

NIST Patriot Act Biometric Testing

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IAD-ITL

Outline

- Statutory Mandates
- Biometrics Testing is Scale Dependent
- Fingerprint Vendor Technology Evaluation (FpVTE)
- Testing Fingerprint Software Development Kits (SDKs)
- US-VISIT Identification System (IDENT)
- Image Quality

Statutory Mandates

- USA Patriot Act (PL 107-56)
- Enhanced Border Security and Visa Entry Reform Act (PL 107-173)
- Develop and certify technology standard to
 - verify identity of foreign nationals applying for a visa
 - visa application at embassies and consulates
 - background check against FBI criminal database and DHS databases and “watch lists”
 - ensure person has not received visa under a different name
 - verify identity of persons seeking to enter the U.S.
 - verify that the person holding the travel document is the same person to whom the document was issued
 - airports, land border crossings, sea entry points

BIOMETRIC TESTING IS SCALE DEPENDENT

- SAMPLE SIZE 100-1,000
Proves feasibility
- SAMPLE SIZE 1,000-10,000
Measures subject variation
- SAMPLE SIZE 10,000-1,000,000
Measures operational quality control
- Existing government databases contain millions of entries and have widely varying quality.

FpVTE

- The evaluations were conducted to
 - Measure the accuracy of fingerprint matching, identification, and verification systems
 - Identify the most accurate fingerprint matching systems
 - Determine the viability of fingerprint systems for near-term deployment in large-scale identification systems
 - Determine the effect of a wide variety of variables on matcher accuracy
 - Develop a well-vetted set of a variety of operational data for use in future research
- The evaluations were not intended to
 - Measure system throughput or speed
 - Evaluate scanners or other acquisition devices
 - Directly measure performance against very large databases
 - Take cost into consideration

FpVTE- Comparison of Systems

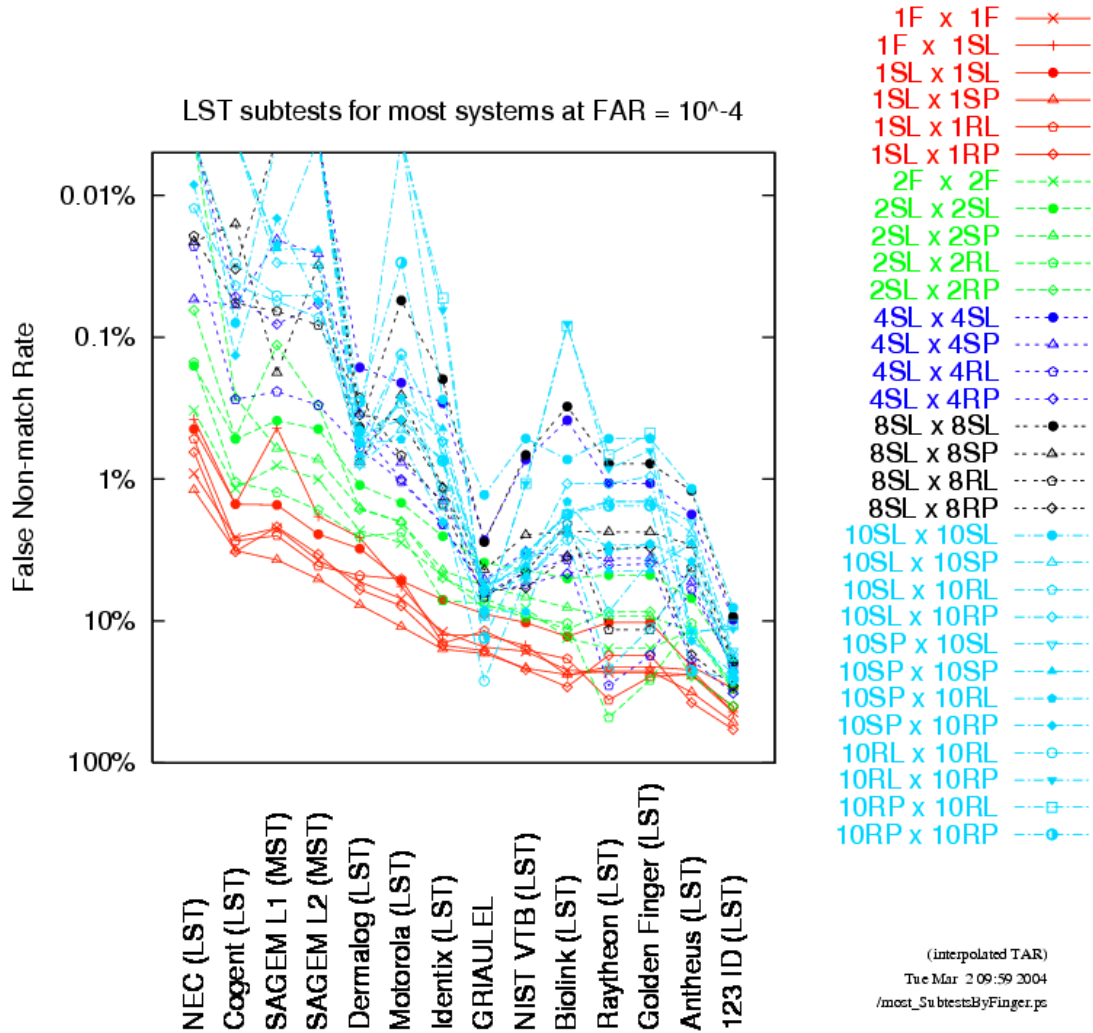
- There is a substantial difference in accuracy between the best systems and the average or worst systems
- The most accurate system were submitted by Cogent, NEC, SAGAM
- The top tier systems are more consistent in performance than the other systems
 - They perform consistently well over a variety of data, and are less affected by fingerprint quality and other variables
- The performance of the most accurate top has been verified by SDK testing.

