Homeland Security

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

The Face Acquisition/Inquisition Challenge

Dr. P. Jonathon Phillips

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- National Institute of Standards and Technology — NIST — ...working with industry to foster innovation, trade, security and jobs

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The Team

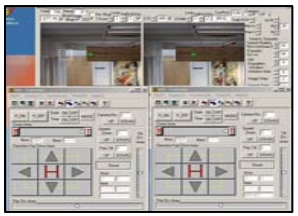
- NIST
  - P. Jonathon Phillips, Test Director
  - Elaine Newton
- Colorado State University
  - Ross Beveridge & Geoff Givens
- SAIC
  - Todd Scruggs
- Schafer Corporation
  - Cathy Schott
- University of Notre Dame
  - Kevin Bowyer & Patrick Flynn
- University of Texas at Dallas
  - Alice O'Toole

Overview

- State of Face Recognition
- Interactions
- Human-Computer Performance
- Challenges of face acquisition

Face Recognition Development

User

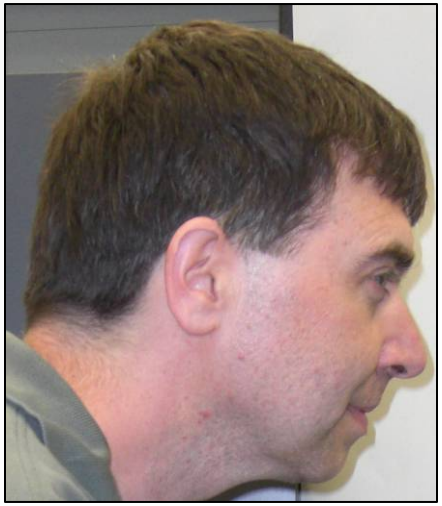


Face Recognition System

Operator

Traditional Automatic Face Recognition Development

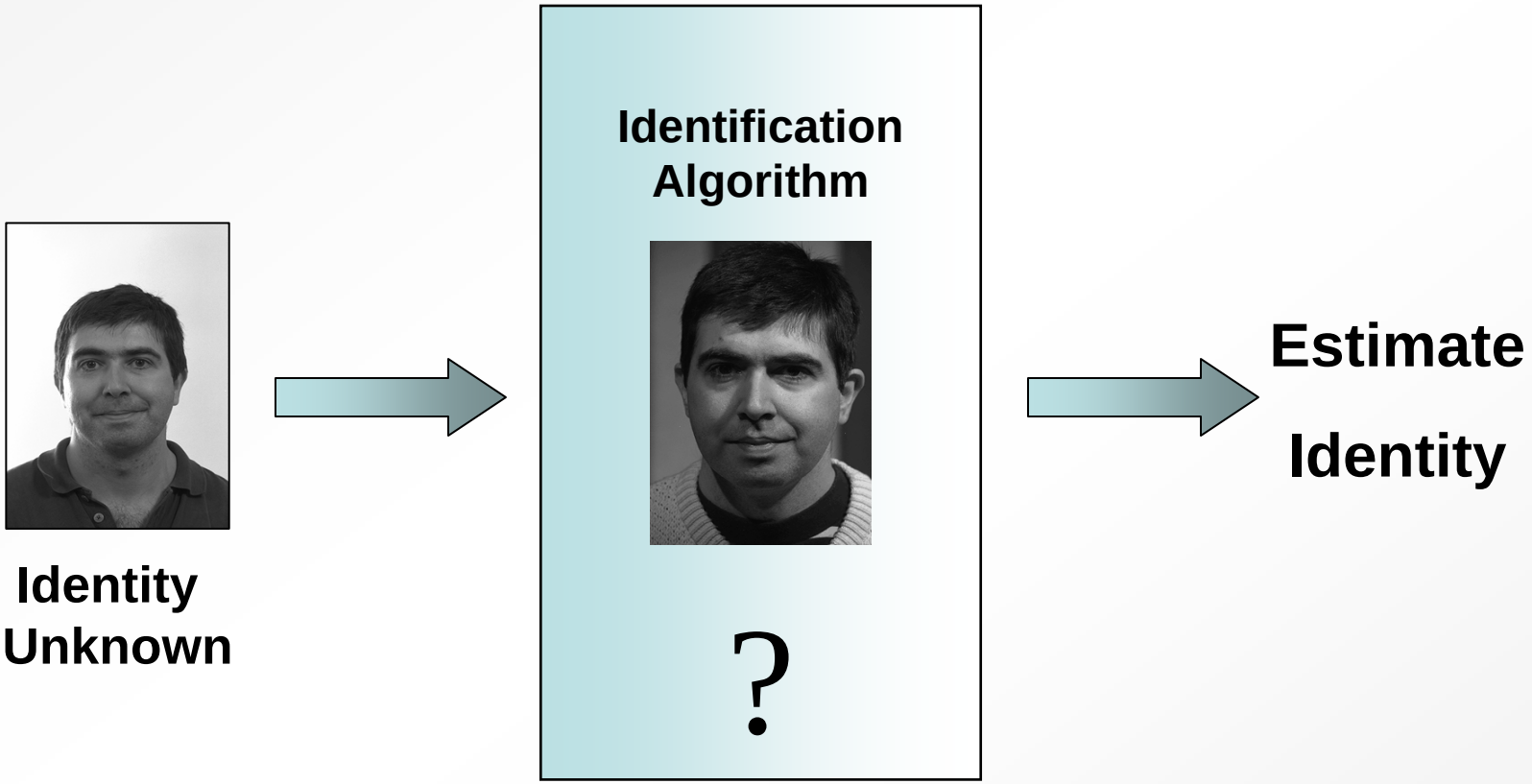
Different Perspective



Computer Vision

Usability

Identification



- Applications:
  - Police identification from mug shots
  - Check for multiple applications for welfare or driver's licenses

Two ROC Measures

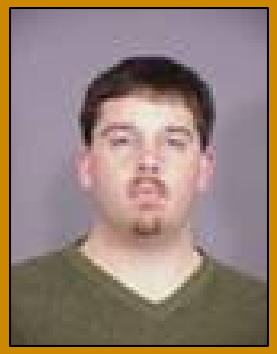
Decision: Same person?

