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Security of Biometric Recognition Frameworks is Enhanced by Image Quality Assessment

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Abstract: To ensure the actual presence of a real legitimate trait in contrast to a fake self-manufactured synthetic or reconstructed sample is a significant problem in biometric authentication, which requires the development of new and efficient protection measures. In this paper, we present a novel software-based fake detection method that can be used in multiple biometric systems to detect different types of fraudulent access attempts. The objective of the proposed system is to enhance the security of biometric recognition frameworks, by adding likeness assessment in a fast, user-friendly, and non-intrusive manner, through the use of image quality assessment. The proposed approach presents a very low degree of complexity, which makes it suitable for real-time applications, using 25 general image quality features extracted from one image (i.e., the same acquired for authentication purposes) to distinguish between legitimate and impostor samples. The experimental results, obtained on publicly available data sets of fingerprint, iris, and 2D face, show that the proposed method is highly competitive compared with other state-of-the-art approaches and that the analysis of the general image quality of real biometric samples reveals highly valuable information that may be very efficiently used to discriminate them from fake traits.

Index Terms: Image Quality Assessment, Biometrics, Security, Attacks, Countermeasures.

INTRODUCTION

A biometric measurement is a physical or behavioral trait. The field of biometrics aims to verify personal identity using such features. These traits are of interest because they are not easily changed or imitated, and they cannot be forgotten as is the case for passwords, nor can they be lost in the same manner as identification cards. Many biometric modes have been examined to date, with the research community and industry centering around a short list of biometric modalities that have exhibited particularly promising results.

Recent focus has shifted towards the face and the iris as biometric modes, and a large corpus of past publications and current research activity has emerged in recent years. While biometrics research has made much progress in recent years, and is nearing perfect recognition rates under ideal circumstances, further research is still necessary. One method of improving recognition rates is to verify that the collected data is of sufficient quality for matching. My research involves analysis of the current quality metrics used in a variety of commercial systems as well as the development of new quality metrics for biometrics.

EXISTING METHOD

Liveness detection methods are usually classified into one of two groups:

(i)Hardware-based techniques, which add some specific device to the sensor in order to detect particular properties of a living trait (e.g., fingerprint sweat, blood pressure, or specific reflection properties of the eye);

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(ii) Software-based techniques, in this case the fake trait is detected once the sample has been acquired with a standard sensor (i.e., features used to distinguish between real and fake traits are extracted from the biometric sample, and not from the trait itself).

PROPOSED SYSTEM

A novel software-based multi-biometric and multi-attack protection method which targets to overcome part of these limitations through the use of image quality assessment (IQA). It is not only capable of operating with a very good performance under different biometric systems (multi-biometric) and for diverse spoofing scenarios, but it also provides a very good level of protection against certain non-spoofing attacks (multi-attack). Moreover, being software-based, it presents the usual advantages of this type of approaches: fast, as it only needs one image (i.e., the same sample acquired for biometric recognition) to detect whether it is real or fake; non-intrusive; user-friendly (transparent to the user); cheap and easy to embed in already functional systems (as no new piece of hardware is required).

BIOMETRICS TERMINOLOGY

Certain terminology has very specific meaning in the context of biometrics. *Biometrics* is the use of physical or behavioral traits to verify personal identity. A specific trait, such as fingerprint or iris, is referred to as the biometric *mode*. The process of obtaining a biometric sample is *acquisition*. Samples are captured and turned into digital signatures using a *sensor*. The database of collected samples and identity information is referred to as the *gallery*. A sample acquired for purposes of querying the gallery is called a *probe*. *Enrolling* is the process of acquiring a biometric sample, along with other information, to be used as part of the gallery, a step which must occur before the system can make positive identification of the person involved. The process of comparing a probe sample and gallery sample is called *matching*, which returns a *match score*. Samples are compared using one of many *algorithms*. A biometrics system usually has a *threshold* value, which determines whether the match score indicates a *match* (meaning that the samples are likely of the same person) or a *non-match* (meaning the samples are probably of two different people). *Multi-modal biometrics* is the process of using multiple biometric modes simultaneously to increase the accuracy of the identification system. More information can be found in the Biometrics Glossary [41].

