Multimodal Biometric Identity Authentication: Benefits, Issues and Challenges

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OUTLINE

- Introduction
- Multimodal biometric identity authentication
- Fusion architectures
- Decision versus score level fusion
- Issues in multimodal fusion
- Quality based fusion of biometric modalities & issues
- Conclusions

Setting the scene

- Person identification is crucial to the fabric of the society
  - Security
  - Access to buildings/services
  - Business transactions
  - Law enforcement
  - Government
    - Border control
    - Identity cards
    - Social security

Pitfalls of classical security techniques

- Reliance on the ability of operators
- Reliance on good memory or alternative mechanisms (users)

Pitfalls of classical security/ forensic techniques

- Human failings
  - Limited capability
  - Limited capacity
  - Genuine ambiguity

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Physiological Biometrics

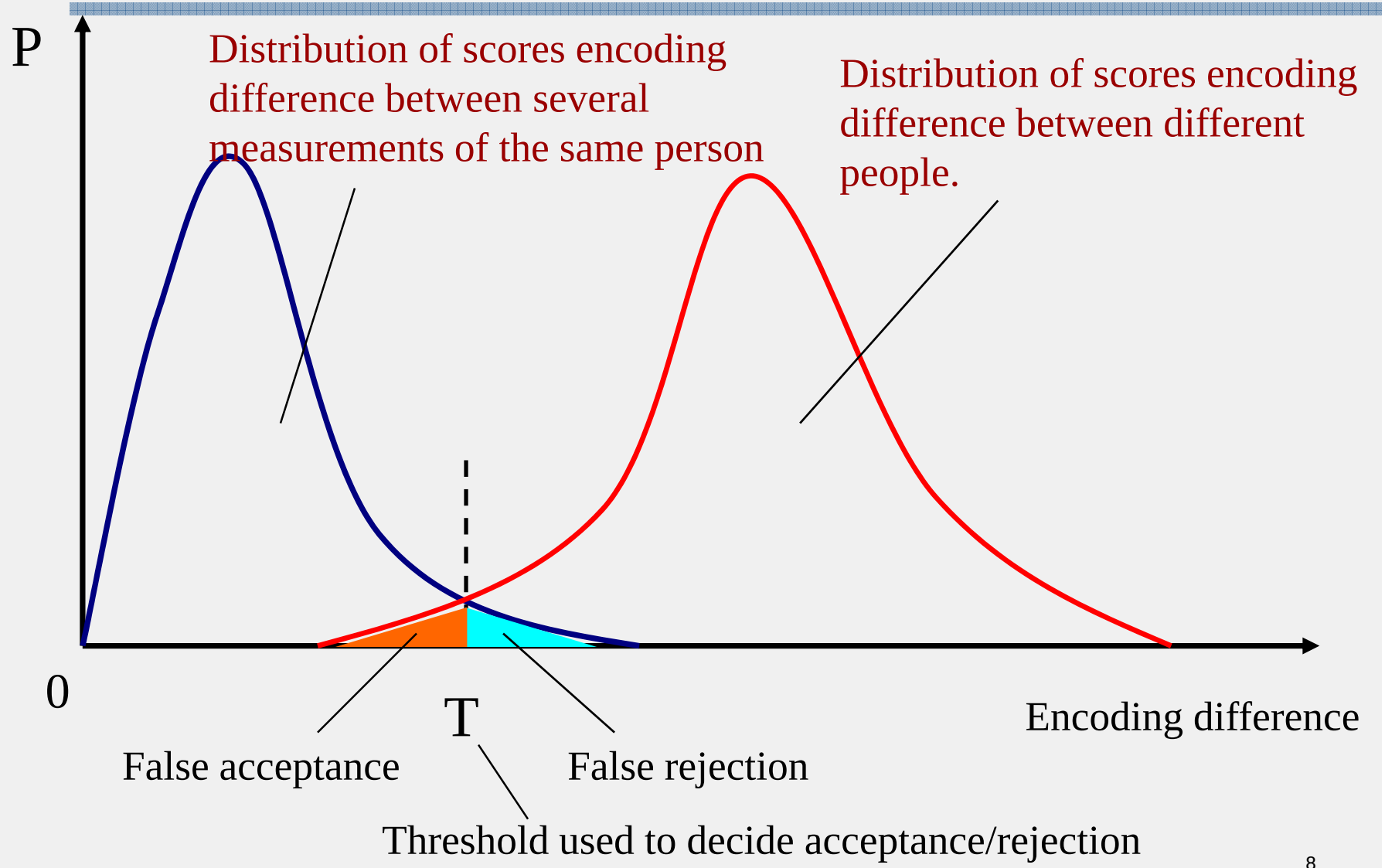
- Fingerprints
- Face
- Iris
- DNA
- Retina
- Hand Geometry
- Ear Shape
- Thermogram

