Biometric Authentication Systems

Chapter 13:

MultiBiometrics

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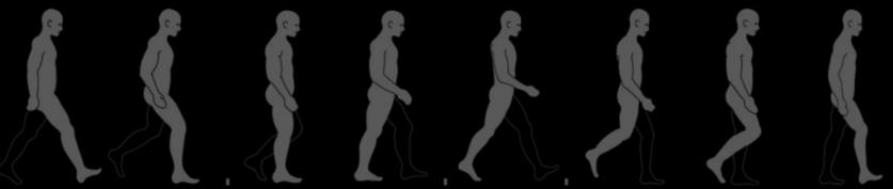


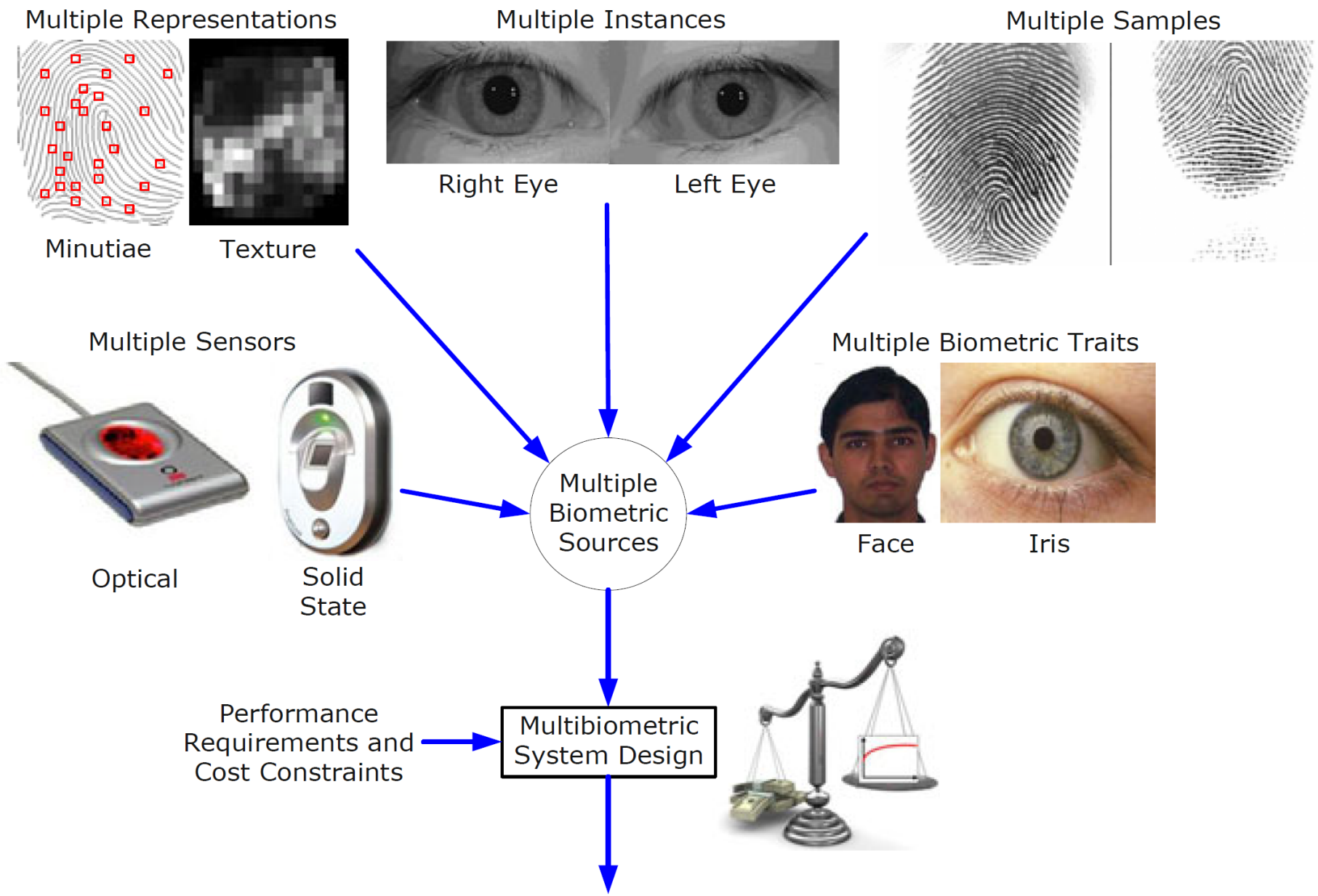
Outline

1. Introduction
2. Multibiometric system
3. Fusion
4. Processing sequence

1-Introduction

- Multimodal biometrics systems consolidate the evidence presented by multiple biometric sources and typically provide better recognition performance compared to systems based on a single biometric modality.

- Multi-biometrics systems provide **anti-spoofing** measures by making it difficult for an intruder to spoof multiple biometric traits simultaneously.


Multiple Representations
Minutiae
Texture
Multiple Instances
Right Eye
Left Eye
Multiple Samples
Multiple Sensors
Optical
Solid State
Multiple Biometric Sources
Multiple Biometric Traits
Face
Iris
Performance Requirements and Cost Constraints
Multibiometric System Design
1. Choice of biometric sources
2. Acquisition sequence
3. Fusion level
4. Fusion methodology

The advantage of Multimodal Biometric

- Multiple biometric sources enhance matching performance.
- Reducing failure to enroll rate.
- Difficult to spoof multiple traits simultaneously.

