Multimodal Biometric Systems

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Why Multimodal Biometrics?

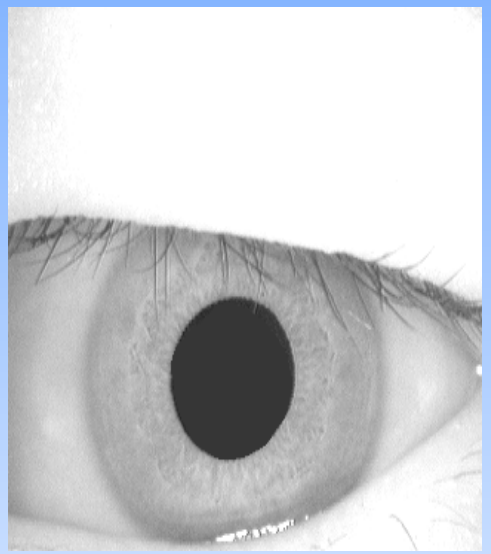
- Unacceptable error rates using a single biometric
- Noisy biometric data
- Flexibility to provide one of several possible biometrics
- Reduce failure to enroll rate (increase population coverage)
- Difficult to employ fake biometric

"State-of-the-art" Error Rates

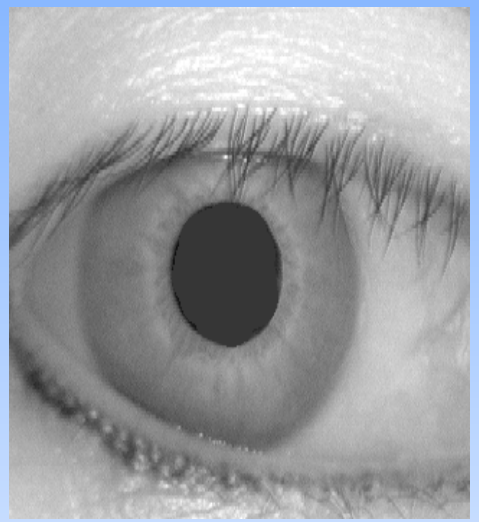
	Test	Test Parameter	False Reject Rate	False Accept Rate
Fingerprint	FVC [2004]	20 years (average age)	2%	2%
Face	FRVT [2002]	Varied lighting, outdoor/indoor	10%	1%
Voice	NIST [2000]	Text Independent	10-20%	2-5%

At NY airports, an average of ~ 300,000 passengers pass through daily. If all of these used biometric-authenticated smart cards for identification, there would be 6,000 falsely rejected (and inconvenienced) passengers per day for fingerprints, 30,000 for face and 45,000 for voice. Similar numbers can be computed for false accepts

