Multibiometric Traits of Identical Twins

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Introduction

- Twin birth rate: 32.2 per 1000 births in the United States (2005)[1]
  - Increased at a rate of 3% per year between 1990 and 2004
  - Causes: use of fertility drugs, older age at childbearing
- (2006) Rape case in Boston, MA[2]
  - Two mistrials
  - Key evidence: DNA
  - Confusion: identical twin brother

Jody Emery

Dr. Fernando
Cardiologia

[1]Martin et al., "Annual Summary of Vital Statistics: 2006," Pediatrics, 788-801 (2008)

[2]http://www.foxnews.com/story/0,2933,188801,00.html

http://www.scribd.com/doc/313998/Jornal-Impressao-Digital

Introduction

- Carjacking case in Georgia[1] (2010)
  - DNA (wrong twin arrested)
  - Fingerprint & cell phone records identified the correct twin
- Health care fraud
  - Identification based on photo ID
  - Similarity of identical twin's faces
  - Health insurance companies in Brazil use fingerprint for authentication

Ability of biometric systems to distinguish identical twins is important and necessary

[1]http://homelandsecuritynewswire.com/identical-dna-problem-georgia-police-which-identical-twin-committed-crime

http://www.scribd.com/doc/313998/Jornal-Impressao-Digital

Fingerprint Discriminability

- Individual characteristics of friction ridge skin are determined during the 7th week of gestational age

- Minor changes in the microenvironment and/or position of the fetus cause the minute skin structures on finger tips to differentiate

- This explains the difference even in fingerprints of identical twins
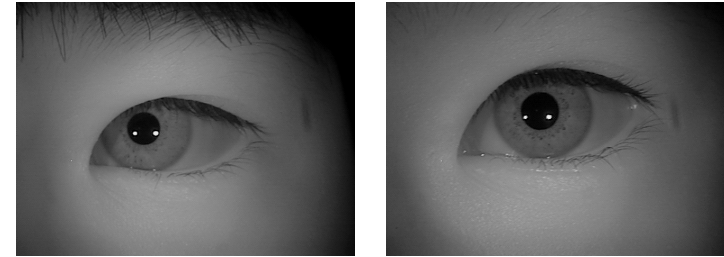
Fingerprints of an identical twin pair

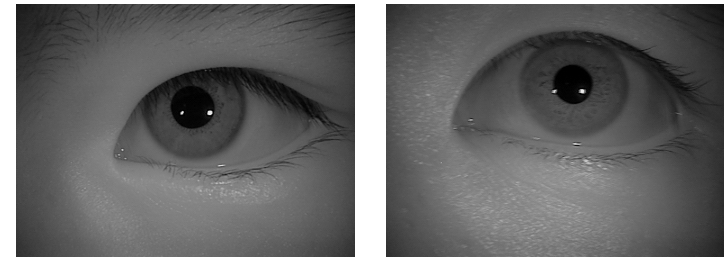Fingerprints of two unrelated persons

Iris Discriminability

- Iris texture pattern is formed and becomes stable after the eighth month of gestation

- Formation of iris pattern is believed to be determined by the gestation environment

- Our study and a more recent one[1] (2010) indicates that iris of identical twins are more similar than iris of unrelated persons
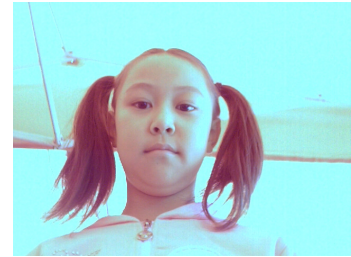

Iris images of an identical twin pair

Iris images of two unrelated persons

1 Hollingsworth, K.; Bowyer, K.; Flynn, P. Similarity of Iris Texture between Identical Twins. *CVPR 2010*.

Face Discriminability

- Face is composed of (i) skull characteristics and (ii) musculature and associated soft tissue

- Facial skeleton = framework for the musculature

- Facial form is also influenced by gender and age

- Muscles vary in their presence, form, location, and control, which change a person's face with aging

- Identical twins are more likely to be distinguished when they are older

Face images of a young identical twin pair
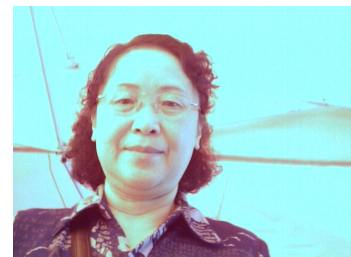
Face images of an older identical twin pair

Previous Studies

These studies focused only on individual biometric traits

Biometric trait	Database size	Correlated?*	Distinguishable?**
Palmprint [5]	53 sets	*Yes*	*Yes*
Fingerprint [4]	94 sets	-	*Yes*
Fingerprint [9]	66 sets	*Yes*	*Yes*
Fingerprint [10]	298 sets of twins	*Yes*	*Yes*
Face (3D) [11]	1 pair	-	*Yes*
Speech [7]	49 sets	-	*Yes*
Speech [13]	12 sets	*Yes*	*Yes*
Iris [8]	6 pairwise comp.	*No*	*Yes*
Iris (UND)	76 pairs	*Yes*	*Yes*

* Similarity of the trait between identical twins is greater than the similarity between unrelated persons.

