NISTIR XXXX Draft

# Ongoing Face Recognition Vendor Test (FRVT)

## Part 1: Verification

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## DISCLAIMER

Specific hardware and software products identified in this report were used in order to perform the evaluations described in this document. In no case does identification of any commercial product, trade name, or vendor, imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the products and equipment identified are necessarily the best available for the purpose.

## ABOUT THIS REPORT

This report is a draft NIST Interagency Report, and is open for comment. It documents the verification-track of the ongoing Face Recognition Vendor Test. The report will be updated continuously as new algorithms are evaluated, as new datasets are added, and as new analyses are included. Comments and suggestions should be directed to frvt@nist.gov.



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

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# 1 News

**2018-11-20**

- FRVT Ongoing is currently closed while FRVT 2018 (1:N search algorithms) continues in Phase 3.
- FRVT Ongoing will resume in 2019 - Algorithms should be submitted during January 28 - February 1, 2019.
- The next full report is scheduled for March 1, 2019.
- The mugshot database will be replaced by that used in FRVT 2018.
- NIST's evaluation of 1:N identification algorithms has produced one public report, documenting accuracy of algorithms submitted to NIST in February and June of 2018. That report will be updated in early 2019 with results for algorithms submitted October 30, 2018. See the webpage here.

# 2 Changelog

**2019-01-29**

- This report adds a few new results for algorithms submitted in September 2018.
- This report re-includes older heatmap figures that were incorrectly omitted from the November 2018 report.

**2018-11-15**

- This report adds results for algorithms submitted by 39 developers during August and September 2018.
- Of these, Anke, Bitmain, Dahua, Saffe, SenseTime, Tech5, and Vion are new entrants.
- The report also adds results from algorithms that had not completed runs at the time of the last report, 2018-06-21.
- An update to this report will be produced as demographic results for the recently submitted algorithms become available.
- Retired older algorithms from many developers, because we only report results for at most two per developer.
- Corrected that a few May 2018 algorithms had been identified as GPU based algorithms - they were CPU based algorithms. GPU-based algorithms are no longer permitted.
- Figures 72 and 78 that, respectively, show FNMR vs. country of birth and age, have been recomputed to a) give larger plots spanning multiple pages, and and b) to use bootstrap estimates of uncertainty that are confined to positive values. The error rates from the leading algorithms applied to adult visa photos are so low, at modest thresholds (FMR = 0.001), that the remaining errors are from childen.

**2018-06-21**

- Added results for algorithms from new developers Panasonic, Shenzhen IAIT / CASIA.
- Completed results for algorithms mentioned in the 2018-06-18 update.
- The next report is scheduled for October 2018.

**2018-06-18**

- Added results for algorithms from new developers Incode, Microfocus, RealNetworks, Visidon.
- Added results for new algorithms from Aware, Any Vision, Cogent, Gorilla, Integrated Systems, Lookman, Megvii / Face++, Ping An, Rank One, Synesis, Tiger IT, Tong Yi Transportation, Visionlabs, Vocord, Yisheng, Yitu.
- For the recent algorithms, some results are in-process and will be added in the next report, scheduled June 2018.

- ▷ We are in the process of retiring all results for the selfie and webcam datasets because the genuine pair images were taken on the same day and were thus poorly representative of many operations.
- ▷ We are in the process of replacing one wild dataset, with a entirely new, larger, but easier one.
- ▷ Given participation totals, performance tables have been split to span multiple pages. This should solve the crowding problem of plotting too many DETs on one graph. Many figures replaced by tiered graphs in which around 20 algorithms of similar accuracy are plotted per page. This gives much better visibility.

**2018-04-03**

- ▷ Added results for some algorithms applied to child exploitation images, including for the most accurate algorithm tested on that dataset so far.

**2018-02-15**

- ▷ Added results for algorithms from new developers Gorilla, Megvii.
- ▷ Added results for new algorithms from Dermalog, Neurotechnology, Visionlabs, Vocord.
- ▷ Retired results for early algorithms from those suppliers because FRVT lists only the two most recent algorithms per organization.
- ▷ Added a column to the FNMR summary Table 5 that gives FNMR for visa photos when FMR is set to 0.0001 for non-zero effort impostors i.e. those of the same sex, age group, and country of origin. This produces markedly higher FNMR over the zero-effort case because rejection of impostors becomes more difficult.

**2018-01-24**

- ▷ Added results for first algorithms from Gemalto Cogent, Intellivision and Ultinous.
- ▷ Added full or partial results for new algorithms from Idemia (Morpho), NTechLab, Shaman, Tevian, and Toshiba, and from Fudan and ITMO universities.
- ▷ Added entries for Fudan University which had incorrectly been omitted from Tables 3 and 7.
- ▷ Retired results for itmo-001, ntechlab-001, vocord-001, and vigilantsolutions-001 - FRVT lists only the two most recent algorithms per organization.
- ▷ Added GPU vs CPU shape designators to the tradeoff summaries in Figures 1 and 2.

**2017-12-14**

- ▷ Added results for algorithms from Aware, RankOne, Shaman, and Tevian.
- ▷ Retired results for RankOne-000 - FRVT lists only the two most recent algorithms per organization.
- ▷ New description of wild images in section 5.2
- ▷ New Figure 79 showing FMR for impostors of same age, sex and worst-case region.

**2017-11-16**

- ▷ Added results for algorithms from 3DiVi, Dermalog, Neurotechnology and Ping An.
- ▷ Retired results for 3DiVi-000, dermalog-002, and neurotechnology-000 - FRVT lists only two algorithms per organization.
- ▷ Retired results for vcognition-001 as the algorithm was inoperable on at least one dataset.
- ▷ Added cross-pose recognition heatmaps for the wild images, Figures 26 and 27.
- ▷ Added Figure 33 to compare effect of providing whole vs. face-cropped child exploitation images.

**2017-10-03**

- ▷ Added results for algorithms from 3DiVi, Camvi, Idemia, Noblis, N-TechLab, and Visionlabs.
- ▷ Added partial results for two algorithms from Zhuhai Yisheng.
- ▷ The ntechlab-000 algorithm has been retired - FRVT lists only two algorithms per organization.
- ▷ Corrected fixed FMR operating point in the legends of some DET plots.

**2017-08-22**

- ▷ Added results for three additional algorithms, rankone-002, neurotechnology-001, and itmo-002.
- ▷ The algorithms dermalog-001 and rank-001 have been retired - FRVT lists only two algorithms per organization
- ▷ The algorithm tupel-001 has been retired as it is not operable on all datasets
- ▷ Clarified the tradeoff Figures 1 and 2 plot only genuine comparison durations.
- ▷ Corrected image type label in section 4.5

**2017-08-07**

- ▷ Added results for 5 new algorithms
- ▷ Added Figure 3 giving simulated example images.
- ▷ Added Figure 1 showing an alternative view of the same tradeoff data in Figure 2
- ▷ Added Figure 80 showing impostor distribution shifts from certain country pairs. Section 5.6.1 in this and prior reports documents high false match rates for individuals from certain countries. That effect, however, is often not confined to anomalously high impostor scores in the tails of the distribution, but arises from systematic shifts of the whole distribution. These shifts sometimes reach $2\sigma$.

**2017-07-29**

- ▷ Added results for 8 new algorithms
- ▷ Added results for a child-exploitation dataset
- ▷ Added Table 5 a standalone tabulation of false non-match rates
- ▷ We have received additional CPU algorithms - Results should appear August 4, 2017
- ▷ We have received additional GPU algorithms - Results to appear as computational resources are released from the Face Recognition Prize Challenge

**2017-06-19**

- ▷ Added five new algorithms, three of which remain in-process
- ▷ Added results for a "wild" dataset of images similar to non-cooperative photojournalism images
- ▷ Added Table 7 a standalone tabulation of failure to enrol rates
- ▷ Added Fig. 2 showing tradeoff between FNMR, template size, template generation time, and match duration.
- ▷ Added Fig. 58 showing how FMR is concentrated in certain images.
- ▷ Restated cross-region false match rates at nominal FMR = 0.0001 instead of 0.001
- ▷ Improved DET legends.

| | Developer | Short | Seq. | Validation | Config[1] | Template | | GPU | Comparison Time (ns)[3] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Name | Name | Num. | Date | Data (KB) | Size (B) | Time (ms)[2] | | Genuine | Impostor |
| 1 | 3DiVi | 3divi | 002 | 2017-10-20 | 190867 | $^{87}$4096 ± 0 | $^{33}$279 ± 48 | Yes | $^{27}$692 ± 22 | $^{31}$707 ± 26 |
| 2 | 3DiVi | 3divi | 003 | 2018-10-09 | 191636 | $^{85}$4096 ± 0 | $^{81}$650 ± 90 | No | $^{24}$627 ± 11 | $^{26}$623 ± 32 |
| 3 | Anke Investments | anke | 001 | 2018-06-26 | 642061 | $^{73}$2072 ± 0 | $^{70}$541 ± 4 | No | $^{19}$540 ± 16 | $^{21}$530 ± 20 |
| 4 | Anke Investments | anke | 002 | 2018-10-19 | 798686 | $^{74}$2072 ± 0 | $^{58}$419 ± 30 | No | $^{17}$501 ± 17 | $^{18}$492 ± 17 |
| 5 | AnyVision | anyvision | 002 | 2018-01-31 | 662659 | $^{26}$1024 ± 0 | $^{28}$248 ± 0 | No | $^{98}$74069 ± 188 | $^{98}$74019 ± 198 |
| 6 | AnyVision | anyvision | 004 | 2018-06-15 | 401001 | $^{29}$1024 ± 0 | $^{45}$355 ± 1 | No | $^{56}$1891 ± 51 | $^{54}$1829 ± 85 |
| 7 | Aware | aware | 002 | 2018-06-15 | 271312 | $^{40}$1572 ± 0 | $^{76}$582 ± 14 | No | $^{32}$810 ± 32 | $^{35}$812 ± 28 |
| 8 | Aware | aware | 003 | 2018-10-19 | 377729 | $^{79}$3108 ± 0 | $^{91}$783 ± 10 | No | $^{48}$1392 ± 42 | $^{45}$1334 ± 80 |
| 9 | Ayonix | ayonix | 000 | 2017-06-22 | 58505 | $^{32}$1036 ± 0 | $^{1}$18 ± 2 | No | $^{23}$621 ± 23 | $^{25}$620 ± 26 |
| 10 | Bitmain | bitmain | 001 | 2018-10-17 | 287734 | $^{1}$64 ± 0 | $^{60}$444 ± 88 | No | $^{55}$1887 ± 31 | $^{55}$1877 ± 26 |
| 11 | Camvi Technologies | camvitech | 001 | 2017-09-13 | 118759 | $^{30}$1024 ± 0 | $^{24}$181 ± 6 | No | $^{15}$481 ± 16 | $^{17}$487 ± 23 |
| 12 | Camvi Technologies | camvitech | 002 | 2018-10-19 | 236278 | $^{25}$1024 ± 0 | $^{83}$677 ± 7 | No | $^{22}$612 ± 26 | $^{23}$603 ± 20 |
| 13 | Gemalto Cogent | cogent | 001 | 2018-05-29 | 530508 | $^{15}$455 ± 0 | $^{73}$557 ± 7 | No | $^{81}$10477 ± 278 | $^{81}$10392 ± 75 |
| 14 | Gemalto Cogent | cogent | 002 | 2018-10-19 | 696959 | $^{44}$1979 ± 0 | $^{100}$941 ± 0 | No | $^{85}$14394 ± 134 | $^{85}$14385 ± 176 |
| 15 | Cognitec Systems GmbH | cognitec | 000 | 2018-10-19 | 474759 | $^{62}$2052 ± 0 | $^{26}$224 ± 1 | No | $^{73}$5274 ± 99 | $^{70}$3846 ± 157 |
| 16 | Cyberextruder | cyberex | 001 | 2017-08-02 | 121211 | $^{7}$256 ± 0 | $^{99}$893 ± 25 | No | $^{40}$1083 ± 16 | $^{42}$1079 ± 19 |
| 17 | Cyberextruder | cyberex | 002 | 2018-01-30 | 168909 | $^{46}$2048 ± 0 | $^{69}$532 ± 6 | No | $^{53}$1803 ± 14 | $^{53}$1779 ± 22 |
| 18 | Dahua Technology Co. Ltd | dahua | 000 | 2018-10-19 | 283642 | $^{54}$2048 ± 0 | $^{48}$363 ± 7 | No | $^{10}$373 ± 16 | $^{10}$364 ± 17 |
| 19 | Dahua Technology Co. Ltd | dahua | 001 | 2018-10-19 | 283642 | $^{57}$2048 ± 0 | $^{49}$363 ± 6 | No | $^{8}$367 ± 10 | $^{9}$354 ± 16 |
| 20 | Dermalog | dermalog | 005 | 2018-02-02 | 0 | $^{3}$128 ± 0 | $^{12}$130 ± 11 | No | $^{16}$499 ± 22 | $^{19}$500 ± 22 |
| 21 | Dermalog | dermalog | 006 | 2018-10-18 | 0 | $^{2}$128 ± 0 | $^{68}$532 ± 12 | No | $^{18}$506 ± 23 | $^{16}$459 ± 23 |
| 22 | Digital Barriers | barriers | 000 | 2017-05-31 | 157794 | $^{65}$2056 ± 0 | $^{9}$104 ± 0 | No | $^{84}$13232 ± 166 | $^{84}$13226 ± 146 |
| 23 | Digital Barriers | barriers | 001 | 2017-07-20 | 236915 | $^{71}$2056 ± 0 | $^{37}$294 ± 1 | No | $^{82}$12311 ± 164 | $^{82}$12347 ± 197 |
| 24 | Ever AI | everai | 000 | 2018-10-19 | 229700 | $^{53}$2048 ± 0 | $^{61}$455 ± 1 | No | $^{12}$385 ± 10 | $^{12}$382 ± 13 |
| 25 | Ever AI | everai | 001 | 2018-10-19 | 449149 | $^{47}$2048 ± 0 | $^{85}$701 ± 1 | No | $^{13}$395 ± 11 | $^{14}$404 ± 23 |
| 26 | Fudan University | fudan | 000 | 2017-11-22 | 202296 | $^{21}$534 ± 0 | $^{6}$84 ± 0 | Yes | $^{51}$1713 ± 28 | $^{52}$1715 ± 20 |
| 27 | Fudan University | fudan | 001 | 2018-01-11 | 345583 | $^{42}$1808 ± 0 | $^{13}$131 ± 0 | Yes | $^{44}$1288 ± 26 | $^{44}$1281 ± 22 |
| 28 | Glory Ltd | glory | 000 | 2018-06-06 | 0 | $^{14}$418 ± 0 | $^{20}$165 ± 2 | No | $^{76}$7003 ± 84 | $^{76}$6978 ± 71 |
| 29 | Glory Ltd | glory | 001 | 2018-06-08 | 0 | $^{41}$1726 ± 0 | $^{53}$393 ± 2 | No | $^{80}$9607 ± 128 | $^{80}$9539 ± 182 |
| 30 | Gorilla Technology | gorilla | 001 | 2018-05-25 | 93768 | $^{76}$2156 ± 0 | $^{19}$160 ± 14 | No | $^{67}$3429 ± 145 | $^{69}$3288 ± 51 |
| 31 | Gorilla Technology | gorilla | 002 | 2018-10-17 | 93869 | $^{35}$1132 ± 0 | $^{43}$322 ± 14 | No | $^{64}$2715 ± 68 | $^{66}$2585 ± 84 |
| 32 | ID3 Technology | id3 | 002 | 2017-08-04 | 225574 | $^{19}$520 ± 0 | $^{64}$482 ± 34 | No | $^{42}$1100 ± 59 | $^{41}$1048 ± 32 |
| 33 | ID3 Technology | id3 | 003 | 2018-10-05 | 265951 | $^{11}$264 ± 0 | $^{42}$316 ± 19 | No | $^{45}$1330 ± 25 | $^{46}$1354 ± 28 |
| 34 | Idemia | Idemia | 003 | 2018-10-19 | 427244 | $^{13}$352 ± 0 | $^{50}$368 ± 6 | No | $^{75}$6654 ± 75 | $^{73}$4835 ± 90 |
| 35 | Incode Technologies Inc | incode | 001 | 2018-06-13 | 155416 | $^{50}$2048 ± 0 | $^{66}$499 ± 9 | No | $^{74}$6154 ± 96 | $^{75}$6045 ± 182 |
| 36 | Incode Technologies Inc | incode | 002 | 2018-10-18 | 73239 | $^{49}$2048 ± 0 | $^{35}$281 ± 15 | No | $^{50}$1544 ± 38 | $^{50}$1488 ± 69 |
| 37 | Innovatrics | innova | 003 | 2018-06-14 | 0 | $^{20}$530 ± 0 | $^{29}$250 ± 0 | No | $^{86}$15709 ± 134 | $^{86}$15193 ± 292 |
| 38 | Innovatrics | innova | 004 | 2018-10-19 | 0 | $^{34}$1076 ± 0 | $^{52}$391 ± 0 | No | $^{79}$8573 ± 274 | $^{78}$7929 ± 244 |
| 39 | Intellivision | intellivision | 001 | 2017-10-10 | 43692 | $^{68}$2056 ± 0 | $^{3}$62 ± 2 | No | $^{62}$2573 ± 91 | $^{65}$2544 ± 38 |
| 40 | Is It You | isityou | 000 | 2017-06-26 | 48010 | $^{99}$19200 ± 0 | $^{10}$113 ± 5 | No | $^{99}$237517 ± 1318 | $^{99}$237374 ± 1279 |
| 41 | Innovation Systems | isystems | 001 | 2018-06-12 | 274621 | $^{45}$2048 ± 0 | $^{36}$291 ± 9 | No | $^{20}$557 ± 16 | $^{22}$564 ± 22 |
| 42 | Innovation Systems | isystems | 002 | 2018-10-18 | 358984 | $^{48}$2048 ± 0 | $^{95}$822 ± 8 | No | $^{29}$749 ± 31 | $^{27}$632 ± 28 |
| 43 | ITMO University | itmo | 004 | 2018-06-13 | 487023 | $^{75}$2100 ± 0 | $^{59}$436 ± 0 | No | $^{78}$8219 ± 100 | $^{79}$8214 ± 130 |
| 44 | ITMO University | itmo | 005 | 2018-10-19 | 482155 | $^{94}$4173 ± 0 | $^{89}$759 ± 1 | No | $^{83}$13214 ± 164 | $^{83}$12576 ± 257 |

