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(classic)

https://www.youtube.com/watch?v=zV-Y0GBL5D8

(modern)

Face Recognition and Identical Twins

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Thanks to …

- Richard Vorder Bruegge
- FBI, TSWG, IARPA, ODNI and ARL
- Jonathon Phillips, Patrick Flynn, Soma Biswas, Patrick Grother, George Quinn, Jeff Paone, Karen Hollingsworth, Vipin Vijayan, Matt Pruitt, Jason Grant, …

Welcome to the 6th IEEE AMFG!

Towards Extreme Face and Gesture Analysis for Social Media

(a) (b)

Figure 1. Examples of identical twin pairs from the 2009 Twins Day collection [18]. Each pair of images in (a) and (b) are two different subjects who are identical twins. Distinguishing between pairs of identical twins is one of the more challenging problems in face recognition.

Distinguishing between pairs of identical twins is one the more challenging problems in face recognition.

Klare, Paulino and Jain, *IJCB 2011*.

Twins and Identity Science

Biology

Why and to what extent are twins different ?

Biometrics

How to better distinguish twins ?

(face, iris, finger, palm, ear, …)

Psychology

How do people distinguish twins ?

Frequency of Twins

- Twin birth rate: 33.7 per 1,000 live births in US in 2013 (CDC stats).
- About ¼ of twins are “identical”.
- More frequent for older mothers, and with use of fertility drugs.
- Becoming more frequent overall.

Fraternal Twins

- Two different fertilized egg cells (zygotes), “dizygotic”, DZ.
- Share 50% of genes.
- No more genetically alike than non-twin siblings.

“Identical” Twins

- Fertilized egg cell splits into two.
- Two individuals with same genetic makeup, “monozygotic”, MZ.

But identical twins are not necessarily identical in appearance.

“Mirror” Identical Twins

- Single fertilized egg cell splits later than regular identical (at 9-12 days).
- Physical asymmetries expressed opposite: left / right handed, mirror-image dental irregularities, …
- About ¼ of MZ twins are mirror.

Mirror Twins
Fascinating Facts About Mirror Image Twins

Mirror twins (also known as mirror image twins) are one of the most fascinating types of twin pairings of the 100 million+ twins all around the world. It's a interesting concept and refers to twins who, when facing each other, appear as matching reflections.

Identical and Non-Identical Twins

The majority of twins are not the rare mirror twins. Fraternal twins win the title of most common. Also known as dizygotic, fraternal twins are created from the fertilization of two separate eggs by two separate sperms. The resulting twins have half of the same DNA, the same as any other sibling, and may or may not have similar physical features.

http://www.twin-pregnancy-and-beyond.com/mirror-twins.html

Point to remember:

Reports of 100% accuracy on images of a few sets of twins may be an accident of the twins being mirror twins.

Where / how do you get images of identical twins ?

www.twinsdays.org

Twins Days Festival in Twinsburg, Ohio

The World's Largest Annual Gathering of Twins! Next Festival: Aug 7-9, 2015

GENERAL INFO | TWINS DAYS TIMES | 2015 FESTIVAL INFO | TWINS DAYS PRE-REGISTRATION | PICTURES | CONTACT

Welcome

Come celebrate Twins Days' 40th!

The Twins Days Festival in Twinsburg, Ohio is the largest annual gathering of twins (& other multiples) in the world! 2015 marks a major milestone for the Twins Days Festival and its twin family...its **40th festival**!

Twins Days Festival - Official
Like 13,808

Follow @TwinsDaysFest 965 followers

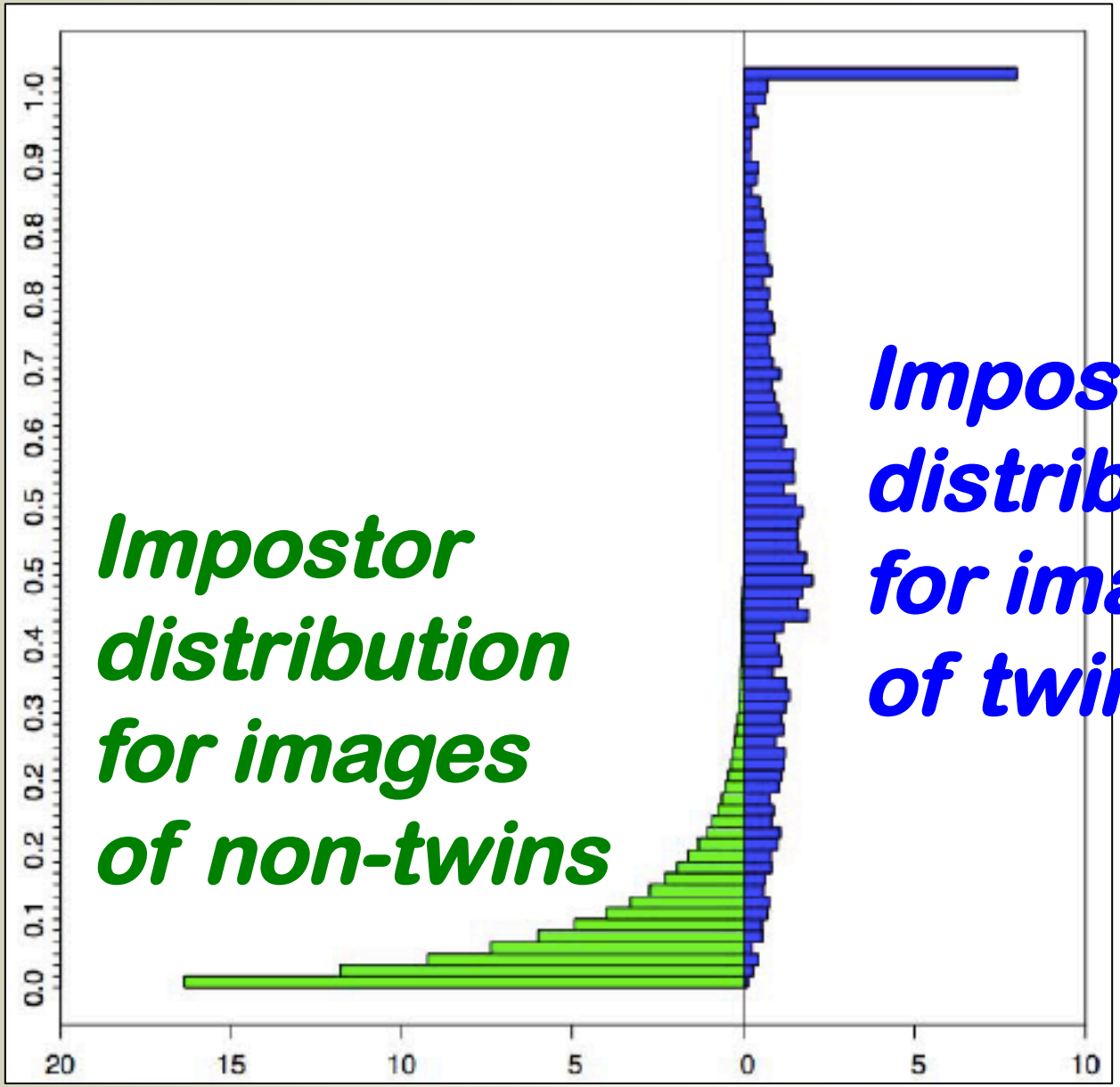
https://www.youtube.com/watch?v=uQJH64QyzPs

- **ND-TWINS-2009-2010.** The data set contains 24050 color photographs of the faces of 435 attendees at the Twins Days Festivals in Twinsburg, Ohio in 2009 and 2010. All images were captured by Nikon D90 SLR cameras. Images were captured under natural light in "indoor" and "outdoor" configurations ("indoor" was a tent). Facial yaw varied from -90 to +90 degrees in steps of 45 degrees (zero degrees was frontal). To obtain access to this data set, retrieve the license agreement and

- **3D Twins Expression Challenge ("3D TEC") Dataset.** The data set contains 3D face scans for 107 pairs of twins. There are 107 x 2 = 214 individuals, each with a 3D face scan with a smiling expression and a scan with a neutral expression, and so 214 x 2 = 428 total scans. The scans were acquired with a Minolta Vivid 910. To obtain access to this data set, retrieve the license agreement and forward it to your institution or

http://www3.nd.edu/~cvrl/CVRL/Data_Sets.html

How hard is it for face recognition algorithms to tell twins apart ?



Impostor distribution for images of non-twins

Impostor distribution for images of twins

EER RESULTS FOR SAME DAY ILLUMINATION

Alg.	Probe-Gallery Conditions		
	Cont.-Cont.	Cont.-Uncont.	Uncont.-Uncont.
Baseline	0.2%	0.5%	1.1%
A	4.7%	5.9%	11.5%
B	35.9%	40.7%	41.4%
C	9.0%	34.1%	32.3%
D	14.5%	20.9%	26.5%
E	10.2%	13.8%	24.0%
F	7.3%	12.4%	19.4%
G	8.0%	7.8%	16.2%

A to G = 3 top alg's in MBE 2010 + 4 commercial.

Baseline = Algorithm A with non-twin impostor pairs.

EER RESULTS FOR SAME DAY EXPRESSION

Alg.	Probe-Gallery Conditions		
	Neutral-Neutral	Neutral-Smiling	Smiling-Smiling
Baseline	0.1%	0.5%	0.3%
A	4.5%	7.0%	4.2%
B	39.4%	39.2%	40.0%
C	6.7%	37.6%	7.4%
D	22.2%	22.9%	19.9%
E	14.4%	13.5%	13.5%
F	9.4%	10.8%	9.3%
G	7.7%	8.8%	6.8%

Alg's generally seem to care little about neutral-, smiling- or mixed-expression pairs, except Alg C.

EER RESULTS FOR SAME DAY GENDER

Alg.	Probe-Gallery Conditions Male	Female
Baseline	<0.1%	0.7%
A	4.1%	8.1%
B	39.4%	39.1%
C	7.3%	35.1%
D	22.3%	21.3%
E	14.1%	16.7%
F	9.8%	13.1%
G	6.7%	11.5%

The best algorithms are *not* gender neutral, with female EER being 1.5x to 2x the male EER .

Possibly tuned on male datasets ??

EER Results for Same Day Age		
Alg.	Probe-Gallery Conditions <=40	>40
Baseline	0.8%	0.6%
A	9.6%	7.4%
B	38.4%	39.0%
C	15.5%	34.1%
D	24.3%	21.6%
E	19.4%	21.6%
F	14.5%	12.5%
G	13.5%	11.0%

Not much difference between very young and young.

Those are "same-session" results, and so are inherently "optimistic".

What about results for non-same-session ?

EER RESULTS FOR CROSS-YEAR ILLUMINATION

Alg.	Probe-Gallery Conditions Cont.-Cont.	Cont.-Uncont.
Baseline	0.8%	2.4%
A	12.8%	17.4%
B	43.3%	47.0%
C	41.9%	51.7%
D	29.8%	34.7%
E	49.3%	48.5%
F	49.3%	50.0%
G	49.5%	49.7%

Best algorithm EER on twins is 13% to 17%.

EER RESULTS FOR CROSS-YEAR EXPRESSION

Alg.	Probe-Gallery Conditions		
	Neutral-Neutral	Neutral-Smiling	Smiling-Smiling
Baseline	0.4%	2.3%	0.6%
A	8.6%	15.8%	8.1%
B	42.7%	46.0%	44.9%
C	34.8%	55.5%	35.7%
D	31.2%	32.0%	25.7%
E	48.8%	47.4%	50.1%
F	47.4%	50.0%	52.0%
G	48.4%	50.0%	49.8%

Best algorithm EER of 9% to 16%.

