Fingerprint Verification Testing Scenarios for Multi-impression Enrollment and Template Adaptation

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1. Introduction

Performance evaluation for biometric systems can be classified into three types: technology, scenario and operational evaluation [1]. The technology evaluation is normally performed under the offline testing scenario and suitable for the algorithm evaluation. On the other hand, the scenario and operational evaluation execute the test under the real testing environments with pre-determined online testing scenario and real operational situations (or minimum environment control), respectively. Fingerprint Verification Competitions (FVC) in 2000, 2002 and 2004 [2-4] are well-known examples of the technology evaluation for fingerprint verification and several online evaluations [5-7] have been conducted by many organizations worldwide.

The evaluation results of the online tests include not only the algorithm's performance but also the effects of the hardware characteristics and/or the environments of the system installation and operation. Therefore, the online evaluation is not appropriate for assessing the performance of algorithm only. Conventional fingerprint technology evaluations including FVC's have a simple evaluation scenario which uses one image for fingerprint enrollment and the other for matching. This simple testing scenario can only represent the performance of simple verification algorithms used in the early biometrics systems. However, it is not adequate to evaluate the true performance of the algorithms having state-of-the-art technology. In addition to the basic feature extraction and matching functionality, for example, current fingerprint verification algorithms have many sophisticated techniques including the use of multiple fingerprint samples for generating a high quality enrolled template and template adaptation capability by utilizing user fingerprint images acquired in matching.

This paper proposes new technology evaluation scenarios for performance evaluation of fingerprint verification algorithms. The proposed scenarios are able to deal with multiple samples for fingerprint enrollment and allow updating the enrolled template by using input fingerprint image. An Application Program Interface (API) specified in this paper must be kept by the algorithm under evaluation, and our evaluation scenarios utilize the API for generating templates and calculating matching scores. New performance indicators presented in this paper can evaluate the enrollment performance of algorithms.

2. API for Fingerprint Verification Algorithm under Evaluation

In order to carry out unbiased performance evaluation, the algorithm under evaluation shall be provided with a binary code only in the form of a single dynamic/shared library file (In our experiments, MS windows based DLL file is used.). Table 1 briefly explains the low-level API functions for feature extraction and matching. Their usage is found in Figure 1.

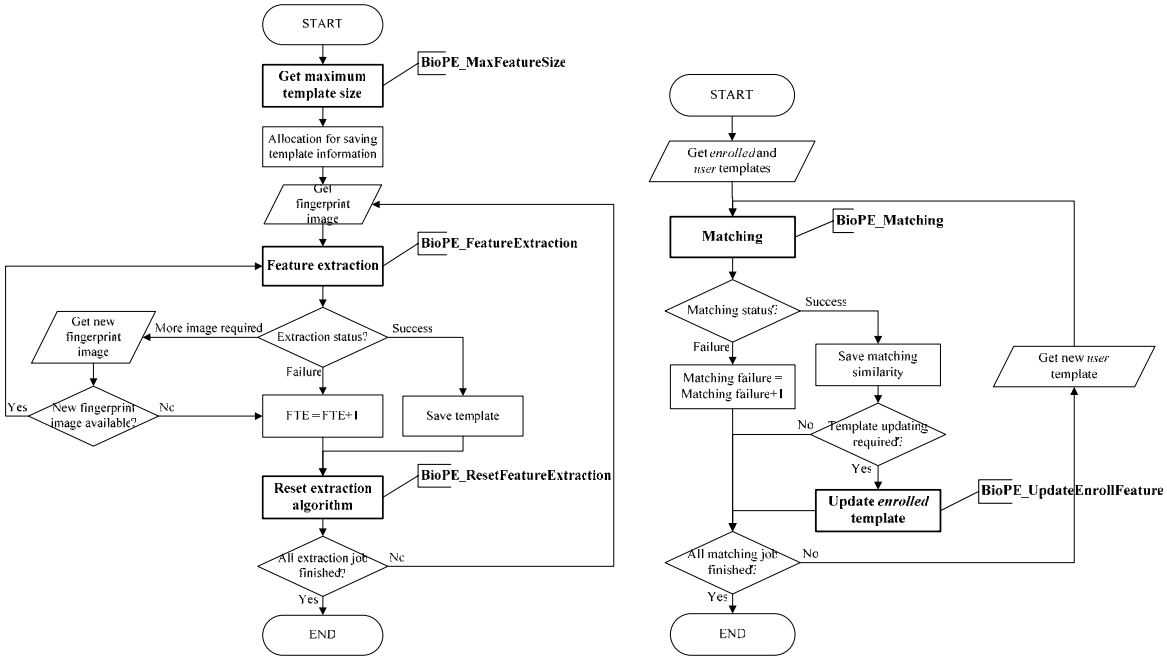
Table 1. API definition for fingerprint feature extraction and matching algorithm

Algorithm	Function name	Remarks
Feature extraction	BioPE_MaxFeatureSize	Get maximum size of the fingerprint template
	BioPE_FeatureExtraction	Extract (enrolled or user) fingerprint template
	BioPE_ResetFeatureExtraction	Initialize or reset algorithm functions
Matching	BioPE_Matching	Calculate similarity between enrolled template and user template
	BioPE_UpdateEnrollFeature	Update enrolled template using user template

3. Evaluation Scenario

By utilizing the API in the previous section, the algorithm is executed according to the function flow of the Figure 1. Figure 1(a) shows the flow of generating an enrolled template, where all three feature extraction API functions in Table 1 are employed. Matching and template adaptation is executed by the flow in Figure 1(b) with the API functions in Table 1. In the enrollment stage, a new fingerprint is supplied to the function *BioPE_FeatureExtraction* when the algorithm requires more fingerprints and more fingerprint images exist. If no more input image exists or the algorithm returns an error code, then FTE (Failure to Enroll) increases. The enrolled template is updated by the function *BioPE_UpdateEnrollFeature* when the matching function *BioPE_Matching* wants to update the enrolled

template. Four evaluation scenarios are proposed under the basic flow of evaluation as shown in Figure 1: *no template adaptation*, *template adaptation with random matching sequence*, *template adaptation with impostor matching first* and *template adaptation with genuine matching first*.



(a) Template enrollment with multiple samples (b) Matching and template adaptation

Fig 1. Evaluation scenario for template enrollment with multiple samples and matching with template adaptation capability

4. Performance Indicators and Experimental Results

A test database consists of 100 subjects with 6 fingers per subject and 39 images per finger. An algorithm under evaluation is provided by an independent developer for a commercial optical fingerprint sensor. The algorithm has capability of multi-impression enrollment and template adaptation during the matching process. In addition to traditional performance indicators as used in FVC's, new performance indicators include the number of images for enrollment, the number of template adaptation, and the error ratios under the four evaluation scenarios. The selected results of the evaluation are presented in Table 2.

Table 2. Selected results of the evaluation

Feature extraction	# of images for enrollment			Performance indicator	No update	Template adaptation		
	Minimum	Maximum	Average			Impostor first	Random matching	Genuine first
Success	3	13	3.56	EER	2.91%	2.22%	2.22%	2.22%
Failure	13	13	13	ZeroFMR	17.18%	11.37%	8.77%	6.38%

5. Conclusions

The paper proposes new technology evaluation scenarios and performance indicators for fingerprint verification algorithms where multiple samples are utilized for fingerprint enrollment and the updating of the enrolled template is allowed by using input fingerprint images. The experimental results demonstrate that the proposed scenarios and indicators are more adequate for performance evaluation of commercial fingerprint recognition algorithms.

6. References

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