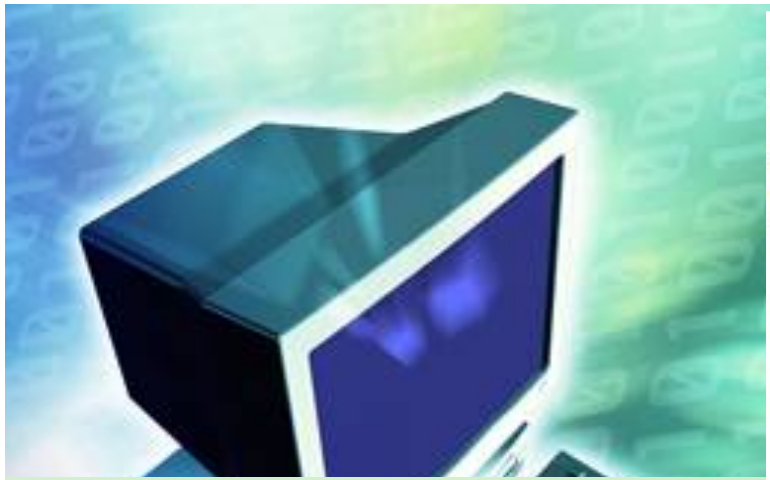

Co-authentication with quality-aware multimodal biometrics



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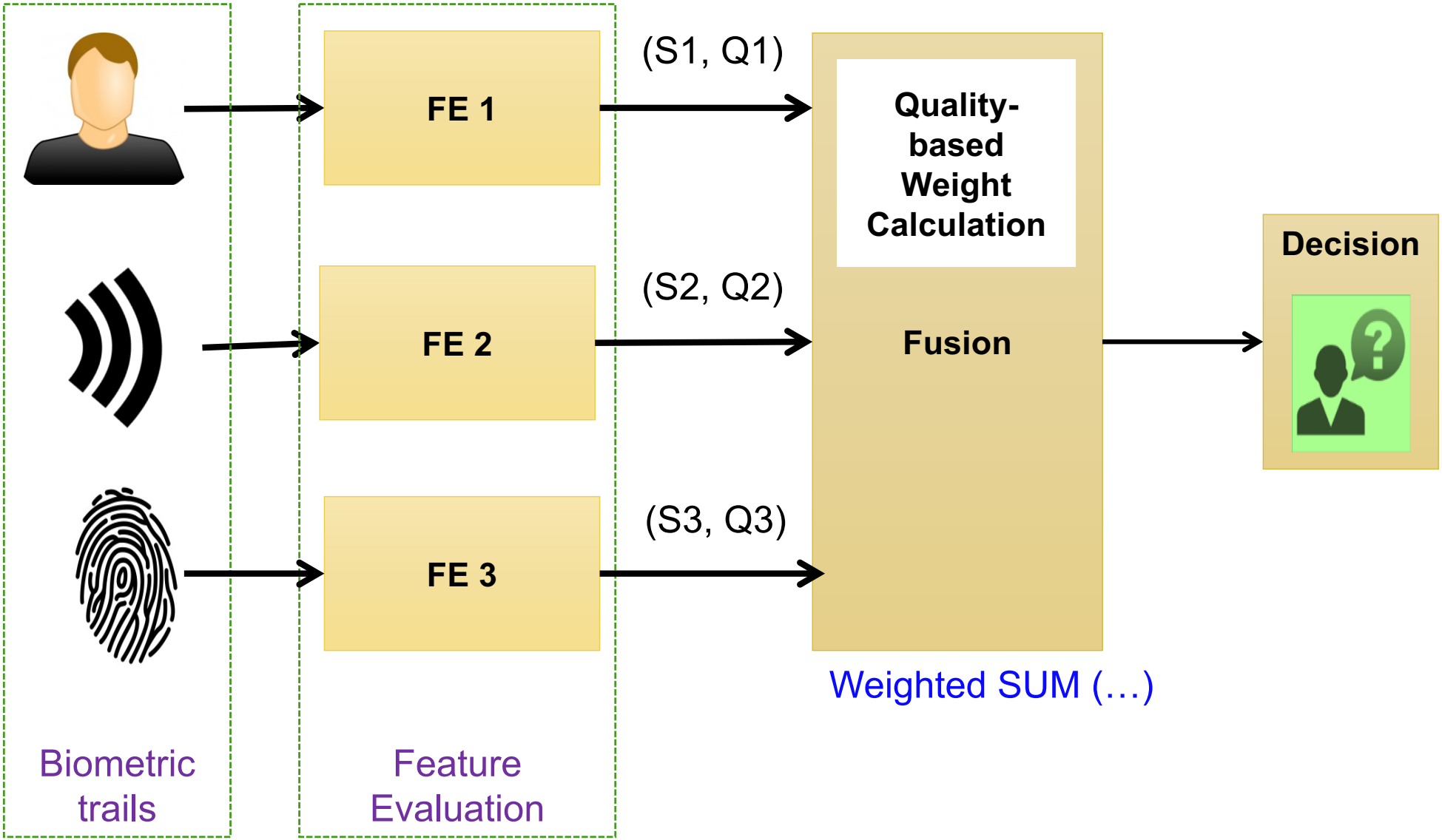
Data SecuriTy Applied Research Lab