EER Results for Cross-Year Gender

Alg.	Probe-Gallery Conditions Male	Female
Baseline	0.6%	2.0%
A	6.5%	13.7%
B	46.7%	43.6%
C	39.7%	46.9%
D	23.6%	29.0%
E	43.9%	50.8%
F	47.1%	50.3%
G	43.5%	51.3%

Best algorithm EER of about 7% to 14%.

EER RESULTS FOR CROSS-YEAR AGE

Alg.	Probe-Gallery Conditions <=40	>40
Baseline	2.0%	1.6%
A	16.3%	14.8%
B	38.0%	44.5%
C	49.2%	45.3%
D	29.7%	31.9%
E	20.4%	23.3%
F	23.9%	22.8%
G	21.1%	20.1%

Best algorithm EER of about 15% to 16%.

Point to remember.

Twin discrimination by face recognition is hard, with lots of room for improvement that should help face recognition in general.

How do humans perform at distinguishing identical twins from face appearance ?

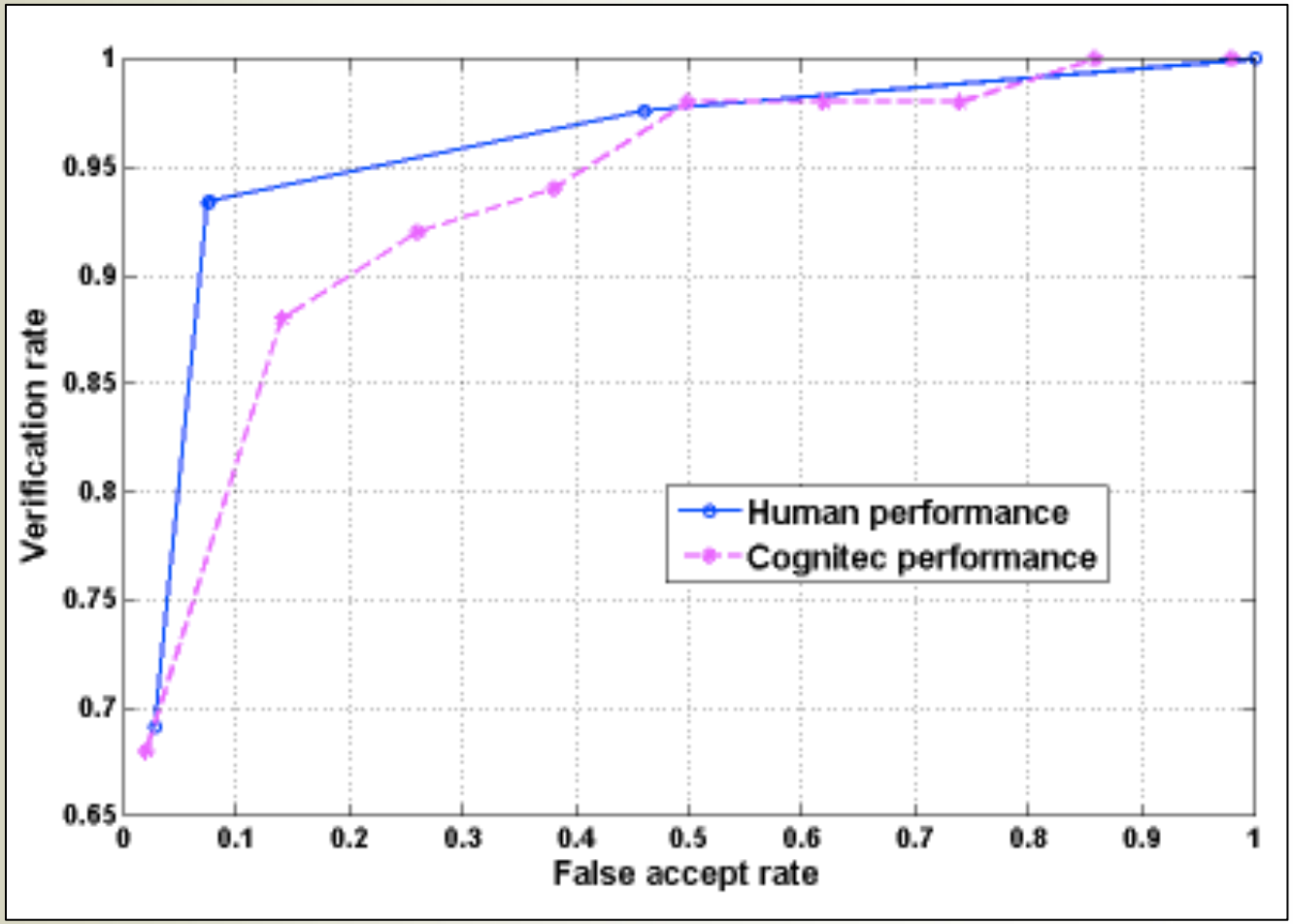
Twins or images of same person ?

Twins or images of same person ?

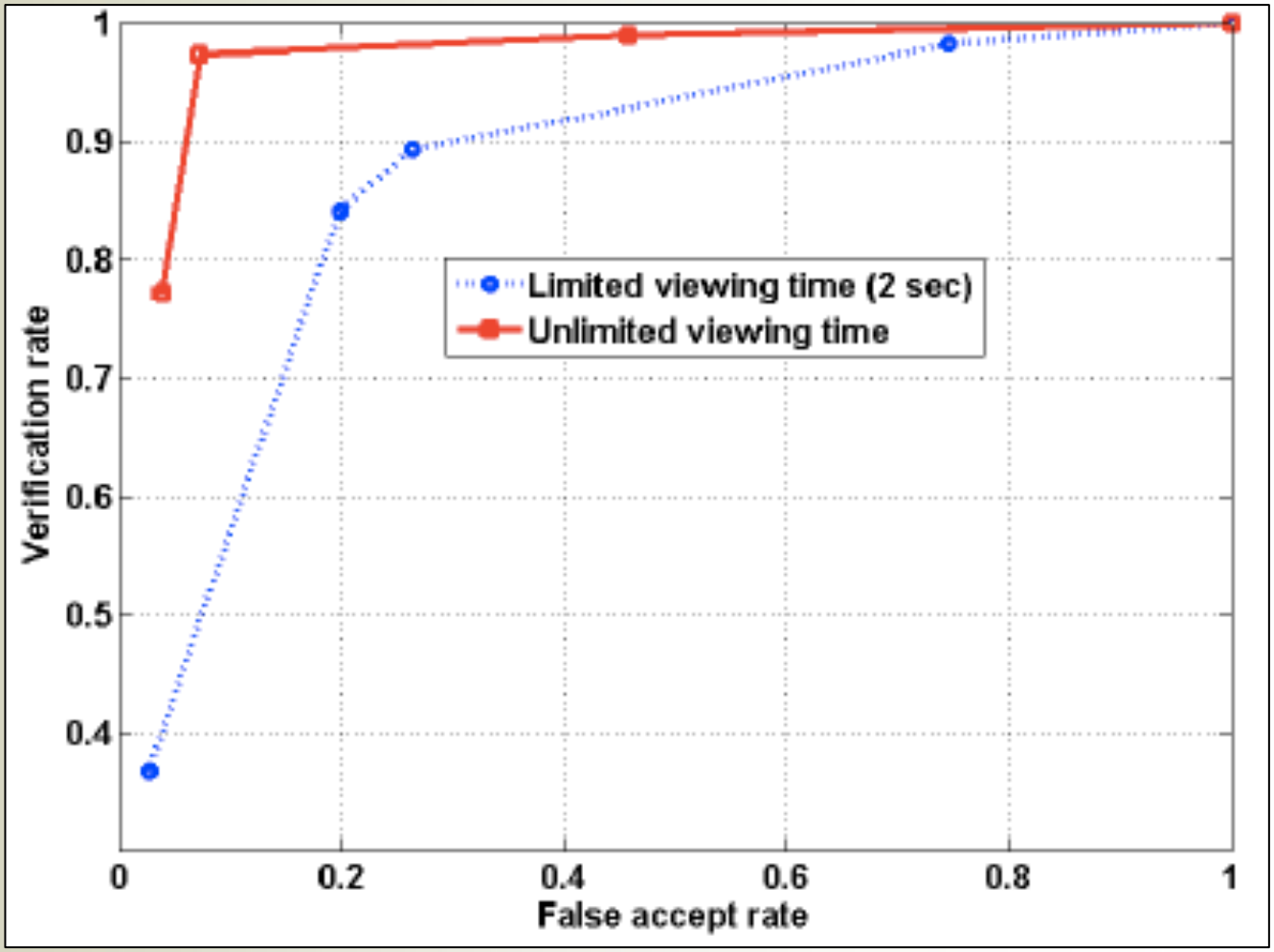
Twins or images of same person ?

Twins or images of same person ?

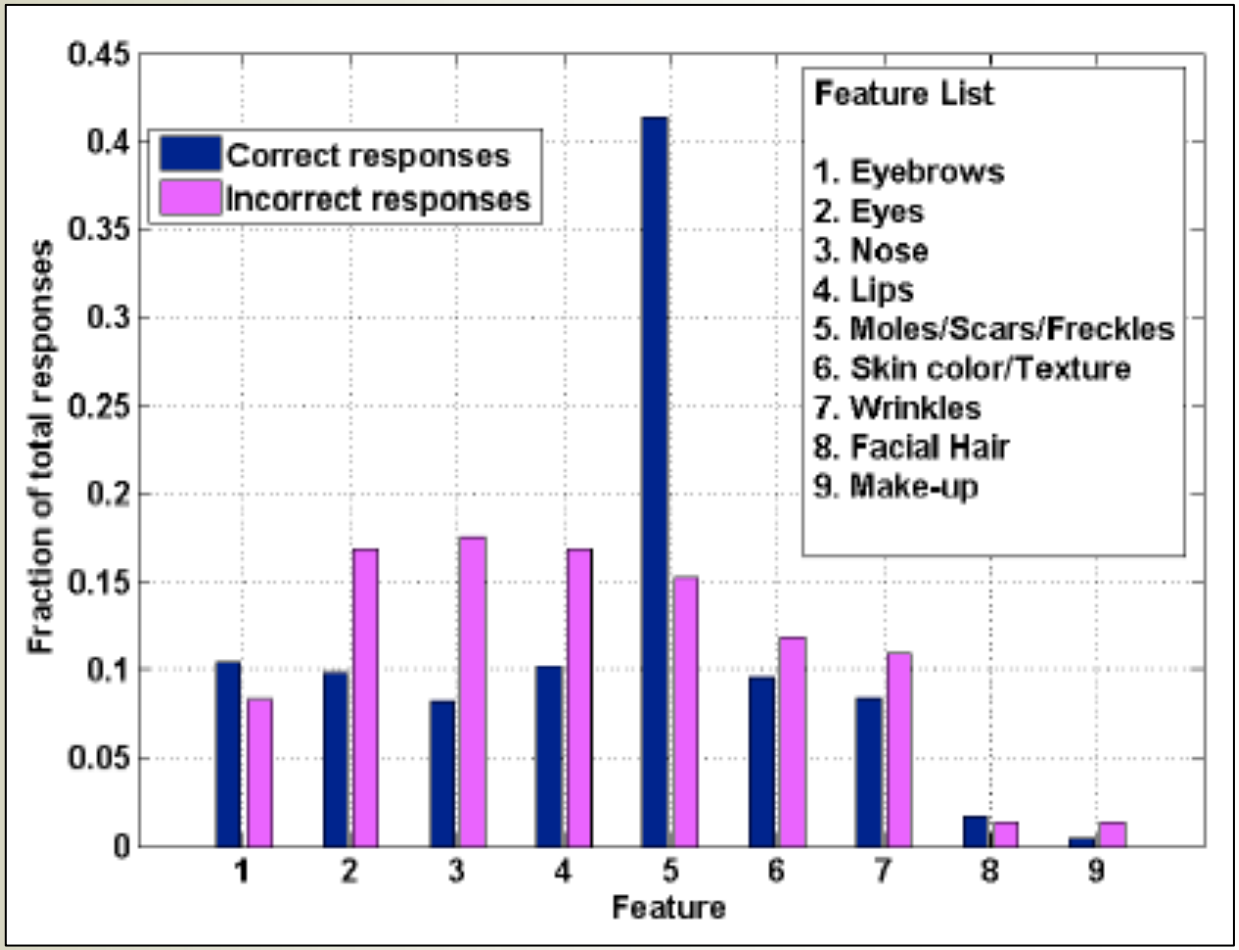
Twins or images of same person ?