Sample Comparison Outcomes

When two biometric samples are matched, a similarity or dissimilarity score is returned. Depending on the system, the score can either be interpreted as a match or a non-match, depending on how it compares to the matching threshold. This decision can either be correct or incorrect. Correct matches are called *true accepts*; incorrect matches are *false accepts*. Accordingly, correct non-matches and incorrect non-matches are known as *true rejects* and *false rejects* (see Figure 2.1). Example distributions of match scores, with annotations can be found in Figure 2.1. Accuracy of biometric systems is measured by the comparison of frequency of false accepts versus true accepts, called the *False Accept Rate* (*FAR*) and *True Accept Rate* (*TAR*). Graphs of the tradeoff between these two rates as the decision threshold changes are *Receiver Operating Characteristic* (*ROC*) curves. Biometrics systems are generally optimized towards minimizing the false accept rate, as it tends to be the more detrimental of the two error cases. See Figure 2.2 for a sample ROC curve. Match distributions for high-quality biometric samples exhibiting a small overlap.

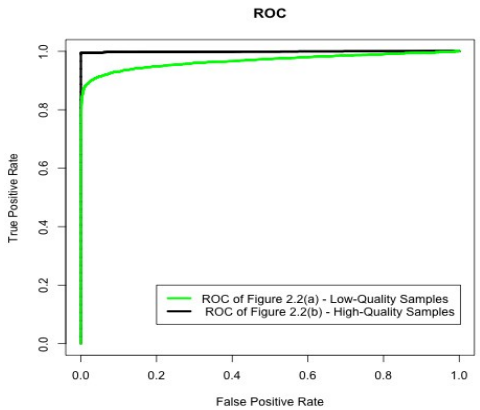


Figure 2.1: Comparison distributions of high-quality biometric samples versus low quality biometric samples

Figure 2.2. ROC curves for the match and non-match distributions in Figure 2.1. ROC curves plotted in this manner ideally have a very low false positive rate at a very high true positive rate. Therefore, ROC curves should ideally be in the top left of the graph. In this ROC chart, high-quality samples are clearly outperforming low-quality samples.

That the subject be enrolled in the gallery of the biometric system. At the time of the verification request, a probe sample is acquired and compared to the gallery samples(s) of the subject whose identity is claimed. If the match score lies on the match side of the threshold set for identity verification, the system will verify ID; otherwise ID will not be verified. Since match scores are only computed for one or a very small number of images, a verification claim can be executed in constant time.

Eye Anatomy and Iris Image Acquisition

The human eye is a complex organ which can focus and regulate the light entering from the pupil, using the lens and iris. The amount of light that enters the eye is controlled by a group of muscles called the iris. The iris and the lens behind it are protected by the cornea, a transparent protective covering that allows the iris to be externally visible. The visible structure of the musculature of the iris is what is used in iris biometrics. The iris was recognized as a potential biometric modality when it was first observed that its visual texture was unique to each individual and relatively stable over time [3]. Figure 2.3 details the anatomy of the eye using a sample acquired by an iris camera.

Iris biometric systems have traditionally required the user to be close to the camera and moderately cooperative (current sensors even give the user audio prompts for a more successful acquisition). The user will generally sit still or stand still very near to the camera, with one or both eyes looking into the aperture, for a few seconds while the acquisition occurs. As newer systems have emerged, the amount of time needed to acquire a sample has decreased, but is not instantaneous. Some newer systems have attempted to reduce the amount of user cooperation needed, but the user must still be facing the camera. Visual feedback is often available during the enrollment phase so a sensor operator can monitor the acquisition.