2-Multibiometric system

- Multi sensors
- Multiple representations of biometric features
- Multiple matchers
- Multiple instances
- Multiple samples
- Multiple traits

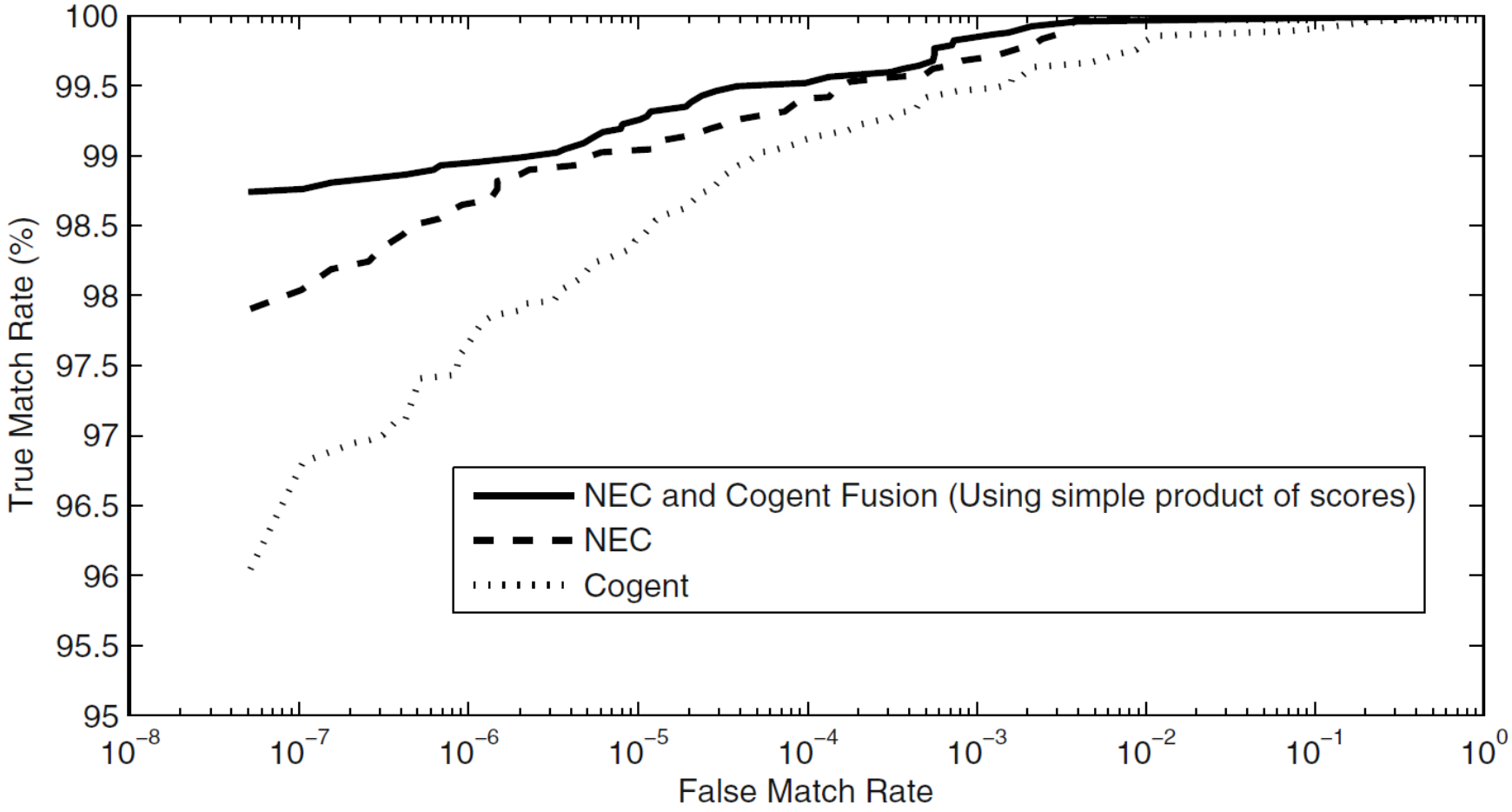
2.a Multi-algorithm systems

- The same biometric data is processed using multiple algorithms. For example, a texture-based algorithm and a minutiae-based algorithm can operate on the same fingerprint image in order to extract diverse feature sets

