NIST Workshop Presentation

Enhancing Identity Resolution

Exploiting relationships between quality attributes and matching scores to optimize candidate lists.

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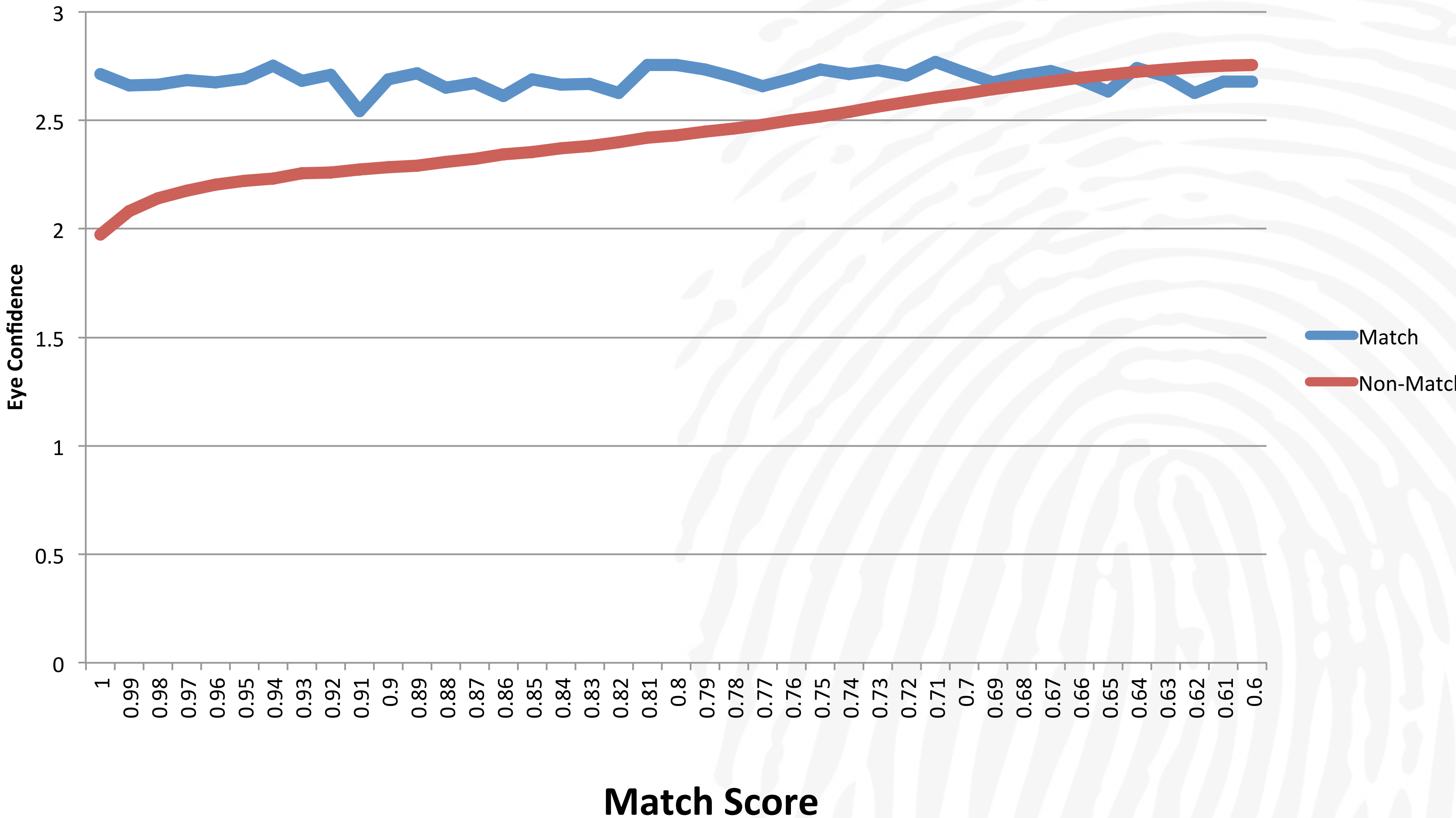
Background: Problem with Biometric Scores and Candidate Lists

- Biometric scores are proprietary pairwise evaluation of the similarity between template features.
- Overall rarity of such features amongst the general population is not considered in the evaluation.
- Match scores are often not intuitive or interpretable in the identification context which requires an "evidential weighting".

Background: Problem with Biometric Scores and Candidate Lists (continued…)

- Risks associated with lights out matching can be better controlled using an evidential framework
- Candidate list inclusion thresholds are based solely upon match scores that do not consider rarity of features.