| Notes | |
|---|---|
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| 2 | The median template creation times are measured on Intel®Xeon®CPU E5-2630 v4 @ 2.20GHz processors or, for GPU-enabled implementations, NVidia Tesla K40. |
| 3 | The comparison durations, in nanoseconds, are estimated using std::chrono::high_resolution_clock which on the machine in (2) counts 1ns clock ticks. Precision is somewhat worse than that however. The ± value is the median absolute deviation times 1.48 for Normal consistency. |

*Table 1: Summary of algorithms and properties included in this report. The red superscripts give ranking for the quantity in that column.*

| | Developer | Short | Seq. | Validation | Config[1] | Template | | GPU | Comparison Time (ns)[3] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Name | Name | Num. | Date | Data (KB) | Size (B) | Time (ms)[2] | | Genuine | Impostor |
| 45 | Lookman Electroplast Industries | lookman | 002 | 2018-06-13 | 138200 | $^{22}548 \pm 0$ | $^{21}173 \pm 1$ | No | $^{21}610 \pm 19$ | $^{24}612 \pm 22$ |
| 46 | Megvii/Face++ | megvii | 001 | 2018-06-15 | 1361523 | $^{55}2048 \pm 0$ | $^{72}543 \pm 0$ | No | $^{72}5228 \pm 32$ | $^{74}5252 \pm 60$ |
| 47 | Megvii/Face++ | megvii | 002 | 2018-10-19 | 1809564 | $^{91}4100 \pm 0$ | $^{80}644 \pm 0$ | No | $^{95}50630 \pm 183$ | $^{96}47591 \pm 716$ |
| 48 | MicroFocus | microfocus | 001 | 2018-06-13 | 104524 | $^{10}256 \pm 0$ | $^{32}264 \pm 18$ | No | $^{1}215 \pm 8$ | $^{1}217 \pm 10$ |
| 49 | MicroFocus | microfocus | 002 | 2018-10-17 | 96288 | $^{6}256 \pm 0$ | $^{30}259 \pm 18$ | No | $^{5}337 \pm 34$ | $^{2}230 \pm 25$ |
| 50 | Idemia | Idemia | 002 | 2017-12-28 | 383021 | $^{12}352 \pm 0$ | $^{57}411 \pm 7$ | No | $^{69}3620 \pm 94$ | $^{64}2481 \pm 65$ |
| 51 | Neurotechnology | neurotech | 003 | 2018-02-02 | 339962 | $^{96}5214 \pm 0$ | $^{75}580 \pm 5$ | No | $^{97}73589 \pm 2548$ | $^{97}72837 \pm 1546$ |
| 52 | Neurotechnology | neurotech | 004 | 2018-10-19 | 293384 | $^{9}256 \pm 0$ | $^{55}401 \pm 0$ | No | $^{2}219 \pm 8$ | $^{3}231 \pm 13$ |
| 53 | Noblis | noblis | 000 | 2017-07-05 | 713573 | $^{33}1061 \pm 0$ | $^{22}174 \pm 20$ | Yes | $^{46}1343 \pm 45$ | $^{48}1373 \pm 56$ |
| 54 | N-Tech Lab | ntech | 004 | 2018-06-14 | 3752378 | $^{80}3482 \pm 1$ | $^{94}818 \pm 11$ | No | $^{93}38929 \pm 81$ | $^{95}38916 \pm 111$ |
| 55 | N-Tech Lab | ntech | 005 | 2018-10-19 | 1726214 | $^{43}1940 \pm 0$ | $^{86}712 \pm 1$ | No | $^{37}882 \pm 42$ | $^{37}880 \pm 29$ |
| 56 | Ping An Technology | Pingan | 002 | 2017-09-25 | 442564 | $^{98}18436 \pm 0$ | $^{14}132 \pm 7$ | Yes | $^{66}3088 \pm 32$ | $^{68}3051 \pm 28$ |
| 57 | Ping An Technology | Pingan | 003 | 2017-05-25 | 714102 | $^{51}2048 \pm 0$ | $^{96}831 \pm 31$ | No | $^{39}962 \pm 23$ | $^{40}914 \pm 38$ |
| 58 | Panasonic R+D Center Singapore | psl | 000 | 2018-06-18 | 260619 | $^{56}2048 \pm 0$ | $^{79}629 \pm 11$ | No | $^{3}280 \pm 17$ | $^{4}280 \pm 17$ |
| 59 | Panasonic R+D Center Singapore | psl | 001 | 2018-10-12 | 382035 | $^{70}2056 \pm 0$ | $^{92}785 \pm 16$ | No | $^{4}298 \pm 13$ | $^{5}292 \pm 14$ |
| 60 | Rank One Computing | rankone | 004 | 2018-06-12 | 0 | $^{4}133 \pm 0$ | $^{5}78 \pm 1$ | No | $^{6}340 \pm 19$ | $^{6}298 \pm 17$ |
| 61 | Rank One Computing | rankone | 005 | 2018-10-09 | 0 | $^{5}133 \pm 0$ | $^{4}71 \pm 2$ | No | $^{14}403 \pm 10$ | $^{7}337 \pm 19$ |
| 62 | Realnetworks Inc | realnetworks | 000 | 2018-05-30 | 99044 | $^{89}4100 \pm 0$ | $^{16}144 \pm 2$ | No | $^{59}2458 \pm 26$ | $^{63}2467 \pm 35$ |
| 63 | Realnetworks Inc | realnetworks | 001 | 2018-10-19 | 99044 | $^{90}4100 \pm 0$ | $^{17}144 \pm 2$ | No | $^{60}2500 \pm 47$ | $^{61}2420 \pm 34$ |
| 64 | Saffe Ltd | saffe | 001 | 2018-10-19 | 85973 | $^{36}1280 \pm 0$ | $^{34}281 \pm 1$ | No | $^{43}1274 \pm 19$ | $^{43}1277 \pm 26$ |
| 65 | Samtech InfoNet Limited | samtech | 000 | 2017-05-02 | 109774 | $^{69}2056 \pm 0$ | $^{31}262 \pm 2$ | No | $^{71}4550 \pm 26$ | $^{72}4541 \pm 28$ |
| 66 | Sensetime Group Ltd | sensetime | 002 | 2018-10-19 | 531783 | $^{60}2052 \pm 0$ | $^{87}725 \pm 3$ | No | $^{61}2546 \pm 102$ | $^{60}2371 \pm 45$ |
| 67 | Sensetime Group Ltd | sensetime | 002 | 2018-10-19 | 531783 | $^{61}2052 \pm 0$ | $^{93}797 \pm 3$ | No | $^{63}2713 \pm 90$ | $^{59}2301 \pm 25$ |
| 68 | Shaman Software | shaman | 000 | 2017-12-05 | 0 | $^{83}4096 \pm 0$ | $^{82}653 \pm 16$ | No | $^{11}380 \pm 25$ | $^{11}379 \pm 31$ |
| 69 | Shaman Software | shaman | 001 | 2018-01-13 | 0 | $^{82}4096 \pm 0$ | $^{38}294 \pm 2$ | No | $^{25}635 \pm 19$ | $^{15}441 \pm 25$ |
| 70 | Shenzhen Inst. Adv. Integrated Tech. CAS | SIAT | 002 | 2018-06-13 | 486842 | $^{63}2052 \pm 0$ | $^{74}579 \pm 0$ | No | $^{31}769 \pm 13$ | $^{32}750 \pm 13$ |
| 71 | Smilart | smilart | 001 | 2018-02-06 | 67339 | $^{16}512 \pm 0$ | $^{27}230 \pm 11$ | No | $^{47}1371 \pm 29$ | $^{47}1356 \pm 57$ |
| 72 | Smilart | smilart | 002 | 2018-02-06 | 111826 | $^{28}1024 \pm 0$ | $^{23}176 \pm 16$ | No | $^{87}18784 \pm 136$ | $^{88}18795 \pm 151$ |
| 73 | Synesis | synesis | 001 | 2018-05-31 | 340264 | $^{18}512 \pm 0$ | $^{11}122 \pm 0$ | No | $^{34}828 \pm 182$ | $^{30}698 \pm 44$ |
| 74 | Synesis | synesis | 003 | 2018-10-19 | 256748 | $^{84}4096 \pm 0$ | $^{7}90 \pm 0$ | No | $^{77}7118 \pm 121$ | $^{77}7162 \pm 100$ |
| 75 | Tech5 SA | tech5 | 000 | 2018-10-09 | 1451185 | $^{27}1024 \pm 0$ | $^{65}498 \pm 4$ | No | $^{30}763 \pm 23$ | $^{33}766 \pm 28$ |
| 76 | Tech5 SA | tech5 | 001 | 2018-10-19 | 636346 | $^{86}4096 \pm 0$ | $^{67}522 \pm 5$ | No | $^{41}1087 \pm 34$ | $^{34}799 \pm 44$ |
| 77 | Tevian | tevian | 002 | 2018-06-14 | 724437 | $^{59}2049 \pm 0$ | $^{39}298 \pm 15$ | No | $^{9}369 \pm 16$ | $^{13}386 \pm 25$ |
| 78 | Tevian | tevian | 003 | 2018-10-19 | 791725 | $^{58}2049 \pm 0$ | $^{56}404 \pm 15$ | No | $^{7}350 \pm 11$ | $^{8}338 \pm 25$ |
| 79 | TigerIT Americas LLC | tiger | 002 | 2018-06-13 | 341638 | $^{66}2056 \pm 0$ | $^{54}393 \pm 20$ | No | $^{58}2135 \pm 29$ | $^{58}2137 \pm 38$ |
| 80 | TigerIT Americas LLC | tiger | 003 | 2018-10-16 | 426164 | $^{67}2056 \pm 0$ | $^{62}458 \pm 21$ | No | $^{57}2031 \pm 35$ | $^{57}2029 \pm 38$ |
| 81 | TongYi Transportation Technology | tongyi | 003 | 2018-10-19 | 947322 | $^{77}2167 \pm 0$ | $^{18}153 \pm 0$ | No | $^{88}18916 \pm 120$ | $^{89}18909 \pm 126$ |
| 82 | TongYi Transportation Technology | tongyi | 002 | 2017-07-15 | 625336 | $^{72}2058 \pm 0$ | $^{40}356 \pm 35$ | No | $^{89}29816 \pm 281$ | $^{87}17799 \pm 127$ |
| 83 | TongYi Transportation Technology | tongyi | 003 | 2018-05-15 | 1769974 | $^{95}4386 \pm 0$ | $^{63}468 \pm 0$ | No | $^{96}61793 \pm 154$ | $^{94}37122 \pm 155$ |
| 84 | Toshiba | toshiba | 001 | 2018-01-11 | 3893310 | $^{78}2580 \pm 0$ | $^{77}615 \pm 3$ | Yes | $^{65}2900 \pm 80$ | $^{67}2881 \pm 60$ |
| 85 | Toshiba | toshiba | 002 | 2018-10-19 | 813606 | $^{39}1560 \pm 0$ | $^{71}541 \pm 0$ | No | $^{68}3521 \pm 369$ | $^{62}2449 \pm 124$ |
| 86 | Ultinous | ultinous | 000 | 2017-12-18 | 90803 | $^{88}4100 \pm 0$ | $^{2}53 \pm 0$ | Yes | $^{70}4263 \pm 50$ | $^{71}4262 \pm 42$ |
| 87 | Ultinous | ultinous | 001 | 2018-02-02 | 403572 | $^{97}12304 \pm 0$ | $^{25}200 \pm 0$ | Yes | $^{91}36357 \pm 223$ | $^{93}36332 \pm 210$ |
| 88 | VCognition | vcog | 002 | 2017-06-12 | 3229434 | $^{100}61504 \pm 5$ | $^{47}357 \pm 25$ | No | $^{100}296154 \pm 3077$ | $^{100}296436 \pm 4183$ |