- No new sensors → cost-effective
- But may be time-consuming

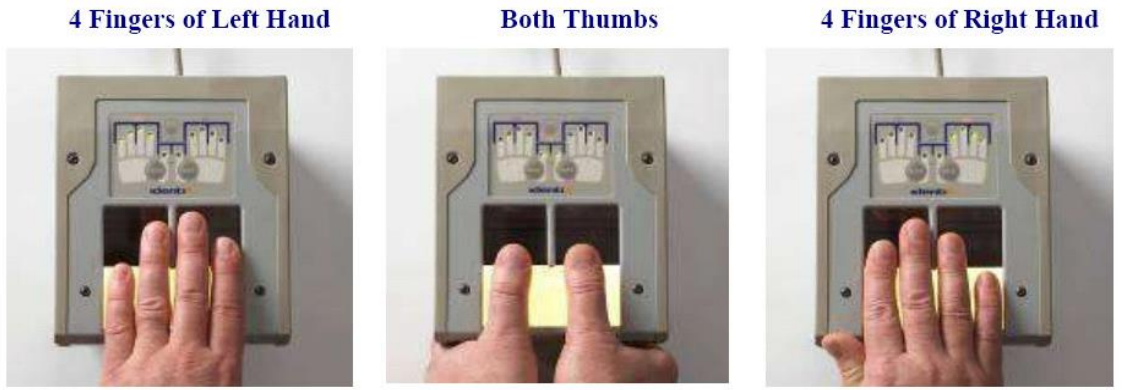
Multi-algorithm systems: example

- ROC curves



2.b Multi-instance systems

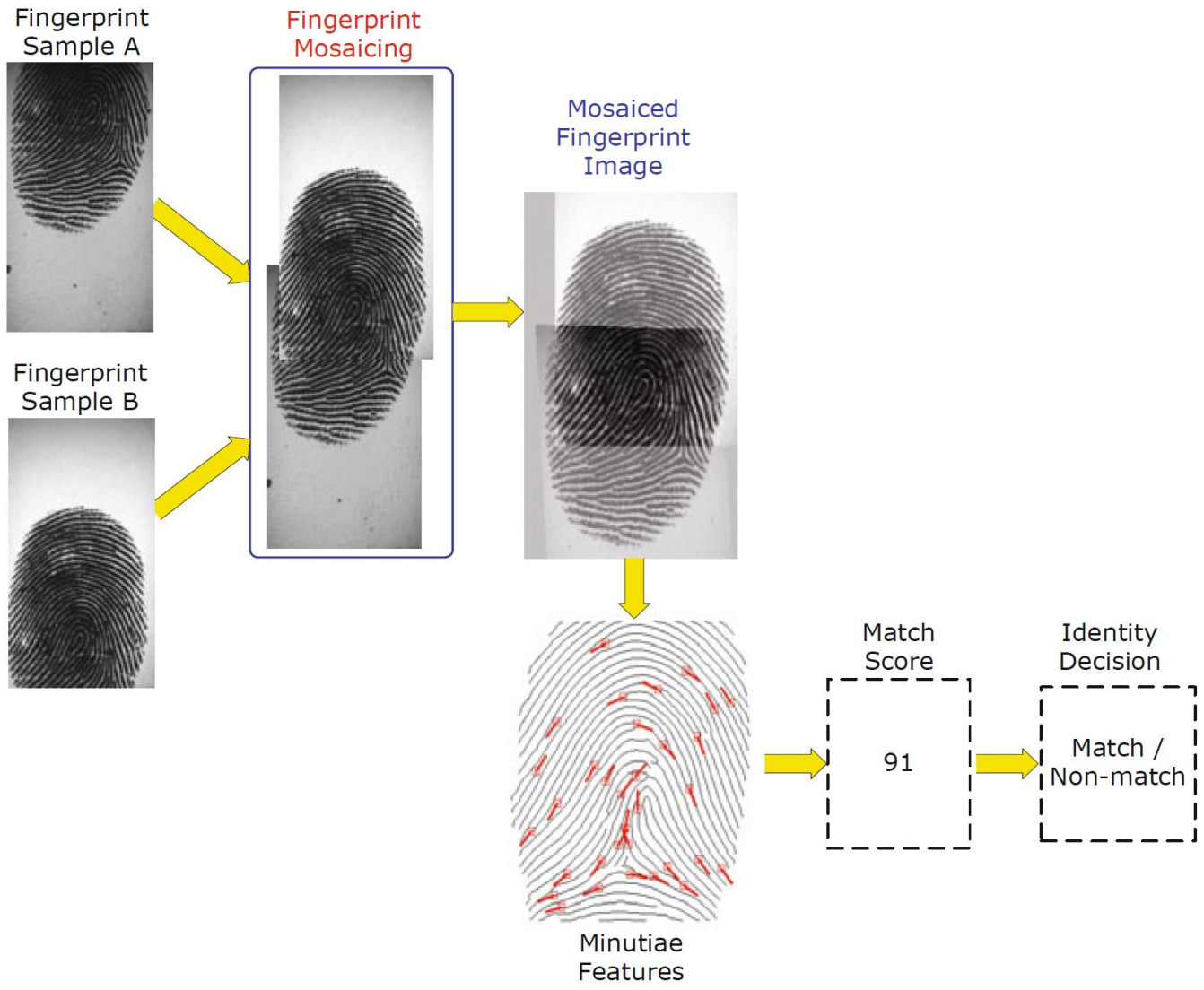
- Multiple instances of the same body trait



A fingerprint sensor developed by Identix that allows rapid acquisition of all ten fingers in three steps.

2.c Multi-sample systems

- Single sensor may be used to acquire multiple samples



2.d Multimodal systems

- Multimodal systems combine the evidence presented by **different body traits** for establishing identity
- The cost of deploying multimodal biometric systems is substantially high

a mobile phone that can acquire multiple modalities like fingerprint, face, and voice

Concept diagram of a whole-hand scanner that can simultaneously acquire palmprint, fingerprints from all five fingers of a hand, and hand-shape

3-Fusion in biometrics

(1) Fusion at the **feature extraction** level :

- 1. The data obtained from each sensor is used to compute a feature vector.
- 2. Concatenate the two vectors into a single new vector.
- 3. Feature reduction techniques may be employed.

Fusion in biometrics

(2) Fusion at the **matching score** level :

- Each system provides a matching score indicating the proximity of the feature vector with the template vector.
- These scores can be combined to assert the veracity of the claimed identity.

Fusion in biometrics

(3) Fusion at the **decision** level:

- Each sensor can capture multiple biometric data and the resulting feature vectors individually classified into the two classes — accept or reject.
- A **majority vote** scheme can be used to make the final decision.

Fusion in biometrics

- Fusion in the context of biometrics can take the following forms :
  - (1) Single biometric multiple representation.
  - (2) Single biometric multiple matchers.
  - (3) Multiple biometric fusion.

Fusion in biometrics

- (1) Single biometric multiple representation.
  - This type of fusion involves using multiple representations on a single biometric indicator.
  - Typically, each representation has its own classifier.

Fusion in biometrics

- (2) Single biometric multiple matchers.
    - It is also possible to incorporate multiple matching strategies in the matching module of a biometric system and combine the scores generated by these strategies.