Match Score versus Eye Confidence for Genuine and Imposter distributions



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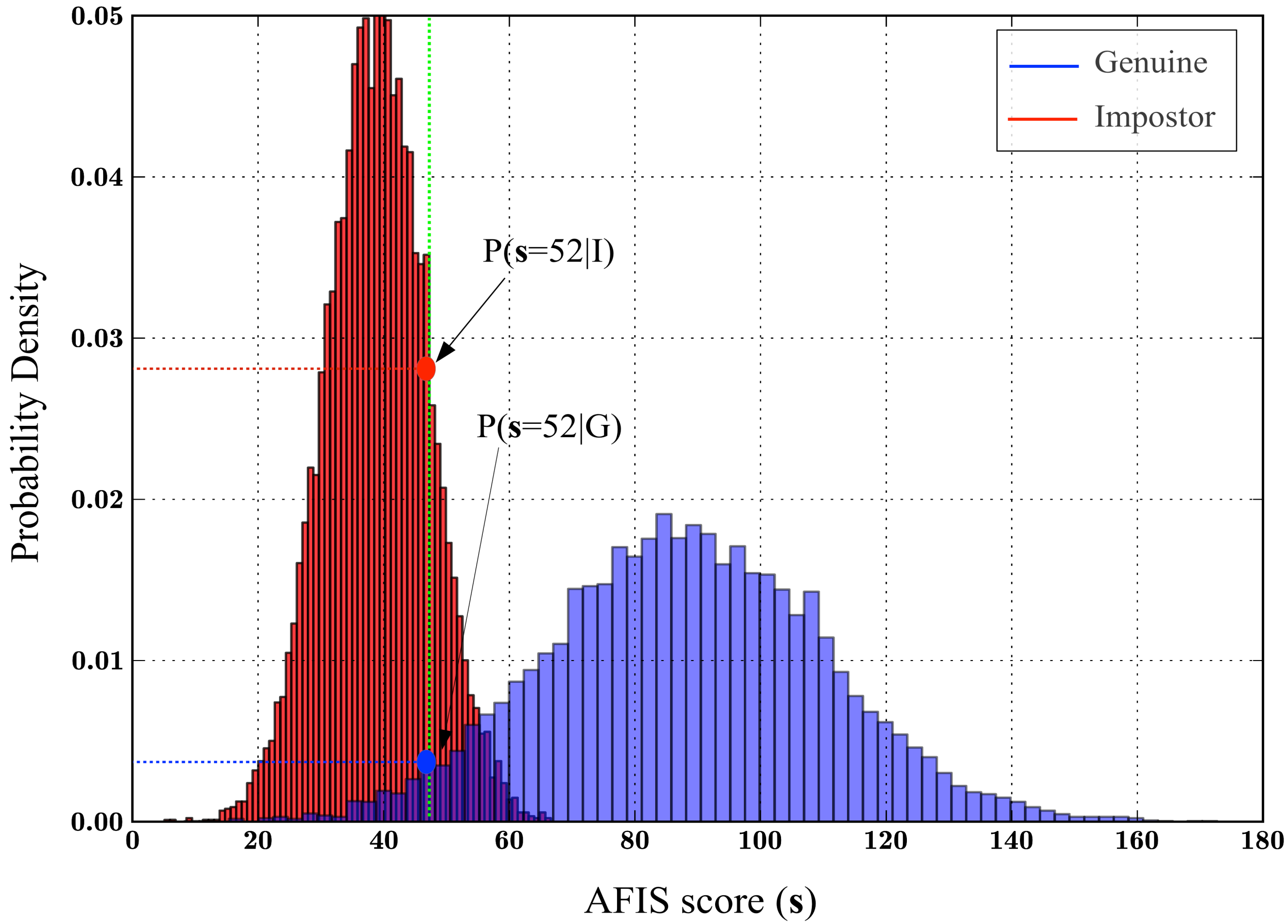
Weighting Match Score on the Rarity of feature set.

- Match scores that are used in identifications should also include the rarity of compared features as a formulation factor.
- Solution: A well known, well established framework derived from Forensic Science: **Likelihood ratios**

Biometric Score vs. Likelihood Ratios



$$LR = \frac{P(score = 52|Genuine)}{P(score = 52|Imposter)} = \frac{0.005}{0.03} = \frac{1}{6}$$

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image source: J. Abraham et. al. (2013)

Proposed Method: Likelihood Ratios Conditioned with Quality Attributes

- Quality attributes have been observed to have a relationship with high scoring imposters.
- Likelihood Ratio (LR)
  – Conditioning can be applied to sub-populations with different **quality settings**:

$$LR_{quality} = \frac{P(score|Genuine, Quality)}{P(score|Imposter, Quality)}$$

Proposed Method: Candidate list Population Analysis

- The proposed likelihood ratio can be further conditioned to analysis the Candidate list population
- Likelihood Ratio (LR):

$$LR_{quality,Rank \leq n} = \frac{P(s|Genuine, Quality, Rank \leq n)}{P(s|Imposter, Quality, Rank \leq n)}$$

