MINEX III Report Card

Matcher aatec+0200

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

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Participant Details

Company: AA Technology Ltd.
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Date Completed: 08/05/2015

Library	Size (bytes)	MD5 Checksum
libminexiii_aatec_0200.so	1528263	`6b0449b2be1a85dcffdb9192b7b99701`

Compliance Test Results

The following presents **PIV compliance** results per the criteria detailed in NIST Special Publication 800-76-2: Biometric Specifications for Personal Identity Verification.

It also includes **MINEX III compliance** results per the criteria detailed in sections 4 through 8 of the Minutiae Interoperability Exchange (MINEX) III Test Plan and Application Programming Interface.

PIV Level One: PASS

- Must match templates from all certified template generators with an $\text{FNMR}_{\text{FMR}}(0.01) \leq 0.01$ using two fingers (4.5.2.1-4). ✓
- Must perform 90% of comparisons in fewer than 0.1 seconds each (4.5.2.1-3). ✓

PIV Level Two: FAIL

- Must pass PIV level one compliance. ✓
- Native template generator must pass level one compliance. ✗
- Must match templates from native template generator with an $\text{FNMR}_{\text{FMR}}(0.0001) \leq 0.02$ using one finger (4.5.3-2) ✓

MINEX III: FAIL

- Must pass MINEX III validation. ✓
- Must pass PIV level two matcher compliance. ✗
- Average template comparison time must be no more than 10 milliseconds (6.4). ✓
- Matcher must produce at least 256 distinct comparison scores over the entire dataset when comparing templates from different subjects. (747) ✓

Notes

- This report will be updated as new matching algorithms and template generators pass the compliance test. These updates will not change the PASS/FAIL decision above.
- NIST reserves the right to decertify a matcher if it later discovers the matcher violates MINEX III or PIV specifications in some previously undetected way.

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1 Introduction

This report card presents measurements of performance and interoperability for a single fingerprint matching algorithm submitted to NIST as part of the ongoing MINEX III Evaluation. It reports whether the matcher passes the technical requirements for MINEX III as described in Section 8 of the MINEX III Test Plan and Application Programming Interface. Full details on the ongoing MINEX III program can be found on the MINEX III homepage. Questions should be directed to minex@nist.gov.

2 Methodology

Testing is performed at a NIST facility. Each participant's submission is validated by NIST (http://www.nist.gov/itl/iad/ig/minexiii_participation.cfm) before undergoing full testing to ensure it operates correctly. If the matcher passes the validation procedure, it is then used to compare standard fingerprint templates. Performance is assessed against templates created by a template generation algorithm submitted by the participant as well as templates created by other MINEX III compliant template generators.

2.1 Dataset

Testing is performed over a single dataset of sequestered fingerprint images. The images were collected by U.S. Visit at ports of entry into the United States. They consist of Live-scan plain impressions of left and right index fingers. WSQ [1] compression was applied to all images at a ratio of 15:1. The most recent capture of each subject was treated as the authentication sample, and the next most recent as the enrolled sample.

The dataset was divided into 533 767 mated and 1 067 530 non-mated subject pairings. Since both left and right index fingerprints are available for each subject, this provides 1 065 347 mated and 2 127 730 non-mated single-finger comparisons (after database consolidation). When left and right index fingers are fused at the score level [2, 6], the sets condense to 532 239 mated and 1 062 818 non-mated comparison scores.

2.2 Accuracy Metrics

Core matching accuracy is presented in the form of Detection Error Tradeoff (DET) plots [5], which show the trade-off between the False Match Rate (FMR) and the False Non-Match Rate (FNMR) as a decision threshold is adjusted. Formally, let m_i ($i = 1 \ldots M$) be the ith mated comparison score, and n_j ($j = 1 \ldots N$) the jth non-mated comparison score. Then the statistics are

$$\mathrm{FNMR}(\tau) = \frac{1}{M} \sum_{i=1}^{M} \mathbb{1}\{m_i < \tau\}, \tag{1}$$

$$\mathrm{FMR}(\tau) = \frac{1}{N} \sum_{j=1}^{N} \mathbb{1}\{n_j \geq \tau\}. \tag{2}$$

where $\mathbb{1}\{A\}$ is the indicator [3] of event A. Equations 1 and 2 define the curve parametrically with the decision threshold, τ, as the free parameter. In some figures and tables, FNMR is presented as a function of FMR. This relationship is determined by

$$\mathrm{FNMR}_{\mathrm{FMR}}(\alpha) = \min_{\tau} \{ \mathrm{FNMR}(\tau) \mid \mathrm{FMR}(\tau) \leq \alpha \}, \tag{3}$$

which reads as the smallest FNMR that can be achieved while maintaining an FMR less than or equal to α, the targeted FMR. This method of relating the two error statistics ensures FNMR is well-defined for all $0 \leq \alpha \leq 1$. When the matching algorithm produces only a few unique comparison scores, the maximum threshold, τ_0, that elicits an FMR(τ_0) $\leq \alpha$ may, in fact, be quite a bit lower than α. Thus, Equation 3 imposes a natural penalty on matching algorithms that produce overly discretized scores.

Some figures show *pooled* DET accuracy, which is a measure of the accuracy of the matcher against all compliant template generators. Accuracy is measured by concatenating all comparison scores involving the matcher together and computing FMR and FNMR using Equations 2 and 1. This roughly simulates performance for a biometric system that employs one matcher and templates created by several template generators.

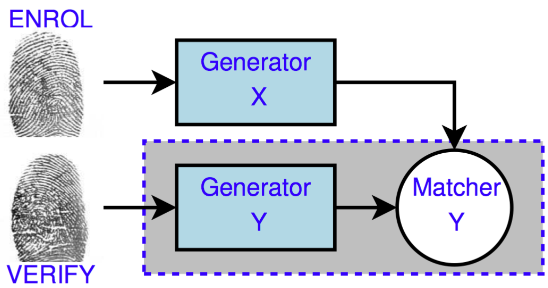

Figure 1: MINEX III Interoperability Test Setup

2.3 Interoperability

Interoperability is tested in a manner similar to *Scenario 1* from the MINEX Evaluation Report [4] (see Figure 1). An enrolment template is prepared using submission X. Submission Y is used to prepare the authentication template and perform the match. The authentication template is always prepared by the same submission used to compare the templates. However, enrolment templates need not originate from the same submission. When they do, we refer to it as ”native” mode.

3 Results

This section details the performance of matcher aatec+0200 when it compares verification templates created by its own template generator to enrolment templates created by all MINEX III compliant template generators. Sections 3.1 and 3.2 present accuracy results for single finger and two finger matching respectively. Sections 3.4 and 3.5 present potentially useful statistics not directly related to the performance of the matcher.

3.1 Single Finger

Singe finger comparison results show the combined results for left and right index comparisons. For reference, *NIST Special Publication 800-76-2* requires that the matcher and template generator achieve a native accuracy of $\mathrm{FNMR}_{\mathrm{FMR}}(0.0001) \leq 0.02$.

