



ICE Mining: Quality and Demographic Investigations of ICE 2006 Performance Results

P. Jonathon Phillips

NIST

Patrick J. Flynn

University of Notre Dame

(NIST Associate, 2007-2008)

**National Institute of
Standards and Technology**



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Outline

- Motivation
- Quality measure correlation
- Quality measure effects on performance
 - Nested quality intervals
 - Disjoint quality quartiles
- Performance variations by demography
- Conclusions and comments

- Note: a report on this work is in preparation



Motivation

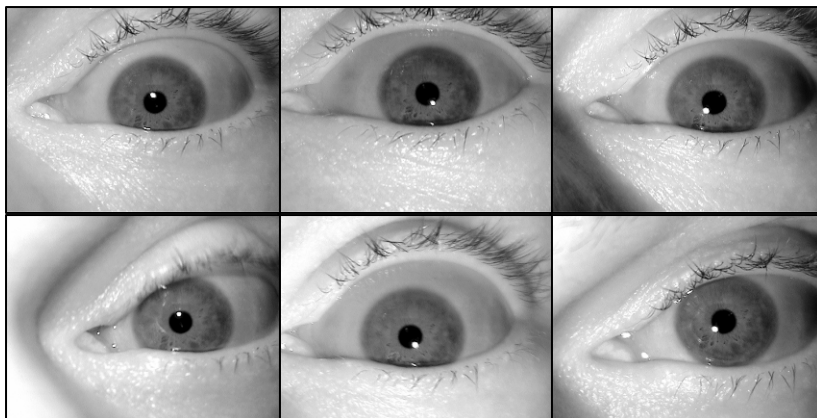
- Iris image acquisition typically expects highly controlled environment
 - Cooperative subject (minimize iris occlusion)
 - Active lighting
 - Active focusing
 - Standoff manipulation
- Strong texture contrast & focus yield subjective “good quality”
 - Strong texture filter responses
 - Reliable phase estimates



Iris Quality in the Literature

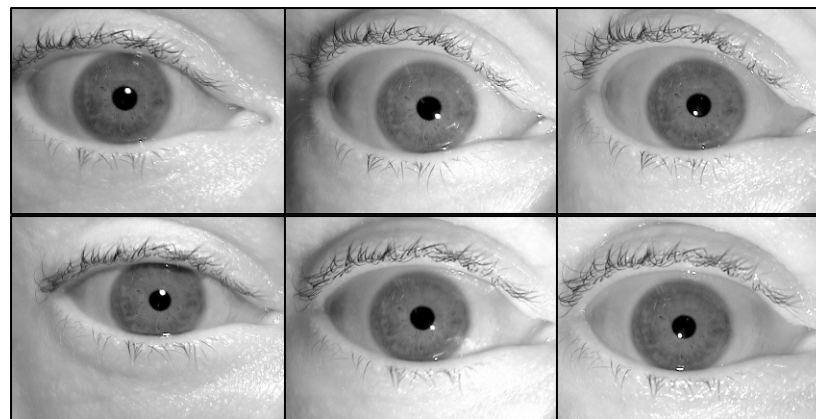
- Common biometric sample quality concepts
 - Fidelity vs. application-specific criteria for quality
 - Methodology for quality based performance analysis (Grother and Tabassi, PAMI 2007)
 - Subject and sensor effects on quality
- Iris-specific aspects
 - Focus (spectral content)
 - Occlusion (e.g., % iris), frontality, motion blur
 - Wasserman 2006 (sensor quality), Kalka 2005, Dass 2006, Valencia 2007

Sample ICE 2006 iris subject session



Left Eye

LG EOU 2200

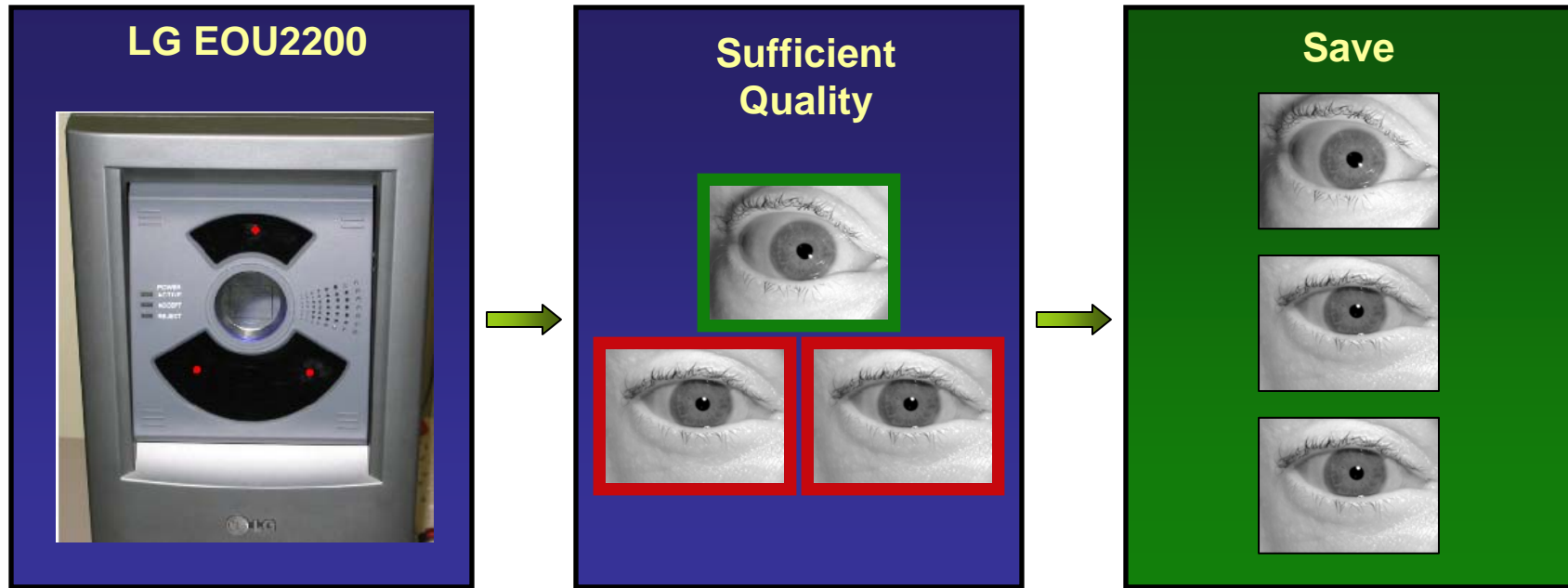


Right Eye

LG EOU 2200

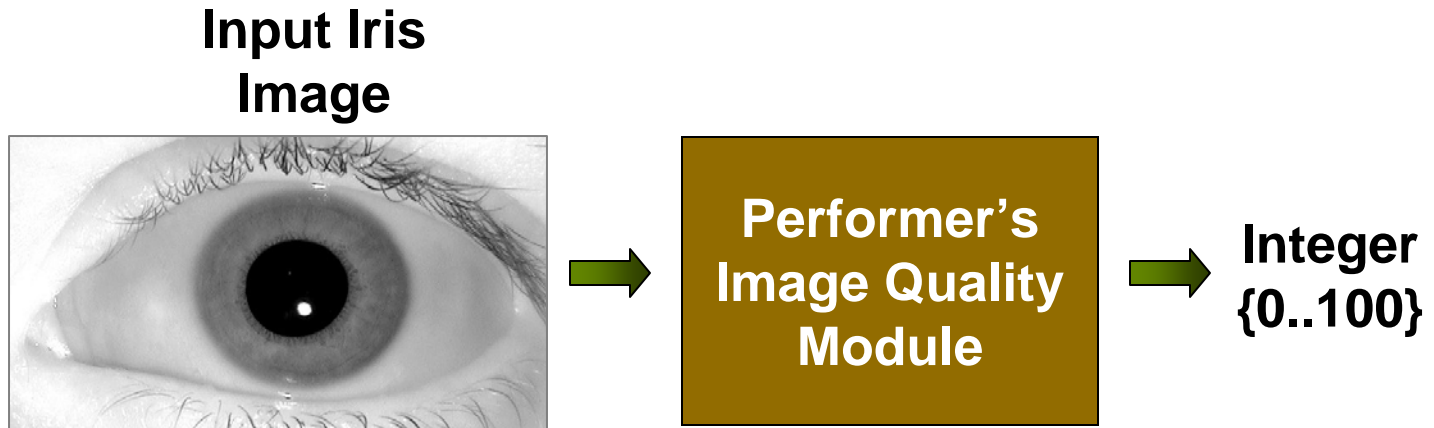
LG EOU 2200 was industry recommended at the inception of data collection.

ICE 2006 data acquisition method



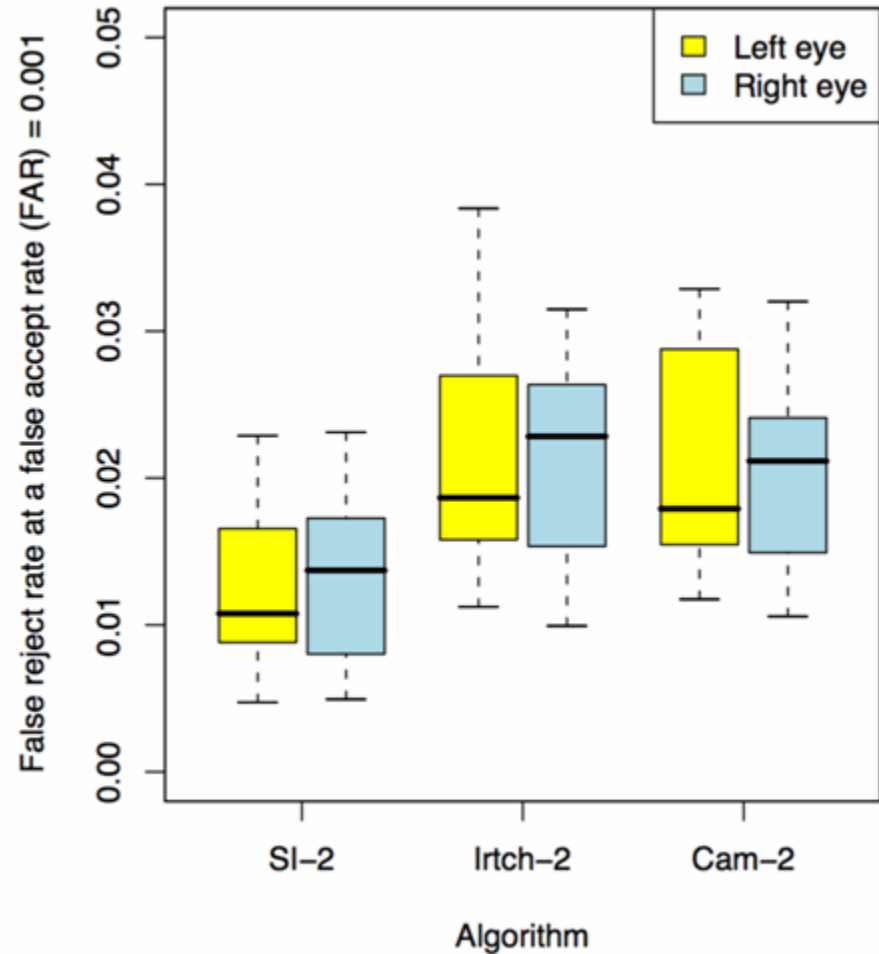
- Take a shot of 3 iris images
- If one or more is of sufficient quality, save all three