** Identical twins could be distinguished, with a slight drop in recognition performance.

Data collection

- Database collected during the twin festival in Beijing (2007)
- 51 sets of identical twins and 15 sets of non-identical twins
  - face, 4 fingerprints, and 2 iris images for each subject
- Average age of subjects: 17 (range 5-65)
- The only multibiometric twin database that we are aware of

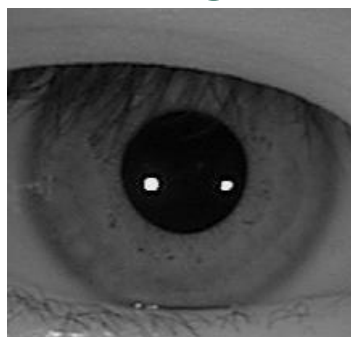Kiosk for biometric acquisition

Face acquisition device

Biometrics of twins

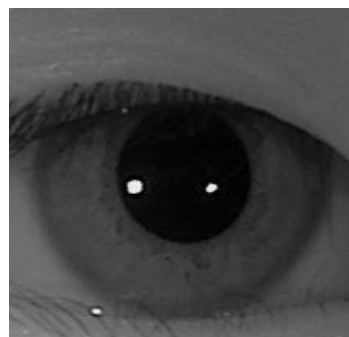- Iris and fingerprint are claimed to be unique for identical twins

Iris

Template **Identical Twin** **Unrelated Person**

Fingerprint

Template **Identical Twin** **Unrelated Person**

Face
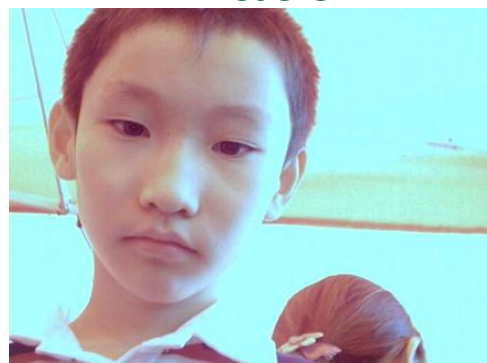
Template **Identical Twin** **Unrelated Person**

Experiments

- Matches performed
  - Genuine matches: 134
  - Identical twin impostor matches: 102
  - General impostor matches: 17,720

- Matchers used
  - Face: FaceVacs from Cognitec
  - Fingerprint: VeriFinger from Neurotechnology
  - Iris: CASIA matcher

