Orientation Recognition Performance Evaluation of GT-511C3 Fingerprint Sensor

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Abstract. The purpose of this research is evaluating GT-511C3 fingerprint sensor recognition performance using different orientation. The GT-511C3 is an embedded fingerprint sensor which has an increased memory capacity up to 200 different fingerprints. The module is small and easy to mount using two mounting tabs on the side of the sensor and have False Acceptance Rate (FAR) < 0.001% and False Rejection Rate (FRR) < 0.1%. Based on the test results, the GT-511C3 sensor has high recognition performance for all orientation testing scenarios, using five fingerprints as test objects, all fingerprints are able to be recognized in all orientations (0°, 90°, 180° and 270°) quickly (515-750ms). These results can later be used as recommendations for the best implementation of sensor module GT-511C3.

1. Introduction

Fingerprint sensors can be implemented for various purposes such as resident identity cards, door lockers, attendant machine [1], smartphone locks, biometric identification and forensics [2]. The GT-511C3 is an embedded fingerprint sensor which has an increased memory capacity up to 200 different fingerprints. The module is small and easy to mount using two mounting tabs on the side of the sensor and have False Acceptance Rate (FAR) < 0.001% and False Rejection Rate (FRR) < 0.1%[3]. Physical details of GT-511C3 sensor can be seen in Figure 1.

Figure 1. GT-511C3 sensor module [4].
False Acceptance Rate (FAR) and False Rejection Rate (FRR) used to determine the similarity of fingerprint data into databases when matching [2][5–7], FAR and FRR are needed to determine the application of fingerprint biometric systems [8–11], in addition to ease of user required fingerprint scanning capabilities with a variety of orientations, some studies use locally adaptive methods [11][12] and high resolution optical sensor with adaptive mean filter [13][14] to accommodate this need. This paper attempts to test and show the performance of the GT-511C3 sensor in a various orientation.

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2. Method
2.1. Wiring module
The module used in this paper consists of 2 main modules, namely the GT-511C3 sensor module and FTDI USB to TTL converter, the sensor module uses USART 3.3V TTL serial communication [1][3]. Detailed sensor pinout can be seen in Figure 2.

![Figure 2. Pinout (left) and assembly version (right) [4].](image-url)

2.2. Testing Software and Orientation Scanning
The testing software is part of the SDK[4], developed using C ++ Language, the main function in the testing software used in this study is Enrol, Verify (1:1), Identify (1: N), and Delete All. Interface of testing software can be seen in Figure 3.
The scanning orientation to be tested is 0°, 90°, 180° and 270°, this angle is chosen because it represents the extreme angle when the user is scanning the fingerprint so that the test results are expected to be able to show the best and worst performance. Detailed orientation of scanning can be seen in Figure 4.

**Figure 3.** GUI of testing software

**Figure 4.** Orientation testing scenario
3. Results and Discussion
In this research, testing is carried out through 3 stages as well as describe below:

1. Enrolling 5 fingerprints (ID0-ID4) with zero angles,
2. Verify (1: 1) and
3. Identify (1: N),

The fingerprint reading test scenario uses 5 fingerprints and each fingerprint gets 4 reading orientation/angles (0°, 90°, 180° and 270°). Based on testing, the results obtained are:

1. Thumb (ID0): in this test, the sensor is able to detect all reading orientations with the fastest reading time of 516ms at orientation 0°.
2. Index finger (ID1): in this test, the sensor is able to detect all reading orientations with the fastest reading time of 531ms at orientation 180°.
3. Middle finger (ID2): in this test, the sensor is able to detect all reading orientations with the fastest reading time of 516ms at orientation 270°.
4. Ring finger (ID3): in this test, the sensor is able to detect all reading orientations with the fastest reading time of 515ms at orientation 270°.
5. Little finger (ID4): in this test, the sensor is able to detect all reading orientations with the fastest reading time of 593ms at orientation 180°.

Meanwhile, the other testing results are:

1. Thumb (ID0): in this test, the sensor is able to detect all reading orientations with the latest reading time of 719ms at orientation 180°.
2. Index finger (ID1): in this test, the sensor is able to detect all reading orientations with the latest reading time of 718ms at orientation 0°.
3. Middle finger (ID2): in this test, the sensor is able to detect all reading orientations with the latest reading time of 703ms at orientation 90°.
4. Ring finger (ID3): in this test, the sensor is able to detect all reading orientations with the latest reading time of 735ms at orientation 0°.
5. Little finger (ID4): in this test, the sensor is able to detect all reading orientations with the latest reading time of 750ms at orientation 750°.

As a result, the fastest time obtained at Ring finger (ID3) which is 515ms, while the latest reading time obtained at Ring finger (ID4) which is 750ms. Average value of fastest and latest reading time tend to be synchronous in the amount of ~500 ms and ~700ms. In this experiments, it can be concluded that reading orientation does not affect recognition performance. It only the reading time has changed. More details can be seen in Table 1.
Table 1. Orientation recognition performance

| Finger       | Orientation | Success/Failed | Time (ms) |
|--------------|-------------|----------------|-----------|
| Thumb (ID0)  | 0°          | Success        | 547       |
|              | 90°         | Success        | 516       |
|              | 270°        | Success        | 547       |
|              | 180°        | Success        | 719       |
|              | 0°          | Success        | 718       |
| Index finger (ID1) | 90°   | Success        | 703       |
|              | 270°        | Success        | 687       |
|              | 180°        | Success        | 531       |
|              | 0°          | Success        | 702       |
| Middle finger (ID2) | 90°   | Success        | 703       |
|              | 270°        | Success        | 516       |
|              | 180°        | Success        | 531       |
|              | 0°          | Success        | 735       |
| Ring finger (ID3) | 90°   | Success        | 547       |
|              | 270°        | Success        | 515       |
|              | 180°        | Success        | 718       |
|              | 0°          | Success        | 750       |
| Little finger (ID4) | 90°   | Success        | 734       |
|              | 270°        | Success        | 735       |
|              | 180°        | Success        | 593       |

4. Conclusions
Based on the test results, the GT-511C3 sensor has high recognition performance for all orientation testing scenarios, using five fingerprints as test objects, all fingerprints are able to be recognized in all orientations quickly, thus this sensor is suitable for use as biometric based authentication. Best time used for matching fingerprints is on the ring finger (ID3) which is 515ms.

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