ICE 2006 Image Quality Reporting



ICE2006 Quality data

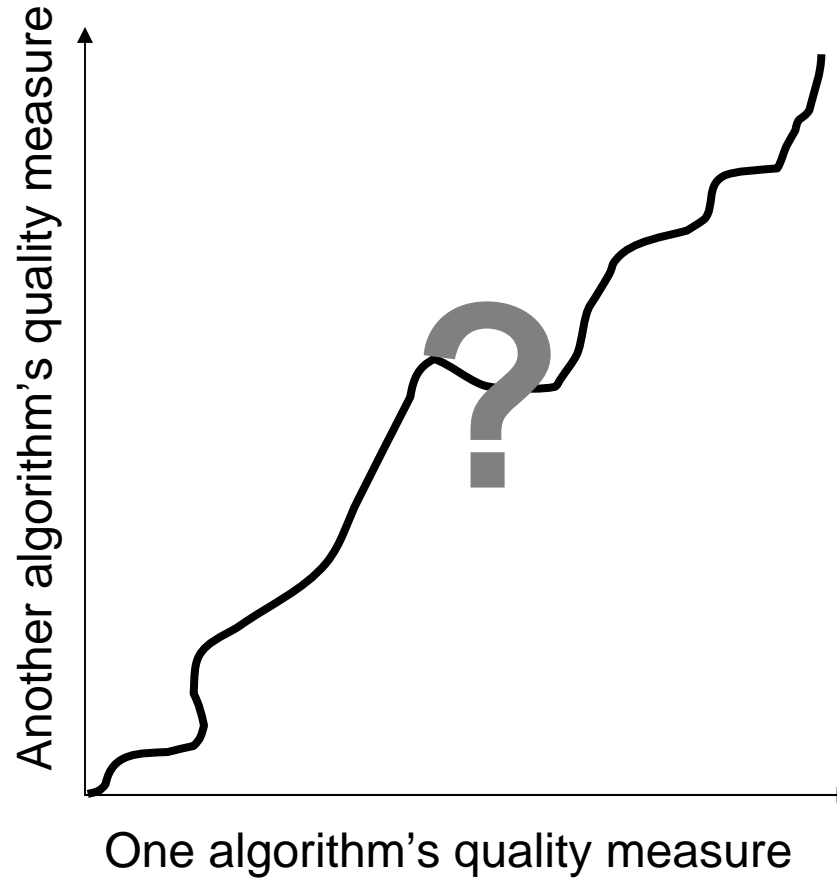
- Three competitive ICE 2006 performers (Sagem-Iridian, Cambridge and Iritech) (de-identified henceforth)
- 59,558 iris images
- Each image has three quality scores (one per performer)



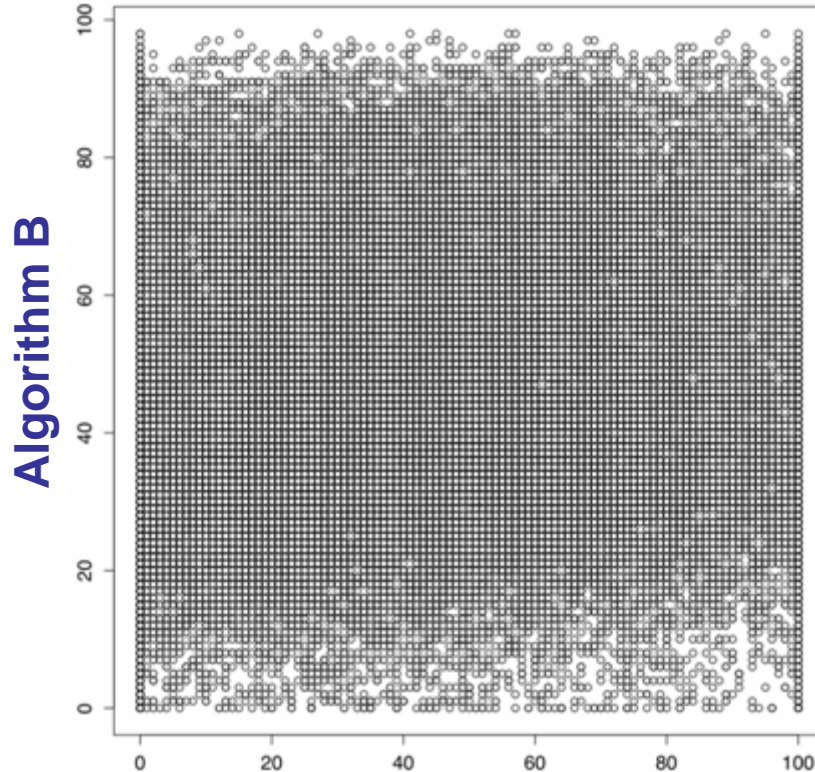


Mining Quality: Generic properties

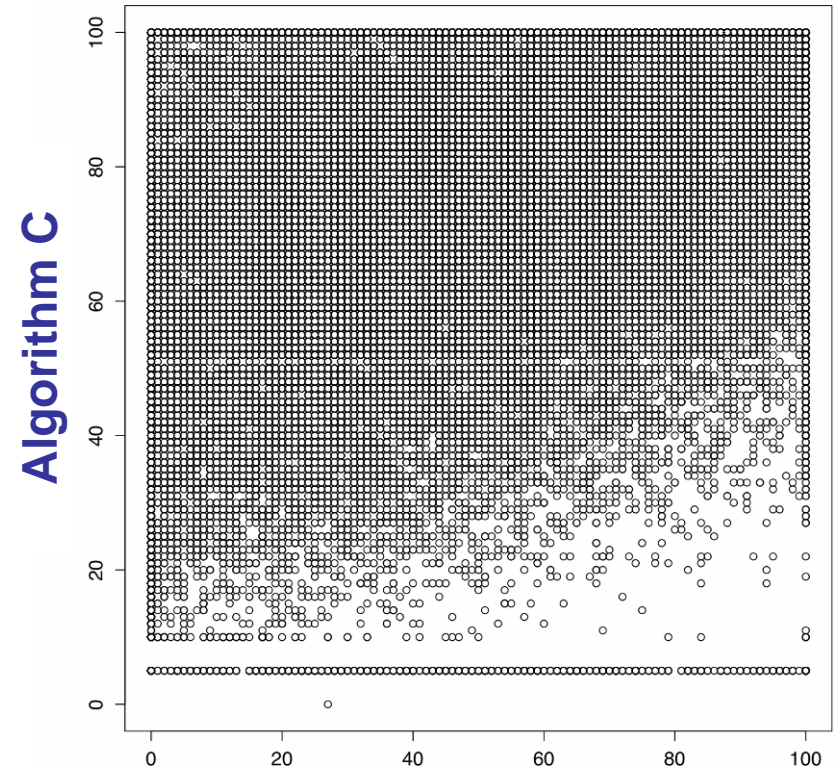
Should quality measures produced by different algorithms be correlated?



Quality measure scatter plots



Algorithm A



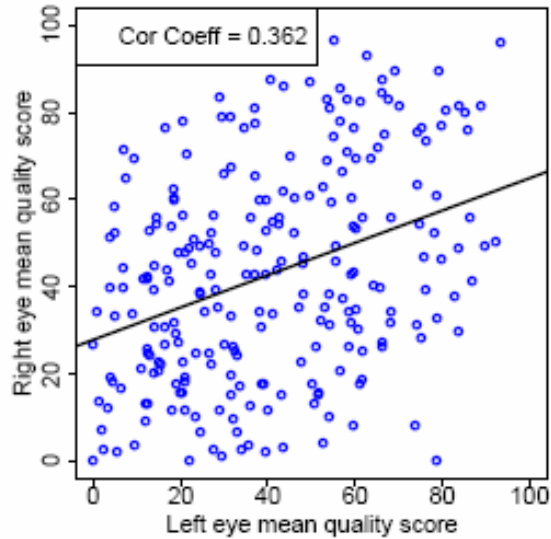
Algorithm A

Correlation of Quality scores table

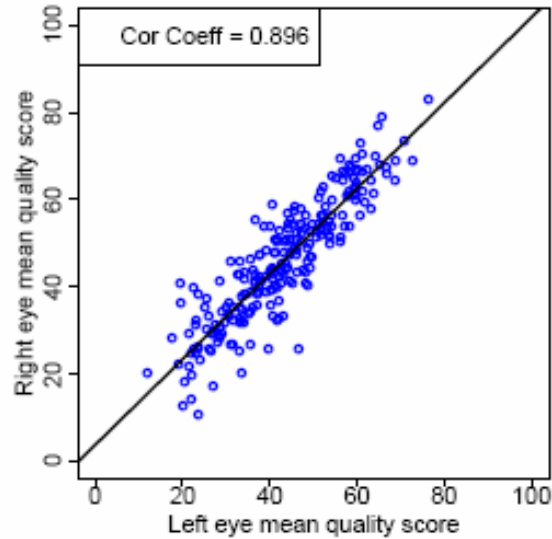
Algorithms	Pearson's r	Spearman's ρ
A vs. B	0.122	0.131
A vs. C	0.349	0.348
B vs. C	0.120	0.108

