usually can be categorized into three main level which are score level fusion, feature level fusion, and decision level fusion (refer Table 1).

Feature level fusion method extracts the different features from biometric modalities and combines the feature set to create single temple. The difficulty of feature level fusion is the incompatible of various feature sets or having high dependencies between each other. In addition, most commercial system do not provide the access to the raw feature sets. Score level fusion method calculates the match score based on the degree of similarity between two biometric samples and the scores are integrated to generate a single matching scores. The effectiveness of score level fusion techniques depends on the accurate information of the score range and performance parameters. Score fusion level can be categorized into classification and combination approach. Classification formulate problem as diving the decision into two classes, the "Accept" genuine and "Reject" imposters. The combination approach is a techniques which combines the multiple scores and calculate a single match scores. Several research using classifiers to consolidate the matching scores of the biometrics. YunHong et al. (2003) used the Fisher's discriminant analysis and Neural Network classifier for the classification of the face and iris matching score results. Lee et al. (2007), Chen and Chu (2005) and Eskandari, Toygar, and Demirel (2013) also presents the score level fusion based on face and iris biometrics using the classification approach. Classification methods requires larger amounts of training data to determine its optimal decision boundary. There are also some study which demonstrates the score level fusion in the combination approach. Dass et al. (2005) combines the matching scores of the multi biometric traits based on generalized density estimation. Robert, Umut, Alan, Michael, and Anil (2005) demonstrate a good results with the multimodal fingerprint and face biometrics through the matching score fusion algorithms using the elaborate evaluation. Slobodan, Ivan, and Kristina (2008) acquired the fingerprints and palm prints and used the extracted eigenpalm and eigenfinger features to perform the score level fusion. Another more recent combination approach with the fusion of face and iris biometrics using Iris on the Move (IOM) sensor are presented by Burge et al. (2012). This sensor is designed for high throughput stand-off iris recognition which features a portal of subjects walk through at normal walking pace. On the other hand, decision level fusion is the easiest fusion level among the others which applied a Boolean response indicating whether or not the comparison is matched. As fusion level progresses from feature level to decision level, the amount of information deceases (Monwar & Gavrilova, 2009). Fusion at decision level is less studied in literature, as it is often considered inferior to matching score-level fusion, on the basis that decisions are too "hard" and have less information content compared to "soft" matching scores (Tao, 2009).

The main goal of this study is to develop a unified framework which: (1) correctly localizes iris boundaries of the off-angle iris images; (2) integrates more features to increase the limited discriminant ability of unimodal biometrics. This research study was done to contribute to the domains of biometric recognition and its practical application to the general population. The framework of biometric recognition proposed had achieved minimal intra-class variations and maximal inter-class variations. In terms of theoretical knowledge, a better segmentation method that has combined geometric calibration and direct least square ellipse fitting has been proposed to correctly localize non-circular boundary of unconstrained off-angle iris images. Another significance of this study is that the proposed "NeuWave Network" to extract features of unconstrained off-angle iris images. Both proposed methods had demonstrated high segmentation and iris recognition accuracy.

Table 1
Related studies of different level of multimodal biometric recognition.

Category	Fusion traits	Related study	Techniques/algorithm	Pros/Cons
Feature level fusion	Face and iris	Tistarelli, Nixon, and Rattani (2009), Byungjun and Yillbyung (2005), Ross and Govindarajan (2005)	Transformation-based score fusion and classifier-based score fusion; scale-invariant feature transform (SIFT) features extractor; Daubechies wavelet transform	Incompatible of various feature sets or having high dependencies
Score level fusion	Face and iris	Eskandari et al. (2013), YunHong et al. (2003), Lee et al. (2007), Chen and Chu (2005)	Fisher's discriminant analysis and neural network; local bit pattern histogram matching; unweighted average based neural network	Best tradeoff between information content and fusion complexity
	Face and speech	Sanderson and Paliwal (2004)	Support vector machine	
	Fingerprints and palmprints	Slobodan et al. (2008)	Eigenpalm and Eigenfinger extractor	
Decision level fusion	Iris and face	Kapale, Kankarale, and Lokhande (2011)	PCA, Haar wavelet and morphological method	Least information content available