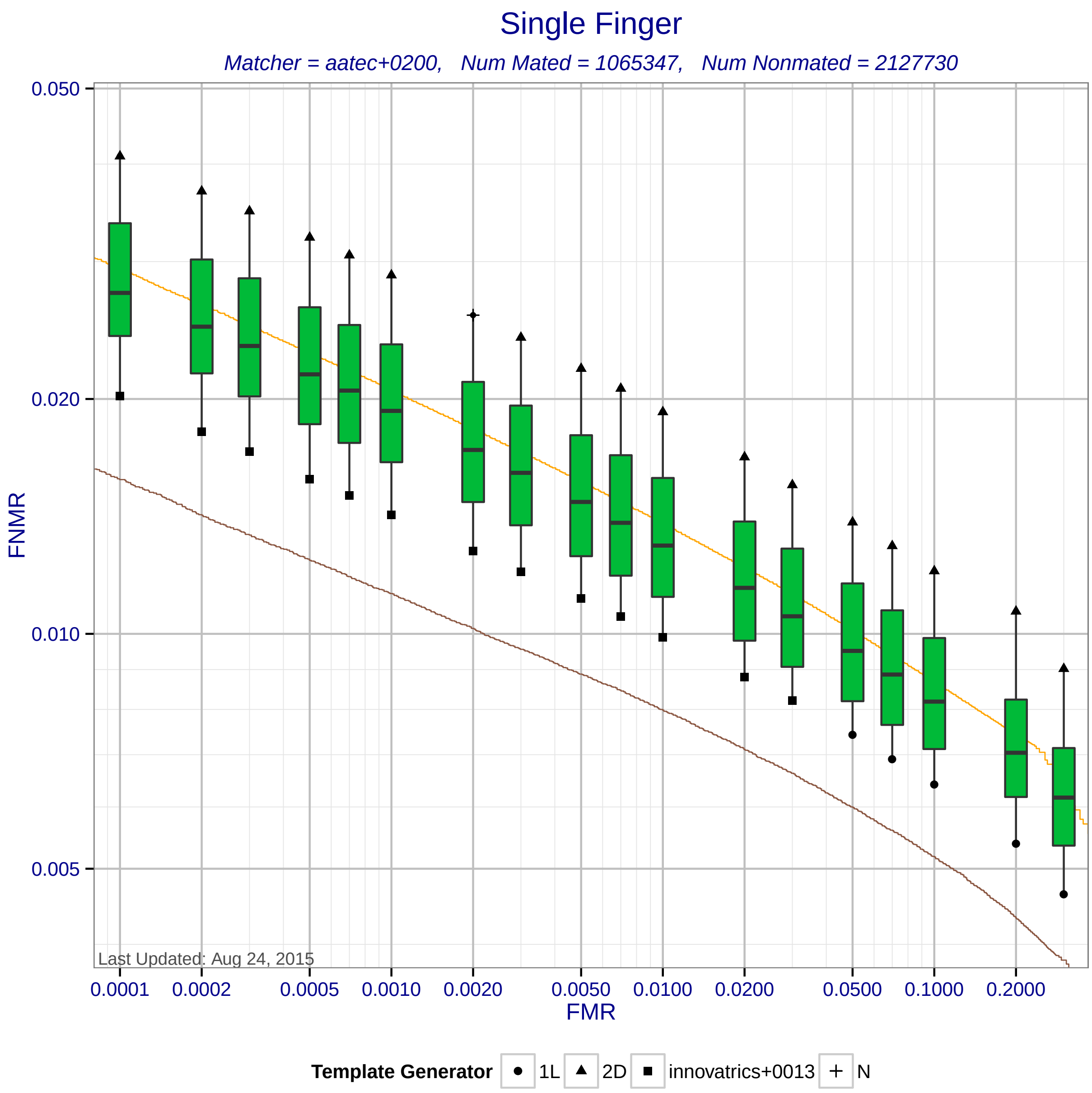

Figure 2: *Single finger DET statistics for matcher aatec+0200. Each box shows the distribution of FNMRs at a fixed FMR across all MINEX III compliant template generators. The ends of the whiskers show the minimum and maximum FNMRs. The orange DET curve shows pooled performance against all template generators.*

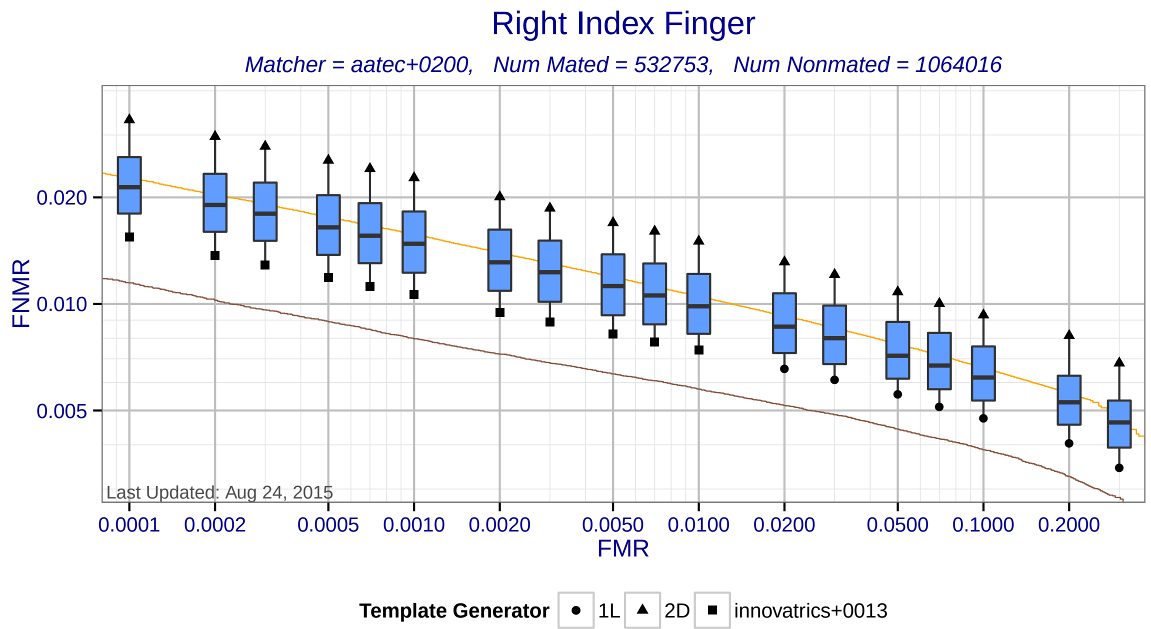

Figure 3: *Left index finger DET statistics for matcher aatec+0200. Each box shows the distribution of FNMR at a fixed FMR across all MINEX III compliant template generators. The ends of the whiskers show the minimum and maximum FNMRs. The orange DET curve shows pooled performance against all template generators.*