| Notes | |
|---|---|
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| | Developer | Short | Seq. | Validation | Config[1] | Template | | GPU | Comparison Time (ns)[3] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Name | Name | Num. | Date | Data (KB) | Size (B) | Time (ms)[2] | | Genuine | Impostor |
| 89 | Visidon | visidon | 000 | 2018-06-13 | 213686 | $^{31}$1028 ± 0 | $^{15}$134 ± 3 | No | $^{49}$1467 ± 19 | $^{49}$1456 ± 16 |
| 90 | Vigilant Solutions | vigilant | 004 | 2018-06-14 | 343048 | $^{37}$1548 ± 0 | $^{97}$837 ± 6 | No | $^{26}$686 ± 14 | $^{29}$688 ± 17 |
| 91 | Vigilant Solutions | vigilant | 005 | 2018-10-11 | 343048 | $^{38}$1548 ± 0 | $^{98}$837 ± 13 | No | $^{36}$874 ± 22 | $^{28}$637 ± 16 |
| 92 | Beijing Vion Technology Inc | vion | 000 | 2018-10-19 | 228219 | $^{64}$2052 ± 0 | $^{44}$333 ± 1 | No | $^{94}$39839 ± 3561 | $^{90}$26830 ± 2241 |
| 93 | VisionLabs | visionlabs | 004 | 2018-06-15 | 313016 | $^{8}$256 ± 0 | $^{40}$304 ± 0 | No | $^{33}$827 ± 26 | $^{36}$865 ± 32 |
| 94 | VisionLabs | visionlabs | 005 | 2018-10-19 | 369602 | $^{17}$512 ± 0 | $^{41}$313 ± 0 | No | $^{35}$848 ± 26 | $^{38}$889 ± 37 |
| 95 | Vocord | vocord | 004 | 2018-06-15 | 1754886 | $^{24}$896 ± 0 | $^{78}$619 ± 1 | No | $^{54}$1885 ± 66 | $^{56}$1889 ± 71 |
| 96 | Vocord | vocord | 005 | 2018-10-19 | 1060445 | $^{23}$768 ± 0 | $^{90}$771 ± 1 | No | $^{52}$1768 ± 48 | $^{51}$1713 ± 77 |
| 97 | Zhuhai Yisheng Electronics Technology | yisheng | 001 | 2017-08-17 | 120112 | $^{52}$2048 ± 0 | $^{8}$103 ± 1 | Yes | $^{38}$906 ± 31 | $^{39}$905 ± 25 |
| 98 | Zhuhai Yisheng Electronics Technology | yisheng | 004 | 2018-06-12 | 486351 | $^{81}$3704 ± 0 | $^{51}$378 ± 12 | No | $^{28}$693 ± 137 | $^{20}$526 ± 34 |
| 99 | Shanghai Yitu Technology | yitu | 001 | 2018-06-12 | 2069440 | $^{92}$4146 ± 0 | $^{88}$751 ± 0 | No | $^{92}$37810 ± 127 | $^{92}$35486 ± 203 |
| 100 | Shanghai Yitu Technology | yitu | 002 | 2018-10-19 | 1726673 | $^{93}$4147 ± 0 | $^{84}$691 ± 0 | No | $^{90}$35435 ± 111 | $^{91}$35325 ± 131 |

| Notes | |
|---|---|
| 1 | The configuration size does not capture static data included in libraries. We do not count these because some algorithms include common ancilliary libraries for image processing (e.g. openCV) or numerical computation (e.g. blas). |
| 2 | The median template creation times are measured on Intel®Xeon®CPU E5-2630 v4 @ 2.20GHz processors or, for GPU-enabled implementations, NVidia Tesla K40. |
| 3 | The comparison durations, in nanoseconds, are estimated using std::chrono::high_resolution_clock which on the machine in (2) counts 1ns clock ticks. Precision is somewhat worse than that however. The ± value is the median absolute deviation times 1.48 for Normal consistency. |

*Table 3: Summary of algorithms and properties included in this report. The red superscripts give ranking for the quantity in that column.*

| | | FALSE NON-MATCH RATE (FNMR) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Algorithm | CONSTRAINED, COOPERATIVE | | | | | | | | | | LESS CONSTRAINED, NON-COOPERATIVE | | | |
| | Name | VISA | | VISA | | VISAMC | | MUGSHOT | | WEBCAM | | SELFIE | | WILD | | CHILD EXP | |
| | FMR | 1E-06 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.01 | |
| 1 | 3divi-002 | 0.154 | 68 | 0.021 | 59 | 0.079 | 64 | 0.029 | 62 | 0.001 | 6 | 0.049 | 12 | 0.107 | 60 | 0.561 | 12 |
| 2 | 3divi-003 | 0.059 | 48 | 0.010 | 38 | 0.032 | 44 | 0.019 | 49 | - | | - | | 0.084 | 53 | - | |
| 3 | anke-001 | 0.024 | 20 | 0.014 | 48 | 0.019 | 26 | 0.984 | 100 | - | | - | | 0.860 | 75 | - | |
| 4 | anke-002 | 0.076 | 57 | 0.014 | 47 | 0.040 | 51 | 0.015 | 38 | - | | - | | 0.065 | 40 | - | |
| 5 | anyvision-002 | 0.090 | 61 | 0.039 | 69 | 0.066 | 63 | 0.030 | 64 | 0.012 | 14 | 0.075 | 17 | - | | 0.696 | 26 |
| 6 | anyvision-004 | 0.038 | 31 | 0.008 | 31 | 0.027 | 38 | 0.015 | 30 | - | | - | | 0.046 | 17 | 0.463 | 5 |
| 7 | aware-002 | 0.320 | 77 | 0.058 | 77 | 0.195 | 78 | 0.026 | 58 | - | | - | | 0.097 | 58 | 0.708 | 29 |
| 8 | aware-003 | 0.116 | 65 | 0.029 | 63 | 0.079 | 65 | 0.025 | 57 | - | | - | | 0.307 | 70 | - | |
| 9 | ayonix-000 | 0.487 | 86 | 0.230 | 93 | 0.435 | 91 | 0.306 | 90 | 0.172 | 24 | 0.360 | 24 | - | | 0.843 | 46 |
| 10 | bm-001 | - | | 0.619 | 98 | 0.743 | 97 | 0.899 | 98 | - | | - | | 0.993 | 76 | - | |
| 11 | camvi-001 | 0.538 | 91 | 0.183 | 91 | 0.382 | 89 | 0.321 | 91 | 0.106 | 22 | 0.268 | 23 | - | | 0.763 | 38 |
| 12 | camvi-002 | 0.022 | 17 | 0.005 | 20 | 0.013 | 17 | 0.013 | 5 | - | | - | | 0.028 | 1 | - | |
| 13 | cogent-001 | 0.039 | 32 | 0.006 | 22 | 0.018 | 24 | 0.014 | 14 | - | | - | | 0.080 | 48 | 0.682 | 20 |
| 14 | cogent-002 | 0.032 | 27 | 0.004 | 17 | 0.015 | 21 | 0.013 | 9 | - | | - | | 0.054 | 33 | - | |
| 15 | cognitec-000 | 0.018 | 15 | 0.004 | 11 | 0.012 | 14 | 0.014 | 25 | - | | - | | 0.094 | 57 | - | |
| 16 | cyberextruder-001 | 0.255 | 74 | 0.076 | 80 | 0.197 | 79 | 0.162 | 85 | 0.029 | 18 | 0.144 | 20 | - | | 0.780 | 42 |
| 17 | cyberextruder-002 | 0.134 | 67 | 0.027 | 62 | 0.081 | 66 | 0.038 | 71 | 0.010 | 11 | 0.023 | 5 | 0.097 | 59 | 0.610 | 15 |
| 18 | dahua-000 | 0.048 | 41 | 0.011 | 43 | 0.025 | 32 | 0.016 | 40 | - | | - | | 0.047 | 20 | - | |
| 19 | dahua-001 | 0.047 | 39 | 0.011 | 42 | 0.025 | 34 | 0.016 | 41 | - | | - | | 0.045 | 14 | - | |
| 20 | dermalog-005 | 0.182 | 70 | 0.066 | 78 | 0.153 | 72 | 0.069 | 79 | 0.027 | 17 | 0.072 | 16 | 0.081 | 49 | 0.684 | 21 |
| 21 | dermalog-006 | 0.037 | 30 | 0.017 | 55 | 0.025 | 35 | 0.016 | 44 | - | | - | | 0.062 | 39 | - | |
| 22 | digitalbarriers-000 | 0.463 | 84 | 0.161 | 88 | 0.368 | 87 | 0.181 | 86 | 0.045 | 21 | 0.170 | 21 | - | | 0.771 | 40 |
| 23 | digitalbarriers-001 | 0.502 | 88 | 0.155 | 86 | 0.468 | 94 | 0.038 | 69 | 0.029 | 19 | 0.115 | 18 | - | | 0.731 | 33 |
| 24 | everai-000 | 0.023 | 19 | 0.004 | 16 | 0.012 | 16 | 0.013 | 3 | - | | - | | 0.029 | 3 | - | |
| 25 | everai-001 | 0.016 | 10 | 0.004 | 14 | 0.009 | 5 | 0.013 | 2 | - | | - | | 0.028 | 2 | - | |
| 26 | fdu-000 | 0.058 | 47 | 0.016 | 52 | 0.039 | 50 | 0.017 | 46 | 0.001 | 5 | 0.009 | 2 | 0.113 | 61 | 0.706 | 28 |
| 27 | fdu-001 | 0.044 | 35 | 0.017 | 54 | 0.035 | 46 | 0.020 | 51 | 0.001 | 4 | 0.014 | 3 | 0.078 | 47 | 0.657 | 19 |
| 28 | glory-000 | 0.129 | 66 | 0.051 | 74 | 0.109 | 70 | 0.129 | 84 | - | | - | | 0.468 | 73 | 0.894 | 49 |
| 29 | glory-001 | 0.108 | 64 | 0.041 | 70 | 0.090 | 68 | 0.093 | 82 | - | | - | | 0.418 | 72 | 0.883 | 47 |
| 30 | gorilla-001 | 0.076 | 54 | 0.016 | 51 | 0.049 | 57 | 0.026 | 59 | - | | - | | 0.055 | 34 | 0.835 | 45 |
| 31 | gorilla-002 | 0.041 | 34 | 0.008 | 30 | 0.026 | 37 | 0.016 | 43 | - | | - | | 0.050 | 28 | - | |
| 32 | id3-002 | 0.239 | 73 | 0.057 | 76 | 0.161 | 74 | 0.029 | 61 | 0.003 | 7 | 0.037 | 7 | - | | 0.686 | 23 |
| 33 | id3-003 | 0.076 | 56 | 0.010 | 41 | 0.036 | 48 | 0.015 | 37 | - | | - | | 0.084 | 52 | - | |
| 34 | idemia-003 | 0.032 | 26 | 0.008 | 33 | 0.022 | 31 | 0.014 | 20 | - | | - | | 0.055 | 35 | - | |
| 35 | incode-001 | 0.077 | 58 | 0.029 | 65 | 0.055 | 60 | 0.016 | 42 | - | | - | | 0.061 | 37 | 0.607 | 14 |
| 36 | incode-002 | 0.055 | 46 | 0.010 | 37 | 0.029 | 40 | 0.016 | 39 | - | | - | | 0.049 | 26 | - | |
| 37 | innovatrics-003 | 0.048 | 42 | 0.012 | 45 | 0.035 | 47 | 0.018 | 47 | - | | - | | 0.134 | 64 | 0.556 | 11 |
| 38 | innovatrics-004 | 0.029 | 23 | 0.007 | 27 | 0.019 | 27 | 0.015 | 31 | - | | - | | 0.045 | 13 | - | |
| 39 | intellivision-001 | 0.221 | 72 | 0.042 | 71 | 0.133 | 71 | 0.033 | 66 | 0.021 | 15 | 0.066 | 15 | - | | 0.777 | 41 |
| 40 | isityou-000 | 0.703 | 94 | 0.414 | 96 | 0.568 | 95 | 0.677 | 96 | 0.690 | 26 | - | | - | | - | |
| 41 | isystems-001 | 0.025 | 22 | 0.007 | 26 | 0.015 | 22 | 0.014 | 28 | - | | - | | 0.052 | 31 | 0.515 | 7 |
| 42 | isystems-002 | 0.018 | 16 | 0.007 | 23 | 0.012 | 15 | 0.014 | 24 | - | | - | | 0.051 | 29 | - | |
| 43 | itmo-004 | 0.054 | 44 | 0.007 | 29 | 0.025 | 36 | 0.014 | 22 | - | | - | | 0.043 | 9 | 0.489 | 6 |
| 44 | itmo-005 | 0.035 | 29 | 0.007 | 25 | 0.018 | 25 | 0.014 | 16 | - | | - | | 0.043 | 10 | - | |
| 45 | lookman-002 | 0.055 | 45 | 0.010 | 40 | 0.030 | 41 | 0.018 | 48 | - | | - | | 0.263 | 69 | - | |
| 46 | megvii-001 | 0.024 | 21 | 0.004 | 18 | 0.016 | 23 | 0.030 | 65 | - | | - | | 0.089 | 55 | 0.442 | 4 |
| 47 | megvii-002 | 0.014 | 8 | 0.004 | 12 | 0.010 | 12 | 0.030 | 63 | - | | - | | 0.068 | 44 | - | |
| 48 | microfocus-001 | 0.552 | 93 | 0.231 | 94 | 0.448 | 93 | 0.347 | 93 | - | | - | | 0.245 | 67 | 0.689 | 24 |
| 49 | microfocus-002 | 0.506 | 89 | 0.157 | 87 | 0.360 | 86 | 0.219 | 88 | - | | - | | 0.149 | 66 | - | |
| 50 | morpho-002 | 0.068 | 53 | 0.009 | 35 | 0.038 | 49 | 0.015 | 36 | 0.000 | 3 | 0.006 | 1 | - | | 0.631 | 18 |