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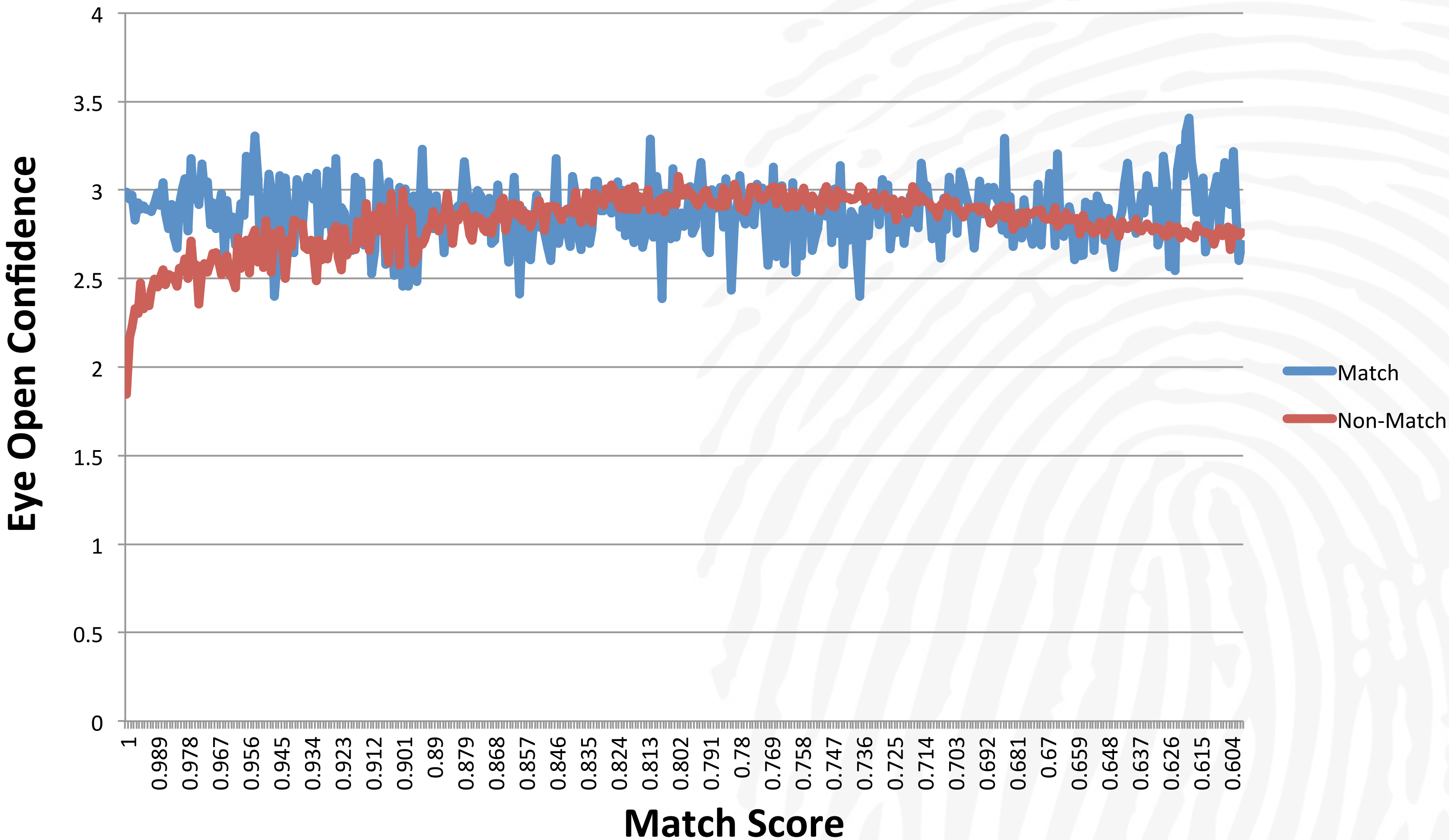
Experiment

- Study based on 12 months of data from the Australian Passport Office.
- Gallery containing 1.6 million images
- Probe set of 200,000 mated pair images
- Identification search with top 100 candidates.
- Match and Quality attributes analyzed

Eye Confidence Quality Attributes

- **EyeConfidence**: confidence metric of eye locations
- **EyeOpenConfidence**: confidence metric of eye being open
- **EyeGazeFrontalConfidence**: confidence metric of eye having frontal gaze.