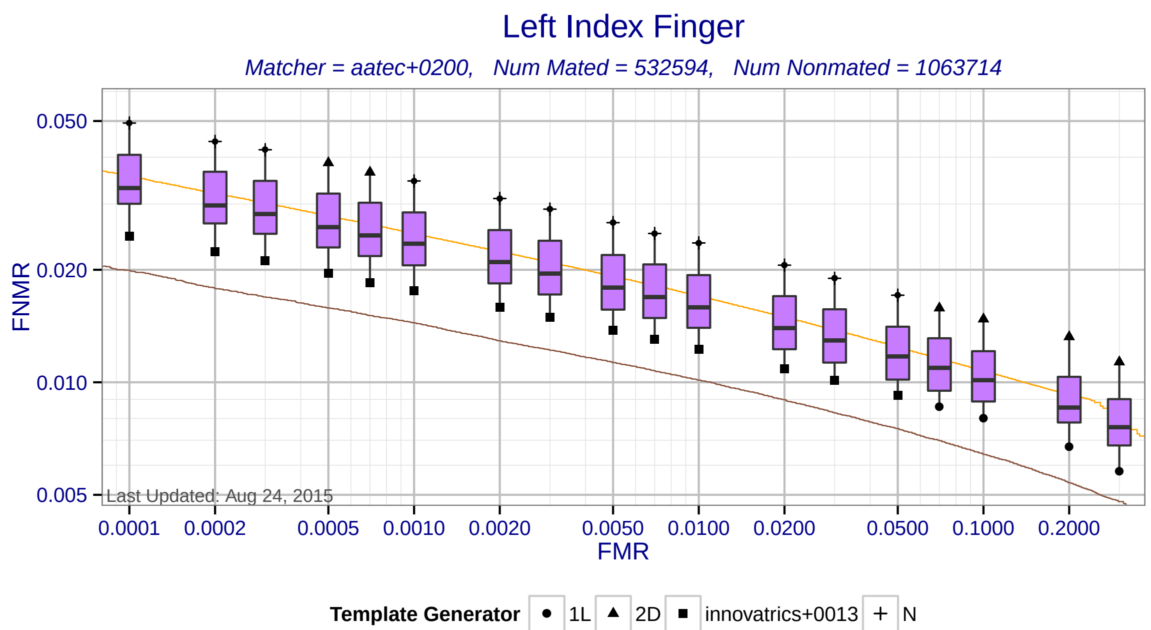

Figure 4: *Right index finger DET statistics for matcher aatec+0200. Each box shows the distribution of FNMRs at a fixed FMR across all MINEX III compliant template generators. The ends of whiskers show the minimum and maximum FNMRs. The orange DET curve shows pooled performance against all template generators.*

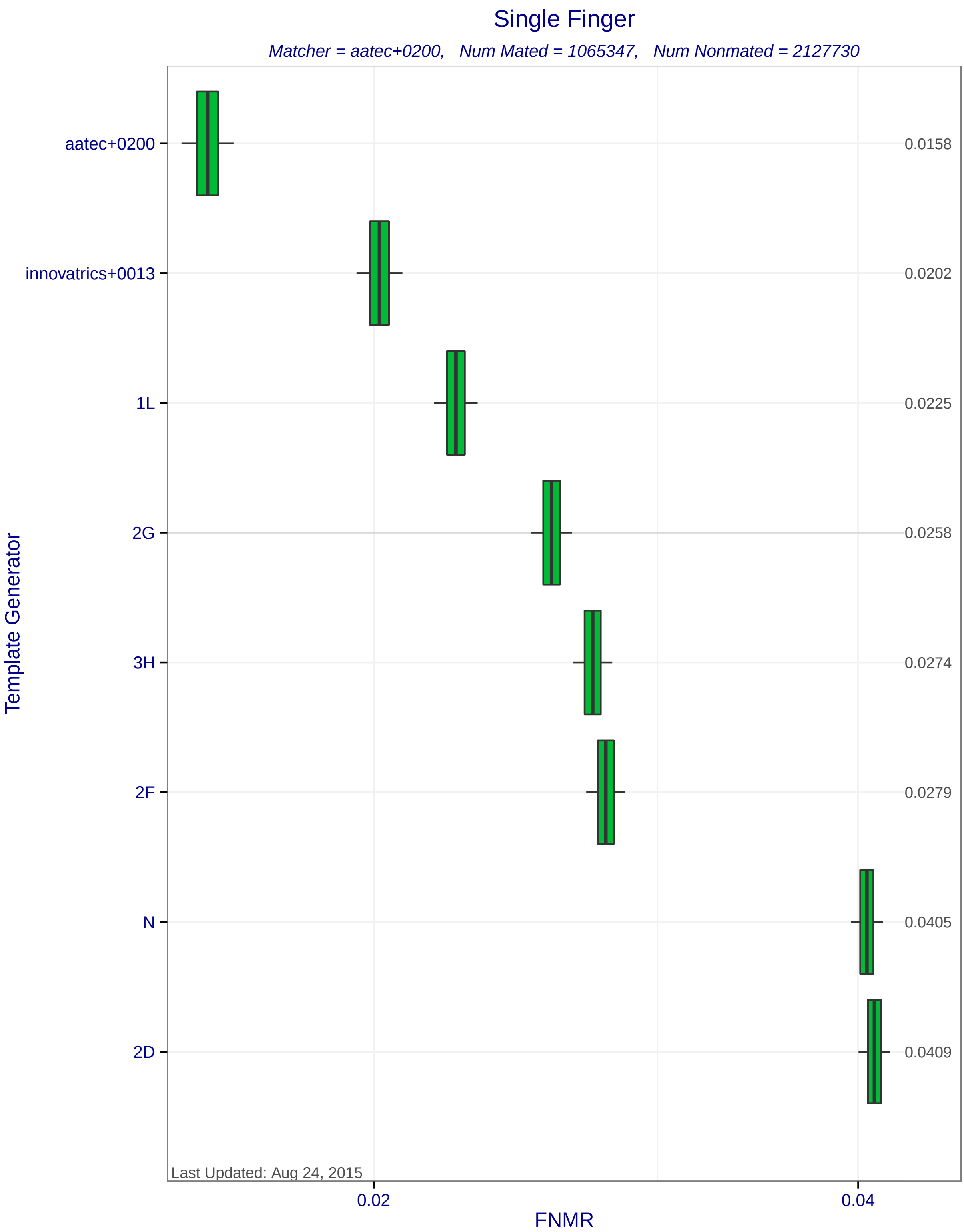

Figure 5: *Single finger FNMRs at FMR = 0.0001 when matcher aatec+0200 compares templates created by different template generators. The ends of the whiskers show the minimum and maximum FNMRs. Each box represents uncertainty about the true FNMR. The box edges mark the 50% confidence intervals while the whiskers mark the 90% confidence intervals. The numbers on the right show the actual computed FNMRs.*