Quality Score Correlation Between Eyes

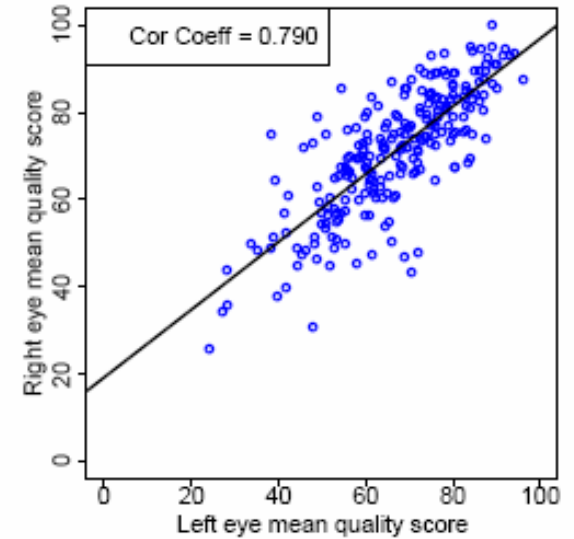
Quality measure A



Quality measure B



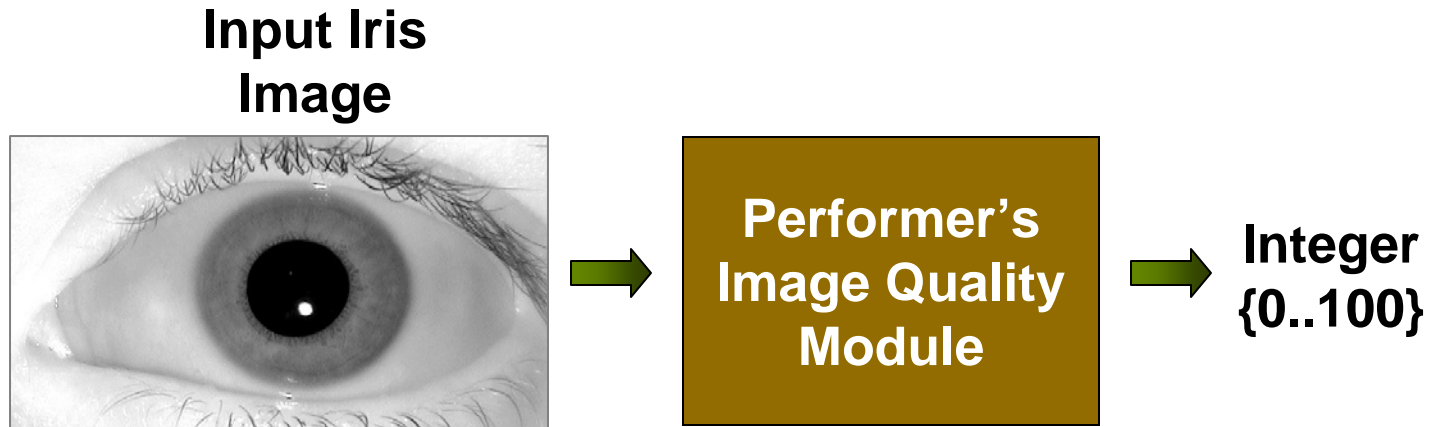
Quality measure C





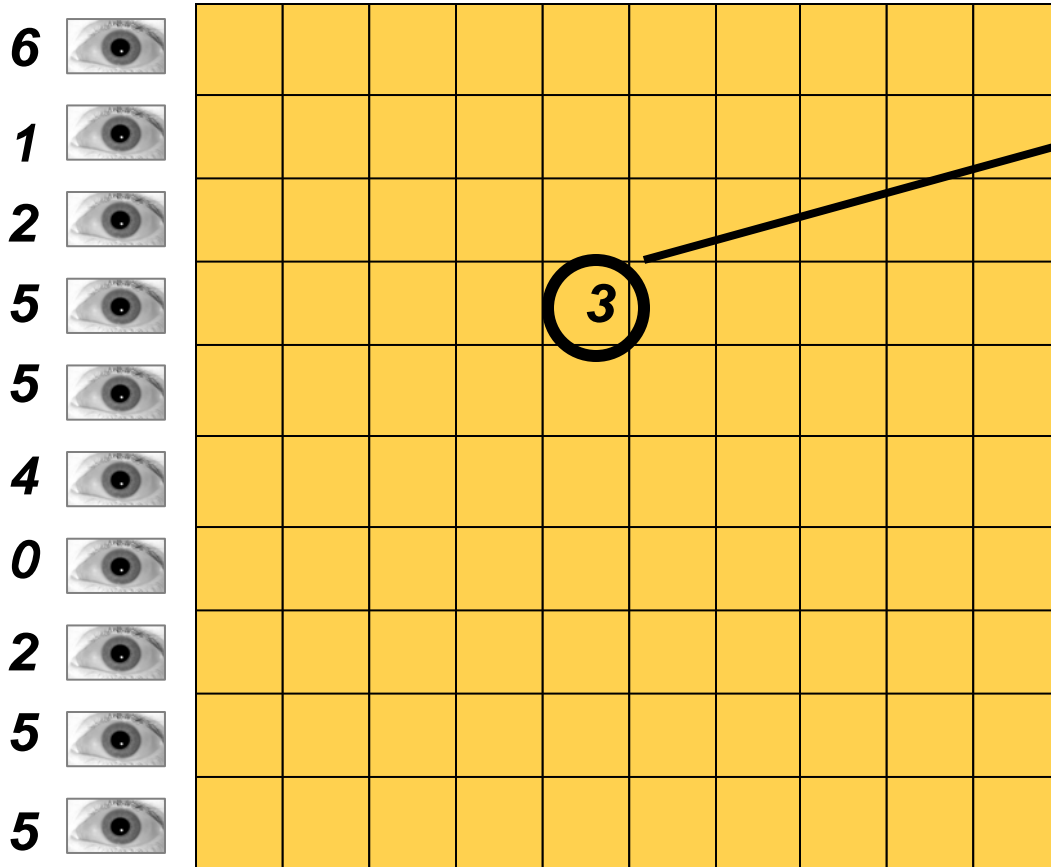
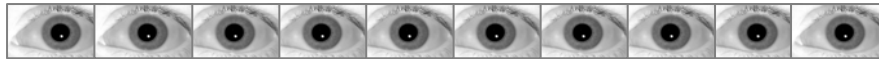
Quality effects on matching performance

Step 1: Compute Image Quality



Step 2: Compute Quality Matrix

6 1 2 5 3 4 5 2 5 0



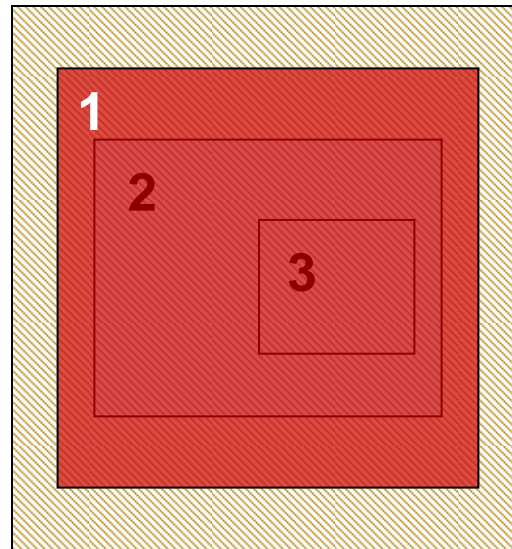
Quality score for a match pair is the minimum of the quality scores of its two signatures

Contains *quality scores* for all possible comparisons



Step 3: Compute global threshold on matching score

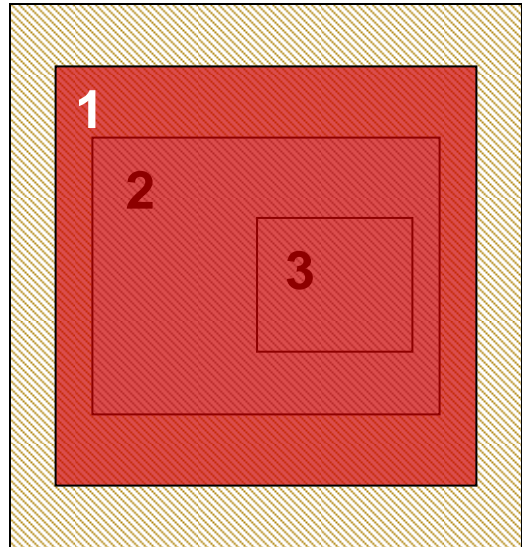
Complete similarity matrix



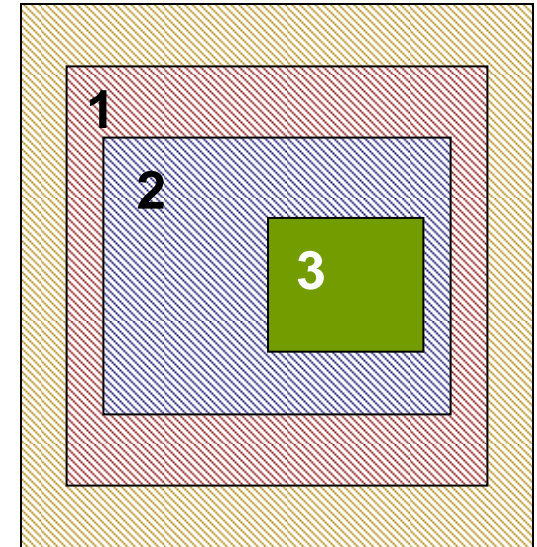
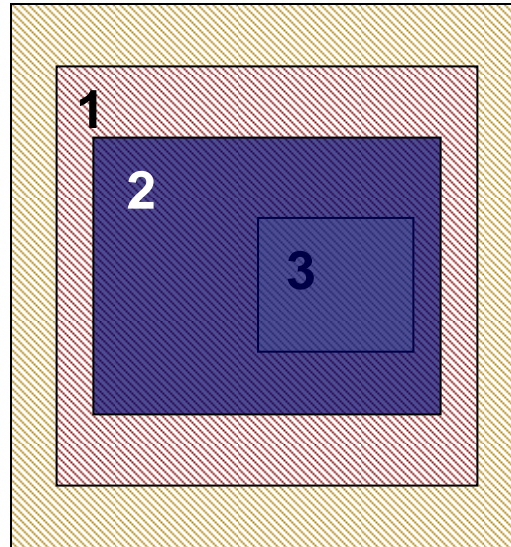
Compute threshold λ that yields FAR = 0.001

Step 4: Prune matching scores by quality

Complete Similarity matrix



Subset by quality threshold



Fused quality threshold values: 5, 10, ... 90, 95, 100

- 20 sub-experiments with nested sets of matching scores)
- Compute FAR, FRR from global threshold λ