FpVTE Comparison with Face

The most accurate fingerprint systems are far more accurate than the most accurate face recognition systems.

- The most accurate face systems:
 - 0.72 true accept rate @ 10^{-4} false accept rate
 - 0.90 true accept rate @ 10^{-2} false accept rate.
- The most accurate fingerprint system, using operational quality single fingerprints:
 - 0.994 true accept rate @ 10^{-4} false accept rate
 - 0.999 true accept rate @ 10^{-2} false accept rate

More Finger Are More Accurate



SDK Tests

Medium scale evaluation of
one-to-one matching for:
16 software matchers
20 single finger datasets

What were the goals of the test?

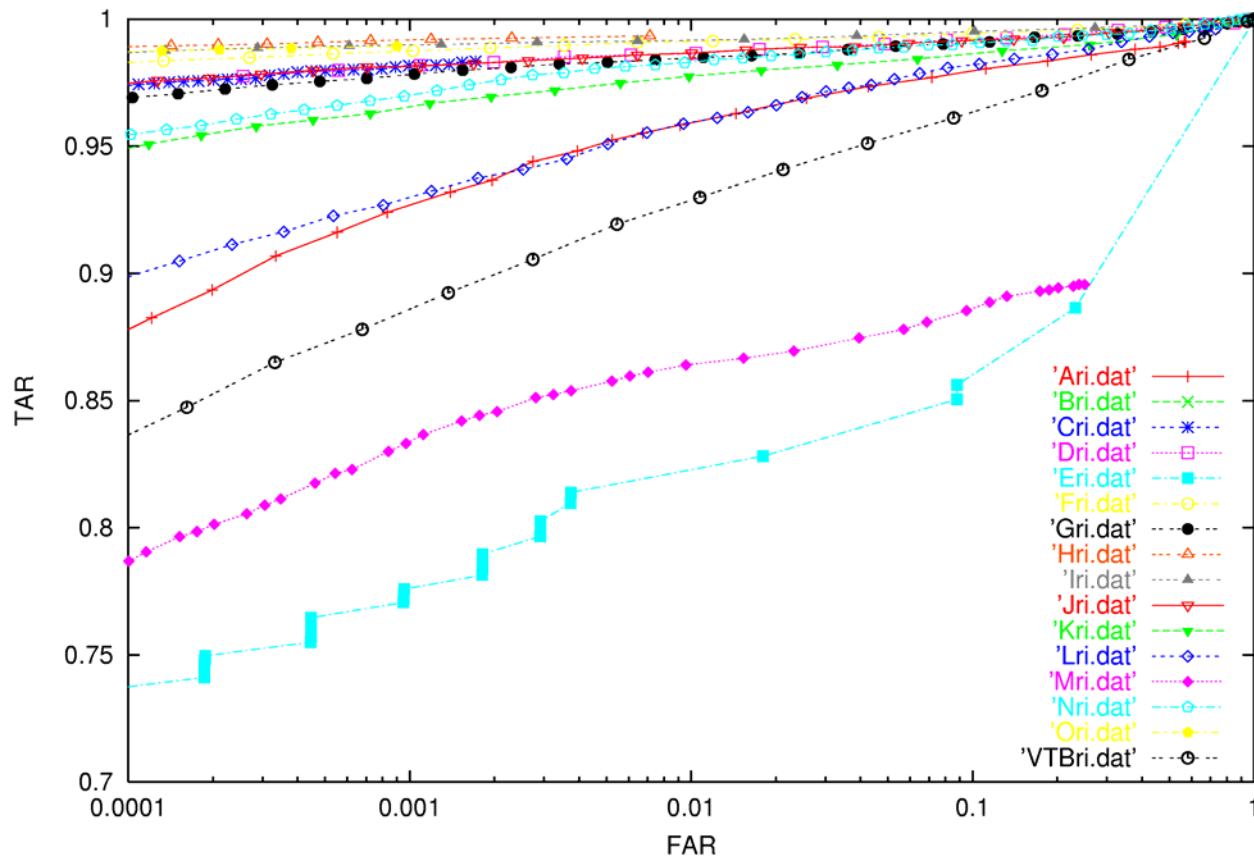
- Determine the feasibility of verification matching in the US-VISIT and DOS clients
- Evaluate vendor accuracy variability
- Evaluate vendor sensitivity to image quality
- Also used to scale the MST in FpVTE