Behavioural Biometrics

- Signature
- Voice
- Gait
- Keystroke

Sources of errors in biometric identification

- For every sample of biometric trait the identification code is slightly different
- Identification is non-unique


P
Distribution of scores encoding difference between several measurements of the same person
Distribution of scores encoding difference between different people.
0
T
Encoding difference
False acceptance
False rejection
Threshold used to decide acceptance/rejection

The probability of misidentification as a function of database size

Database of 1,000
Chance of error:

$$1.0 - 0.9999^{1,000} = 0.09$$

Database of 10,000
Chance of error:

$$1.0 - 0.9999^{10,000} = 0.63$$

Database of 100,000
Chance of error:

$$1.0 - 0.9999^{100,000} = 0.99995$$

Multimodal biometrics

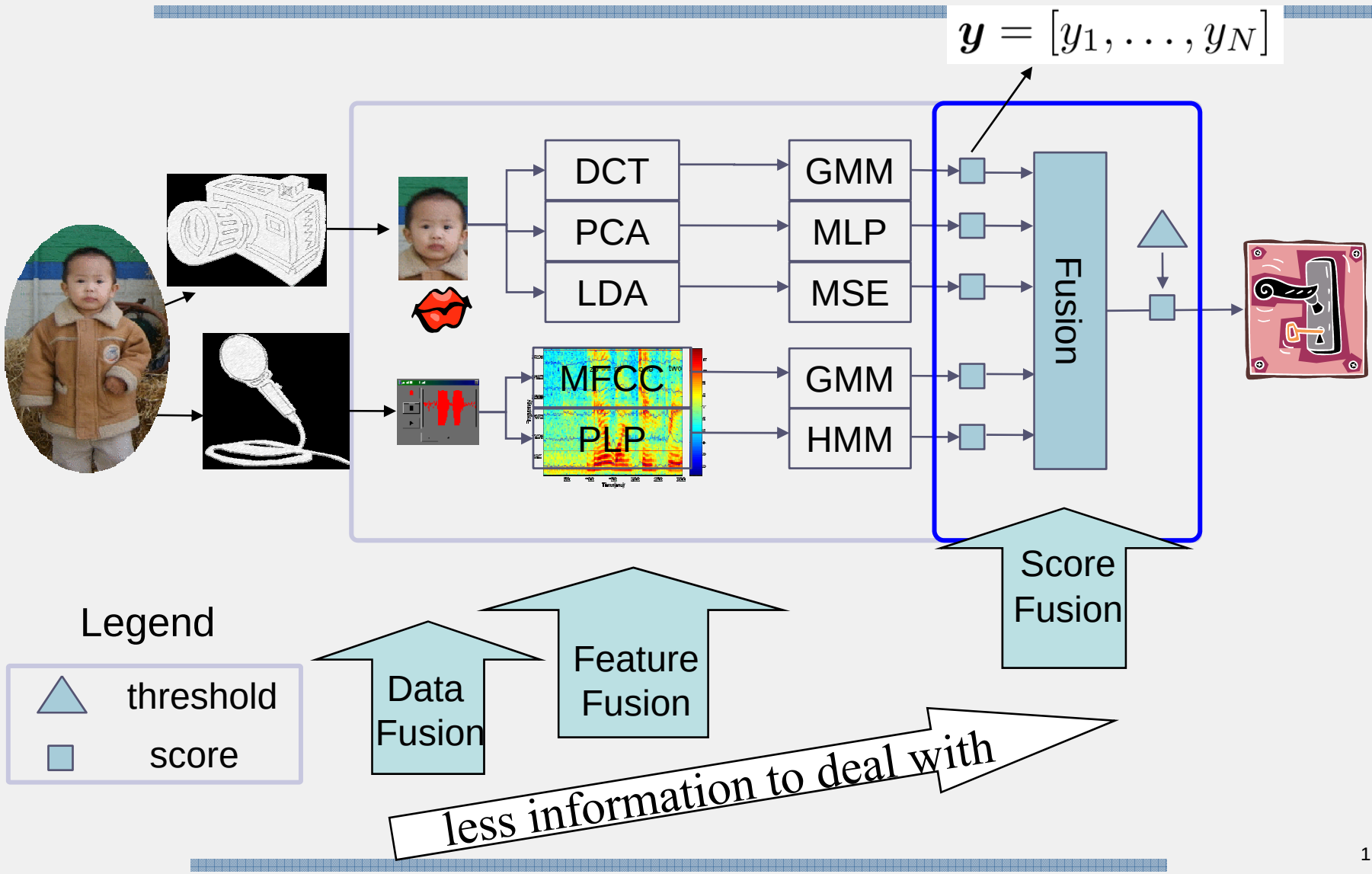
Different traits- different properties

- usability
- personal preferences
- acceptability
- performance
- robustness in changing environment
- reliability
- applicability (different scenarios)

Benefits of multimodality

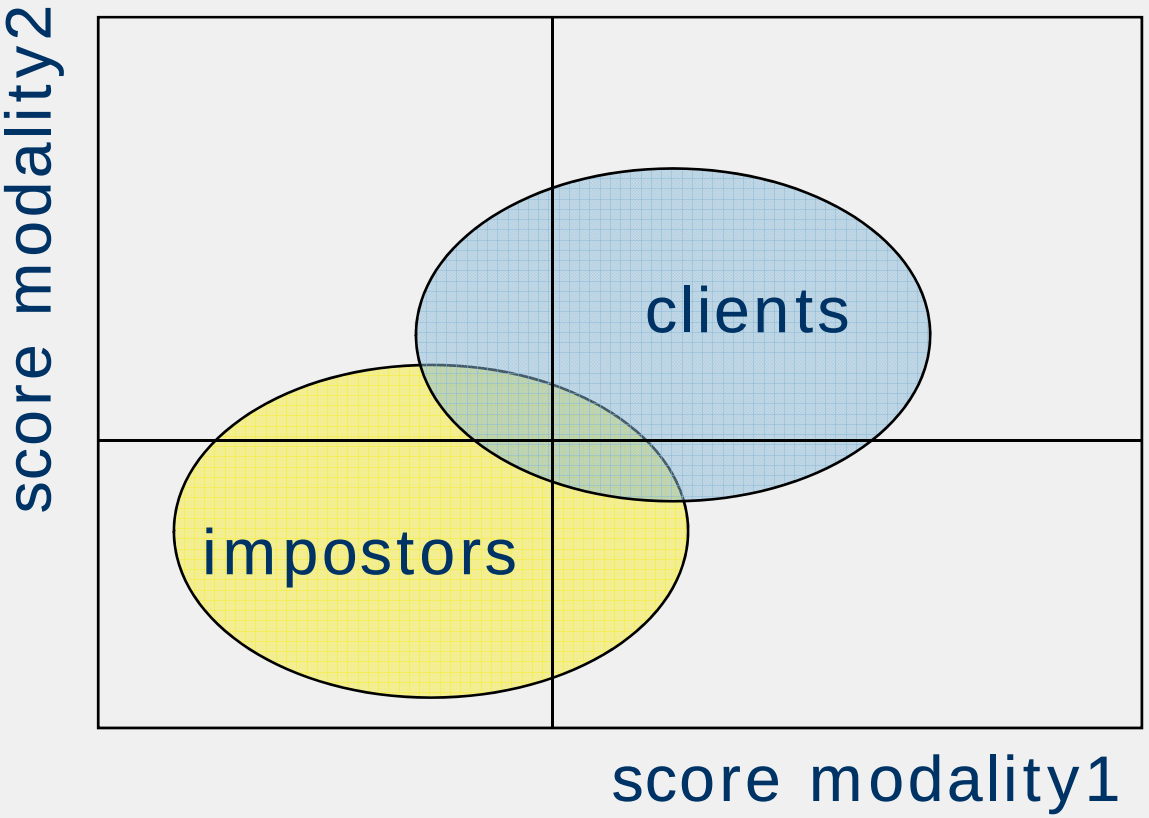
- Motivation for multiple biometrics
  - To enhance performance
  - To increase population coverage by reducing the failure to enroll rate
  - To improve resilience to spoofing
  - To permit choice of biometric modality for authentication
  - To extend the range of environmental conditions under which authentication can be performed