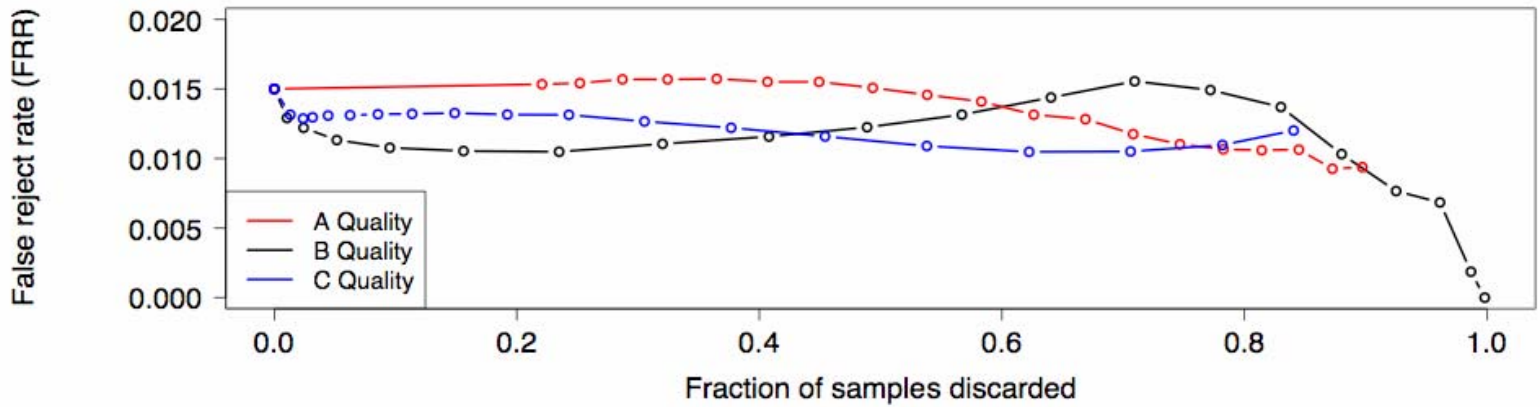


Calculation of FAR and FRR

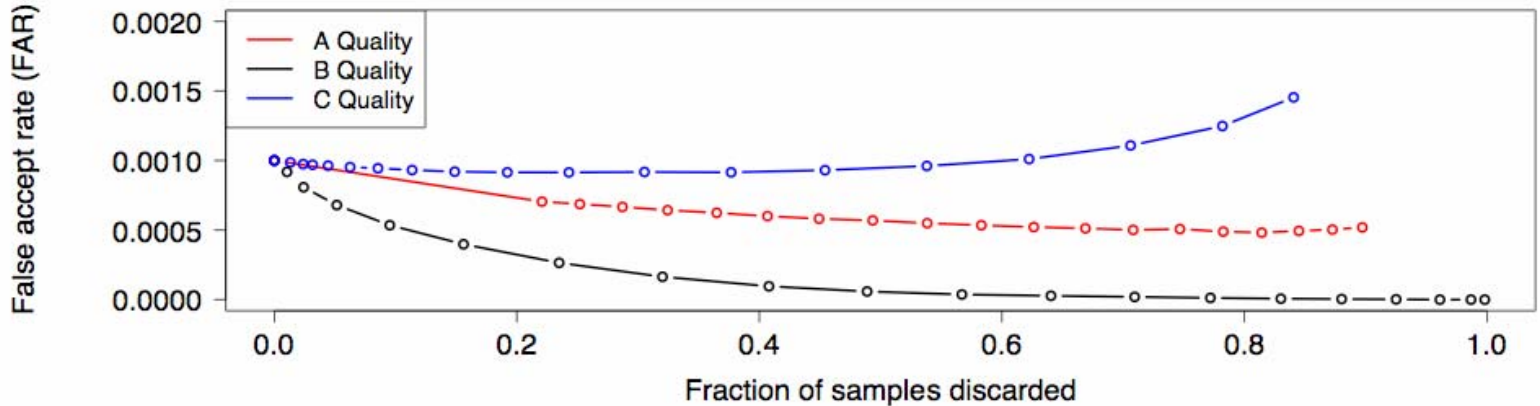
- From unpruned set, compute threshold λ that yields $FAR = 0.001$ (ICE 2006 operating point)
- Let $Q_F(g)$ and $Q_F(p)$ be the qualities of target and query samples g and p
- Using λ , calculate FAR and FRR from all match pairs (g', p') with $\min\{Q_F(g'), Q_F(p')\} \geq \lambda$