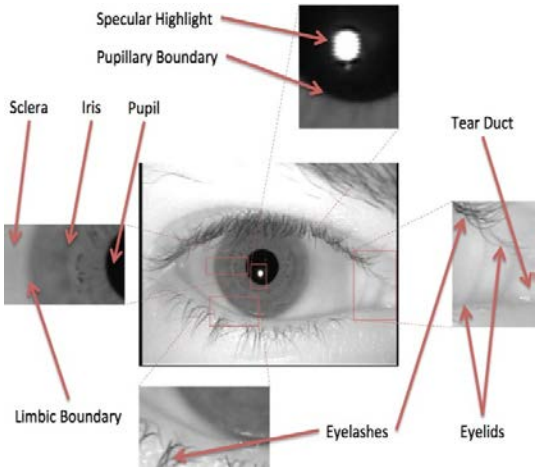
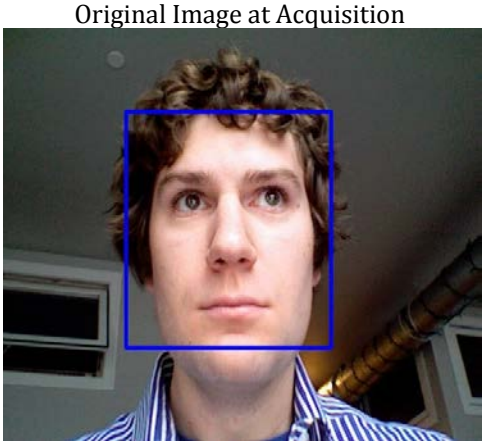


Figure 2.2: Anatomy of the human eye and features of a typical iris image

Figure 2.3: Example of Iris Acquisition using an LG2200 camera. Once a face is identified, the raw sample data needs to be turned into a template

Original Image at Acquisition

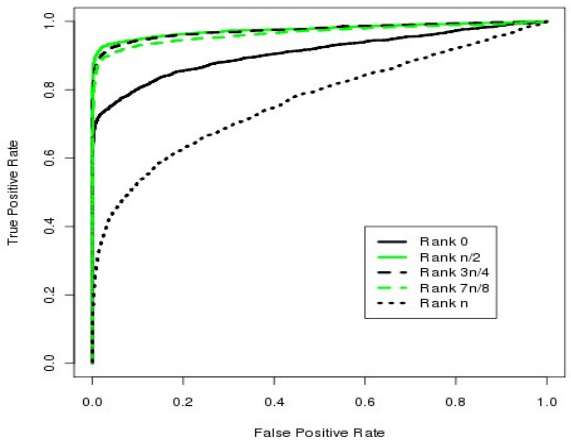


Face Image with Detected Face Marked by Colored Square

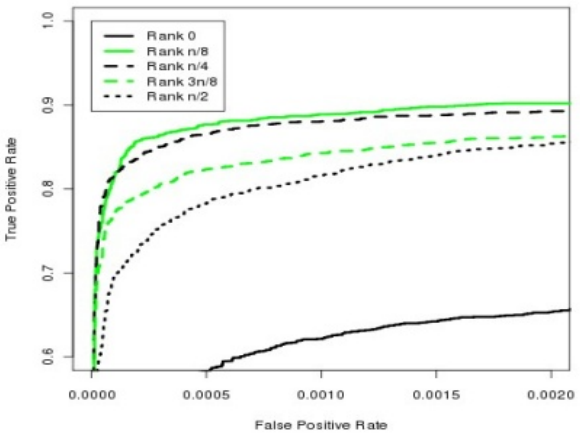
Example of face detection suitable for matching. Multiple methods exist for transforming the sample data, including holistic approaches, feature-based approaches, model-based approaches and classifier-based approaches [49]. Holistic approaches use the entire face as input, as it appears in the detected face region, and then perform some conversion on the data as a whole to produce a template. Feature-based approaches extract local feature information from the face region to build a template. Using features with low variance can help counter some effects of expression. Model-based approaches use fundamentals of reflection to generate a 3D face template from the 2D sample data. Classifier-based approaches use machine-learning techniques to classify regions of the image as either face or non-face.