Fusion in biometrics

- (3) Multiple biometric fusion.
  - By integrating matching scores obtained from multiple biometric sources.
  - These include majority voting, sum and product rules, k-NN classifiers, SVMs, decision trees, Bayesian methods, etc.

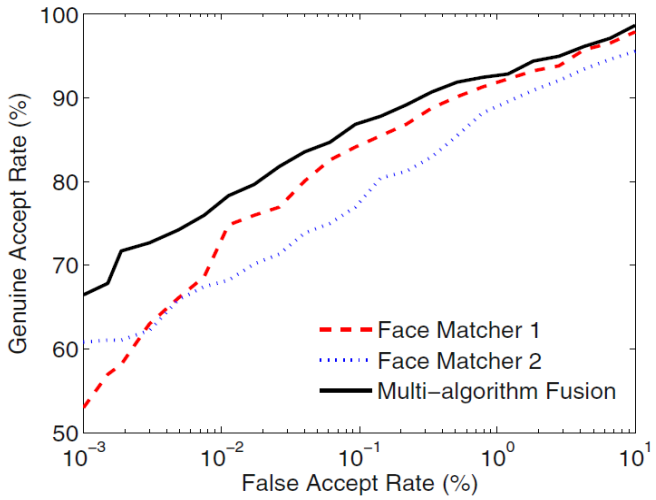
Fusion in biometrics

- (4) Others
  - 1. Store multiple templates in database.
  - Example : A fingerprint biometric system may store multiple templates of a users fingerprint (same finger) in its database. When a fingerprint impression is presented to the system for verification, it is compared against each of the templates, and the matching score generated by these multiple matchings are integrated.

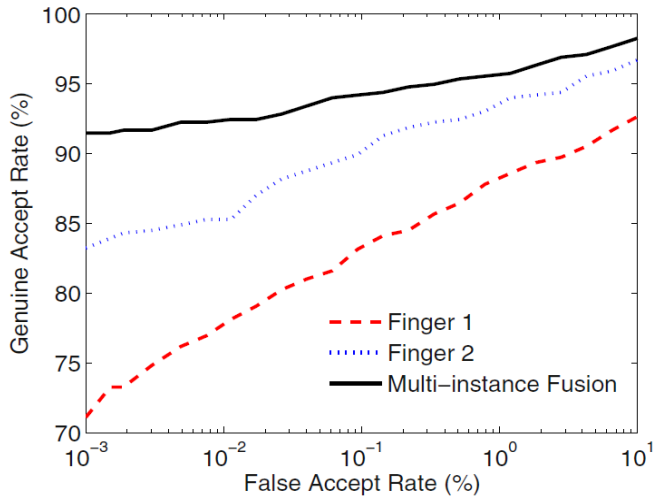
Fusion in biometrics

- (4) Others
  - 2. A system may store a single template of a users finger, but acquire multiple impressions of the finger during verification.
  - 3. Another possibility would be to acquire and use impressions of multiple fingers for every user.

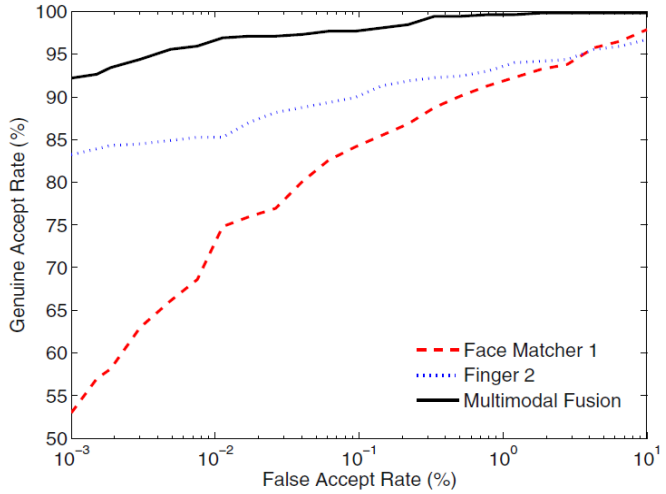
Multibiometric system examples



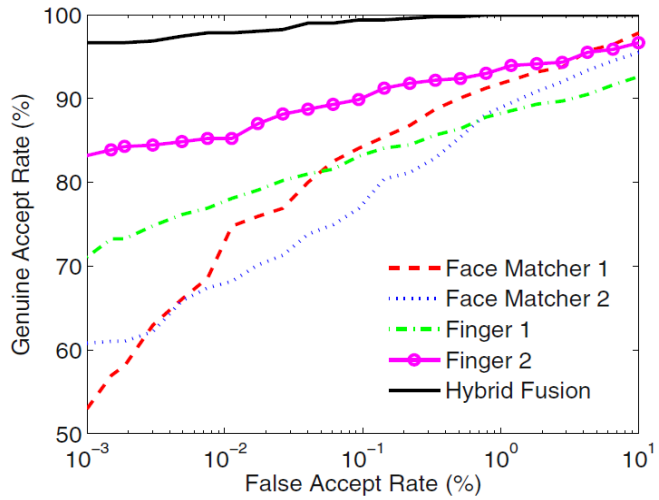
(a)



(b)