Performance by Quality

ICE2006 B – false reject rate

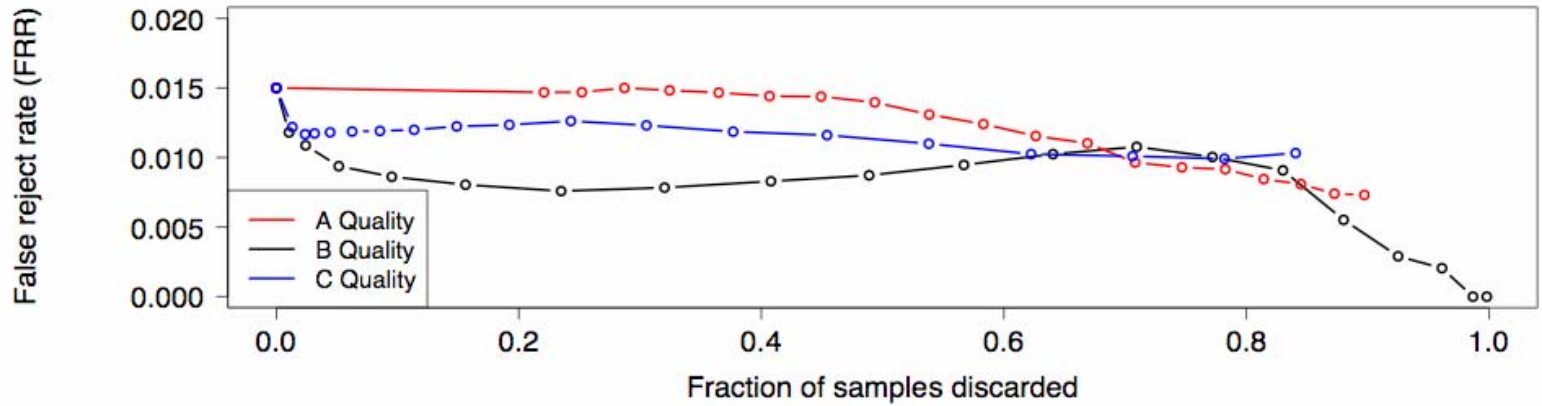


ICE2006 B – false accept rate

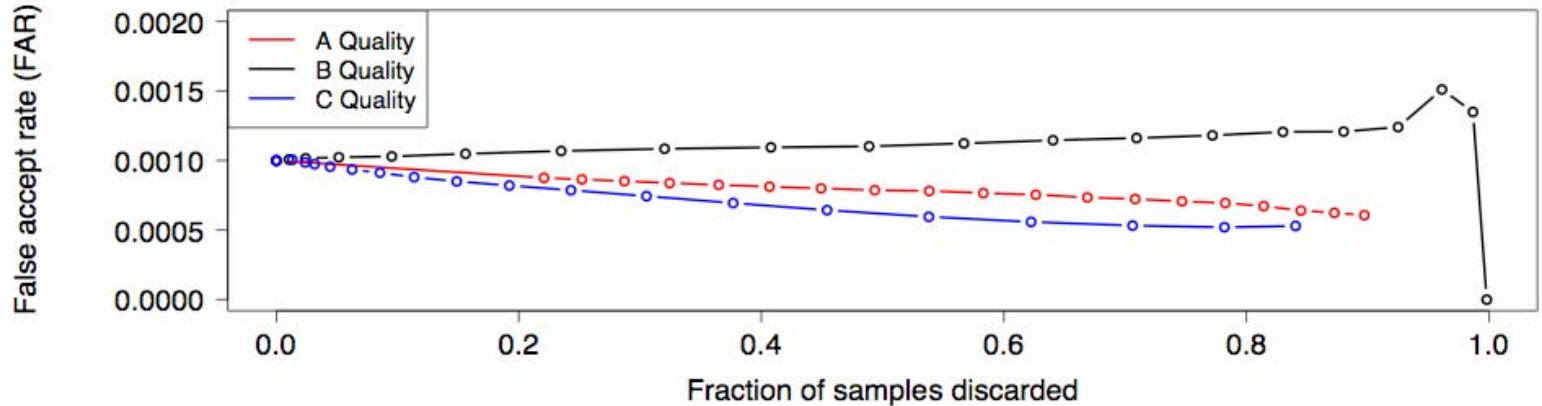


Performance by Quality

ICE2006 A – false reject rate



ICE2006 A – false accept rate





Covariate Analyses

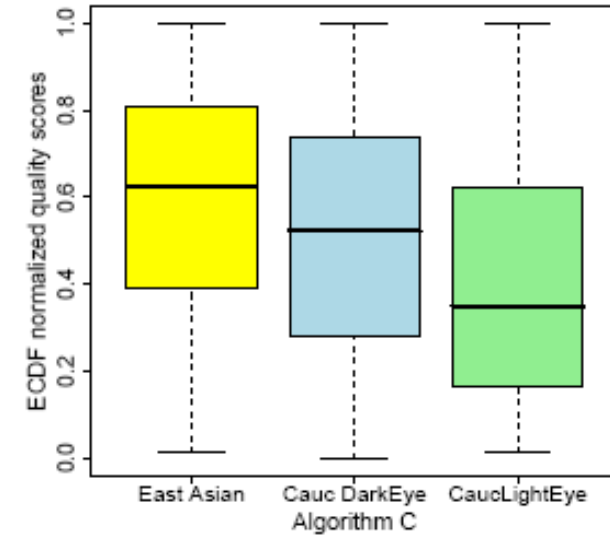
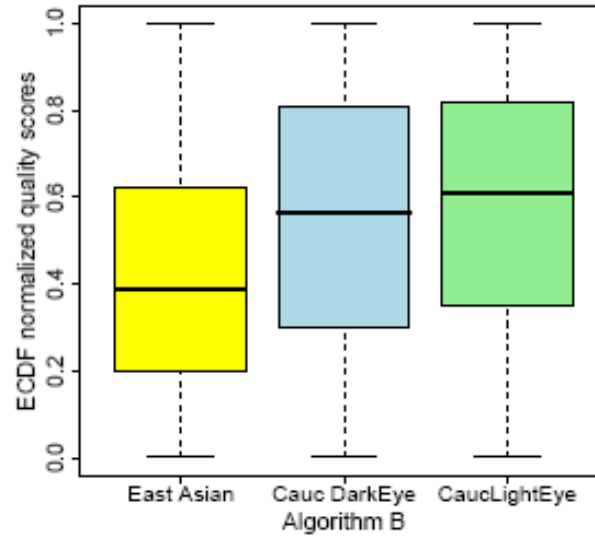
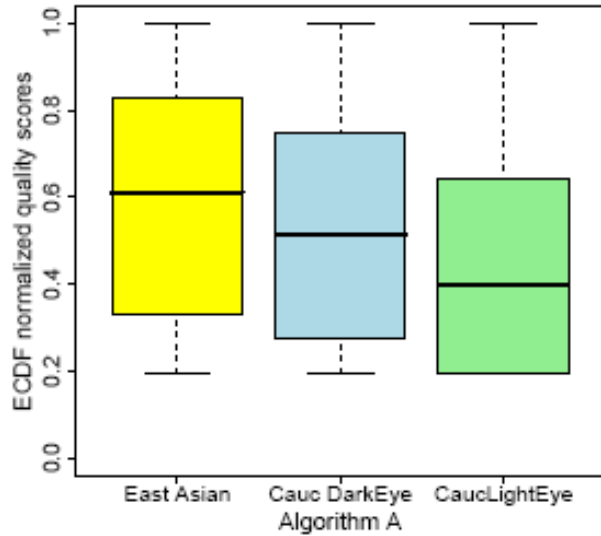
- Response of quality algorithms to demographic subsets
- Response of vendor matchers to demographic subsets



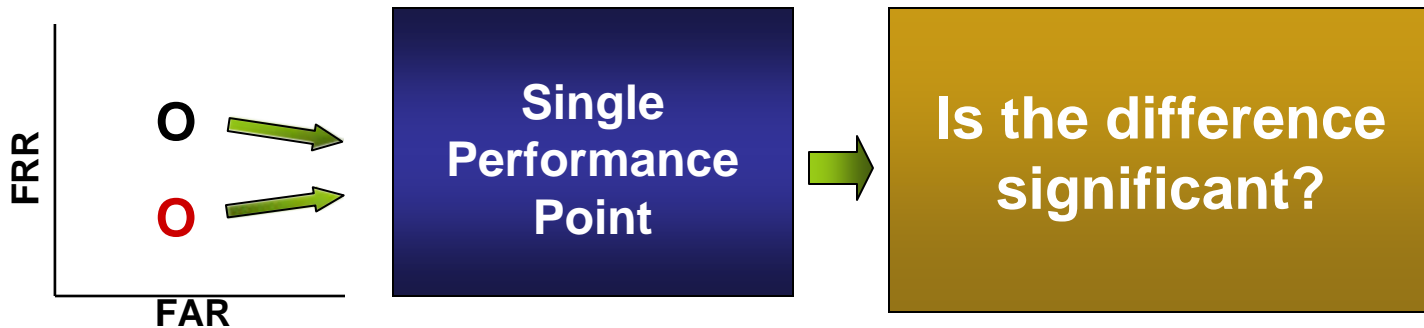
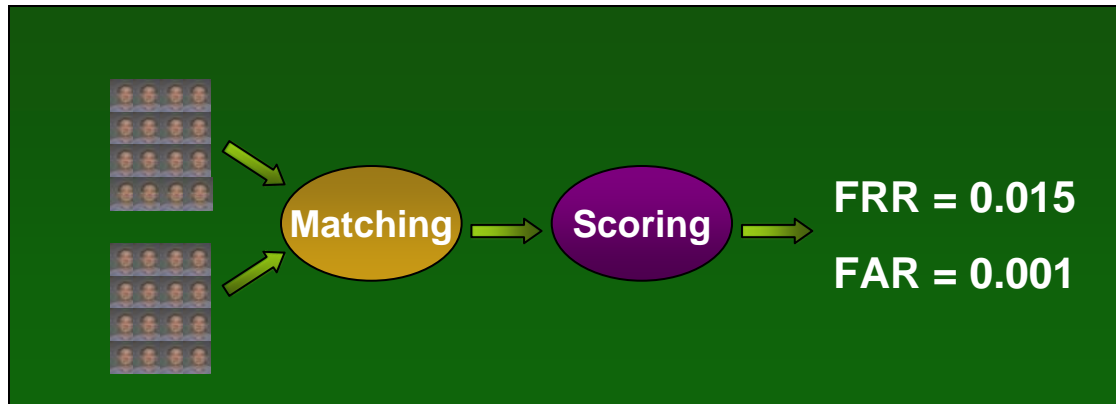
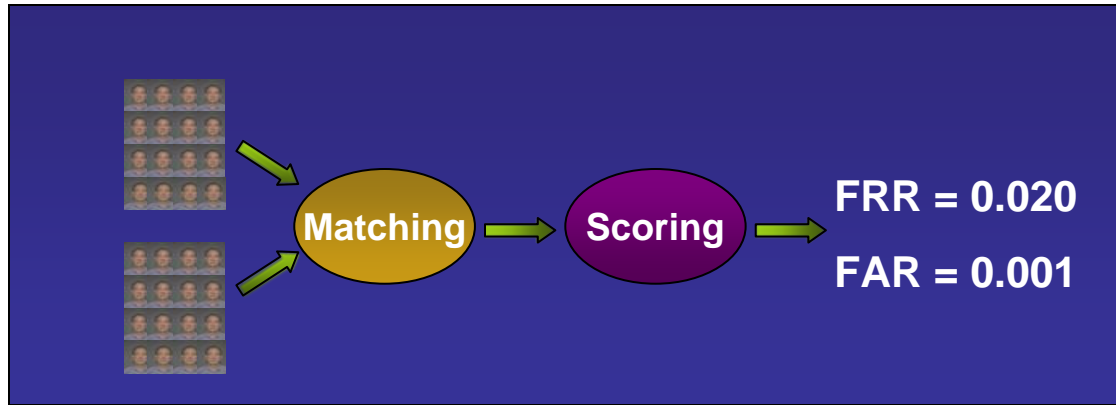
Quality Covariate Study

- Race and eye color
- Three covariates
 - East Asian
 - Caucasian w/Light Eyes
 - Caucasian w/Dark Eyes
- Quality scores normalized
 - Empirical CDF