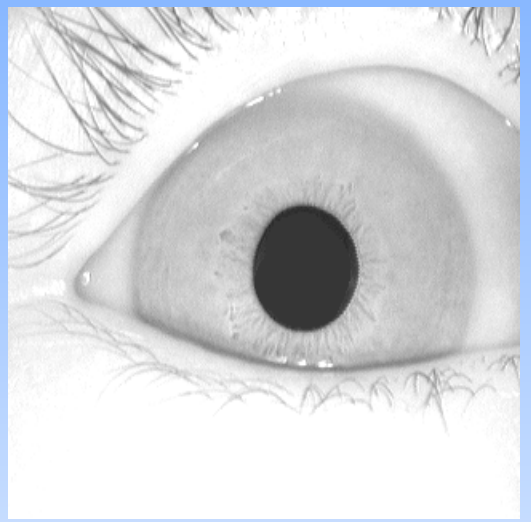
Poor Quality Iris Images



Drooping eyelids



Large pupil

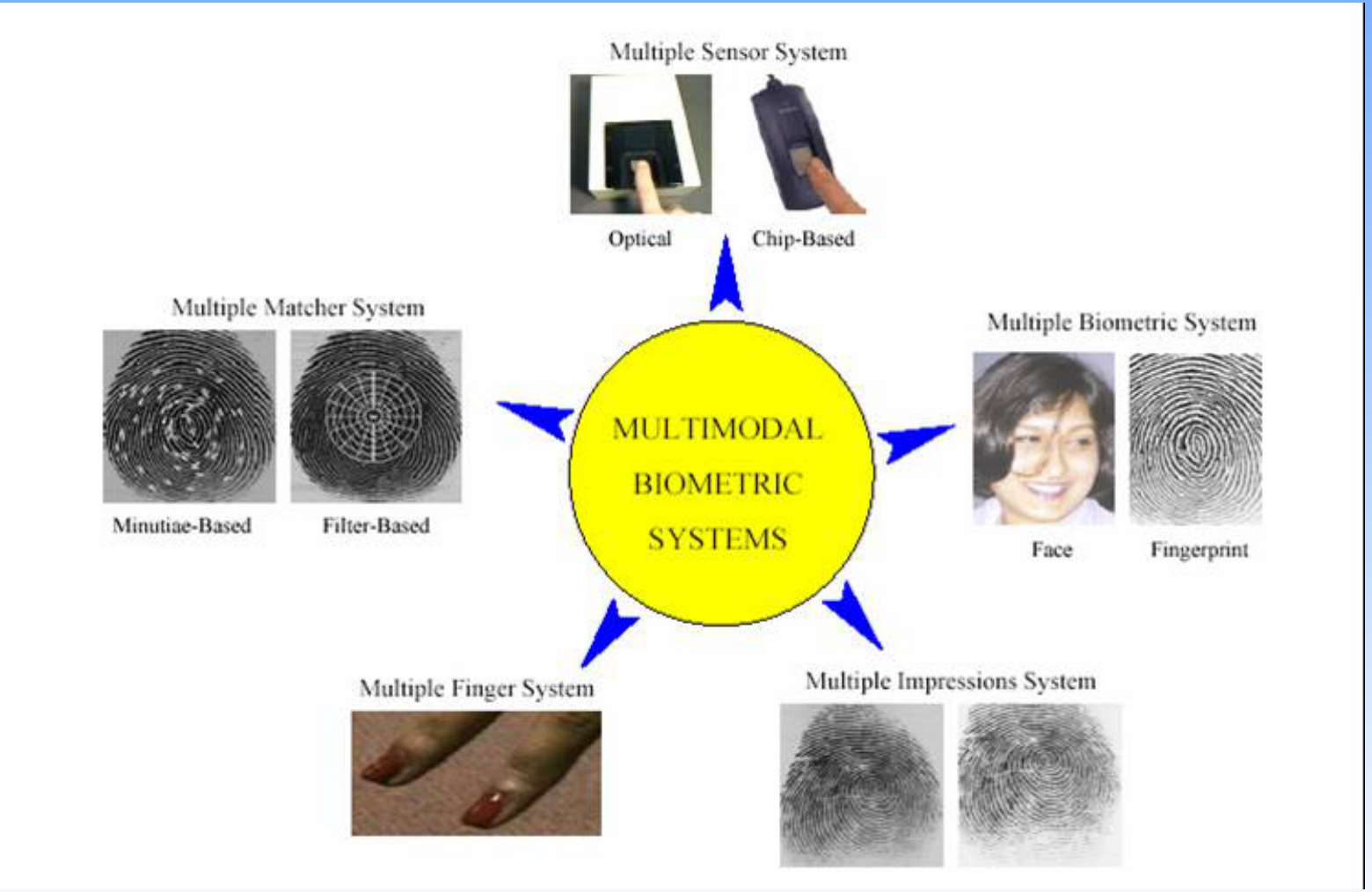