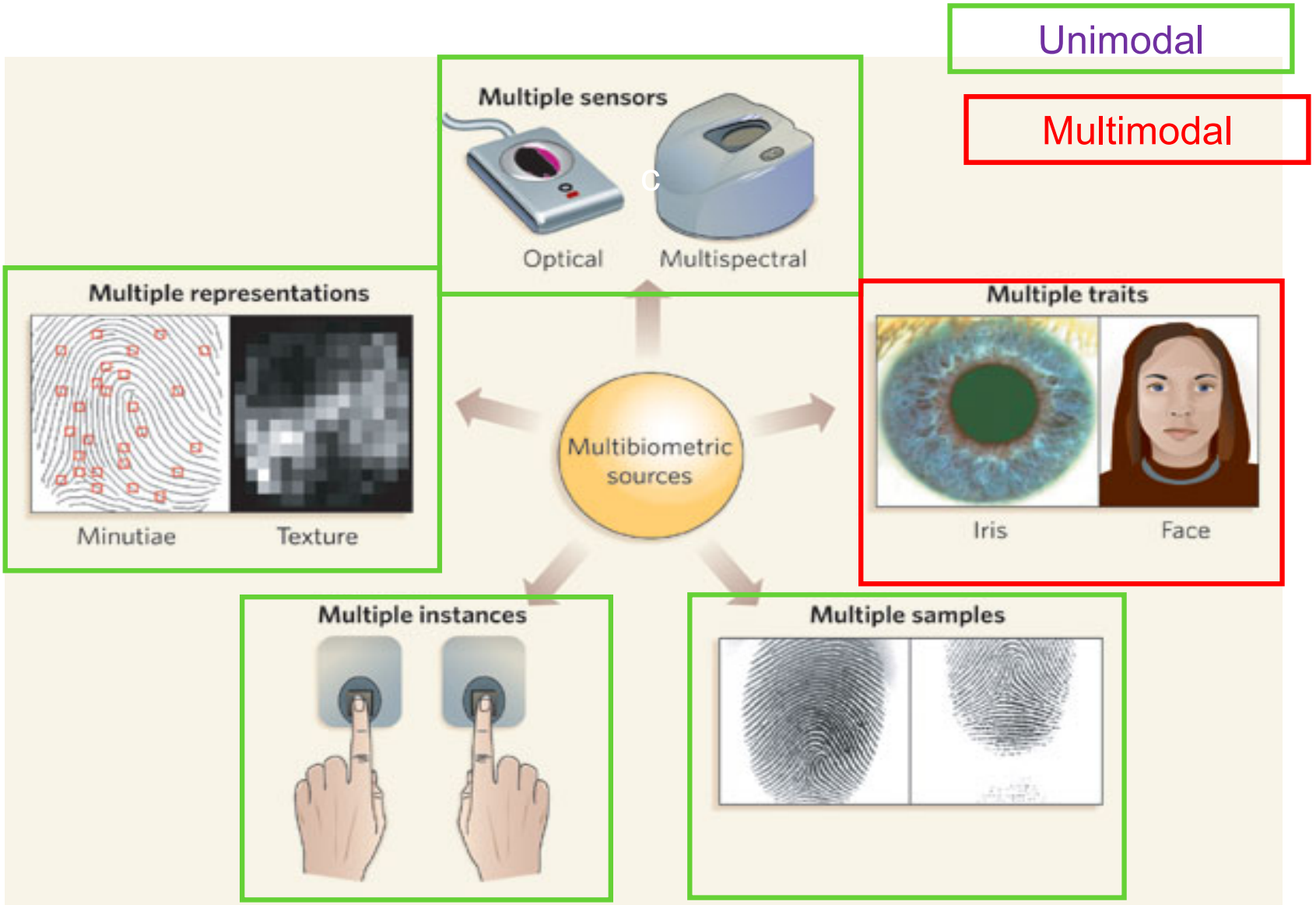
Outline

- Biometric co-authentication systems with quality concerns
- Review of score level fusion
- Towards a general (intrinsic & extrinsic) score-level fusion in co-authentication systems
  - Part 1: Face quality measure for face authentication
- Reading:
  - Quynh Chi Truong, Tran Khanh Dang, Trung Ha: *Face Quality Measure for Face Authentication*. FDSE 2016: 189-198
  - Chapter 6 [1]

Biometric co-authentication systems with quality concerns



Multibiometric sources



Advantages of multimodal systems

- Improve the matching accuracy of a biometric system
- Increase the feature space available to individuals
- Address the issue of non-universality or insufficient population coverage.
- Be difficult for an impostor to spoof multiple biometric traits of a legitimately enrolled individual
- Address the problem of noisy data
- Be viewed as a fault tolerant system

and disadvantages

- Cost benefits: the added cost and the improvement in matching performance
- Determining sources of biometric information
- Fusion methodology
  - Processing sequence
  - Type of information
- Users' acceptance