Image 1 of subject A1

Image 2 of subject A1

Image 1 of subject A1

Image 1 of subject A2

Image 1 of subject A1

Image 1 of subject B1

Unimodal and Multimodal Biometrics
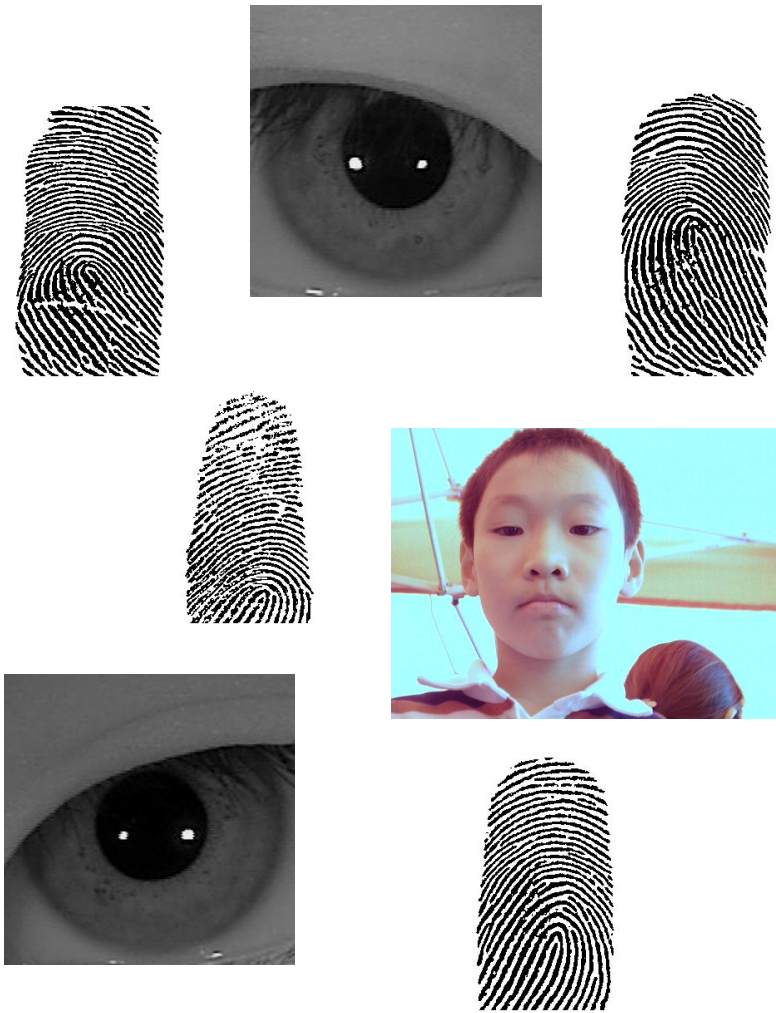
Unimodal experiments: one finger, one iris and face
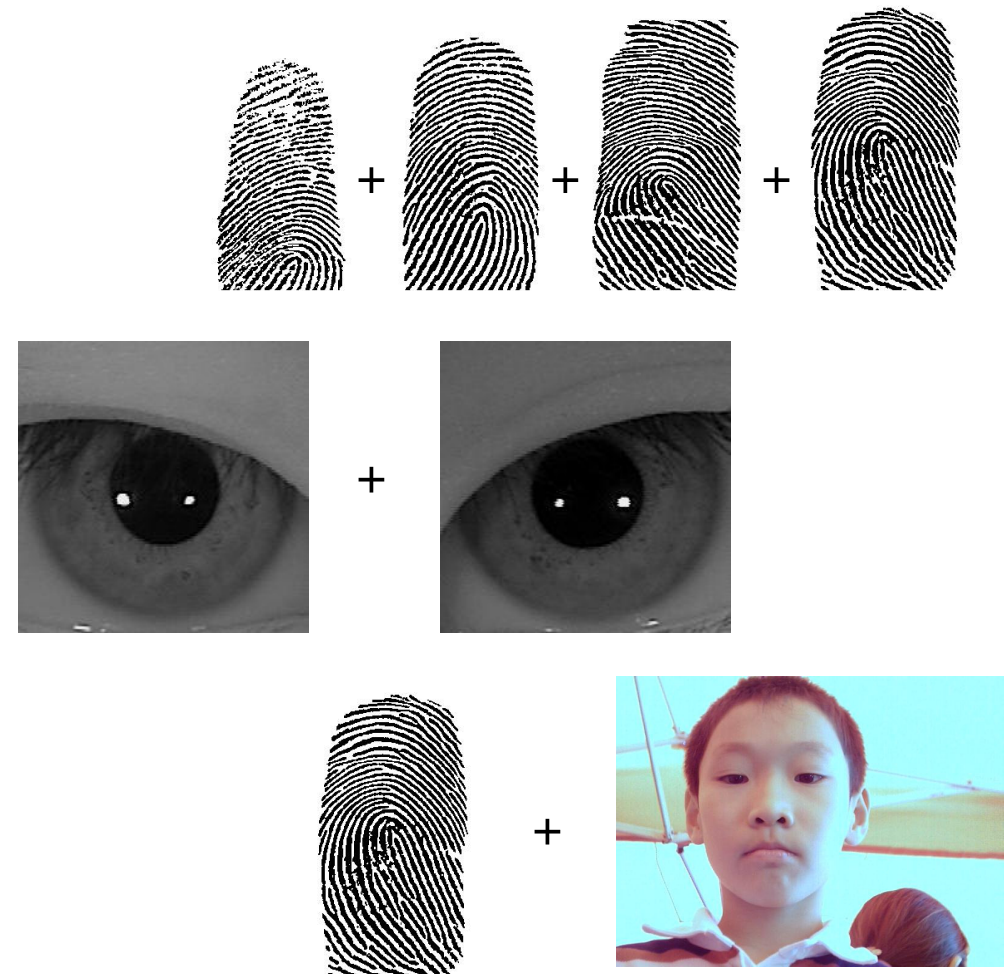
Multimodal experiments: fusion of 4 fingers, 2 irides, face + finger 4