Eye Open Confidence vs. Match Score for Genuine and Imposter distributions



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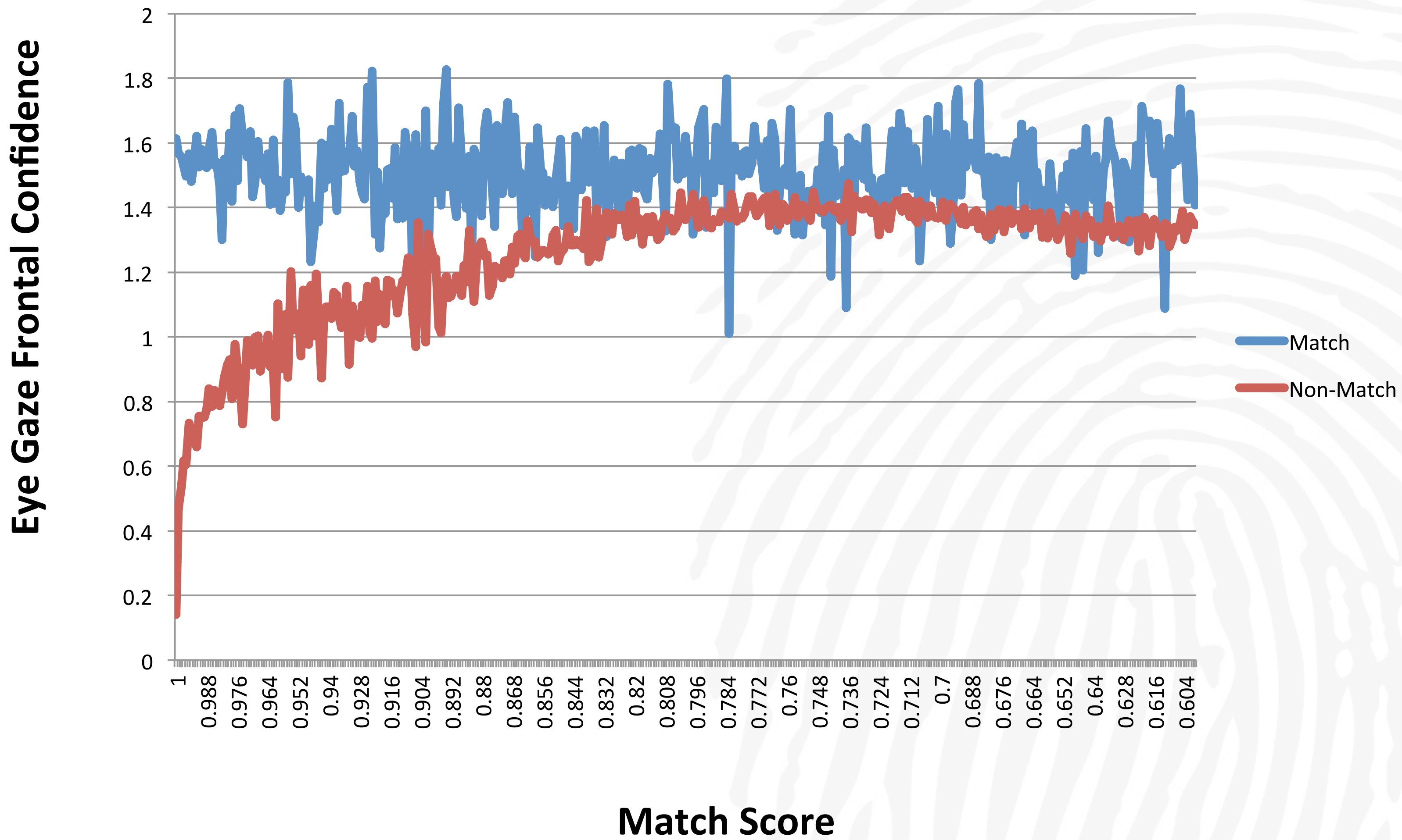
Eye Frontal Gaze Confidence vs. Match Score



General LR Analysis

- Given a probe/candidate pair with an almost perfect match score we can assign a LR value based on the confidence of eye quality metrics.
  - For this example, the rank 1 population:
    - **LR(score>0.98, low quality eye metrics, rank<100)=11.9**
    - **LR(score>0.98, high quality eye metrics, rank<100)=383.6**

Using LR to re-order Candidate List

- The LR can be used to re-order a candidate list
- For example:

Score	A	B	C	D	E
	0.9995	**0.9962**	**0.9883**	**0.9532**	**0.8741**
LR	B	A	C	E	D
	383.6	**11.9**	**11.9**	**1.90**	**1.09**