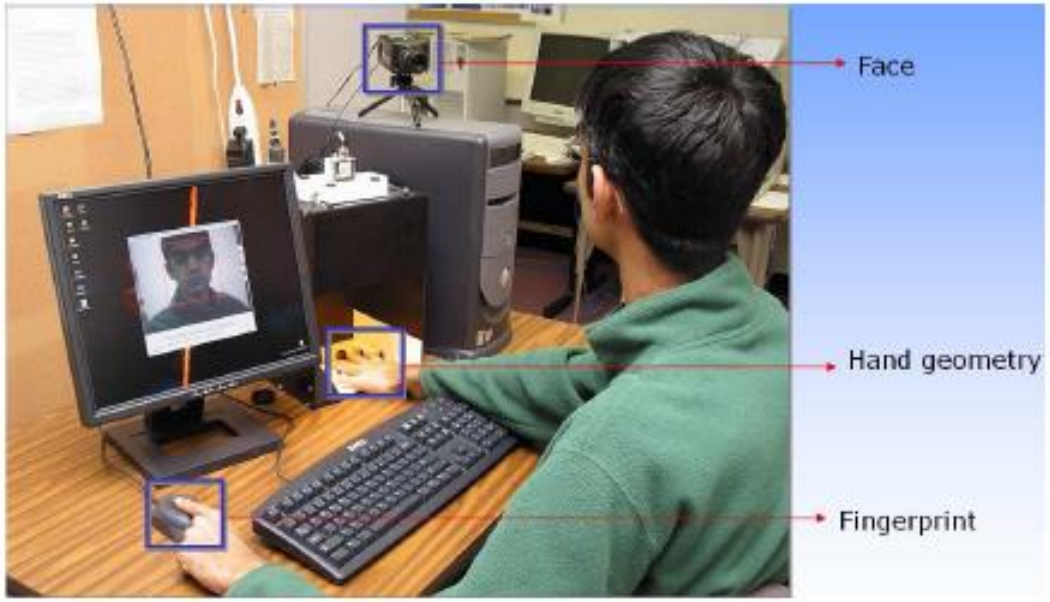
(c)



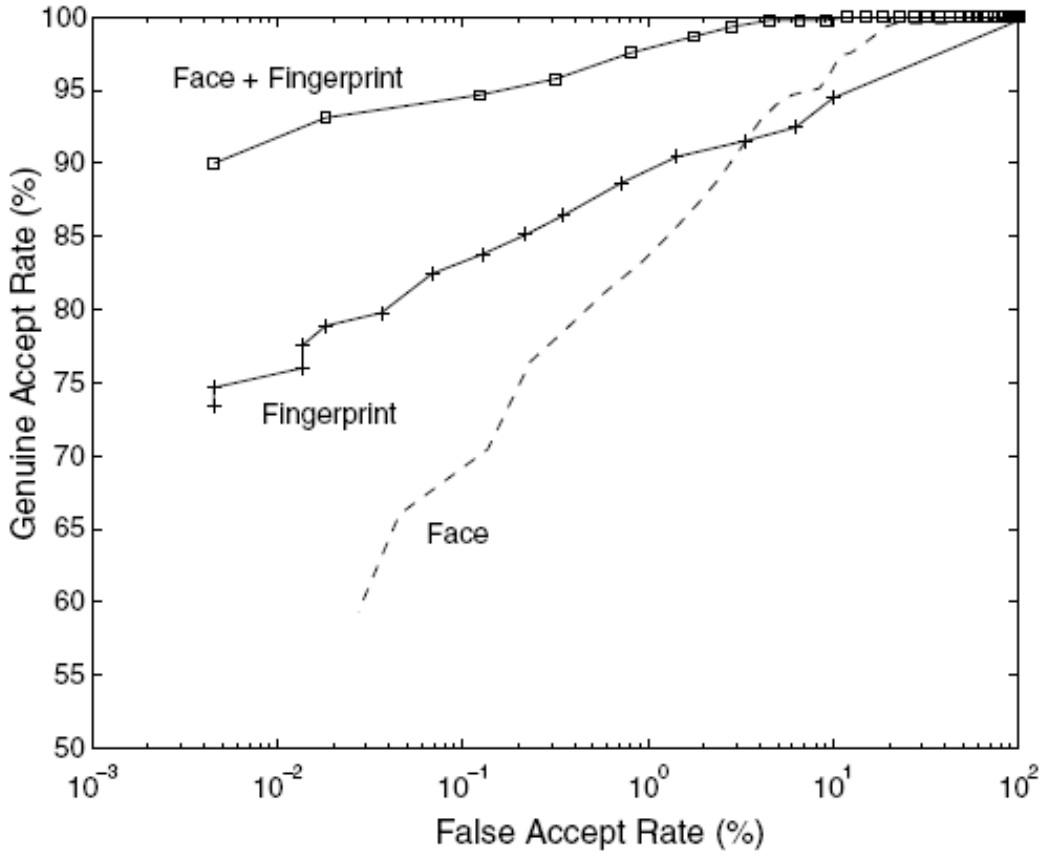
(d)