Experimental Results

Fingerprint Results - ROC Curves

Experimental Results

Iris Results - ROC Curves

Experimental Results

FaceResults - ROC - Face
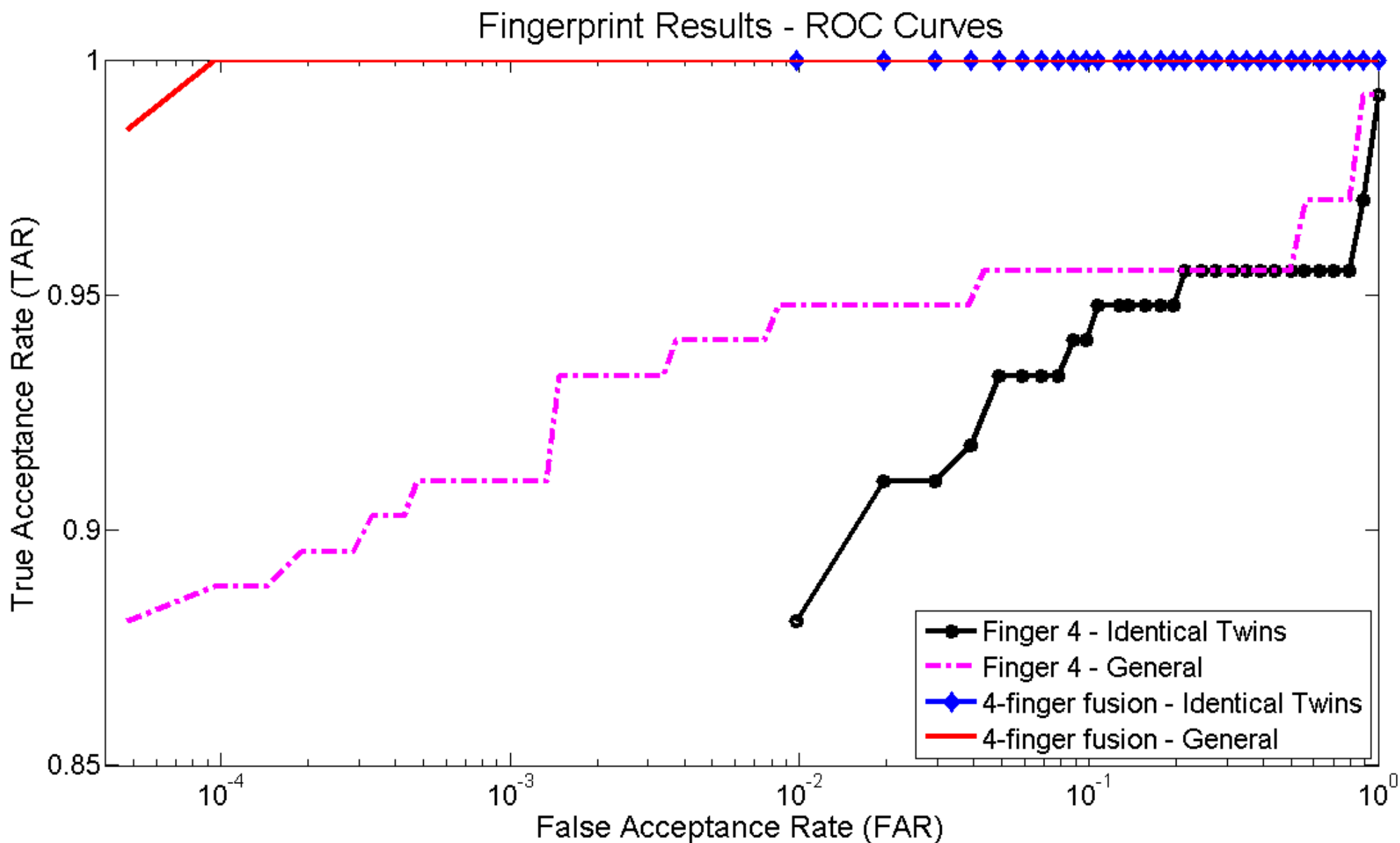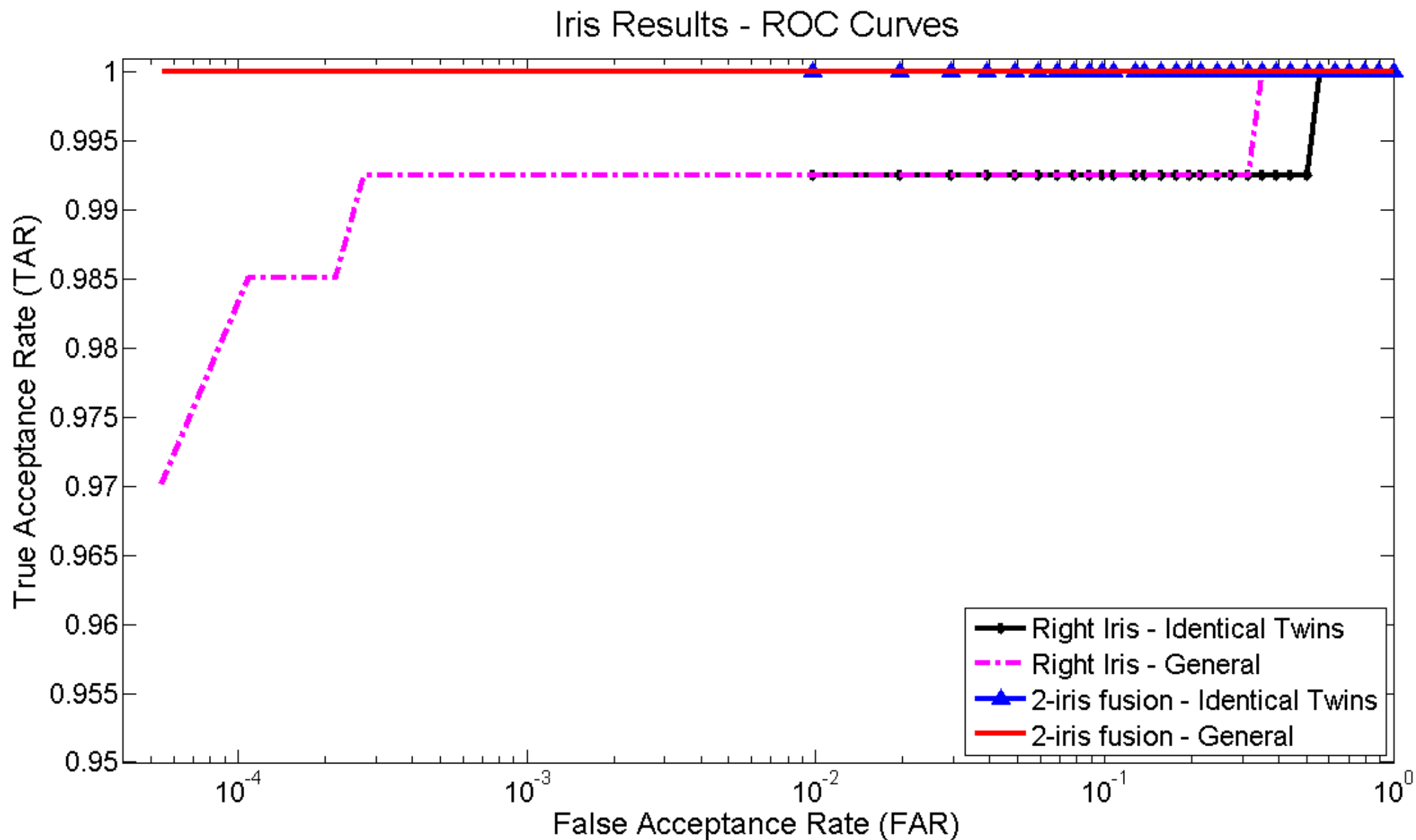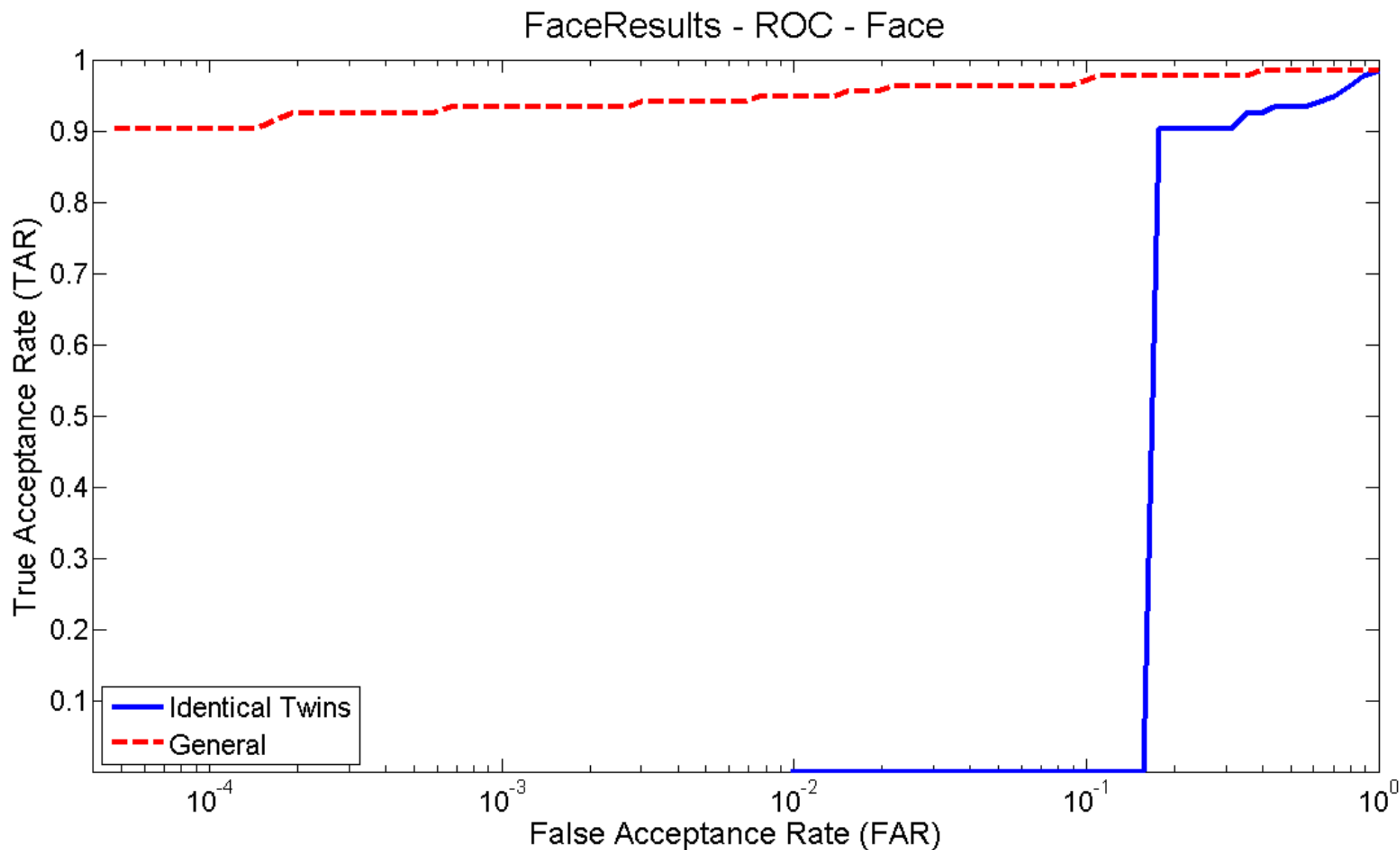
Experimental Results