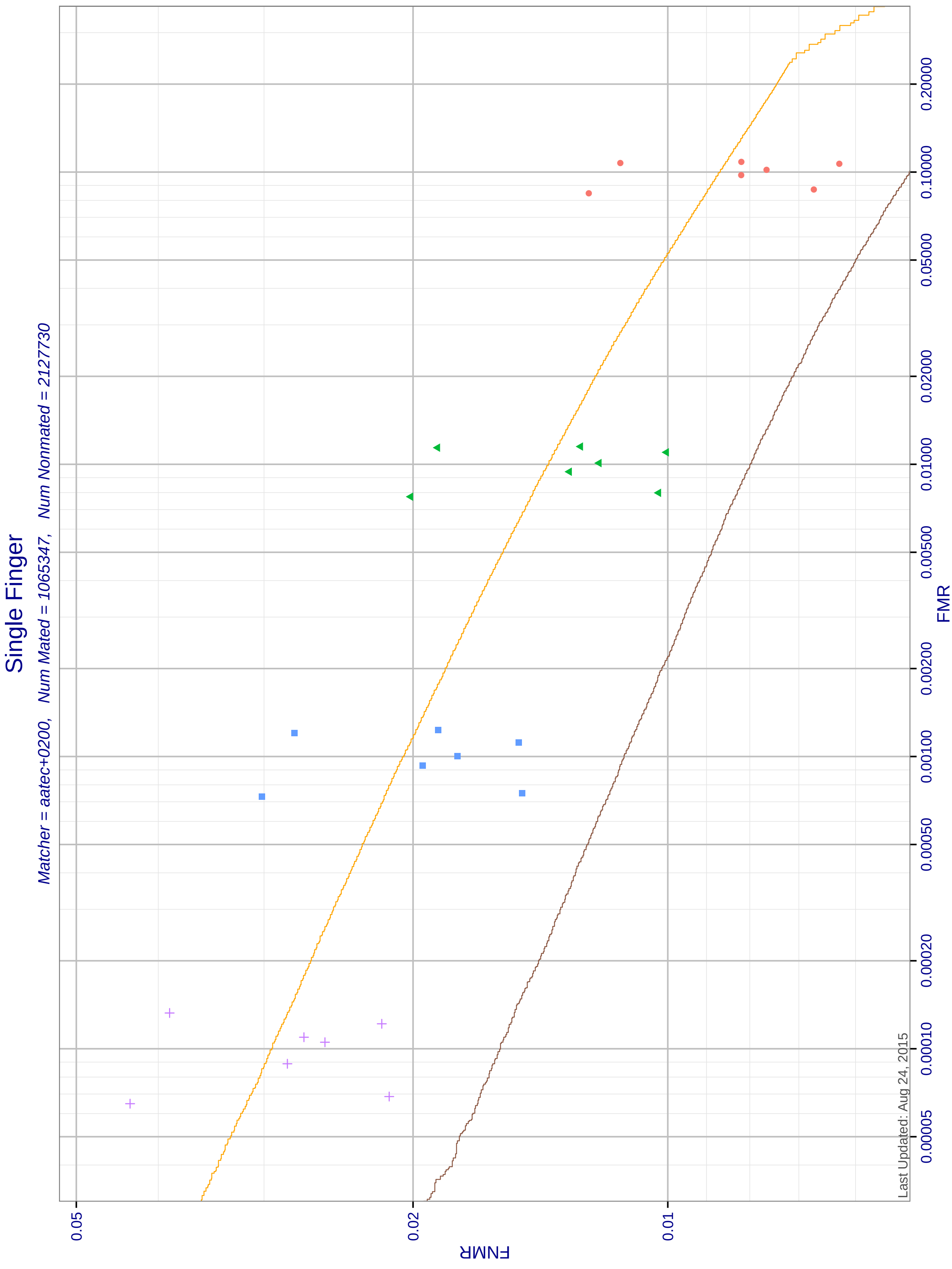

Figure 6: *Single finger DET accuracy for matcher aatec+0200. Each cluster of points represents the variation in FMR and FNMR across MINEX III compliant template generators at a fixed decision threshold. Each point corresponds to an (FMR, FNMR) pair for a specific template generator at a particular decision threshold. Four clusters are produced corresponding to four decision thresholds which produce pooled FMRs of 10^{-1}, 10^{-2}, 10^{-3}, and 10^{-4}. The orange DET curve shows pooled performance against all template generators.*

3.2 Two Finger

This section presents accuracy when matcher aatec+0200 compares templates created by all MINEX III compliant template generators. Two-finger fusion is achieved by averaging the scores for left and right index fingers for each person. *NIST Special Publication 800-76-2* requires the matcher to achieve an accuracy of $\text{FNMR}_{\text{FMR}}(0.01) \leq 0.01$ for all MINEX III compliant template generators.

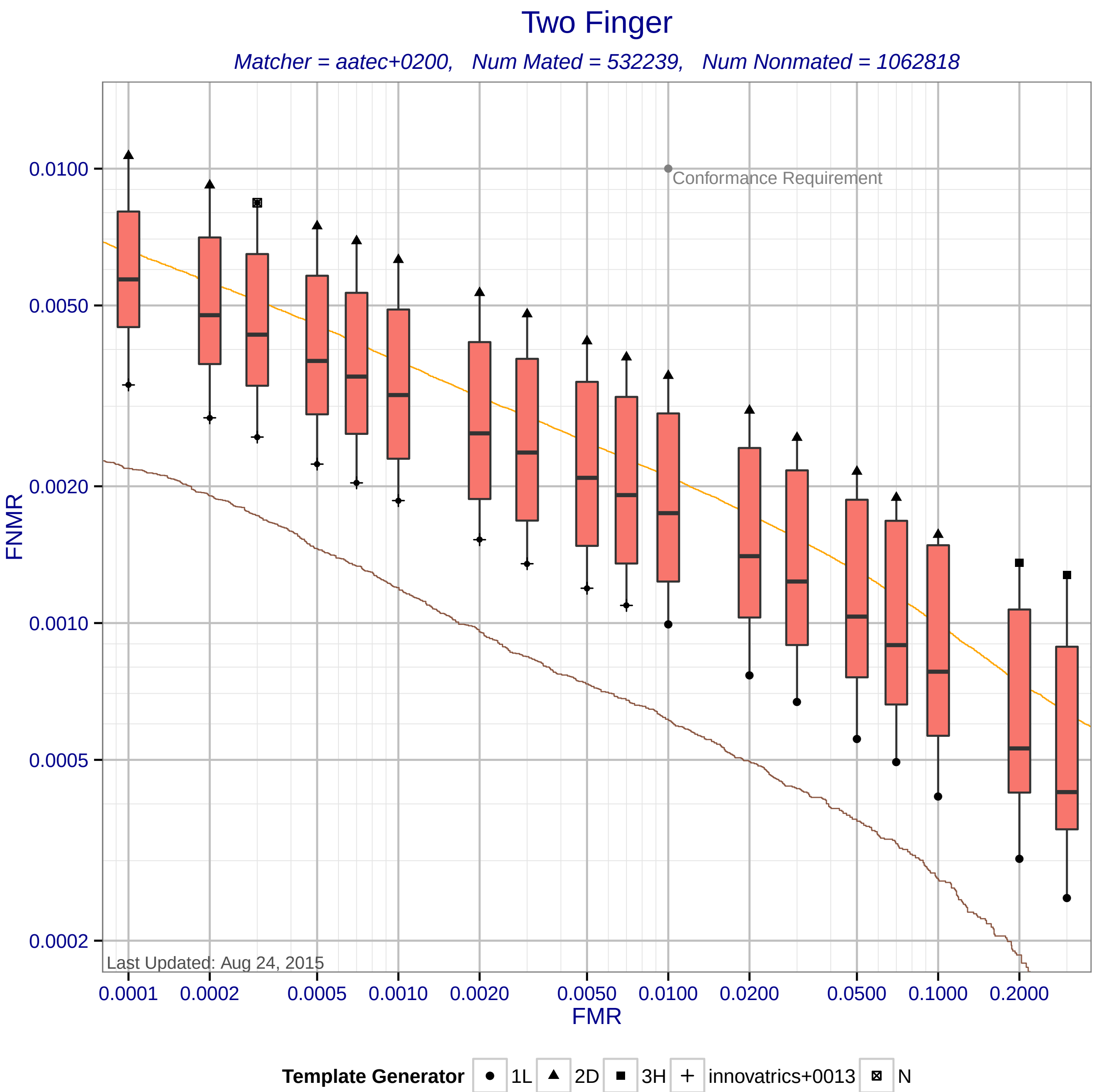

Figure 7: *Two finger DET statistics for matcher aatec+0200. Each box shows the distribution of FNMRs at a fixed FMR across all MINEX III compliant template generators. The whisker ends show the minimum and maximum FNMRs. The orange DET curve shows pooled performance against all template generators. Score-level fusion is achieved by averaging the scores for left and right index fingers.*

