

# Liveness Detection Using An Intensity Based Approach in Fingerprint Scanners

Bozhao Tan and Stephanie Schuckers

Department of Electrical and Computer Engineering, Clarkson University, Potsdam, NY 13676, USA  
[tanb@clarkson.edu](mailto:tanb@clarkson.edu) and [sschucke@clarkson.edu](mailto:sschucke@clarkson.edu)

## 1. Introduction

Biometric systems are emerging technologies that enable the authentication of an individual based on physiological or behavioral characteristics. Biometric techniques include recognizing faces, fingerprints, hands geometry, palms, voices, gait, irises, signature, etc. Among these biometric identifiers, fingerprint recognition is considered as the most popular and efficient technique. However, a fingerprint sensor system is subject to various threats like attacks at the sensor level, replay attacks on the data communication stream and attacks on the database [1]. Previous work has shown it is possible to spoof a variety of fingerprint sensors through fake fingers using moldable plastic, clay, Play-Doh, wax or gelatin [1]. From a security and accountability perspective, there is an urgent need that a biometric system should have the ability to detect spoof biometric samples. One technique is to determine if the biometric sample is measured from a live source ensuring that only 'real' fingerprints, facial images, irises etc are presented for enrollment or authentication.

Our laboratory has demonstrated that the time-varying perspiration pattern can be used as a measure to detect liveness for fingerprint systems. Unlike spoof or cadaver fingers, live fingers have a distinctive spatial perspiration phenomenon both statically and dynamically. Based on this principle, a ridge signal algorithm and a wavelet algorithm have been developed to detect the perspiration pattern [2, 3]. These methods are capable of producing classification rates in the range of 90% ~100% for the three scanners tested. However, the processing speed is relatively slow due to the complicated image processing and wavelet algorithms. Therefore improvement of the speed with reasonable performance for fingerprint liveness is the motivation for this work. This new method utilizes static and dynamic features derived from intensity histograms of the zero and fifth second images of a fingerprint.

## 2. Proposed Method

Figure 1 shows an example of a typical live and spoof fingerprint. The perspiration phenomenon is visible only in the live subject. An intensity based approach quantifies this using histogram distribution statistics and finds distinct differences between live and non-live images. First, in live fingers, perspiration starts from the pores, either completely covering them or leaving the pore as a dry dot. Typically, the live fingerprint looks "patchy" due to this process compared to spoof and cadaver subjects. From the intensity distribution perspective, the live one has a distinct contrast between white ( $> 250$ , ASCII gray level range 0:255) and dark ( $< 20$ ) grey level. Spoof and cadaver images look much greyer ( $< 150$ ) and have very small contrast difference. This forms the basis of our *static* features. Second, the perspiration diffuses along the ridges in time, making the dry (white) regions between the pores moister and darker in the live image. Therefore the live finger images have a larger difference in the histogram distribution between zero and fifth second compared to the spoof and cadaver subjects, which forms the basis of our *dynamic* features.

Based on static (one image) and dynamic features (two images at zero and fifth second), we generate the decision rules to perform liveness classification. The basic steps are listed as follows:

- Pre-process to remove the noise and normalize;
- Adaptively select an interesting square area in the middle part of the image while avoiding large scars;
- Perform histogram distribution analysis for both zero and fifth second images;
- Extract the static and dynamic features for efficient classification;
- Generate classification tree for each device type using the training data set;
- Test the classification tree using the test data set.

Classification trees derive a sequence of if-then-else rules using the training set in order to assign a class label to the input data. In our samples, while there are general trends, there are some live fingers which may be very wet and change very little, and some cadaver ones which may be very dry and change over time. The classification tree can work efficiently taking into consideration these situations. An Excel tool developed by Dr. A. Saha was applied to generate the classification tree automatically [5].

### 3. Results

The dataset for training and testing contained approximately 30 live fingerprints, 40 spoof (Play-Doh) and 14 cadaver fingerprints captured by three different scanners: optical (Secugen), capacitive DC (Precise Biometrics) and electro-optical (Ethentica). Three-fifths of the total dataset were used for training and the other two-fifths were used for testing. Different static and dynamic features were extracted for each scanner since intensity distributions varied across technologies. Here we take optical scanner (Secugen) as an example.