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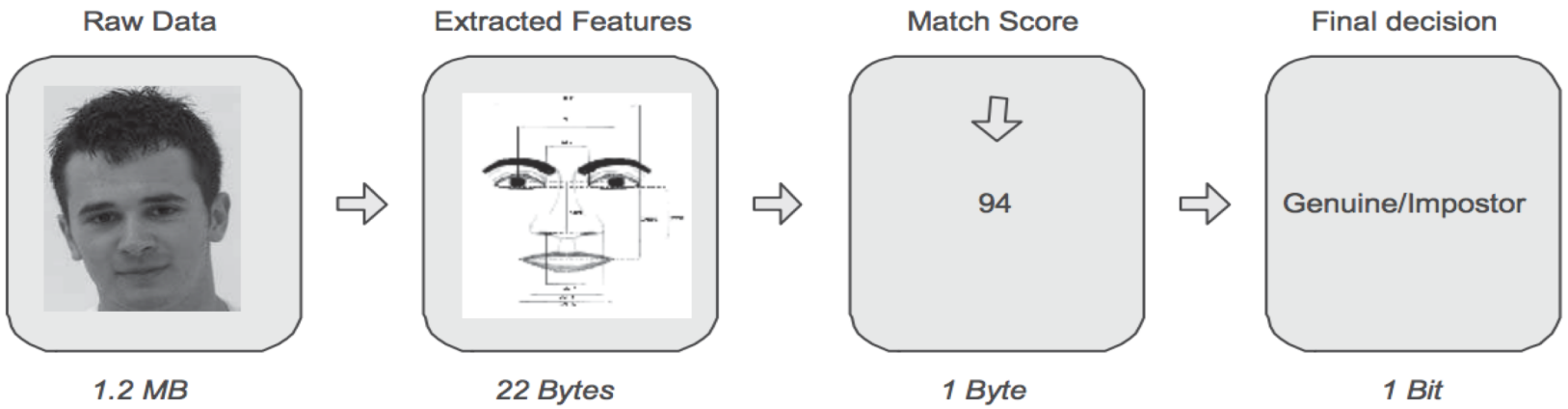
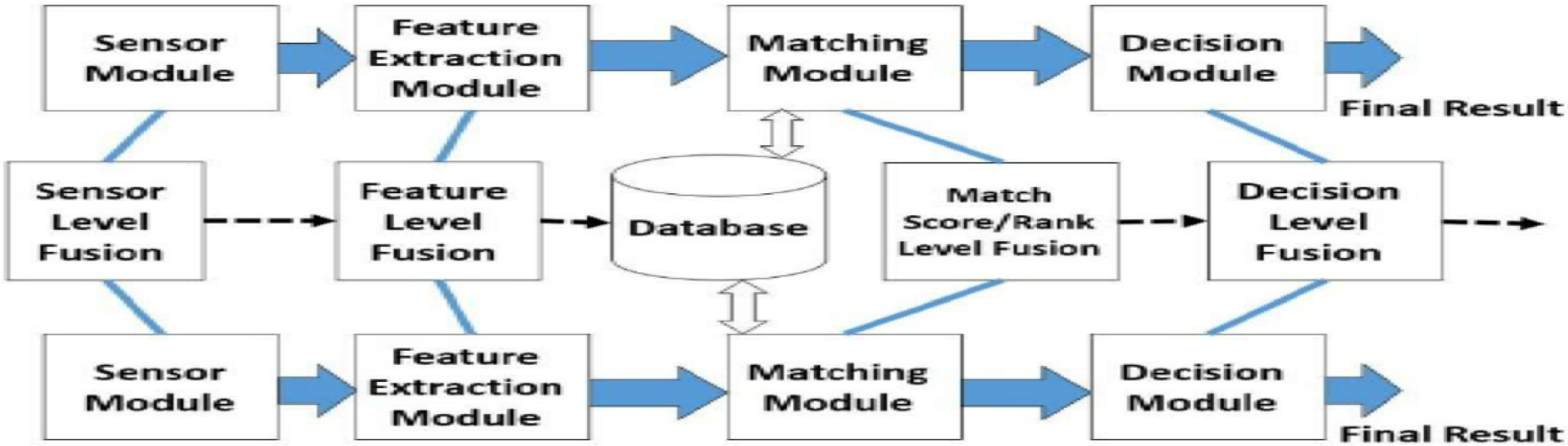
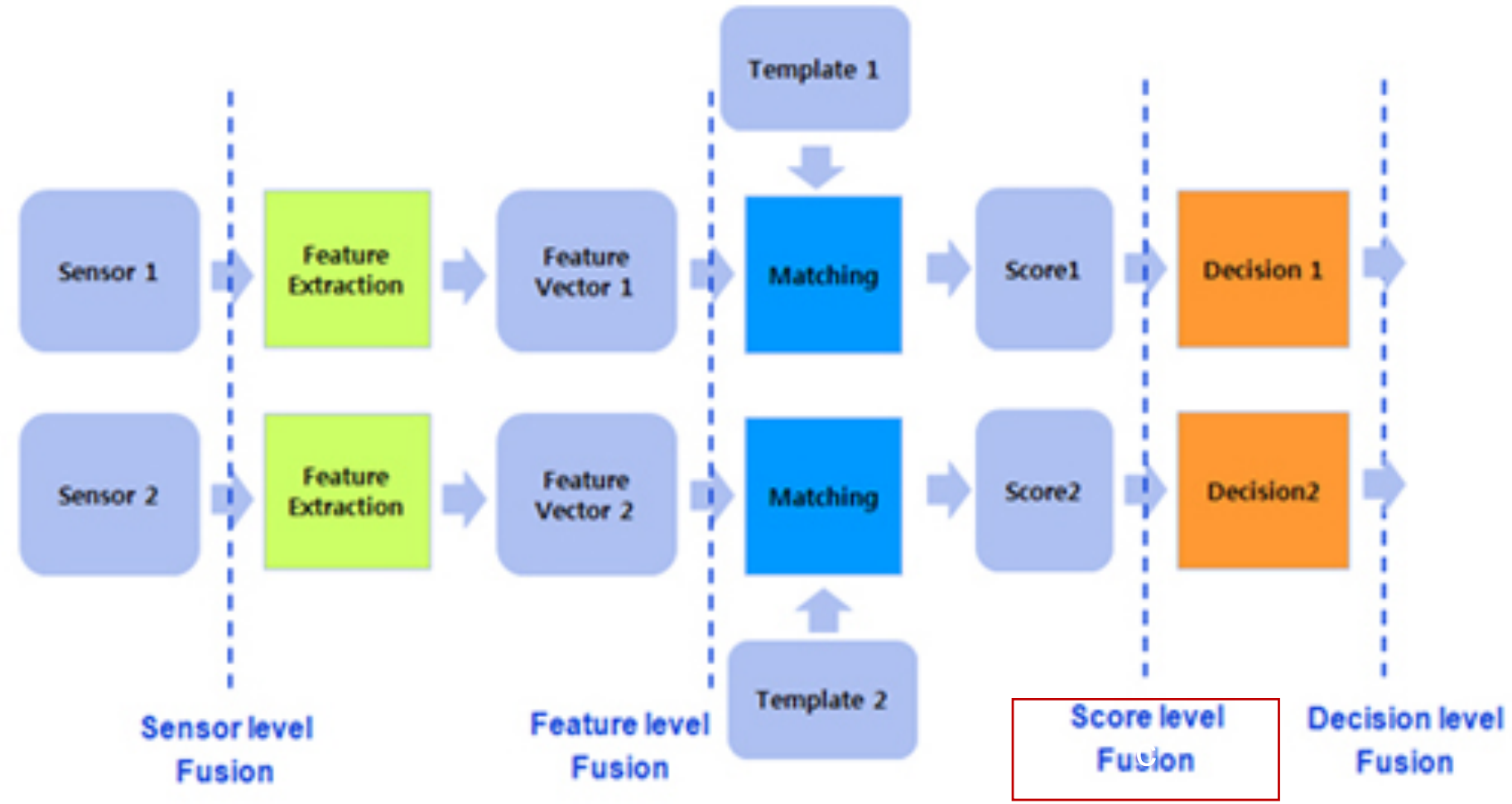
Review of score level fusion





