MINEX III Report Card

Template Generator 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 Minutia Interoperability Exchange (MINEX) III Test Plan and Application Programming Interface.

PIV: FAIL

- All certified matchers must be able to match templates from this template generator with an $\text{FNMR}_{\text{FMR}}(0.01) \leq 0.01$ using two fingers (4.5.2.2-3). ✓
- Average template creation time must be no more than 500 milliseconds (4.5.2.2-2). ✓
- Minutia density plots derived from generated templates do not exhibit a periodic, grid-like, or geometric structure without reasonable justification. ✗ *(See Section 3.5)*

MINEX III: FAIL

- Must pass MINEX III validation. ✓
- Must be PIV compliant. ✗
- No more than two compliant template generators from the submitting organization, or its subsidiaries, acquisitions, or mergers allowed (8.8). ✓

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 template generator if it later discovers the template generator violates MINEX III or PIV specifications in some previously undetected way.

Contents

List of Figures

List of Tables

1 Introduction

Testing is performed at a NIST facility. Each participant's submission is validated by NIST 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 generator submitted by the participant as well as templates created by other MINEX III compliant template generators.

2 Methodology

Testing is performed at a NIST facility. Each participant's submission is validated by NIST before undergoing full testing to ensure it operates correctly. If the template generator passes the validation procedure, performance is assessed by using MINEX III compliant matching algorithms to compare templates created by the template generator. These matchers were submitted to the ongoing MINEX III program by various participants.

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 [3, 8], 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 [7], 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

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

$$\mathrm{FNMR}(\tau) = \frac{1}{M} \sum_{i=1}^{M} \mathbb{1}\{m_i < \tau\}. \tag{2}$$

where $\mathbb{1}\{A\}$ is the indicator [4] 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 $0 \leq \alpha \leq 1$. It also imposes a natural penalty on matching algorithms that produce heavily discretized scores.

2.3 Uncertainty Estimation

Some figures in this report include boxplots that convey the uncertainty associated with a statistic. The boxplots are intended to show the expected variation in the observed value if one assumes repeated iid sampling from the same population. They are not intended to reflect how the statistic might change over different test data or even different sampling strategies over the same data.

Estimates of uncertainty are computed using the Wilson Score method [10] which overcomes certain problems associated with applying the Central Limit Theorem to a discretized estimator. We make several simplifying assumptions when applying the method to biometric identification. Most notably, separate searches against the same enrollment database are treated as independent samples, yet we know positive correlations exist due to Doddingtons Zoo [2]. We also report estimates of the variability of FNIR at a fixed FPIR when in fact it is the decision threshold that is fixed. Uncertainty with respect to what decision threshold corresponds to the targeted FPIR results in increased uncertainty about the true value of FNIR. However, our estimates of FPIR are fairly

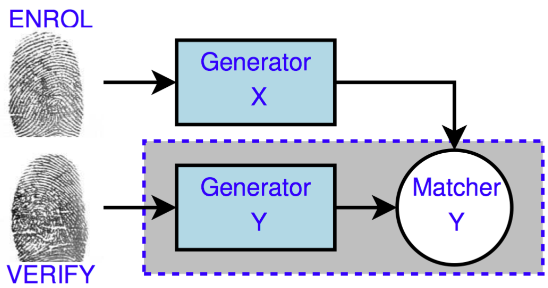


Figure 1: MINEX III Interoperability Test Setup

tight due to the large number of non-mated searches performed, so they are not expected to have a large impact on the estimates.

2.4 Interoperability

Interoperability is tested in a manner similar to *Scenario 1* from the MINEX Evaluation Report [5] (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 as ”native” mode.

3 Results

This section details the performance of template generator aatec+0200. Sections 3.1 and 3.2 present accuracy results for single finger and two finger matching respectively. Section 3.4 presents information on the number of minutia the template generator finds in the samples.

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 template generator achieve an accuracy of $\mathrm{FNMR}_{\mathrm{FMR}}(0.01) \leq 0.01$ against all compliant matchers.