Off-centered iris

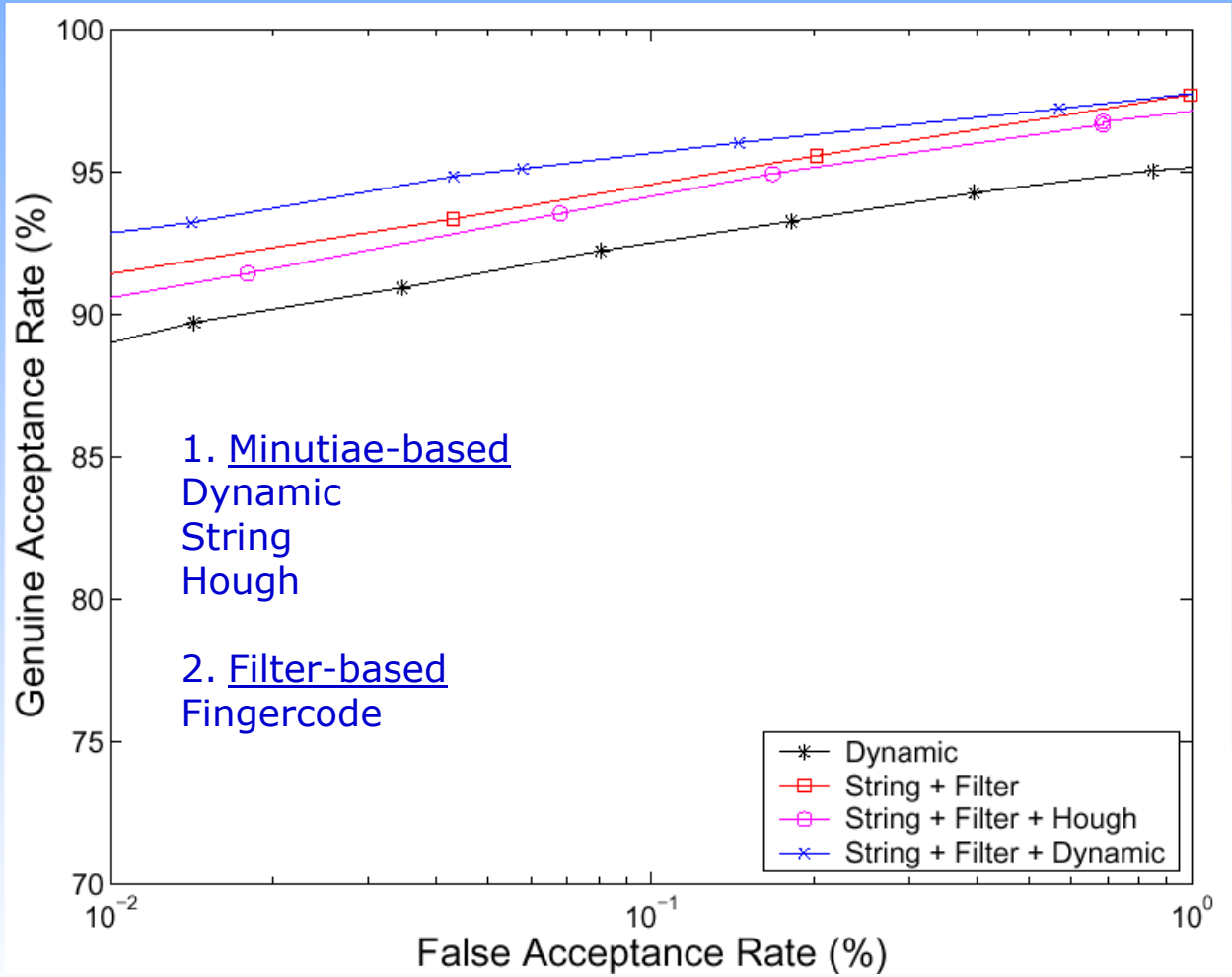
- Failure to enroll (FTE) for iris is ~7%*

