Improvement of an algorithm for recognition of liveness using perspiration in fingerprint devices

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Biometric devices are susceptible to attempts to gain unauthorized access through several means including artificial fingers created from fingerprints of authorized users called “spoofs” or in the worst-case scenario dismembered fingers. Previous work in our laboratory and others have demonstrated that spoof fingers made of a variety of materials including silicon, Play-Doh, clay, and gelatin (gummy finger) can be scanned and verified when compared to a live enrolled finger. In addition, our research has shown that cadaver fingers can be scanned and verified against enrolled cadaver fingers. Previously, we developed a new liveness method based on perspiration changes in the fingerprint image. The basis for our method is that live fingers, as opposed to cadaver or spoof, demonstrate a distinctive spatial moisture pattern which evolves in time due to the physiological perspiration process. The algorithm utilizes two images in time and performs a comparison generating six features, which quantify the changes in moisture over time, particularly around the perspiration pores. Prior work utilizing a variety of fingerprint sensor technologies demonstrated that approximately 90% classification is possible considering standard pattern recognition algorithms and a common set of features. However, for most applications, it is desirable that the live classification rate takes precedence over spoof classification even if that results in a weaker spoof classification rate. For this work we sought to improve the live classification rate using weight decay method for neural networks and ROC analysis to optimize output thresholds.

METHODS: In our research, different fingerprint scanner technologies including optical (SecuGen), capacitive DC (Precise Biometrics), and electro-optical (Ethentica) technologies were used. The dataset included fingerprint images from 33 live subjects, 33 spoofs created with dental material and Play-Doh, and fourteen cadaver fingers. In the results, both cadaver and spoof are included in the “spoof” dataset. The live dataset includes a broad age range (11 people between ages 20-30 years, 9 between 30-40, 7 between 40-50, and 6 greater than 50), diverse ethnicities (Asian-Indian, Caucasian, Middle Eastern), and approximately equal numbers of men and women. Spoof fingerprint casts were created from most live subjects. Spoof fingerprint images were collected using Play-Doh as the mold. Fourteen cadaver fingers collected (from 4 subjects, of male age 41, female ages 55, 65, and 66) in collaboration with the Musculoskeletal Research Center (MSRC) at the West Virginia University Health Science Center were also used for spoof testing. Two time windows were tested: two and five seconds.

A back propagation neural network (with weight decay and momentum 0.1) was used with a hidden layer of 5 nodes (derived from attributes + groups)/2), a 'logsig' transfer function for hidden layer, and 'tansig' for the output layer. Outputs were trained to +1 for live and –1 for spoof. In the weight decay method, a decay constant (0.0001) is subtracted from the hidden layer and output layer for each iteration during training, such that insignificant weights are reduced to zero. This method reduces model variance to make the network more generalizable. For this method, 75% of the data was used for training and 25% data was for testing. Various thresholds (steps 0.05) were tested on the output of the neural network to achieve 100% live classification rate along with the maximum possible spoof classification rate.

RESULTS: For the test set, the capacitive DC device demonstrates 100% classification for live fingers and 88.9% for spoof fingers, for 2 sec and 5 sec time window, for threshold values ranging from 0 to 0.1 and –0.05 to 0.2. The electro-optical device demonstrates 100% classification for live fingers and spoof fingers, for 2 sec and 5 sec time window, for threshold values ranging from -0.15 to 0.85 and -0.05 to 0.9. The optical device demonstrates 100% classification for live fingers and for spoof fingers, for 2 sec time window, for threshold values ranging from -0.55 to -0.45 and for 5 sec window it demonstrates 100% classification for live and 81.8% for spoof fingers for threshold values ranging from -0.7 to -0.4.

CONCLUSION: The research describes a unique method to determine liveness through measurement of perspiration process in the finger. Results are presented which improve upon past reports by increasing the live and spoof classification rate. 100% live classification was achieved with 81.8 to 100% spoof classification, depending on the device technology. This liveness method is totally software based and no additional hardware is required. Spoofing vulnerability can be minimized with addition of a liveness detection algorithm.