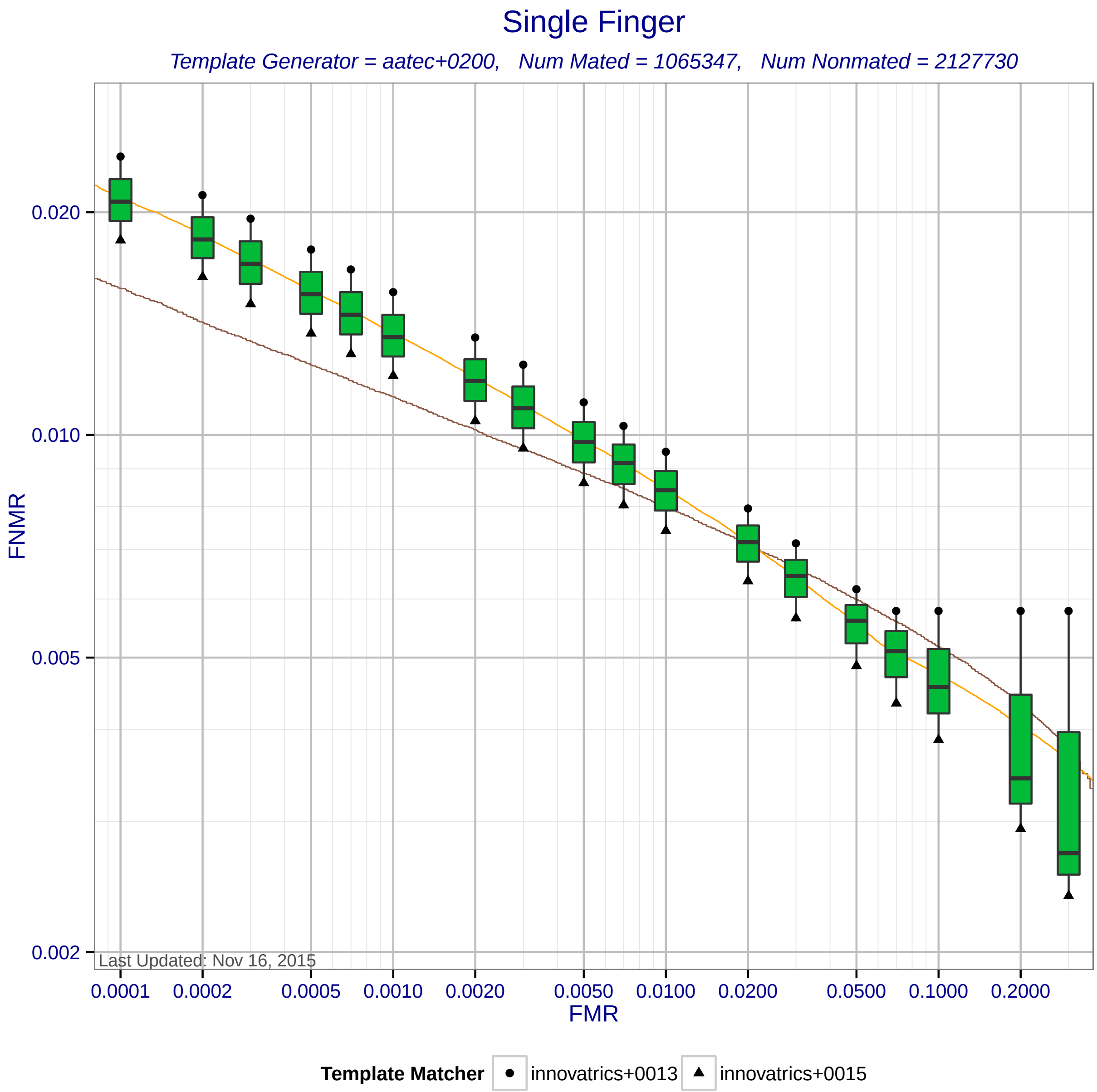


Figure 2: *Single finger DET statistics for template generator aatec+0200. Each box shows the distribution of FNMRs at a fixed FMR across different matchers. The whisker ends show the minimum and maximum FNMRs. The brown curve shows the DET curve when the matcher and template generators were submitted by the same participant. The orange DET curve shows pooled performance when all matchers compare templates created by aatec+0200.*

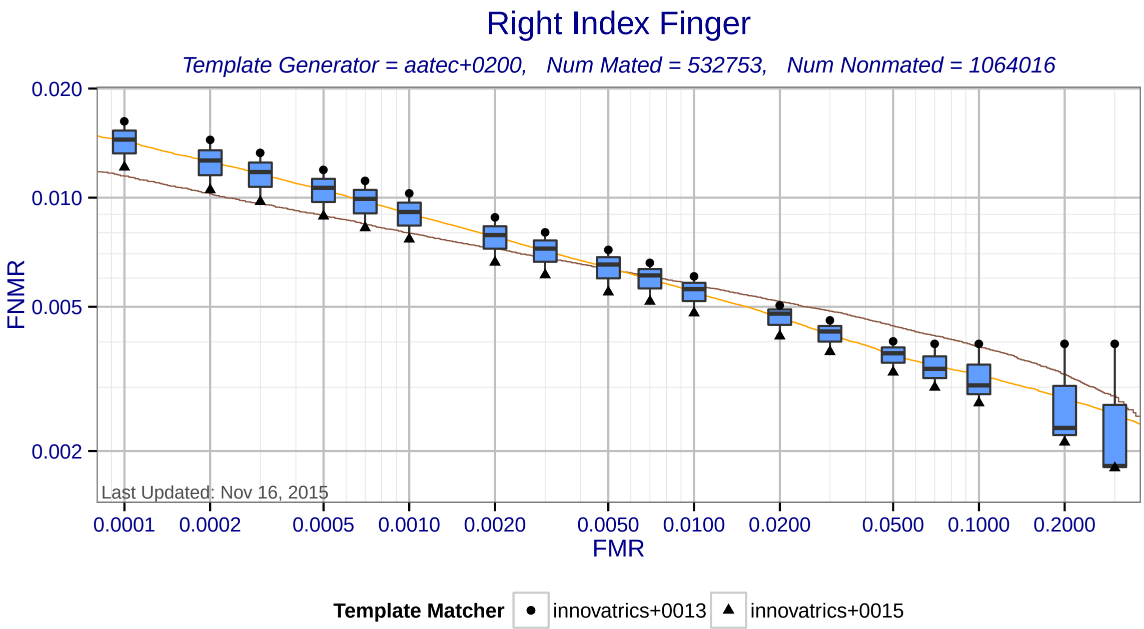


Figure 3: *Right Index Finger DET statistics for template generator aatec+0200. Each box shows the distribution of FNMRs at a fixed FMR across different matchers. The whisker ends show the minimum and maximum FNMRs. The brown curve shows the DET curve when the matcher and template generators were submitted by the same participant. The orange DET curve shows pooled performance when all matchers use templates created by aatec+0200.*