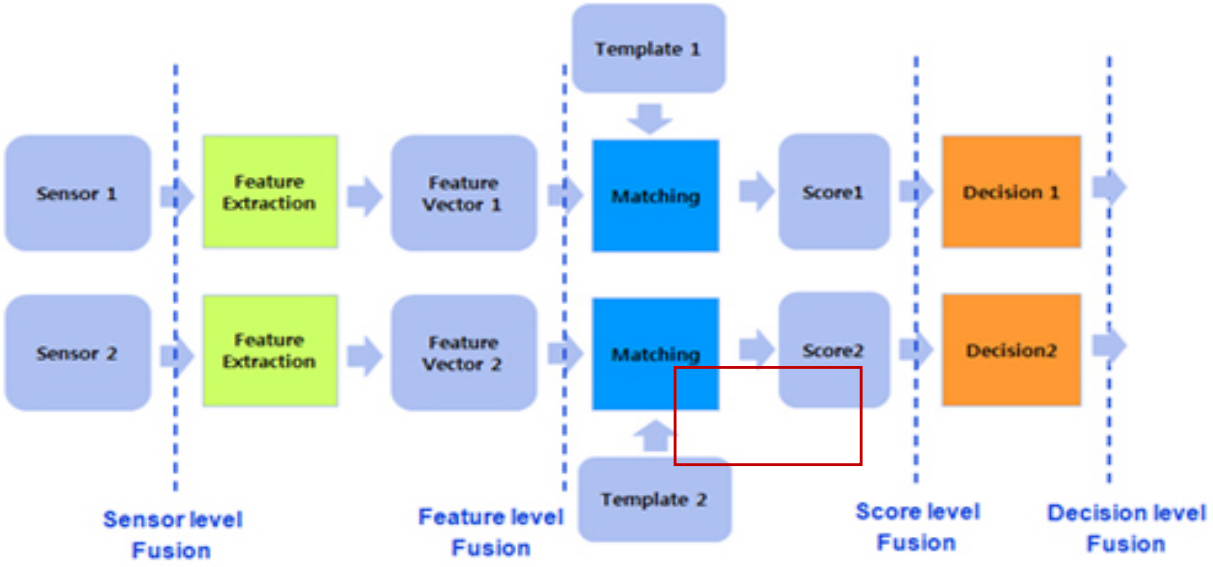
Developing efficient matching algorithms is often the most challenging aspect in the design of a biometric system and, thus, fusion at the sensor or feature levels introduces additional processing complexities

Review of score level fusion

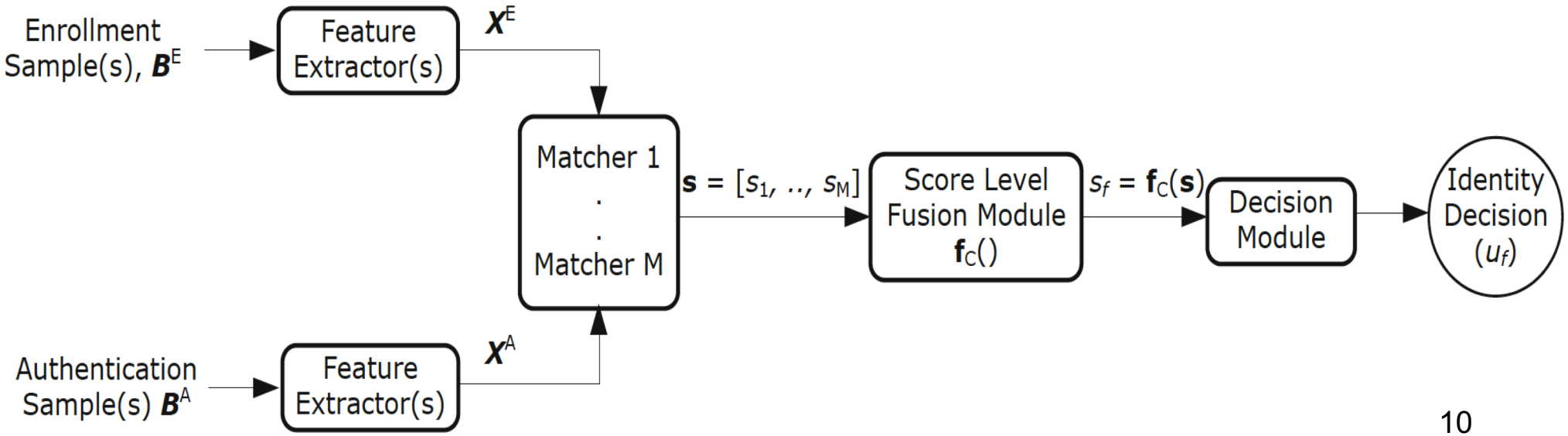


Score level Fusion: When each biometric system outputs a match score indicating the proximity of the input data to a template, integration can be done at the *match score level*

Review of score level fusion



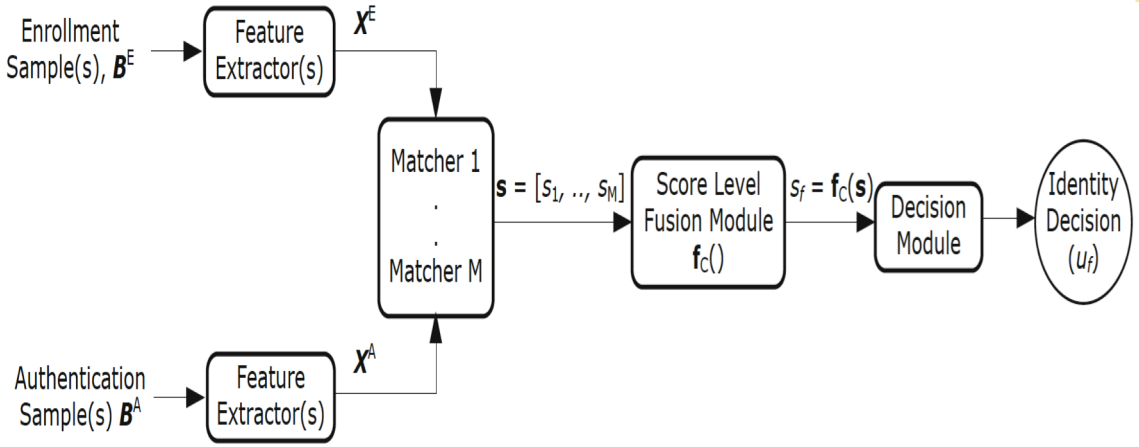
Score level fusion:
When each biometric system outputs a match score indicating the proximity of the input data to a template, integration can be done at the *match score level*