Scale of Tests

- Each test involved 36M matches on a 3GHz Pentium platform.
- Gallery 6K probe 6K
- Match time must be less than 10ms per fingerprint pair
- Each test results in an ROC curve

SDK Testing - 16 Algorithms, POE right index, 0.576G matches

SDK ROC: VISIT_POE Index P2P



SDK LETTER	VENDOR NAME
A	Name Not Released
B	Name Not Released
C	NEC
D	Cogent Systems, Inc.
E	Name Not Released
F	Cogent Systems, Inc.
G	SAGEM Morpho, Inc.
H	NEC
I	Cogent Systems, Inc.
J	SAGEM Morpho, Inc
K	Neurotechnologija Ltd.
L	Name Not Released
M	Name Not Released
N	Dermalog
O	NEC
VTB	NIST

SDK - Conclusions

- All vendors are sensitive to image quality.
- Three algorithms vendors are clearly more effective.
- Combining two fingers will provide very effective one-to-one verification for the US-VISIT program TAR 99.6% FAR 0.1%
- The NIST VTB algorithm is better than many commercial products.

US-VISIT IDENT System

- IDENT is the primary fingerprint matcher for US-VISIT
- Three functions:
 - Watch list checking at enrollment
 - Duplicate identification check for visa holders
 - One-to-one verification for enrolled travelers

US-VISIT Identification

many-to-one matching

- Using Department of State (DOS) Mexican visa (BCC) data, the true accept rate (TAR) using index finger pairs is independent of background database size over the range from 100,000 entries to 6,000,000 entries and is 96% with shape filtering on.
- The false accept rate (FAR) using index finger pairs is linearly increasing with database size and is 0.09% using existing threshold parameters for a gallery size of 6,000,000.
- At the operating level used by the IDENT system, the trade-off between TAR and FAR is such that a large change in FAR results in only a small change in TAR. The trade-off curve is flat, with very small slope change.
- All the results given here require that the test data be consolidated, checked for correct ground truth by fingerprint examiners, since between 0.5% and 1.5% of the original data was found to be incorrectly matched. Approximately 0.1% of the questioned data is of insufficient quality to be resolved by examiners. This 0.1% error rate is the minimum error limit detected in existing government fingerprint databases.