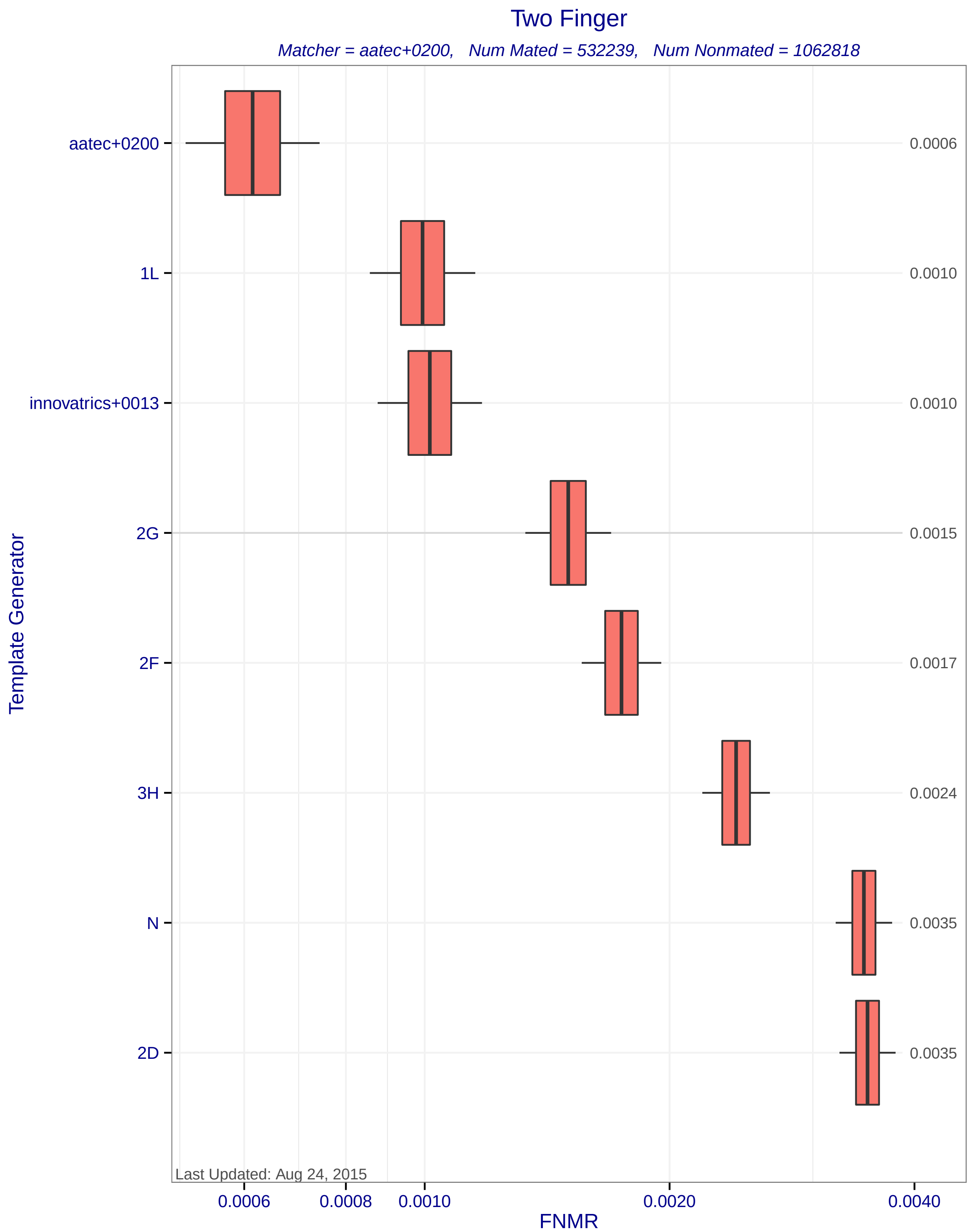

Figure 8: *Two finger FNMR at FMR=0.01 when matcher aatec+0200 compares templates created by different template generators. Each box represents uncertainty about the true FNMR. The box edges mark the 50% confidence intervals while the whiskers mark the 90% confidence intervals. The numbers on the right show the actual computed FNMRs. Score-level fusion is achieved by averaging the scores for left and right index fingers.*