Score versus LR for Non-Matches

Likeihood Ratio

Match Score

nlr	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.10	1.20	1.30	2.00	2.50	3.30	3.60	4.80	5.90	11.90	14.10	383.60
nscore																						
0.60		2,596																				
0.62		5,354																				
0.64		3,039	2,292																			
0.66	101	141	4,832																			
0.68	143	141	4,893																			
0.70		291	2,381	2,309																		
0.72		212	144	2,476	2,066																	
0.74			181		4,801																	
0.76					2,707	1,866	135															
0.78						4,097	166			121												
0.80						3,583				154	118											
0.82						1,823		1,430			134	108										
0.84								2,828				105		84								
0.86								1,421	989					106	56							
0.88									1,163		927				78		45					
0.90											1,155					27	34					
0.92											939					27			16			
0.94											708	682						26	25			
0.96												765	863					27			29	
0.98													1,176							1,535	30	49

Non-matches with **low match score** and **high likelihood** ratios

Non-matches with **high match score** and **high likelihood** ratios

Produced using Performix (performix.biometix.com)

Conclusion

- The use of quality metrics to form conditional likelihood ratios we have shown to empirically improve candidate ranking.
- Likelihood ratios
  - allow for re-ranking candidate list
  - reduce risk of poor lights-out resolution
  - improve the human understanding of match results
  - supports forensic investigation
- The best combination of quality metrics will be likely to involve a mixture of confidence attributes

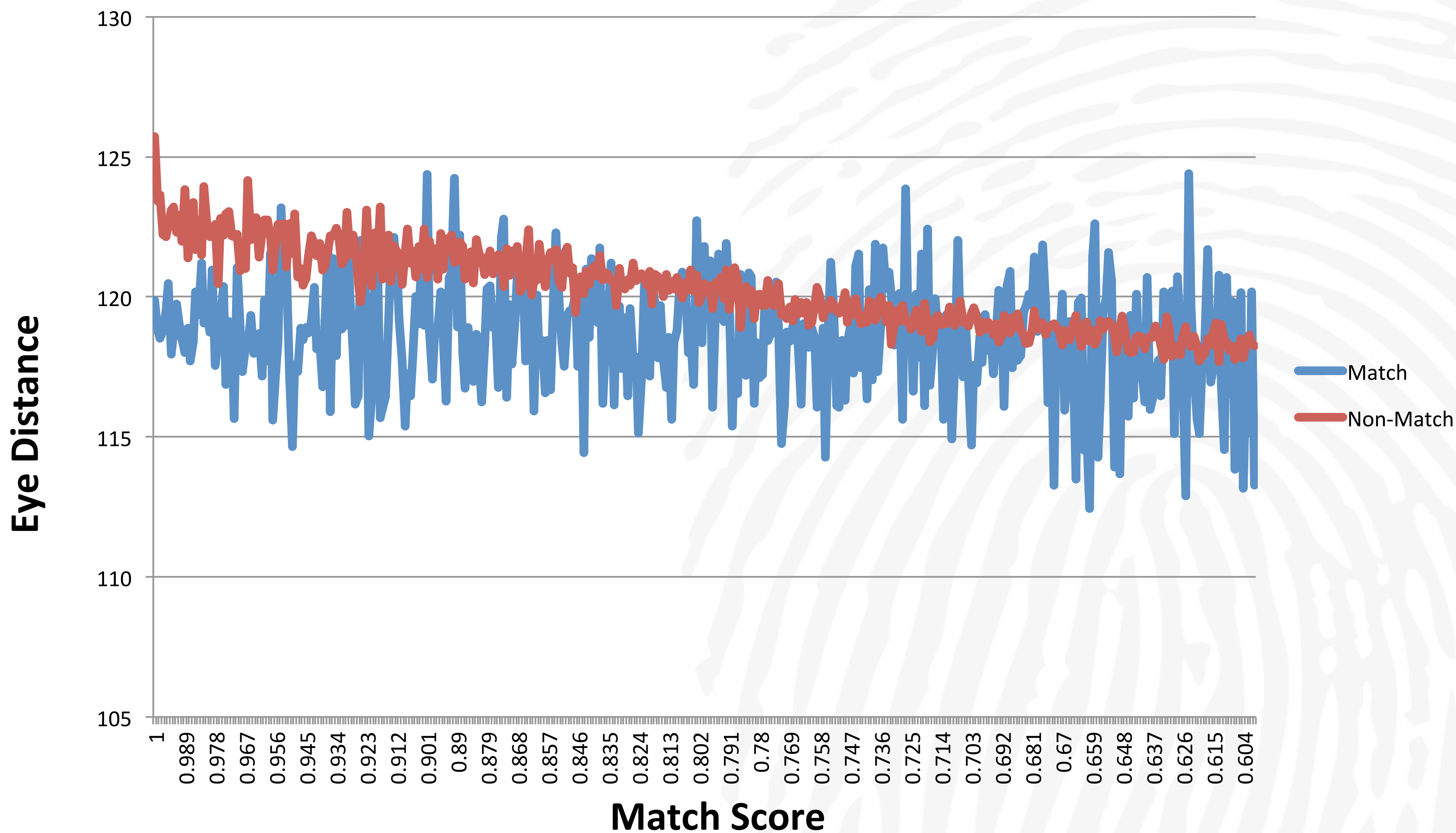
Questions?

