December 28, 2018

Measuring end-to-end latency of fingerprint authenticators

Jose Rodriguez

Firas Sammoura

Measuring end-to-end latency of fingerprint authenticators

ABSTRACT

The techniques of this disclosure enable accurate measurement of end-to-end latency of a fingerprint sensor, e.g., of a mobile device. A touch sensor in proximity to the fingerprint sensor is coupled to an oscilloscope. A photodiode in proximity to the screen of the device is coupled to another channel of the same oscilloscope. An accelerometer attached to the device to measure device vibrations, and is coupled to yet another channel of the same oscilloscope. The oscilloscope logs the signals generated by the touch sensor, the photodiode, and the accelerometer. An accept decision results in the brightening of the device screen and a corresponding increase in photodiode signal. A reject decision results in the haptics motor issuing a double-pulse vibration. End-to-end latency is measured accurately and free of human reaction-time error by measuring via the oscilloscope the time elapsed between the signals generated by the touch sensor and the photodiode, or the touch sensor and the accelerometer.

KEYWORDS

latency measurement; fingerprint sensor; oscilloscope; haptic sensor; touch sensor

BACKGROUND

Latency is the time interval between stimulation and response, or more generally, the time delay between the cause and the effect of some physical change in a system being observed.

Fingerprint sensor latency, e.g., of fingerprint sensors on mobile devices, has different phases and interpretations. The wake-up latency is the time elapsed between a finger touching the sensor surface and the fingerprint sensor waking up to authenticate the user. The fingerprint image-capturing latency is the time elapsed between the sensor detecting the fingerprint touch (wake-up) and the capturing of the raw images. The identification latency is the period during which the raw captured data is post-processed and matched against a set of enrolled templates before issuing an accept/reject matching decision. The end-to-end latency is the total time elapsed between a finger touching a fingerprint sensor and the unlocking of the screen of the mobile device (or rejection of the fingerprint).

End-to-end latency is traditionally measured with a high-speed camera. The number of frames between finger touch and the accept/reject decision is counted and translated to time in seconds. Such measurement introduces an error due to human reaction time. Humans cannot exactly detect the moment of finger touch or the moment of the display turning on. Hence the opening and closing of the camera shutter are invariably slightly off-sync with the events they are supposed to track.

DESCRIPTION

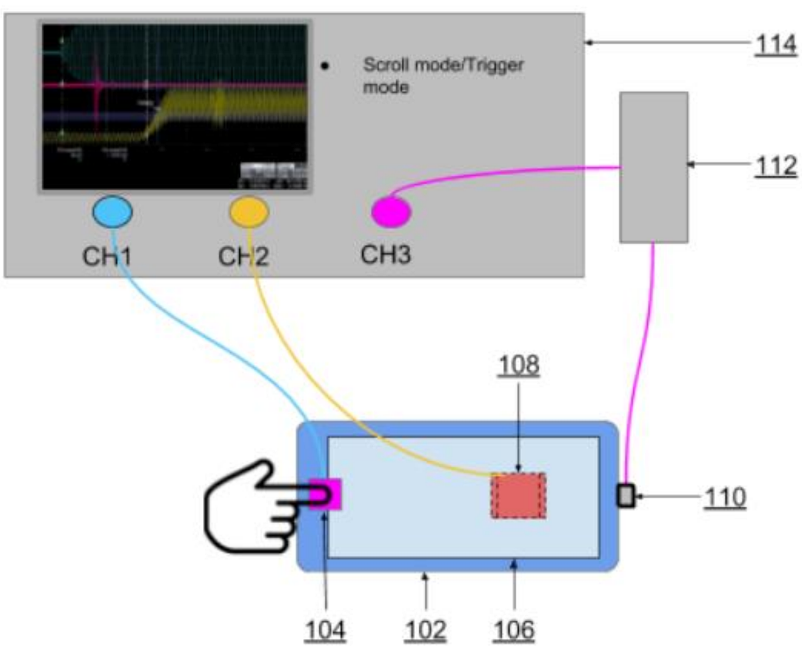

Fig. 1: Experimental setup for measuring end-to-end latency

Fig. 1 illustrates an example experimental setup for measuring end-to-end latency, per techniques of this disclosure. A device under test (102) is, e.g., a mobile device, with a fingerprint sensor (104) and a screen (106). Upon a user touching the fingerprint sensor, the device either accepts the user (indicated by the screen brightening up), or the device rejects the user (indicated by a vibration of the device).

