NIST Fingerprint Image Quality and relation to PIV

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quality is important …

- The performance of a fingerprint matcher is directly affected by the quality of fingerprint images captured and present in the database.

- In FPVTE “many types and characteristics of fingerprints were analyzed; the variables that had the clearest effect on system accuracy were the number of fingers used and *fingerprint quality*…Poor quality fingerprints greatly reduced accuracy”.
- If the quality of the fingerprint images is poor, the AFIS system's identification performance is certain to be reduced.

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… and 5 reasons why

knowledge of biometric sample quality prior to matching can be used to improve the operation and performance of a biometric system.

- if we can perform real-time quality assessment
  - we can prompt to recapture samples of insufficient quality
  - improve reference database integrity
- process samples differently based on their qualities
  - poor quality samples can be processed using different algorithms or thresholds
- cause higher quality sample dominate fusion
- collect relevant statistics
  - correlation among fingers
  - compare capture devices and/or environments

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NIST Fingerprint Image Quality (NFIQ)

- NFIQ number is a *prediction of a matcher's performance*; it reflects the predictive positive or negative contribution of an individual sample to the overall performance of a fingerprint matching system.

- NFIQ's 5 levels of quality are intended to be predictive of the relative performance of a minutia based fingerprint matching system.
- NFIQ=1 indicates high quality samples, so lower FMR and/or FNMR is expected.
- NFIQ=5 indicates poor quality samples, so higher FMR and/or FNMR is expected.

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NIST Fingerprint Image Quality

feature extraction → neural network → quality number {1,2,3,4,5}

feature extraction: computes appropriate signal or image fidelity characteristics and results in an 11-dimensional feature vector.

neural network:classifies feature vectors into five classes of quality based on various quantiles of the normalized match score distribution.

quality number: an integer value between 1(highest) and 5 (poorest).

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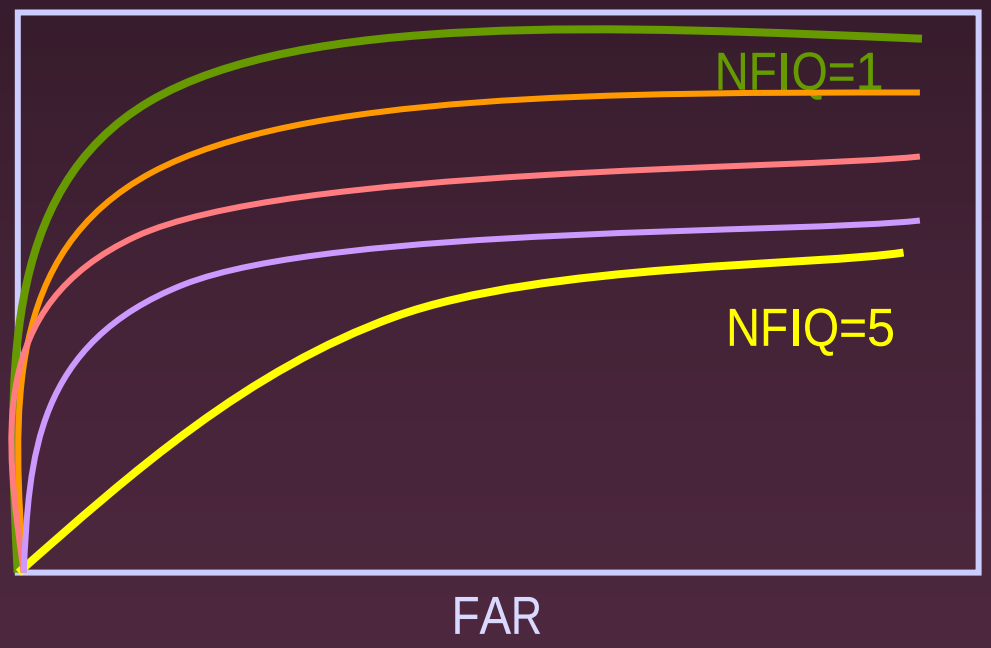
NFIQ and performance