*Table 4: FNMR is the proportion of mated comparisons below a threshold set to achieve the FMR given in the header on the fourth row. FMR is the proportion of impostor comparisons at or above that threshold. The light grey values give rank over all algorithms in that column. The green column applies to "matched-covariates" i.e. impostors of the same sex, age group, and country of birth. All other columns use fully zero effort impostors. Note that the webcam and selfie values apply to images collected on the same day, and that will often yield optimisticlly low FNMR values. We discontinued use of the webcam and selfie datasets in early 2018, so results for newer algorithms are missing.*

| | | FALSE NON-MATCH RATE (FNMR) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Algorithm | CONSTRAINED, COOPERATIVE | | | | | | | | | | LESS CONSTRAINED, NON-COOPERATIVE | | | |
| | Name | VISA | | VISA | | VISAMC | | MUGSHOT | | WEBCAM | | SELFIE | | WILD | | CHILD EXP | |
| | FMR | 1E-06 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.0001 | | 0.01 | |
| 51 | neurotechnology-003 | 0.088 | 59 | 0.018 | 57 | 0.062 | 61 | 0.023 | 54 | 0.000 | 1 | 0.017 | 4 | 0.065 | 41 | 0.691 | 25 |
| 52 | neurotechnology-004 | 0.030 | 24 | 0.005 | 21 | 0.015 | 20 | 0.013 | 13 | - | | - | | 0.046 | 18 | - | |
| 53 | noblis-000 | 0.542 | 92 | 0.212 | 92 | 0.442 | 92 | 0.347 | 92 | 0.153 | 23 | 0.239 | 22 | - | | 0.757 | 37 |
| 54 | ntechlab-004 | 0.013 | 6 | 0.003 | 5 | 0.009 | 8 | 0.013 | 12 | - | | - | | 0.043 | 8 | 0.420 | 2 |
| 55 | ntechlab-005 | 0.014 | 7 | 0.002 | 2 | 0.009 | 10 | 0.013 | 10 | - | | - | | 0.046 | 16 | - | |
| 56 | pa-002 | 0.286 | 76 | 0.086 | 83 | 0.185 | 77 | 0.038 | 70 | 0.010 | 12 | 0.043 | 10 | - | | 0.722 | 32 |
| 57 | pa-003 | 0.068 | 52 | 0.023 | 61 | 0.045 | 56 | 0.047 | 77 | - | | - | | 0.116 | 62 | - | |
| 58 | psl-000 | 0.033 | 28 | 0.014 | 49 | 0.022 | 28 | 0.015 | 35 | - | | - | | 0.057 | 36 | 0.551 | 10 |
| 59 | psl-001 | 0.093 | 62 | 0.020 | 58 | 0.055 | 59 | 0.014 | 18 | - | | - | | 0.042 | 6 | - | |
| 60 | rankone-004 | 0.102 | 63 | 0.015 | 50 | 0.055 | 58 | 0.017 | 45 | - | | - | | 0.083 | 51 | 0.713 | 30 |
| 61 | rankone-005 | 0.076 | 55 | 0.010 | 39 | 0.040 | 52 | 0.014 | 27 | - | | - | | 0.075 | 46 | - | |
| 62 | realnetworks-000 | 0.046 | 38 | 0.012 | 46 | 0.032 | 45 | 0.020 | 53 | - | | - | | 0.048 | 23 | 0.548 | 9 |
| 63 | realnetworks-001 | 0.046 | 36 | 0.012 | 44 | 0.032 | 43 | 0.020 | 52 | - | | - | | 0.049 | 24 | - | |
| 64 | saffe-001 | 0.526 | 90 | 0.234 | 95 | 0.434 | 90 | 0.413 | 94 | - | | - | | 0.381 | 71 | - | |
| 65 | samtech-000 | 0.443 | 82 | 0.161 | 89 | 0.342 | 85 | 0.040 | 73 | 0.021 | 16 | 0.063 | 14 | - | | 0.765 | 39 |
| 66 | sensetime-001 | 0.009 | 3 | 0.003 | 6 | 0.006 | 3 | 0.013 | 11 | - | | - | | 1.000 | 78 | - | |
| 67 | sensetime-002 | 0.010 | 4 | 0.003 | 10 | 0.007 | 4 | 0.015 | 29 | - | | - | | 1.000 | 77 | - | |
| 68 | shaman-000 | 0.977 | 98 | 0.913 | 100 | 0.930 | 100 | 0.968 | 99 | 0.992 | 27 | 0.997 | 26 | - | | 0.962 | 53 |
| 69 | shaman-001 | 0.462 | 83 | 0.136 | 85 | 0.335 | 84 | 0.080 | 81 | 0.030 | 20 | 0.115 | 19 | - | | 0.899 | 50 |
| 70 | siat-002 | 0.013 | 5 | 0.004 | 15 | 0.009 | 9 | 0.014 | 15 | - | | - | | 0.051 | 30 | 0.428 | 3 |
| 71 | smilart-001 | 0.878 | 95 | 0.097 | 84 | 0.648 | 96 | 0.036 | 68 | - | | - | | 0.129 | 63 | - | |
| 72 | smilart-002 | 0.353 | 80 | 0.082 | 82 | 0.244 | 82 | 0.094 | 83 | - | | - | | - | | 0.700 | 27 |
| 73 | synesis-001 | - | | 0.046 | 72 | 0.178 | 75 | 0.040 | 72 | - | | - | | 1.000 | 98 | - | |
| 74 | synesis-003 | 0.886 | 96 | 0.732 | 99 | 0.838 | 99 | 0.559 | 95 | - | | - | | 0.647 | 74 | - | |
| 75 | tech5-000 | 0.016 | 12 | 0.003 | 9 | 0.011 | 13 | 0.014 | 26 | - | | - | | 0.082 | 50 | - | |
| 76 | tech5-001 | 0.018 | 14 | 0.004 | 13 | 0.013 | 18 | 0.014 | 21 | - | | - | | 0.093 | 56 | - | |
| 77 | tevian-002 | 0.039 | 33 | 0.008 | 32 | 0.028 | 39 | 0.015 | 33 | - | | - | | 0.049 | 25 | 0.541 | 8 |
| 78 | tevian-003 | 0.030 | 25 | 0.007 | 24 | 0.022 | 29 | 0.014 | 23 | - | | - | | 0.045 | 15 | - | |
| 79 | tiger-002 | 0.089 | 60 | 0.023 | 60 | 0.066 | 62 | 0.024 | 55 | - | | - | | 0.049 | 27 | 0.786 | 44 |
| 80 | tiger-003 | 0.060 | 50 | 0.009 | 34 | 0.031 | 42 | 0.014 | 19 | - | | - | | 0.047 | 21 | - | |
| 81 | tongyi-004 | 0.054 | 43 | 0.018 | 56 | 0.043 | 54 | 0.306 | 89 | - | | - | | 0.062 | 38 | - | |
| 82 | tongyitrans-002 | 0.066 | 51 | 0.030 | 66 | 0.044 | 55 | 0.035 | 67 | 0.010 | 13 | 0.063 | 13 | - | | 0.746 | 34 |
| 83 | tongyitrans-003 | 0.047 | 40 | 0.009 | 36 | 0.025 | 33 | 0.020 | 50 | - | | - | | 0.065 | 42 | 0.615 | 16 |
| 84 | toshiba-001 | 0.193 | 71 | 0.033 | 68 | 0.106 | 69 | 0.041 | 74 | 0.004 | 8 | 0.049 | 11 | - | | 0.783 | 43 |
| 85 | toshiba-002 | 0.022 | 18 | 0.005 | 19 | 0.013 | 19 | 0.013 | 6 | - | | - | | 0.042 | 7 | - | |
| 86 | ultinous-000 | 0.348 | 79 | 0.076 | 81 | 0.234 | 81 | 0.070 | 80 | 0.005 | 9 | 0.040 | 8 | - | | 0.945 | 52 |
| 87 | ultinous-001 | 0.400 | 81 | 0.075 | 79 | 0.249 | 83 | 0.045 | 76 | 0.005 | 10 | 0.029 | 6 | 0.068 | 45 | 0.685 | 22 |
| 88 | vcog-002 | 0.903 | 97 | 0.504 | 97 | 0.752 | 98 | 0.691 | 97 | 0.559 | 25 | 0.666 | 25 | - | | 0.752 | 35 |
| 89 | vd-000 | 0.497 | 87 | 0.172 | 90 | 0.379 | 88 | 0.208 | 87 | - | | - | | 0.142 | 65 | 0.901 | 51 |
| 90 | vigilantsolutions-004 | 0.260 | 75 | 0.054 | 75 | 0.178 | 76 | 0.025 | 56 | - | | - | | 0.067 | 43 | 0.617 | 17 |
| 91 | vigilantsolutions-005 | 0.470 | 85 | 0.017 | 53 | 0.161 | 73 | 0.014 | 17 | - | | - | | 0.048 | 22 | - | |
| 92 | vion-000 | 0.059 | 49 | 0.029 | 64 | 0.042 | 53 | 0.058 | 78 | - | | - | | 0.247 | 68 | - | |
| 93 | visionlabs-004 | 0.046 | 37 | 0.007 | 28 | 0.022 | 30 | 0.013 | 4 | - | | - | | 0.042 | 5 | 0.392 | 1 |
| 94 | visionlabs-005 | 0.016 | 11 | 0.003 | 4 | 0.009 | 6 | 0.013 | 1 | - | | - | | 0.041 | 4 | - | |
| 95 | vocord-004 | 0.017 | 13 | 0.003 | 8 | 0.010 | 11 | 0.015 | 34 | - | | - | | 0.044 | 12 | 0.890 | 48 |
| 96 | vocord-005 | 0.016 | 9 | 0.003 | 3 | 0.009 | 7 | 0.015 | 32 | - | | - | | 0.044 | 11 | - | |
| 97 | yisheng-001 | 0.160 | 69 | 0.032 | 67 | 0.089 | 67 | 0.045 | 75 | 0.000 | 2 | 0.043 | 9 | - | | 0.756 | 36 |
| 98 | yisheng-004 | 0.333 | 78 | 0.048 | 73 | 0.199 | 80 | 0.028 | 60 | - | | - | | 0.089 | 54 | 0.715 | 31 |
| 99 | yitu-001 | 0.007 | 2 | 0.003 | 7 | 0.005 | 2 | 0.013 | 8 | - | | - | | 0.054 | 32 | 0.579 | 13 |
| 100 | yitu-002 | 0.004 | 1 | 0.001 | 1 | 0.003 | 1 | 0.013 | 7 | - | | - | | 0.047 | 19 | - | |

*Table 5: FNMR is the proportion of mated comparisons below a threshold set to achieve the FMR given in the header on the fourth row. FMR is the proportion of impostor comparisons at or above that threshold. The light grey values give rank over all algorithms in that column. The green column applies to "matched-covariates" i.e. impostors of the same sex, age group, and country of birth. All other columns use fully zero effort impostors. Note that the webcam and selfie values apply to images collected on the same day, and that will often yield optimisticlly low FNMR values. We discontinued use of the webcam and selfie datasets in early 2018, so results for newer algorithms are missing.*

*Figure 1: The points show false non-match rates (FNMR) versus the size of the encoded template. FNMR is the geometric mean of FNMR values for visa and mugshot images (from Figs. 13 and 18) at a false match rate (FMR) of 0.0001. The size of the points encodes template generation time - which spans at least one order of magnitude. The color of the points encodes one-to-one genuine template comparison duration - which span three orders of magnitude. Durations are measured on a single core of a c. 2016 Intel Xeon CPU E5-2630 v4 running at 2.20GHz.*

*Figure 2: The points show false non-match rates (FNMR) versus the duration of the template generation operation. Some algorithms run on GPU, most on CPU - see Table 3. FNMR is the geometric mean of FNMR values for visa and mugshot images (from Figs. 13 and 18) at a false match rate (FMR) of 0.0001. Template generation time is a median estimated over 640 x 480 pixel portraits. It is measured on a single core of a c. 2016 Intel Xeon CPU E5-2630 v4 running at 2.20GHz. The size of the points encodes template size - which span two orders of magnitude. The color of the points encodes one-to-one genuine template comparison duration - which span three orders of magnitude.*

# 3 Metrics

## 3.1 Core accuracy

Given a vector of N genuine scores, $u$, the false non-match rate (FNMR) is computed as the proportion below some threshold, T:

$$\text{FNMR}(T) = 1 - \frac{1}{N}\sum_{i=1}^{N} H(u_i - T) \tag{1}$$

where $H(x)$ is the unit step function, and $H(0)$ taken to be 1.