Fingerprint touch detection

To detect fingerprint touch, a touch sensor is placed in close proximity to the fingerprint sensor. The touch sensor can be, for example, a thin-gauge wire wrapped around the fingerprint sensor, a thin-gauge wire extending across the one side of the fingerprint sensor, etc. The touch sensor is connected to a channel of oscilloscope (114) such that the output of this sensor is measured live. When the user touches the fingerprint sensor, the user touches the wire gauge as well, and as such, the touch is detected without delay or subjective assessment.

Screen unlock completion

When a fingerprint is accepted, the screen unlocks and its brightness modulates, e.g., increases. Therefore, to detect the timing of the acceptance of the fingerprint by the device, a sensitive photodiode (108) is placed on the screen of the device. The photodiode measures the brightness of the screen, and is connected to a second channel of the oscilloscope. Screen unlock start-time can be detected as the time when the display brightness starts to change, and unlock completeness is detected as the time when the photodiode signal level reaches a steady state.

Haptics response detection

After fingerprint authentication, the haptics motor issues a single pulse feedback to the user. After fingerprint rejection, the haptics motor issues a double pulse response. The device vibration, created by the haptics motor, is detected by an accelerometer (110) attached to the device under test. The accelerometer is placed in a position to optimize the level of the detected vibration, and is connected to a third channel of the oscilloscope. The output signal of the accelerometer travels through a signal conditioner (112), which enhances the signal prior to reception by the oscilloscope.

The signals generated by the touch sensor, the photodiode, and the accelerometer have the same time base, e.g., they are synchronized. Therefore, the end-to-end latency of the fingerprint sensor is measured by simply measuring on the oscilloscope the time elapsed between the rise of the touch-sensor signal and the rise of the photodiode signal. End-to-end latency can also be measured by measuring on the oscilloscope the time between the touch-sensor signal and the accelerometer signal. For greater precision, the photodiode rise and fall time, typically 60 nanoseconds, can be accounted for in the calculations.

In this manner, the techniques of this disclosure use embedded sensors to detect finger touch, haptic response, and display brightness levels to accurately measure end-to-end latency of a fingerprint authenticator.

CONCLUSION

The techniques of this disclosure enable accurate measurement of end-to-end latency of a fingerprint sensor, e.g., of a mobile device. A touch sensor in proximity to the fingerprint sensor is coupled to an oscilloscope. A photodiode in proximity to the screen of the device is coupled to another channel of the same oscilloscope. An accelerometer attached to the device to measure device vibrations, and is coupled to yet another channel of the same oscilloscope. The oscilloscope logs the signals generated by the touch sensor, the photodiode, and the accelerometer. An accept decision results in the brightening of the device screen and a corresponding increase in photodiode signal. A reject decision results in the haptics motor issuing a double-pulse vibration. End-to-end latency is measured accurately and free of human reaction-time error by measuring via the oscilloscope the time elapsed between the signals generated by the touch sensor and the photodiode, or the touch sensor and the accelerometer.

REFERENCES

[1] Casiez, Géry, Thomas Pietrzak, Damien Marchal, Sébastien Poulmane, Matthieu Falce, and Nicolas Roussel. "Characterizing latency in touch and button-equipped interactive systems." In *Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology*, pp. 29-39. ACM, 2017.

[2] Kaaresoja, Topi, and Stephen Brewster. "Feedback is... late: measuring multimodal delays in mobile device touchscreen interaction." In *International Conference on Multimodal Interfaces and the Workshop on Machine Learning for Multimodal Interaction*, p. 2. ACM, 2010.