Fingerprints of **identical twins** with the highest impostor match score:

34 for finger 4

Finger 4

Fingerprints of two **unrelated persons** with the highest impostor match score:

53 for fingers 3 and 4

Finger 3

Finger 4

Observation: Average number of matched minutiae
Genuine pairs: 22 (+-9.5)
Identical twin pairs: 6.44 (+-3.97)
General impostors: 4.22 (+-2.82)

Experimental Results

Iris of **identical twins** with the highest impostor match scores:

0.59 for left iris and **0.58** for right iris

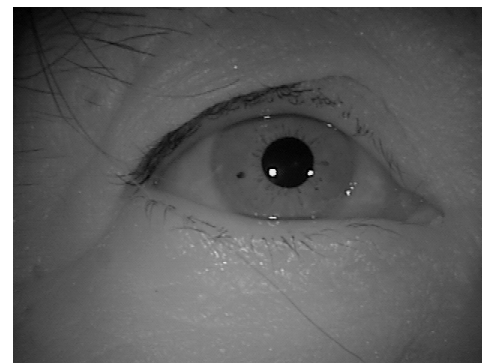
Left iris
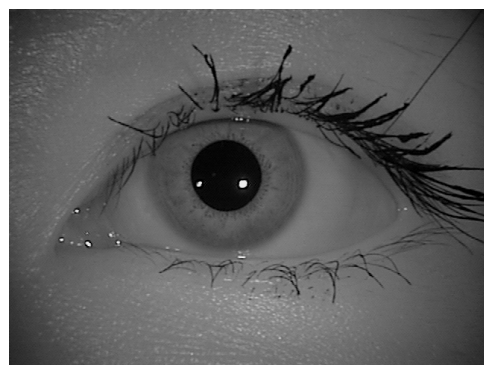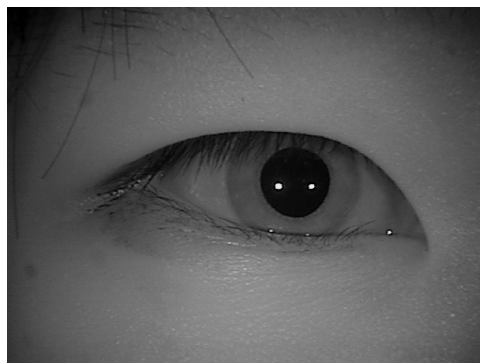
Right iris

Iris of two **unrelated persons** with the highest impostor match scores:

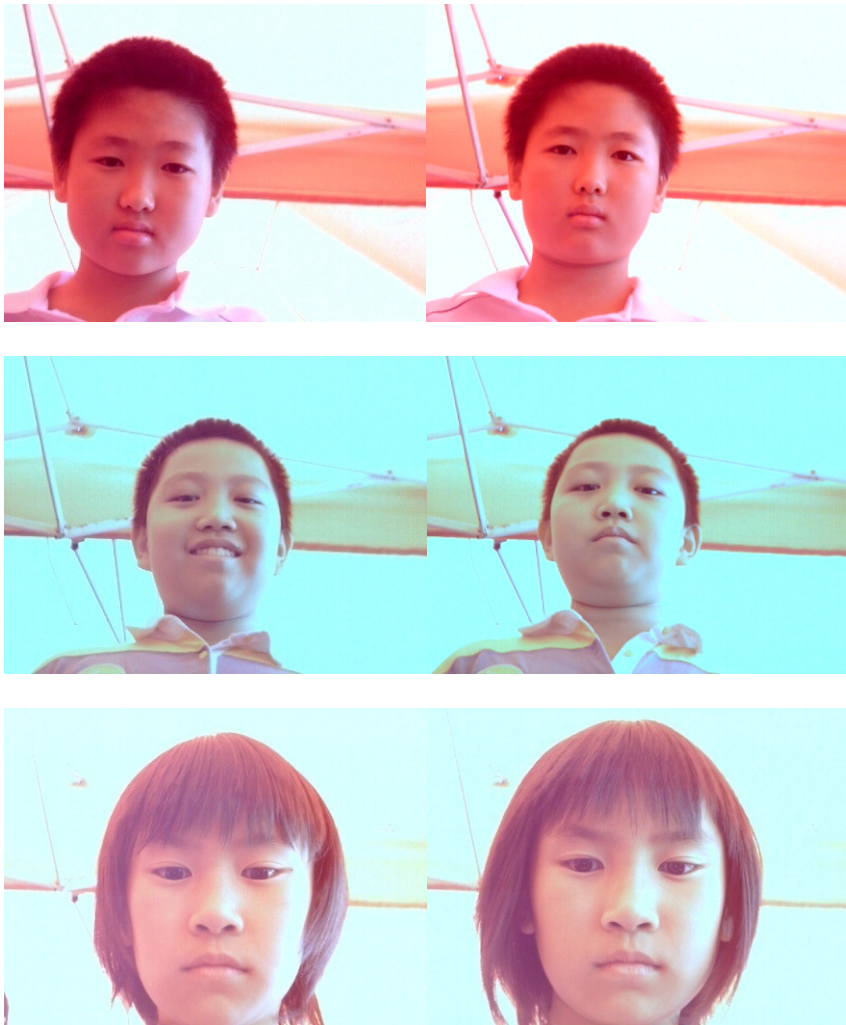**0.59** for left iris and **0.61** for right iris
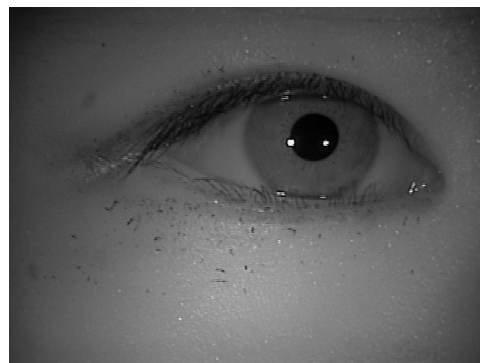
Left iris
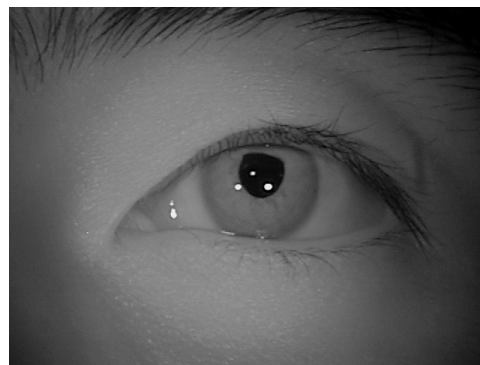
Right iris

Experimental Results

Faces of **identical twins** with the highest impostor match score:

0.999 for face

Faces of two **unrelated persons** with the highest impostor match scores:
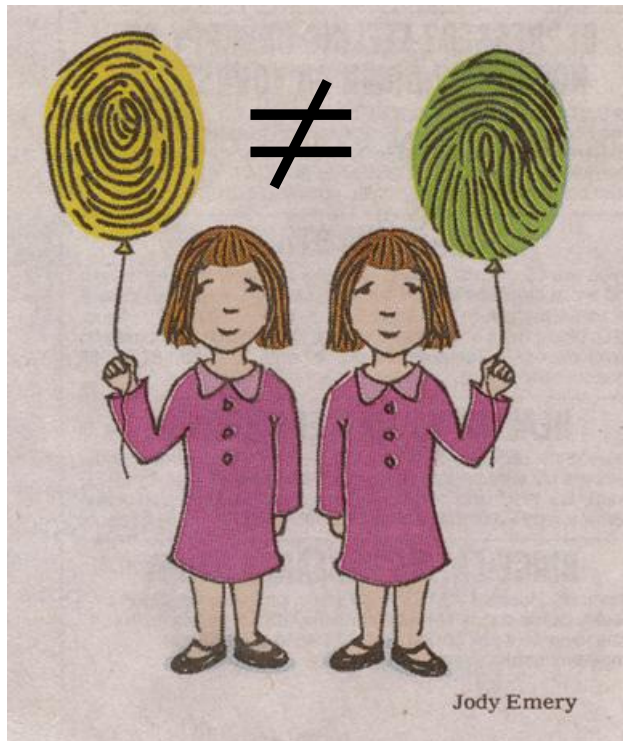
0.998 for face

Conclusions (Unimodal)

Can identical twins be distinguished
by current biometric systems?