NFIQ → quality number

poor quality samples result in low performance



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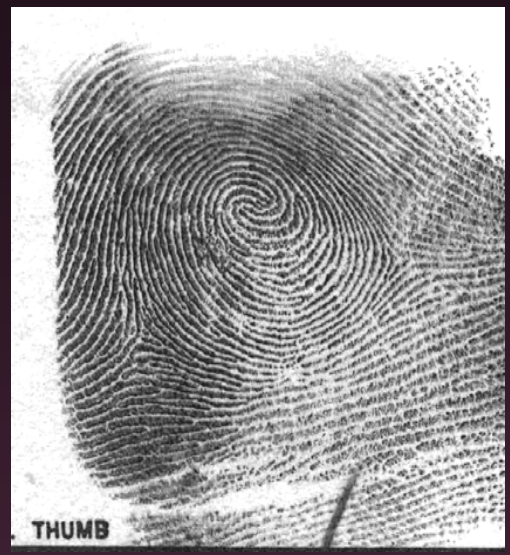
poor quality samples

distorted source e.g. scars on a fingertip

nfiq=5

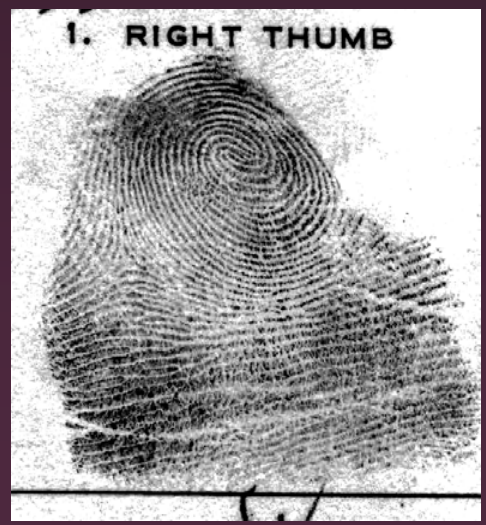


nfiq=5

low character source the sample may subjectively be assessed as “good” quality, but a matcher may not be able to match it to its mate.

distortion in one or more steps of the process e.g. capture or compression

nfiq=5



These are goats and lambs of the biometric zoo.

nfiq=5

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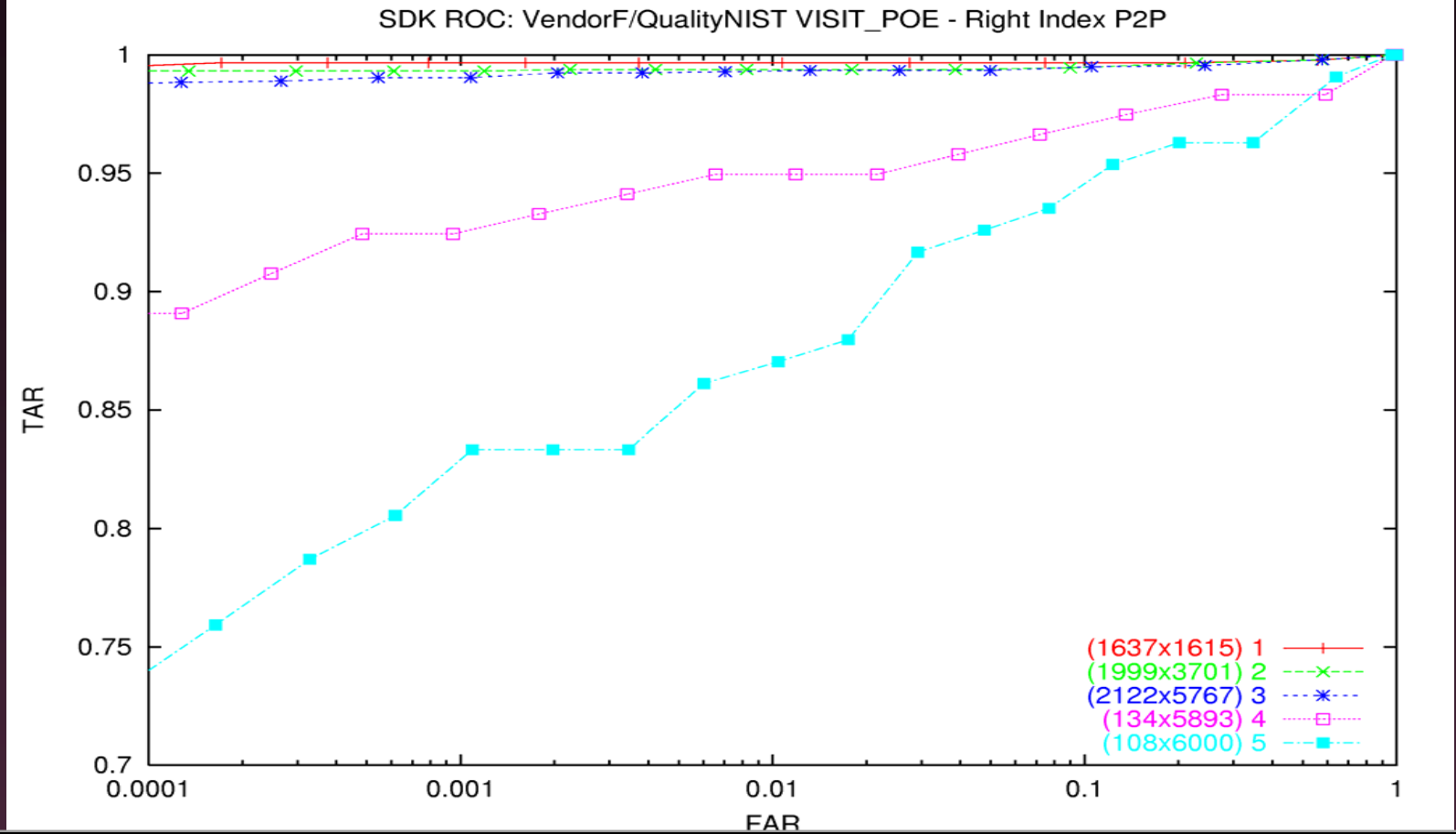
NFIQ effectiveness