Experiment Results

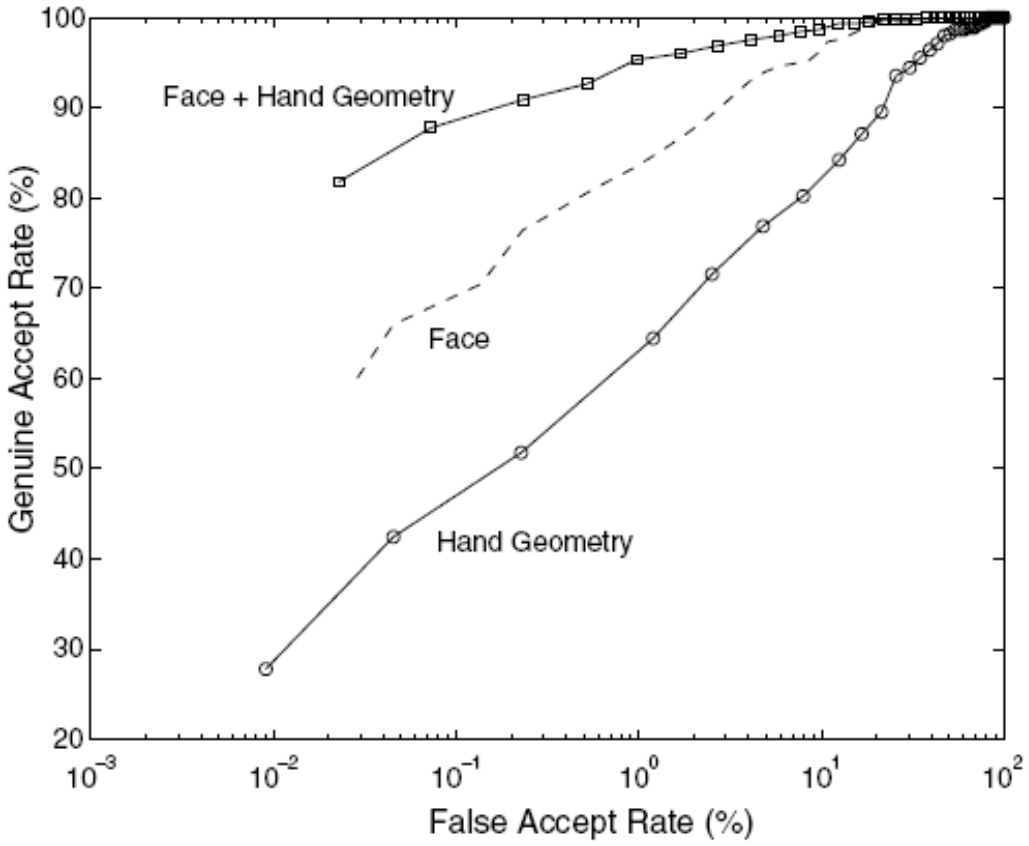
- 50 users
- Multimodal Biometrics : fingerprint , face , hand geometry
- Fusion: Sum rule