Levels of Fusion



Decision-level fusion

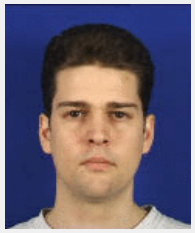
- How useful?



- "The key to resolving the apparent paradox," writes Daugman, "is that when two tests are combined, one of the resulting error rates (False Accept or False Reject rate) becomes *better than that of the stronger of the two tests*, while the other error rate becomes *worse even than that of the weaker of the tests.* If the two biometric tests differ significantly in their power, and each operates at its own cross-over point, then combining them gives significantly worse performance than relying solely on the stronger biometric.

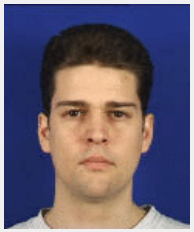
Biometric Personal Identity Authentication

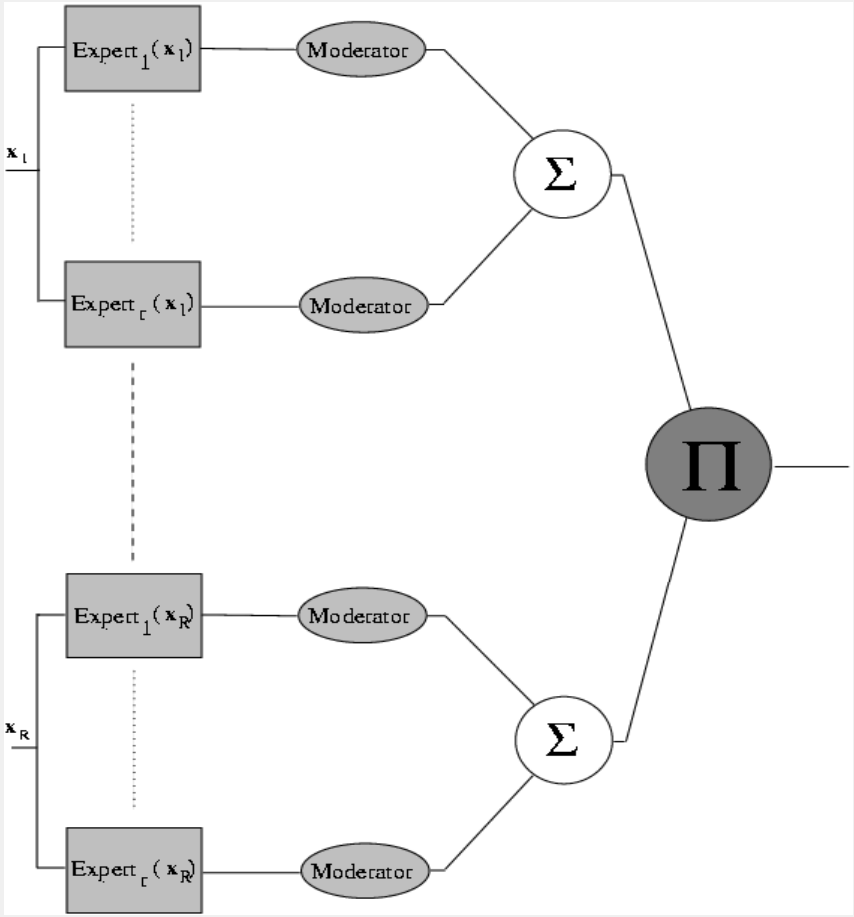
FACE



VOICE

LIPS





Fusion of face, voice and lips dynamics

Fusion of multiple biometric modalities

Modalities	XM2VTS Configuration I		
	FAR	**FRR**	HTER
Face 1	**7.25**	**7.78**	7.52
Face 2	**5.00**	**4.45**	4.73
Face 3	**6.00**	**8.12**	14.12
Voice 1	**7.00**	**1.42**	4.21
Voice 2	**0.00**	**1.48**	0.74
Lips	**14.00**	**12.67**	13.34