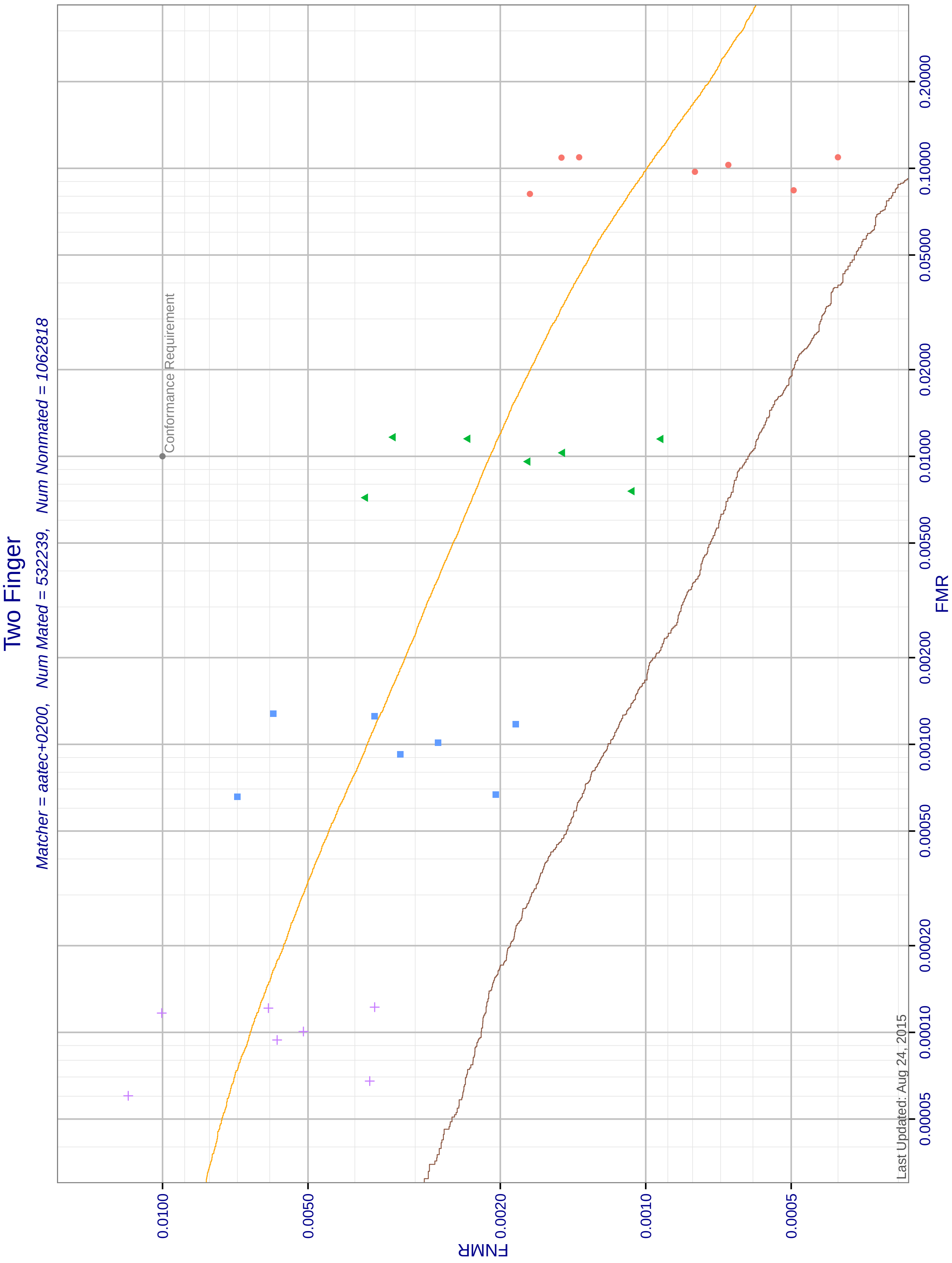

Figure 9: *Two finger DET accuracy for matcher aatec+0200. Each cluster of points represents the variation in FMR and FNMR across MINEX III compliant template generators at a fixed decision threshold. Each point corresponds to an (FMR, FNMR) pair for a specific template generator at a particular decision threshold. Four clusters are produced corresponding to four decision thresholds which produce pooled FMRs of 10^{-1}, 10^{-2}, 10^{-3}, and 10^{-4}. The orange DET curve shows pooled performance against all template generators. Score-level fusion is achieved by averaging the scores for left and right index fingers.*

3.3 Match Times

To achieve MINEX III compliance, the matcher must average no more than 10 milliseconds (0.01 seconds) per comparison. To achieve PIV compliance, 90% of comparisons must take no more than 100 milliseconds (0.1 seconds). Speeds are timed on a machine with an Intel Xeon E5-2680 CPU.

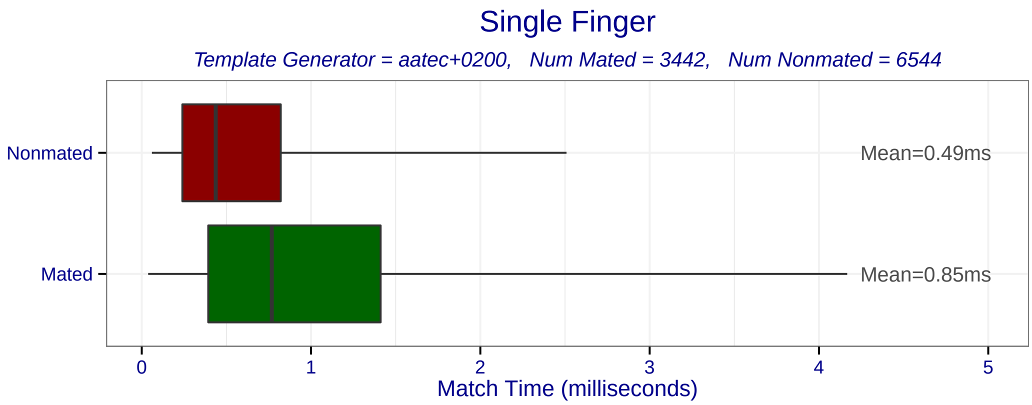

Figure 10: *Boxplot of match times for single finger comparisons. The box edges mark the 10th and 90th percentiles while the whiskers mark the maximum and minimum comparison times.*

3.4 Threshold Statistics

Results in this section are computed by concatenating comparison scores for matcher aatec+0200 across all MINEX III compliant template generators.

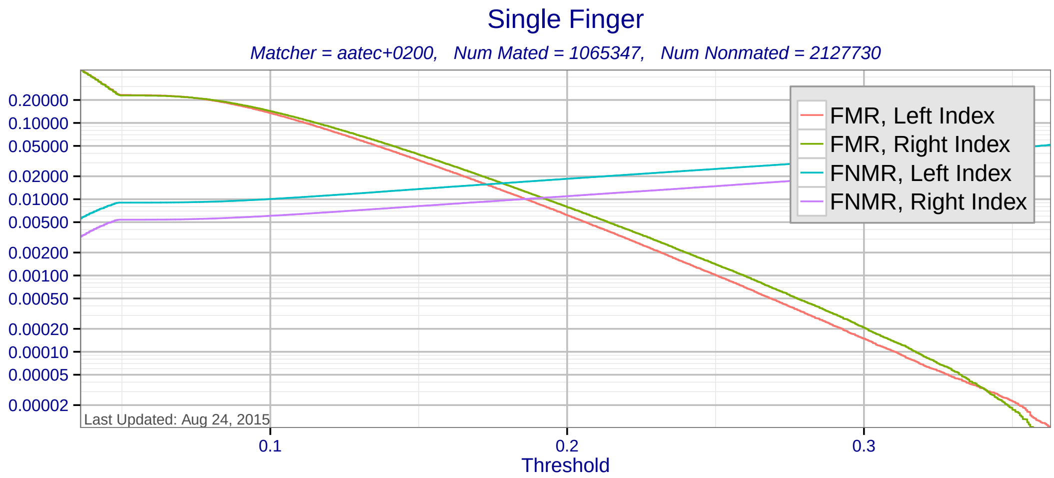

Figure 11: *Single finger FMR and FNMR as a function of score threshold for matcher aatec+0200 using templates created by all MINEX III compliant template generators. Separate curves are presented for left and right index fingers.*

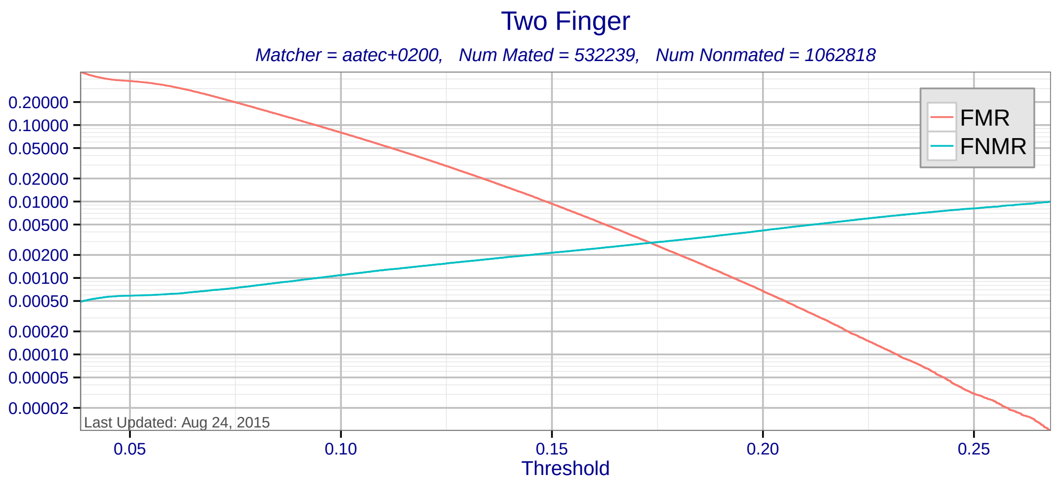

Figure 12: *Two finger FMR and FNMR as a function of score threshold for matcher aatec+0200 using templates created by all MINEX III compliant template generators. Score-level fusion is achieved by averaging scores for the left and right index fingers.*

	FMR=0.1	FMR=0.01	FMR=0.001	FMR=0.0001
Right index finger	0.11600	0.19300	0.2595	0.3175
Left index finger	0.11200	0.18650	0.2505	0.3105
Single finger	0.11400	0.19000	0.2555	0.3145
Two finger	0.09425	0.14875	0.1930	0.2320

Table 1: *Threshold calibration table. The cells show the thresholds corresponding to the FMR indicated by the column header.*

3.5 Q-Q Plot

The Q-Q plot compares two probability distributions. It plots the quantile of one distribution as a function of the other. If the curve follows the $y = x$ line, then the distributions are identical. If the FMR curve is above the $y = x$ line, then the right index finger tends to produce lower non-mated scores than the left index finger. If the FNMR curve is above the $y = x$ line, then the right index finger tends to produce lower mated scores than the left index finger.