- Contact Us
  - ted@biometix.com, joshua@biometix.com
- References
  - J. Abraham et. al. (2013), Modern statistical models for forensic fingerprint examinations: A critical review, *Forensic Science International*, Volume 232, Issues 1-3, Pages 131-150.
- Acknowledgements
  - Australian Passports Office (APO)

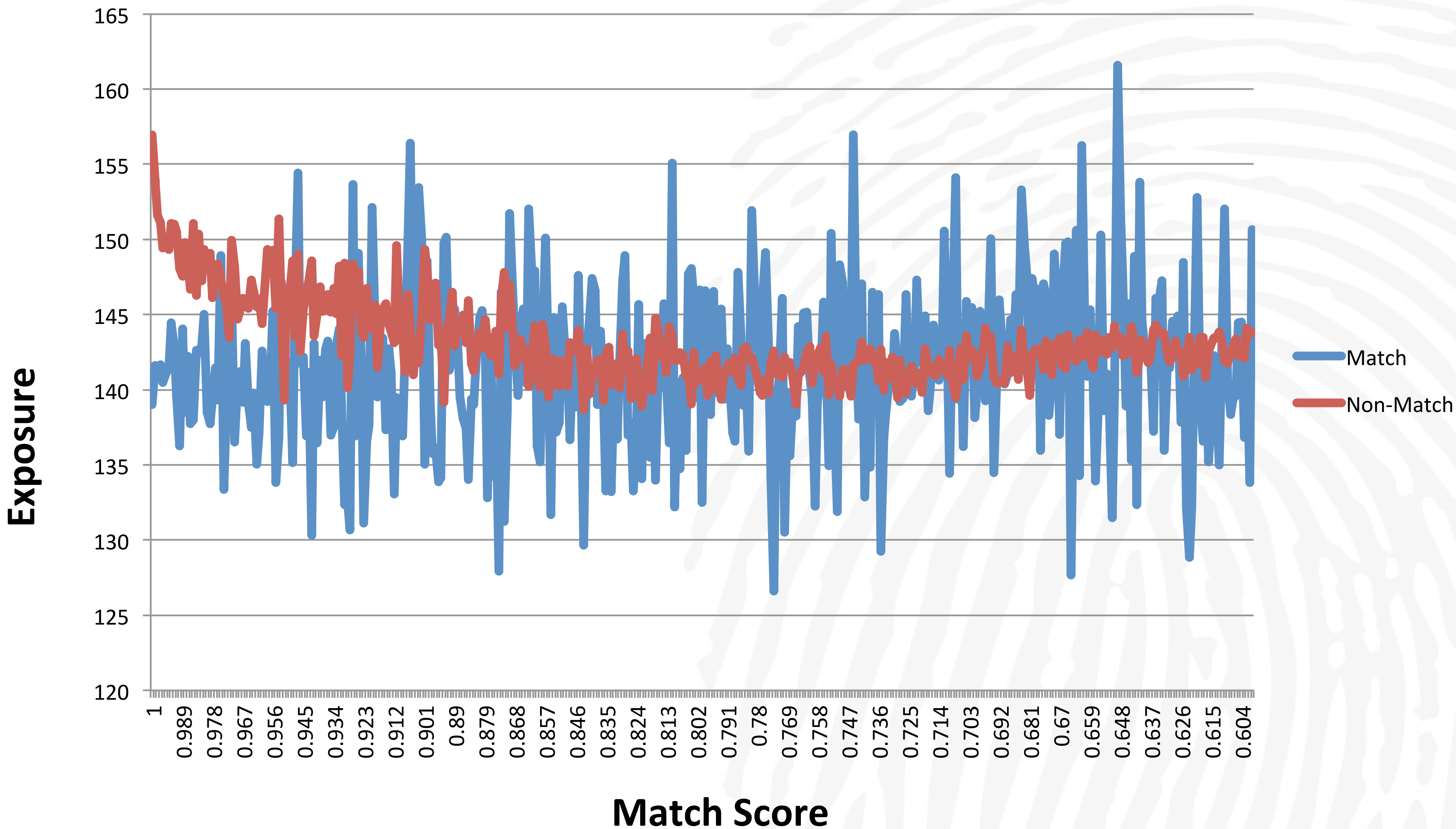
Other Quality/Feature Metrics

- **Inter-Eye Distance**
- **Exposure**

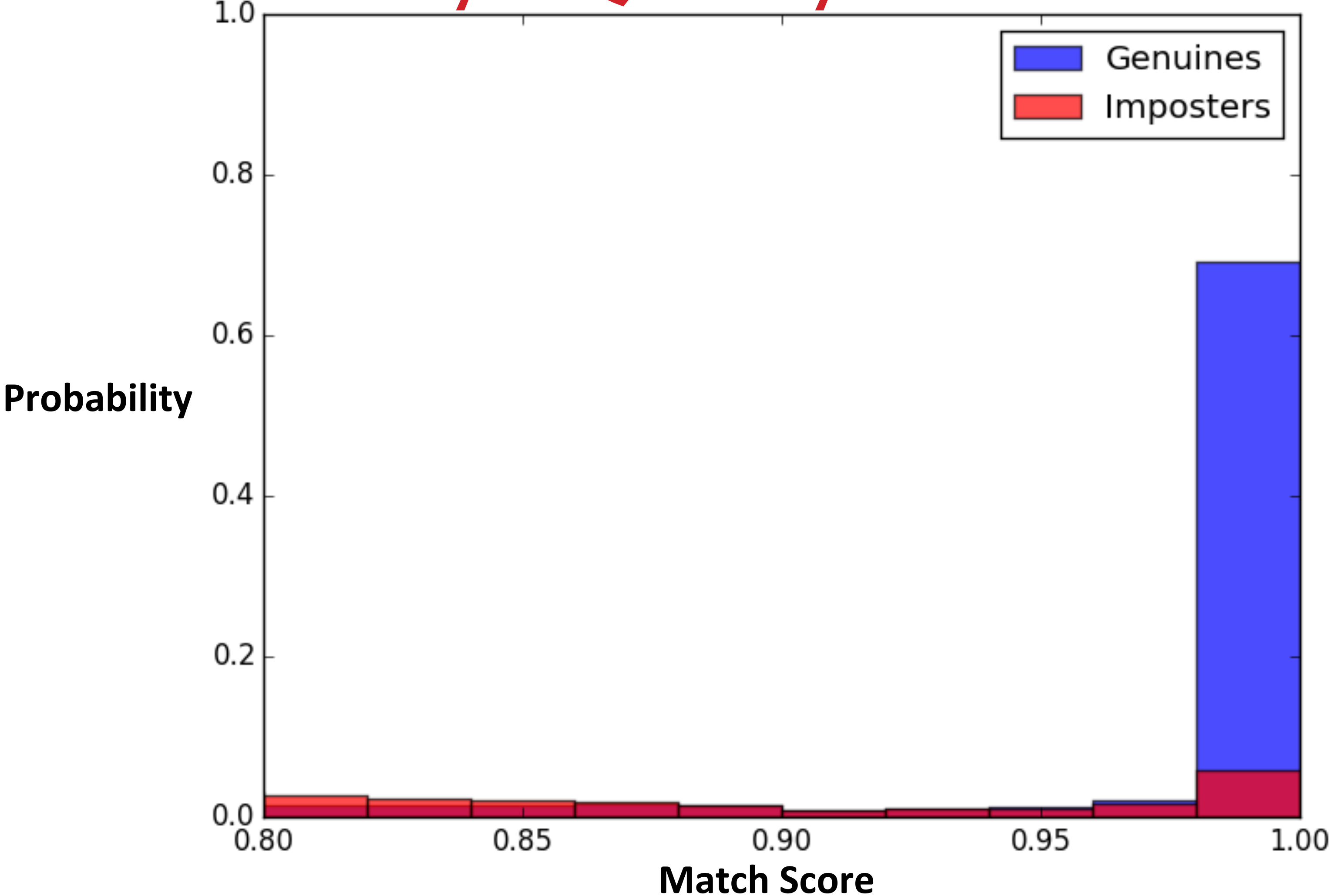
Eye Distance vs. Match Score for Genuine and Imposter distributions