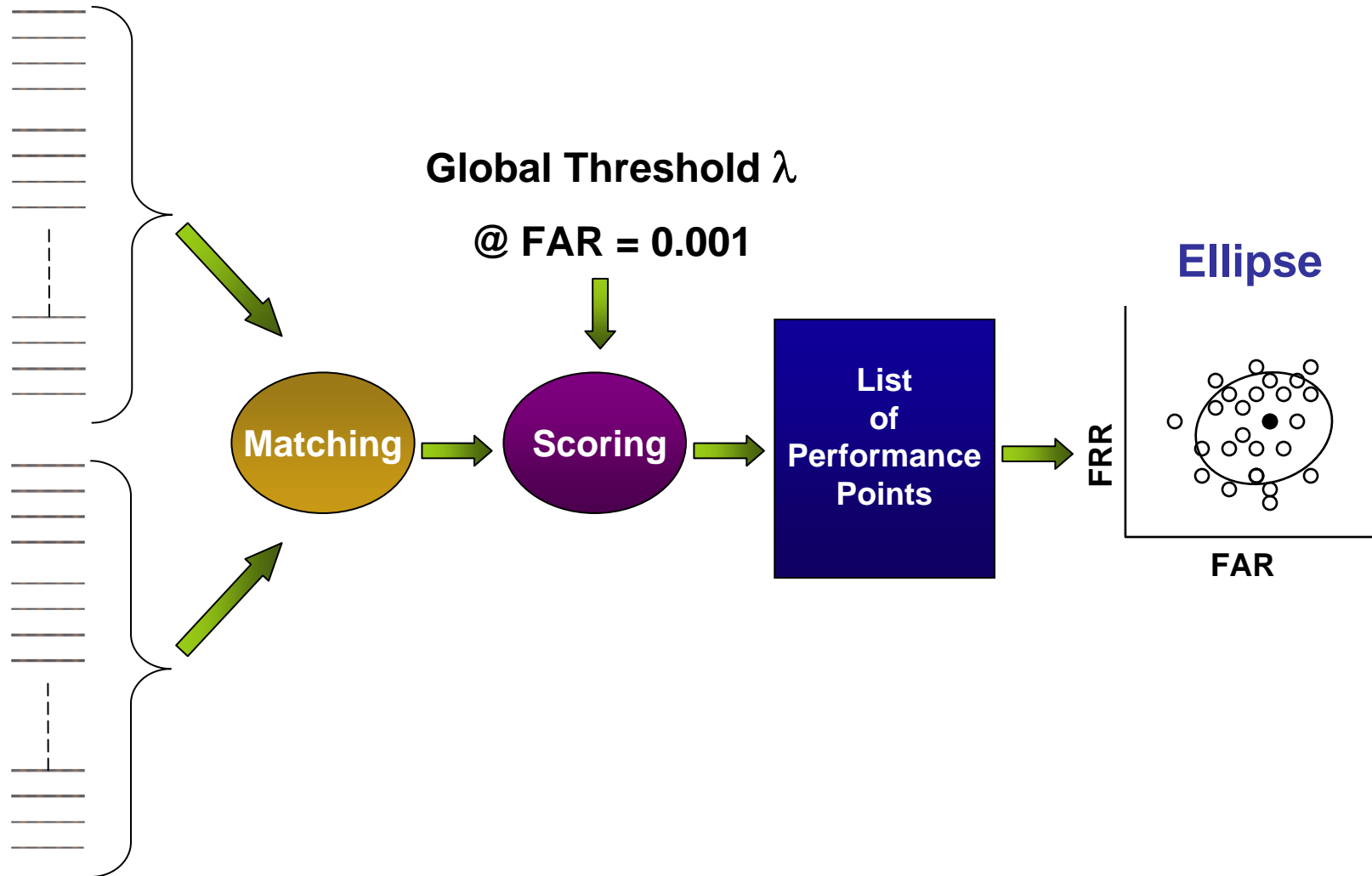
Quality Covariate Study



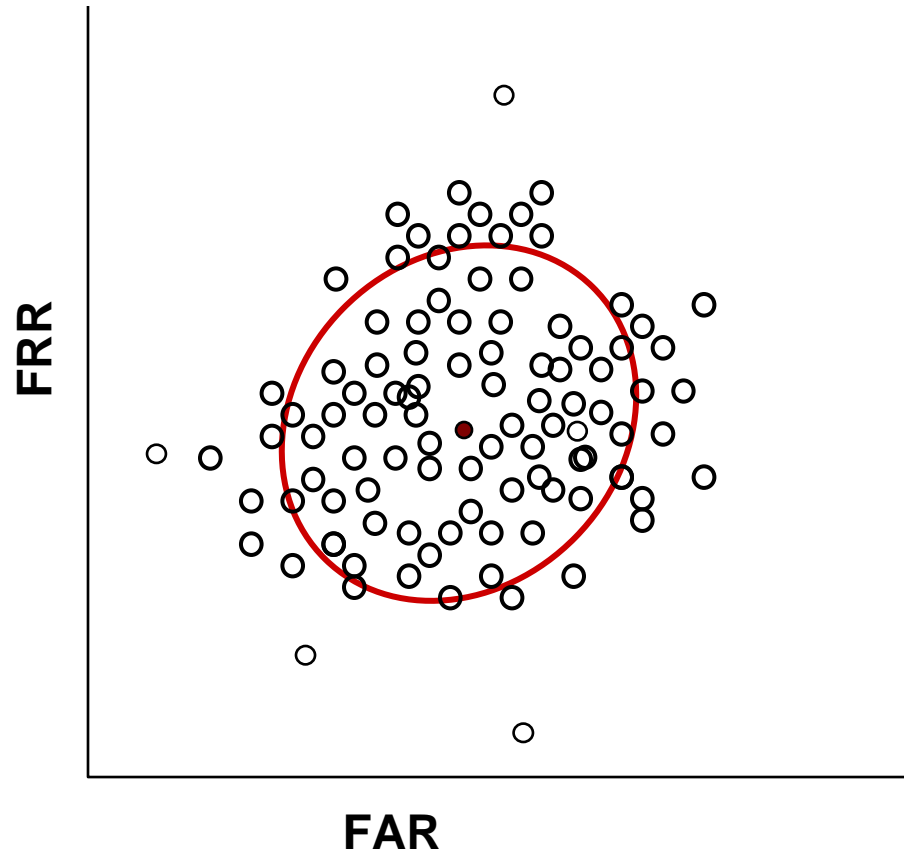
Classic Scoring of Results



Re-sampling Techniques

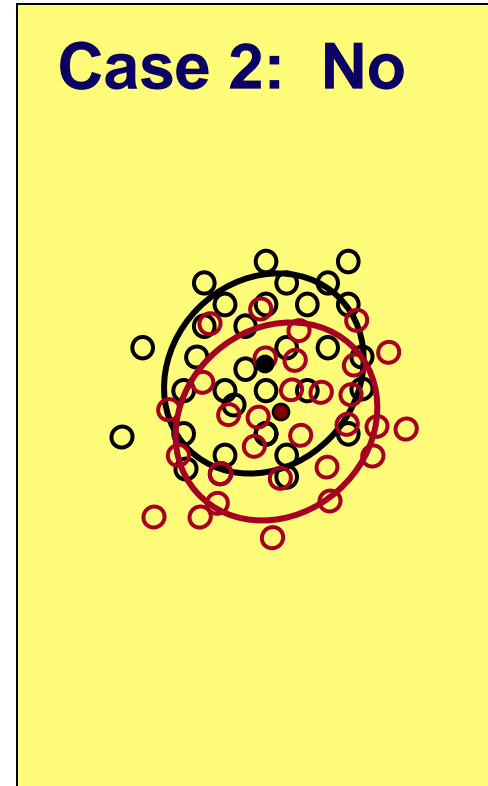
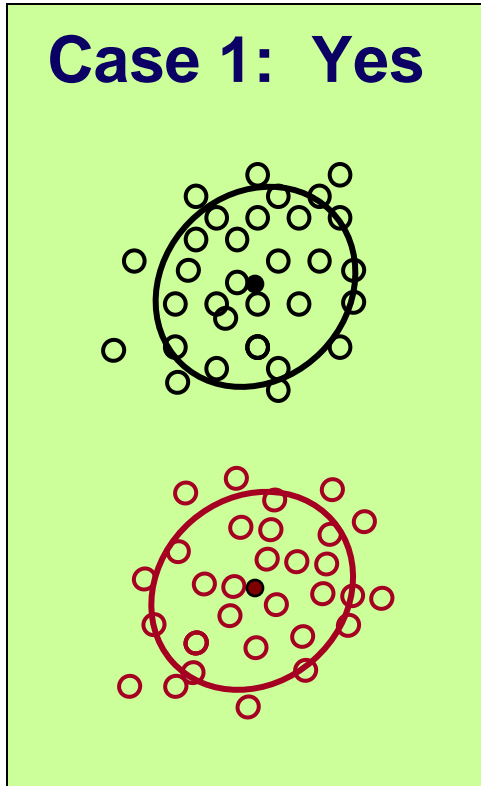


Error Ellipse



Ellipse

- Is the level of difference significant?





Performance Covariate Study

- Race, eye color, eye
- Covariates
 - East Asian
 - Caucasian w/Light Eyes
 - Left eye
 - Right eye
- Measure effect
 - FAR
 - FRR



Performance variations by combination of matcher and demographic

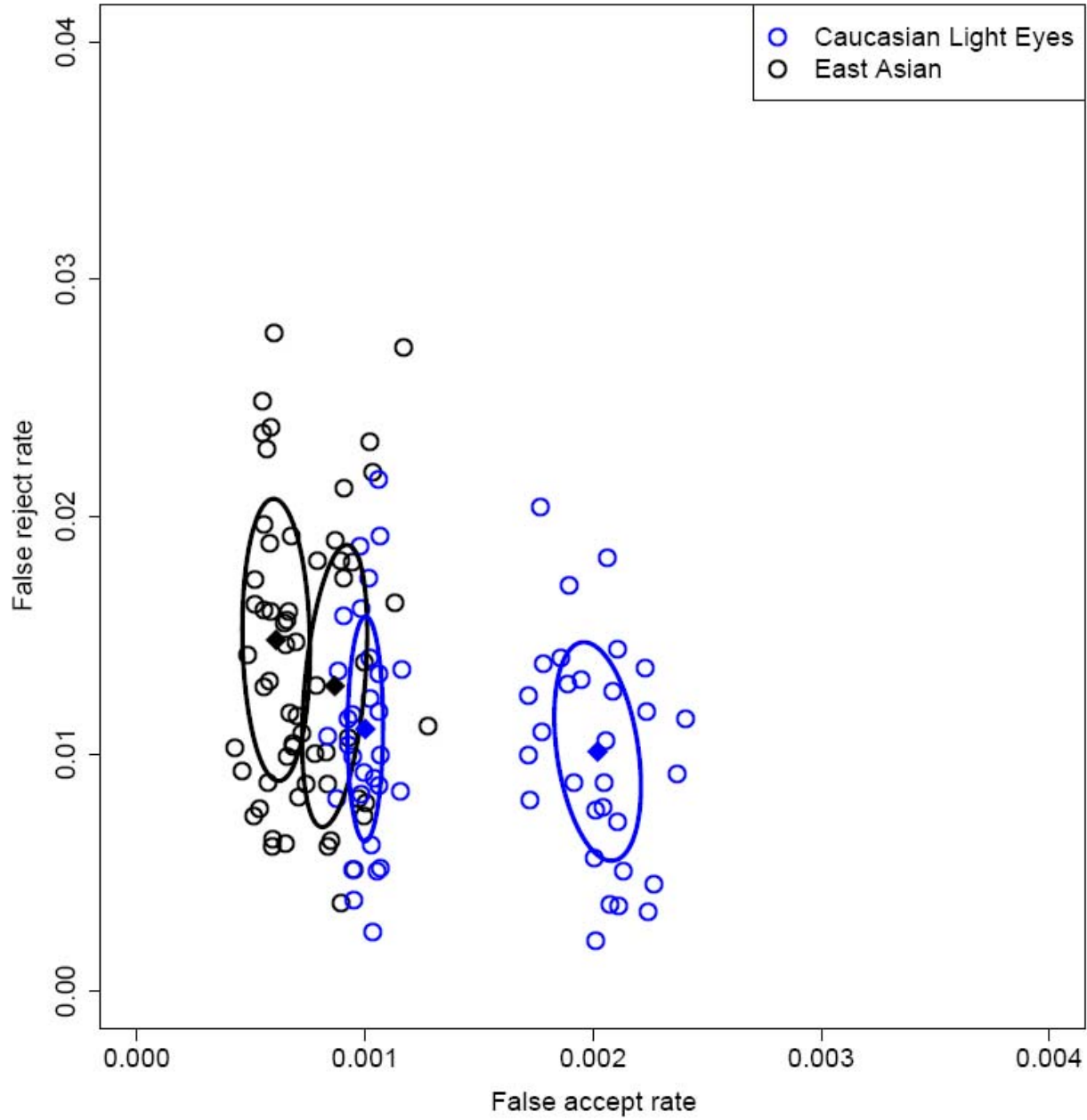
- For each matcher
 - Compute similarity threshold that yields $FAR = 0.001$ for entire data set
 - For each demographic category in {East Asian, Caucasian Light eyes}
 - Divide match pairs with target and query in demographic category into 60 equal-sized subsets of matches
 - For each subset
 - Compute and plot FAR, FRR for each subset using global threshold