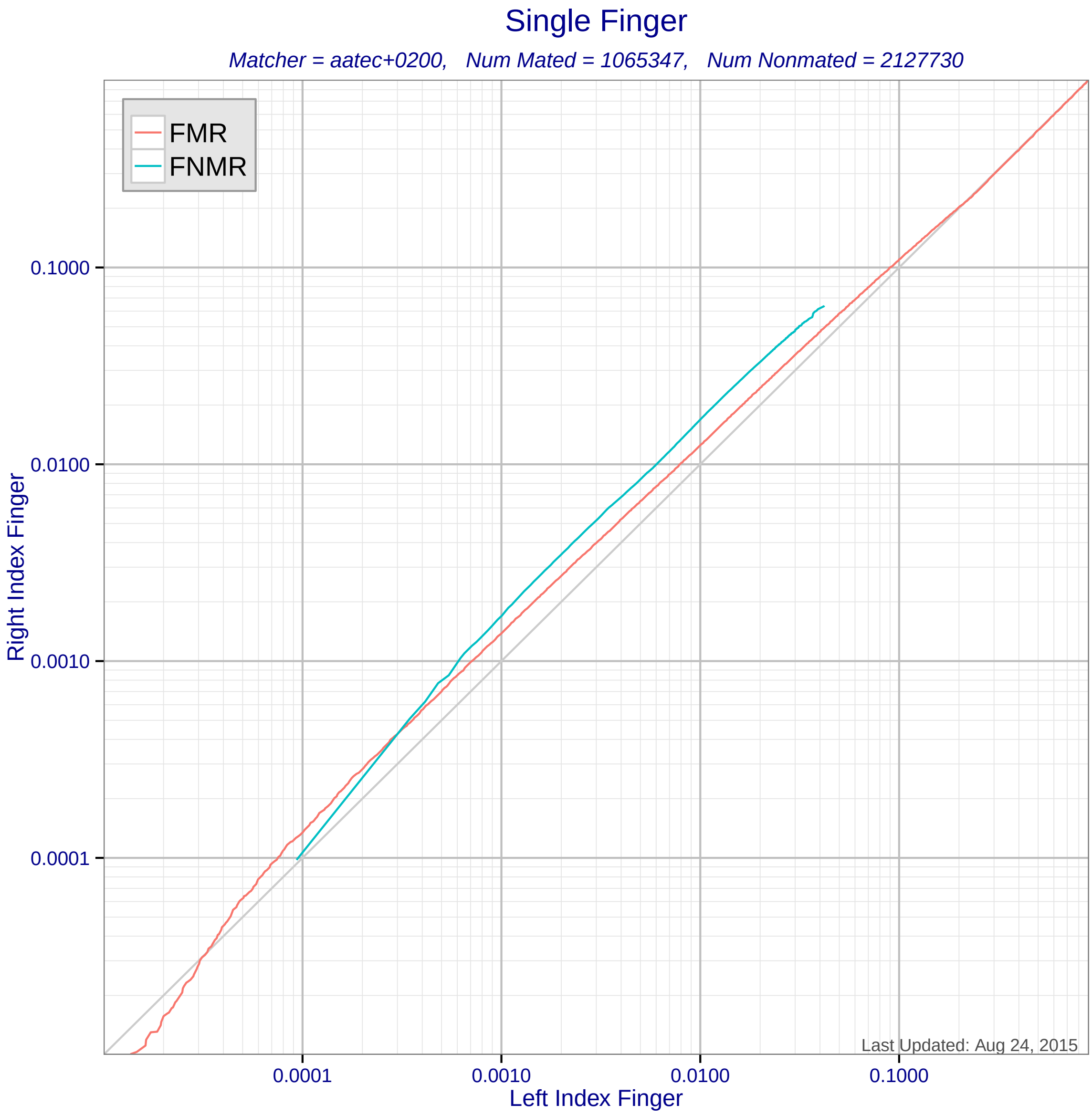

Figure 13: *Q-Q plot comparing score distributions for left and right index fingers.*

3.6 Effect of Minutia Count on Accuracy

This section shows how the number of minutia found in the samples affects recognition accuracy. To be robust to spoofing and other active attacks, the algorithm should not allow FMR to rise sharply as the number of available minutia decreases. Nor should it allow FMR to rise sharply as the number of detected minutia increases.

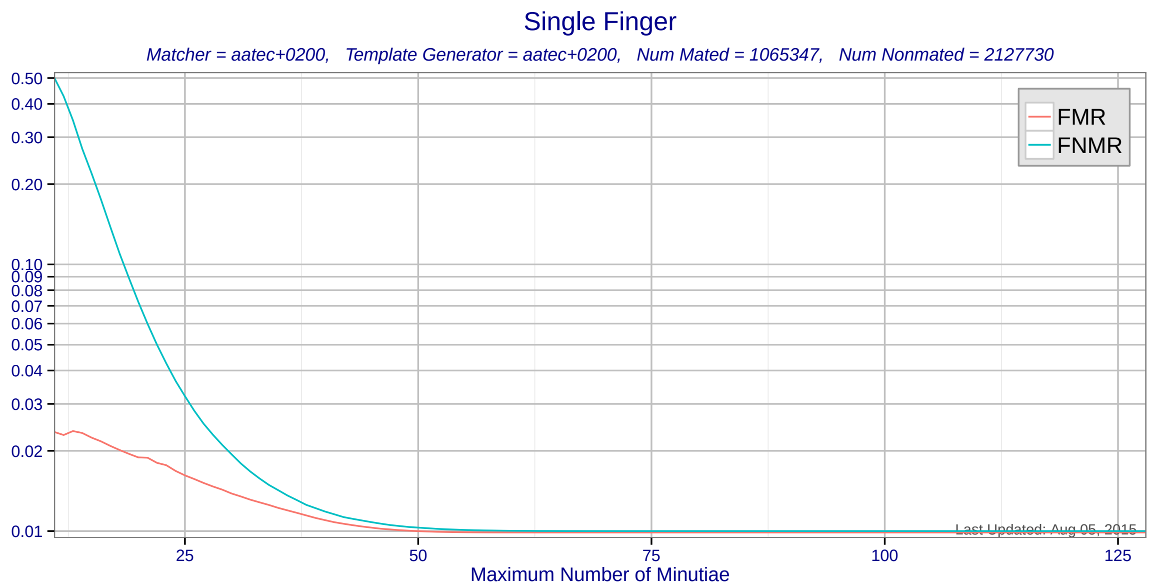

Figure 14: *FNMR and FMR as a function of the number of minutia found by the template generator. The vertical axis defines a filter criterion such that FNMR and FMR are computed over only those comparisons where at least one of the compared templates has* no more *than the specified number of minutia. The threshold is fixed separately for FNMR and FMR to elicit an error rate of approximately 0.01 over unfiltered comparisons.*