Performance of individual modalities (early versions of algorithms)

(In collaboration with IDIAP and AUT)

Fusion results
•weighted averaging

Modalities	XM2VTS Configuration I		
	FAR	**FRR**	HTER
Lips & face	**4.50**	**0.73**	2.62
Lips & voice	**0.00**	**1.39**	0.70
Face & voice	**0.00**	**1.25**	0.63
Lips, face & voice	**0.00**	**1.31**	0.66
No lips	**0.00**	**0.52**	0.26
all	**0.00**	**0.29**	0.15

Issues in Fusion

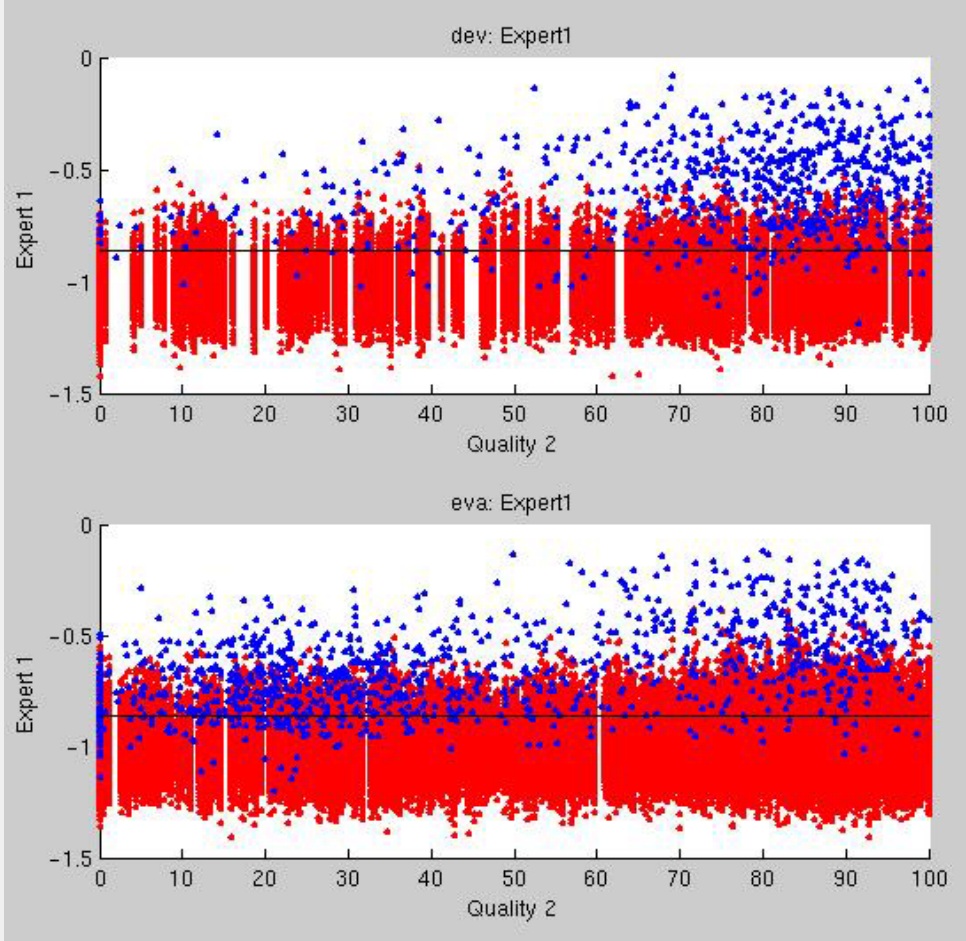
- accuracy
- diversity
- competence
- quality
- score normalisation
- class coding

Face Quality Measures

- Face
  - Frontal quality
  - Illumination
  - Rotation
  - Reflection
  - Spatial resolution (between eyes)
  - Color bit per pixel
  - Focus
  - Brightness
  - Background uniformity
  - Glasses