* BBC News, "Long lashes thwart ID scan trial", 7 May 2004, news.bbc.co.uk/2/hi/uk_news/politics/3693375.stm

What is Multimodal Biometrics?

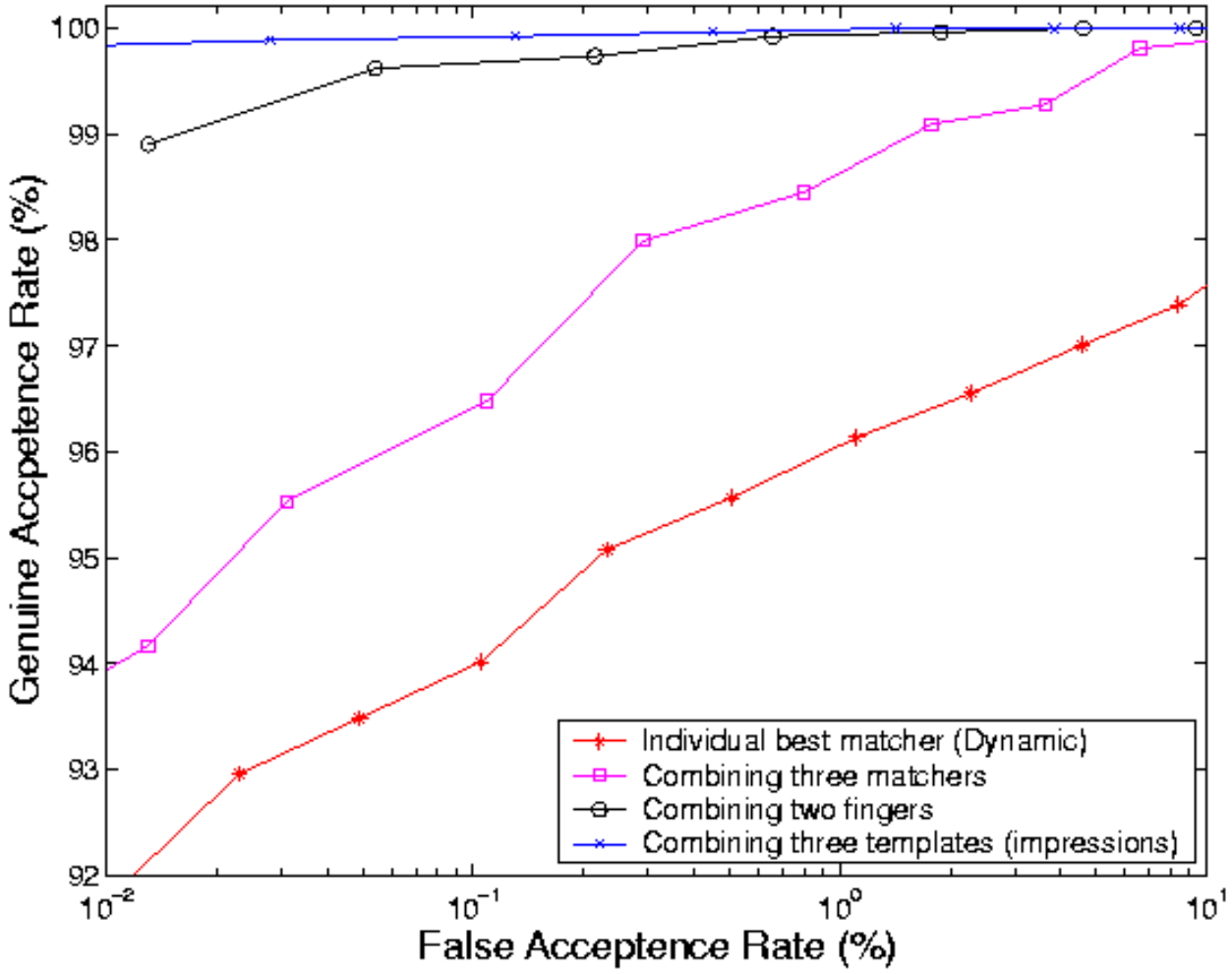


Intra-modal Fusion: Combination of Fingerprint Matchers



Jain, Prabhakar, Chen, " Combining Multiple Matchers for a High Security Fingerprint Verification System", Pattern Recognition Letters, Vol 20, No. 11-13, pp. 1371-1379, 1999.