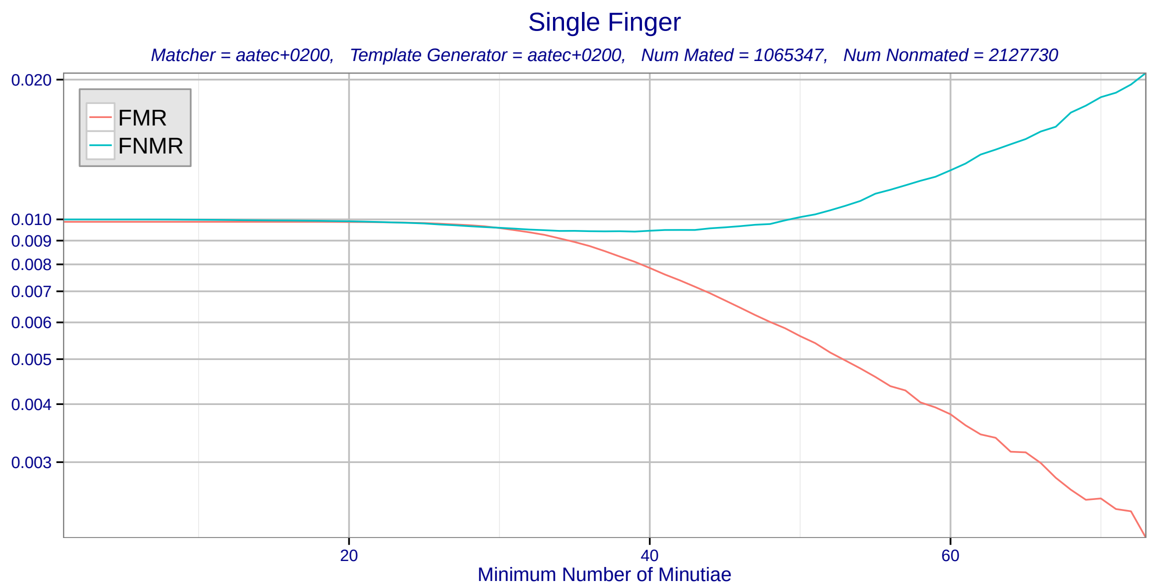

Figure 15: *FNMR and FMR as a function of the number of minutia found by the template generator. The vertical axis defines a filter criterion such that FNMR and FMR are computed over only those comparisons where at least one of the compared templates has* at least *the indicated number of minutia. The threshold is fixed separately for FNMR and FMR to elicit an error rate of approximately 0.01 over unfiltered comparisons.*

4 Performance Tables

The following tables present accuracy number, including estimates of uncertainty in the form of 90% confidence bounds. These tables are provided because most of the figures in the main body of this report do not present numerical results.

Table 2: *Single finger FNMRs at various FMRs when matcher aatec+0200 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
1L	0.0102 ± 0.0002	0.0154 ± 0.0002	0.0225 ± 0.0002
2D	0.0192 ± 0.0002	0.0288 ± 0.0003	0.0409 ± 0.0003
2F	0.0130 ± 0.0002	0.0193 ± 0.0002	0.0279 ± 0.0003
2G	0.0122 ± 0.0002	0.0179 ± 0.0002	0.0258 ± 0.0003
3H	0.0130 ± 0.0002	0.0193 ± 0.0002	0.0274 ± 0.0003
innovatrics+0013	0.0099 ± 0.0002	0.0142 ± 0.0002	0.0202 ± 0.0002
N	0.0192 ± 0.0002	0.0286 ± 0.0003	0.0405 ± 0.0003
Neurotechnology+0105	–	–	–
aatec+0200	0.0080 ± 0.0001	0.0113 ± 0.0002	0.0158 ± 0.0002

Table 3: *Right index finger FNMRs at various FMRs when matcher aatec+0200 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
1L	0.0074 ± 0.0002	0.0111 ± 0.0002	0.0166 ± 0.0003
2D	0.0150 ± 0.0003	0.0227 ± 0.0003	0.0331 ± 0.0004
2F	0.0098 ± 0.0002	0.0148 ± 0.0003	0.0214 ± 0.0003
2G	0.0091 ± 0.0002	0.0135 ± 0.0003	0.0196 ± 0.0003
3H	0.0100 ± 0.0002	0.0150 ± 0.0003	0.0214 ± 0.0003
innovatrics+0013	0.0074 ± 0.0002	0.0106 ± 0.0002	0.0155 ± 0.0003
N	0.0147 ± 0.0003	0.0222 ± 0.0003	0.0316 ± 0.0004
Neurotechnology+0105	$-$	$-$	$-$
aatec+0200	0.0057 ± 0.0002	0.0080 ± 0.0002	0.0115 ± 0.0002

Table 4: *Left index finger FNMRs at various FMRs when matcher aatec+0200 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
1L	0.0130 ± 0.0003	0.0193 ± 0.0003	0.0283 ± 0.0004
2D	0.0233 ± 0.0003	0.0345 ± 0.0004	0.0481 ± 0.0005
2F	0.0161 ± 0.0003	0.0235 ± 0.0003	0.0343 ± 0.0004
2G	0.0151 ± 0.0003	0.0219 ± 0.0003	0.0319 ± 0.0004
3H	0.0159 ± 0.0003	0.0235 ± 0.0003	0.0331 ± 0.0004
innovatrics+0013	0.0122 ± 0.0002	0.0176 ± 0.0003	0.0246 ± 0.0003
N	0.0236 ± 0.0003	0.0346 ± 0.0004	0.0494 ± 0.0005
Neurotechnology+0105	−	−	−
aatec+0200	0.0101 ± 0.0002	0.0144 ± 0.0003	0.0199 ± 0.0003

Table 5: *Two finger FNMRs at various FMRs when matcher aatec+0200 compares templates created by its template generator and PIV-compliant template generators.*

Enroller	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
1L	0.00099 ± 0.00007	0.00195 ± 0.00010	0.0039 ± 0.0001
2D	0.0035 ± 0.0001	0.0063 ± 0.0002	0.0107 ± 0.0002
2F	0.00175 ± 0.00009	0.0032 ± 0.0001	0.0057 ± 0.0002
2G	0.00150 ± 0.00009	0.0027 ± 0.0001	0.0052 ± 0.0002
3H	0.0024 ± 0.0001	0.0038 ± 0.0001	0.0062 ± 0.0002
innovatrics+0013	0.00101 ± 0.00007	0.00186 ± 0.00010	0.0033 ± 0.0001
N	0.0035 ± 0.0001	0.0062 ± 0.0002	0.0104 ± 0.0002
Neurotechnology+0105	$-$	$-$	$-$
aatec+0200	0.00061 ± 0.00006	0.00120 ± 0.00008	0.0022 ± 0.0001

5 References

[1] Jonathan N. Bradley, Christopher M. Brislawn, and Thomas Hopper. FBI wavelet/scalar quantization standard for gray-scale fingerprint image compression. In *SPIE, Visual Information Processing II*, 1961. 3

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