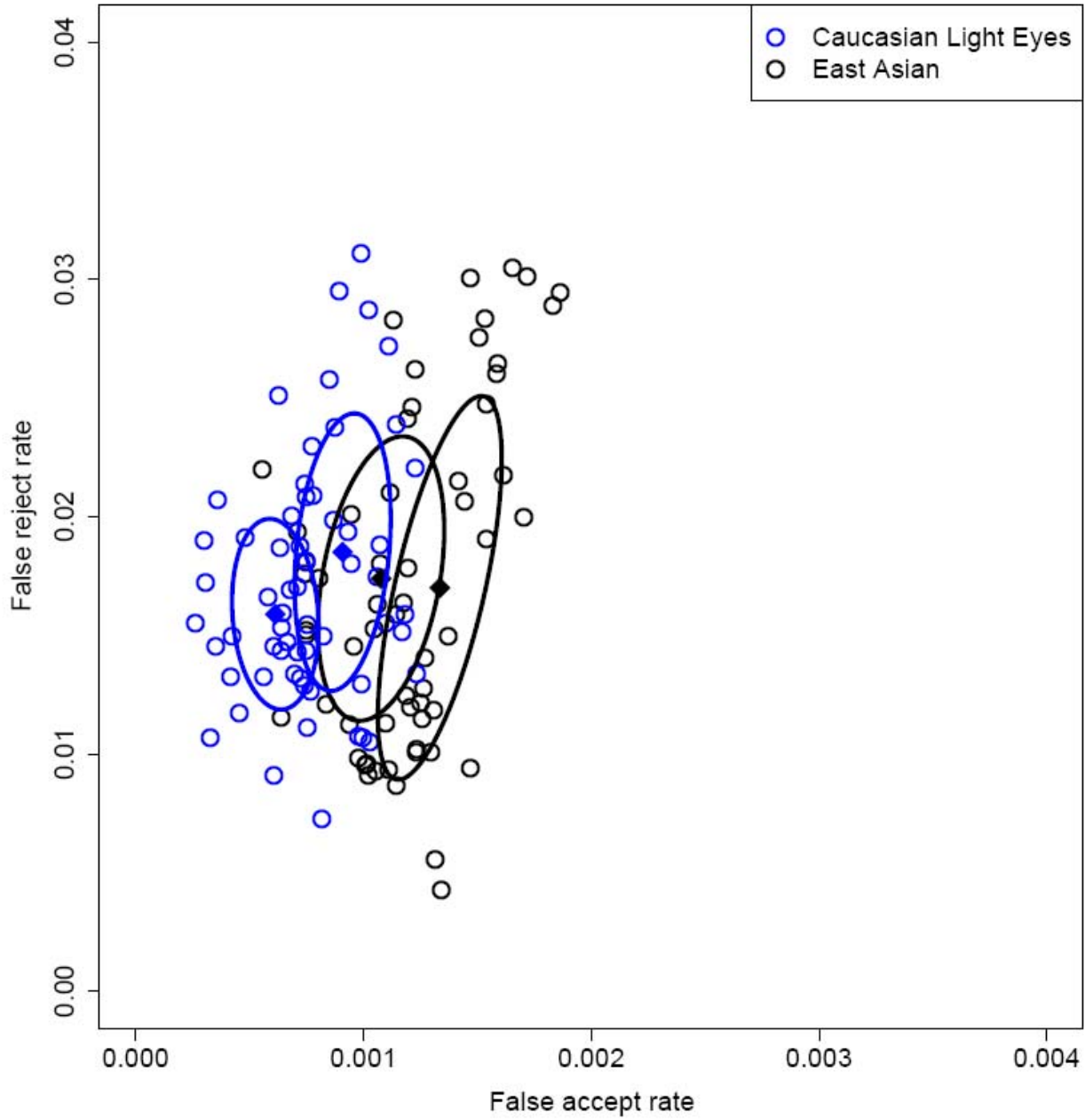
Performance Covariate Study

- First look
 - East Asian
 - Caucasian w/Light Eyes
- Four groupings
 - Left eye -- East Asian
 - Right eye -- East Asian
 - Left eye -- Caucasian w/Light Eyes
 - Right eye -- Caucasian w/Light Eyes

Algorithm A



Algorithm B

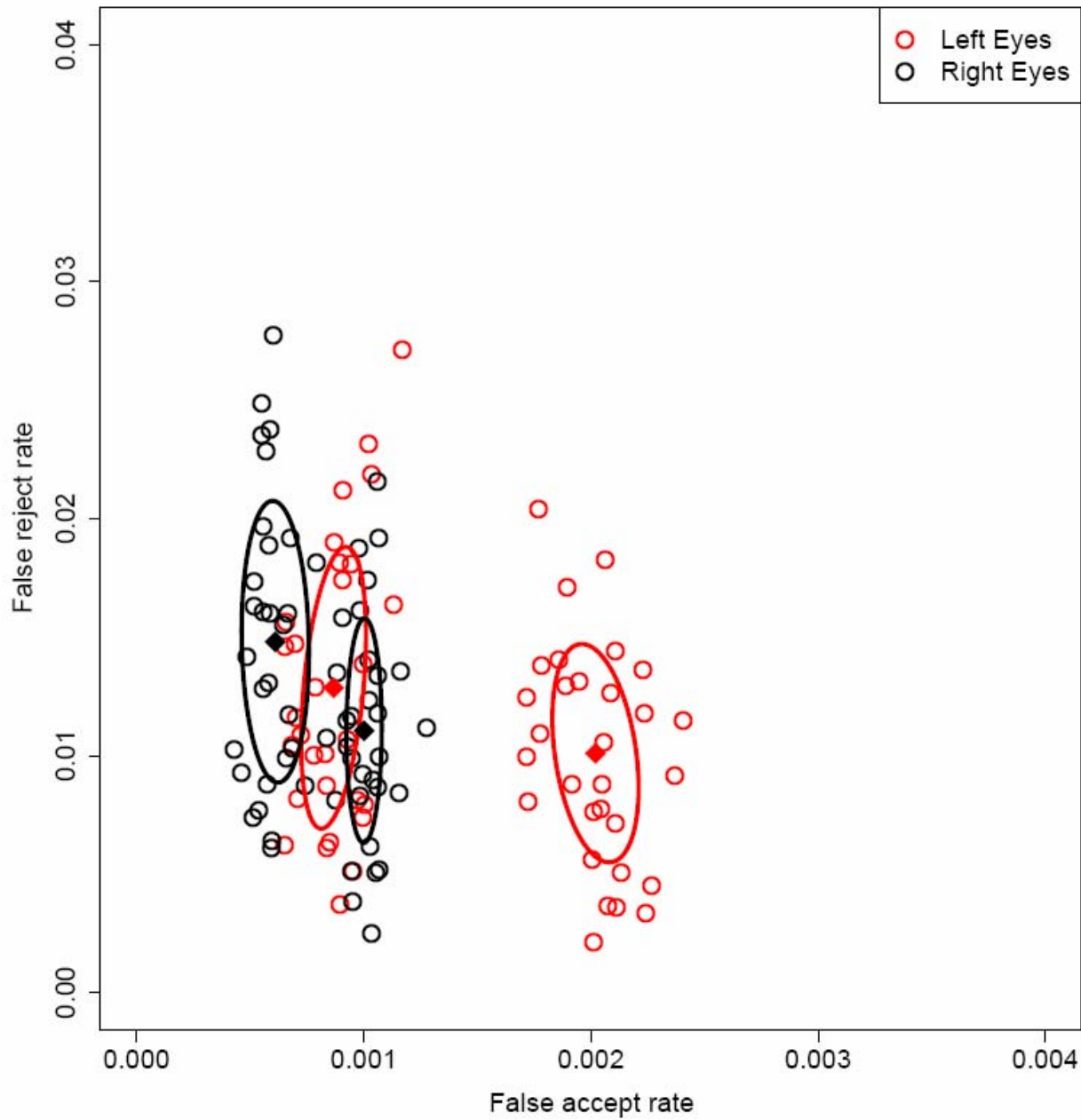




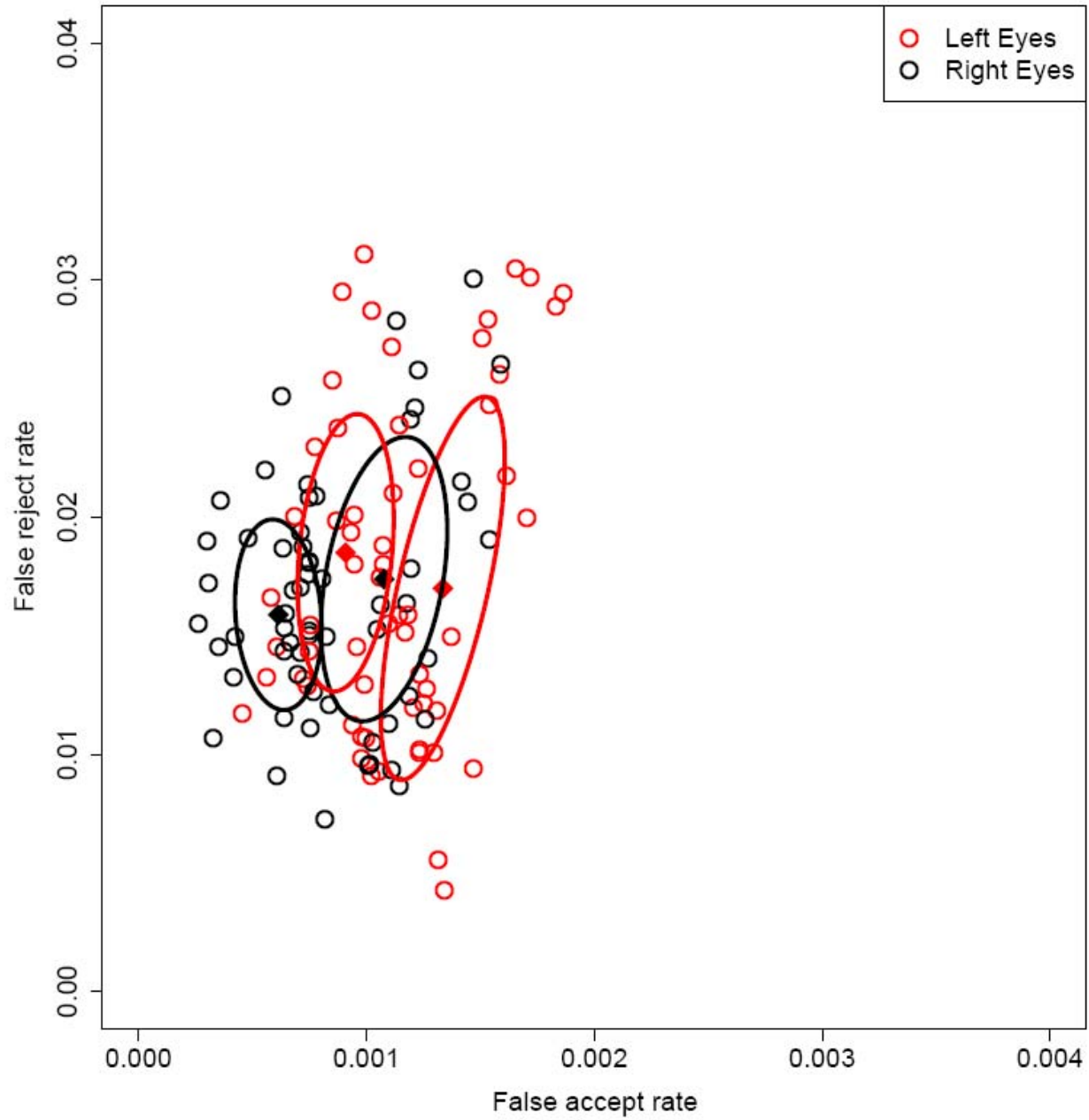
Performance Covariate Study

- Next look
 - Left eye
 - Right eye
- Four groupings
 - Left eye -- East Asian
 - Right eye -- East Asian
 - Left eye -- Caucasian w/Light Eyes
 - Right eye -- Caucasian w/Light Eyes