US-VISIT Identification

many-to-one matching

- The Cogent image quality is a good predictor of the IDENT many-to-one matching performance. The best quality images, quality 1, produce a TAR of 98% at a FAR of 0.01%. The worst quality images, quality 8, produce a TAR of 47% at a FAR of 0.01%.
- Image quality distributions for BCC, the Atlanta pilot study, and OHIO web check were studied to determine how well the operational US-VISIT system could be expected to track BCC and Ohio results. The Atlanta data has slightly more quality 8 images and slightly less quality 1 images but should result in a TAR near BCC. The Ohio data has less quality 8 images and more quality 1 images. This is reflected in a TAR of 98% using the IDENT system.
- The matcher used in this study achieves a match rate of 1,045,000 matches/second with shape filtering on and 731,000 matches/second with shape filtering off.

US-VISIT Verification

one-to-one matching

- Using BCC quality data on two index fingers a one-to-one matching with a TAR of 99.7% at a FAR of 0.1% should be achieved.
- These results were achieved using the a Software Development Kit (SDK) program set supplied by Cogent that is the same algorithm planned for use in VISIT.
- Testing of eleven other SDK's proved that this algorithm is as accurate as any of the algorithms tested although further testing of additional algorithms is planned.
- All algorithms tested have a significant change in accuracy with image quality. High accuracy algorithms are less sensitive to image quality than low accuracy algorithms.

US-VISIT Verification

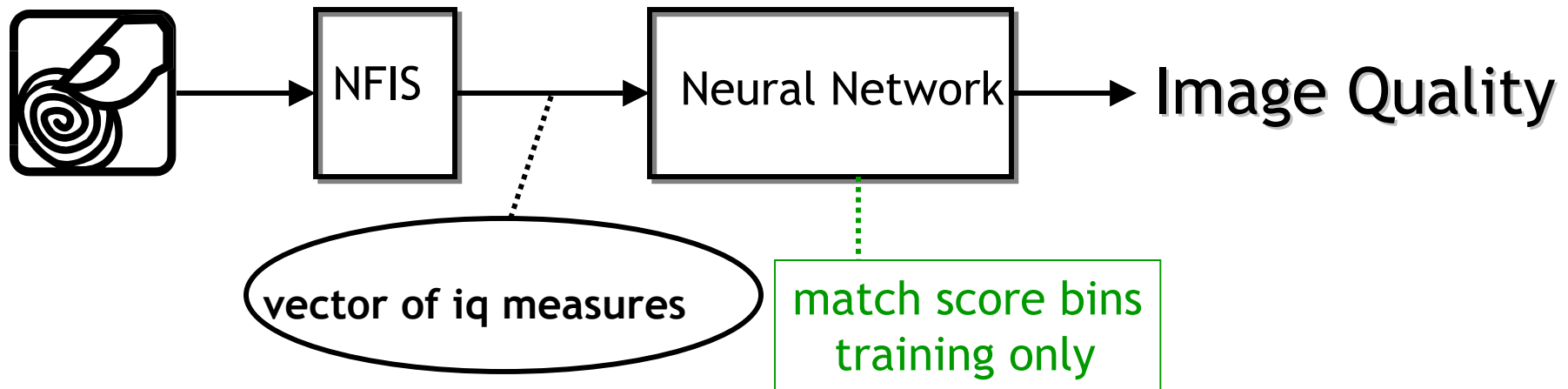
one-to-one matching

- Cogent image quality is a good rank statistic for all the algorithms tested for all the datasets used. The error rate of quality 1 (best) fingerprints is always lower than the error rate of any other image quality sample and the error rate of quality 8 (worst) fingerprints is always the highest. All other image quality levels result in the expected ordering of the error rates.
- Consolidation results on various datasets available to NIST demonstrate that the errors obtained for one-to-one matching is less than the clerical error rate in most government databases. Clerical errors will be more common than biometric errors for one-to-one matching.

NIST Image Quality

- Define and develop a fingerprint image quality measure that can predict fingerprint recognition performance
- Use ROC curves to check the quality of the quality
- Not in terms of traditional image processing (contrast, SNR, ...)
- BUT quality in terms of characteristics and features of a fingerprint that convey information for a matching algorithm

Predicting Performance From Image Quality



A fingerprint with image quality $n \in \{1,2,3,4,5\}$ means that the match score for that fingerprint will be in bin n .

This Image Quality Measure Works

- The method has been tested by ranking ROCs from 14 SDK algorithms.
- The method has been tested using all 20 SDK datasets.
- In all 280 cases the image quality rank predicted matching performance.