Humans are more accurate than current face matching algorithms.



Humans do better with more time.



Humans appear to use skin markings as a major factor in this task.

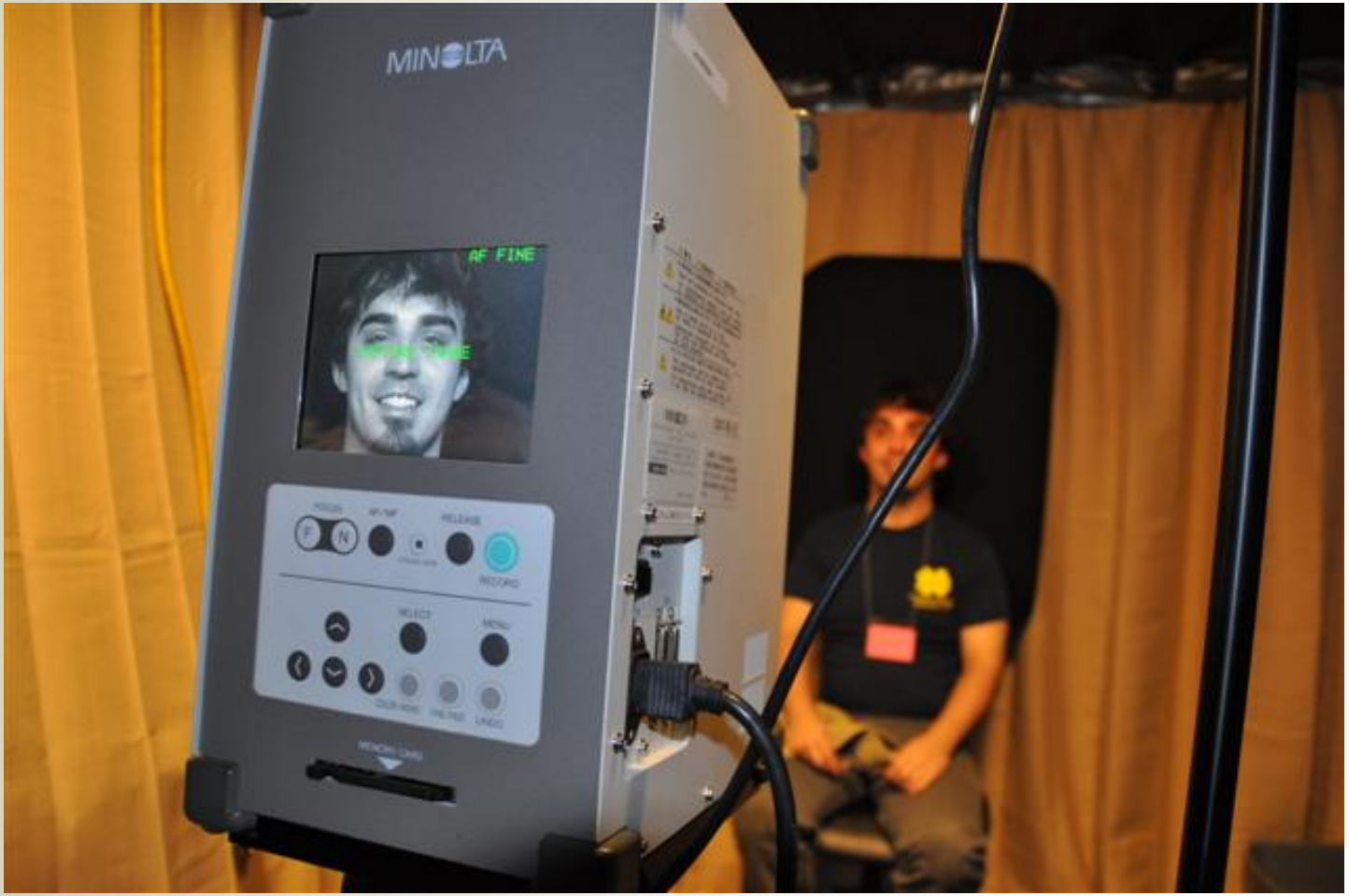
Point to remember.

Humans appear to learn to discriminate twins by interpreting skin marks in a "forensic" manner.

(This interpretation is compatible with results by Sarah Stevenage, *British Journal of Psychology*, 2011.)

What about 3D face analysis for identical twins ?

Figure 1: Images of two twins acquired in a single session. The top row shows the images obtained from one twin and the bottom row, the other twin. The left two images contain the neutral expression. The right two are of the smiling expression. (The texture images were brightened to increase visibility in this figure.)


MINOLTA
AF FINE

- Minolta 910 with “tele” lens.
- About 100K points on face.
- 107 pairs of twins.
- Smile + neutral expression.
- “Same session” data.

Algorithm	Rank-1 Recognition Rate			
	I	II	III	IV
Alg. 1 (E_{pkn})	93.5%	93.0%	72.0%	72.4%
Alg. 1 (E_{minmax})	94.4%	93.5%	72.4%	72.9%
Alg. 2 (SI)	92.1%	93.0%	83.2%	83.2%
Alg. 2 (eLBP)	91.1%	93.5%	77.1%	78.5%
Alg. 2 (Range PFI)	91.6%	93.9%	68.7%	71.0%
Alg. 2 (Text. PFI)	95.8%	96.3%	91.6%	92.1%
Alg. 3	62.6%	63.6%	54.2%	59.4%
Alg. 4	**98.1%**	**98.1%**	**91.6%**	**93.5%**

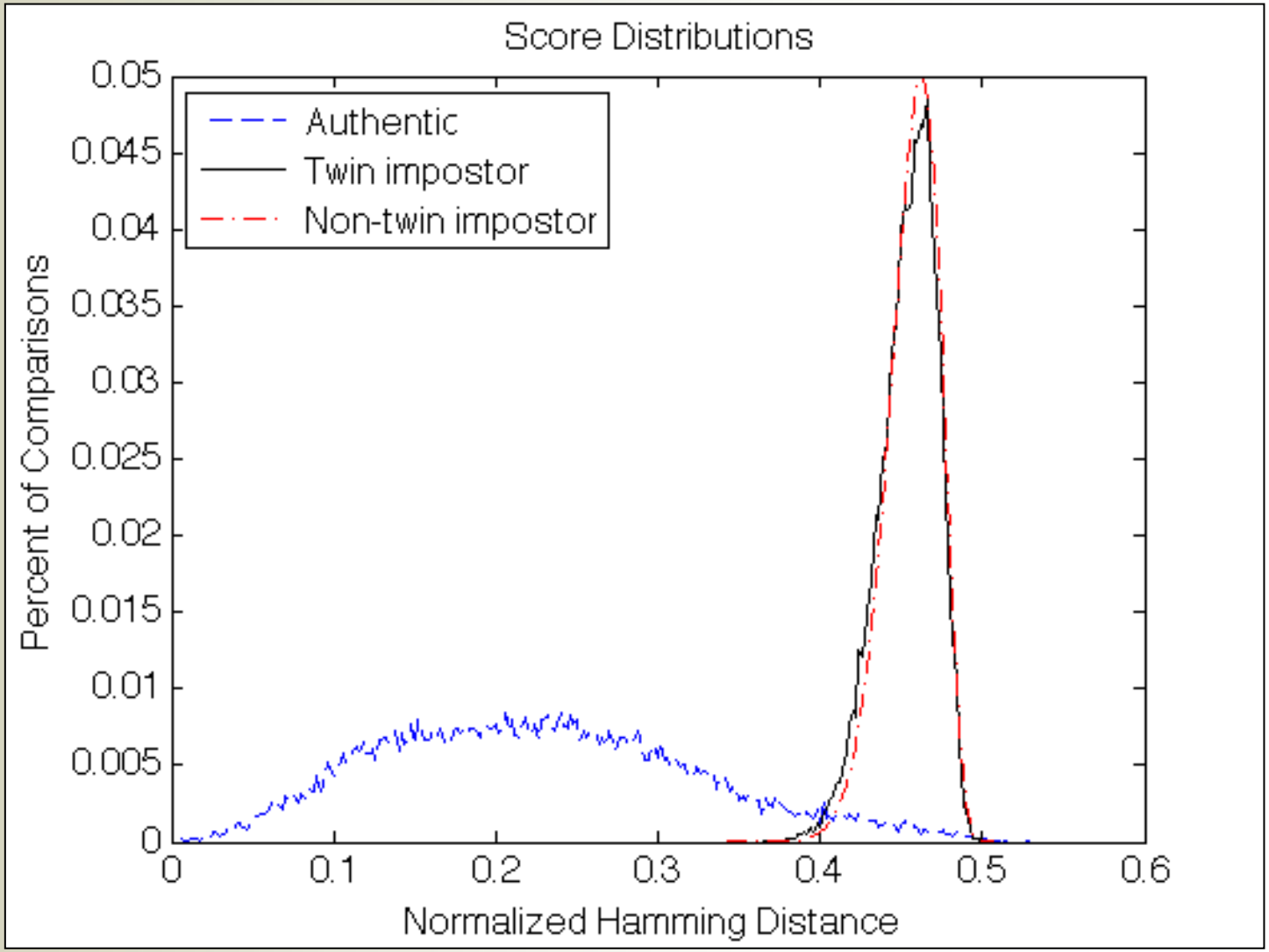
Alg. 4 = I. Kakadiaris, U. of Houston's "UR3D".

Good, but compare to performance on FRGC v2.