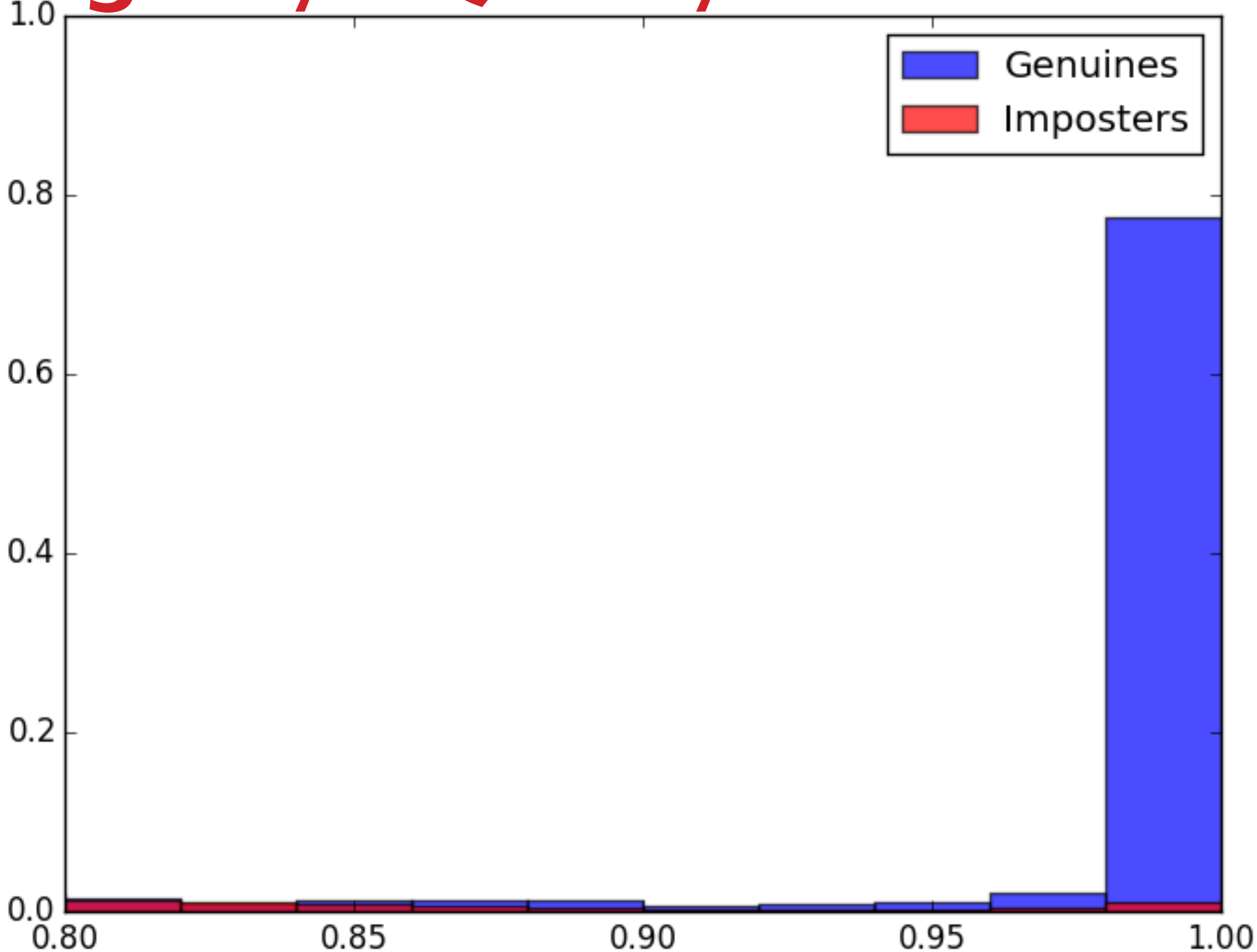
Exposure vs. Match Score for Genuine and Imposter distributions



Rank 1 Distribution
Low Eye Quality Confidence



Rank 1 Distribution
High Eye Quality Confidence



Probability

Match Score

Score vs. Quality vs. LR

- Ratio of average LR for score vs. quality categories:

Match Score	Avg. Low Quality LR	Avg. High Quality LR	High to Low LR Ratio
0.6	0.12	0.06	0.52
0.62	0.13	0.07	0.49
0.64	0.17	0.07	0.41
0.66	0.21	0.06	0.29
0.68	0.24	0.16	0.69
0.7	0.30	0.20	0.68
0.72	0.38	0.26	0.68
0.74	0.39	0.40	1.01
0.76	0.47	0.52	1.11
0.78	0.51	0.75	1.46
0.8	0.56	1.10	1.98
0.82	0.65	0.88	1.36
0.84	0.65	1.44	2.22
0.86	0.86	1.90	2.21
0.88	1.01	2.66	2.63
0.9	1.08	2.94	2.72
0.92	1.01	3.30	3.28
0.94	1.09	3.51	3.22
0.96	1.30	14.10	10.81
0.98	11.90	383.60	32.24