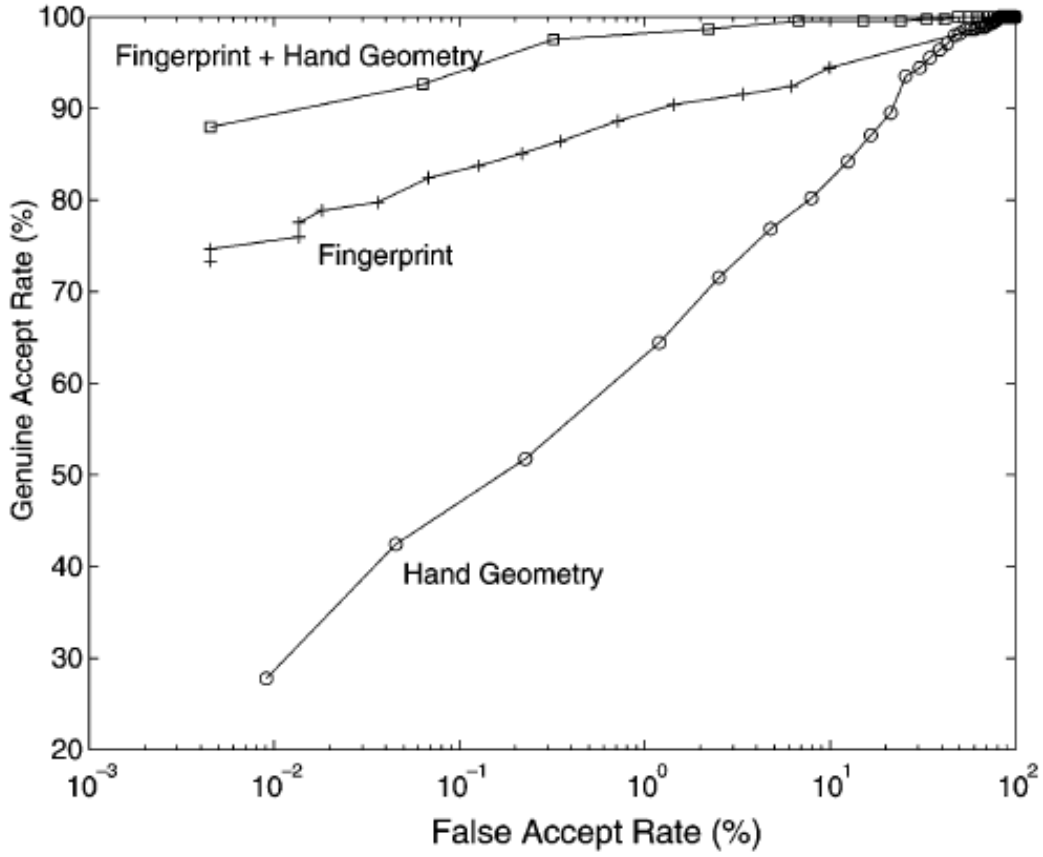
Experiment Results



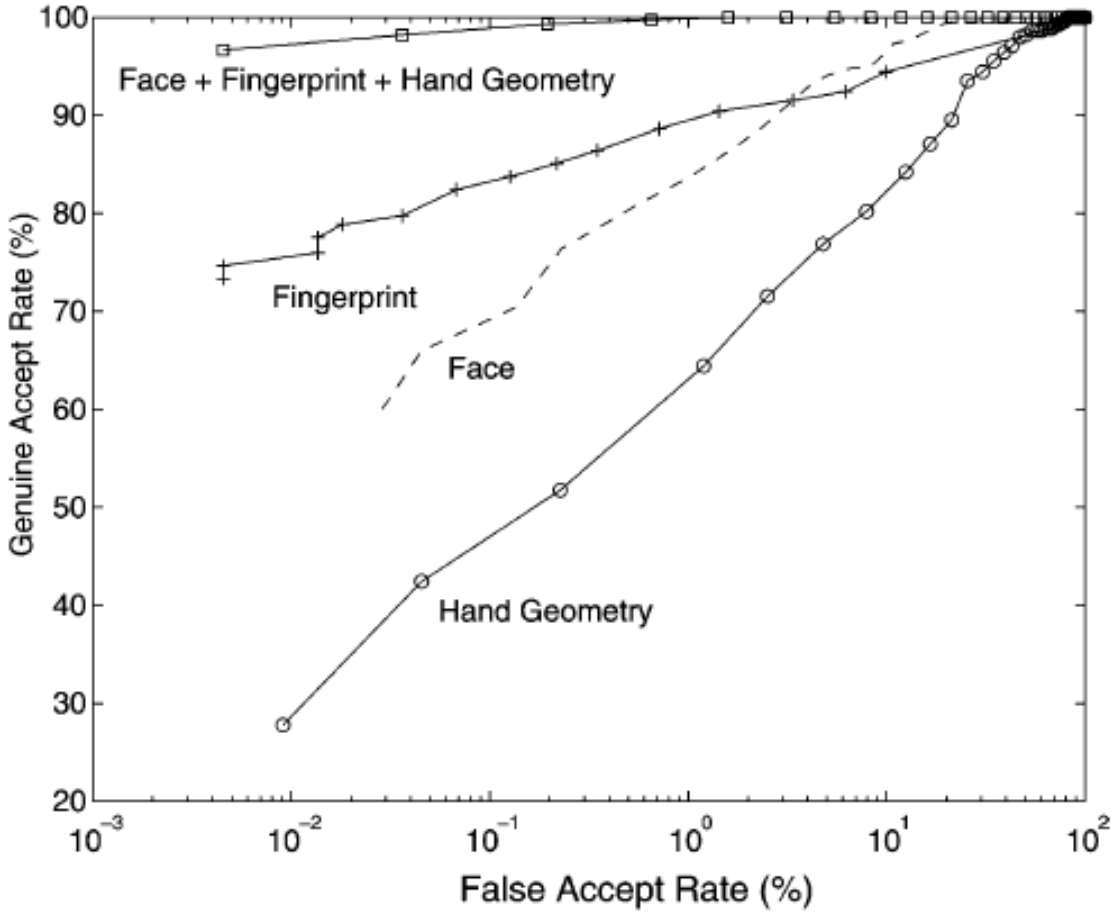
Experiment Results



Experiment Results



Experiment Results



Dependencies between the design choices in a multibiometric system

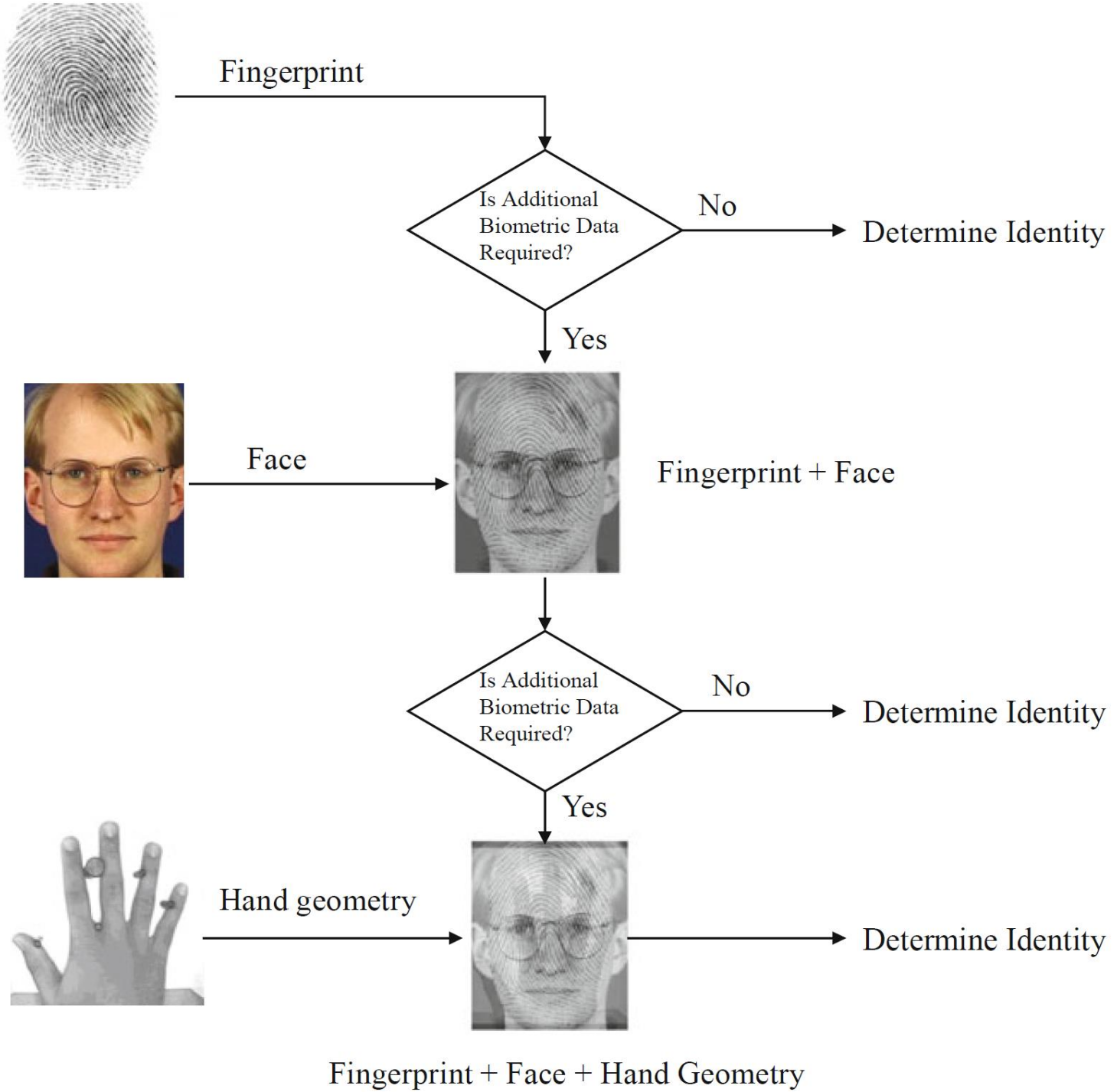
Multibiometric sources	Type of information fused				Acquisition architecture		Processing architecture	
	Raw data	Features	Scores	Decisions	Serial	Parallel	Serial	Parallel
Multiple sensors	✓	✓	✓	✓	✓	✓	✓	✓
Multiple representations	×	✓	✓	✓	×	✓	✓	✓
Multiple matchers	×	×	✓	✓	×	✓	✓	✓
Multiple instances	×	✓	✓	✓	✓	✓	✓	✓
Multiple samples	✓	✓	✓	✓	✓	×	✓	✓
Multiple traits	×	✓	✓	✓	✓	✓	✓	✓