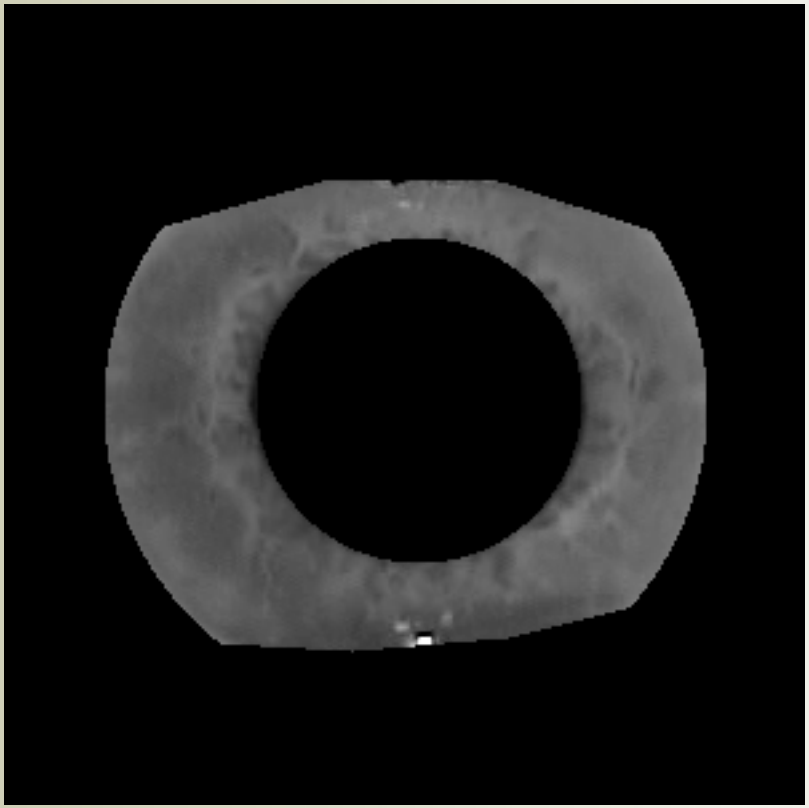
What about irises of identical twins ?

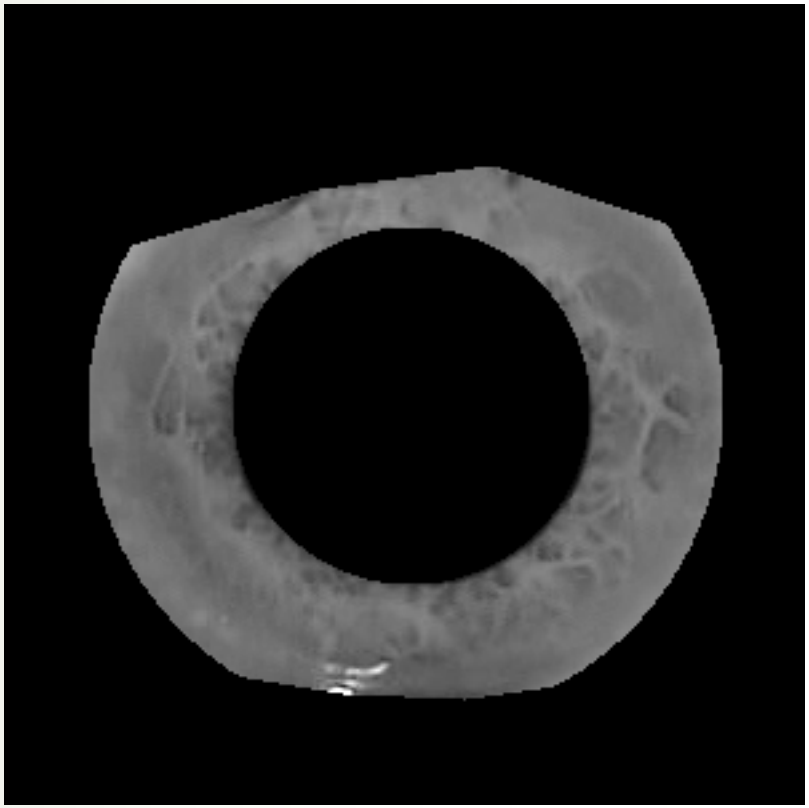
"… comparisons among the eyes of actual monozygotic twins also yielded a result expected for unrelated eyes …"

"How iris recognition works," John Daugman, *IEEE Trans CVST*, 2004.

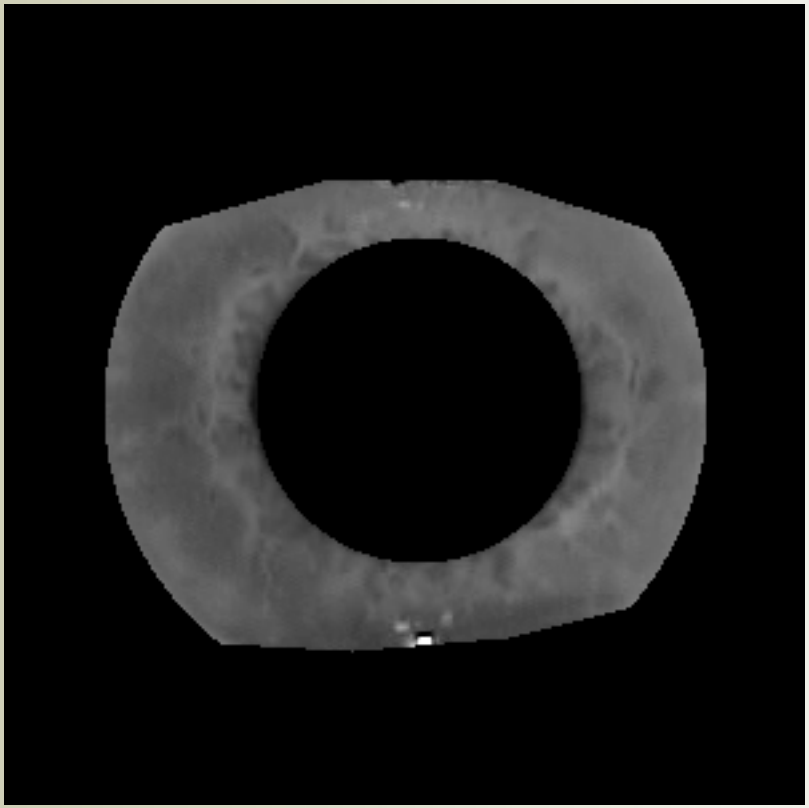


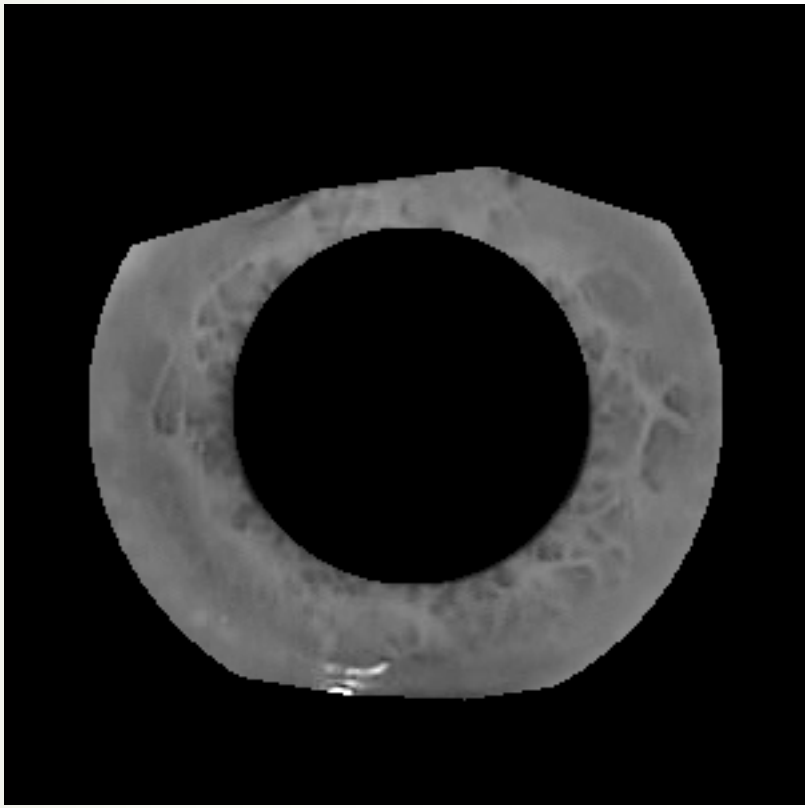
Verification of John Daugman's claim.



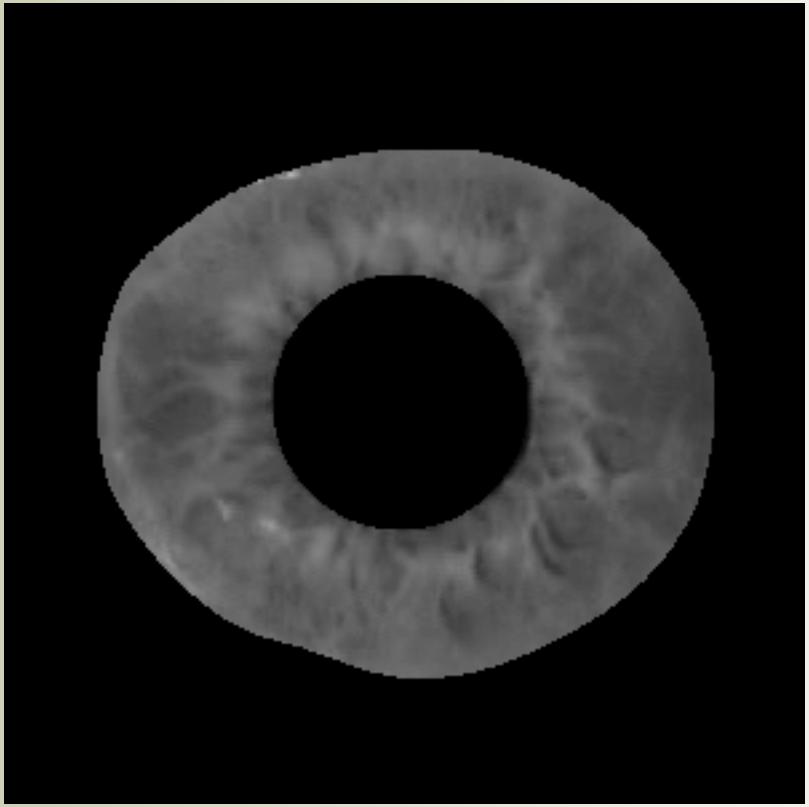


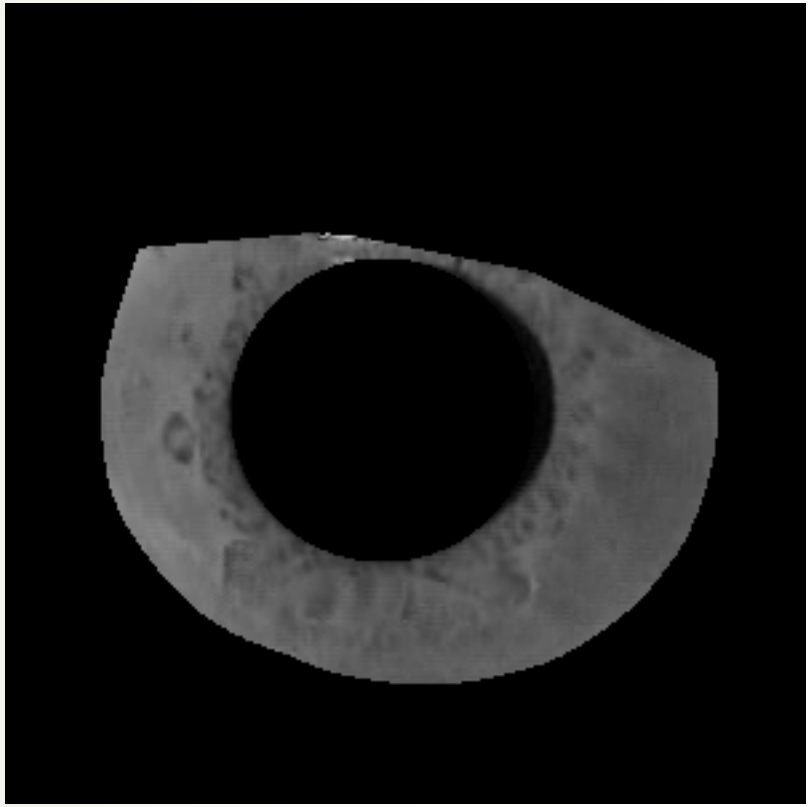
Twins or Unrelated ?