Well illuminated	Side illuminated
	
Glass=89%	Glass=15%
Illum.=100%	Illum=56%

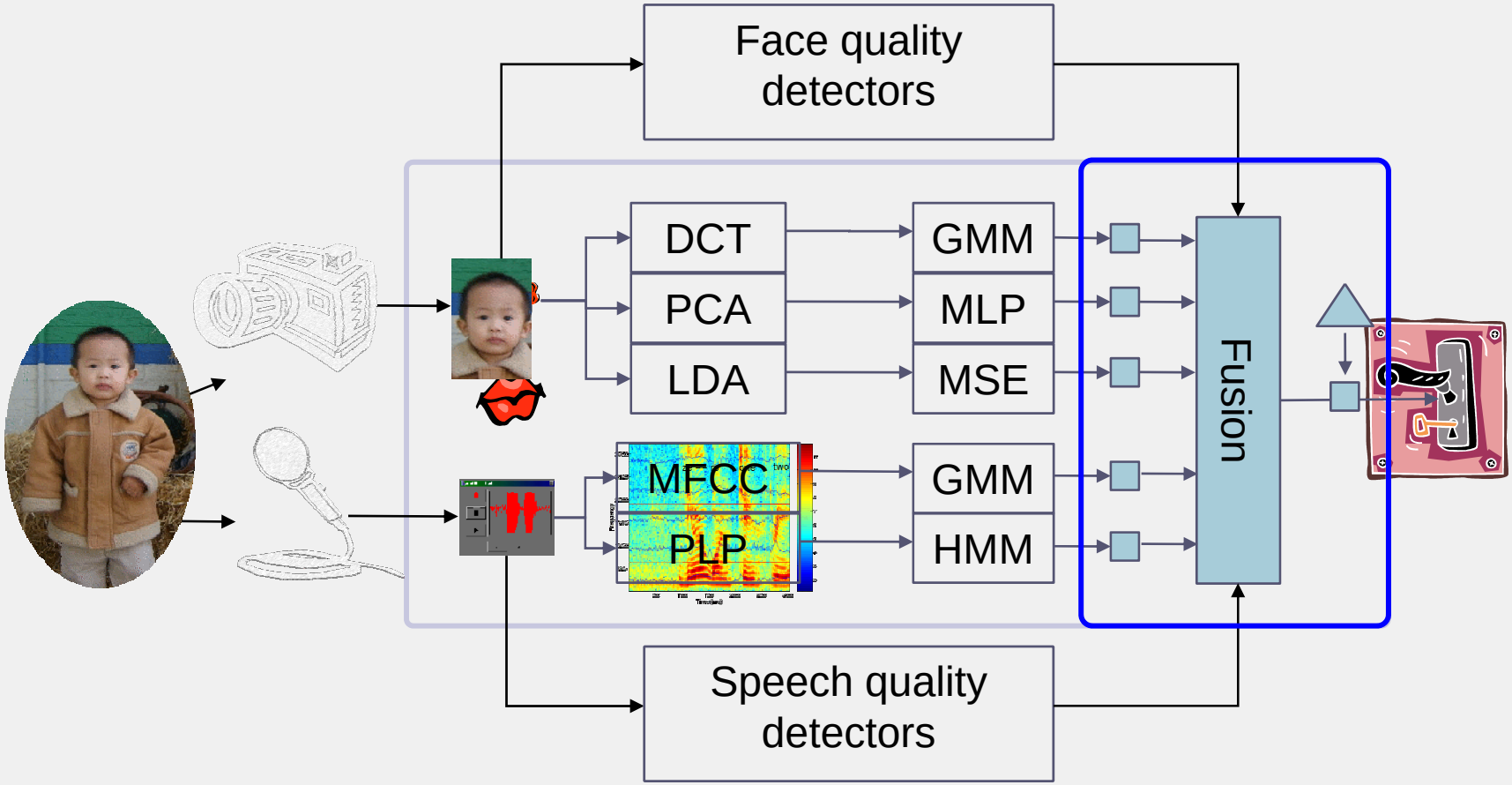
Scores versus quality



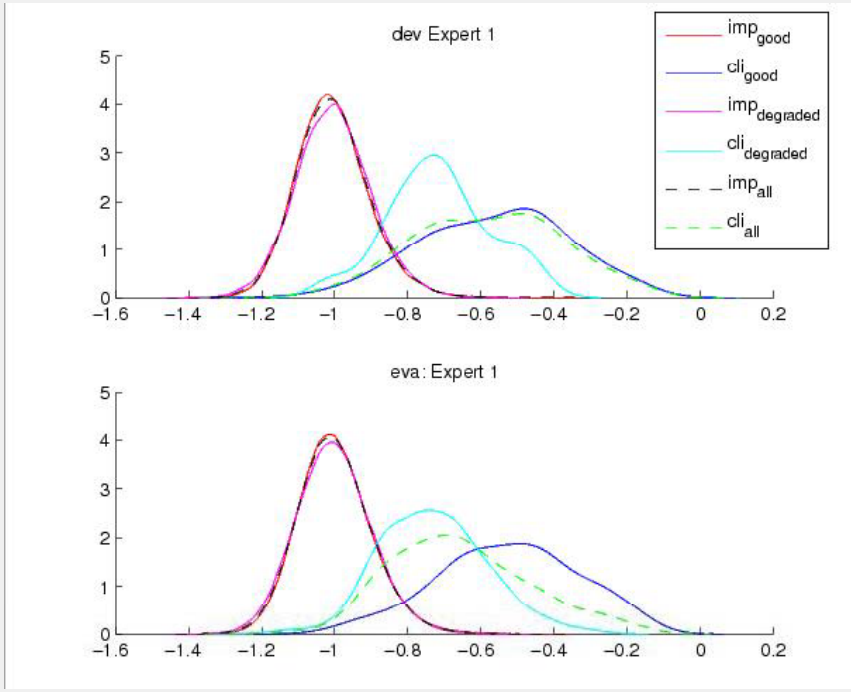
Biometric trait quality