Similarly, given a vector of N impostor scores, $v$, the false match rate (FMR) is computed as the proportion above T:

$$\text{FMR}(T) = \frac{1}{N}\sum_{i=1}^{N} H(v_i - T) \tag{2}$$

The threshold, T, can take on any value. We typically generate a set of thresholds from quantiles of the observed impostor scores, $v$, as follows. Given some interesting false match rate range, $[\text{FMR}_L, \text{FMR}_U]$, we form a vector of K thresholds corresponding to FMR measurements evenly spaced on a logarithmic scale

$$T_k = Q_v(1 - \text{FMR}_k) \tag{3}$$

where $Q$ is the quantile function, and $\text{FMR}_k$ comes from

$$\log_{10}\text{FMR}_k = \log_{10}\text{FMR}_L + \frac{k}{K}\,[\log_{10}\text{FMR}_U - \log_{10}\text{FMR}_L] \tag{4}$$

Error tradeoff characteristics are plots of FNMR(T) vs. FMR(T). These are plotted with $\text{FMR}_U \to 1$ and $\text{FMR}_L$ as low as is sustained by the number of impostor comparisons, N. This is somewhat higher than the "rule of three" limit $3/N$ because samples are not independent, due to re-use of images.

# 4 Datasets

## 4.1 Child exploitation images

- ▷ The number of images is on the order of $10^4$.
- ▷ The number of subjects is on the order of $10^3$.
- ▷ The number of subjects with two images on the order of $10^3$.
- ▷ The images are operational. They are taken from ongoing investigations of child exploitation crimes. The images are arbitrarily unconstrained. Pose varies considerably around all three axes, including subject lying down. Resolution varies very widely. Faces can be occluded by other objects, including hair and hands. Lighting varies, although the images are intended for human viewing. Mis-focus is rare. Images are given to the algorithm without any cropping; faces may occupy widely varying areas.
- ▷ The images are usually large from contemporary cameras. The mean interocular distance (IOD) is 70 pixels.
- ▷ The images are of subjects from several countries, due to the global production of this imagery.
- ▷ The images are of children, from infancy to late adolescence.
- ▷ All of the images are live capture, none are scanned. Many have been cropped.
- ▷ When these images are input to the algorithm, they are labelled as being of type ”EXPLOITATION” - see Table 4 of the FRVT API.

## 4.2 Visa images

- ▷ The number of images is on the order of $10^5$.
- ▷ The number of subjects is on the order of $10^5$.
- ▷ The number of subjects with two images on the order of $10^4$.
- ▷ The images have geometry in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type. Pose is generally excellent.
- ▷ The images are of size 252x300 pixels. The mean interocular distance (IOD) is 69 pixels.
- ▷ The images are of subjects from greater than 100 countries, with significant imbalance due to visa issuance patterns.
- ▷ The images are of subjects of all ages, including children, again with imbalance due to visa issuance demand.
- ▷ Many of the images are live capture. A substantial number of the images are photographs of paper photographs.
- ▷ When these images are input to the algorithm, they are labelled as being of type ”ISO” - see Table 4 of the FRVT API.

## 4.3 Mugshot images

- ▷ The number of images is on the order of $10^6$.
- ▷ The number of subjects is on the order of $10^5$.
- ▷ The number of subjects with two images on the order of $10^5$.

- ▷ The images have geometry in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type.
- ▷ The images are of variable sizes. The median IOD is 104 pixels. The mean IOD is 123 pixels.
- ▷ The images are of subjects from the United States.
- ▷ The images are of adults.
- ▷ The images are all live capture.
- ▷ When these images are input to the algorithm, they are labelled as being of type ”mugshot” - see Table 4 of the FRVT API.

## 4.4 Selfie images

- ▷ The number of images is below 500.
- ▷ The number of subjects is below 500.
- ▷ All subjects have a selfie image, and a portrait image.
- ▷ The portrait images are in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type.
- ▷ The selfie images vary: taken with camera above and below eye level, with one hand or two hands. Pitch angles vary more than yaw angles, which are frontal. Some perspective distortion is evident.
- ▷ The images have mean IOD of 140 pixels.
- ▷ The images are of subjects from the United States.
- ▷ The images are of adults.
- ▷ The images are all live capture.
- ▷ When these images are input to the algorithm, they are labelled as being of type ”WILD” - see Table 4 of the FRVT API.

## 4.5 Webcam images

- ▷ The number of images is below 1500.
- ▷ The number of subjects is below 1500.
- ▷ All subjects have a webcam image, and a portrait image.
- ▷ The portrait images are in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type.
- ▷ The webcam images are taken with camera at a typical head height, with mild pitch angles, low yaw angles, but some variation in range, such that low perspective distortion is sometimes evident.
- ▷ The images have mean IOD of 68 pixels (sd=12).
- ▷ The images are of subjects from the United States.
- ▷ The images are of adults.
- ▷ The images are all live capture.
- ▷ When these images are input to the algorithm, they are labelled as being of type ”MUGSHOT” - see Table 4 of the FRVT API.

(a) Visa (b) Mugshot (c) Webcam (d) Selfie (e) Wild

*Figure 3: The figure gives simulated samples of image types used in this report.*

### 4.6 Wild images

- ▷ The number of images is on the order of $10^5$.
- ▷ The number of subjects is on the order of $10^3$.
- ▷ The number of subjects with two images on the order of $10^3$.
- ▷ The images include many photojournalism-style images. Images are given to the algorithm using a variable but generally tight crop of the head. Resolution varies very widely. The images are very unconstrained, with wide yaw and pitch pose variation. Faces can be occluded, including hair and hands.
- ▷ The images are of adults.
- ▷ All of the images are live capture, none are scanned.
- ▷ When these images are input to the algorithm, they are labelled as being of type "WILD" - see Table 4 of the FRVT API.

## 5 Results

### 5.1 Test goals

- ▷ To state overall accuracy.
- ▷ To compare algorithms.

### 5.2 Test design

**Method:** For wild images:

- ▷ The comparisons are of wild photos against wild photos.
- ▷ The number of genuine comparisons is on the order of $10^6$.
- ▷ The number of impostor comparisons is on the order of $10^7$.



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of $10^4$.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

**Method:** For visa images:

- ▷ The comparisons are of visa photos against visa photos.
- ▷ The number of genuine comparisons is on the order of $10^4$.
- ▷ The number of impostor comparisons is on the order of $10^{10}$.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates. However, later analysis is conducted on subsets.
- ▷ The number of persons is on the order of $10^5$.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

For mugshot images:

- ▷ The comparisons are of mugshot photos against mugshot photos.
- ▷ The number of genuine comparisons is on the order of $10^5$.
- ▷ The number of impostor comparisons is on the order of $10^7$.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of $10^6$.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

For selfie images:

- ▷ The comparisons are of selfie photos against portrait photos.
- ▷ The number of genuine comparisons is on the order of $10^2$.
- ▷ The number of impostor comparisons is on the order of $10^8$ selfies are compared with portraits of on the order of $10^6$ other subjects.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of $10^6$.

- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

For webcam images:

- ▷ The comparisons are of webcam photos against portrait photos.
- ▷ The number of genuine comparisons is on the order of $10^3$.
- ▷ The number of impostor comparisons is on the order of $10^9$ webcams are compared with portraits of on the order of $10^6$ other subjects.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of $10^6$.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.

For child exploitation images:

- ▷ The comparisons are of unconstrained child exploitation photos against others of the same type.
- ▷ The number of genuine comparisons is on the order of $10^4$.
- ▷ The number of impostor comparisons is on the order of $10^7$.
- ▷ The comparisons are fully zero-effort, meaning impostors are paired without attention to sex, age or other covariates.
- ▷ The number of persons is on the order of $10^3$.
- ▷ The number of images used to make 1 template is 1.
- ▷ The number of templates used to make each comparison score is two corresponding to simple one-to-one verification.
- ▷ We produce two performance statements. First, is a DET as used for visa and mugshot images. The second is a cumulative match characteristic (CMC) summarizing a simulated one-to-many search process. This is done as follows.
  - We regard $M$ enrollment templates as items in a gallery.
  - These $M$ templates come from $M > N$ individuals, because multiple images of a subject are present in the gallery under separate identifiers.
  - We regard the verification templates as search templates.
  - For each search we compute the rank of the highest scoring mate.
  - This process should properly be conducted with a 1:N algorithm, such as those tested in NIST IR 8009. We use the 1:1 algorithms in a simulated 1:N mode here to a) better reflect what a child exploitation analyst does, and b) to do show algorithm efficacy is better than that revealed in the verification DETs.

## 5.3 Failure to enrol

| Algorithm | Failure to Enrol Rate[1] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | CHILD-EXPLOIT | | MUGSHOT | | SELFIES | | VISA | | WEBCAM | | WILD | |
| 3divi-002 | 0.3103 | 42 | 0.0039 | 88 | 0.0376 | 19 | 0.0010 | 72 | 0.0027 | 16 | 0.0447 | 70 |
| 3divi-003 | - | 100 | 0.0007 | 68 | - | 100 | 0.0006 | 59 | - | 100 | 0.0295 | 63 |
| anke-001 | - | 100 | 0.0030 | 83 | - | 100 | 0.0047 | 97 | - | 100 | 0.0413 | 69 |
| anke-002 | - | 100 | 0.0001 | 52 | - | 100 | 0.0009 | 69 | - | 100 | 0.0094 | 42 |
| anyvision-002 | 0.4866 | 52 | 0.0070 | 98 | 0.0578 | 23 | 0.0090 | 99 | 0.0095 | 19 | - | 100 |
| anyvision-004 | 0.1660 | 29 | 0.0000 | 27 | - | 100 | 0.0004 | 44 | - | 100 | 0.0081 | 34 |
| aware-002 | 0.4878 | 53 | 0.0002 | 53 | - | 100 | 0.0006 | 57 | - | 100 | 0.0237 | 61 |
| aware-003 | - | 100 | 0.0003 | 58 | - | 100 | 0.0013 | 79 | - | 100 | 0.0744 | 74 |
| ayonix-000 | 0.0000 | 5 | 0.0109 | 101 | 0.0751 | 25 | 0.0137 | 101 | 0.0109 | 20 | - | 100 |
| bm-001 | - | 100 | 0.0000 | 14 | - | 100 | 0.0000 | 12 | - | 100 | 0.0000 | 7 |
| camvi-001 | 0.3931 | 48 | 0.0033 | 85 | 0.0231 | 17 | 0.0010 | 74 | 0.0027 | 17 | - | 100 |
| camvi-002 | - | 100 | 0.0000 | 2 | - | 100 | 0.0000 | 2 | - | 100 | 0.0000 | 1 |
| cogent-001 | 0.2099 | 33 | 0.0000 | 34 | - | 100 | 0.0004 | 46 | - | 100 | 0.0065 | 30 |
| cogent-002 | - | 100 | 0.0000 | 35 | - | 100 | 0.0004 | 49 | - | 100 | 0.0064 | 27 |
| cognitec-000 | - | 100 | 0.0005 | 61 | - | 100 | 0.0007 | 67 | - | 100 | 0.0395 | 67 |
| cyberextruder-001 | 0.5338 | 57 | 0.0036 | 87 | 0.0376 | 18 | 0.0029 | 89 | 0.0205 | 24 | - | 100 |
| cyberextruder-002 | 0.2672 | 41 | 0.0026 | 82 | 0.0058 | 12 | 0.0028 | 88 | 0.0123 | 22 | 0.0334 | 66 |
| dahua-000 | - | 100 | 0.0000 | 15 | - | 100 | 0.0000 | 14 | - | 100 | 0.0000 | 9 |
| dahua-001 | - | 100 | 0.0000 | 19 | - | 100 | 0.0000 | 18 | - | 100 | 0.0000 | 13 |
| dermalog-005 | 0.1796 | 31 | 0.0016 | 78 | 0.0000 | 7 | 0.0041 | 93 | 0.0014 | 11 | 0.0166 | 55 |
| dermalog-006 | - | 100 | 0.0007 | 67 | - | 100 | 0.0041 | 94 | - | 100 | 0.0166 | 54 |
| digitalbarriers-000 | 0.5469 | 58 | 0.0043 | 91 | 0.0925 | 26 | 0.0019 | 84 | 0.0184 | 23 | - | 100 |
| digitalbarriers-001 | 0.5102 | 56 | 0.0044 | 92 | 0.0925 | 27 | 0.0018 | 83 | 0.0232 | 25 | - | 100 |
| everai-000 | - | 100 | 0.0000 | 24 | - | 100 | 0.0004 | 34 | - | 100 | 0.0004 | 16 |
| everai-001 | - | 100 | 0.0000 | 28 | - | 100 | 0.0004 | 48 | - | 100 | 0.0007 | 17 |
| fdu-000 | 0.4992 | 55 | 0.0025 | 81 | 0.0029 | 11 | 0.0011 | 78 | 0.0020 | 13 | 0.0536 | 71 |
| fdu-001 | 0.1380 | 27 | 0.0015 | 76 | 0.0000 | 6 | 0.0009 | 70 | 0.0007 | 9 | 0.0209 | 56 |
| glory-000 | 0.0000 | 9 | 0.0058 | 97 | - | 100 | 0.0013 | 80 | - | 100 | 0.1584 | 78 |
| glory-001 | 0.0000 | 11 | 0.0056 | 96 | - | 100 | 0.0010 | 71 | - | 100 | 0.1667 | 79 |
| gorilla-001 | 0.1347 | 26 | 0.0000 | 41 | - | 100 | 0.0004 | 51 | - | 100 | 0.0118 | 45 |
| gorilla-002 | - | 100 | 0.0000 | 39 | - | 100 | 0.0004 | 50 | - | 100 | 0.0118 | 44 |
| id3-002 | 0.3168 | 43 | 0.0030 | 84 | 0.0202 | 16 | 0.0032 | 90 | 0.0020 | 12 | - | 100 |
| id3-003 | - | 100 | 0.0007 | 69 | - | 100 | 0.0011 | 77 | - | 100 | 0.0319 | 64 |
| idemia-003 | - | 100 | 0.0000 | 10 | - | 100 | 0.0004 | 33 | - | 100 | 0.0042 | 22 |
| incode-001 | 0.3333 | 44 | 0.0006 | 65 | - | 100 | 0.0035 | 91 | - | 100 | 0.0211 | 57 |
| incode-002 | - | 100 | 0.0002 | 54 | - | 100 | 0.0007 | 64 | - | 100 | 0.0082 | 35 |
| innovatrics-003 | 0.1728 | 30 | 0.0000 | 43 | - | 100 | 0.0005 | 52 | - | 100 | 0.0643 | 73 |
| innovatrics-004 | - | 100 | 0.0000 | 29 | - | 100 | 0.0004 | 45 | - | 100 | 0.0042 | 23 |
| intellivision-001 | 0.5495 | 60 | 0.0052 | 94 | 0.0491 | 21 | 0.0042 | 95 | 0.0252 | 26 | - | 100 |
| isityou-000 | 0.4714 | 51 | 0.0022 | 80 | 0.0665 | 24 | 0.0010 | 73 | 0.0116 | 21 | - | 100 |
| isystems-001 | 0.1421 | 28 | 0.0003 | 59 | - | 100 | 0.0007 | 65 | - | 100 | 0.0130 | 47 |
| isystems-002 | - | 100 | 0.0003 | 60 | - | 100 | 0.0007 | 66 | - | 100 | 0.0130 | 48 |
| itmo-004 | 0.2351 | 35 | 0.0000 | 42 | - | 100 | 0.0004 | 47 | - | 100 | 0.0091 | 41 |
| itmo-005 | - | 100 | 0.0000 | 33 | - | 100 | 0.0002 | 21 | - | 100 | 0.0075 | 31 |
| lookman-002 | - | 100 | 0.0000 | 5 | - | 100 | 0.0000 | 5 | - | 100 | 0.0000 | 3 |
| megvii-001 | 0.0274 | 16 | 0.0043 | 90 | - | 100 | 0.0004 | 38 | - | 100 | 0.0153 | 52 |
| megvii-002 | - | 100 | 0.0043 | 89 | - | 100 | 0.0004 | 37 | - | 100 | 0.0127 | 46 |
| microfocus-001 | 0.0791 | 25 | 0.0012 | 75 | - | 100 | 0.0016 | 82 | - | 100 | 0.0220 | 59 |
| microfocus-002 | - | 100 | 0.0012 | 74 | - | 100 | 0.0016 | 81 | - | 100 | 0.0220 | 58 |
| morpho-002 | 0.0572 | 21 | 0.0009 | 70 | 0.0000 | 5 | 0.0004 | 35 | 0.0007 | 8 | - | 100 |