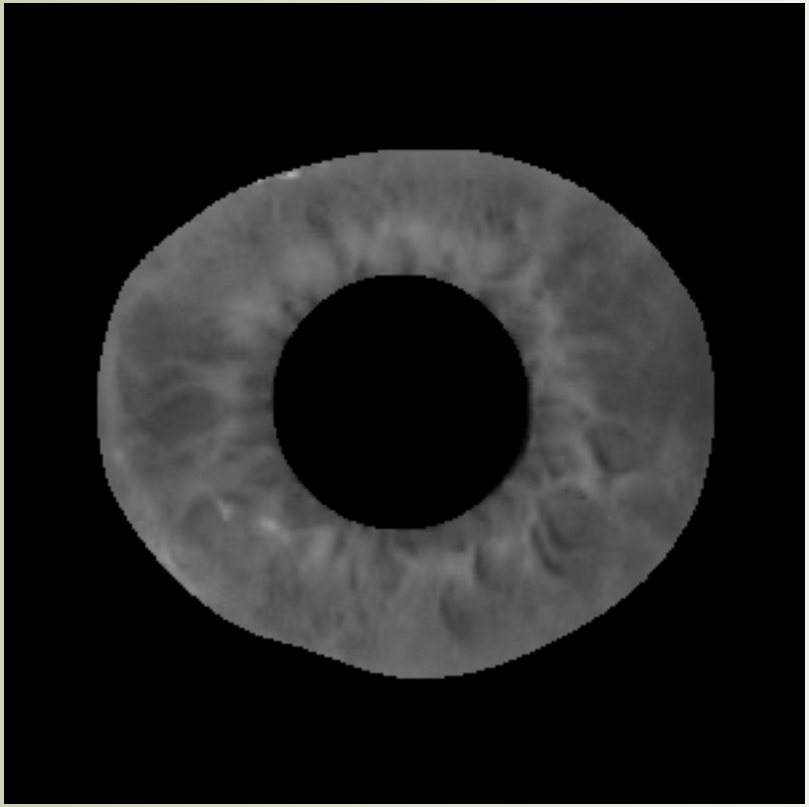


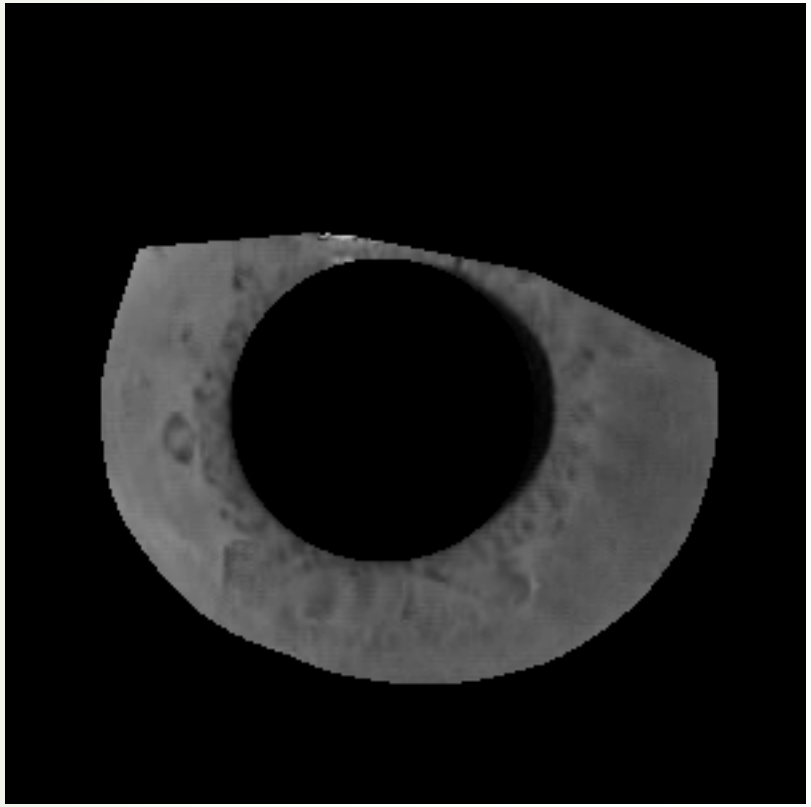
Twins.





Twins or Unrelated ?





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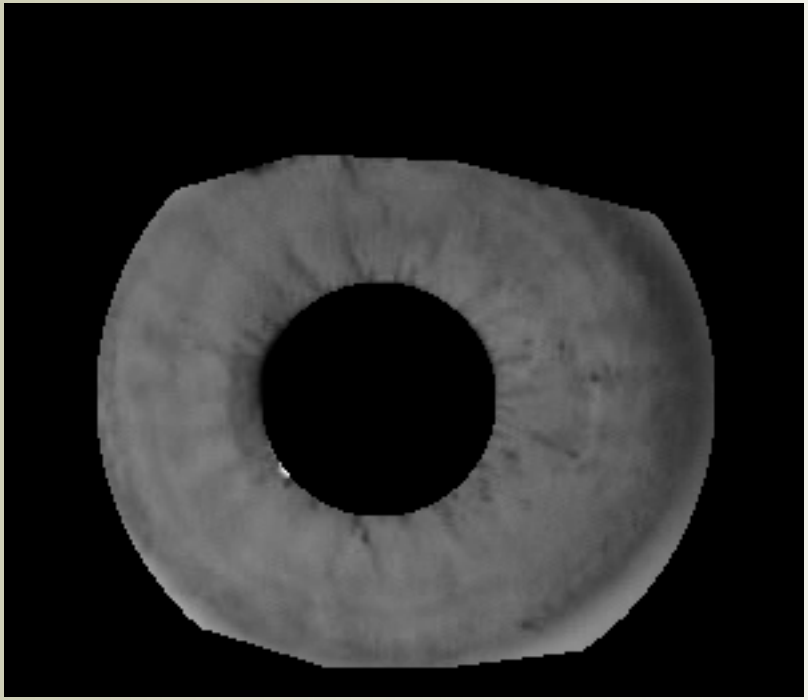
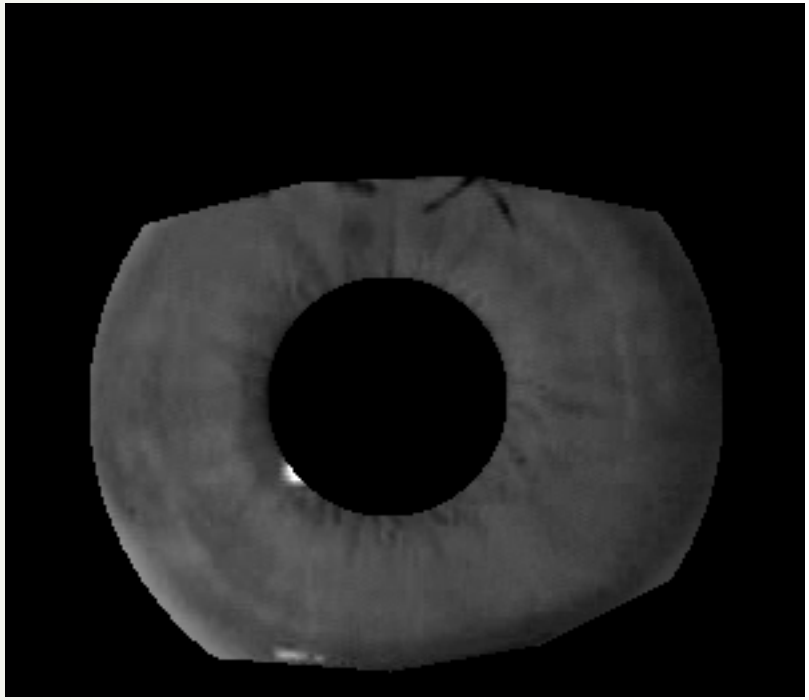
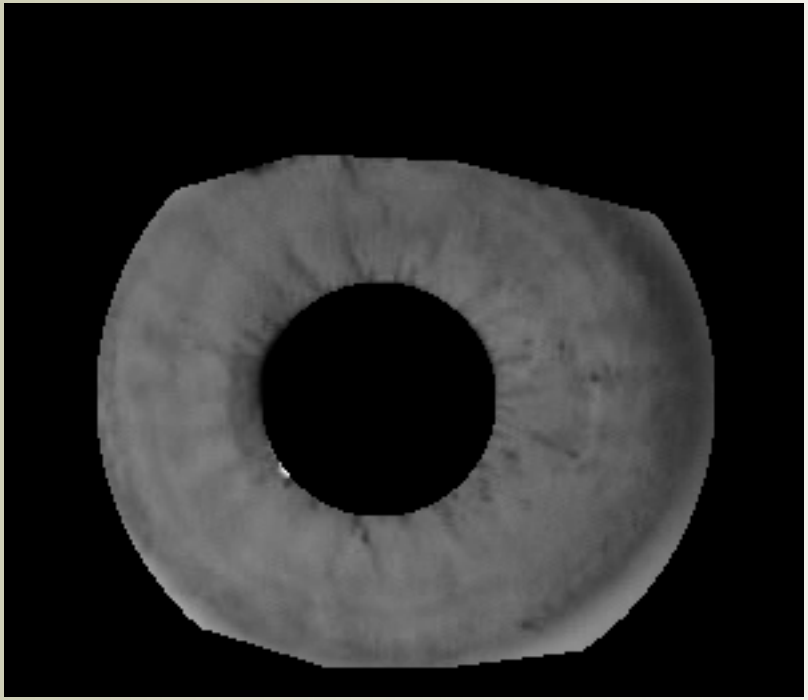
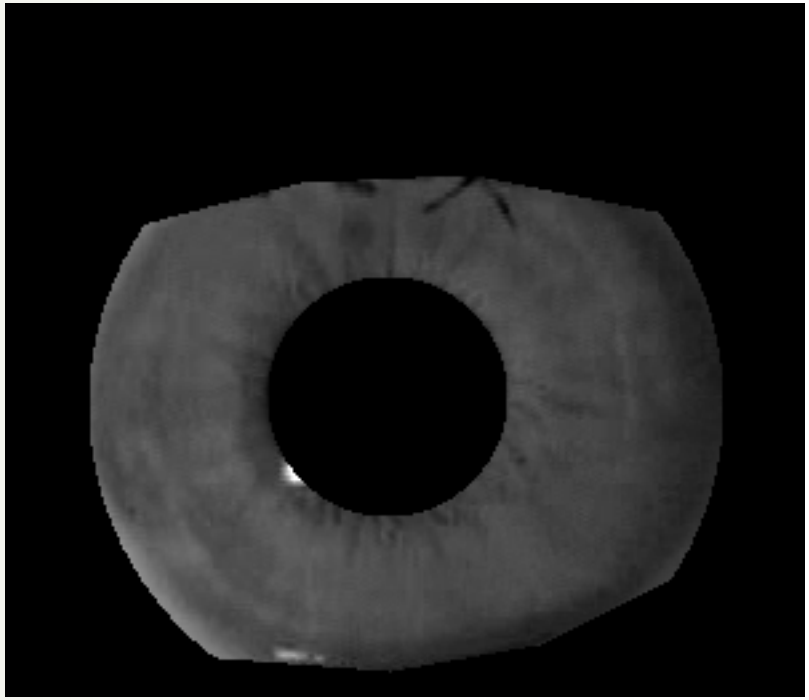