Verification Rate

Same Person

You are who you say you are

False Accept Rate



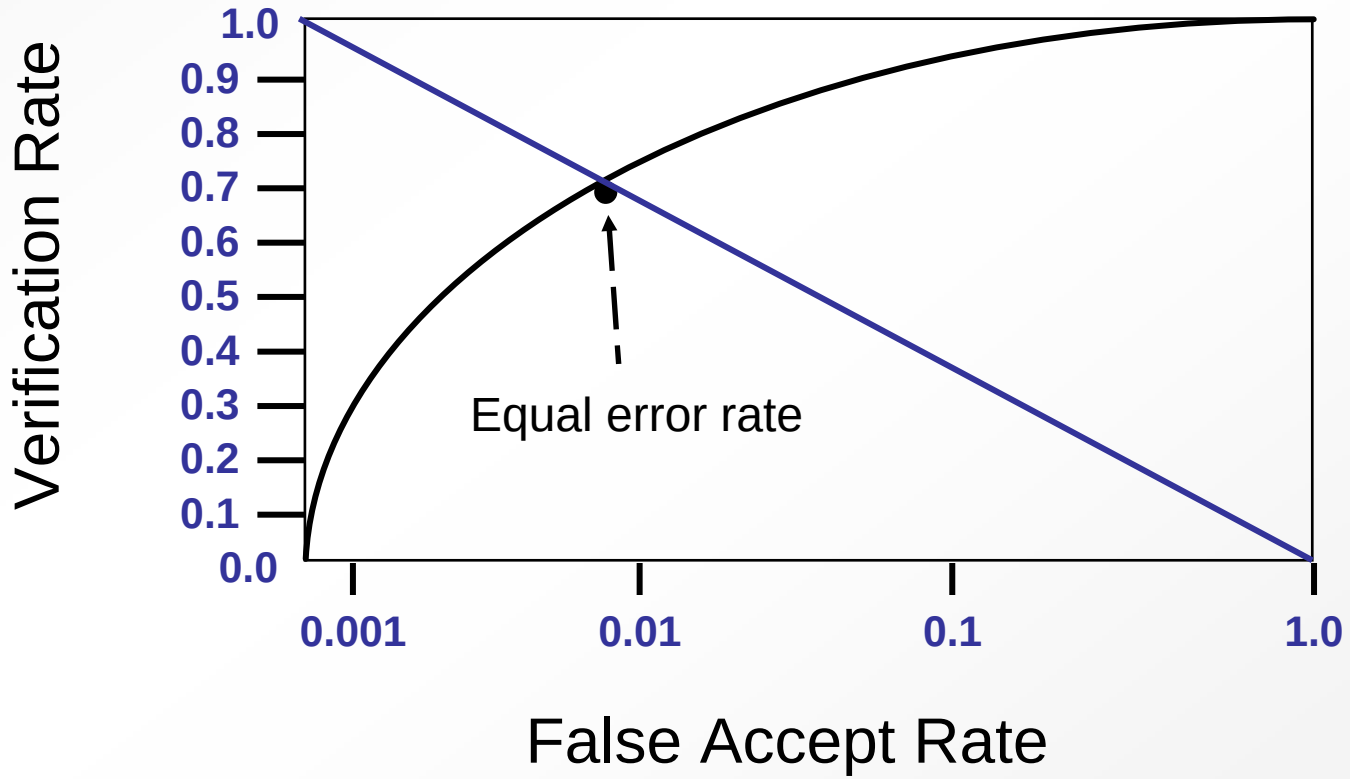
Different People

You claim to be someone you are not, and are falsely verified as that person

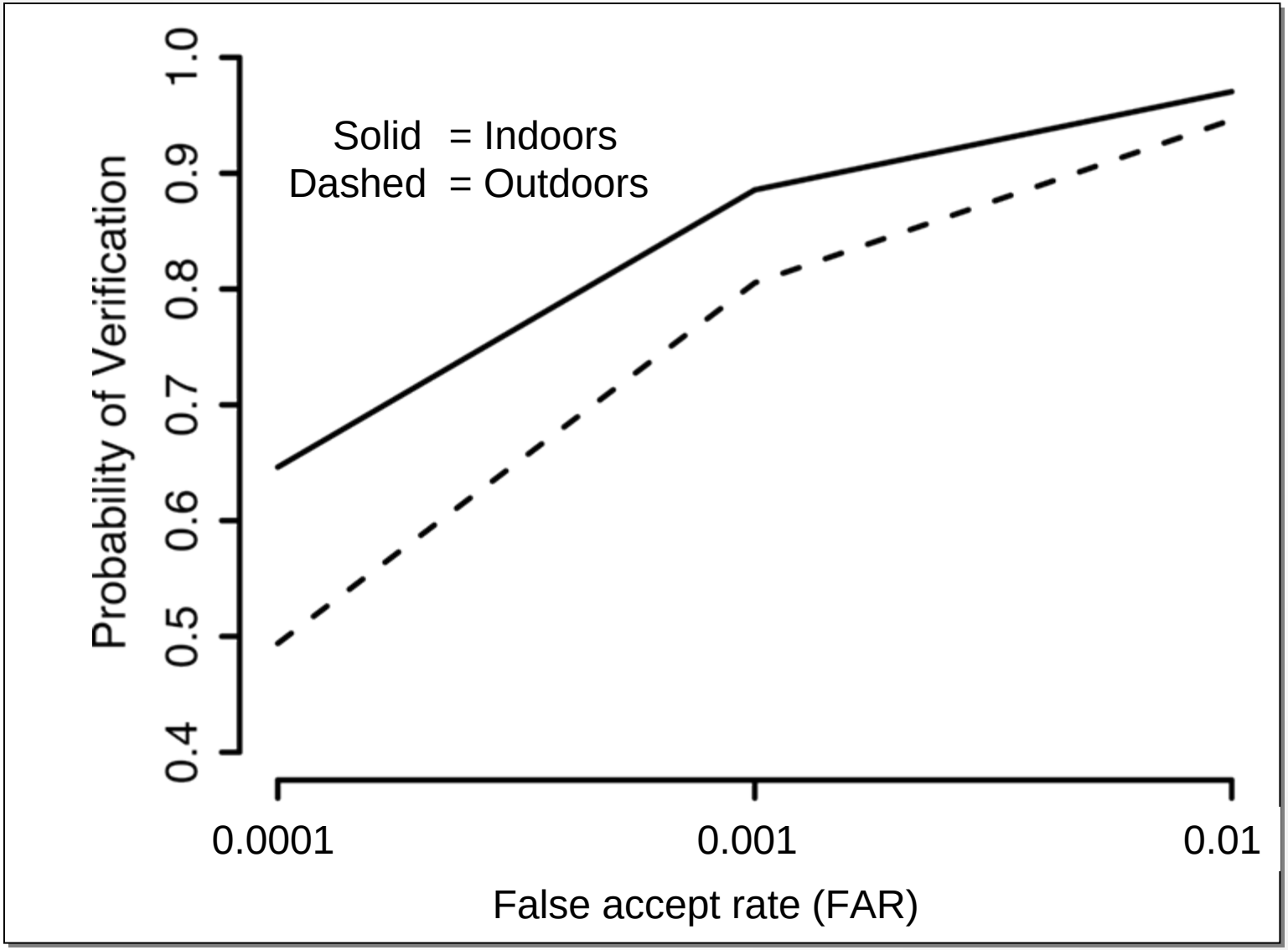
Verification Scoring

Results are reported on Receive Operating Characteristic (ROC)