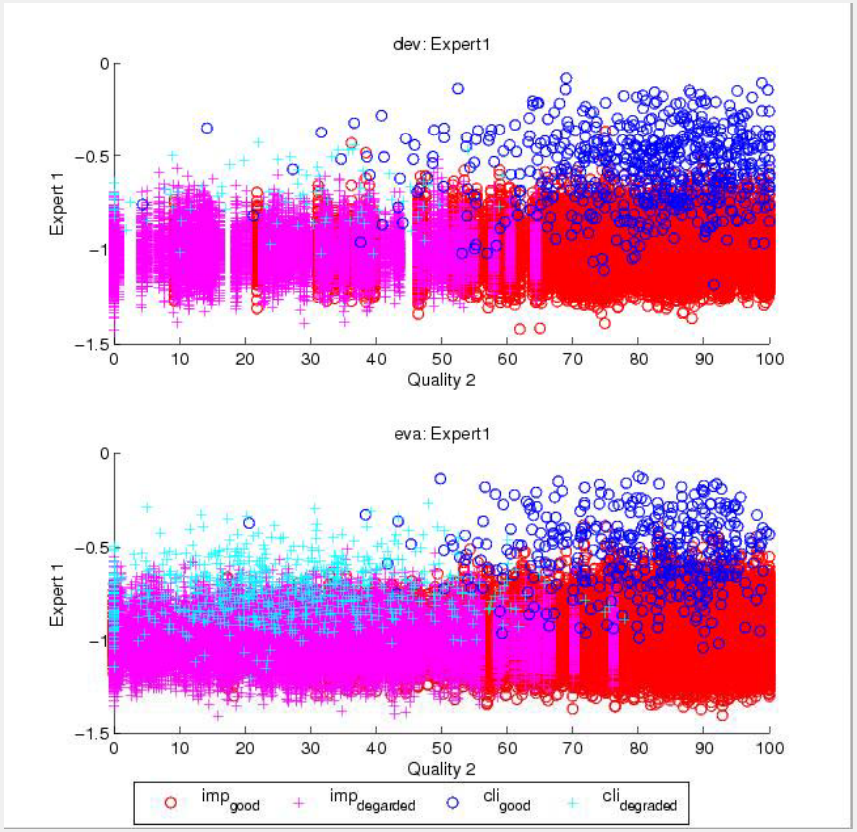
- global quality
- local quality
- multiple aspects of quality
- genuine/fake samples
- accuracy versus quality
  - algorithm independent quality measures?
- quality controlled fusion mechanisms

