Liveliness Detection based on Color Variations in Fingerprint Images

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Fingerprint sensors are accepted in the world gradually. However, the threat of finger replicas is also reported. Liveliness detection of a finger is desired for unattended fingerprint identification systems. Here, we have studied the technique based on the area and color variations in a series of fingerprint images acquired during an input action.

First, a fingerprint sensor based on scattered-light detection was constructed with a quasi-white LED. Series of fingerprint images were captured and the area and color variations were extracted from these images. Analysis on the 158 input trials performed by 37 volunteers and one replica proved that the live fingers and the replica could be separated completely. Next, six kinds of replicas were created with various materials and the same experiment was repeated. The ratio of successful trials for liveliness detection decreased to 82.9 % on condition that all the replicas were rejected.

Second, we studied the design of the light source in order to improve the reliability for liveliness detection. Its emission spectra were adjusted so that the finger color varied significantly during an input action. It turned out that a light source having a red and a green LED was promising. The intensity ratio at each peak wavelength was G:R=0.65:1. We constructed a fingerprint sensor with this dual-LED source and acquired 150 input trial data with 42 volunteers' live fingers and 8 kinds of replicas. We were able to set up some indices for liveliness detection that separated the living fingers and the replicas completely. Such an index was effective by itself and combination of these indices would improve the reliability of liveliness detection further.

Third, the finger temperature might influence its color variation. We cooled our fingers in iced water and repeated input trials while its temperature recovered to the normal level. We applied our detection algorithm for each of the input trials. Even if the finger temperature varied between 15 to 34℃, the temperature did not affect the results of the liveliness detection.

Finally, a fingerprint sensor based on scattered-light detection previously needed a lid in order to decrease the ambient light intensity. However, it was not comfortable for us to insert a finger under such a lid. So we re-designed the sensor hardware to remove the lid and demonstrated normal fingerprint acquisition as well as the liveliness detection under 3,000 lx.