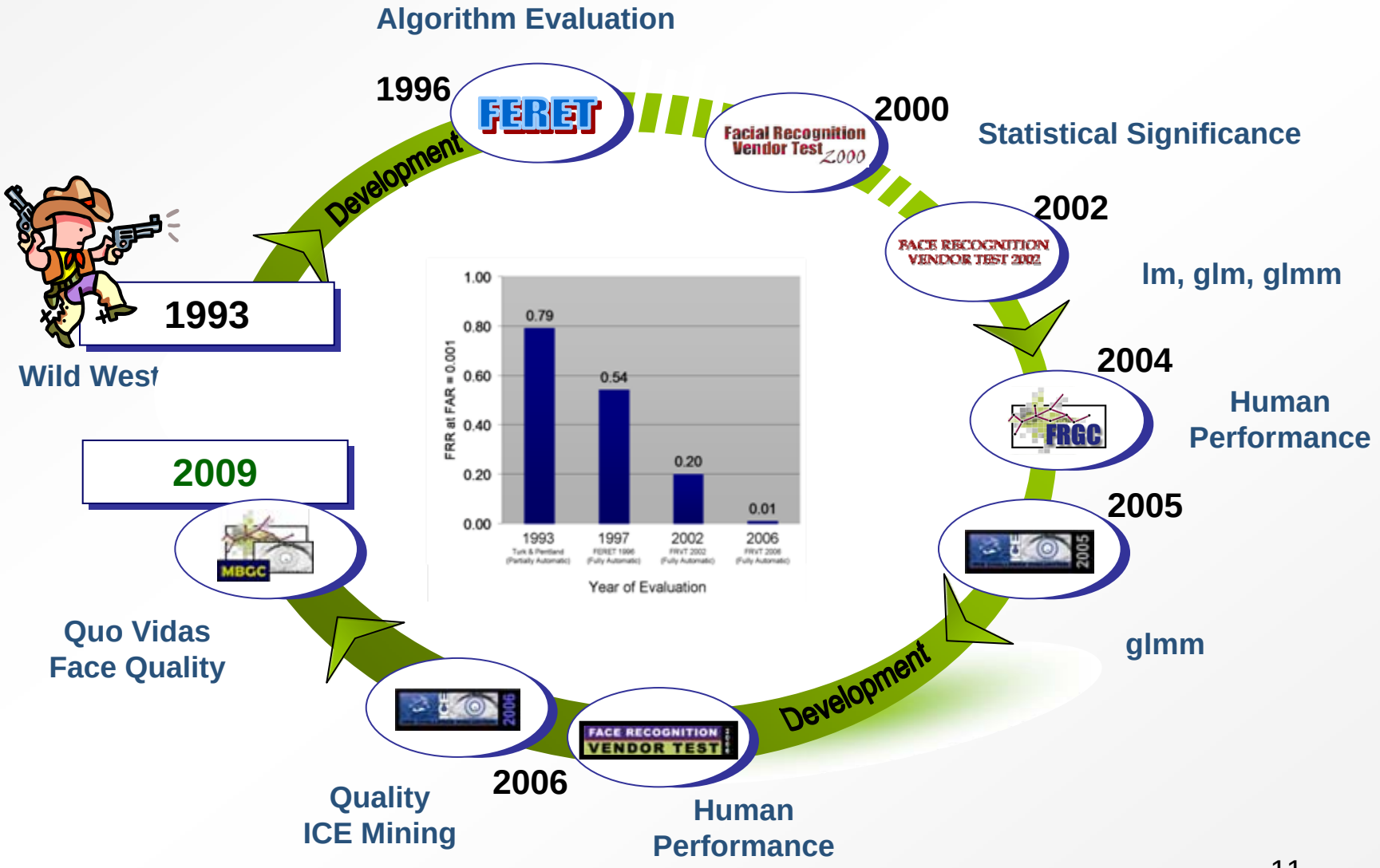
Equal error rate is summary statistic



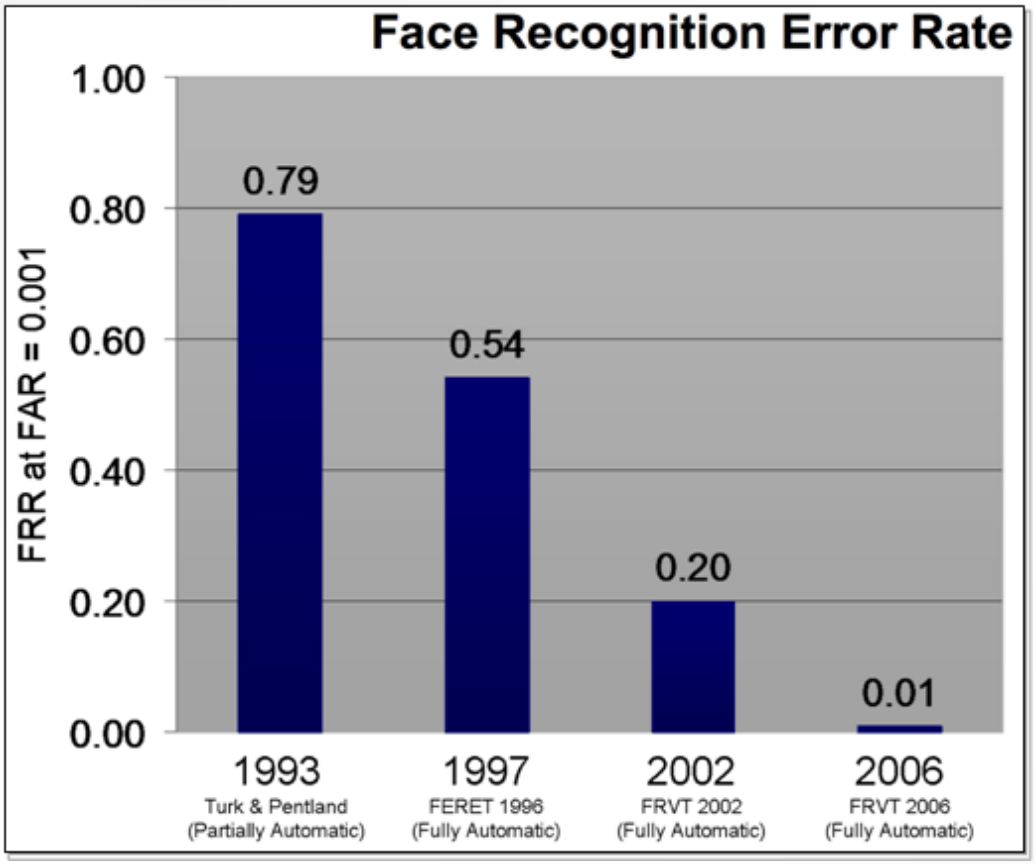
Receiver Operating Characteristic



Technology Progress



Controlled vs Controlled Still



2006 - Falsely turn away 1/100 people, when only admitting 1/1000 imposters.

For controlled frontal still images

"FRVT 2006 and ICE 2006 Large Scale Results," P. J. Phillips, W. T. Scruggs, A. J. O'Toole, P. J. Flynn, K. W.Bowyer, C. L. Schott, M. Sharpe, Under review IEEE trans Pattern Analysis and Machine Intelligence

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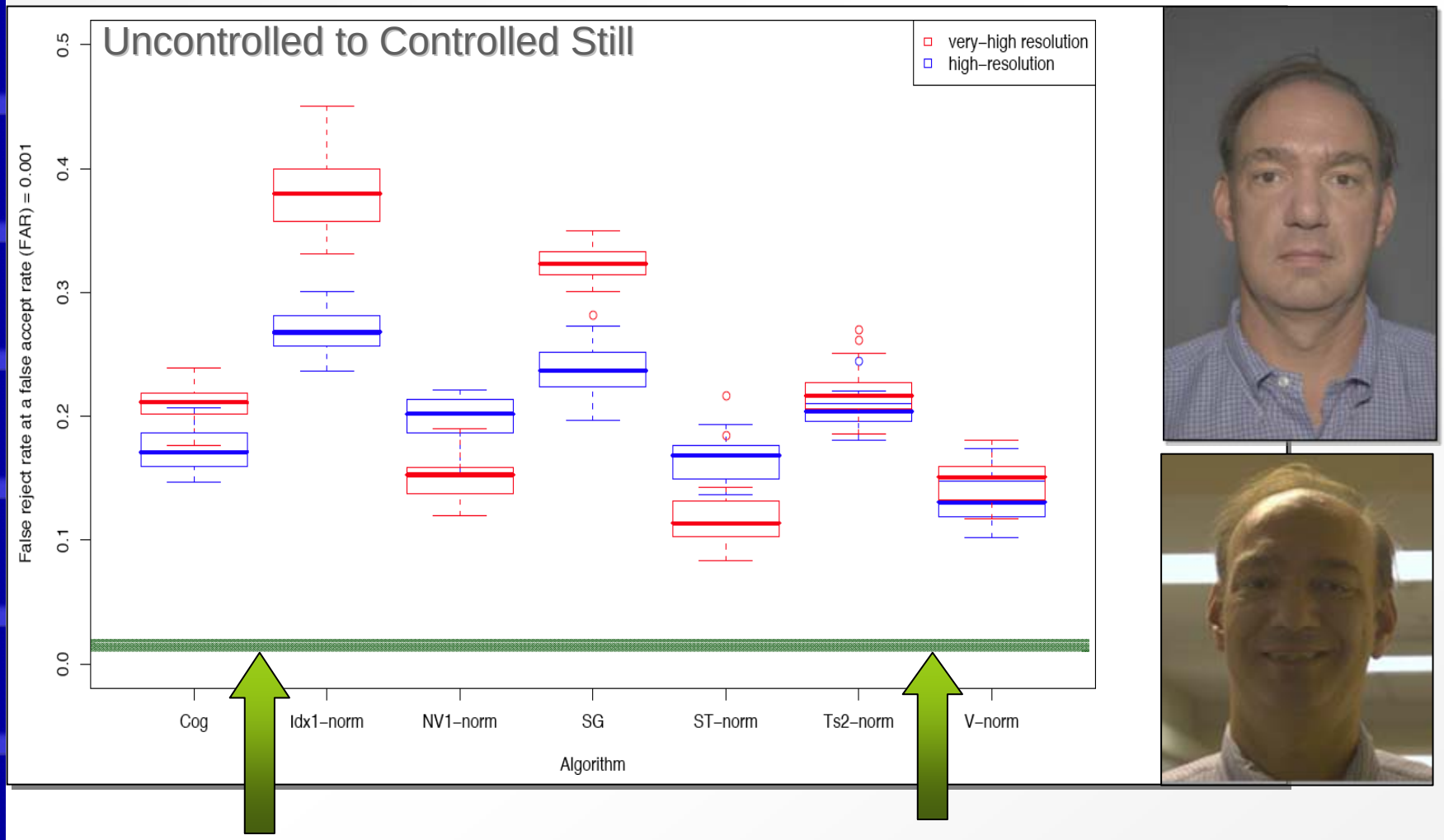
2006 - Falsely turn away 10/100 to 40/100 people, when only admitting 1/1000 impostors.



