

NIST Internal Report NIST IR 8439

Ongoing Face Recognition Vendor Test (FRVT)

*Part 9a: Face Recognition Verification Accuracy on
Distinguishing Twins*

Kayee Hanaoka
Mei Ngan
Patrick Grother
Austin Hom

This publication is available free of charge from:
<https://doi.org/10.6028/NIST.IR.8439>

NIST Internal Report
NIST IR 8439

**Ongoing Face Recognition Vendor
Test (FRVT)**

*Part 9a: Face Recognition Verification Accuracy on
Distinguishing Twins*

Kayee Hanaoka

Mei Ngan

Patrick Grother

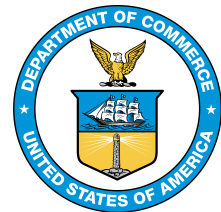
Austin Hom

Information Access Division

Information Technology Laboratory

This publication is available free of charge from:
<https://doi.org/10.6028/NIST.IR.8439>

September 2022



U.S. Department of Commerce
Gina M. Raimondo, Secretary

National Institute of Standards and Technology
Laurie E. Locascio, NIST Director and Under Secretary of Commerce for Standards and Technology

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.

Institutional Review Board

The National Institute of Standards and Technology's Research Protections Office reviewed the protocol for this project and determined it is not human subjects research as defined in Department of Commerce Regulations, 15 CFR 27, also known as the Common Rule for the Protection of Human Subjects (45 CFR 46, Subpart A).

NIST Technical Series Policies

[Copyright, Fair Use, and Licensing Statements](#)

[NIST Technical Series Publication Identifier Syntax](#)

Publication History

Approved by the NIST Editorial Review Board on 2022-09-19

How to cite this NIST Technical Series Publication:

Kayee Hanaoka, Mei Ngan, Patrick Grother, Austin Hom (2022) Ongoing Face Recognition Vendor Test (FRVT). (National Institute of Standards and Technology, Gaithersburg, MD), NIST IR 8439. <https://doi.org/10.6028/NIST.IR.8439>

Contact Information

frvt@nist.gov

Acknowledgments

Certain commercial entities, equipment, or materials may be identified in this document in order to describe an experimental procedure or concept adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the entities, materials, or equipment are necessarily the best available for the purpose.

The authors would like to thank the Department of Homeland Security's Office of Biometric Identity Management (OBIM), and Prof. Jeremy Dawson and the staff of the West Virginia University Biometrics Collection Lab for their support and making twins data available to NIST.

The authors are grateful to staff in the NIST Biometrics Research Laboratory for infrastructure supporting rapid evaluation of algorithms. Thank you to Dr. Jim Matey, Joyce Yang, and Karen Marshall for the comments of the paper.

Abstract

This report documents the ability of face recognition algorithms to correctly distinguish face images of identical and fraternal twins. The algorithms were submitted to the ongoing one-to-one verification track of the Face Recognition Vendor Test (FRVT) executed by the National Institute of Standards and Technology (NIST)

Keywords

face recognition; FR; FRVT; Ongoing Face Recognition Vendor Test; twins

Table of Contents

Executive Summary	1
Technical Summary	3
1. Introduction	6
2. Image Datasets	6
2.1. Twins Days Images	6
2.2. Immigration-related Images	7
2.3. Data Limitation and Caveats	8
3. Algorithms	10
4. Results	22
References	38

List of Tables

Table 1. False Match Rate	2
Table 2. Means IOD	5
Table 3. Algorithm summary	11
Table 4. Algorithm summary	12
Table 5. Algorithm summary	13
Table 6. Algorithm summary	14
Table 7. Algorithm summary	15
Table 8. Algorithm summary	16
Table 9. Algorithm summary	17
Table 10. Algorithm summary	18
Table 11. Algorithm summary	19
Table 12. Algorithm summary	20
Table 13. Algorithm summary	21
Table 14. False Match Rate	24
Table 15. False Match Rate	25
Table 16. False Match Rate	26
Table 17. False Match Rate	27
Table 18. False Match Rate	28
Table 19. False Match Rate	29
Table 20. False Match Rate	30
Table 21. False Match Rate	31
Table 22. False Match Rate	32
Table 23. False Match Rate	33
Table 24. False Match Rate	34
Table 25. False Match Rate	35
Table 26. False Match Rate	36

Table 27.False Match Rate	37
-------------------------------------	----

List of Figures

Fig. 1. scores distribution sample	3
Fig. 2. Twins Days photo samples	7
Fig. 3. Twins Days same-day image samples	7
Fig. 4. Immigration-related images samples	8

Executive Summary

Overview

This report documents the ability of face recognition algorithms to correctly distinguish face images of identical and fraternal twins. The algorithms were submitted to the ongoing one-to-one verification track of the Face Recognition Vendor Test (FRVT) executed by the National Institute of Standards and Technology (NIST).

Motivation

Face recognition is increasingly used in public and private sector applications for authentication of a person's identity, for authorization of transactions, and for logical and physical access control. These uses have been supported by the massive improvements in accuracy documented in [NIST FRVT evaluation](#) [3] over the last decade. Since the COVID-19 pandemic, these gains include the ability of [some algorithms](#) [4] to recognize individuals wearing protective face masks. However, despite these gains, face recognition algorithms continue [14] to give false matches when comparing face images of twins, and this report documents results on the most recent algorithms. This is a problem, because in 2020 approximately 3% of babies born in the US were twins and multiple births [13]. The numbers of twins are rising due to increased age of having babies and use of infertility treatments [11]; The twin birth rate has risen over 70% since 1980 [7].

What we did

We applied one-to-one face comparison algorithms to face images of twins and to face images of the general population. The algorithms were submitted to the FRVT by corporate research and development laboratories, and universities. These algorithms were prototypes and not available for commercial use. Their performance is detailed in [FRVT](#) [3]. We used two sets of face images. The first dataset was from West Virginia University collected at Twins Days Festivals [6] [8] from 2010 to 2018. These images have good compliance with image capture standards. The second set consists of images collected by the U.S. Government in operational travel and immigration processes. The images are of lower quality given constraints on capture duration and environment, and are only in partial compliance with image capture standards. This data consist of all same-sex twins but unknown twin types. Together we used a total of 5 938 images from 698 pairs of twins. Both datasets were accompanied by sex, birth year and matching twin identifiers for the photographed individuals. The Twins Days data also included the twin types, identical or fraternal, noting that fraternal twins can be of different sex. We quantified false match rates - statements of

how well face recognition algorithms are able to differentiate twins. We report results by age groups and twin types.

What we found

All of the algorithms submitted to the FRVT verification track are unable to distinguish between identical twins: They give false match on identical twins pairs (see Tables 1 and 14-27). Likewise, most algorithms give false matches for same-sex fraternal twins - this becomes modestly less likely for older people. For different-sex fraternal twins, most algorithms do not give false matches. These results show that identical twins and same-sex fraternal twins give outcomes that are inconsistent with the intended or expected behaviour from a face recognition algorithm.

	ALGORITHM		MUGSHOT	TEMPLATES	TWINS DAY		
					IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFFER-SEX
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR
1	sensitive-006	2021-12-28	0.0021	0.000	0.996	0.812	0.029
2	sensitive-005	2021-05-24	0.0021	0.000	0.996	0.790	0.029
3	paravision-010	2022-02-02	0.0021	0.000	0.995	0.783	0.044
4	psl-009	2021-12-08	0.0021	0.000	0.995	0.848	0.162
5	idemia-008	2021-07-07	0.0022	0.000	0.996	0.783	0.059

Table 1. This table presents results for five algorithms with good performance on FRVT 1:1 mugshot data with FNMR @ FMR = 0.0001. They all give high False Match Rate (FMR) on identical twin comparisons. However, identical twins FMR is not 1 because there are identical twins comparisons have scores below the threshold, because the images of the twins do not look alike, have different face shapes, and wearing hats. (Threshold is set to give FMR = 0.0001 when executing same-sex non-mated comparisons in a general mugshot population.)

Technical Summary

Score distributions

False matches are the result of high similarity scores produced by algorithms when comparing images of different people, in our case, twins. Figure 1 shows the distributions of scores for two accurate and representative algorithms.

The highest scores arise from comparison of images of the same person taken on the same day - these are labeled “mated twins”. The next highest scores come from a general mugshot population adopted here as a control. These are labeled “mated mugshot”. Scores from comparing images of two identical twins are similarly high and are labeled “non-mated identical twins”. Almost as high are scores from “non-mated fraternal same-sex twins”. All of these are above threshold, which we set to give $FMR = 0.0001$ on a set of non-mated mugshot pairs. It is impractical to elevate the threshold to suppress false matches from twins without simultaneously elevating false non-match rates to operationally useless levels.