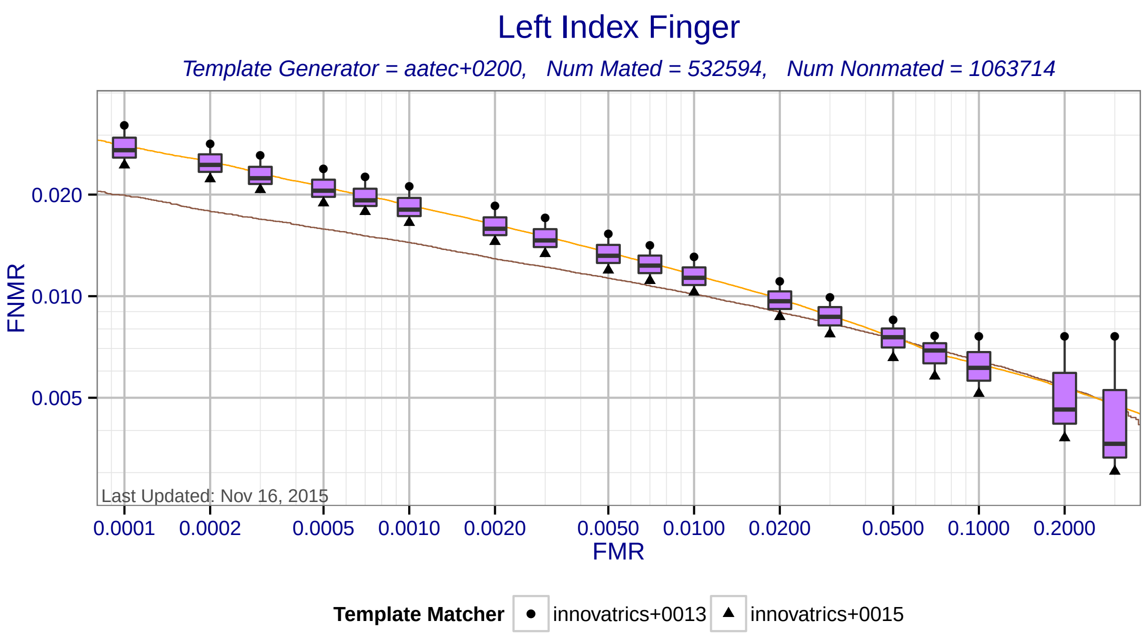


Figure 4: *Left Index Finger DET statistics for template generator aatec+0200. Each box shows the distribution of FNMRs at a fixed FMR across different template generators. The brown curve shows the DET curve when the matcher and template generators were submitted by the same participant. The orange DET curve shows pooled performance when all matchers use templates created by aatec+0200.*