FRVT 2006 Performance
(Controlled vs Controlled)

Turn Away 1/100
(at 1/1,000 FAR)

"FRVT 2006 and ICE 2006 Large Scale Results," P. J. Phillips, W. T. Scruggs, A. J. O'Toole, P. J. Flynn, K. W.Bowyer, C. L. Schott, M. Sharpe, Under review IEEE trans Pattern Analysis and Machine Intelligence

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Three Classes of Application

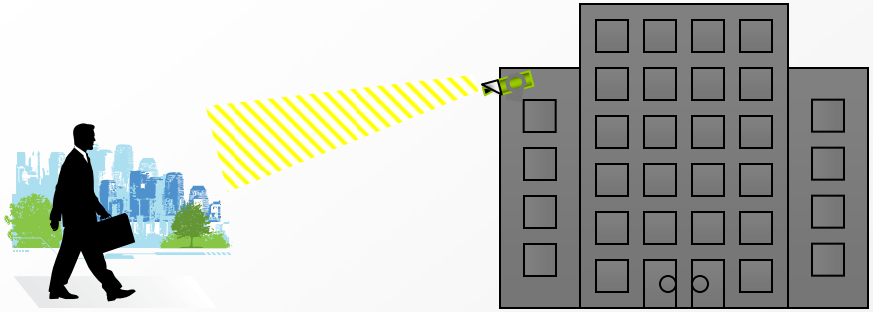
- Operator assisted

- Unattended cooperative