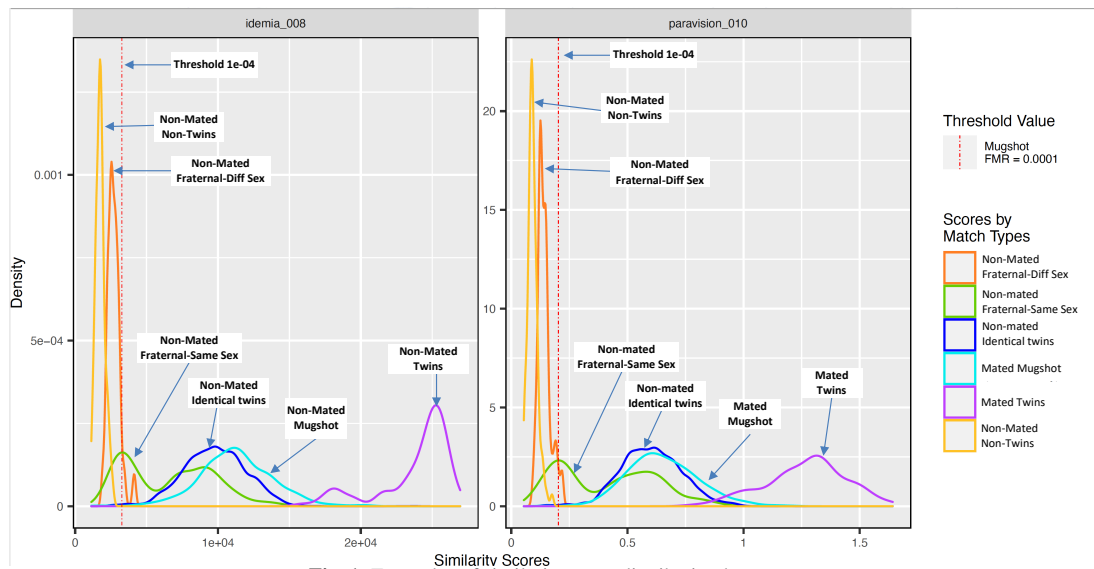


Fig. 1. Examples of similarity score distribution by group.

Age effects

When examining twins in different age groups, both datasets show declines in similarity scores for non-mated twins in the older age groups. There are four age groups in the Twins Days dataset, age 0-19, age 20-39, age 40-59, and age 60-up. The results show algorithms

have lower similarity scores for twins in the oldest age group than the youngest age group when comparing images of fraternal same-sex twins and identical twins. Immigration-related datasets have all same sex twins and three age groups, age 0-19, age 20-39, and age 40-59. The distributions of similarity scores in the age 0-19 are closer to the mated twins scores, while the similarity scores in the age 40-59 are lower and away from the mated twins score distribution. Even though both datasets show a decline in similarity scores in the older age groups, scores are still above the thresholds where the algorithm would still consider the non-mated twins comparison a match. Therefore, the algorithms are not able to differentiate same-sex fraternal twins and identical twins as different people.

Longitudinal effects

As face recognition algorithms performance improves, the ability to differentiate same-sex twins shows no improvement. Algorithms with good performance on mugshot data show no improved or declined performance when comparing fraternal same-sex twins and identical twins in the Twins Days data. See Tables [14-27](#)

Anomalous algorithms

In the main results tables in the report, there are a handful of algorithms that give low false match rates for identical twins. These algorithms, also fail to match mated twin pairs also i.e. the algorithms are very inaccurate.

Implications and future work

Identical twins have extremely similar facial appearance, because they share the same genes[2]. Fraternal same-sex twins share half of the genes and may look different from each other[1]. In the NIST face recognition verification test, algorithms have high false matches and cannot distinguish identical and fraternal same-sex twins as different people. The operational consequences of this are application dependent.

Future mitigation of this problem may involve accessing facial information that is not phenotypic and determined by genetics. Facial landmarks are distinctive and useful, but usually there only few of these features on the face and sometimes they cannot be observed in low resolution of the images. High resolution images may provide more details about the facial skins, perhaps match by certain facial skin areas, pores pattern, facial skin patterns[12]. We suggest this because a patented algorithm from 2004, [US Patent: US7369685B2](#), was known to be able to correctly differentiate twins by extracting features from skin texture

visible in higher resolution images. An ISO-compliant frontal portrait with a minimum of 120 pixels between the eyes was considered suitable for skin texture based analysis - that format is achieved using a 480 x 640 (VGA) pixel image.

Going forward we expect to use Twins Days images which have interocular distances (as defined in ISO/IEC 39794-5:2019) of 500 pixels and above, and conformance to the ANSI-NIST level 50 specifications [8][5] (see Table 2) to challenge industry to demonstrate low false match in twins. In FRVT, we note that many convolutional neural networks are configured to consume lower resolution inputs to optimize for speed, and the images are either resized to a lower resolution or are heavily compressed which would remove the higher resolution features.

DATA	INTEROCULAR DISTANCE								
	1%	5%	10%	25%	50%	75%	90%	95%	99%
Twins Day Images	598.1	634.3	670.6	760.6	804.9	843.7	881.6	905.5	954.8
Immigration-related Images	24.0	27.1	29.5	34.0	42.0	59.4	76.4	119.7	151.7

Table 2. Quantile of the mean interocular distance calculated from 5 algorithms (cubox-002, psl-008, idemia-008, clearviewai-000, paravision-008) reported eye coordinates for the images during template creation.

1. Introduction

Face recognition algorithms are used around the world in a diverse range of biometric applications [10] to authenticate users, for identity de-duplication in databases, and more. These algorithms are rapidly improving in performance and accuracy, and take on new challenges at the same time, such as authenticating users while wearing face masks. However, distinguishing twins remains a problem for face recognition, because face recognition algorithms continue to mis-identify twins as the same person.

This report contains the twins accuracy measurement for 1:1 verification algorithms. We tested algorithms that were submitted to [FRVT 1:1 Ongoing](#) [3]. At this time, we do not have any information regarding whether or not any of the algorithms were designed to distinguish between twins.

The FRVT evaluation is an ongoing test that remains open to new participation. Comments and suggestions should be directed to frvt@nist.gov.

2. Image Datasets

There are three different types of comparisons - Mated Twins which compares images of the same person, Non-Mated Twins which compares images of twin siblings, and Non-Mated Non-Twins which compares images of different people in the same dataset who are not the twin siblings. In the Twins Days dataset, images used in mated and non-mated twins comparisons are taken on the same day of the event (figure 3).

2.1. Twins Days Images

These images were collected at Twins Days Festivals from 2010 to 2018 by staff from the West Virginia University – Biometrics and Identification Innovation Center. The collections were carried out under IRB protocols with informed consent from each participants. Images for each year were collected at various sizes: 2010 at 2848x4288, 2011 at 3744x5616, and 2012 to 2018 at 3300x4400 and 2400x3200. The images are all high-quality frontal portraits, conforming to NIST SAP50 specification which specifies the head and shoulders composition requirements, and SAP 51 specification which specifies the head only composition requirements [8][5].



Fig. 2. Example of twins images from University of Notre Dame Twins Days Database. (Different people)



Fig. 3. Example of twins genuine same-day images from University of Notre Dame Twins Days Database. (Same person taken from the same.)

2.2. Immigration-related Images

All images in this set are live capture. The set is composed of mostly webcam images and some visa application images. All subjects have webcam images taken with a camera oriented by an attendant toward a cooperating subject. This is done under time constraints so there are roll, pitch and yaw angle variations. Background illumination is sometimes bright, so the face is under-exposed. There is some perspective distortion due to close range images. Some faces are partially cropped. The images are in poor conformance with the ISO/IEC 19794-5 Full Frontal image type. The images have mean interocular distance of 38 pixels. Some subjects also have visa application images that are collected in an attended interview setting using dedicated capture equipment and lighting. These visa application images have geometry in good conformance with the ISO/IEC 19794-5 Full Frontal image type, collected at size 300x300, and pose is closely frontal.

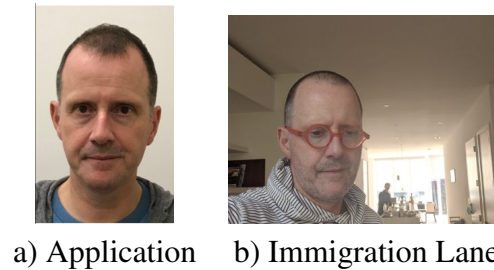


Fig. 4. The figure gives simulated samples in the Immigration-related dataset.

2.3. Data Limitation and Caveats

Small population: The twins dataset is relatively small when compared to other NIST FRVT 1:1 datasets, both Twins Days data and immigration-related data combined total just over 5 900 images. During the ground-truth process, many images and twin pairs were excluded in the Twins Days data due to inconsistent or missing metadata. For example, there were mis-matched twin pairs where person A is twin to person B, but person B is twin to person C. Some images had missing or inconsistent twin type where person A is fraternal twin to person B, but person B is identical twin to person A. Other images were excluded in the Twins Days dataset that had relationship labeled as siblings, parent or child. NIST was able to keep most of the images in the immigration-related dataset, which amounted to 152 twin pairs with 2 478 images.

Different identifiers: In the Twins Days data, usually the same twins identifiers would be assigned to the same participants from year to year. However, there are cases where twins were assigned new identifiers. Therefore, a small percentage of the comparison scores were above the threshold in the non-mated non-twins comparisons leading to apparent false matches when they were actually correct matches.