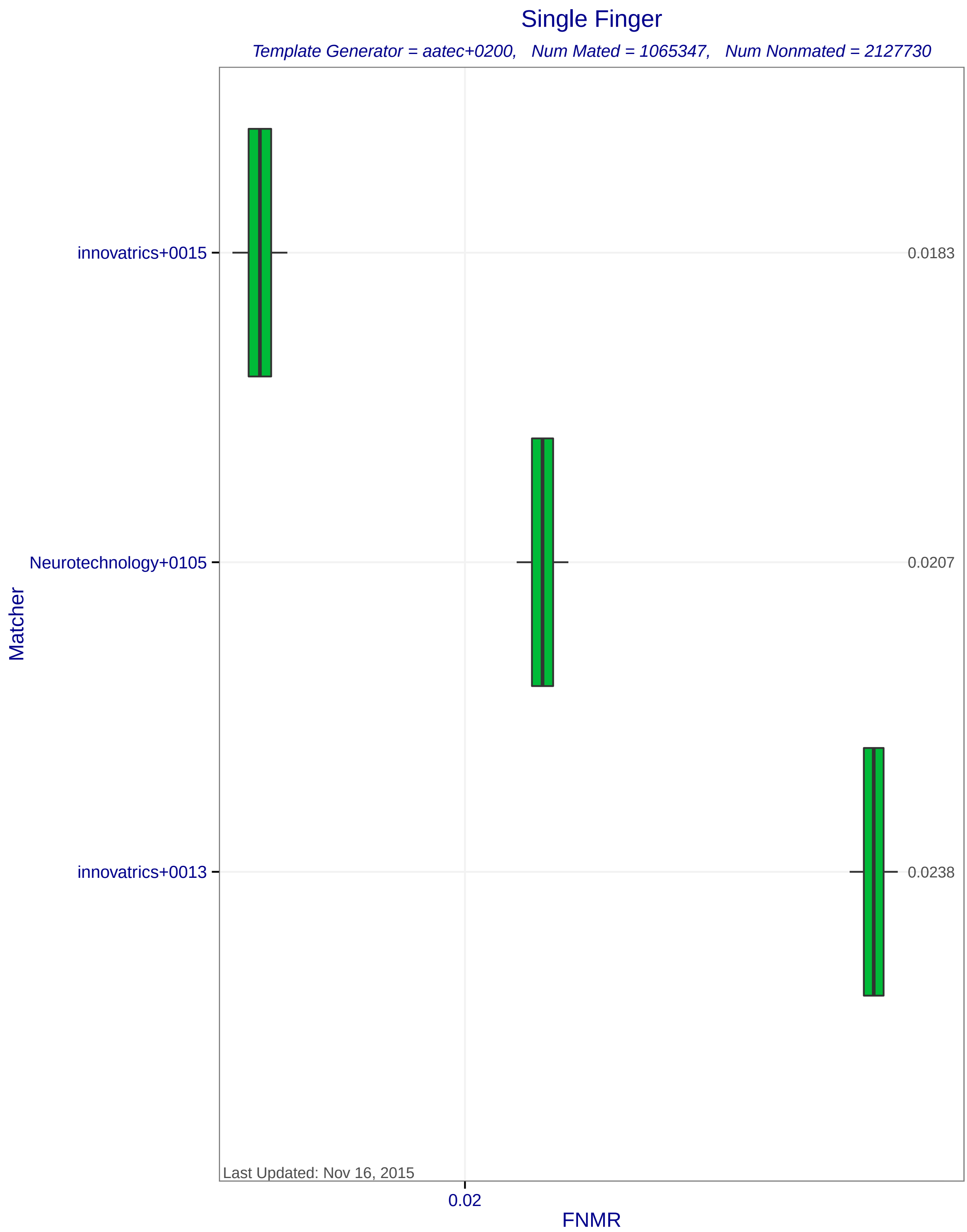


Figure 5: *Single Finger FNMRs at FMR=0.0001 when MINEX III compliant matchers compare templates created by template generator aatec+0200. Each box represents uncertainty about the true FNMR. The box edges mark the 50% confidence intervals while the whiskers mark the 90% confidence intervals. The numbers on the right show the actual computed FNMRs.*

3.2 Two Finger

This section presents accuracy when different MINEX III compliant matchers compare templates created by template generator aatec+0200. Two finger fusion is achieved by averaging the scores for left and right index fingers for each person.