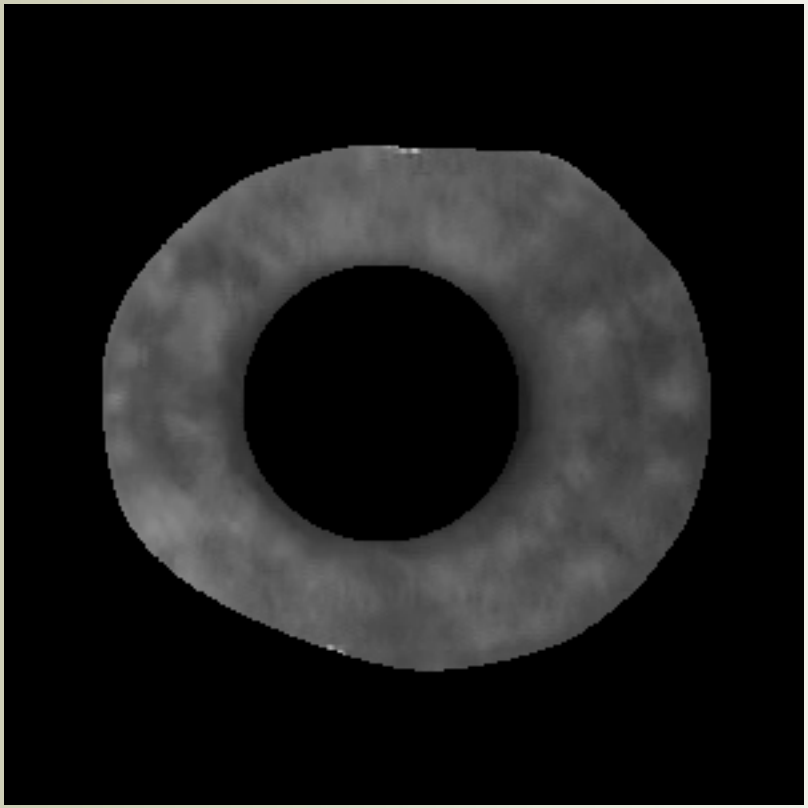


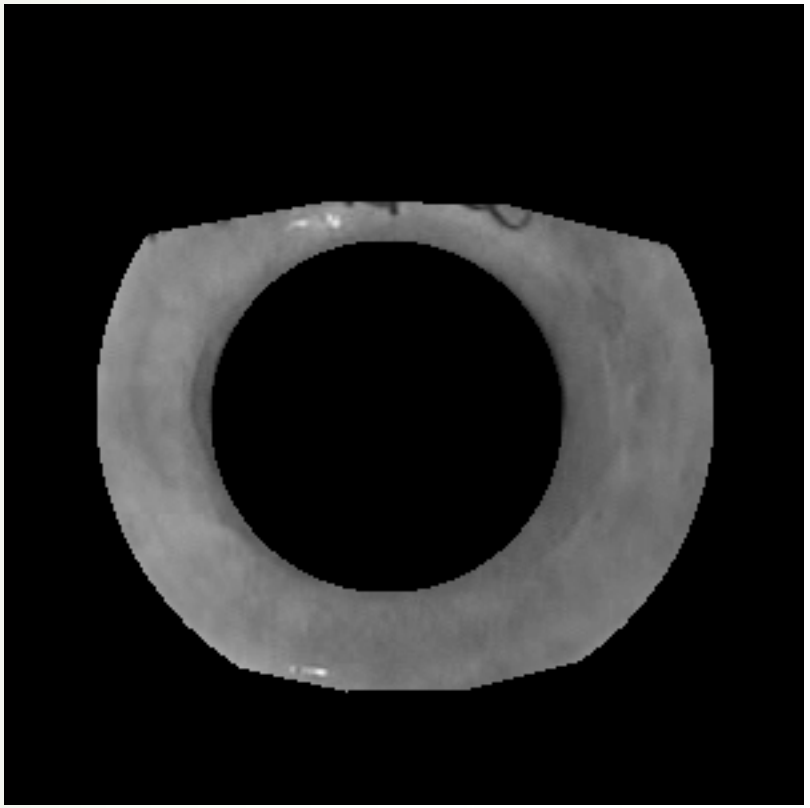
Twins or Unrelated ?



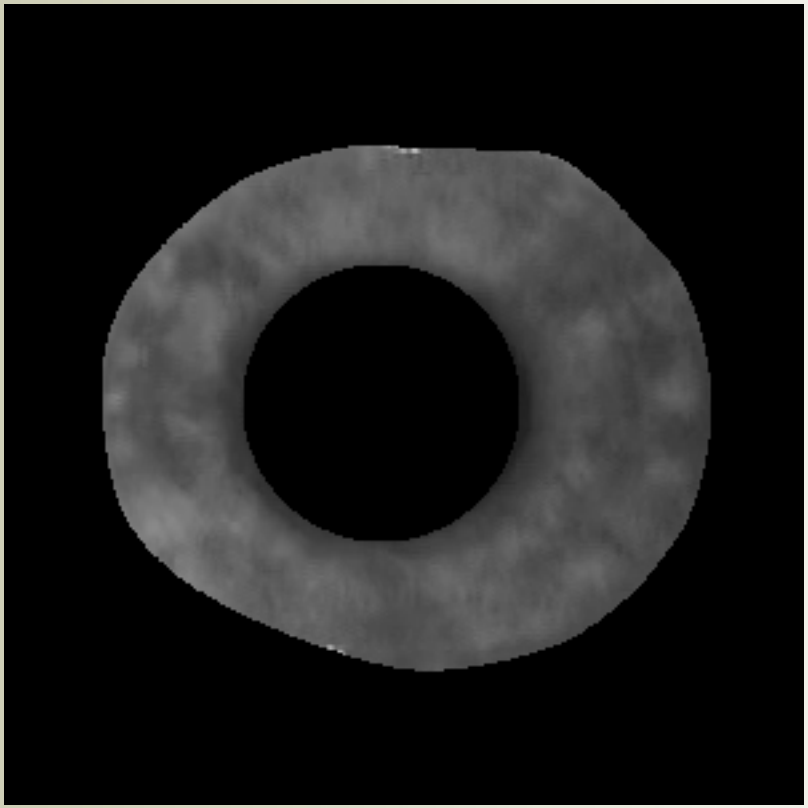


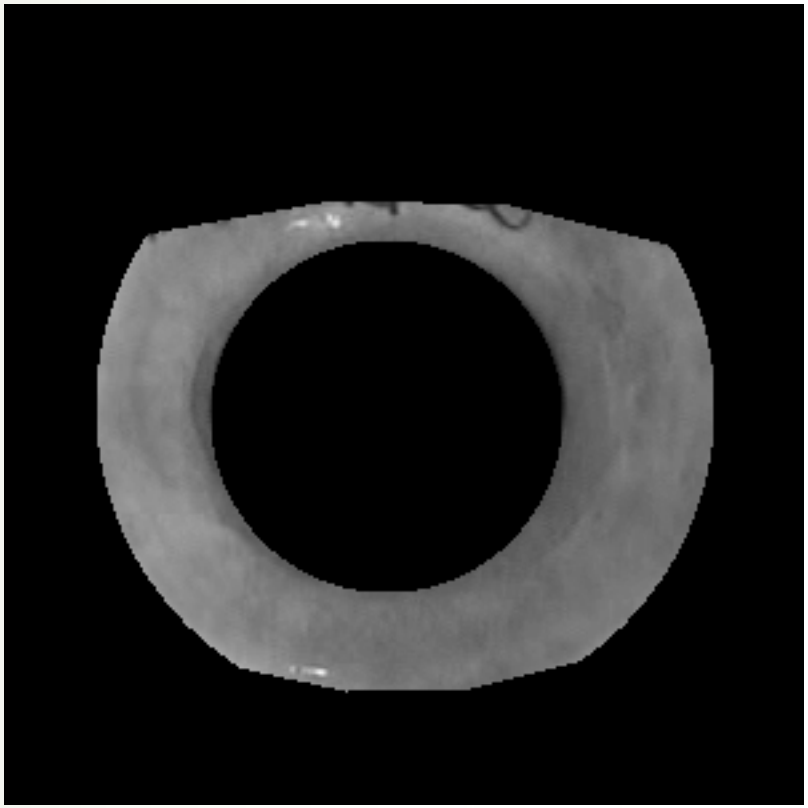
Twins.





Twins or Unrelated ?