*Table 6: FTE is the proportion of failed template generation attempts. Failures can occur because the software throws an exception, or because the software electively refuses to process the input image. This would typically occur if a face is not detected. FTE is measured as the number of function calls that give a non-zero error code, OR that give a "small" template. This is defined as one whose size is less than 0.3 times the median template size. This second rule is needed because some algorithms incorrectly fail to return a non-zero error code when template generation fails.*

[1] *The effects of FTE are included in the accuracy results of this report by regarding any template comparison involving a failed template enrollment to produce a low similarity score. Thus higher FTE results in higher FNMR.*

| Algorithm | Failure to Enrol Rate[1] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | CHILD-EXPLOIT | | MUGSHOT | | SELFIES | | VISA | | WEBCAM | | WILD | |
| neurotechnology-003 | 0.2371 | 36 | 0.0011 | 72 | 0.0058 | 13 | 0.0005 | 53 | 0.0020 | 15 | 0.0162 | 53 |
| neurotechnology-004 | - | 100 | 0.0000 | 22 | - | 100 | 0.0001 | 20 | - | 100 | 0.0026 | 18 |
| noblis-000 | 0.0000 | 8 | 0.0000 | 13 | 0.0000 | 10 | 0.0000 | 11 | 0.0000 | 7 | - | 100 |
| ntechlab-004 | 0.0473 | 17 | 0.0000 | 21 | - | 100 | 0.0004 | 39 | - | 100 | 0.0050 | 26 |
| ntechlab-005 | - | 100 | 0.0000 | 6 | - | 100 | 0.0004 | 36 | - | 100 | 0.0032 | 19 |
| pa-002 | 0.0000 | 1 | 0.0000 | 8 | 0.0000 | 8 | 0.0000 | 7 | 0.0000 | 5 | - | 100 |
| pa-003 | 0.0000 | 6 | 0.0000 | 12 | - | 100 | 0.0000 | 10 | - | 100 | 0.0000 | 6 |
| psl-000 | 0.0000 | 12 | 0.0000 | 18 | - | 100 | 0.0000 | 17 | - | 100 | 0.0000 | 12 |
| psl-001 | - | 100 | 0.0000 | 16 | - | 100 | 0.0000 | 15 | - | 100 | 0.0000 | 10 |
| rankone-004 | 0.0000 | 2 | 0.0000 | 20 | - | 100 | 0.0000 | 19 | - | 100 | 0.0002 | 14 |
| rankone-005 | - | 100 | 0.0000 | 9 | - | 100 | 0.0000 | 8 | - | 100 | 0.0000 | 5 |
| realnetworks-000 | 0.0076 | 15 | 0.0000 | 46 | - | 100 | 0.0003 | 23 | - | 100 | 0.0064 | 28 |
| realnetworks-001 | - | 100 | 0.0000 | 47 | - | 100 | 0.0003 | 24 | - | 100 | 0.0064 | 29 |
| saffe-001 | - | 100 | 0.0000 | 17 | - | 100 | 0.0000 | 16 | - | 100 | 0.0000 | 11 |
| samtech-000 | 0.5474 | 59 | 0.0052 | 95 | 0.0491 | 22 | 0.0042 | 96 | 0.0252 | 27 | - | 100 |
| sensetime-001 | - | 100 | 0.0000 | 23 | - | 100 | 0.0004 | 42 | - | 100 | 0.0003 | 15 |
| sensetime-002 | - | 100 | 0.0005 | 63 | - | 100 | 0.0005 | 54 | - | 100 | 0.0222 | 60 |
| shaman-000 | 0.0000 | 7 | 0.0000 | 3 | 0.0000 | 3 | 0.0000 | 3 | 0.0000 | 3 | - | 100 |
| shaman-001 | 0.0000 | 3 | 0.0000 | 1 | 0.0000 | 1 | 0.0000 | 1 | 0.0000 | 1 | - | 100 |
| siat-002 | 0.0616 | 23 | 0.0000 | 26 | - | 100 | 0.0004 | 43 | - | 100 | 0.0048 | 25 |
| smilart-001 | - | 100 | 0.0090 | 100 | - | 100 | 0.0273 | 103 | - | 100 | 0.0577 | 72 |
| smilart-002 | 0.2422 | 37 | 0.0012 | 73 | - | 100 | 0.0011 | 76 | - | 100 | - | 100 |
| synesis-001 | 0.5504 | 61 | 0.0034 | 86 | - | 100 | 0.0021 | 86 | - | 100 | 0.1134 | 75 |
| synesis-003 | - | 100 | 0.0044 | 93 | - | 100 | 0.1184 | 104 | - | 100 | 0.1222 | 76 |
| tech5-000 | - | 100 | 0.0000 | 32 | - | 100 | 0.0003 | 29 | - | 100 | 0.0290 | 62 |
| tech5-001 | - | 100 | 0.0000 | 31 | - | 100 | 0.0003 | 28 | - | 100 | 0.0412 | 68 |
| tevian-002 | 0.2423 | 38 | 0.0000 | 45 | - | 100 | 0.0005 | 56 | - | 100 | 0.0076 | 32 |
| tevian-003 | - | 100 | 0.0000 | 44 | - | 100 | 0.0005 | 55 | - | 100 | 0.0077 | 33 |
| tiger-002 | 0.0619 | 24 | 0.0000 | 37 | - | 100 | 0.0004 | 40 | - | 100 | 0.0082 | 36 |
| tiger-003 | - | 100 | 0.0000 | 38 | - | 100 | 0.0004 | 41 | - | 100 | 0.0082 | 37 |
| tongyi-004 | - | 100 | 0.0001 | 48 | - | 100 | 0.0006 | 60 | - | 100 | 0.0135 | 49 |
| tongyitrans-002 | 0.3609 | 47 | 0.0078 | 99 | 0.0462 | 20 | 0.0040 | 92 | 0.0055 | 18 | - | 100 |
| tongyitrans-003 | 0.3468 | 46 | 0.0001 | 49 | - | 100 | 0.0006 | 61 | - | 100 | 0.0135 | 50 |
| toshiba-001 | 0.0000 | 4 | 0.0000 | 11 | 0.0000 | 9 | 0.0000 | 9 | 0.0000 | 6 | - | 100 |
| toshiba-002 | - | 100 | 0.0000 | 7 | - | 100 | 0.0000 | 6 | - | 100 | 0.0000 | 4 |
| ultinous-000 | 0.0007 | 13 | 0.0002 | 56 | 0.0000 | 2 | 0.0003 | 26 | 0.0000 | 2 | - | 100 |
| ultinous-001 | 0.0007 | 14 | 0.0002 | 57 | 0.0000 | 4 | 0.0003 | 27 | 0.0000 | 4 | 0.0089 | 40 |
| vcog-002 | 0.2209 | 34 | 0.0021 | 79 | 0.0087 | 14 | 0.0019 | 85 | 0.0007 | 10 | - | 100 |
| vd-000 | 0.0000 | 10 | 0.0000 | 4 | - | 100 | 0.0000 | 4 | - | 100 | 0.0000 | 2 |
| vigilantsolutions-004 | 0.2538 | 40 | 0.0000 | 36 | - | 100 | 0.0004 | 31 | - | 100 | 0.0041 | 20 |
| vigilantsolutions-005 | - | 100 | 0.0000 | 40 | - | 100 | 0.0004 | 32 | - | 100 | 0.0041 | 21 |
| vion-000 | - | 100 | 0.0205 | 102 | - | 100 | 0.0078 | 98 | - | 100 | 0.1407 | 77 |
| visionlabs-004 | 0.1947 | 32 | 0.0000 | 30 | - | 100 | 0.0008 | 68 | - | 100 | 0.0088 | 39 |
| visionlabs-005 | - | 100 | 0.0000 | 25 | - | 100 | 0.0023 | 87 | - | 100 | 0.0085 | 38 |
| vocord-004 | 0.4902 | 54 | 0.0005 | 62 | - | 100 | 0.0003 | 22 | - | 100 | 0.0044 | 24 |
| vocord-005 | - | 100 | 0.0002 | 55 | - | 100 | 0.0003 | 30 | - | 100 | 0.0103 | 43 |
| yisheng-001 | 0.4277 | 49 | 0.0016 | 77 | 0.0173 | 15 | 0.0006 | 58 | 0.0020 | 14 | - | 100 |
| yisheng-004 | 0.4279 | 50 | 0.0006 | 66 | - | 100 | 0.0006 | 62 | - | 100 | 0.0327 | 65 |
| yitu-001 | 0.3468 | 45 | 0.0001 | 51 | - | 100 | 0.0006 | 63 | - | 100 | 0.0135 | 51 |
| yitu-002 | - | 100 | 0.0001 | 50 | - | 100 | 0.0000 | 13 | - | 100 | 0.0000 | 8 |

*Table 7: FTE is the proportion of failed template generation attempts. Failures can occur because the software throws an exception, or because the software electively refuses to process the input image. This would typically occur if a face is not detected. FTE is measured as the number of function calls that give a non-zero error code, OR that give a "small" template. This is defined as one whose size is less than 0.3 times the median template size. This second rule is needed because some algorithms incorrectly fail to return a non-zero error code when template generation fails.*

*[1] The effects of FTE are included in the accuracy results of this report by regarding any template comparison involving a failed template enrollment to produce a low similarity score. Thus higher FTE results in higher FNMR.*

## 5.4 Recognition accuracy

Core algorithm accuracy is stated via:

- ▷ **Cooperative subjects**
  - The summary table of Figure 5;
  - The visa image DETs of Figure 13;
  - The mugshot DETs of Figure 18;
  - The selfie-portrait DETs of Figure 19;
  - The webcam-portrait DETs of Figure 20;
- ▷ **Non-cooperative subjects**
  - The photojournalism DET of Figure 25
  - The sensitivity of photojournalism FNMR to relative yaw angles in Figure 26.
  - The sensitivity of photojournalism FMR to relative yaw angles in Figure 27.
  - The child-exploitation DET of Figure 30;
  - The child-exploitation CMC of Figure 32.

Figure 57 shows dependence of false match rate on algorithm score threshold. This allows a deployer to set a threshold to target a particular false match rate appropriate to the security objectives of the application.

Figure 63 likewise shows FMR(T) but for mugshots, and specially four subsets of the population.

Note that in both the mugshot and visa sets false match rates vary with the ethnicity, age, and sex, of the enrollee and impostor - see section 5.6.