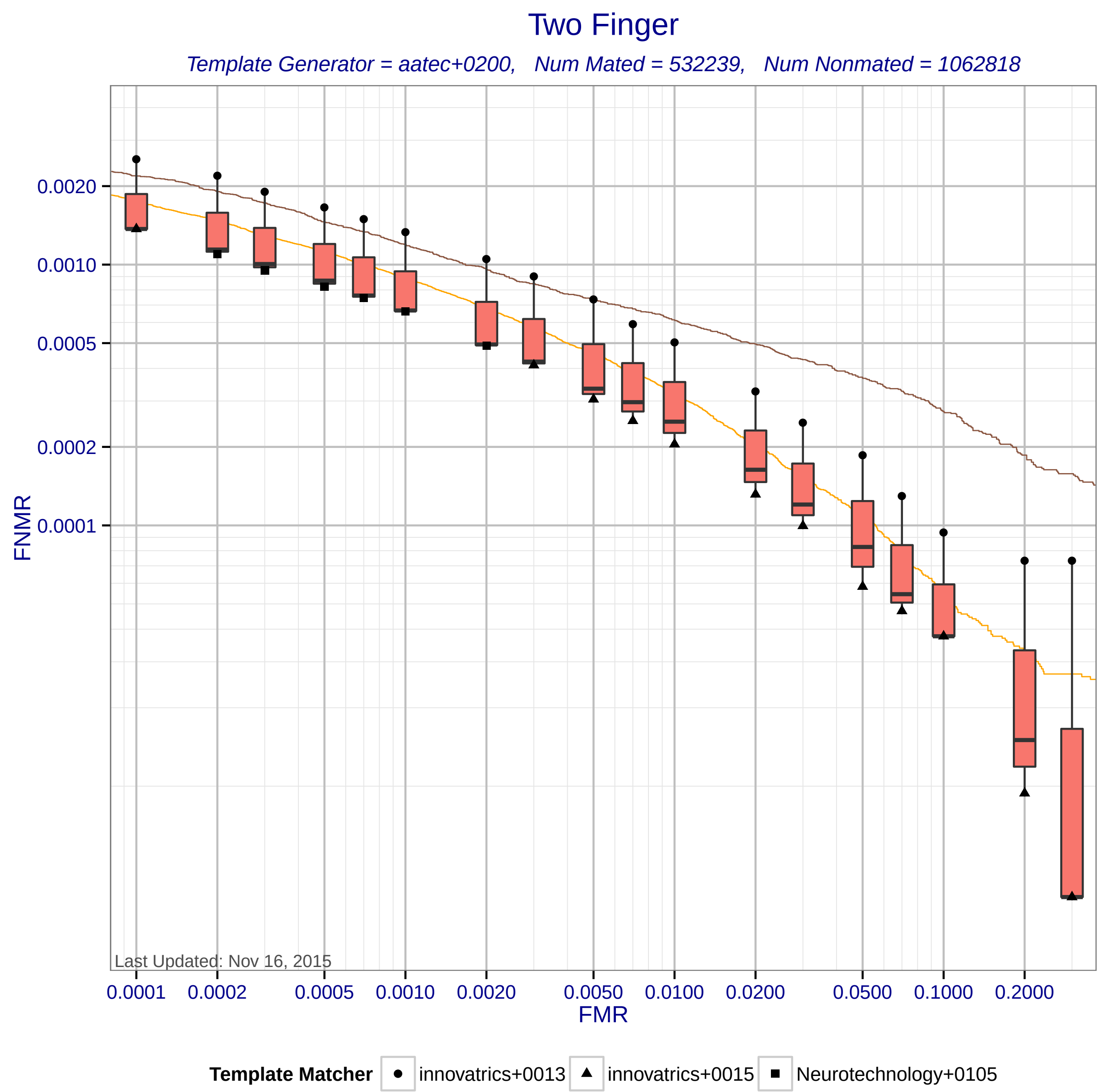


Figure 6: *Two Finger DET statistics for template generator aatec+0200. Each box shows the distribution of FNMRs at a fixed FMR across different matchers. The whisker ends show the minimum and maximum FNMRs. The brown curve shows the DET curve when the matcher and template generators were submitted by the same participant. The orange DET curve shows pooled performance when all matchers use templates created by aatec+0200. Score-level fusion is achieved by averaging the scores for left and right index fingers.*