Intramodal Fusion: Multiple Fingers, Matchers and Templates



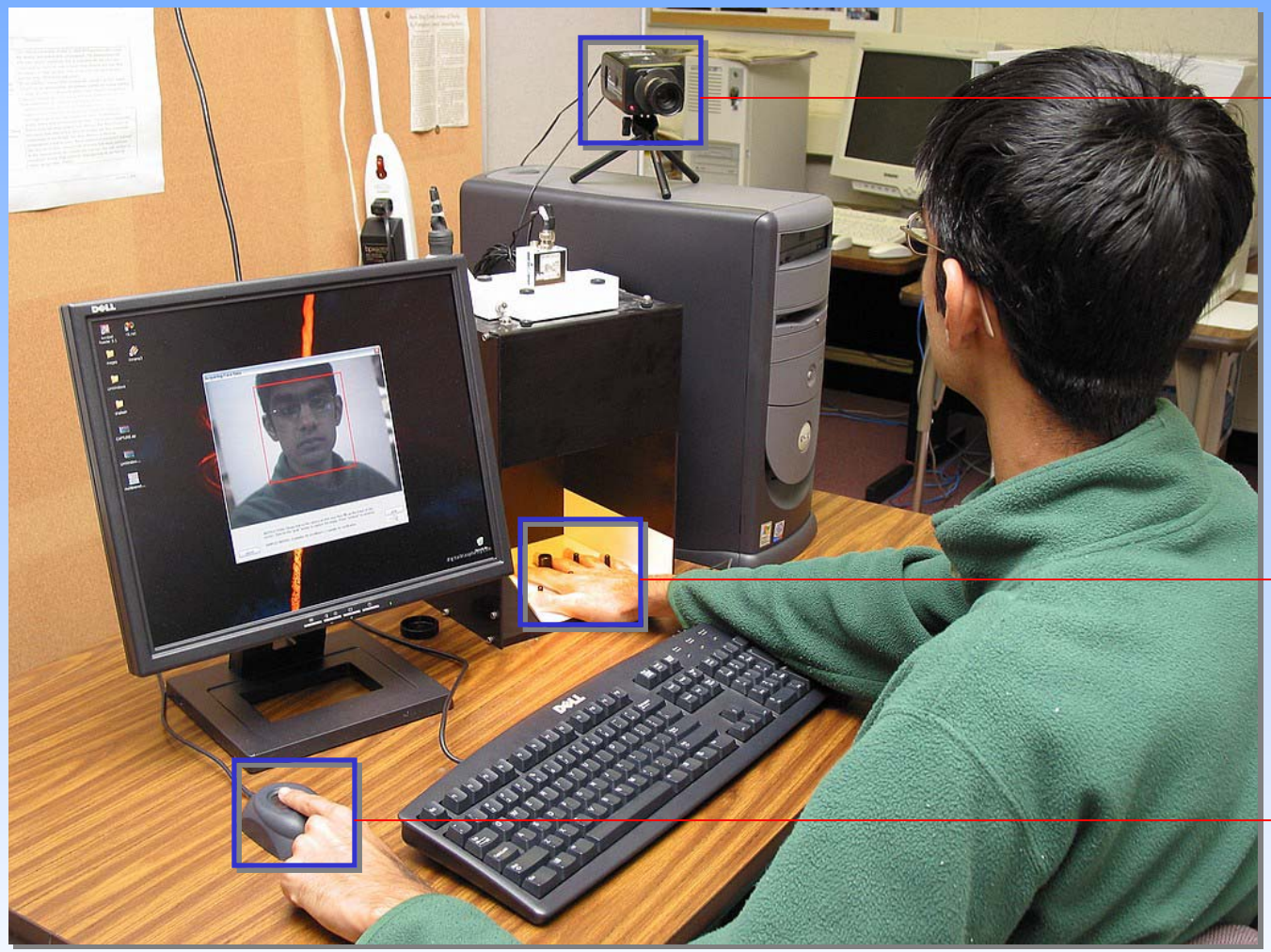
Design of Multimodal Systems

- Cost vs. performance
- Throughput
- Verification vs. Identification mode
- Choice and number of biometrics
- Level of fusion
- Fusion methodology
- Assigning weights to biometrics
- Multimodal databases

Which Biometric Modalities to Fuse?

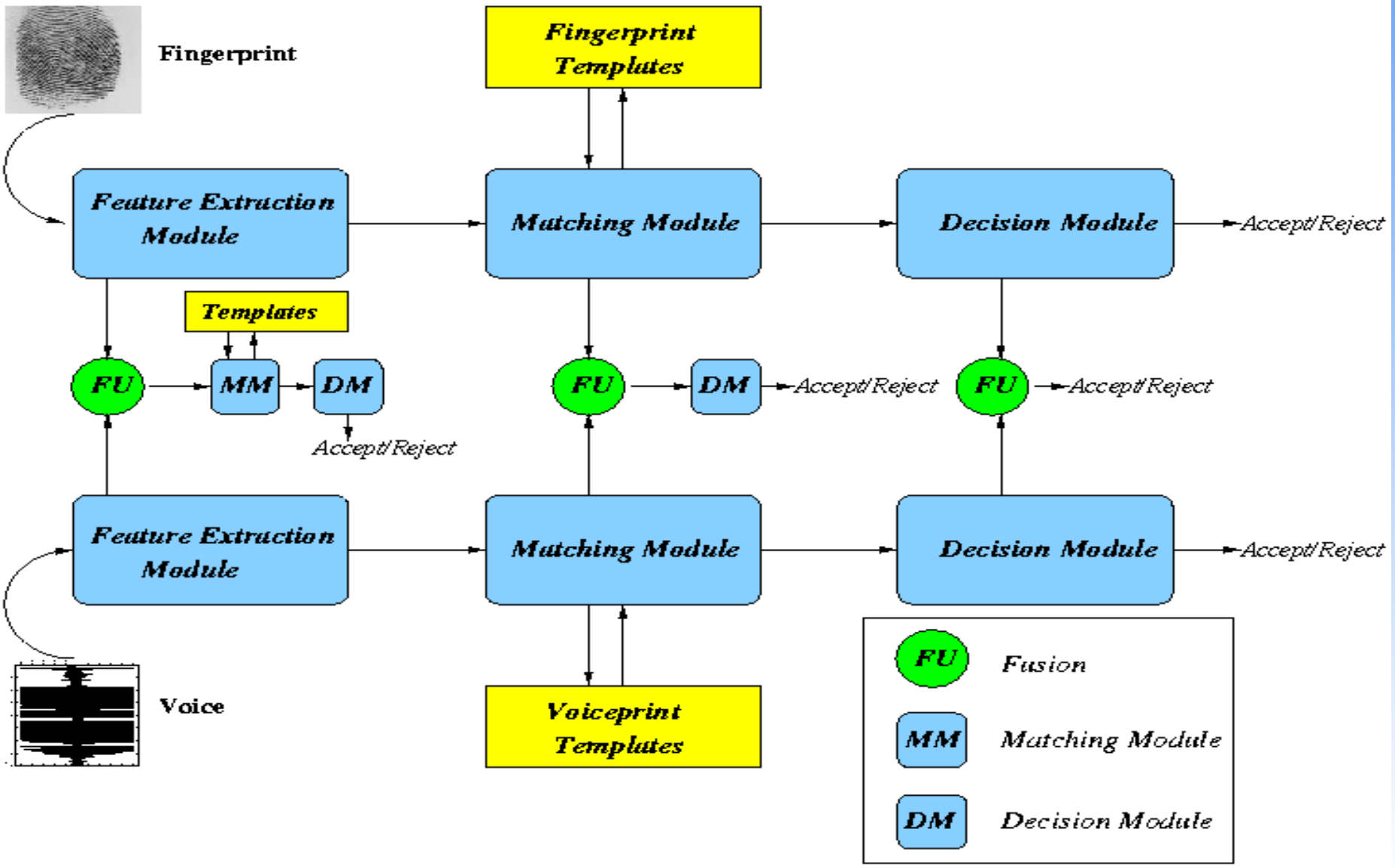
Voice, Face
Voice, Lip Movement
Voice, Face, Lip Movement
Fingerprint, Face
Fingerprint, Face, Voice
Fingerprint, Face, Hand geometry
Fingerprint, Voice, Hand geometry
Fingerprint, Hand geometry
Facial thermogram, Face
Iris, Face
Palmprint, Hand geometry
Ear, Voice

Multibiometric Login System



Casacaded versus Parallel mode of operation

Levels of Fusion



Ross, Jain, "Information Fusion in Biometrics", Pattern Recognition Letters, September 2003.