Incorrect/missing Metadata: Most or all metadata was missing for Twins Days data collected in year 2011, 2014, 2015, 2016. Supplemental metadata files were later provided to NIST, but most of the information could not be match with the original data. Incorrect twin types, birthdays, and other mis-match metadata caused many images to be omitted from the study. The immigration-related images data do not have fraternal or identical twins type information, except that the images are all same sex twins. Therefore NIST cannot thoroughly analyze algorithms performance on differentiating twins by type in the operational environment.

Imbalanced Data: The overall Twins Days images distribution by twin types is uneven; 2.8% fraternal different-sex, 6.7% fraternal same-sex, and 90.5% identical twins. The

datasets have imbalanced age groups with most of the images in age-group 20-39. Both datasets have a very low percentage of images for the older age groups 40-59 and 60-up. The immigration-related data does not have images for age group 60-up.

Ethnicity: Twins Days data includes participants' ethnic identities, 85% of the participants identified as caucasian, 10% as African-American, and 5% as others. With the disproportionate number of ethnic groups, any analysis based on race would be meaningless.

3. Algorithms

The FRVT activity is open to participation worldwide, and the test will evaluate submissions on an ongoing basis. There is no charge to participate. The requirements to submit algorithms to NIST are described in the FRVT 1:1 Verification Application Programming Interface (API)[9] document. Participants provide their submissions in the form of libraries compiled on a specific Linux kernel, which are linked against NIST's test harness to produce executables. NIST provides a validation package to participants to ensure that NIST's execution of submitted libraries produces the expected output on NIST's test machines.

This report documents the results of algorithms submitted to FRVT 1:1 for testing from 2019 to mid-February 2022, without specific claim to be able to distinguish between twins. Tables 3-13 lists the algorithms that were tested. Note that algorithms that expired or algorithms with Failed-to-enroll(FTE)=1.00 were not included in this report.

	Developer	Algorithm	Submission Date
1	20Face	20face-000	2021-04-12
2	20Face	20face-001	2021-09-29
3	3Divi	3divi-004	2019-07-22
4	3Divi	3divi-005	2020-08-28
5	3Divi	3divi-006	2021-04-14
6	3Divi	3divi-007	2021-09-27
7	Ability Enterprise - Andro Video	androvideo-000	2021-01-25
8	Acer Incorporated	acer-000	2020-01-08
9	Acer Incorporated	acer-001	2020-06-30
10	Acer Incorporated	acer-002	2021-11-10
11	ACI Software	acisw-003	2020-08-03
12	ACI Software	acisw-006	2021-02-25
13	ACI Software	acisw-007	2021-11-15
14	Adera Global PTE	adera-002	2021-02-16
15	Adera Global PTE	adera-003	2021-07-12
16	ADVANCE.AI	advance-002	2019-12-19
17	ADVANCE.AI	advance-003	2021-08-05
18	AFIS and Biometrics Consulting	afisbiometrics-000	2022-01-27
19	Ai First	aifirst-001	2019-11-21
20	Aigen	aigen-001	2020-10-06
21	Aigen	aigen-002	2021-03-15
22	AiUnion Technology	aiunionface-000	2019-10-22
23	Ajou University	ajou-001	2021-03-08
24	Akurat Satu Indonesia	ptakuratsatu-000	2020-09-11
25	Alchera Inc	alchera-000	2019-03-01
26	Alchera Inc	alchera-001	2019-03-01
27	Alchera Inc	alchera-002	2021-03-05
28	Alchera Inc	alchera-003	2021-07-13
29	Alfabeta	alfabeta-001	2021-12-02
30	Alice Biometrics	alice-000	2021-06-15

Table 3. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
31	AllGoVision	allgovision-000	2019-03-01
32	AlphaSSTG	alphaface-001	2019-09-03
33	AlphaSSTG	alphaface-002	2020-02-20
34	Anke Investments	anke-004	2019-06-27
35	Anke Investments	anke-005	2019-11-21
36	Antheus Technologia	antheus-000	2019-12-05
37	Antheus Technologia	antheus-001	2020-06-25
38	AnyVision	anyvision-005	2021-02-03
39	Armatura LLC	armatura-001	2022-01-04
40	ASUSTek Computer Inc	asusaics-000	2019-10-24
41	ASUSTek Computer Inc	asusaics-001	2020-02-25
42	AuthenMetric	authenmetric-002	2021-03-10
43	AuthenMetric	authenmetric-003	2021-08-09
44	AuthenMetric	authenmetric-004	2022-01-03
45	Aware	aware-004	2019-03-01
46	Aware	aware-005	2020-02-27
47	Aware	aware-006	2021-07-03
48	Awidit Systems	awiros-001	2019-09-23
49	Awidit Systems	awiros-002	2020-10-28
50	AYF Technology	ayfttech-001	2020-07-06
51	Bee the Data	beethedata-000	2021-07-26
52	Beihang University-ERCACAT	ercacat-001	2020-07-06
53	Beijing Alleyes Technology	alleyes-000	2020-03-09
54	Beijing DeepSense Technologies	deepsense-000	2021-03-19
55	Beijing Hisign Technology	hisign-001	2021-09-24
56	Beijing Mendaxia Technology	mendaxiatech-000	2021-09-15
57	Beyne.AI	beyneai-000	2022-01-03
58	Biocube Matrics	biocube-001	2021-09-08
59	BioID Technologies SA	bioidtechswiss-000	2019-11-15
60	BioID Technologies SA	bioidtechswiss-001	2020-08-28
61	BioID Technologies SA	bioidtechswiss-002	2021-02-17
62	BitCenter UK	farfaces-001	2021-04-09
63	BOE Technology Group	boetech-001	2021-06-22
64	BOE Technology Group	boetech-002	2021-12-21
65	Bresee Technology	bresee-000	2020-08-07
66	Bresee Technology	bresee-001	2020-12-30
67	Bresee Technology	bresee-002	2021-06-30
68	Camvi Technologies	camvi-004	2019-07-12
69	Canon Inc	canon-002	2020-12-29
70	Canon Inc	canon-003	2021-09-15
71	Canon Inc	cib-000	2019-12-11
72	Canon Inc	cib-001	2020-08-05
73	China Electronics Import-Export Corp	ceiec-002	2019-06-12
74	China Electronics Import-Export Corp	ceiec-003	2020-01-06
75	China Electronics Import-Export Corp	ceiec-004	2021-01-18

Table 4. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
76	China University of Petroleum	upc-001	2019-06-05
77	Chosun University	chosun-000	2020-02-12
78	Chosun University	chosun-001	2020-07-01
79	Chosun University	chosun-002	2020-11-25
80	Chunghwa Telecom	chtface-002	2019-12-07
81	Chunghwa Telecom	chtface-003	2020-06-24
82	Chunghwa Telecom	chtface-004	2021-10-08
83	Clearview AI Inc	clearviewai-000	2021-09-22
84	Closeti Inc	closeli-001	2021-07-15
85	CloudSmart Consulting LLC	csc-001	2020-11-20
86	CloudSmart Consulting LLC	csc-002	2021-03-24
87	CloudSmart Consulting LLC	csc-003	2021-08-26
88	Cloudwalk - Hengrui AI Technology	cloudwalk-hr-003	2020-09-25
89	Cloudwalk - Hengrui AI Technology	cloudwalk-hr-004	2021-02-10
90	Cloudwalk - Moontime Smart Technology	cloudwalk-mt-000	2019-06-03
91	Cloudwalk - Moontime Smart Technology	cloudwalk-mt-003	2020-12-22
92	Cloudwalk - Moontime Smart Technology	cloudwalk-mt	2021-11-09
93	Code Everest Pvt	facex-001	2021-03-08
94	Code Everest Pvt	facex-002	2021-08-24
95	Cognitec Systems GmbH	cognitec-002	2021-02-24
96	Cognitec Systems GmbH	cognitec-003	2021-07-30
97	Cognitec Systems GmbH	cognitec-004	2022-02-10
98	Coretech Knowledge Inc	coretech-000	2021-07-12
99	Corsight	corsight-001	2021-03-11
100	Corsight	corsight-002	2021-09-01
101	Cortica	cor-001	2020-09-24
102	CSA IntelliCloud Technology	intellicloudai-001	2019-08-13
103	CSA IntelliCloud Technology	intellicloudai-002	2020-12-17
104	CTBC Bank	ctbcbank-000	2019-06-28
105	CTBC Bank	ctbcbank-001	2019-10-28
106	Cubox	cubox-001	2020-12-07
107	Cubox	cubox-002	2021-08-24
108	CUDO Communication	cudocommunication-001	2021-10-20
109	Cybercore	cybercore-000	2020-08-26
110	Cybercore	cybercore-001	2021-12-15
111	Cyberlink Corp	cyberlink-004	2020-02-27
112	Cyberlink Corp	cyberlink-005	2020-07-31
113	Cyberlink Corp	cyberlink-006	2021-01-08
114	Cyberlink Corp	cyberlink-007	2021-07-16
115	Cyberlink Corp	cyberlink-008	2022-01-07
116	Dahua Technology	dahua-005	2020-08-13
117	Dahua Technology	dahua-006	2020-12-30
118	Dahua Technology	dahua-007	2021-12-20
119	Daon	daon-000	2021-11-03
120	Decatur Industries Inc	decatur-000	2020-08-18