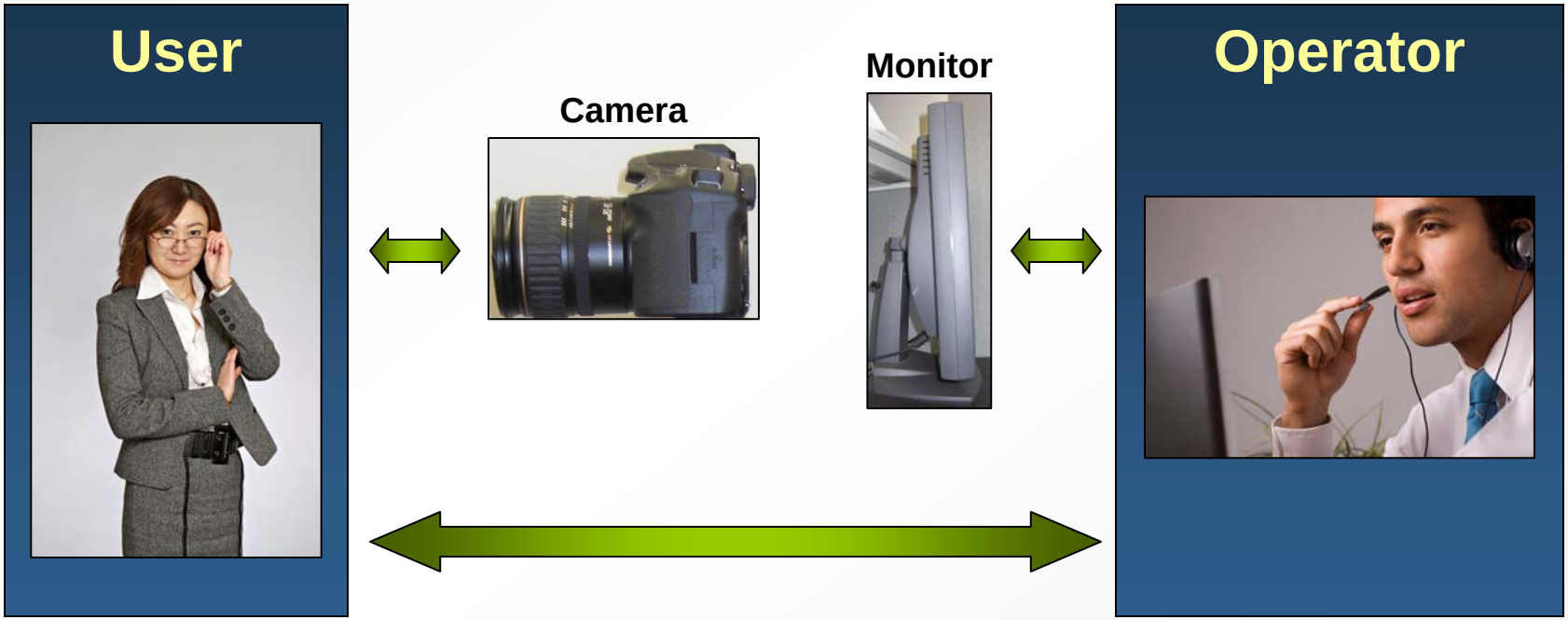
SmartGate

Australian CUSTOMS Service

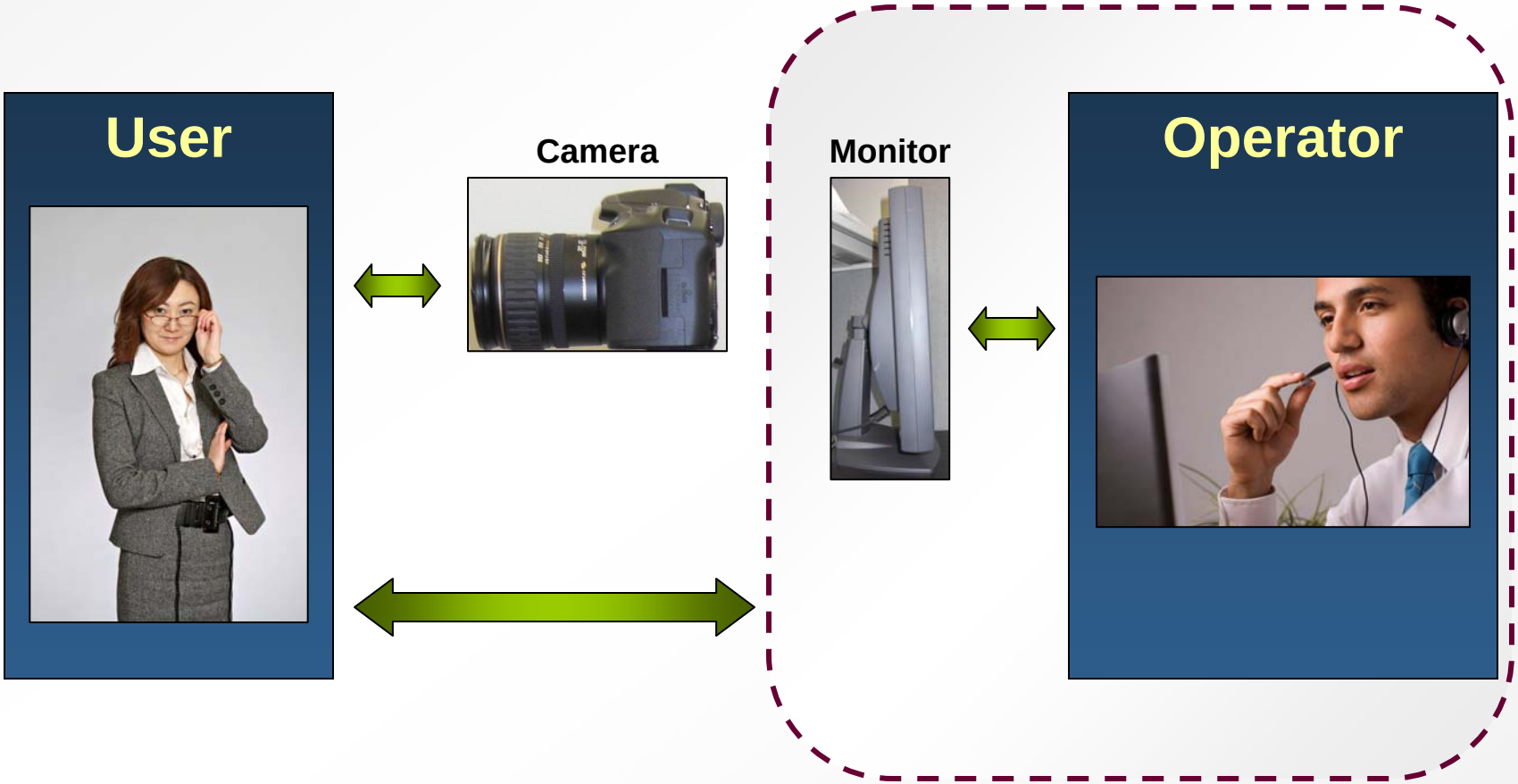
- Covert



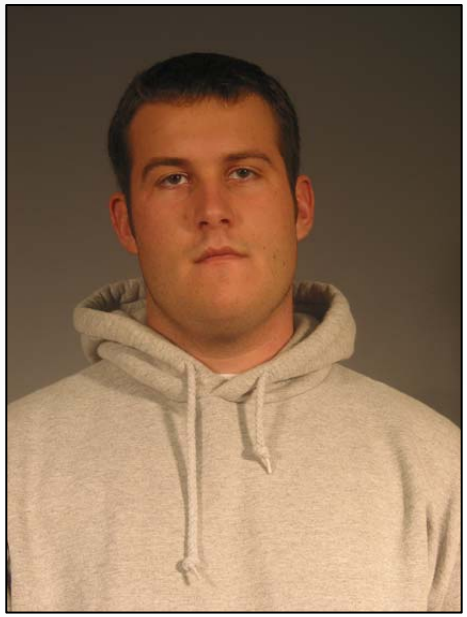
Up to Three Interactions



Operator Interaction



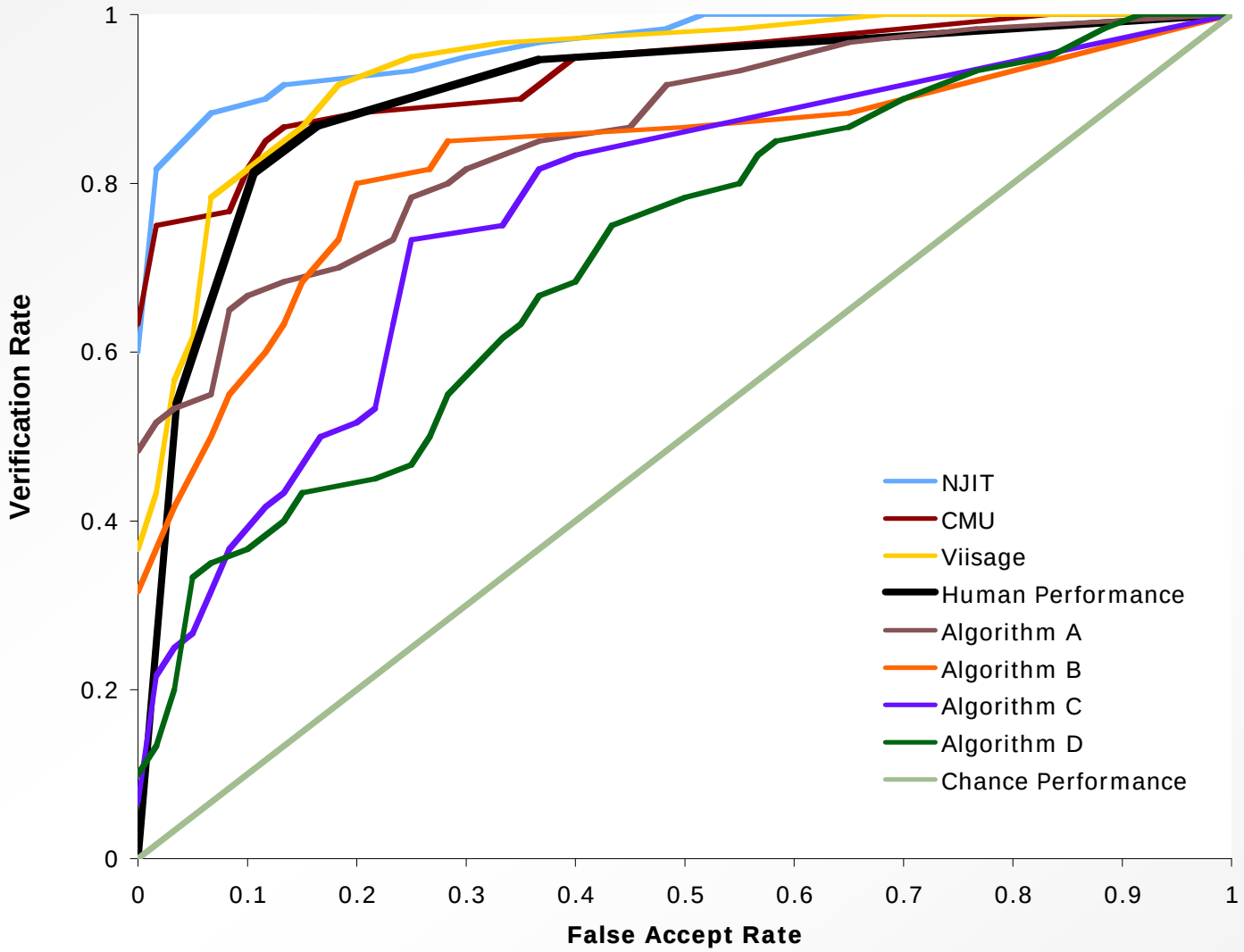
Procedure



- Human subject raters respond…
  - 1. sure they are the same person
  - 2. think they are the same person
  - 3. not sure
  - 4. think they are not the same person
  - 5. sure they are not the same person