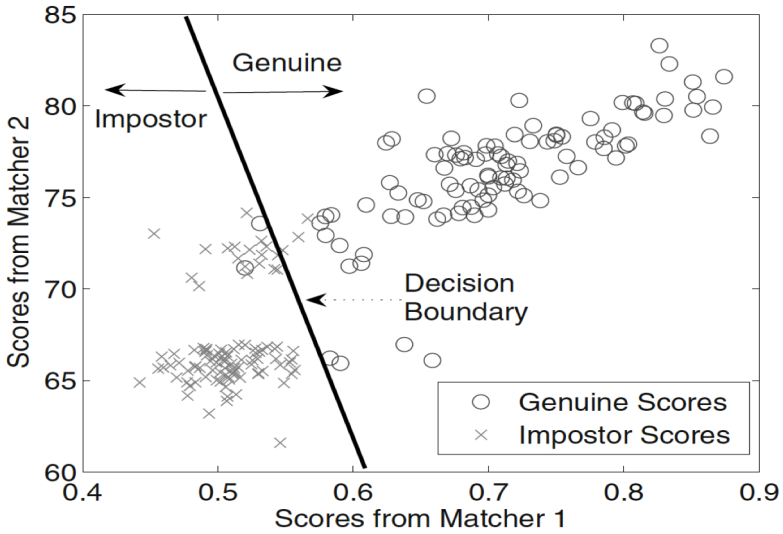


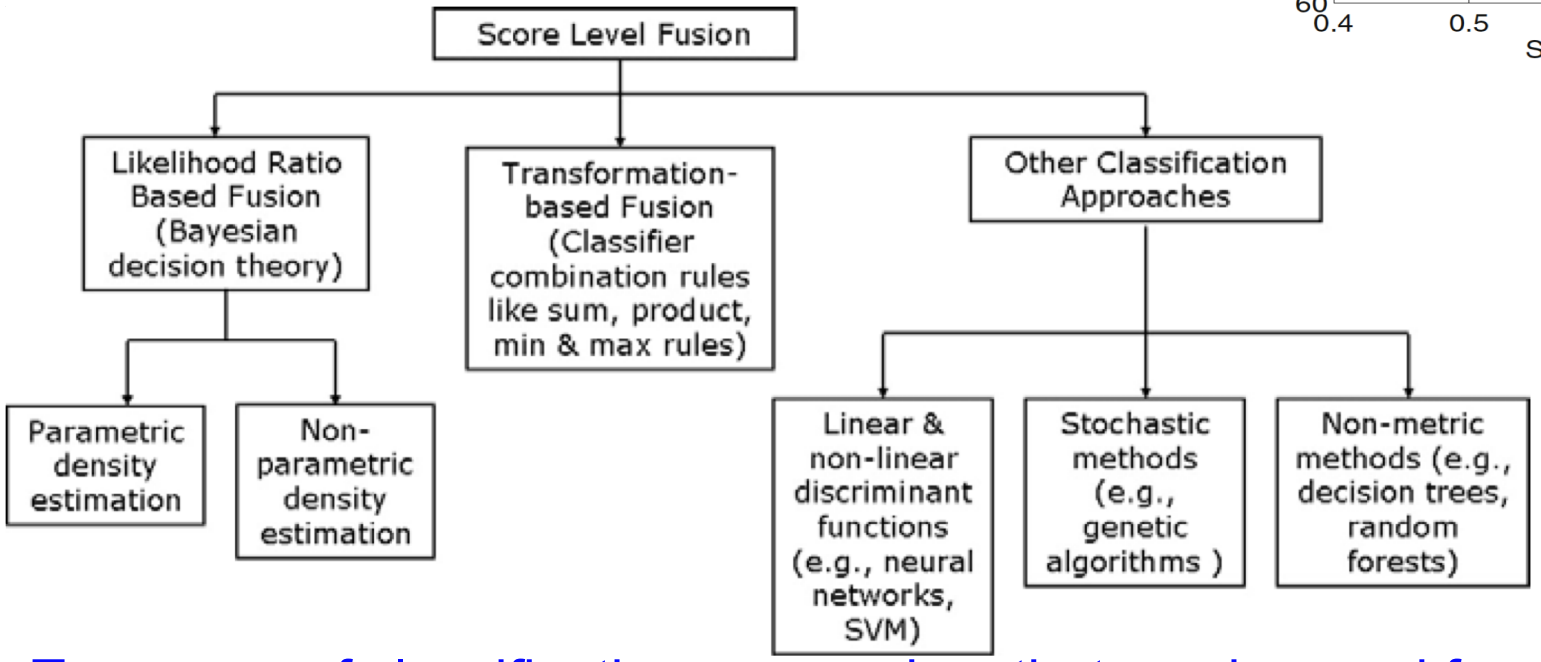
Review of score level fusion

- Next to the feature vectors, the match scores output by biometric matchers contain the richest information about the input pattern
- Also, it is relatively easy to access and combine the scores generated by the different matchers
- Consequently, integration of information at the match score level is the most common approach in multibiometric systems
- Score-level fusion is a challenging problem when the match scores generated by the individual matchers are not homogeneous

Review of score level fusion







Example of a linear decision boundary

Taxonomy of classification approaches that can be used for score level fusion

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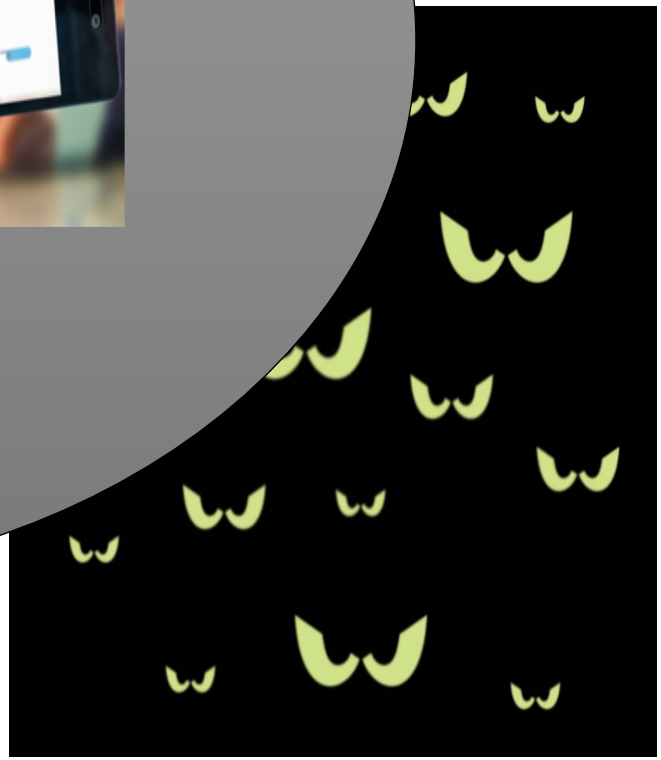
Towards a general (intrinsic & extrinsic) score-level fusion in co-authentication systems

Seminar: Week 11 (part 1)

Quynh Chi Truong, Tran Khanh Dang, Trung Ha: Face Quality Measure for Face Authentication. FDSE 2016: 189-198

Extrinsic factors (Quality factor)



Extrinsic factors (Quality factor)

- Quality of the input biometric data affects the system performance.
- Qualities of different input modals can be used as weights of each modal in multimodal systems.