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 4: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 5: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 6: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 7: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 8: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 9: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 10: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 11: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 12: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 13: For the visa images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR.*

*Figure 14: For the mugshot images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of FMR.*

*Figure 15: For the mugshot images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of FMR.*

*Figure 16: For the mugshot images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of FMR.*

*Figure 17: For the mugshot images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of FMR.*

*Figure 18: For the mugshot images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show decades of FMR.*

*Figure 19: For the selfie-to-portrait comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR. Caution: The FNMR values here are optimistic statements of accuracy because the image pairs were collected on the same day. This is known across biometrics to give better accuracy, and is operationally relevant only in special cases.*

FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 20: For the webcam-to-portrait comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR. Caution: The FNMR values here are optimistic statements of accuracy because the image pairs were collected on the same day. This is known across biometrics to give better accuracy, and is operationally relevant only in special cases.*

*Figure 21: For the 2018 wild image comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR.*

*Figure 22: For the 2018 wild image comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR.*

*Figure 23: For the 2018 wild image comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR.*

*Figure 24: For the 2018 wild image comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR.*

*Figure 25: For the 2017 wild image comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show several decades of FMR.*

*Figure 26: For wild images, the heatmap show* FNMR *as a function of the yaw of the enrollment and verification images. The threshold is the same in all cells, and is set to the value that yeilds* FMR *= 0.003 on near frontal pairs i.e. where yaw is in the interval* $(-15, 15]$*. Poor algorithms give generally red figures. The better algorithms show a) diagonal dominance, indicating ability to authenticate when pairs have the same yaw angle, and b) off-diagonal cross-pose capability also. The yaw estimates are from an automated pose estimator, and are themselves noisy. The figure assumes that the pose estimates are not systematically incorrect.*

*Figure 27: For wild images, the heatmaps show* FMR *dependence on the yaw of the enrollment and verification images. The threshold is the same in all cells, and is set to the value that yields* FMR *= 0.003 on near frontal pairs, i.e. where yaw is in the interval* $(-15, 15]$*. Thus the center of each panel is grey. The desired behavior is that* FMR *does not vary with relative yaw. However, some algorithms gives elevated* FMR *when yaw differs. The yaw estimates are from an automated pose estimator, and are themselves noisy. The figure assumes that the pose estimates are not systematically incorrect.*

*Figure 28: For child exploitation images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR. Accuracy is poor because many images have adverse quality characteristics, and because detection and enrollment fails.*

*Figure 29: For child exploitation images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR. Accuracy is poor because many images have adverse quality characteristics, and because detection and enrollment fails.*

*Figure 30: For child exploitation images, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. The scales are logarithmic in order to show many decades of FMR. Accuracy is poor because many images have adverse quality characteristics, and because detection and enrollment fails.*

*Figure 31: For child exploitation images, cumulative match characteristics (CMC) showing true positive identification rate vs. rank. This is simulation of a one-to-many search experiment - see discussion in section 5.2. The scales are logarithmic in order to show the effect of long candidate lists. Accuracy is poor but much improved relative to the 1:1 DETs of Fig. 30 because a search can succeed if any of a subject's several enrolled images matches the search image with a high score.*

*Figure 32: For child exploitation images, cumulative match characteristics (CMC) showing true positive identification rate vs. rank. This is simulation of a one-to-many search experiment - see discussion in section 5.2. The scales are logarithmic in order to show the effect of long candidate lists. Accuracy is poor but much improved relative to the 1:1 DETs of Fig. 30 because a search can succeed if any of a subject's several enrolled images matches the search image with a high score.*

*Figure 33: For child exploitation images, cumulative match characteristics (CMC) showing true positive identification rate vs. rank for two cases: 1. Whole image provided to the algorithm; 2. Human annotated rectangular region, cropped and provided to the algorithm. The difference between the traces is associated with detection of difficult faces, and fine localization.*

*Figure 34: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how* both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 63. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

*Figure 35: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how* both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 63. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

*Figure 36: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how* both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 63. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

*Figure 37: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how* both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 63. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

*Figure 38: For the mugshot images, error tradeoff characteristics for white females, black females, black males and white males. The grey lines correspond to fixed thresholds, showing how* both *FNMR and FMR vary at one operating threshold. Important: Many of the plots will naively be read as saying whites gives lower error rates than blacks because the blue traces lie beneath the red ones. However, this is misleading and incomplete: The grey lines show the traces are generally shifted horizontally. Thus for the dermalog-001 algorithm FNMR for whites is* higher *than for blacks* at a fixed threshold *but, at the same time, FMR is higher for blacks - see Figure 63. As access control systems almost always operate at a fixed threshold, the naive interpretation is incorrect.*

*Figure 39: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).*

*Figure 40: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).*

*Figure 41: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).*

*Figure 42: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between $(FMR,FNMR)_{MALE}$ and $(FMR,FNMR)_{FEMALE}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).*

*Figure 43: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between $(FMR,FNMR)_{MALE}$ and $(FMR,FNMR)_{FEMALE}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).*

*Figure 44: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).*

*Figure 45: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between $(FMR,FNMR)_{MALE}$ and $(FMR,FNMR)_{FEMALE}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).*

*Figure 46: For the visa images, FNMR and FMR at six operating points along the DET characteristic. At each point a line is drawn between (FMR,FNMR)$_{\text{MALE}}$ and (FMR,FNMR)$_{\text{FEMALE}}$ showing how which sex has lower FMR and/or FNMR. The "M" label denotes male, the other end of the line corresponds to female. The six operating thresholds are selected to give the nominal false match rates given in the legend, and are computed over all impostor pairs regardless of age, sex, and place of birth. The plotted FMR values are broadly an order of magnitude larger than the nominal rates because FMR is computed over demographically-matched impostor pairs i.e individuals of the same sex, from the same geographic region (see section 5.6.1), and the same age group (see section 5.6.2).*

*Figure 47: For the wild image comparisons, detection error tradeoff (DET) characteristics showing false non-match rate vs. false match rate plotted parametrically on threshold, T. Error rates are higher here than in the generic wild DET (Fig 25) becuase the impostor pairs here are same-sex only. The scales are logarithmic in order to show several decades of FMR.*

*Figure 48: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 49: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 50: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 51: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 52: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 53: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 54: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 55: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 56: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 57: For the visa images, the false match calibration curves show false match rate vs. threshold. These curves apply to zero-effort impostors. As shown later (sec. 5.6), FMR is higher for demographic-matched impostors.*

*Figure 58: For the visa images, the curves show how false matches are concentrated in certain images. Specifically each line plots FMR($k$) with $k$ the number of images rejected in decreasing order of how many false matches that image was involved in. FMR$(0) = 10^{-4}$. In terms of the biometric zoo, the most "wolf-ish" images are rejected first i.e. those enrollment or verification images most often involved in false matches. A flatter response is considered superior. A steeply descending response indicates that certain kinds of images false match against others, e.g. if hypothetically images of men with particular mustaches would falsely match others.*

*Figure 59: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.*

*Figure 60: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.*

*Figure 61: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.*

*Figure 62: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.*

*Figure 63: For the mugshot images, the false match calibration curves show false match rate vs. threshold. Separate curves appear for white females, black females, black males and white males.*

## 5.5 Genuine distribution stability

### 5.5.1 Effect of birth place on the genuine distribution

**Background**: Both skin tone and bone structure vary geographically. Prior studies have reported variations in FNMR and FMR.

**Goal**: To measure false non-match rate (FNMR) variation with country of birth.

**Methods**: Thresholds are determined that give FMR = $\{0.001, 0.0001\}$ over the entire impostor set. Then FNMR is measured over 1000 bootstrap replications of the genuine scores. Only those countries with at least 140 individuals are included in the analysis.

**Results**: Figure 72 shows FNMR by country of birth for the two thresholds.



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 64: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 65: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 66: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 67: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 68: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 69: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 70: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 71: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 72: For the visa images, the dots show FNMR by country of birth for two globally set operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.1. The figures shows an order of magnitude variation in FNMR across country of birth; these effects are likely due quality variations, then demographics like age and race. The error rates in some cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

**Caveats**: The results may not relate to subject-specific properties. Instead they could reflect image-specific quality differences, which could occur due to collection protocol or software processing variations.



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

### 5.5.2 Effect of age on genuine subjects

**Background**: Faces change appearance throughout life. Face recognition algorithms have previously beeen reported to give better accuracy on older individuals (See NIST IR 8009).

**Goal**: To quantify false non-match rates (FNMR) as a function of age. We do not aim to quantify ageing effects here as the separation between two samples is limited to just a few years.

**Methods**: Using the visa images, thresholds are determined that give FMR = 0.001 and 0.0001 over the entire impostor set. Then FNMR is measured over 1000 bootstrap replications of the genuine scores.

**Results**: For the visa images, Figure 78 shows how false non-match rates for genuine users, as a function of age group.

The notable aspects are:

- ▷ Younger subjects give considerably higher FNMR. This is likely due to rapid growth and change in facial appearance.
- ▷ FNMR trends down throughout life. The last bin, AGE $>$ 72, contains fewer than 140 mated pairs, and may be affected by small sample size.



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 73: For the visa images, the dots show FNMR by age group for two operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.2. Given a pair of face images taken at different times, we assign the comparison to the bin that is the arithmetic average of the subject's ages. This plot shows only the effect of age, not ageing. The number of comparisons in each bin is generally in the thousands, however the first and last bins are computed over 149 and 124 respectively. The error rates in some (adult) cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 74: For the visa images, the dots show FNMR by age group for two operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.2. Given a pair of face images taken at different times, we assign the comparison to the bin that is the arithmetic average of the subject's ages. This plot shows only the effect of age, not ageing. The number of comparisons in each bin is generally in the thousands, however the first and last bins are computed over 149 and 124 respectively. The error rates in some (adult) cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 75: For the visa images, the dots show FNMR by age group for two operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.2. Given a pair of face images taken at different times, we assign the comparison to the bin that is the arithmetic average of the subject's ages. This plot shows only the effect of age, not ageing. The number of comparisons in each bin is generally in the thousands, however the first and last bins are computed over 149 and 124 respectively. The error rates in some (adult) cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 76: For the visa images, the dots show FNMR by age group for two operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.2. Given a pair of face images taken at different times, we assign the comparison to the bin that is the arithmetic average of the subject's ages. This plot shows only the effect of age, not ageing. The number of comparisons in each bin is generally in the thousands, however the first and last bins are computed over 149 and 124 respectively. The error rates in some (adult) cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 77: For the visa images, the dots show FNMR by age group for two operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.2. Given a pair of face images taken at different times, we assign the comparison to the bin that is the arithmetic average of the subject's ages. This plot shows only the effect of age, not ageing. The number of comparisons in each bin is generally in the thousands, however the first and last bins are computed over 149 and 124 respectively. The error rates in some (adult) cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

*Figure 78: For the visa images, the dots show FNMR by age group for two operating thresholds corresponding to FMR = $\{0.001, 0.0001\}$ computed over all on the order of $10^{10}$ impostor scores. The FMR in each bin will vary also - see subsequent impostor heatmaps in sec. 5.6.2. Given a pair of face images taken at different times, we assign the comparison to the bin that is the arithmetic average of the subject's ages. This plot shows only the effect of age, not ageing. The number of comparisons in each bin is generally in the thousands, however the first and last bins are computed over 149 and 124 respectively. The error rates in some (adult) cases are zero, and in others the DET is flat so the error rates at the two thresholds are identical. The lines span 1% and 99% of boostrap replicated FNMR estimates.*

**Caveats**: None.

## 5.6 Impostor distribution stability

### 5.6.1 Effect of birth place on the impostor distribution

**Background**: Facial appearance varies geographically, both in terms of skin tone, cranio-facial structure and size. This section addresses whether false match rates vary intra- and inter-regionally.

**Goals**:

- ▷ To show the effect of birth region of the impostor and enrollee on false match rates.
- ▷ To determine whether some algorithms give better impostor distribution stability.

**Methods**:

- ▷ For the visa images, NIST defined 10 regions: Sub-Saharan Africa, South Asia, Polynesia, North Africa, Middle East, Europe, East Asia, Central and South America, Central Asia, and the Caribbean.
- ▷ For the visa images, NIST mapped each country of birth to a region. There is some arbitrariness to this. For example, Egypt could reasonably be assigned to the Middle East instead of North Africa. An alternative methodology could, for example, assign the Philippines to *both* Polynesia and East Asia.
- ▷ FMR is computed for cases where all face images of impostors born in region $r_2$ are compared with enrolled face images of persons born in region $r_1$.

$$\text{FMR}(r_1, r_2, T) = \frac{\sum_{i=1}^{N_{r_1,r_2}} H(s_i - T)}{N_{r_1,r_2}} \tag{5}$$

  where the same threshold, T, is used in all cells, and H is the unit step function. The threshold is set to give FMR(T) = 0.001 over the entire set of visa image impostor comparisons.

- ▷ This analysis is then repeated by country-pair, but only for those country pairs where both have at least 1000 images available. The countries[1] appear in the axes of graphs that follow.
- ▷ The mean number of impostor scores in any cross-region bin is 33 million. The smallest number of impostor scores in any bin is 135000, for Central Asia - North Africa. While these counts are large enough to support reasonable significance, the number of individual faces is much smaller, on the order of $N^{0.5}$.
- ▷ The numbers of impostor scores in any cross-country bin is shown in Figure 206.

**Results**: Subsequent figures show heatmaps that use color to represent the base-10 logarithm of the false match rate. Red colors indicate high (bad) false match rates. Dark colors indicate benign false match rates. There are two series of graphs corresponding to aggregated geographical regions, and to countries. The notable observations are:

- ▷ The on-diagonal elements correspond to within-region impostors. FMR is generally above the nominal value of FMR = 0.001. Particularly there is usually higher FMR in, Sub-Saharan Africa, South Asia, and the Caribbean. Europe and Central Asia, on the other hand, usually give FMR closer to the nominal value.
- ▷ The off-diagonal elements correspond to across-region impostors. The highest FMR is produced between the Caribbean and Sub-Saharan Africa.
- ▷ Algorithms vary.

[1] These are Argentina, Australia, Brazil, Chile, China, Costa Rica, Cuba, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Germany, Ghana, Great Britain, Greece, Guatamala, Haiti, Hong Kong, Honduras, Indonesia, India, Israel, Jamaica, Japan, Kenya, Korea, Lebanon, Mexico, Malaysia, Nepal, Nigeria, Peru, Philippines, Pakistan, Poland, Romania, Russia, South Africa, Saudi Arabia, Thailand, Trinidad, Turkey, Taiwan, Ukraine, Venezuela, and Vietnam.