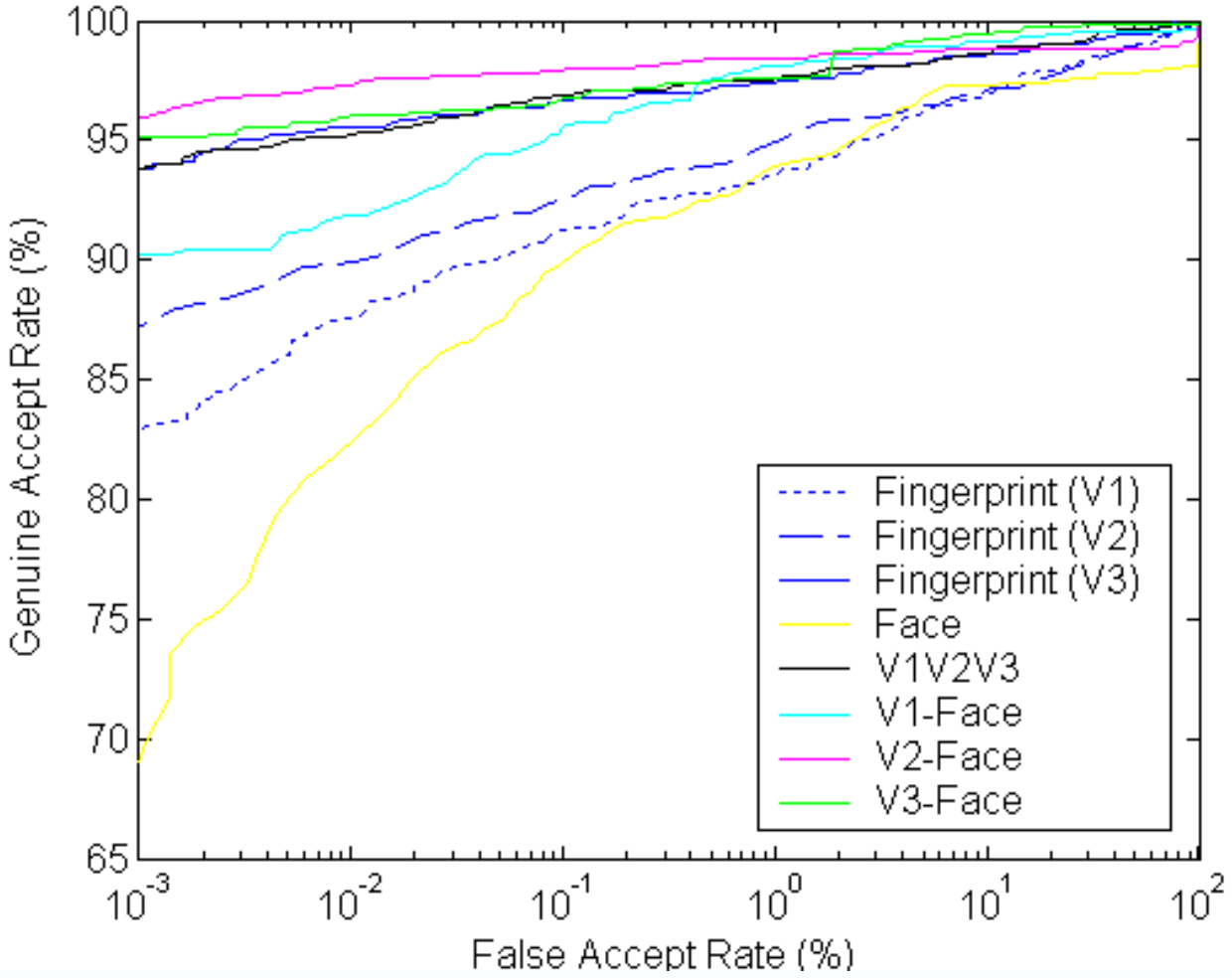
Fusion of Commercial Fingerprint and Face Systems

- Three commercial fingerprint matchers and one face matcher with EER values of 3.96%, 3.72%, 2.16% and 3.76%, respectively, were combined
- 972 individuals in the database
- The best EER values in individual columns (rows) are indicated with bold typeface (star (*))