Quality factors for fingerprints

Quality Index in the Frequency Domain

Quality Index in the Spatial Domain

Quality factors for face images

Brightness

Contrast

Focus

Illumination

Quality factors for face images

- **Brightness (Q_B)** is defined as an attribute of a visual sensation according to which a given visual stimulus appears to be more or less intense
- Image **contrast (Q_C)** is the difference in color intensities of the object and other objects within the same field of view.
- Image **focus (Q_F)** refers to the degree of blurring of face images.
- **Luminance (Q_l)** is used to describe the amount of light that passes through or is emitted from a particular area of the image.

General face quality measure

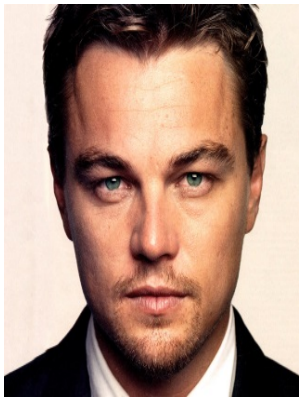
- General face quality measure is defined as follows:

$$Q = \frac{w_B.Q_B + w_C.Q_C + w_F.Q_F + w_I.Q_I}{w_B + w_C + w_F + w_I}$$

- where w_B, w_C, w_F, w_I are correlation values of quality factors brightness, contrast, focus, and illumination respectively

Proposed face quality measure

- A face quality measure should show how good a face image is for an authentication process
- In our approach, an image has a good quality if it is taken under a similar condition with the template image



Template image
(Registration)

Brightness: B_t
Contrast: C_t
Focus: F_t
Illumination: I_t

Compare

Brightness: B_q
Contrast: C_q
Focus: F_q
Illumination: I_q

Query image
(Authentication)

Quality measure for Face Authentication

Individual quality factor measure (Brightness)

- Let $B_{template}$, B_{query} be the brightness values of the template and query images and D_B be the distance of these values.

$$D_B = | B_{template} - B_{query} |$$

- D_B is normalized in the range [0, 1]. The normalized distance is also the brightness quality measure Q_B.

$$Q_B = 1 - \frac{D_B - D_{Bmin}}{D_{Bmax} - D_{Bmin}}$$

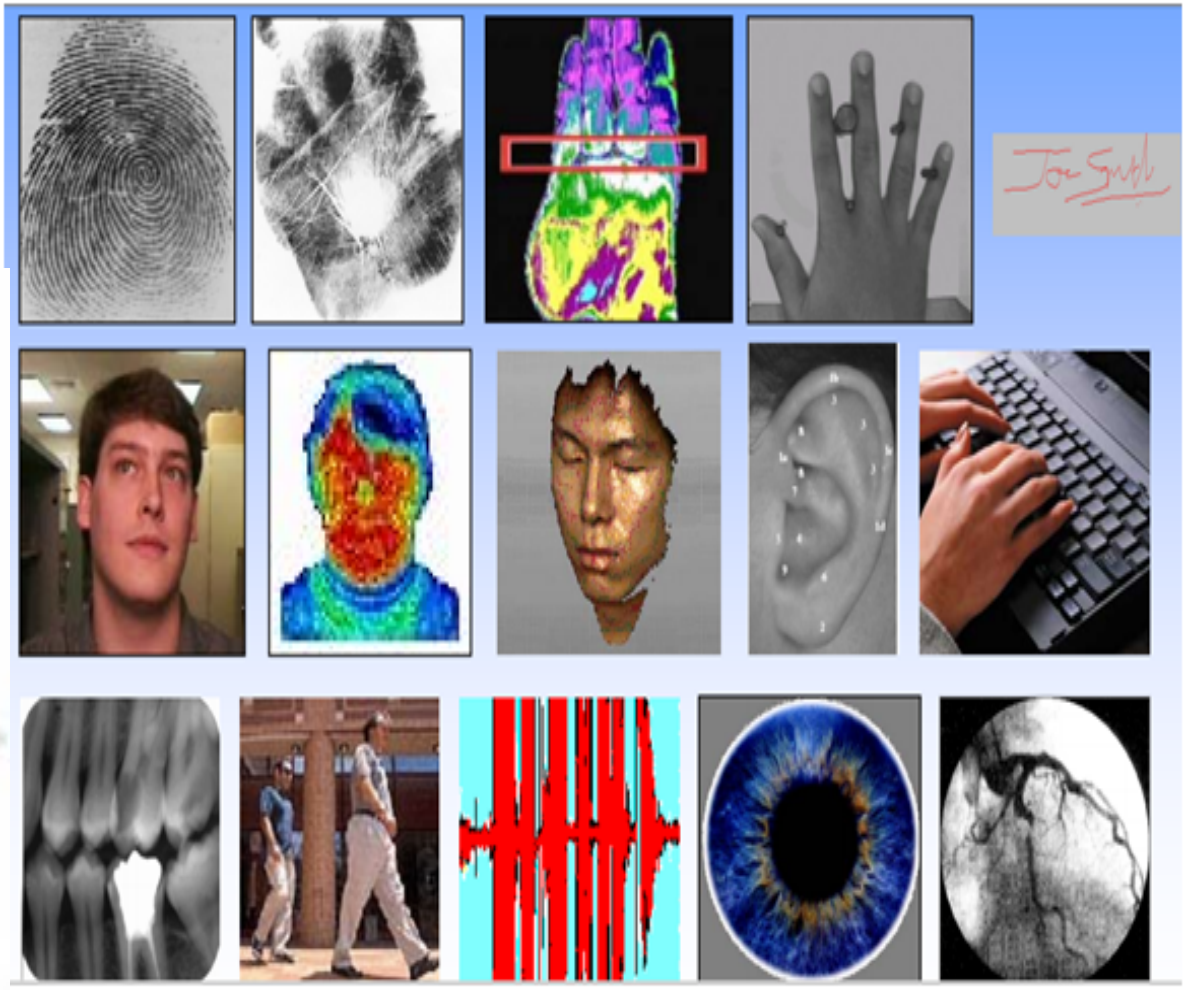
General face quality measure

- General face quality measure is defined as follows:

$$Q = \frac{w_B.Q_B + w_C.Q_C + w_F.Q_F + w_I.Q_I}{w_B + w_C + w_F + w_I}$$

- where w_B, w_C, w_F, w_I are *correlation values* of quality factors brightness, contrast, focus, and illumination respectively