Table 5. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
121	Decatur Industries Inc	decaturn-001	2021-09-27
122	Deepglint	deepglint-001	2019-06-21
123	Deepglint	deepglint-002	2019-11-15
124	Deepglint	deepglint-003	2021-03-03
125	Deepglint	deepglint-004	2021-09-17
126	Deepsense	dps-000	2021-07-16
127	Dermalog	dermalog-007	2020-11-25
128	Dermalog	dermalog-008	2021-03-25
129	Dermalog	dermalog-009	2021-10-06
130	DiDi ChuXing Technology	didiglobalface-001	2019-10-23
131	Digidata	digidata-000	2022-01-27
132	Digital Barriers	digitalbarriers-002	2019-03-01
133	DSK	dsk-000	2019-06-28
134	Ekin Smart City Technologies	ekin-002	2021-05-04
135	Enface	enface-000	2021-04-09
136	Enface	enface-001	2021-12-17
137	Euronovate SA	euronovate-001	2021-11-15
138	Expasoft LLC	expasoft-000	2020-01-06
139	Expasoft LLC	expasoft-001	2020-09-03
140	Expasoft LLC	expasoft-002	2021-07-26
141	FaceOnLive Inc	faceonlive-001	2021-11-23
142	FaceSoft	facesoft-000	2019-07-10
143	FaceTag Co	facetag-000	2021-03-22
144	FaceTag Co	facetag-001	2021-08-17
145	FaceTag Co	facetag-002	2022-01-06
146	Fiberhome Telecommunication Technologies	fiberhome-nanjing-002	2020-08-10
147	Fiberhome Telecommunication Technologies	fiberhome-nanjing-003	2021-03-12
148	Fiberhome Telecommunication Technologies	fiberhome-nanjing-004	2021-09-14
149	Fincore Ltd	fincore-000	2021-06-07
150	Fujitsu Research and Development Center	fujitsulab-000	2020-02-04
151	Fujitsu Research and Development Center	fujitsulab-001	2020-09-30
152	Fujitsu Research and Development Center	fujitsulab-002	2021-02-24
153	Fujitsu Research and Development Center	fujitsulab-003	2021-07-12
154	Gemalto Cogent	cogent-005	2020-12-29
155	Gemalto Cogent	cogent-006	2021-07-28
156	GeoVision Inc	geo-000	2020-06-29
157	GeoVision Inc	geo-001	2020-10-30
158	GeoVision Inc	geo-002	2021-04-01
159	GeoVision Inc	geo-003	2021-09-15
160	GeoVision Inc	geo-004	2022-02-10
161	Glory	glory-002	2019-11-12
162	Glory	glory-003	2021-01-15
163	Glory	glory-004	2022-02-08
164	Gorilla Technology	gorilla-004	2019-11-04
165	Gorilla Technology	gorilla-005	2020-03-11

Table 6. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
166	Gorilla Technology	gorilla-006	2020-07-31
167	Gorilla Technology	gorilla-007	2021-06-28
168	Gorilla Technology	gorilla-008	2021-11-08
169	Graymatics	graymatics-001	2022-01-13
170	Griaule	griaule-000	2021-08-20
171	Guangzhou Pixel Solutions	pixelall-003	2019-10-15
172	Guangzhou Pixel Solutions	pixelall-004	2020-07-02
173	Guangzhou Pixel Solutions	pixelall-005	2021-02-05
174	Guangzhou Pixel Solutions	pixelall-006	2021-06-17
175	Guangzhou Pixel Solutions	pixelall-007	2021-12-01
176	Hangzhou Ailu Network Information Technology	hzailu-001	2022-01-27
177	Herta Security	hertasecurity-000	2021-01-05
178	Herta Security	hertasecurity-001	2022-01-18
179	Hikvision Research Institute	hik-001	2019-03-01
180	HyperVerge Inc	hv-001	2020-12-13
181	HyperVerge Inc	hyperverge-002	2021-05-27
182	ICM Airport Technics	icm-002	2020-11-13
183	ICM Airport Technics	icm-003	2021-09-06
184	ID3 Technology	id3-005	2020-08-04
185	ID3 Technology	id3-006	2020-12-17
186	ID3 Technology	id3-007	2021-05-17
187	ID3 Technology	id3-008	2021-11-10
188	Idemia	idemia-005	2019-10-11
189	Idemia	idemia-006	2020-07-06
190	Idemia	idemia-007	2020-12-04
191	Idemia	idemia-008	2021-07-07
192	Imageware Systems	iws-000	2020-08-12
193	Imperial College London	imperial-000	2019-03-01
194	Imperial College London	imperial-002	2019-08-28
195	Incode Technologies Inc	incode-005	2019-10-17
196	Incode Technologies Inc	incode-006	2020-02-20
197	Incode Technologies Inc	incode-007	2020-08-25
198	Incode Technologies Inc	incode-008	2021-01-19
199	Incode Technologies Inc	incode-009	2021-06-22
200	Incode Technologies Inc	incode-010	2021-10-22
201	Innef Labs	innefulabs-000	2020-09-04
202	Innovative Technology	innovativetechnologyltd-001	2019-10-22
203	Innovative Technology	innovativetechnologyltd-002	2020-02-26
204	Innovatrics	innovatrics-006	2019-08-13
205	Innovatrics	innovatrics-007	2020-08-19
206	Innovatrics	innovatrics-008	2021-12-15
207	InsightFace AI	insightface-000	2021-03-17
208	InsightFace AI	insightface-001	2021-09-27
209	InsightFace AI	insightface-002	2022-01-31
210	Institute of Computing Technology	icthtc-000	2020-11-29

Table 7. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
211	Institute of Information Technologies	iit-001	2019-07-05
212	Institute of Information Technologies	iit-002	2019-12-04
213	Institute of Information Technologies	iit-003	2020-12-01
214	Intel Research Group	intelresearch-000	2019-07-08
215	Intel Research Group	intelresearch-001	2020-01-14
216	Intel Research Group	intelresearch-003	2021-01-18
217	Intel Research Group	intelresearch-004	2021-08-24
218	Intel Research Group	intelresearch-005	2022-02-13
219	Intellivision	intellivision-002	2019-08-23
220	ioNetworks Inc	ionetworks-000	2021-07-20
221	iQIYI Inc	iqface-000	2019-06-04
222	iQIYI Inc	iqface-001	2019-12-11
223	iQIYI Inc	iqface-003	2021-02-23
224	IrexAI	irex-000	2020-12-17
225	iSAP Solution Corporation	isap-002	2020-09-01
226	ITMO University	itmo-006	2019-03-01
227	ITMO University	itmo-008	2021-11-19
228	IVA Cognitive	ivacognitive-001	2021-01-29
229	Kakao Enterprise	kakao-002	2019-06-19
230	Kakao Enterprise	kakao-003	2020-02-26
231	Kakao Enterprise	kakao-004	2020-10-28
232	Kakao Enterprise	kakao-005	2021-03-09
233	Kakao Enterprise	kakao-007	2022-01-12
234	Kakao Pay Corp	kakaopay-001	2021-07-06
235	Kedacom International Pte	kedacom-000	2019-06-03
236	Kneron Inc	kneron-003	2019-07-01
237	Kneron Inc	kneron-005	2020-02-21
238	KnowUTech LLC	knowutech-000	2022-02-13
239	Kookmin University	kookmin-001	2020-09-28
240	Kookmin University	kookmin-002	2021-03-05
241	KuKe3D Technology	kuke3d-001	2021-10-28
242	Lema Labs	lemalabs-001	2021-04-13
243	Line Corporation	line-000	2021-03-31
244	Line Corporation	line-001	2021-09-26
245	Lomonosov Moscow State University	intsysmsu-001	2019-10-22
246	Lomonosov Moscow State University	intsysmsu-002	2020-03-12
247	Lookman Electroplast Industries	lookman-004	2019-06-03
248	Luxand Inc	luxand-000	2019-11-07
249	Mantra Softech India	mantra-000	2021-10-28
250	Maxvision Technology	maxvision-000	2021-10-27
251	Megvii/Face++	megvii-003	2021-03-08
252	Megvii/Face++	megvii-004	2021-11-19
253	Minivision	minivision-000	2020-10-28
254	Mobai	mobai-000	2020-08-26
255	Mobai	mobai-001	2021-02-17