Face

Not distinguishable by
current face recognition
systems

Fingerprints
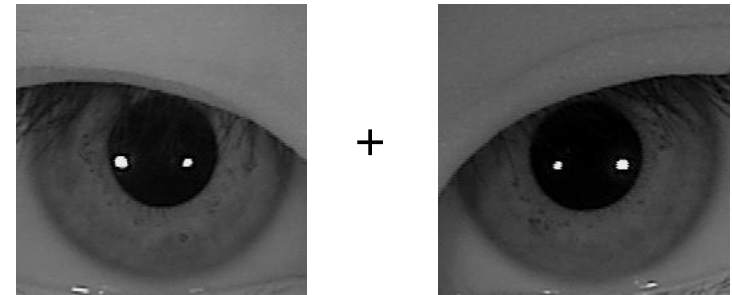
Distinguishable,
although more
similar

Iris

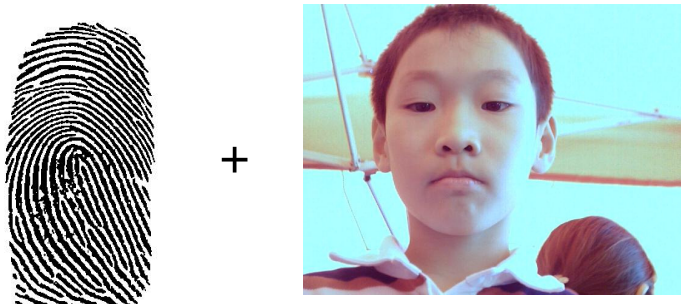Distinguishable, although
might be more similar

Jody Emery

Conclusions (Multimodal)

Can identical twins be distinguished
by current biometric systems?

4-finger or 2-iris

Almost completely distinguishable

One Finger + Face

Worse than or equal to one finger alone

Ongoing and Future work

- Analyze and compare fingerprint pattern type (whorl,..) between twins

Fingerprints of identical twin 1

Fingerprints of identical twin 2

Ongoing and Future work

- Analyze and compare fingerprint pattern type (whorl,..) between twins

Fingerprints of

non-identical twin 1

Fingerprints of

non-identical twin 2

Ongoing and Future work

- Perform experiments with a new multibiometric twin database
- Improve the performance of face recognition systems for identical twins
  - Use face marks to distinguish identical twins
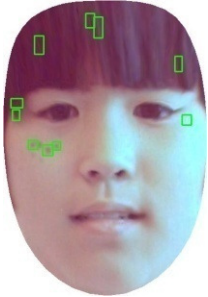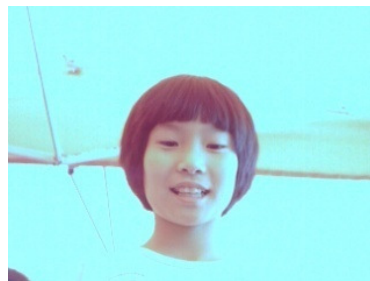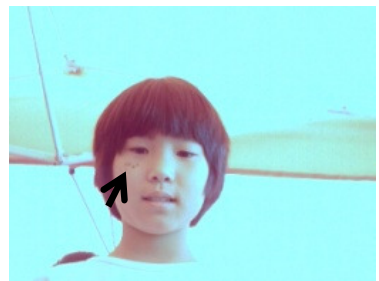 - Initial results:

Distinguishing Identical Twins using Facial Marks

- Fusion of FaceVACS + facial marks can sometimes help distinguish identical twins
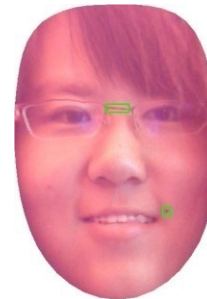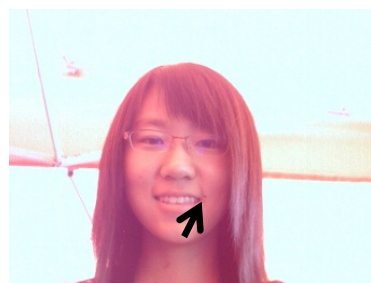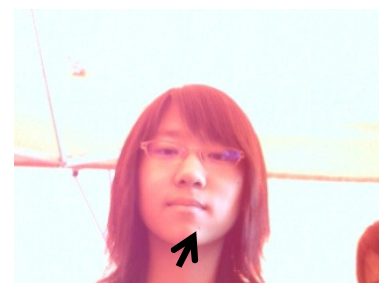
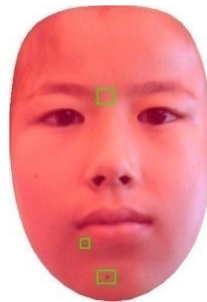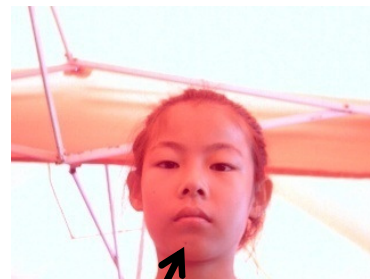|	Rank	
	FaceVacs	**+ face marks**
	1	5
	1	1
	1	45

A. K. Jain and U. Park, "Facial Marks: Soft Biometric For Face Recognition", *Proc. International Conference on Image Processing*, Nov., 2009.

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