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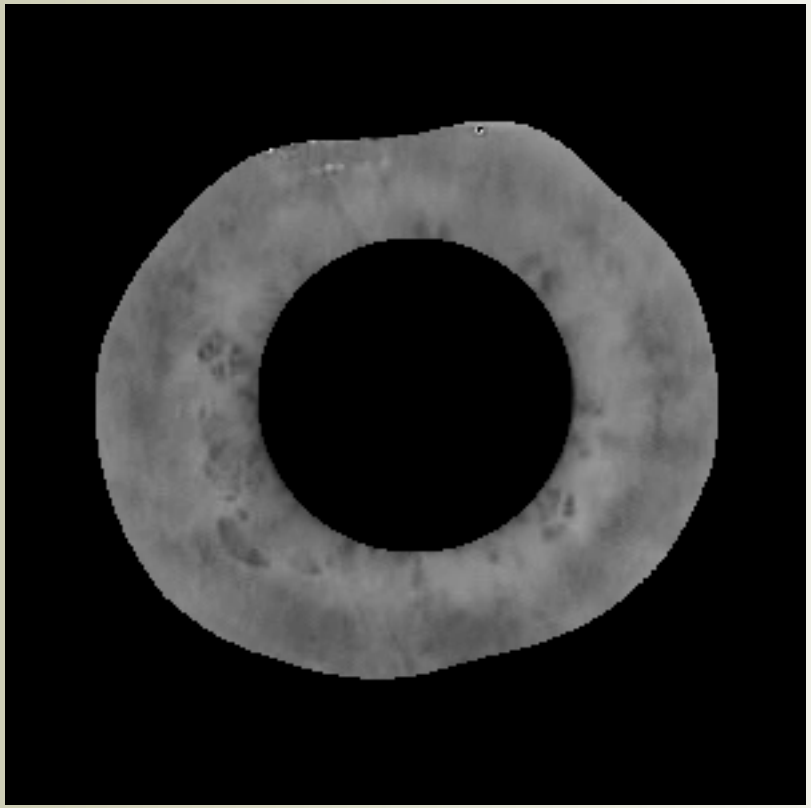
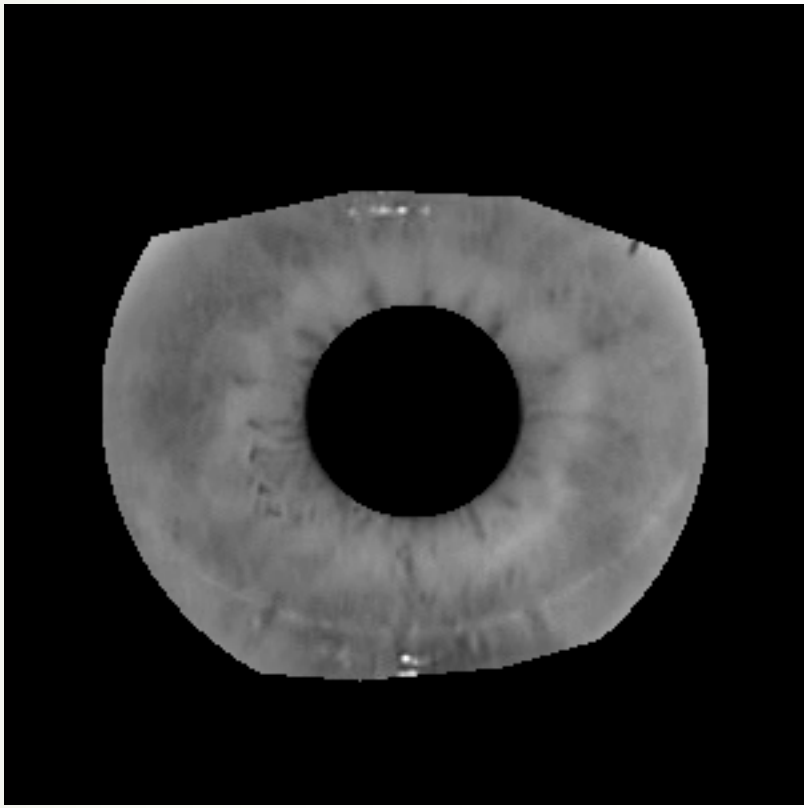
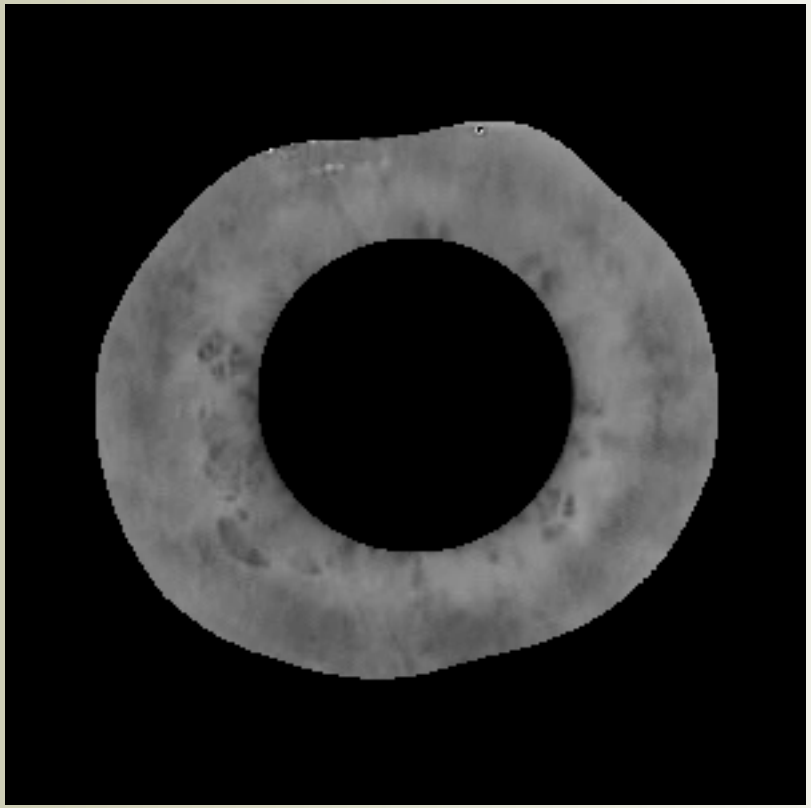
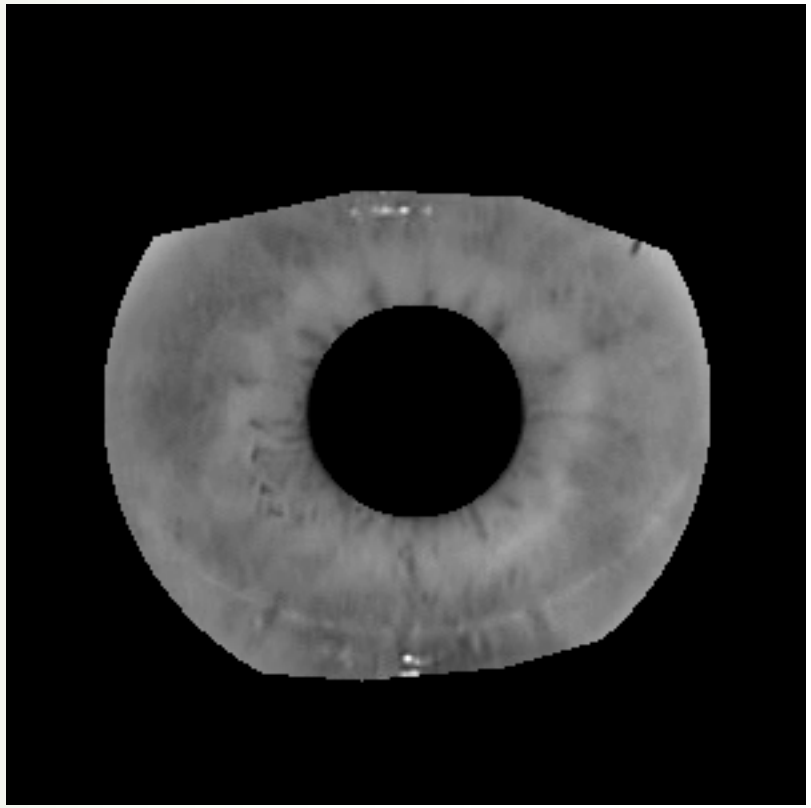


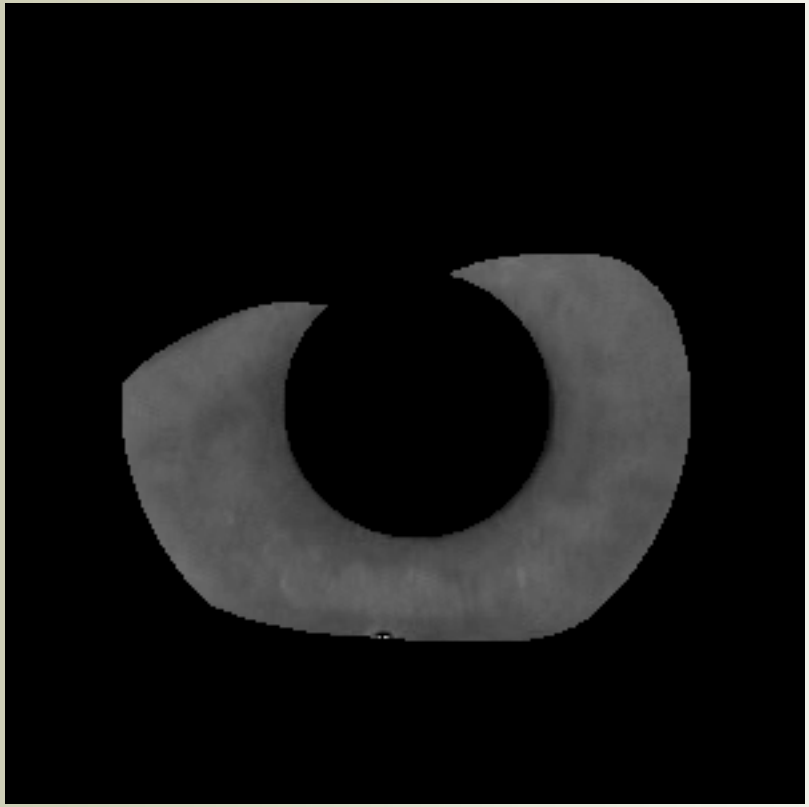


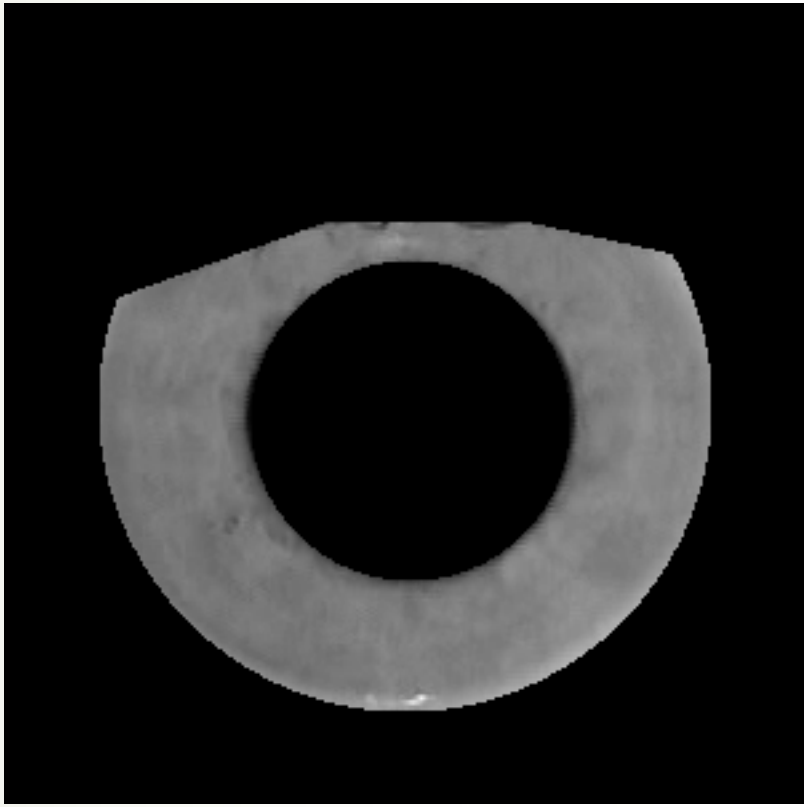
Twins or Unrelated ?