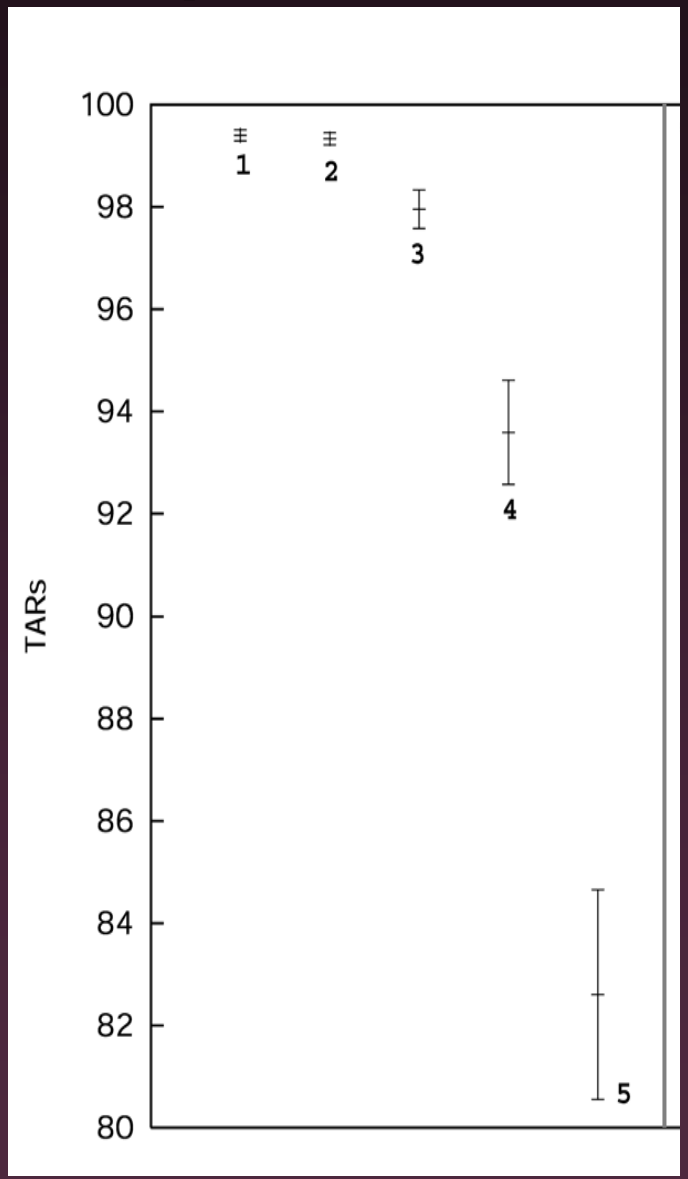
- evaluation criterion is rank ROC as a function of image quality
- used various fingerprint matching algorithms and various datasets to evaluate NFIQ
  - 15 different COTS fingerprint matching algorithms
  - 22 different datasets of different fingers captured by various devices and at different operational settings
  - each test dataset has 2 fingerprint images of 6000 person
- compared (TAR,FAR) of levels of quality at a fixed threshold
  - as quality degrades, true accept rate decreases for all the matchers, FAR increase for some.
- levels 2,3,4, and 5 are statistically separable.
- It takes about one third of a second to compute quality of a flat fingerprint image.