Algorithm A



Algorithm B

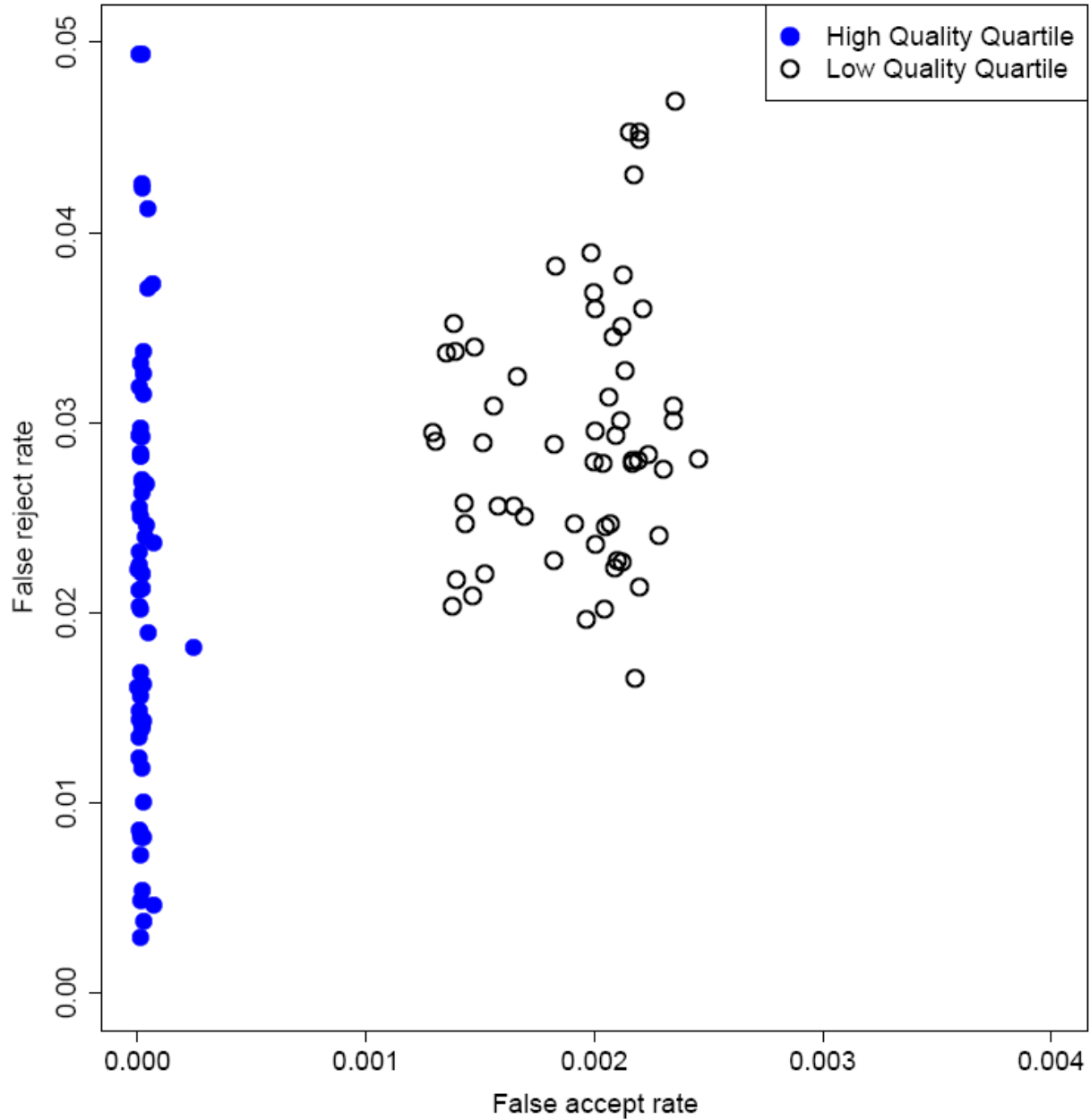




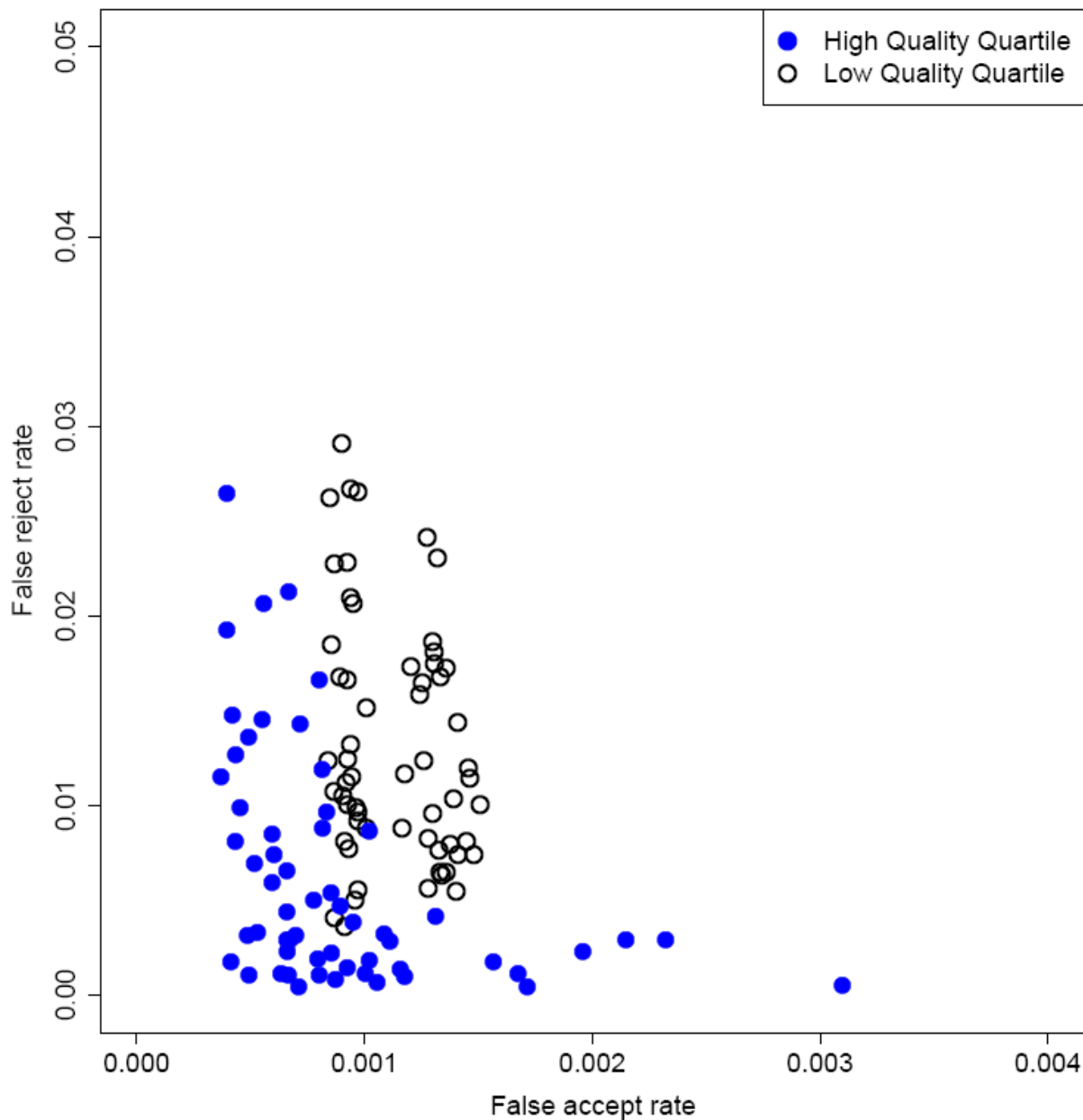
Quartile Quality Study

- Effect of Quality
 - FAR
 - FRR
- Bracket Quality by Quartile
 - High Quality Quartile
 - 25% highest quality samples
 - Low Quality Quartile
 - 25% lowest quality samples
 - **Disjoint** quality intervals; no matches in common

Algorithm B and Quality Measure B



Algorithm A and Quality Measure A





Error estimation: Data-imposed limitations

- Number of Non-Matches (impostors) in ICE 2006: **562,301,273**

Expected false accepts	False accept rate	
	1:1000	1:1,000,000
Number of false accepts	562,301	562
60 partitions	9400	9.4
Eye, race, eye color	1000	1

Observations and Conclusions

- Initial examination of ICE 2006 quality data
- Iris image quality affects performance (general trends, from aggregated ICE 2006 performance data)
 - FAR decays with quality @ fixed FRR
 - FRR nearly invariant for a range of quality ranks after an initial drop, at fixed FAR
- Also:
 - Demographic effects for quality measures
 - Demographic effects on FAR
- Non-match distribution affected by quality and demographics (not presented here)



Conclusions (contd.)

- Iris image quality measurement needs more research and thorough testing
 - Lack of correlation between three ICE2006 responders suggests that they were measuring different aspects of quality, or measuring them with different degrees of accuracy
 - Opportunities:
 - for further research
 - Fusion
- Quality is not in the eye of the beholder; it is in the recognition performance figures!



ICE Mining

- Should enable development of formal structural models, with specialized analyses
 - e.g., Generalized Linear Mixed Models



Thank You

Robert Frost, *Harper's Magazine*, 1920



*Some say the world will end in fire;
Some say in ice.*

*From what I've tasted of desire
I hold with those who favor fire.*

But if it had to perish twice,

I think I know enough of hate

To know that for destruction ice

Is also great

And would suffice.