Normalization Technique	*Fusion Technique*				
	Sum	Min	Max	MW	UW
Min-Max	0.99	5.43	0.86	**1.16**	***0.63**
Z-Score	*1.71	5.28	1.79	1.72	1.86
Tanh	1.73	**4.65**	1.82	*1.50	1.62
QLQ	**0.94**	5.43	***0.63**	**1.16**	***0.63**

MW – Matcher Weighting; UW – User Specific Weights

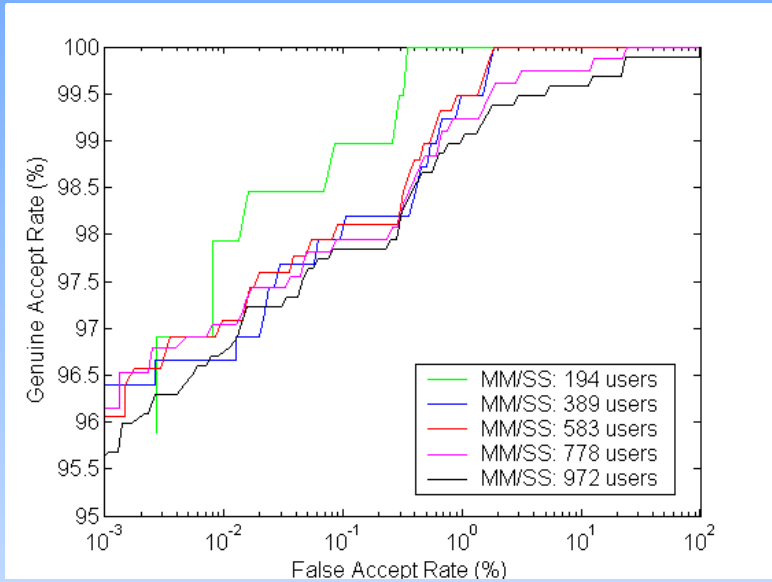
Fusing Commercial Face & Fingerprint Systems



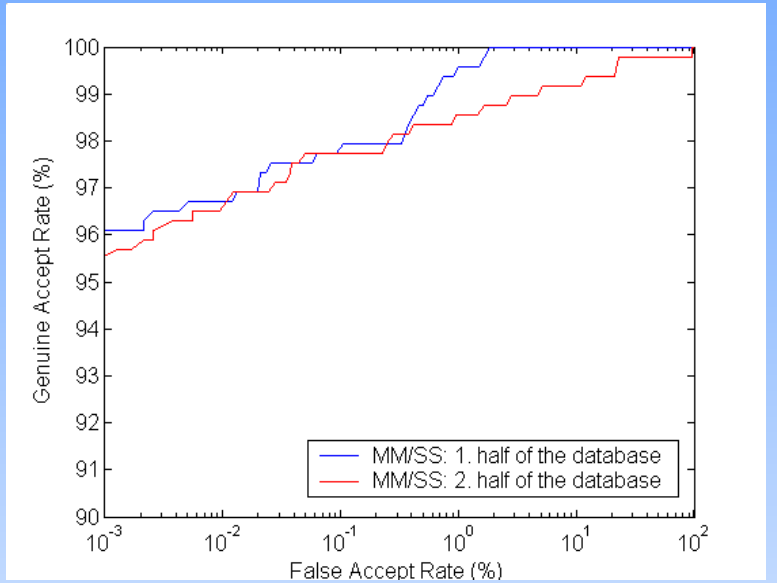
- Min/Max Normalization of matching scores
- Sum Rule
- 1000 Subjects

Performance Variability

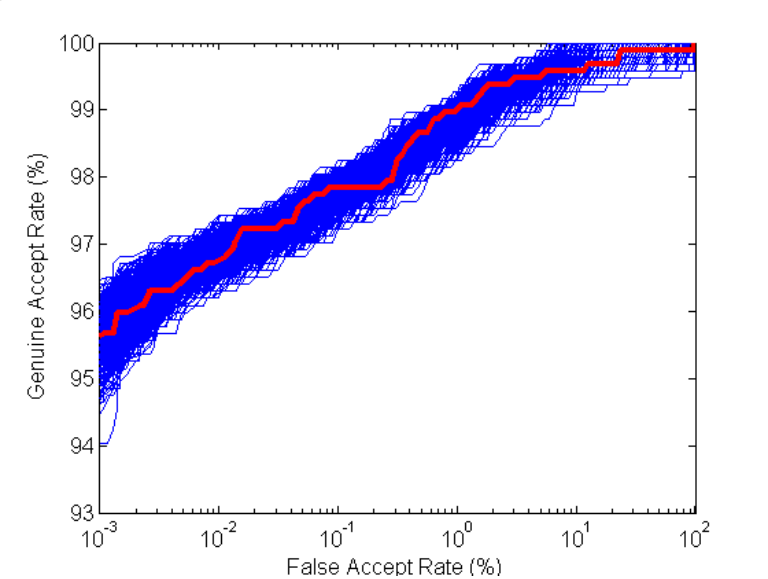
Scalability



Generalizability



Effects of Virtual Subjects



Cascaded Multibiometric System

- Capture biometric measurements as needed (Sequential pattern recognition)
- Verification - reduces the average verification time
- Identification - successively prunes the database (indexing)
- To reduce the average verification time, the modalities must be cascaded in the decreasing order of accuracy
- In user-friendly systems, the user can be allowed to choose the order of the modalities