"Face recognition algorithms surpass humans matching faces across changes in illumination," A. J. O'Toole, P. J. Phillips, F. Jiang, J. Ayyad, N. Pénard, H. Abdi IEEE trans. Pattern Analysis and Machine Intelligence, Vol 29, 1642-1646, 2007

Identity Matching for Difficult Face Pairs



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Human versus Computer Performance

Human

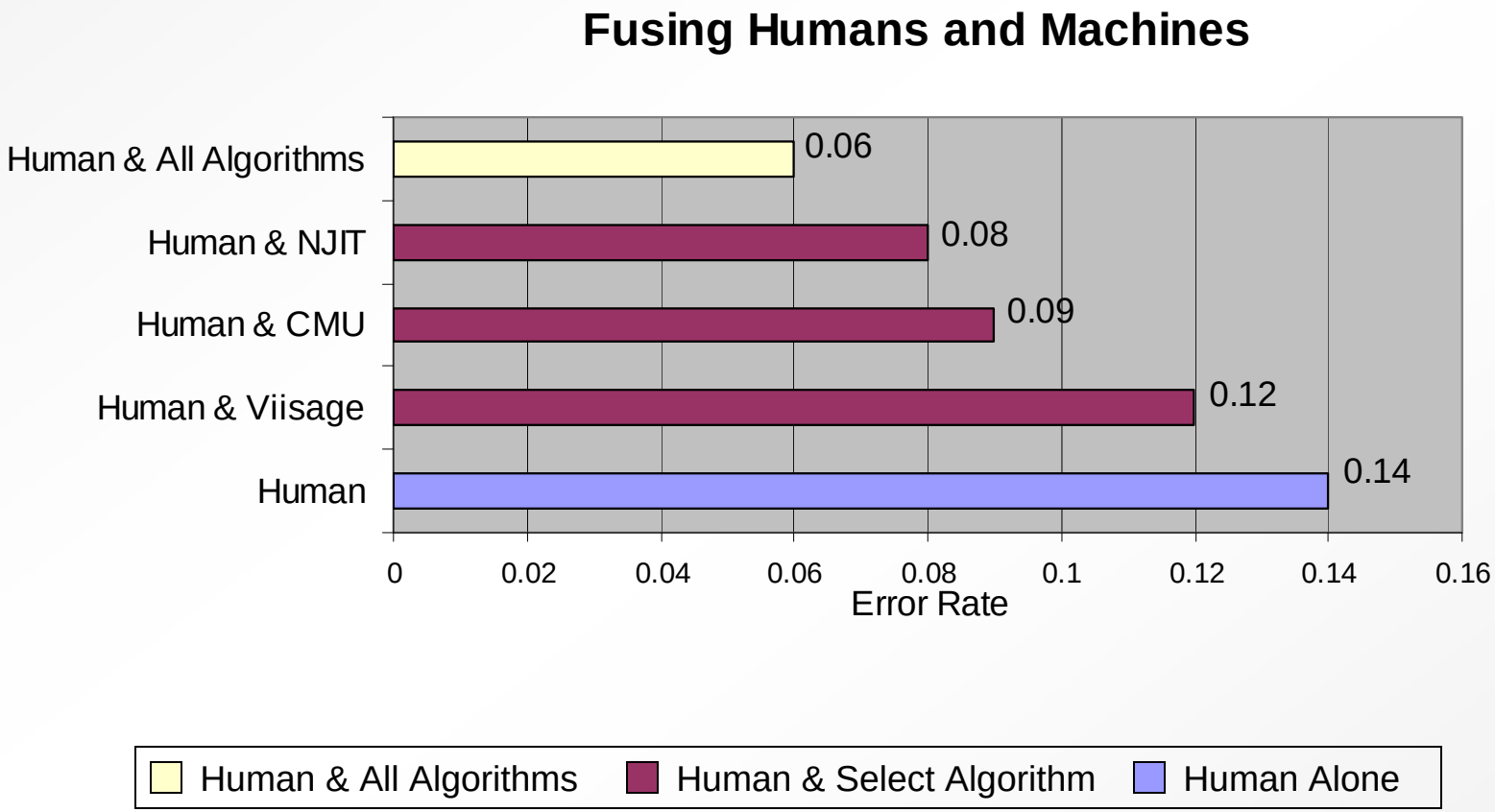
OR

Machine

Fusing Humans with Computers

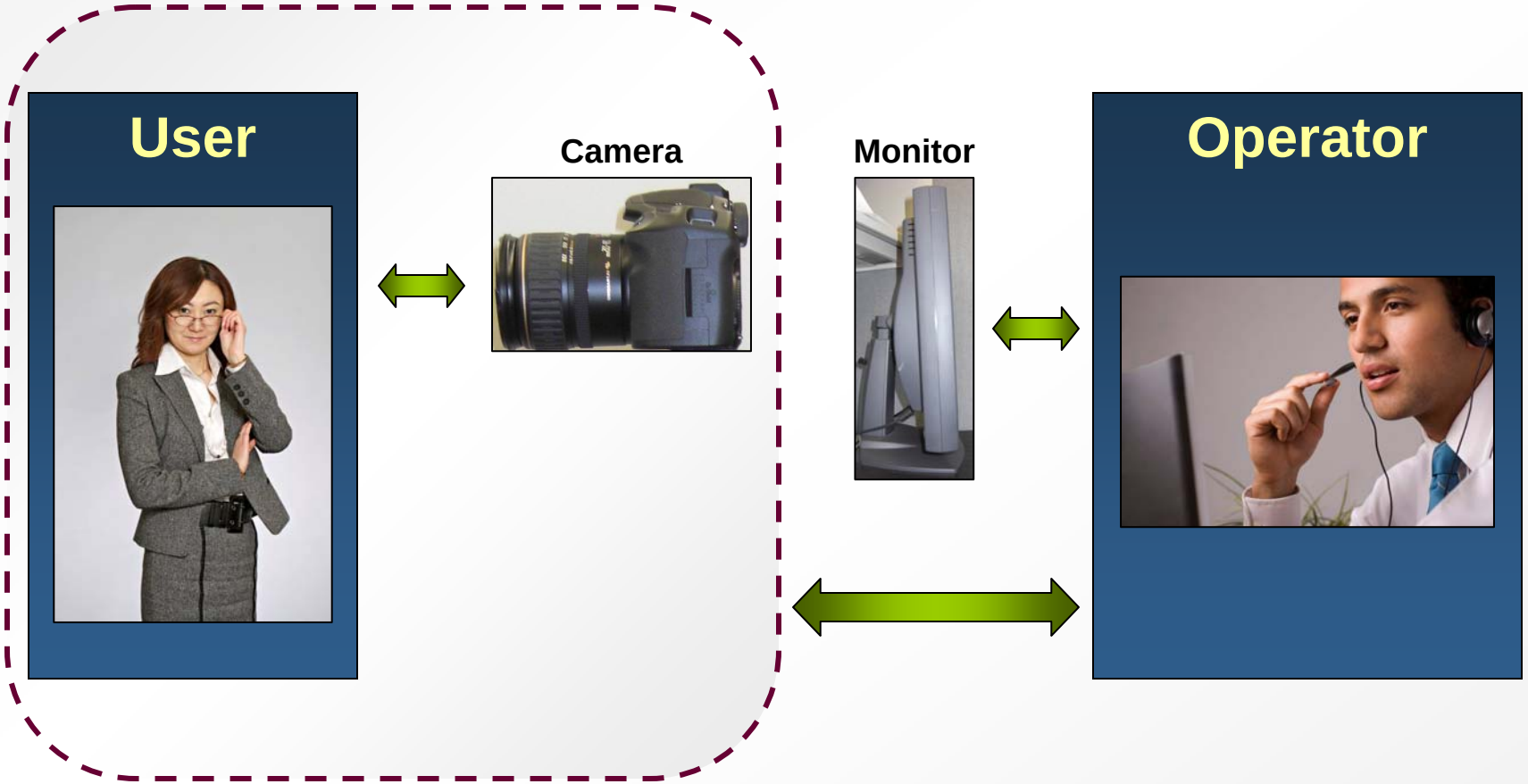
Fusion Algorithm

Total Error Rate



"Fusing individual algorithms and humans improves face recognition accuracy." O'Toole, A.J., Abdi, H., Jiang, F. & Phillips, P.J. (2006). Advances in Visual Computing. G. Bebis et al. (Eds.) Berlin Heidelberg: Springer Verlag, pp 447-456.