Vendor F – VISIT_POE – Right index
threshold=350 (far,tar)=(0.012,0.99)

quality	1 excellent	2 veryGood	3 good	4 fair	5 poor
FAR	0.0037	0.0083	0.0131	0.0216	0.0477
TAR	0.997	0.994	0.993	0.9496	0.926

separable levels of quality



For each quality levels 1 through 5, we calculated 95% confidence intervals of TARs @ FAR=0.1% for six top matchers and sixteen operational datasets.

NFIQ levels 2,3,4, and 5 are statistically separate.

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public release

- subject to US export control laws
- the first and only publicly available fingerprint quality assessment algorithm
- technical report NISTIR-7151

  fingerprint.nist.gov

NFIQ and PIV

"The procedure [for the collection of fingerprints] employs NFIQ to guide a real-time quality assessment and reacquisition of the images."

SP 800-76 Biometric Specification for Personal Identity Verification

- If the images of the two index fingers and the two thumbs do not all have NFIQ values of 1,2, or 3, recapture the image up to three more times.
- If unsuccessful after four acquisitions then select whichever repeated set that has the highest number of images with NFIQ values of 1,2,3 or 4.
- NFIQ values for each finger shall be specified in its data record.

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conclusion

- a novel definition of fingerprint image quality
- it works as a rank statistic for performance for all -330 combinations - of COTS fingerprint matchers and operational datasets tested
- NFIQ can be used for real-time quality assessment
- all government agencies shall use NFIQ to assess the quality of fingerprints for PIV cards
- will be used by FBI to assess quality of FBI's plain impression transactions (May 2005)
- NFIQ is publicly available but subject to US export control laws