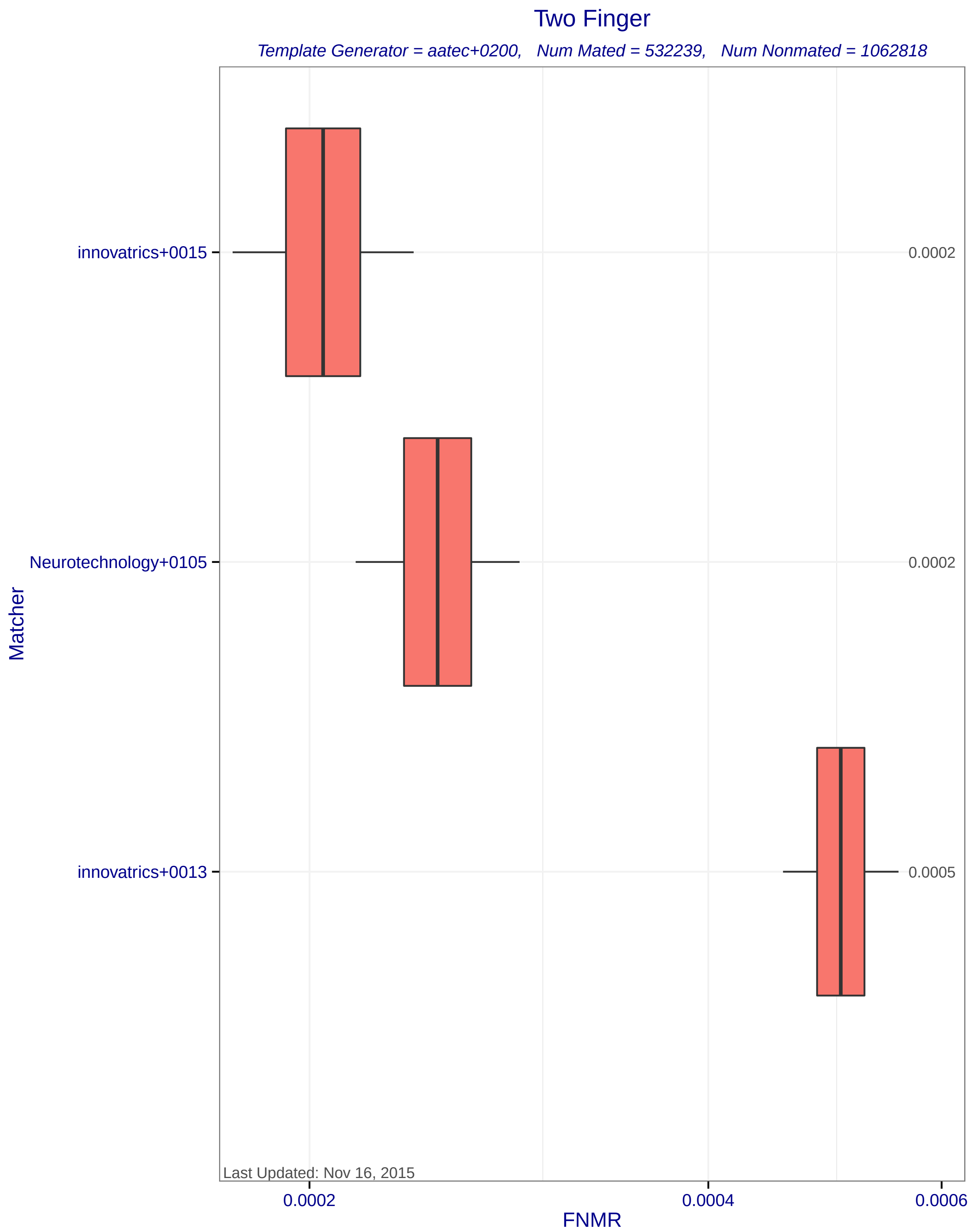


Figure 7: *Two Finger FNMR at FMR=0.01 when different matchers compare templates created by template generator aatec+0200. Each box represents uncertainty about the true FNMR. The box edges mark the 50% confidence intervals while the whiskers mark the 90% confidence intervals. The numbers on the right show the actual computed FNMRs. Score-level fusion is achieved by averaging the scores for left and right index fingers.*

3.3 Template Creation Times

To achieve PIV compliance, the template generator must create templates in no more than 0.5 seconds (500 milliseconds) on average.

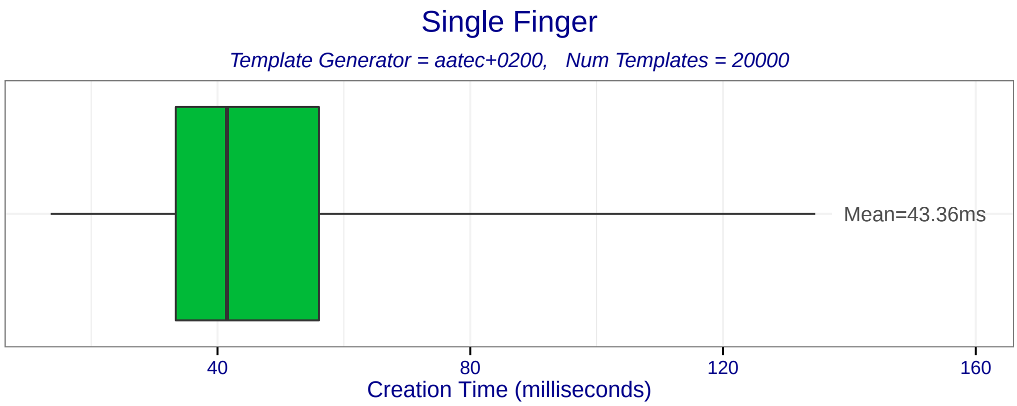


Figure 8: *Boxplot of template creation times for template generator aatec+0200. The box edges mark the 10th and 90th percentiles while the whiskers mark the maximum and minimum creation times.*

3.4 Minutia Counts

This section presents information relating to the number of minutia the template generator finds in fingerprint images. The relative number of minutia found in common fingerprint images has been shown to influence matching outcomes [9, 6].

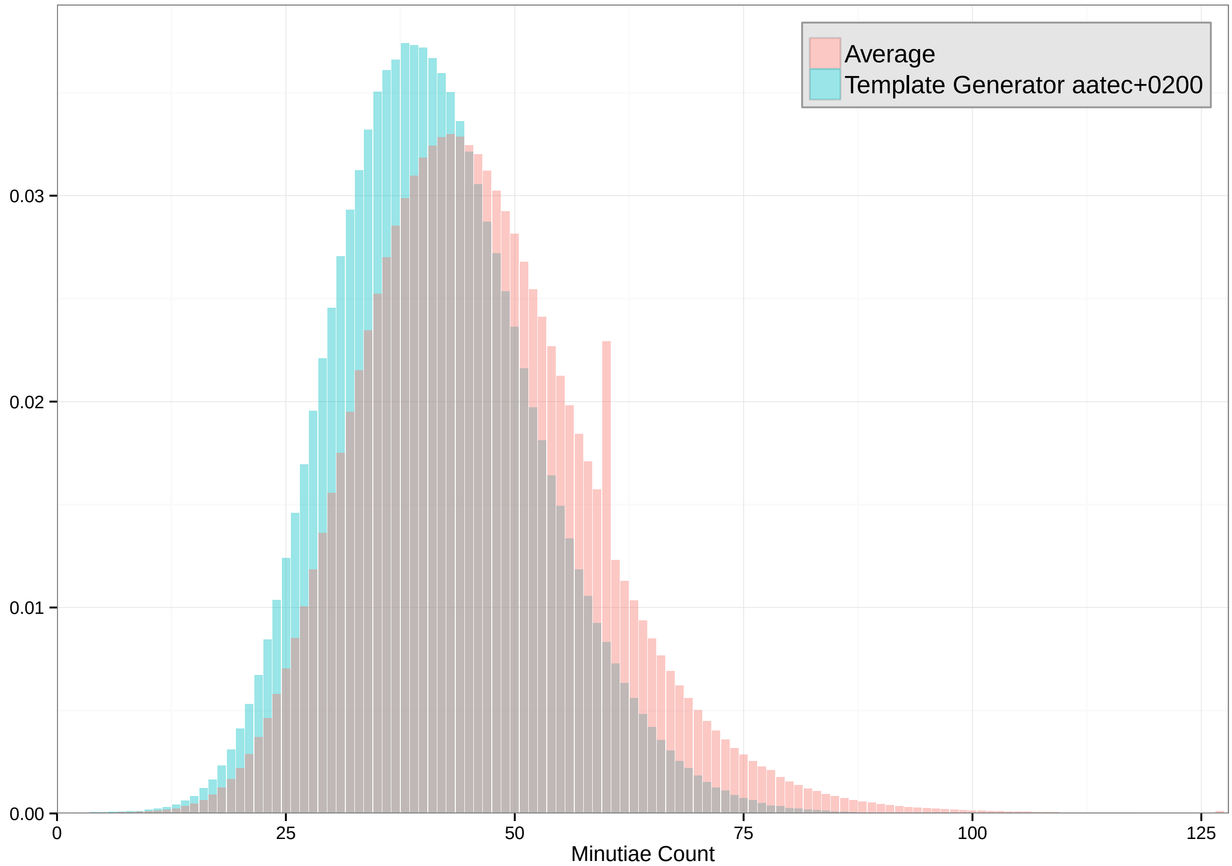
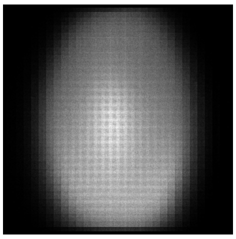