Confidence-based Fusion Algorithms

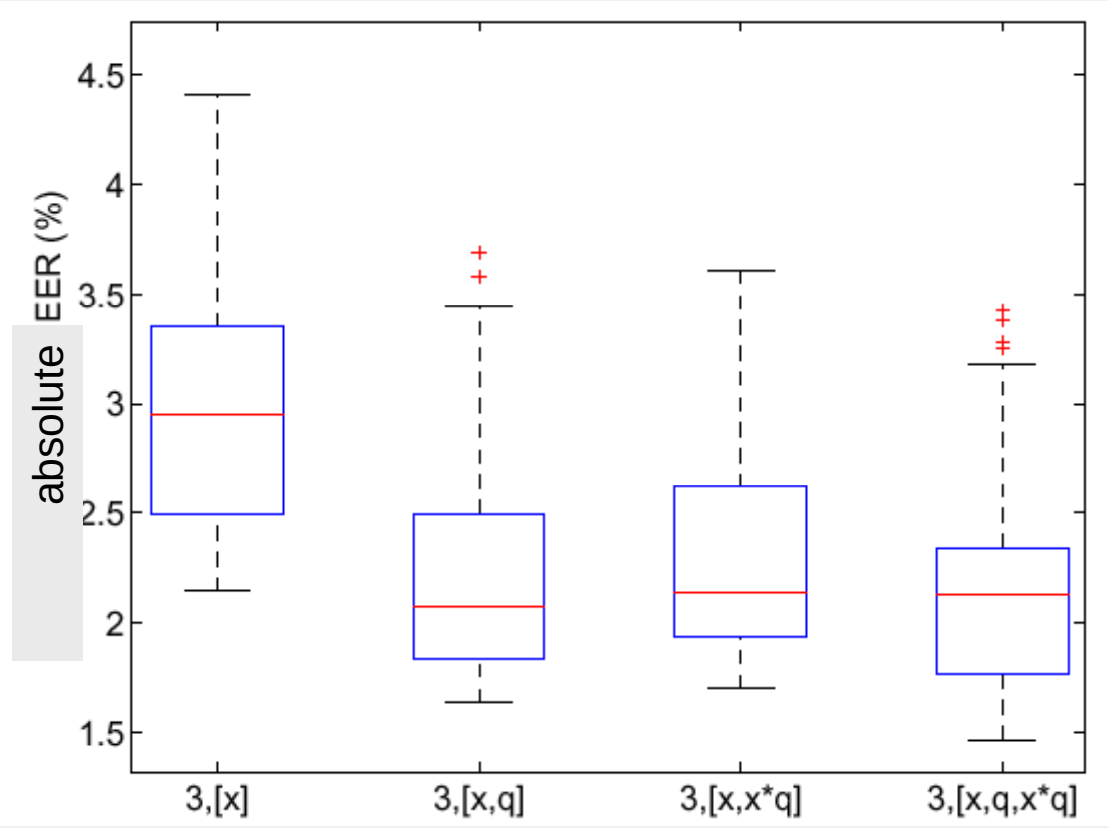


Face Expert 1





Analysis of Multimodal Fusion (I)



Biomeric sample quality: issues

- Quality is relative
- Class separability is algorithm dependent
  - Illumination

  - Pose

Quality-based fusion: issues

- Quality of biometrics is multi-facetted
- The use of too many quality measures can cause over fitting
- Independence assumption
- How should a biometrics expert assess its own competence
- How should quality information control the fusion process
- Algorithm dependent ambiguity
- Fusion architecture

Conclusions

- Multiple classifiers provide a powerful basis for improving the performance of biometric systems
- Quality dependent fusion (QDF) in mulitmodal as well as intramodal biometric fusion shows promise
- Many key issues in classical fusion of biometric experts (accuracy-diversity trade-off) and QDF remain open
- Other design issues need to be considered