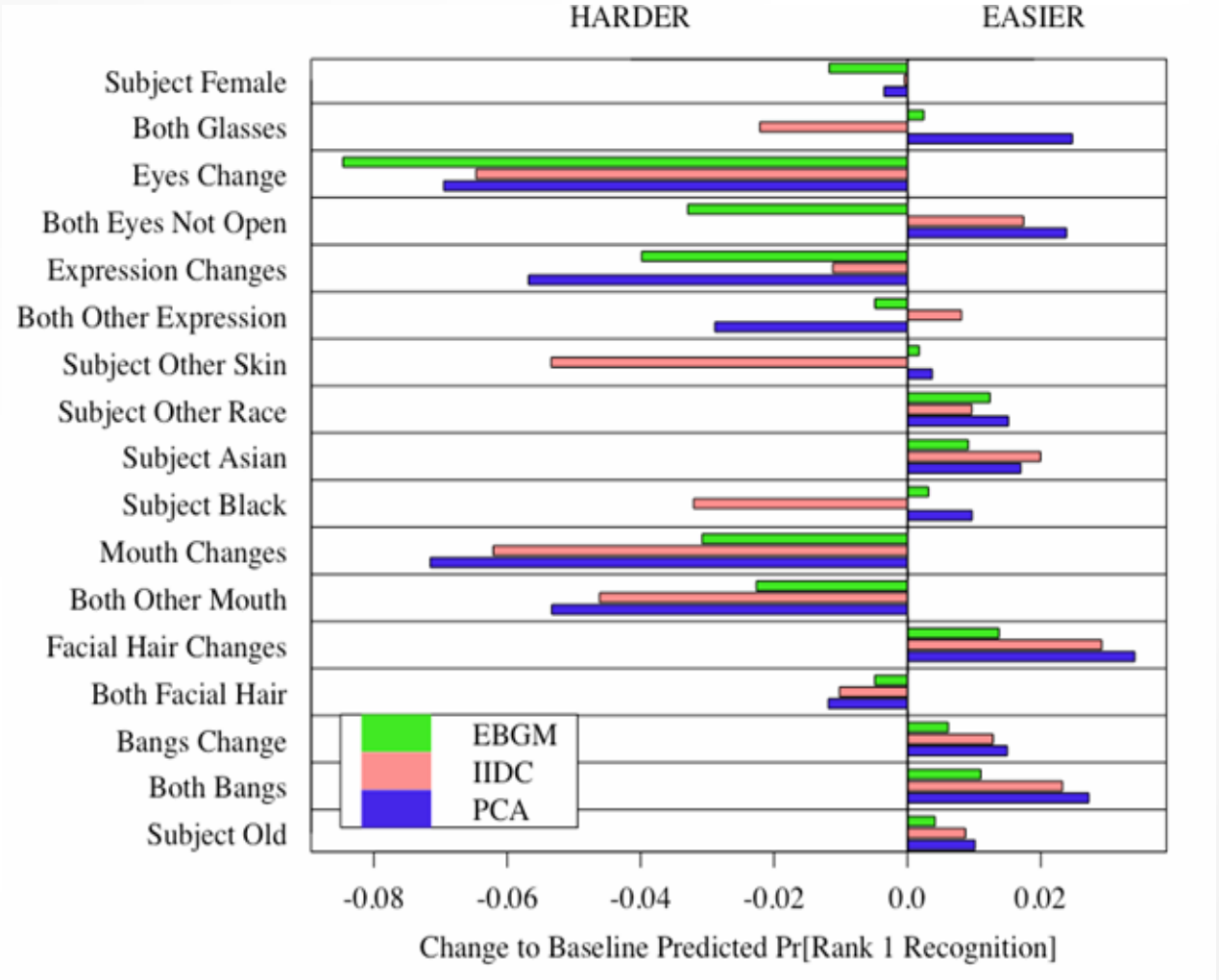
User Interaction



Face Recognition

- Algorithm performance
  - FRR = 1% @ FAR = 0.1% on “high” quality data
  - FRR = 15%-30% on uncontrolled illumination
- Data collection
  - Can collect “high” quality data on large experimental set-up
- Challenge
  - Collecting “high” quality data operationally

Linear Models & Generalized Linear Models for Probability of Correct Rank 1 Identification



Givens, Beveridge, Draper, Grother, and Phillips (CVPR 2004)

Challenge: What is a quality image?

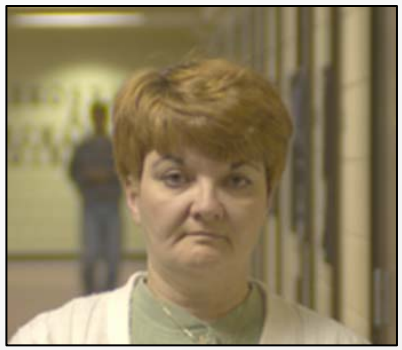
- Quantifying factors effect performance
- Measurable:

Facial Hair

Hair Across Eye

Hair Style

Makeup



Face Quality Standards

From Covariates to Quality Measures ….

Factors Affecting Face Image Quality				
	Character **RICHNESS OF IDENTIFYING CHARACTERISTIC – BIOLOGICAL CHARACTERS**	**Behavior** **SPOOFING**	**Imaging** **ACQUISITION PROCESS AND CAPTURE DEVICE PROPERTIES**	**Environment** **AMBIENT CONDITION**
FACE	1. anatomical characteristic (e.g. head dimensions, eye position) 2. injuries and scars 3. ethnic group 4. impairment 5. Heavy facial wears, such as thick or dark glasses	1. closed eyes 2. (exaggerated) expression 3. hair across the eye 4. head pose 5. makeup 6. subject posing (frontal / non-frontal to camera)	1. image enhancement and data reduction process 2. physical properties (e.g. resolution and contrast) 3. optical distortions 4. static properties of the background (e.g. wallpaper) 5. camera characteristics • sensor resolution 6. scene characteristics • geometric distortion	1. dynamic characteristics of the background like moving objects 2. variation in lighting and relate potential defects as • deviation from the symmetric lighting • uneven lighting on the face area • extreme strong or weak illumination 3. subject posing, e.g.: • too far (face too small), or too near (face too big) • out of focus (low sharpness) • partial occlusion of the face

What is range of quality?