Table 8. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
256	Mobbeel Solutions	mobbl-000	2021-01-28
257	Mobbeel Solutions	mobbl-001	2021-06-16
258	Mobbeel Solutions	mobbl-002	2021-12-16
259	Mobipin Technology	mobipintech-000	2021-11-23
260	Momentum Digital	sertis-000	2019-10-07
261	Momentum Digital	sertis-001	2020-07-30
262	Momentum Digital	sertis-002	2021-05-13
263	MoreDian Technology	moredian-000	2021-02-24
264	Multi-Modality Intelligence	multimodality-000	2021-10-19
265	MVision	mvision-001	2019-11-12
266	N-Tech Lab	ntech-007	2019-06-25
267	N-Tech Lab	ntech-008	2020-01-06
268	N-Tech Lab	ntechlab-009	2020-12-30
269	N-Tech Lab	ntechlab-010	2021-04-30
270	N-Tech Lab	ntechlab-011	2021-09-13
271	N-Tech Lab	ntechlab-012	2022-01-20
272	Nanjing Kiwi Network Technology	kiwitech-000	2021-03-19
273	Naver Corp	clova-000	2020-10-21
274	NEO Systems	neosystems-001	2021-03-02
275	NEO Systems	neosystems-002	2021-07-03
276	NEO Systems	neosystems-003	2021-11-11
277	Neosecu Co	openface-001	2021-06-15
278	Netbridge Technology Incoporation	netbridgetech-001	2020-01-08
279	Netbridge Technology Incoporation	netbridgetech-002	2020-08-11
280	Neurotechnology	neurotechnology-008	2020-01-08
281	Neurotechnology	neurotechnology-009	2020-07-07
282	Neurotechnology	neurotechnology-010	2020-11-26
283	Neurotechnology	neurotechnology-011	2021-03-26
284	Neurotechnology	neurotechnology-012	2021-07-26
285	Neurotechnology	neurotechnology-013	2022-01-07
286	NHN Corp	nhn-001	2021-03-15
287	NHN Corp	nhn-002	2021-07-15
288	Nodeflux	nodeflux-002	2019-08-13
289	NotionTag Technologies Private Limited	notiontag-001	2021-03-04
290	NotionTag Technologies Private Limited	notiontag-002	2021-09-17
291	NSENSE Corp	nsensecorp-002	2021-05-06
292	NSENSE Corp	nsensecorp-003	2021-10-29
293	Omnigarde Ltd	omnigarde-000	2021-04-05
294	Omnigarde Ltd	omnigarde-001	2021-08-23
295	Omnigarde Ltd	omnigarde-002	2022-01-19
296	One More Security	omface-000	2021-12-15
297	Oz Forensics LLC	oz-001	2020-07-29
298	Oz Forensics LLC	oz-002	2021-01-18
299	Oz Forensics LLC	oz-003	2021-08-09
300	Oz Forensics LLC	oz-004	2021-12-13

Table 9. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
301	Panasonic R+D Center Singapore	psl-003	2019-10-01
302	Panasonic R+D Center Singapore	psl-004	2020-03-03
303	Panasonic R+D Center Singapore	psl-005	2020-07-06
304	Panasonic R+D Center Singapore	psl-006	2020-11-13
305	Panasonic R+D Center Singapore	psl-007	2021-03-19
306	Panasonic R+D Center Singapore	psl-008	2021-07-21
307	Panasonic R+D Center Singapore	psl-009	2021-12-08
308	Papilon Savunma	papsav1923-001	2021-03-10
309	Papilon Savunma	papsav1923-002	2022-01-20
310	Paravision	paravision-006	2021-02-01
311	Paravision	paravision-008	2021-06-30
312	Paravision (EverAI)	everai paravision-003	2019-07-01
313	Paravision (EverAI)	paravision-004	2019-12-11
314	Paravision (EverAI)	paravision-010	2022-02-02
315	Pensees Pte	pensees-001	2020-08-17
316	PXL Vision AG	pxl-001	2020-06-30
317	Qnap Security	qnap-000	2021-08-09
318	Qnap Security	qnap-001	2021-12-09
319	Quantasoft	quantasoft-003	2021-04-19
320	Rank One Computing	rankone-009	2020-06-26
321	Rank One Computing	rankone-010	2020-11-05
322	Rank One Computing	rankone-011	2021-08-27
323	Rank One Computing	rankone-012	2021-12-27
324	Realnetworks Inc	realnetworks-002	2019-02-28
325	Realnetworks Inc	realnetworks-003	2019-06-12
326	Realnetworks Inc	realnetworks-004	2021-04-15
327	Realnetworks Inc	realnetworks-005	2021-09-27
328	Realnetworks Inc	realnetworks-006	2022-02-09
329	Regula Forensics	regula-000	2021-04-13
330	Regula Forensics	regula-001	2021-12-14
331	Remark Holdings	remarkai-001	2019-03-01
332	Remark Holdings	remarkai-002	2019-11-21
333	Remark Holdings	remarkai-003	2021-06-22
334	Rendip	rendip-000	2021-04-19
335	Reveal Media Ltd	revealmedia-005	2021-09-24
336	Reveal Media Ltd	revealmedia-006	2022-01-26
337	Rokid Corporation	rokid-000	2019-08-01
338	Rokid Corporation	rokid-001	2019-12-13
339	Saffe	saffe-002	2019-03-01
340	Samsung S1 Corp	s1-001	2019-12-06
341	Samsung S1 Corp	s1-002	2021-03-24
342	Samsung S1 Corp	s1-003	2021-08-24
343	Samsung S1 Corp	s1-004	2022-01-04
344	Samsung-SDS	samsungsds-000	2021-10-28
345	Satellite Innovation/Eocortex	eocortex-000	2020-08-26

Table 10. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
346	Scanovate	scanovate-001	2019-11-12
347	Scanovate	scanovate-002	2020-06-26
348	Scanovate	scanovate-003	2021-11-15
349	Securif AI	securifai-001	2020-10-06
350	Securif AI	securifai-002	2021-03-19
351	Securif AI	securifai-003	2021-08-03
352	Securif AI	securifai-004	2021-12-21
353	Sensetime Group	sensetime-004	2020-11-20
354	Sensetime Group	sensetime-005	2021-05-24
355	Sensetime Group	sensetime-006	2021-12-28
356	Seventh Sense Artificial Intelligence	seventhsense-000	2021-06-29
357	Shanghai Jiao Tong University	sjtu-002	2020-02-12
358	Shanghai Jiao Tong University	sjtu-003	2020-11-02
359	Shanghai Jiao Tong University	sjtu-004	2021-05-13
360	Shanghai Ulucu Electronics Technology	uluface-002	2019-07-10
361	Shanghai University - Shanghai Film Academy	shu-002	2019-12-10
362	Shanghai University - Shanghai Film Academy	shu-003	2020-06-24
363	Shenzhen AiMall Tech	aimall-002	2020-03-12
364	Shenzhen AiMall Tech	aimall-003	2020-08-12
365	Shenzhen Inst Adv Integrated Tech CAS	siat-005	2022-02-08
366	Shenzhen Intellifusion Technologies	intellifusion-001	2019-08-22
367	Shenzhen Intellifusion Technologies	intellifusion-002	2020-03-18
368	Shenzhen University-Macau University of Science and Technology	sztu-000	2020-12-17
369	Shenzhen University-Macau University of Science and Technology	sztu-001	2021-07-13
370	SK Telecom	sktelecom-000	2021-07-09
371	Smart Engines	smartengines-000	2021-08-25
372	Smilart	smilart-003	2019-03-01
373	Sodec App Inc	sodec-000	2021-06-02
374	SQIsoft	sqisoft-001	2021-07-27
375	SQIsoft	sqisoft-002	2021-11-03
376	Staqu Technologies	staqu-000	2020-07-15
377	Star Hybrid Limited	starhybrid-001	2019-06-19
378	Su Zhou NaZhiTianDi intelligent technology	nazhi-000	2020-06-25
379	Sukshi Technology Innovation	sukshi-000	2022-02-13
380	Suprema AI Inc	suprema-000	2021-03-31
381	Suprema AI Inc	suprema-001	2021-09-23
382	Suprema AI Inc	suprema-002	2022-02-11
383	Suprema ID Inc	supremaid-001	2021-05-04
384	Synology Inc	synology-000	2019-10-23
385	Synology Inc	synology-001	2020-02-26
386	Synology Inc	synology-002	2020-08-20
387	T4iSB	t4isb-000	2022-01-28
388	Taiwan AI Labs	ailabs-001	2019-12-18
389	Taiwan-Certificate Authority Incorporation	twface-000	2021-05-14
390	Taiwan-Certificate Authority Incorporation	twface-001	2021-09-14