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thanks

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extra

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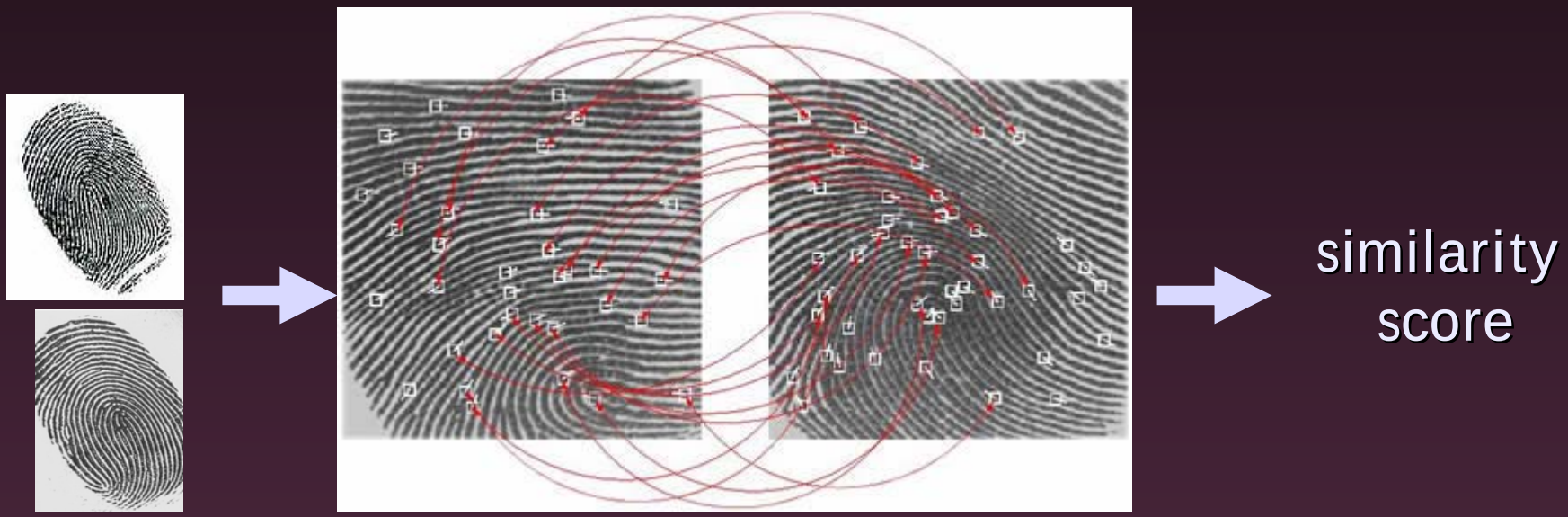
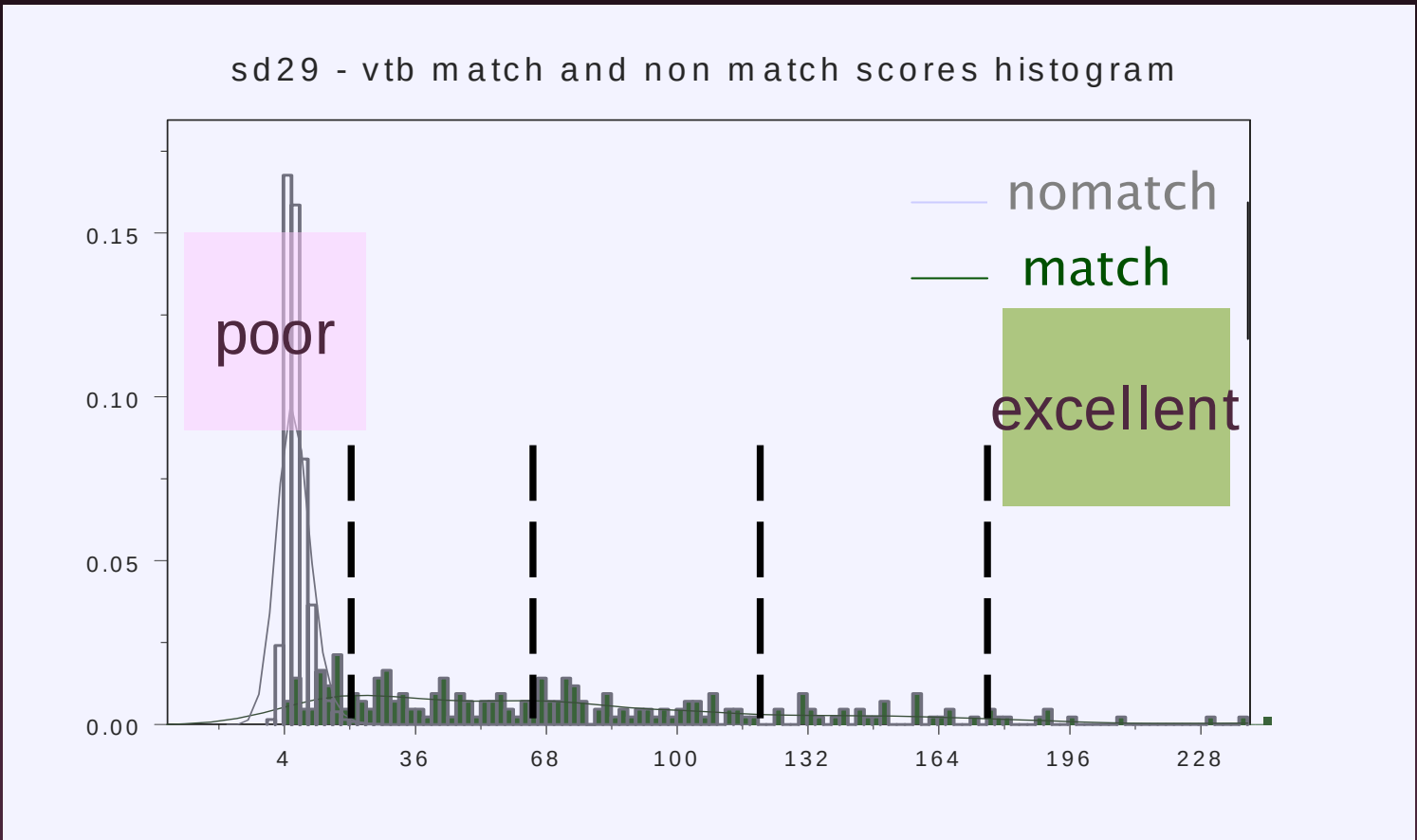
fingerprint matching algorithms