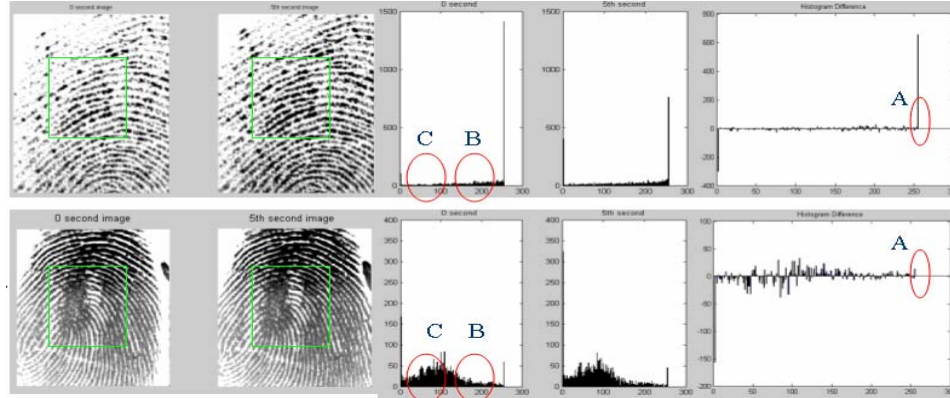


Fig. 1. The 0 and 5<sup>th</sup> second image, their corresponding histogram distributions and difference for optical scanner

In Figure 1, the upper is a typical live subject, the lower is a typical spoof subject and the green square area is the selected analysis window. Two static parameters from the zero second image and one dynamic parameter from the difference are calculated as follows:

$$Gray\_percentage = \frac{sum(B)}{sum(C)}; H1\_sum\_behind = sum(B); Dif\_255 = sum(A); \tag{1}$$

where A=255, B=151:254, C=0:150. Figure 2 shows the generated classification tree. The classification rates of live/non-live are shown in Table 1 for each device, each with different decision trees.

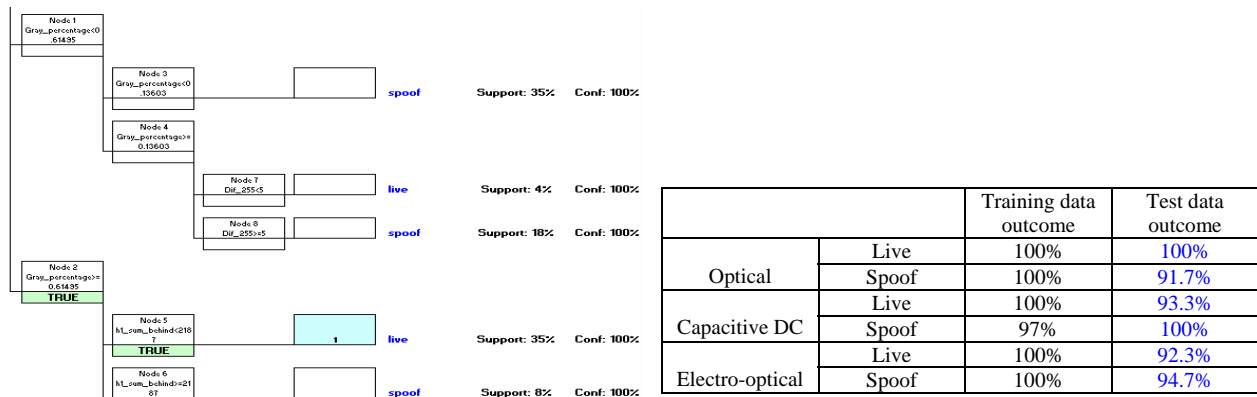


Fig. 2. Classification tree of Secugen      Table 1. Training and test outcomes for three different scanners

### 4. Conclusion

An intensity based approach to detect liveness in fingerprint scanners is presented. The outcome shows that this method can extract simple features which perform good classification using a classification tree. This method is economical, accurate, and saves time without the need for large computational resources. Future work is to test on a wider data set with different image quality.

### 5. References

1. S. A. C. Schuckers, "Spoofing and anti-spoofing measures," *Information Security Technical Report*, Vol. 7, No. 4, pages 56 – 62, 2002.
2. R. Derakhshani, S. A. C. Schuckers, L. Hornak, and L. O’Gorman, "Determination of vitality from a non-invasive biomedical measurement for use in fingerprint scanners." *Pattern Recognition Journal*, Vol. 36, No.2, 2003.
3. Schuckers SAC, Abhyankar A, A Wavelet Based Approach to Detecting liveness in Fingerprint Scanners, *Proceedings of Biometric Authentication Workshop, ECCV*, Prague, May, 2004
4. A. Saha, Classification Tree in Excel, Available at <http://www.geocities.com/adotsaha/CTree/CtreinExcel.html>