Table 11. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
391	Tech5 SA	tech5-003	2019-08-19
392	Tech5 SA	tech5-004	2020-03-09
393	Tech5 SA	tech5-005	2020-07-24
394	Techsign	techsign-000	2021-08-25
395	Tencent Deepsea Lab	deepsea-001	2019-06-03
396	Tevian	tevia-005	2019-09-21
397	Tevian	tevia-006	2020-09-11
398	Tevian	tevia-007	2021-08-06
399	Tevian	tevia-008	2021-12-06
400	TigerIT Americas LLC	tiger-004	2020-12-01
401	TigerIT Americas LLC	tiger-005	2021-07-29
402	TigerIT Americas LLC	tiger-006	2021-12-13
403	Tinkoff Bank	tinkoff-001	2021-05-13
404	Toppan ID Gate	toppanidgate-000	2021-09-28
405	Toshiba	toshiba-004	2021-09-27
406	Toshiba	toshiba-005	2022-02-09
407	Tripleize	aize-001	2021-04-23
408	Tripleize	aize-002	2021-10-08
409	TuringTech.vip	turingtechvip-001	2022-02-03
410	Unissey	unissey-001	2021-11-29
411	Universidade de Coimbra	visteam-000	2020-01-14
412	Universidade de Coimbra	visteam-001	2021-03-16
413	Universidade de Coimbra	visteam-002	2021-08-20
414	Universidade de Coimbra	visteam-003	2022-01-31
415	Veridas Digital Authentication Solutions S.L.	veridas-003	2019-11-27
416	Veridas Digital Authentication Solutions S.L.	veridas-004	2020-07-21
417	Veridas Digital Authentication Solutions S.L.	veridas-005	2020-12-15
418	Veridas Digital Authentication Solutions S.L.	veridas-006	2021-04-15
419	Veridas Digital Authentication Solutions S.L.	veridas-007	2021-09-02
420	Verigram	verigram-000	2021-09-06
421	Verihubs	verihubs-inteligensia-000	2021-07-27
422	Via Technologies Inc	via-000	2019-07-08
423	Via Technologies Inc	via-001	2020-01-08
424	Videmo Intelligente Videoanalyse	videmo-000	2019-12-19
425	Videmo Intelligente Videoanalyse	videmo-001	2021-12-22
426	Videonetics Technology Pvt	videonetics-001	2019-06-19
427	Videonetics Technology Pvt	videonetics-002	2019-11-21
428	Vietnam Posts and Telecommunications Group	vnpt-001	2021-01-08
429	Vietnam Posts and Telecommunications Group	vnpt-002	2021-06-08
430	Vietnam Posts and Telecommunications Group	vnpt-003	2021-12-01
431	Viettel Group	vts-000	2020-11-04
432	Viettel High Technology	viettelhightech-000	2021-08-04
433	Vigilant Solutions	vigilantsolutions-007	2019-06-27
434	Vigilant Solutions	vigilantsolutions-008	2020-08-03
435	Vigilant Solutions	vigilantsolutions-009	2020-12-07

Table 12. List of algorithms included in this report.

	Developer	Algorithm	Submission Date
436	Vigilant Solutions	vigilantsolutions-010	2021-04-07
437	Vigilant Solutions	vigilantsolutions-011	2021-08-07
438	VinAI Research VietNam	vinai-000	2020-09-24
439	VinBigData	vinbigdata-001	2022-01-06
440	Visage Technologies	visage-000	2020-12-09
441	Visidon	vd-002	2021-04-12
442	Visidon	vd-003	2021-10-12
443	Vision Intelligence Center of Meituan	meituan-000	2021-05-14
444	Vision-Box	visionbox-000	2019-02-26
445	Vision-Box	visionbox-001	2019-03-01
446	Vision-Box	visionbox-002	2021-04-29
447	VisionLabs	visionlabs-008	2020-01-06
448	VisionLabs	visionlabs-009	2020-07-27
449	VisionLabs	visionlabs-010	2021-01-25
450	VisionLabs	visionlabs-011	2021-10-13
451	Vixvizon	imagus-000	2019-06-19
452	Vixvizon	imagus-002	2020-12-31
453	Vixvizon	imagus-003	2021-05-18
454	Vixvizon	imagus-004	2021-09-20
455	Vocord	vocord-007	2019-06-06
456	Vocord	vocord-008	2020-01-31
457	Vocord	vocord-009	2020-12-28
458	Vocord	vocord-010	2021-12-20
459	Winsense	winsense-000	2019-06-17
460	Winsense	winsense-001	2019-10-16
461	Winsense	winsense-002	2020-11-20
462	Wuhan Tianyu Information Industry	wuhantianyu-001	2021-08-05
463	X-Laboratory	x-laboratory-000	2019-09-03
464	X-Laboratory	x-laboratory-001	2020-01-21
465	Xforward AI Technology	xforwardai-000	2020-02-06
466	Xforward AI Technology	xforwardai-001	2020-09-25
467	Xforward AI Technology	xforwardai-002	2021-02-10
468	Xiamen University	xm-000	2020-10-19
469	YooniK	yoonik-000	2020-06-24
470	YooniK	yoonik-001	2020-10-26
471	YooniK	yoonik-002	2021-09-06
472	YooniK	yoonik-003	2022-01-06
473	Yuan High-Tech Development	yuan-000	2020-06-30
474	Yuan High-Tech Development	yuan-001	2021-01-08
475	Yuan High-Tech Development	yuan-002	2021-05-17
476	Yuan High-Tech Development	yuan-003	2021-09-17
477	Yuan High-Tech Development	yuan-004	2022-01-14
478	Yuntu Data and Technology	ytu-000	2021-06-16

Table 13. List of algorithms included in this report.

4. Results

This section includes accuracy results for 478 one-to-one comparison algorithms submitted to FRVT during the period 2019 to mid February 2022. The algorithms are listed in section 3. We do not include speed and computational resource requirements - they are given on the [webpage](#) and in Table 1 of the FRVT [report](#). This section includes the discussion below and the results tables that follow.

Tables 14-27 show for each algorithm; its submission date, its overall false non-match rate (FNMR) on mugshot images (to show capability of the algorithm), the failure-to-enroll rate (FTE) and then false match rates for the two datasets. For Twins Days images, false match rates are included for three sets of twins (identical, and same- and different-sex fraternal). For twins images collected in immigration, a single false match rate is provided for the mixed population of identical and same-sex fraternal twins. In all cases, FMR is computed as the proportion of comparisons yielding a score at or above threshold. The threshold is obtained from a set of non-twins non-mate mugshot comparisons at that value which gives a FMR of 0.0001. In those separate comparisons, mugshot¹ FNMR is used as the control for Twins Days data, both data are full frontal image type. We adopt FNMR from comparisons of border control images² with visa like images as a control for immigration-related twins data. This allows consideration of the accuracy of algorithms. The table also includes FNMR values from mugshot and visa-border data.

The notable results are:

- ▷ **High FMR in identical twins:** In the sixth column, the identical twins FMR values are typically above 0.99 meaning almost a complete ability of a twin to be an impostor for their twin sibling. Those not above 0.99 fall into two categories: First, those³ that do not extract features from many or all images (i.e. FTE is high); and second, those⁴ that do not match any pairs (always producing low scores, so FMR is low and FNMR is high). Some of these issues arise because the algorithms do not process large images (of the size used here).
- ▷ **Few algorithms with lower FMR on identical twins:** There are some algorithms, that are generally accurate and do correctly not match some identical twins as the same person. We define these as giving $FNMR \leq 0.02$, $FTE \leq 0.02$, and $FMR \leq 0.7$ on identical twins. These include aigen-001 and aigen-002, beyneai-000, glory-004, mobai-000, and iqface-001. The identical-twin false match rates are, at best, 0.475 for aigen-002, correctly not to match about half of identical twins as their siblings.

¹Mugshot - [FRVT report-section 2.4](#)

²Border crossing - [FRVT report-section 2.3](#)

³For example, glory-002, glory-003, id3-007, and s1-001.

⁴For example, acisw-007, facex-001, cybercore-001, csc-001, chosun-000, moreidian-000, videonetics-001.

Such FMR values are far higher than nominal ($FMR = 0.0001$) but somewhat below the 0.98 and 0.99 values that occur for most algorithms.