4- Processing sequence

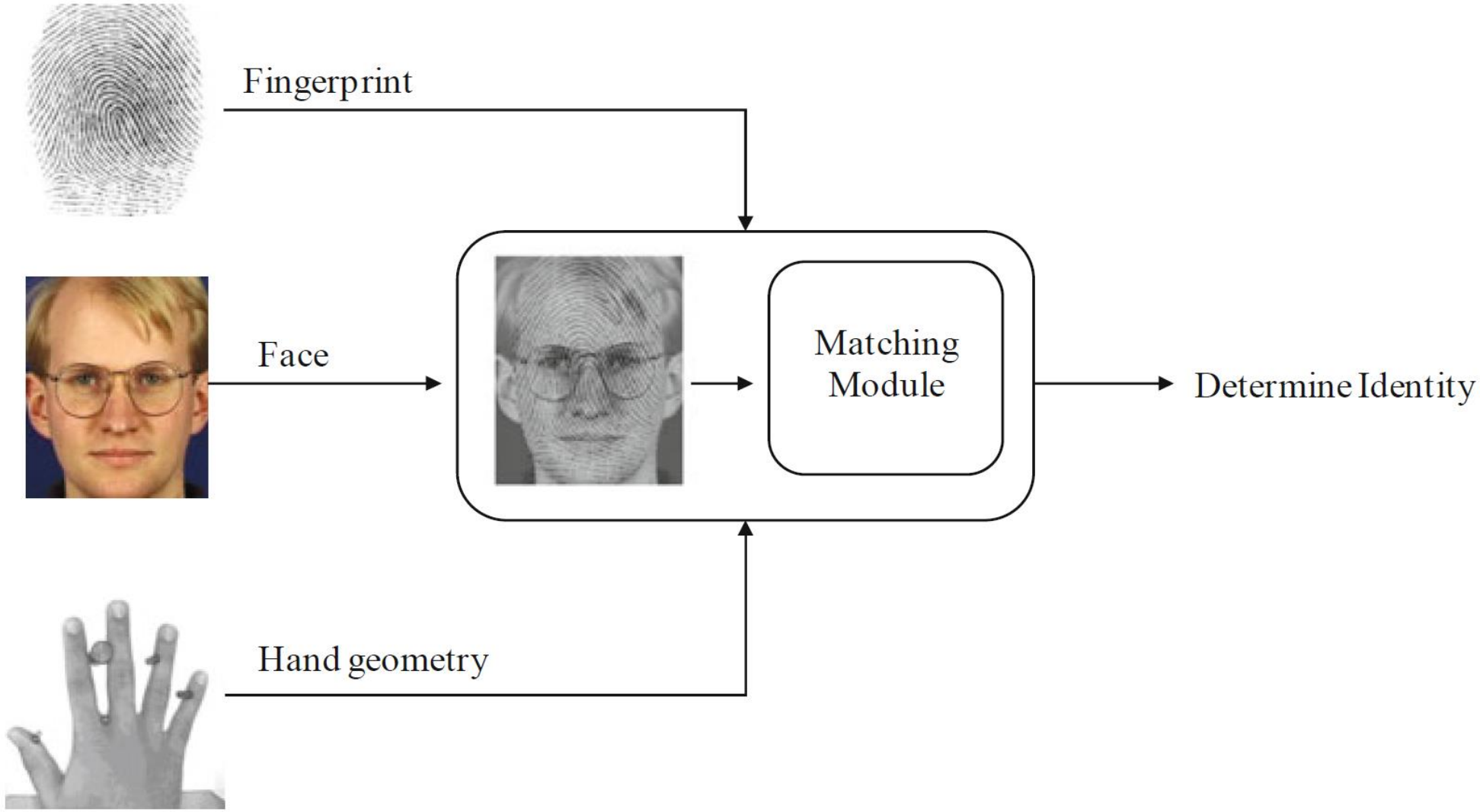
- Acquired sequentially but processed simultaneously
  - Cascade mode
  - Parallel mode

Cascade mode

- It enhances user convenience while reducing the average processing time since a decision can be made without having to acquire all the biometric traits.



Parallel mode



Thank you very much