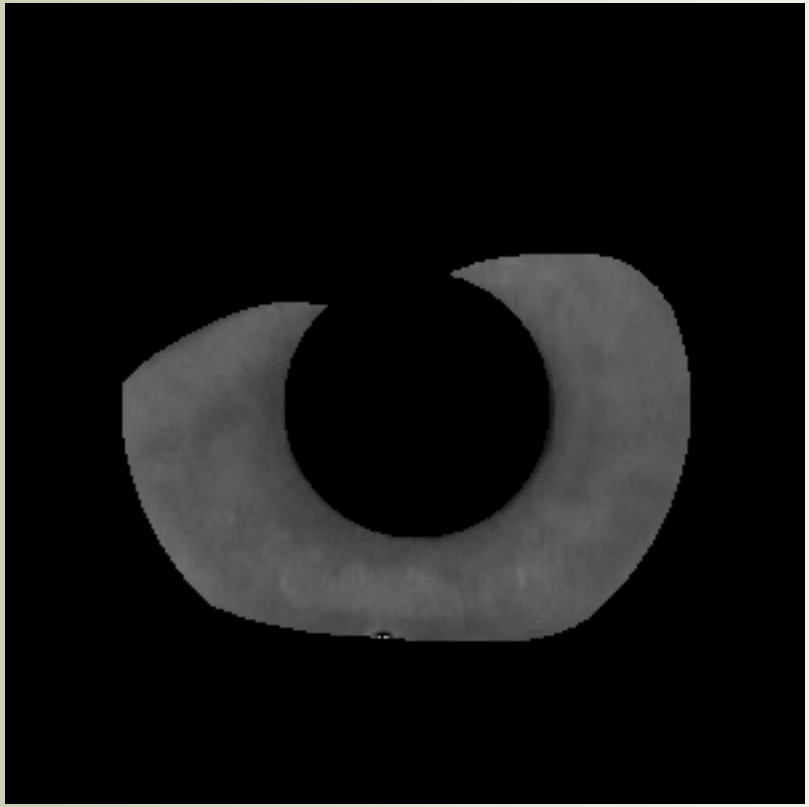


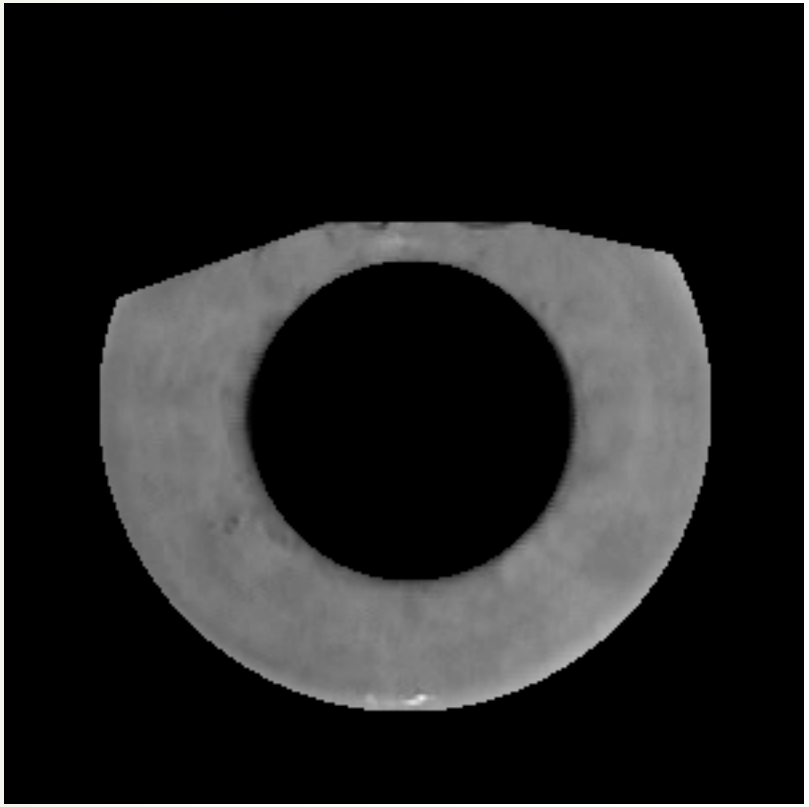
Twins.





Twins or Unrelated ?





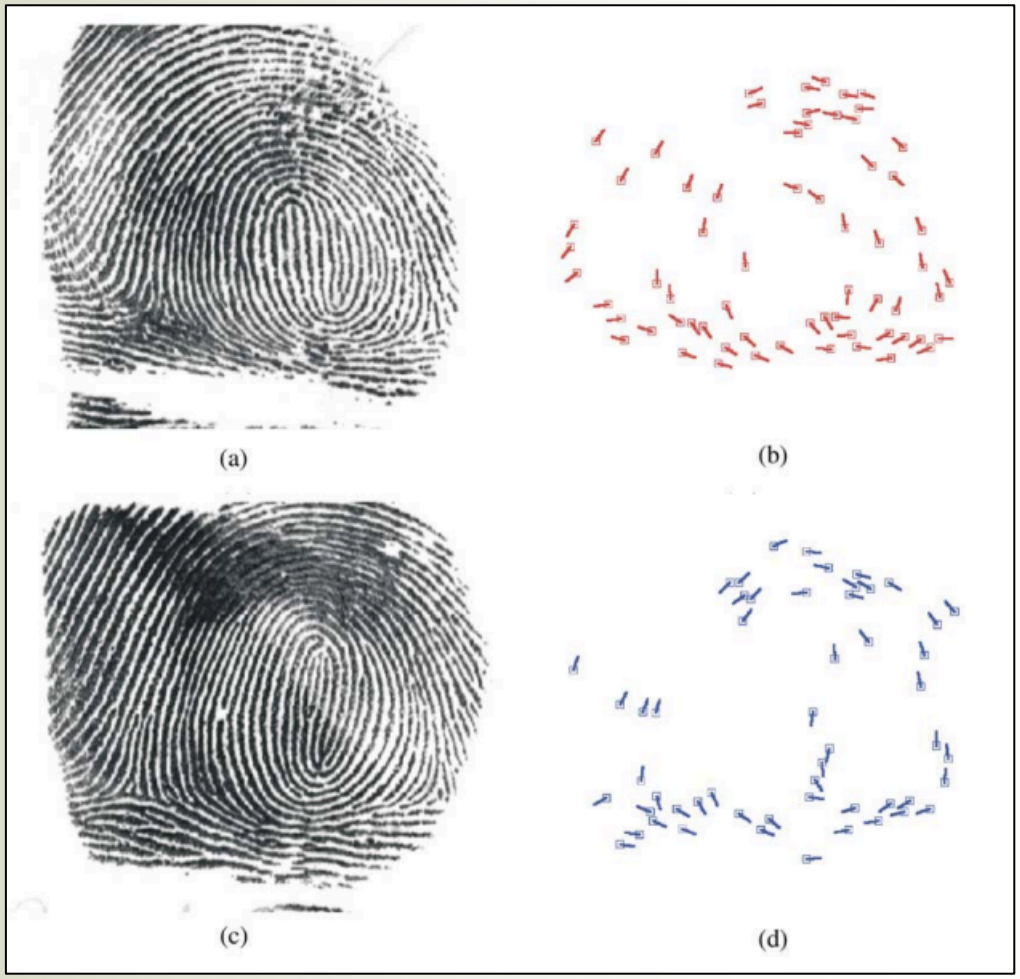
Unrelated.

- 76 pairs of twins, plus non-twins.
- Image pair presented for 3 sec.
- 5-point response scale.
- Over 80% accurate in twins / non-twin classification.
- 92% - 93% accuracy for “certain” responses.

Point to remember.

Humans readily perceive iris texture similarity that current iris recognition technology does not.

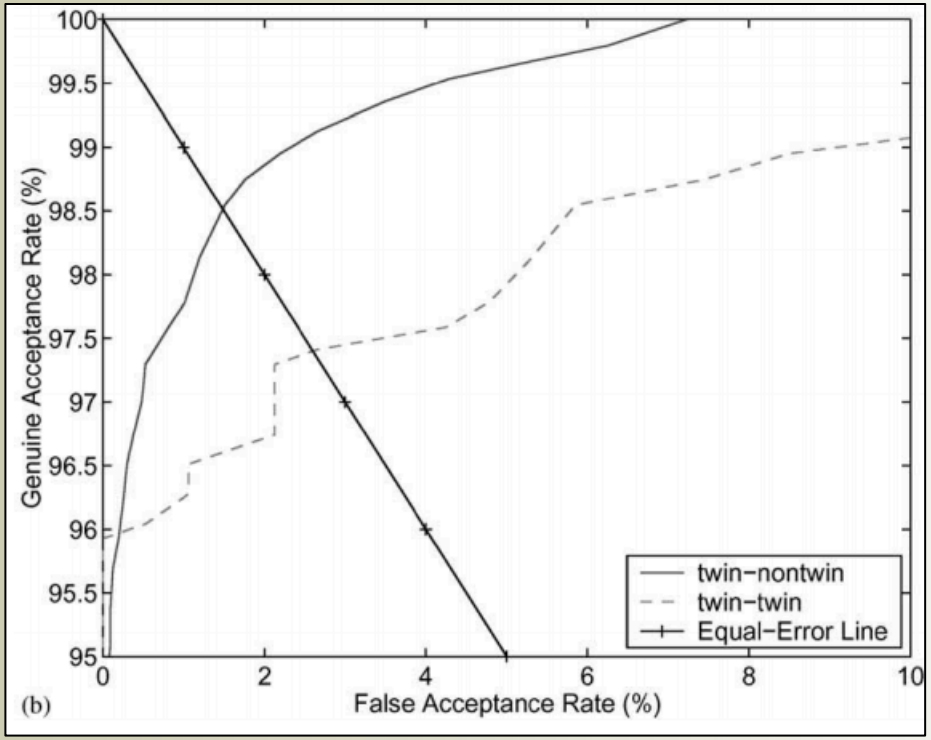
What about fingerprints of identical twins ?

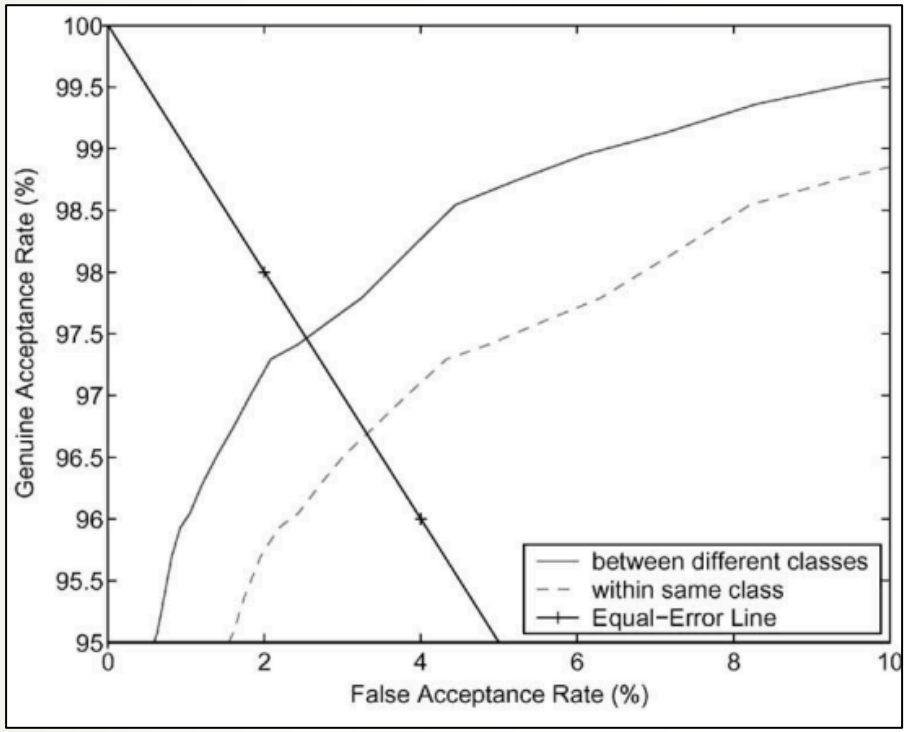


Jain, Prabhakar and Pankanti, On the similarity of identical twin fingerprints, *Pattern Recognition* 35, 2653-2663, 2002.

Essence of Jain et al conclusions:

- Twin prints match more closely than those of unrelated persons.
- Twin prints very likely to have same print category: whorl, …
- Twin prints may be like matching unrelated person prints within the same category.





Jain, Prabhakar and Pankanti, On the similarity of identical twin fingerprints, *Pattern Recognition* 35, 2653-2663, 2002.

Point to remember.

Fingerprints do allow reliable means of distinguishing between identical twins.

Questions ?

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