Figure 9: *Probability distribution of the number of minutia the template generator found in the samples. The* average *probability distribution shows the combined distribution of minutia counts across all compliant template generators.*

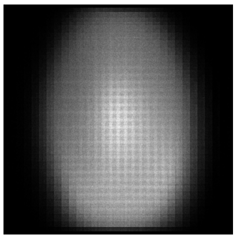
3.5 Minutia Density Plots

Minutia density plots show where the template generator tends to find minutia in fingerprint images. They are 2D histograms where the degree of illumination at an (x, y) coordinate indicates how frequently the software located a minutiae point at that location. The purpose of showing minutia density plots is to determine whether the template generator exhibits regional preference when locating minutia.

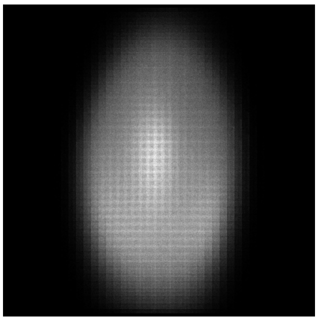
NIST has determined that this template generator produces minutia exhibiting a periodic structure. This is an indication that the template generator is departing from the minutia placement requirements of INCITS 378, clause 5. The expected pattern is a locally uniform distribution, and the appearance of local structure indicates systematic non-conformance with the standard. Given such behavior negatively affects interoperability[9], developers are asked to determine the cause of such behavior – for example, as an artifact of a tilebased image processing algorithms applied to the input fingerprint image and to resubmit corrected algorithms.



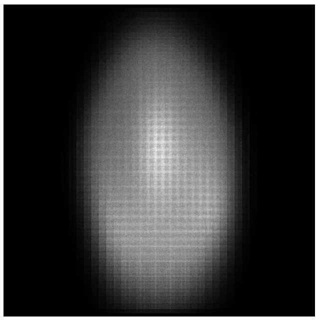
(a) Minutia density plot for 546 625 368x368 left indexes.



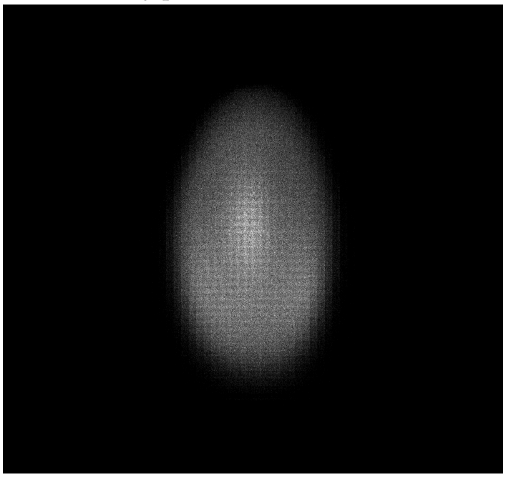
(b) Minutia density plot for 546 466 368x368 right indexes.



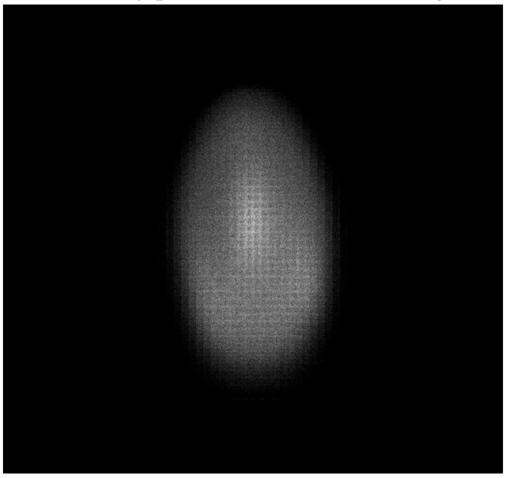
(c) Minutia density plot for 477 312 500x500 left indexes.