Data Acquisition

Videos captured for this experiment cover a wide variety of locations and cameras, and every video had a significant amount of subject movement. As a result, the quality of data collected for the face experiment is far inferior to the highly-



(a) Iris BEE Quality Module experiment results as ROC curves, selected octiles



Data Selection

To evaluate the performance of quality metrics for face biometrics, a set *V* of1,621 test videos was chosen from 30,897 videos acquired from 2008-2011 and stored

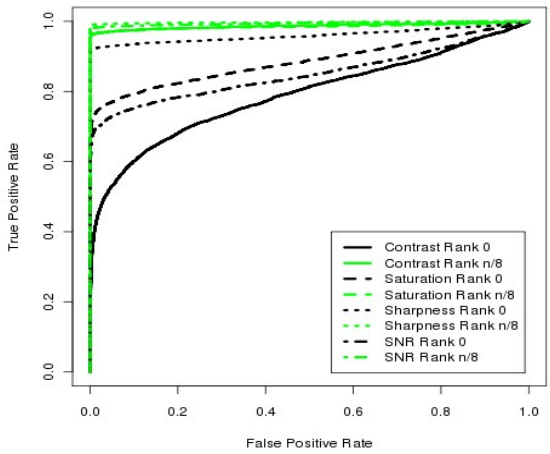


Figure 2.4: MIRLIN Quality Metrics experiments results as ROC curves. Normalized video length represented by n

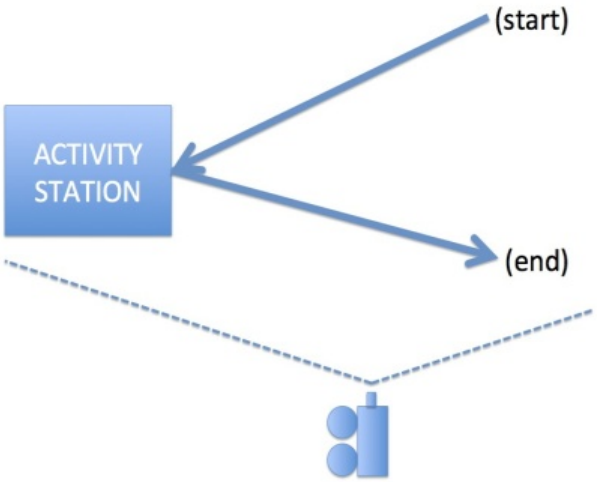
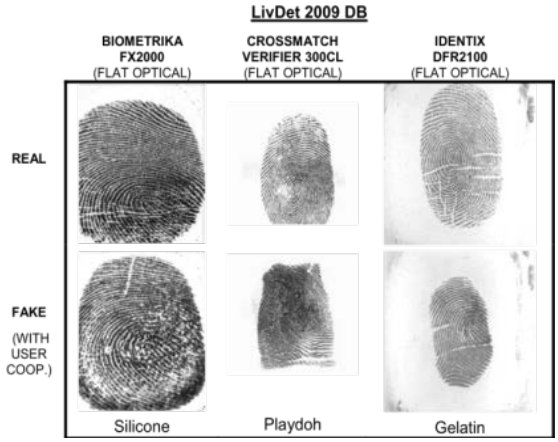


Figure The video camera records while the subject moves from one side of the field-of-view to the other to perform the activity, then returns to the original side of the field-of-view, while walking towards the camera. At all times, the subject is roughly facing the camera, but some activities involve occluding the face or looking away from the camera.

1) Results: Fingerprints-Spoofing LivDet: The LivDet 2009 DB [10] was captured in the framework of the 2009 Fingerprint Liveness Detection Competition and it is distributed through the site of the competition. [1]It comprises



CONCLUSION

Simple visual inspection of an image of a real biometric trait and a fake sample of the same trait shows that the two images can be very similar and even the human eye may find it difficult to make a distinction between them after a short inspection. Yet, some disparities between the real and fake images may become evident once the images are translated into a proper feature space. These differences come from the fact that biometric traits, as 3D objects, have their own optical qualities (absorption, reflection, scattering, refraction), which other materials (paper, gelatin, electronic display) or synthetically produced samples do not possess. Furthermore, biometric sensors are designed to provide good quality samples when they interact, in a normal operation environment, with a real 3D trait. If this scenario is changed, or if the trait presented to the scanner is an unexpected fake artifact (2D, different material, etc.), the characteristics of the captured image may significantly vary.

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