a higher similarity scores construed to indicate a higher likelihood that the samples come from the same individual.

Statement of performance



the quality measure should be indicative of the degree to which the histogram of match scores is separated from the histogram of non-match scores.

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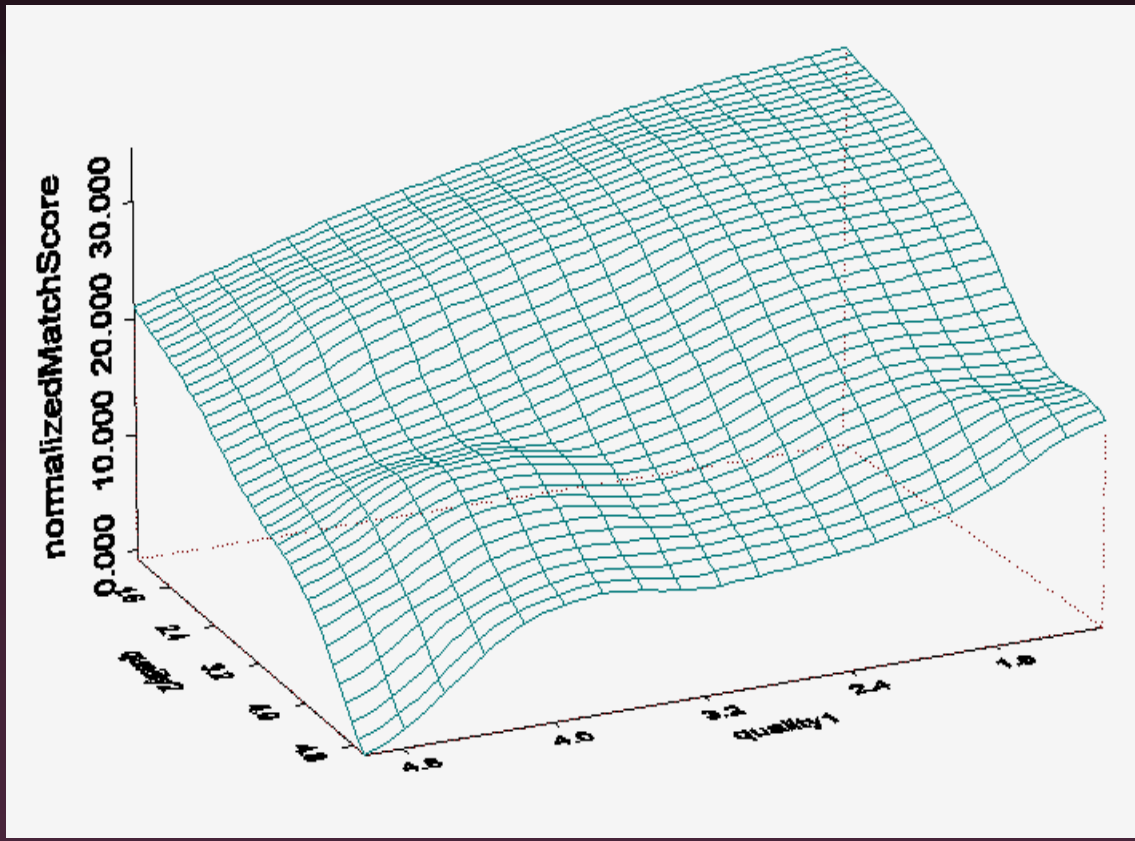
pair-wise quality



when the enrollment sample is of good quality and better than that of the use phase (search) sample, the search sample's quality is sufficient to predict performance.

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