- ▷ **Algorithm-specific results:** There are individual algorithm plots of comparison score distributions by match types and age groups for both datasets (ex: Figure 1). The plots will be of primary interest to algorithm developers and end-users of those algorithms. Please refer to the algorithm report cards that are linked in the accuracy summary tables 14-27 by clicking on the algorithm name.
 - **Twins Days data similarity scores by match types:** The density plot has a red vertical line at a fixed threshold. The threshold is calibrated to give $FMR = 0.0001$ from the FRVT 1:1 mugshot comparisons. The mugshot scores distribution in light blue represents the control scores. Algorithms with non-mated twin similarity scores to the right of threshold line authenticating the twin siblings as the same person. The threshold can be adjusted so that algorithms do not match the twin siblings; however, in a normal operational environment, it would caused the general population to fail authentication (increased false non-match error).
 - **Immigration-related data similarity scores by match types:** The density plot has a red vertical line at a fixed threshold. The threshold is calibrated to give $FMR = 0.0001$ from the FRVT 1:1 visa-border comparisons. The visa-border scores distribution in light blue represents the control scores for immigration-related data. Similarity scores to the right of the threshold line for the same-sex twins are authenticating the twins as the same person.
 - **Twins Days data similarity scores by age groups:** The plot has a red horizontal line, that is a fixed threshold calibrated to give $FMR = 0.0001$ from the FRVT 1:1 mugshot comparisons. Many algorithms show a decline in similarity scores in older age groups, but scores are still above the threshold to match the twins siblings as the same person.
 - **Immigration-related data similarity scores by age groups:** The plot has a red horizontal line, that is a fixed threshold calibrated to give $FMR = 0.0001$ from the visa-border comparisons. Most algorithms don't show any decline or change in similarity scores in the older age groups.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
1	20face-000	2021-04-12	0.0767	0.000	0.969	0.609	0.000	0.0301	0.000	0.639
2	20face-001	2021-09-29	0.0614	0.000	0.959	0.609	0.000	0.0130	0.000	0.701
3	3divi-004	2019-07-22	0.0068	0.000	0.990	0.728	0.000	0.0109	0.004	0.749
4	3divi-005	2020-08-28	0.0049	0.000	0.990	0.721	0.015	0.0064	0.000	0.746
5	3divi-006	2021-04-14	0.0033	0.000	0.991	0.739	0.007	0.0046	0.000	0.773
6	3divi-007	2021-09-27	0.0026	0.000	0.996	0.797	0.015	0.0039	0.000	0.827
7	acer-000	2020-01-08	0.2356	0.000	0.929	0.543	0.000	0.1516	0.001	0.503
8	acer-001	2020-06-30	0.0102	0.000	0.989	0.656	0.000	0.0122	0.000	0.701
9	acer-002	2021-11-10	0.0055	0.000	0.994	0.710	0.000	0.0059	0.000	0.756
10	acisw-003	2020-08-03	0.5831	0.000	0.715	0.471	0.000	0.4934	0.000	0.273
11	acisw-006	2021-02-25	0.3828	0.000	0.830	0.514	0.000	0.3840	0.000	0.253
12	acisw-007	2021-11-15	0.7157	0.000	0.622	0.351	0.000	0.4858	0.000	0.252
13	adera-002	2021-02-16	0.0036	0.000	0.993	0.793	0.000	0.0066	0.000	0.808
14	adera-003	2021-07-12	0.0031	0.000	0.995	0.739	0.000	0.0062	0.000	0.795
15	advance-002	2019-12-19	0.0043	0.000	0.993	0.732	0.000	0.0293	0.000	0.718
16	advance-003	2021-08-05	0.0038	0.000	0.993	0.728	0.000	0.0350	0.000	0.705
17	afisbiometrics-000	2022-01-27	0.0023	0.000	0.991	0.728	0.007	0.0025	0.000	0.790
18	aifirst-001	2019-11-21	0.0057	0.000	0.989	0.692	0.044	0.0054	0.000	0.749
19	aigen-001	2020-10-06	0.0092	0.000	0.493	0.377	0.022	0.0121	0.000	0.726
20	aigen-002	2021-04-09	0.0137	0.000	0.475	0.359	0.088	0.0164	0.000	0.720
21	ailabs-001	2019-12-18	0.0105	0.008	0.972	0.678	0.000	0.0189	0.004	0.733
22	aimall-002	2020-03-12	0.0098	0.000	0.989	0.670	0.000	0.0093	0.003	0.724
23	aimall-003	2020-08-12	0.0029	0.000	0.994	0.786	0.110	0.0039	0.000	0.803
24	aiunionface-000	2019-10-22	0.0055	0.000	0.990	0.699	0.015	0.0071	0.000	0.747
25	aize-001	2021-04-23	0.0114	0.000	0.988	0.674	0.029	0.0155	0.004	0.709
26	aize-002	2021-10-08	0.0133	0.157	0.245	0.112	0.081	0.0175	0.000	0.689
27	ajou-001	2021-03-08	0.0038	0.000	0.995	0.717	0.000	0.0076	0.000	0.780
28	alchera-000	2019-03-01	0.0070	0.000	0.991	0.710	0.000	0.0104	0.003	0.741
29	alchera-001	2019-03-01	0.0077	0.000	0.990	0.656	0.000	0.0111	0.003	0.729
30	alchera-002	2021-03-05	0.0054	0.000	0.994	0.736	0.029	0.0088	0.000	0.784
31	alchera-003	2021-07-15	0.0027	0.000	0.995	0.736	0.007	0.0031	0.001	0.822
32	alfabeta-001	2021-12-02	0.5116	0.000	0.566	0.217	0.000	0.4714	0.051	0.230
33	alice-000	2021-06-15	0.0064	0.000	0.991	0.714	0.029	0.0054	0.000	0.746
34	alleyes-000	2020-03-09	0.0034	0.000	0.992	0.688	0.000	0.0033	0.000	0.764
35	allgovision-000	2019-03-01	0.0150	0.001	0.977	0.678	0.015	0.0190	0.004	0.705

Table 14. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
36	alphaface-001	2019-09-03	0.0025	0.000	0.994	0.728	0.000	0.0041	0.000	0.771
37	alphaface-002	2020-02-20	0.0023	0.000	0.992	0.768	0.015	0.9999	0.000	0.945
38	androvideo-000	2021-01-25	0.0141	0.000	0.990	0.667	0.029	0.0266	0.000	0.685
39	anke-004	2019-06-27	0.0045	0.000	0.991	0.692	0.000	0.0047	0.001	0.749
40	anke-005	2019-12-09	0.0035	0.000	0.990	0.728	0.000	0.0043	0.001	0.771
41	antheus-000	2019-12-05	0.5297	0.000	0.653	0.275	0.000	0.4975	0.000	0.271
42	antheus-001	2020-06-25	0.2996	0.000	0.775	0.417	0.000	0.3802	0.000	0.325
43	anyvision-005	2021-02-03	0.0023	0.000	0.995	0.790	0.000	0.0032	0.000	0.801
44	armatura-001	2022-01-04	0.0028	0.000	0.995	0.775	0.051	0.0045	0.001	0.822
45	asusaics-000	2019-10-24	0.0052	0.000	0.991	0.678	0.029	0.0066	0.000	0.727
46	asusaics-001	2020-02-25	0.0052	0.000	0.991	0.678	0.029	0.0066	0.000	0.727
47	authenmetric-002	2021-03-10	0.0053	0.000	0.991	0.736	0.000	0.0097	0.000	0.769
48	authenmetric-003	2021-08-09	0.0032	0.000	0.995	0.703	0.022	0.0077	0.000	0.801
49	authenmetric-004	2022-01-03	0.0029	0.000	0.993	0.736	0.029	0.0071	0.000	0.811
50	aware-004	2019-03-01	0.0365	0.000	0.988	0.696	0.029	0.0275	0.001	0.680
51	aware-005	2020-02-27	0.0259	0.000	0.988	0.696	0.029	0.0149	0.000	0.743
52	aware-006	2021-07-16	0.0226	0.000	0.991	0.703	0.029	0.0221	0.000	0.746
53	awiros-001	2019-09-27	0.4107	0.175	0.599	0.406	0.007	0.0766	0.063	0.534
54	awiros-002	2020-10-28	0.1872	0.000	0.885	0.514	0.000	0.1032	0.017	0.579
55	ayfttech-001	2020-07-06	0.1247	0.035	0.893	0.576	0.000	0.0395	0.002	0.651
56	beethedata-000	2021-07-26	0.0050	0.000	0.994	0.750	0.000	0.0089	0.006	0.760
57	beyneai-000	2022-01-03	0.0080	0.000	0.605	0.478	0.066	0.0106	0.000	0.753
58	biocube-001	2021-09-28	0.5990	0.004	0.728	0.409	0.000	0.4581	0.074	0.228
59	bioidechswiss-000	2019-11-15	0.0054	0.000	0.993	0.714	0.015	0.0038	0.000	0.793
60	bioidechswiss-001	2020-08-28	0.0037	0.000	0.993	0.757	0.022	0.0027	0.000	0.815
61	bioidechswiss-002	2021-02-17	0.0035	0.000	0.994	0.746	0.029	0.0038	0.000	0.816
62	boetech-001	2021-06-22	0.0219	0.001	0.973	0.634	0.000	0.0405	0.054	0.664
63	boetech-002	2021-12-21	0.0090	0.001	0.992	0.745	0.000	0.0365	0.054	0.711
64	bresee-000	2020-08-07	0.9443	0.000	0.052	0.069	0.000	0.9393	0.001	0.016
65	bresee-001	2020-12-30	0.0052	0.000	0.993	0.714	0.029	0.0046	0.001	0.780
66	bresee-002	2021-06-30	0.0058	0.000	0.993	0.739	0.000	0.0109	0.002	0.796
67	camvi-004	2019-07-12	0.0034	0.000	0.996	0.855	0.059	0.0046	0.000	0.785
68	canon-002	2020-12-29	0.0023	0.000	0.992	0.779	0.029	0.0027	0.000	0.804
69	canon-003	2021-09-15	0.0023	0.000	0.996	0.746	0.044	0.0026	0.000	0.821
70	ceiec-002	2019-06-12	0.0095	0.001	0.993	0.750	0.037	0.0234	0.008	0.755