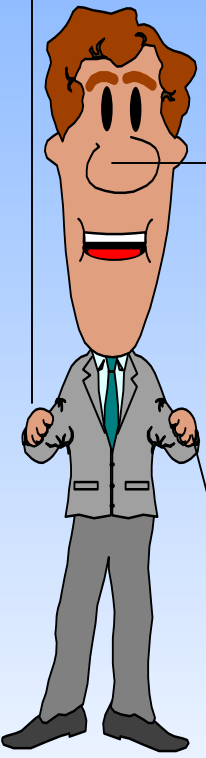
Cascaded Multimodal Biometric System

Additional Biometric?

No

Results

Yes



Fusion of Matching Scores

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Results

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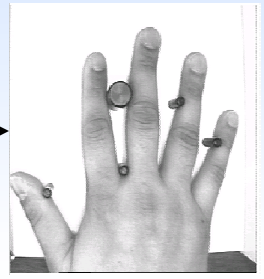
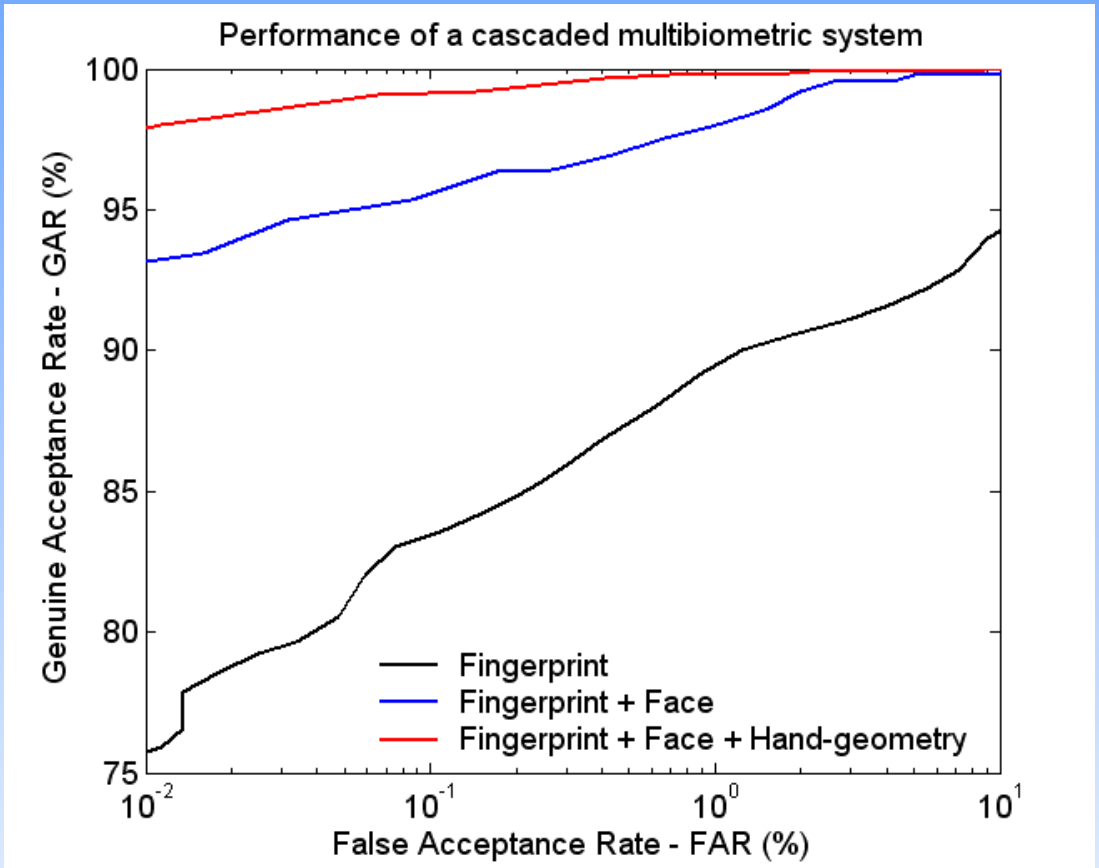


Fusion of Matching Scores

Results

Cascaded System Performance



- 28% of the genuine users required only fingerprint, 13% required both fingerprint and face, and 59% required all three modalities
- Impostors had to submit all three modalities