(d) Minutia density plot for 477 317 500x500 right indexes.



(e) Minutia density plot for 43 120 800x750 left indexes.



(f) Minutia density plot for 43 121 800x750 right indexes.

Figure 10: 2D Minutia density plots.

3.6 Comparison to Ongoing MINEX

MINEX III uses a larger set of comparisons than the older ongoing MINEX evaluation. Although this is generally good because it provides more accurate estimates of performance in MINEX III, it makes it more difficult to directly compare the results in this report to the archived ones from ongoing MINEX. The tables below report DET accuracy at fixed FMRs computed over the same set of comparisons that were used in ongoing MINEX. Ongoing MINEX reported FNMR at FMR $= 0.01$ for two-finger, and FNMR at FMR $= 0.0001$ for native single-finger.

Table 1: *Single finger FNMRs at various FMRs when aatec+0200 and MINEX III-compliant matchers compare templates created by template generator aatec+0200.*

Matcher	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
innovatrics+0013	0.0063 ± 0.0003	0.0117 ± 0.0004	0.0208 ± 0.0005
innovatrics+0015	0.0060 ± 0.0003	0.0109 ± 0.0003	0.0177 ± 0.0004
Neurotechnology+0105	0.0078 ± 0.0003	0.0140 ± 0.0004	0.0228 ± 0.0005
aatec+0200	0.0060 ± 0.0003	0.0097 ± 0.0003	0.0149 ± 0.0004

Table 2: *Two finger FNMRs at various FMRs when aatec+0200 and MINEX III-compliant matchers compare templates created by template generator aatec+0200.*

Matcher	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
innovatrics+0013	0.00031 ± 0.00008	0.0009 ± 0.0001	0.0017 ± 0.0002
innovatrics+0015	0.00020 ± 0.00007	0.0007 ± 0.0001	0.0012 ± 0.0002
Neurotechnology+0105	0.00030 ± 0.00008	0.0007 ± 0.0001	0.0015 ± 0.0002
aatec+0200	0.0005 ± 0.0001	0.0009 ± 0.0001	0.0020 ± 0.0002

4 Performance Tables

The following tables present accuracy numbers, 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 the report do not present actual accuracy numbers.

Table 3: *Single finger FNMRs at various FMRs when aatec+0200 and MINEX III-compliant matchers compare templates created by template generator aatec+0200.*

Matcher	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
innovatrics+0013	0.0095 ± 0.0002	0.0156 ± 0.0002	0.0238 ± 0.0002
innovatrics+0015	0.0074 ± 0.0001	0.0120 ± 0.0002	0.0183 ± 0.0002
Neurotechnology+0105	0.0084 ± 0.0001	0.0136 ± 0.0002	0.0207 ± 0.0002
aatec+0200	0.0080 ± 0.0001	0.0113 ± 0.0002	0.0158 ± 0.0002

Table 4: *Right index finger FNMRs at various FMRs when aatec+0200 and MINEX III-compliant matchers compare templates created by template generator aatec+0200.*

Matcher	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
innovatrics+0013	0.0061 ± 0.0002	0.0103 ± 0.0002	0.0162 ± 0.0003
innovatrics+0015	0.0048 ± 0.0002	0.0077 ± 0.0002	0.0121 ± 0.0002
Neurotechnology+0105	0.0056 ± 0.0002	0.0091 ± 0.0002	0.0145 ± 0.0003
aatec+0200	0.0057 ± 0.0002	0.0080 ± 0.0002	0.0115 ± 0.0002

Table 5: *Left index finger FNMRs at various FMRs when aatec+0200 and MINEX III-compliant matchers compare templates created by template generator aatec+0200.*

Matcher	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
innovatrics+0013	0.0131 ± 0.0003	0.0212 ± 0.0003	0.0321 ± 0.0004
innovatrics+0015	0.0103 ± 0.0002	0.0165 ± 0.0003	0.0245 ± 0.0003
Neurotechnology+0105	0.0113 ± 0.0002	0.0181 ± 0.0003	0.0271 ± 0.0004
aatec+0200	0.0101 ± 0.0002	0.0144 ± 0.0003	0.0199 ± 0.0003

Table 6: *Two finger FNMRs at various FMRs when aatec+0200 and MINEX III-compliant matchers compare templates created by template generator aatec+0200.*

Matcher	FNMR @ FMR=0.01	FNMR @ FMR=0.001	FNMR @ FMR=0.0001
innovatrics+0013	0.00050 ± 0.00005	0.00133 ± 0.00008	0.0025 ± 0.0001
innovatrics+0015	0.00020 ± 0.00003	0.00067 ± 0.00006	0.00137 ± 0.00008
Neurotechnology+0105	0.00025 ± 0.00004	0.00066 ± 0.00006	0.00137 ± 0.00008
aatec+0200	0.00061 ± 0.00006	0.00120 ± 0.00008	0.0022 ± 0.0001

5 References

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