Intrinsic factors



Intrinsic weights

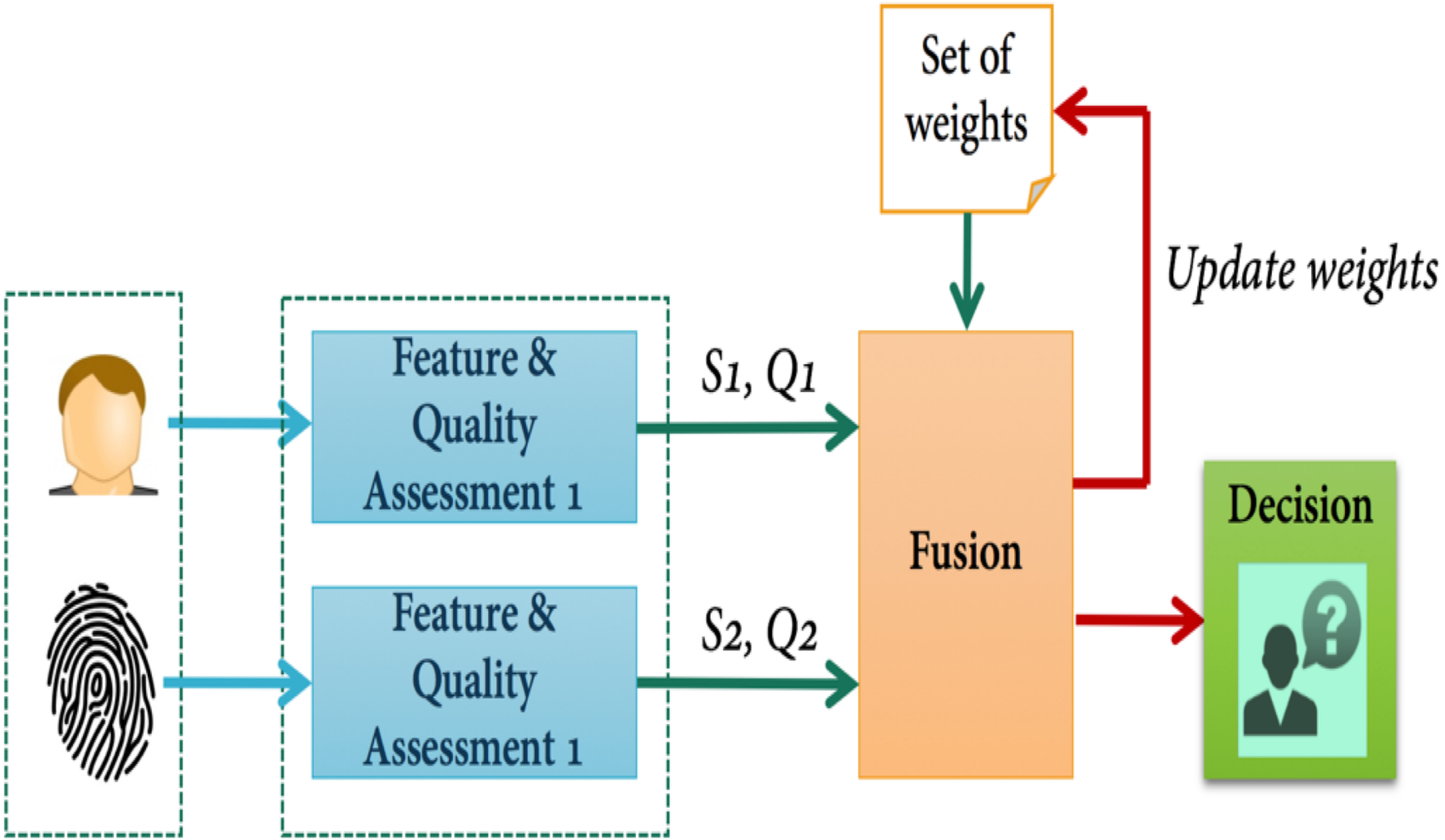
- Equal Error Rate Weighted:

$$w_k = \frac{\frac{1}{EER_k}}{\sum_{k=1}^{N} \frac{1}{EER_k}}$$

- D-Prime weighted: to measure the separation between the genuine and the imposter scores

$$d'_k = \frac{\mu_k^G - \mu_k^I}{\sqrt{(\sigma_k^G)^2 + (\sigma_k^I)^2}} \qquad w_k = \frac{d'_k}{\sum_{k=1}^{N} d'_k}$$

- High separation indicates a higher performance of the biometric source. Given that σ^G_k and σ_k^I are the genuine scores and imposter scores standard deviations and μ^G_k and μ^I_k are their mean values
- it is directly proportional to the performance of the biometric source and thus the weight w_k can be calculated as above


Set of weights
Update weights
Feature & Quality Assessment 1
S1, Q1
Feature & Quality Assessment 1
S2, Q2
Fusion
Decision