*Figure 79: For the visa images, the dots show FMR for impostor comparisons of individuals of the same sex and same age group for the region of the world that gives the worst (highest) FMR when the threshold is set to give FMR = 0.001 (red vertical line) over all on the order of $10^{10}$ impostor scores i.e. zero-effort. The shift of the dots to right shows massive increases in FMR when impostors have the same sex, age, and region of birth. The color code indicates which region gives the worst case FMR. If the observed variation is due to the prevalence of one kind of images in the training imagery, then algorithms developed on one kind of data might be expected to give higher FMR on other kinds.*

- We computed the same quantities for a global FMR = 0.0001. The effects are similar.

**Caveats**:

- The effects of variable impostor rates on one-to-many identification systems may well differ from what's implied by these one-to-one verification results. Two reasons for this are a) the enrollment galleries are usually imbalanced across countries of birth, age and sex; b) one-to-many identification algorithms often implement techniques aimed at stabilizing the impostor distribution. Further research is necessary.
- In principle, the effects seen in this subsection could be due to differences in the image capture process. We consider this unlikely since the effects are maintained across geography - e.g. Caribbean vs. Africa, or Japan vs. China.

*Figure 80: For visa images, the heatmap shows how the mean of the impostor distribution for the country pair (a,b) is shifted relative to the mean of the global impostor distribution, expressed as a number of standard deviations of the global impostor distribution. This statistic is designed to show shifts in the entire impostor distribution, not just tail effects that manifest as the anomalously high (or low) false match rates that appear in the subsequent figures. The countries are chosen to show that skin tone alone does not explain impostor distribution shifts. The reduced shift in Asian populations with the Yitu and TongYiTrans algorithms, is accompanied by positive shifts in the European populations. This reversal relative to most other algorithms, may derive from use of nationally weighted training sets. The Visionlabs algorithm appears most insensitive to country effects. The figure is computed from same-sex and same-age impostor pairs.*

*Figure 81: For algorithm 3divi-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 82: For algorithm 3divi-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 83: For algorithm anke-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 84: For algorithm anke-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 85: For algorithm anyvision-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 86: For algorithm anyvision-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 87: For algorithm aware-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 88: For algorithm aware-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 89: For algorithm ayonix-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 90: For algorithm bm-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 91: For algorithm camvi-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 92: For algorithm camvi-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 93: For algorithm cogent-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 94: For algorithm cogent-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 95: For algorithm cognitec-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 96: For algorithm cyberextruder-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 97: For algorithm cyberextruder-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 98: For algorithm dahua-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 99: For algorithm dahua-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 100: For algorithm dermalog-005 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 101: For algorithm dermalog-006 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 102: For algorithm digitalbarriers-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 103: For algorithm digitalbarriers-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 104: For algorithm everai-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 105: For algorithm everai-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 106: For algorithm fdu-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 107: For algorithm fdu-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 108: For algorithm glory-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 109: For algorithm glory-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 110: For algorithm gorilla-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 111: For algorithm gorilla-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 112: For algorithm id3-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 113: For algorithm id3-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 114: For algorithm idemia-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 115: For algorithm incode-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 116: For algorithm incode-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 117: For algorithm innovatrics-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 118: For algorithm innovatrics-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 119: For algorithm intellivision-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 120: For algorithm isityou-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 121: For algorithm isystems-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 122: For algorithm isystems-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 123: For algorithm itmo-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 124: For algorithm itmo-005 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 125: For algorithm lookman-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 126: For algorithm megvii-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 127: For algorithm megvii-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 128: For algorithm microfocus-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 129: For algorithm microfocus-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 130: For algorithm morpho-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 131: For algorithm neurotechnology-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 132: For algorithm neurotechnology-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 133: For algorithm noblis-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 134: For algorithm ntechlab-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 135: For algorithm ntechlab-005 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 136: For algorithm pa-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 137: For algorithm pa-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 138: For algorithm psl-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 139: For algorithm psl-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 140: For algorithm rankone-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 141: For algorithm rankone-005 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 142: For algorithm realnetworks-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 143: For algorithm realnetworks-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 144: For algorithm saffe-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 145: For algorithm samtech-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 146: For algorithm shaman-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 147: For algorithm shaman-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 148: For algorithm siat-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 149: For algorithm smilart-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 150: For algorithm synesis-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 151: For algorithm tevian-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 152: For algorithm tiger-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 153: For algorithm tongyitrans-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 154: For algorithm tongyitrans-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 155: For algorithm toshiba-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 156: For algorithm ultinous-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 157: For algorithm ultinous-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 158: For algorithm vcog-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 159: For algorithm vd-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 160: For algorithm vigilantsolutions-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 161: For algorithm visionlabs-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 162: For algorithm vocord-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 163: For algorithm yisheng-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 164: For algorithm yisheng-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 165: For algorithm yitu-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given region pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 166: For algorithm 3divi-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 167: For algorithm anke-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 168: For algorithm anyvision-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 169: For algorithm aware-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 170: For algorithm ayonix-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 171: For algorithm camvi-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 172: For algorithm cogent-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 173: For algorithm cyberextruder-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 174: For algorithm cyberextruder-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 175: For algorithm dermalog-005 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 176: For algorithm digitalbarriers-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 177: For algorithm digitalbarriers-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 178: For algorithm fdu-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 179: For algorithm fdu-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 180: For algorithm glory-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 181: For algorithm gorilla-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 182: For algorithm id3-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 183: For algorithm incode-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 184: For algorithm innovatrics-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 185: For algorithm intellivision-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 186: For algorithm isityou-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 187: For algorithm isystems-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 188: For algorithm itmo-004 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 189: For algorithm lookman-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 190: For algorithm megvii-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 191: For algorithm microfocus-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 192: For algorithm morpho-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 193: For algorithm neurotechnology-003 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 194: For algorithm noblis-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 195: For algorithm pa-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 196: For algorithm samtech-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 197: For algorithm shaman-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 198: For algorithm shaman-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 199: For algorithm smilart-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 200: For algorithm tongyitrans-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 201: For algorithm toshiba-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 202: For algorithm ultinous-000 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 203: For algorithm ultinous-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 204: For algorithm vcog-002 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 205: For algorithm yisheng-001 operating on visa images, the heatmap shows false match rates observed over impostor comparisons of faces from different individuals who were born in the given country pair. False matches are counted against a recognition threshold fixed globally to give the target FMR in the plot title, computed over all on the order of $10^{10}$ impostor comparisons. If text appears in each box it give the same quantity as that coded by the color. Grey indicates FMR is at the intended FMR target level. Light red colors present a security vulnerability to, for example, a passport gate. Each +1 increase in log10 FMR corresponds to a factor of 10 increase in FMR. The matrix is not quite symmetric because images in the enrollment and verification sets are different.*

*Figure 206: For visa images, the heatmap shows the count of impostor comparisons of faces from different individuals who were born in the given country pair.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

### 5.6.2 Effect of age on impostors

**Background**: This section shows the effect of age on the impostor distribution. The ideal behaviour is that the age of the enrollee and the impostor would not affect impostor scores. This would support FMR stability over sub-populations.

**Goals**:

- ▷ To show the effect of relative ages of the impostor and enrollee on false match rates.
- ▷ To determine whether some algorithms have better impostor distribution stability.

**Methods**:

- ▷ Define 14 age group bins, spanning 0 to over 100 years old.
- ▷ Compute FMR over all impostor comparisons for which the subjects in the enrollee and impostor images have ages in two bins.
- ▷ Compute FMR over all impostor comparisons for which the subjects are additionally of the same sex, and born in the same geographic region.

**Results**:

The notable aspects are:

- ▷ Diagonal dominance: Impostors are more likely to be matched against their same age group.
- ▷ Same sex and same region impostors are more successful. On the diagonal, an impostor is more likely to succeed by posing as someone of the same sex. If $\Delta \log_{10} \text{FMR} = 0.2$, then same-sex same-region FMR exceeds the all-pairs FMR by factor of $10^{0.2} = 1.6$.
- ▷ Young children impostors give elevated FMR against young children. Older adult impostor give elevated FMR against older adults. These effects are quite large, for example if $\Delta \log_{10} \text{FMR} = 1.0$ larger than a 32 year old, then these groups have higher FMR by a factor of $10^1 = 10$. This would imply an FMR above 0.01 for a nominal (global) FMR = 0.001.
- ▷ Algorithms vary.
- ▷ We computed the same quantities for a global FMR = 0.0001. The effects are similar.

Note the calculations in this section include impostors paired across all countries of birth.

*Figure 207: For algorithm 3divi-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 208: For algorithm 3divi-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 209: For algorithm anke-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 210: For algorithm anke-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 211: For algorithm anyvision-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 212: For algorithm anyvision-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 213: For algorithm aware-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 214: For algorithm aware-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 215: For algorithm ayonix-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 216: For algorithm bm-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 217: For algorithm camvi-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 218: For algorithm camvi-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 219: For algorithm cogent-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 220: For algorithm cogent-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 221: For algorithm cognitec-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 222: For algorithm cyberextruder-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 223: For algorithm cyberextruder-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 224: For algorithm dahua-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 225: For algorithm dermalog-005 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 226: For algorithm dermalog-006 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 227: For algorithm digitalbarriers-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 228: For algorithm digitalbarriers-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 229: For algorithm everai-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 230: For algorithm everai-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 231: For algorithm fdu-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 232: For algorithm fdu-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 233: For algorithm glory-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 234: For algorithm gorilla-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 235: For algorithm gorilla-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 236: For algorithm id3-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 237: For algorithm id3-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 238: For algorithm idemia-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 239: For algorithm incode-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 240: For algorithm incode-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 241: For algorithm innovatrics-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 242: For algorithm innovatrics-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 243: For algorithm intellivision-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 244: For algorithm isityou-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 245: For algorithm isystems-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 246: For algorithm isystems-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 247: For algorithm itmo-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 248: For algorithm itmo-005 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 249: For algorithm lookman-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 250: For algorithm megvii-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 251: For algorithm megvii-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 252: For algorithm microfocus-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 253: For algorithm microfocus-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 254: For algorithm morpho-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 255: For algorithm neurotechnology-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 256: For algorithm neurotechnology-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 257: For algorithm noblis-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 258: For algorithm ntechlab-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 259: For algorithm ntechlab-005 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 260: For algorithm pa-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 261: For algorithm pa-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 262: For algorithm psl-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 263: For algorithm psl-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 264: For algorithm rankone-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 265: For algorithm rankone-005 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 266: For algorithm realnetworks-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 267: For algorithm realnetworks-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 268: For algorithm saffe-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 269: For algorithm samtech-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 270: For algorithm sensetime-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 271: For algorithm sensetime-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 272: For algorithm shaman-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 273: For algorithm shaman-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 274: For algorithm siat-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 275: For algorithm smilart-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 276: For algorithm smilart-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 277: For algorithm synesis-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 278: For algorithm synesis-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 279: For algorithm tech5-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 280: For algorithm tech5-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 281: For algorithm tevian-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 282: For algorithm tevian-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 283: For algorithm tiger-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 284: For algorithm tiger-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*

*Figure 285: For algorithm tongyi-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 286: For algorithm tongyitrans-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 287: For algorithm tongyitrans-003 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 288: For algorithm toshiba-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 289: For algorithm toshiba-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 290: For algorithm ultinous-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 291: For algorithm ultinous-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 292: For algorithm vcog-002 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 293: For algorithm vd-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 294: For algorithm vigilantsolutions-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
FMR(T) "False match rate"

*Figure 295: For algorithm vigilantsolutions-005 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 296: For algorithm vion-000 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 297: For algorithm visionlabs-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 298: For algorithm visionlabs-005 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 299: For algorithm vocord-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 300: For algorithm vocord-005 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 301: For algorithm yisheng-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 302: For algorithm yisheng-004 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



FNMR(T) "False non-match rate"
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*Figure 303: For algorithm yitu-001 operating on visa images, the heatmap shows false match observed over impostor comparisons of faces from different individuals who have the given age pair. False matches are counted against a recognition threshold fixed globally to give FMR = 0.001 over all on the order of $10^{10}$ impostor comparisons. The text in each box gives the same quantity as that coded by the color. Light colors present a security vulnerability to, for example, a passport gate.*



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# Accuracy Terms + Definitions

In biometrics, Type II errors occur when two samples of one person do not match – this is called a **false negative**. Correspondingly, Type I errors occur when samples from two persons do match – this is called a **false positive**. Matches are declared by a biometric system when the native comparison score from the recognition algorithm meets some **threshold**. Comparison scores can be either **similarity scores**, in which case higher values indicate that the samples are more likely to come from the same person, or **dissimilarity scores**, in which case higher values indicate different people. Similarity scores are traditionally computed by **fingerprint** and **face** recognition algorithms, while dissimilarities are used in **iris recognition**. In some cases, the dissimilarity score is a distance; this applies only when **metric** properties are obeyed. In any case, scores can be either **mate** scores, coming from a comparison of one person's samples, or **nonmate** scores, coming from comparison of different persons' samples. The words **genuine** or **authentic** are synonyms for mate, and the word **impostor** is used a synonym for nonmate. The words mate and nonmate are traditionally used in identification applications (such as law enforcement search, or background checks) while genuine and impostor are used in verification applications (such as access control).

A **error tradeoff** characteristic represents the tradeoff between Type II and Type I classification errors. For verification this plots false non-match rate (FNMR) vs. false match rate (FMR) parametrically with T.

The error tradeoff plots are often called **detection error tradeoff (DET)** characteristics or **receiver operating characteristic** (ROC). These serve the same function but differ, for example, in plotting the complement of an error rate (e.g. TMR = 1 – FNMR) and in transforming the axes most commonly using logarithms, to show multiple decades of FMR. More rarely, the function might be the inverse Gaussian function.

More detail and generality is provided in formal biometrics testing standards, see the various parts of ISO/IEC 19795 Biometrics Testing and Reporting. More terms, including and beyond those to do with accuracy, see ISO/IEC 2382-37 Information technology -- Vocabulary -- Part 37: Harmonized biometric vocabulary



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