"High" Quality

Very Low Quality

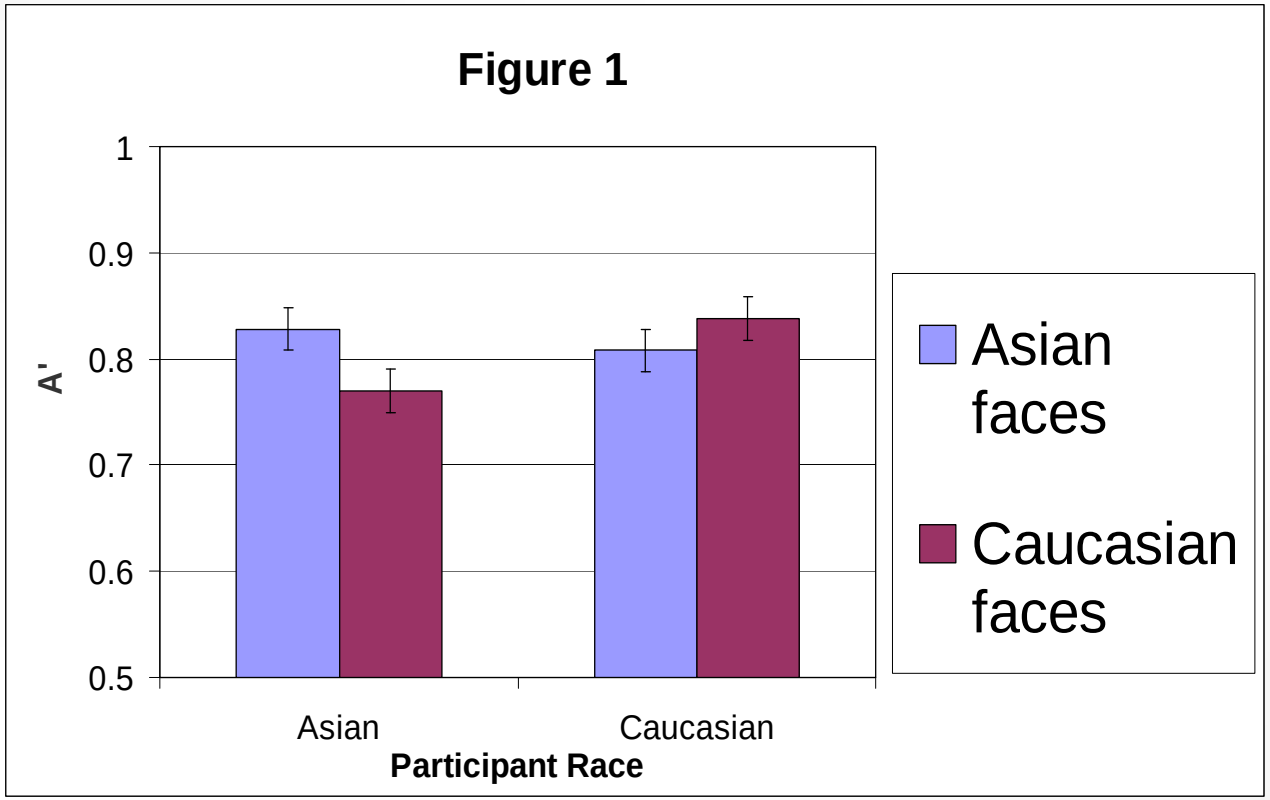
What's wrong with this face image?

Quality

What are “high” quality images?

Other Race Effect

Human Accuracy as Measured by A’

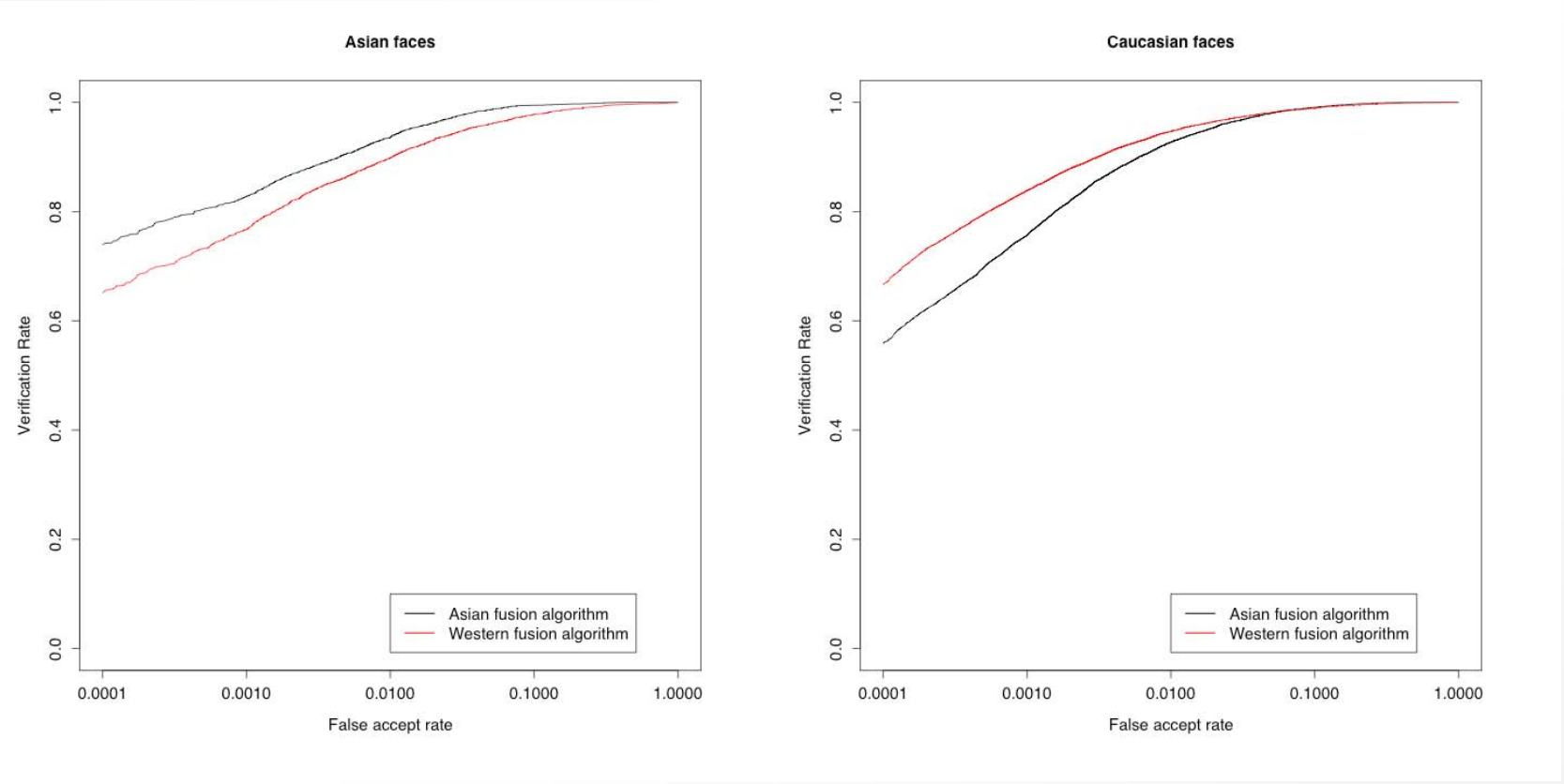


“Face recognition algorithms and the other-race effect: computational mechanisms for a developmental contact hypothesis,” Nicholas Furl a, P. Jonathon Phillips, Alice J. O’Toole. Cognitive Science 26 (2002) 797–815.

Machine Other-Race Effect

- Question:
  - Are algorithms better at recognizing faces from race of developers?
- Two Fused Algorithm Performance
  - East Asian
  - Western Algorithms
- Performance of Caucasian and East Asian Faces

Algorithm Performance
All face pairs



Forthcoming paper on the Algorithm Other Race Effect by Alice J. O'Toole and P. Jonathon Phillips.

Summary

- Face recognition has improved significantly
  - Controlled illumination
    - Two orders of magnitude (100 times) in 15 years
    - One order of magnitude (10 times) in 4 years
- Computers can be better than humans
  - Fusion is better still
- Acquisition challenge
- Quality is NOT in the eyes of the beholder
  - It is in the performance numbers