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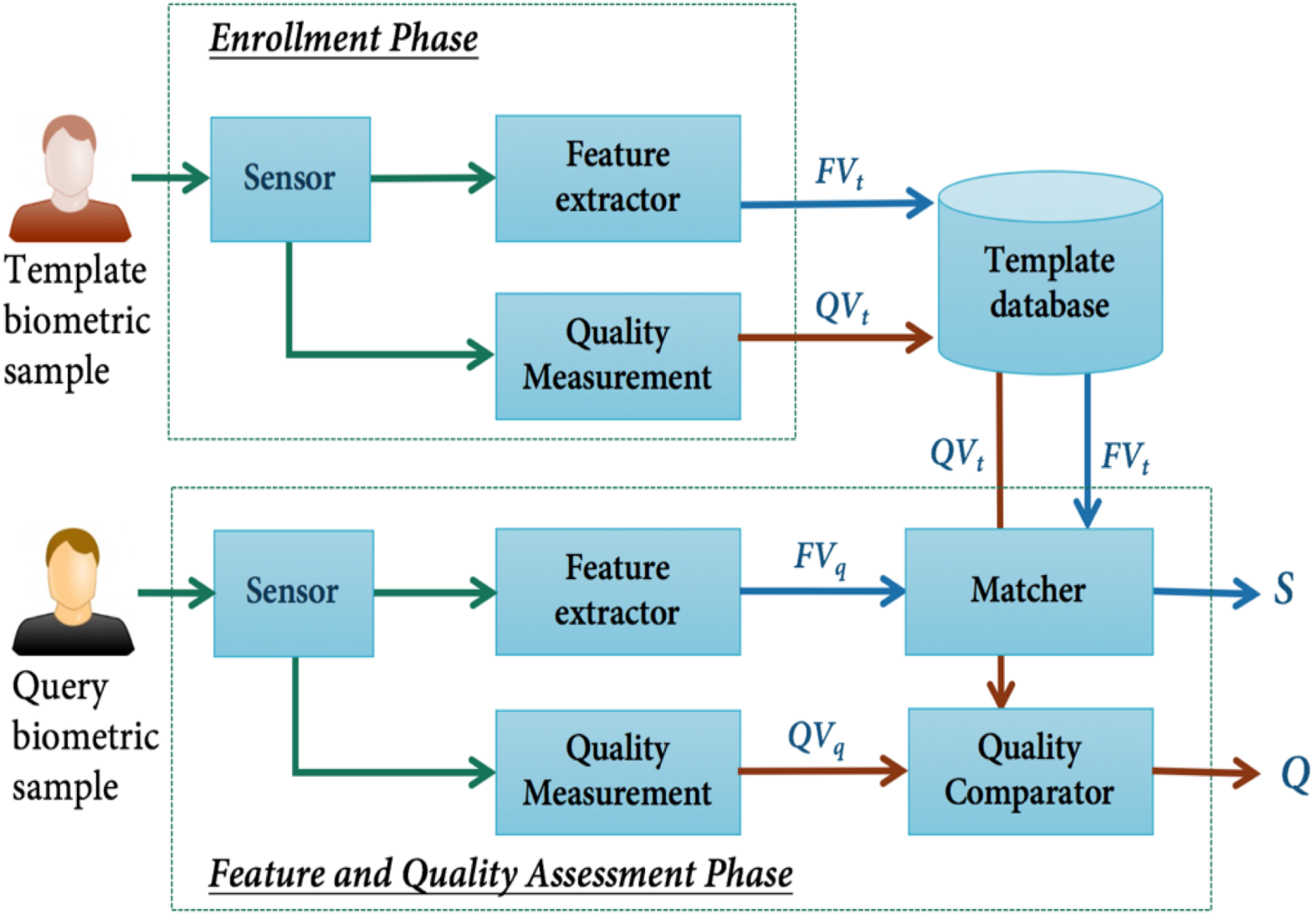
Enrollment Phase
Template biometric sample
Sensor
Feature extractor
Quality Measurement
FV_t
QV_t
Template database
QV_t
FV_t
Query biometric sample
Sensor
Feature extractor
Quality Measurement
FV_q
QV_q
Matcher
Quality Comparator
S
Q
Feature and Quality Assessment Phase

Evaluation

- Face

Quality index	Correlation coefficient value
Brightness	0.824
Contrast	0.484
Focus	0.071
Illumination	0.106
Face quality measure (mean)	0.749
Face quality measure (weighted mean)	0.836

Evaluation

- Fingerprint

Quality index	Correlation coefficient value
Quality Index in the Frequency Domain	0.78
Quality Index in the Spatial Domain	0.621
FP quality measure (mean)	0.683
FP quality measure (weighted mean)	0.801

Evaluation

- Equal Error Rate

Modal	EER (best case)
Face (PCA)	0.09
Fingerprint (Minutiae-based matching)	0.289

Fusion scheme

- $S_{fusion} = \sum_{i=1}^{N} w_i \cdot S_i$

- **Geometric mean: $w_i = w_{qi} \times w_{ei}$**
- **Mean: $w_i = w_{qi} + w_{ei}$**

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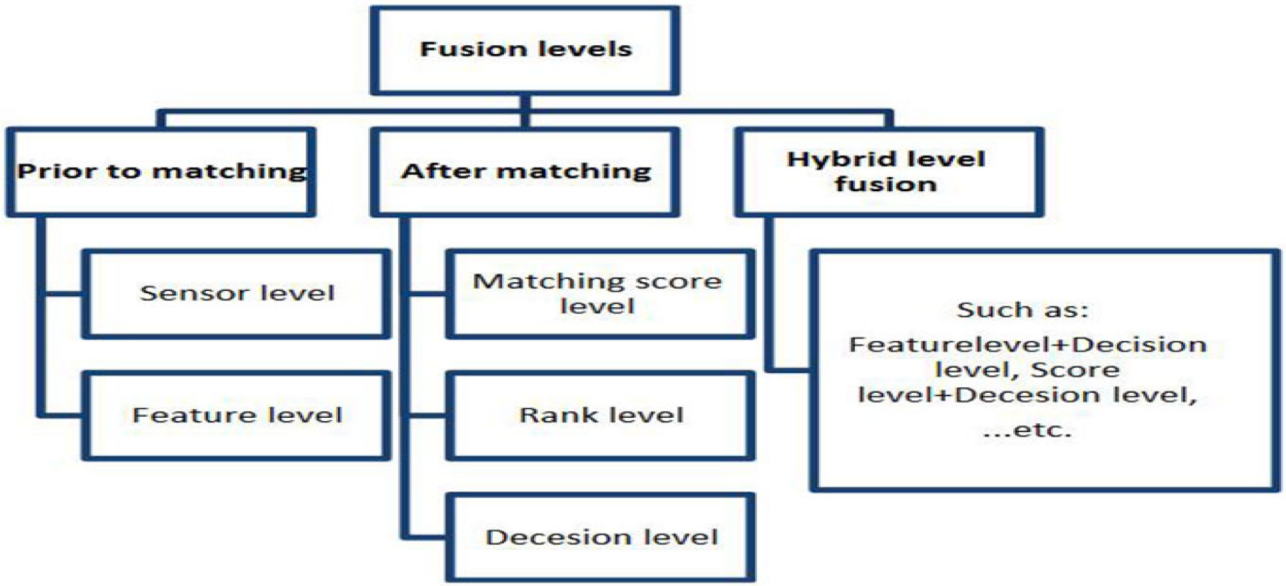

Q&A

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