Table 15. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
71	ceiec-003	2020-01-06	0.0050	0.000	0.991	0.728	0.015	0.0122	0.000	0.763
72	ceiec-004	2021-01-18	0.0036	0.000	0.993	0.786	0.000	0.0045	0.000	0.806
73	chosun-000	2020-02-12	0.9475	0.000	0.318	0.163	0.000	0.9466	0.000	0.038
74	chosun-001	2020-07-01	0.0319	0.000	0.960	0.656	0.029	0.0374	0.000	0.671
75	chosun-002	2020-11-25	0.0176	0.000	0.983	0.652	0.000	0.0186	0.000	0.701
76	chtface-002	2019-12-09	0.0054	0.000	0.992	0.710	0.015	0.0071	0.002	0.741
77	chtface-003	2020-06-24	0.0051	0.000	0.992	0.768	0.029	0.0061	0.000	0.751
78	chtface-004	2021-10-08	0.0031	0.000	0.995	0.775	0.029	0.0043	0.000	0.784
79	cib-000	2019-12-11	0.0043	0.000	0.992	0.761	0.044	0.0238	0.000	0.789
80	cib-001	2020-08-05	0.0024	0.000	0.993	0.721	0.029	0.0030	0.000	0.787
81	clearviewai-000	2021-09-22	0.0021	0.000	0.994	0.797	0.015	0.0024	0.000	0.853
82	closeli-001	2021-07-15	0.0028	0.000	0.993	0.772	0.015	0.0039	0.000	0.785
83	cloudwalk-hr-003	2020-09-25	0.0030	0.023	0.909	0.699	0.000	0.0043	0.000	0.797
84	cloudwalk-hr-004	2021-02-10	0.0032	0.000	0.996	0.899	0.125	0.0046	0.000	0.846
85	cloudwalk-mt-000	2019-06-03	0.0043	0.000	0.993	0.699	0.022	0.0051	0.000	0.740
86	cloudwalk-mt-003	2020-12-22	0.0024	0.000	0.996	0.844	0.125	0.0031	0.000	0.846
87	cloudwalk-mt-004	2021-11-09	0.0023	0.000	0.996	0.855	0.125	0.0024	0.000	0.854
88	clova-000	2020-10-21	0.0057	0.000	0.991	0.692	0.000	0.0064	0.002	0.752
89	cogent-005	2020-12-29	0.0056	0.000	0.995	0.851	0.059	0.0058	0.000	0.795
90	cogent-006	2021-07-28	0.0029	0.000	0.995	0.750	0.015	0.0043	0.000	0.790
91	cognitec-002	2021-02-24	0.0058	0.000	0.993	0.725	0.029	0.0104	0.001	0.758
92	cognitec-003	2021-07-30	0.0048	0.000	0.995	0.714	0.029	0.0201	0.001	0.795
93	cognitec-004	2022-02-10	0.0048	0.000	0.994	0.775	0.059	0.0072	0.001	0.793
94	cor-001	2020-09-24	0.0034	0.000	0.991	0.736	0.051	0.0034	0.000	0.765
95	coretech-000	2021-07-12	0.2530	0.000	0.896	0.511	0.000	0.4232	0.000	0.222
96	corsight-001	2021-03-11	0.0026	0.000	0.993	0.783	0.000	0.0025	0.000	0.801
97	corsight-002	2021-09-01	0.0024	0.000	0.993	0.804	0.000	0.0021	0.000	0.797
98	csc-001	2020-11-20	0.9778	0.000	0.402	0.199	0.000	0.9960	0.000	0.021
99	csc-002	2021-03-24	0.0048	0.000	0.990	0.692	0.000	0.0074	0.001	0.776
100	csc-003	2021-08-26	0.0033	0.000	0.993	0.743	0.000	0.0064	0.001	0.810
101	ctbcbank-000	2019-06-28	0.0078	0.000	0.991	0.725	0.015	0.0095	0.005	0.737
102	ctbcbank-001	2019-10-28	0.0082	0.000	0.986	0.728	0.029	0.0085	0.002	0.723
103	cubox-001	2020-12-07	0.0027	0.000	0.996	0.764	0.000	0.0033	0.000	0.789
104	cubox-002	2021-08-24	0.0024	0.000	0.996	0.746	0.022	0.0027	0.000	0.834
105	cudocommunication-001	2021-10-20	0.3892	0.000	0.626	0.337	0.007	0.5427	0.000	0.385

Table 16. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
106	cybercore-000	2020-08-26	0.0718	0.000	0.957	0.620	0.000	0.0579	0.004	0.597
107	cybercore-001	2021-12-23	0.5145	0.000	0.423	0.232	0.000	0.4869	0.000	0.170
108	cyberlink-004	2020-02-27	0.0050	0.000	0.991	0.736	0.015	0.0045	0.000	0.758
109	cyberlink-005	2020-07-31	0.0047	0.000	0.994	0.779	0.015	0.0044	0.000	0.796
110	cyberlink-006	2021-01-08	0.0035	0.000	0.994	0.822	0.029	0.0034	0.000	0.814
111	cyberlink-007	2021-07-16	0.0034	0.000	0.996	0.862	0.044	0.0039	0.000	0.838
112	cyberlink-008	2022-01-07	0.0029	0.000	0.994	0.772	0.000	0.0035	0.000	0.805
113	dahua-005	2020-08-13	0.0026	0.000	0.992	0.743	0.029	0.0028	0.000	0.791
114	dahua-006	2020-12-30	0.0025	0.000	0.993	0.764	0.000	0.0027	0.000	0.804
115	dahua-007	2021-12-20	0.0022	0.000	0.993	0.783	0.029	0.0025	0.000	0.824
116	daon-000	2021-11-03	0.0056	0.000	0.991	0.692	0.000	0.0062	0.000	0.778
117	decat-000	2020-08-18	0.0214	0.000	0.991	0.623	0.000	0.0161	0.002	0.688
118	decat-001	2021-09-27	0.0083	0.000	0.994	0.667	0.000	0.0139	0.000	0.739
119	deepglint-001	2019-06-21	0.0034	0.000	0.846	0.697	0.022	0.0043	0.000	0.802
120	deepglint-002	2019-11-15	0.0027	0.000	0.995	0.848	0.074	0.0037	0.000	0.841
121	deepglint-003	2021-03-03	0.0026	0.000	0.995	0.819	0.059	0.0037	0.000	0.857
122	deepglint-004	2021-09-17	0.0028	0.000	0.992	0.707	0.000	0.0040	0.000	0.814
123	deepsea-001	2019-06-03	0.0090	0.000	0.991	0.721	0.037	0.0085	0.000	0.760
124	deepsense-000	2021-03-19	0.0063	0.000	0.993	0.819	0.044	0.0049	0.000	0.763
125	dermalog-007	2020-11-25	0.0584	0.000	0.982	0.605	0.000	0.0616	0.000	0.660
126	dermalog-008	2021-03-25	0.0054	0.000	0.988	0.681	0.007	0.0096	0.000	0.743
127	dermalog-009	2021-10-06	0.0038	0.000	0.992	0.714	0.037	0.0080	0.000	0.776
128	didiglobalface-001	2019-10-23	0.0024	0.000	0.994	0.768	0.029	0.0037	0.000	0.768
129	digidata-000	2022-02-07	0.1371	0.000	0.971	0.652	0.000	0.0081	0.001	0.731
130	digitalbarriers-002	2019-03-01	0.0363	0.001	0.974	0.649	0.000	0.0179	0.005	0.667
131	dps-000	2021-07-16	0.0100	0.000	0.804	0.764	0.699	0.0074	0.000	0.735
132	dsk-000	2019-06-28	0.2244	0.000	0.921	0.529	0.000	0.1048	0.000	0.494
133	ekin-002	2021-05-04	0.0729	0.000	0.935	0.609	0.000	0.0469	0.000	0.629
134	enface-000	2021-04-09	0.0029	0.000	0.991	0.770	0.000	0.0041	0.000	0.814
135	enface-001	2021-12-17	0.0036	0.000	0.992	0.768	0.000	0.0043	0.000	0.804
136	ecocortex-000	2020-08-26	0.0440	0.005	0.957	0.620	0.007	0.0831	0.042	0.642
137	ercacat-001	2020-07-06	0.0026	0.000	0.992	0.739	0.029	0.0089	0.000	0.792
138	euronovate-001	2021-11-15	0.2802	0.000	0.840	0.420	0.000	0.1725	0.009	0.440
139	everai-paravision-003	2019-07-01	0.0028	0.000	0.993	0.775	0.044	0.0074	0.000	0.809
140	expasoft-000	2020-01-06	0.0129	0.000	0.989	0.678	0.007	0.0440	0.000	0.689

Table 17. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
141	expasoft-001	2020-09-03	0.0118	0.000	0.988	0.638	0.022	0.0426	0.000	0.689
142	expasoft-002	2021-07-26	0.0731	0.000	0.990	0.696	0.015	0.1485	0.000	0.633
143	faceonlive-001	2021-11-23	0.0160	0.000	0.987	0.652	0.000	0.0089	0.001	0.727
144	facesoft-000	2019-07-10	0.0037	0.000	0.991	0.670	0.000	0.0042	0.000	0.791
145	facetag-000	2021-04-02	0.1587	0.000	0.955	0.576	0.007	0.1121	0.000	0.543
146	facetag-001	2021-08-17	0.1700	0.000	0.935	0.576	0.029	0.1429	0.000	0.494
147	facetag-002	2022-01-06	0.0035	0.000	0.991	0.743	0.015	0.0045	0.000	0.752
148	facex-001	2021-03-08	1.0000	0.009	0.000	0.000	0.000	1.0000	0.037	0.000
149	facex-002	2021-08-24	0.0602	0.009	0.956	0.623	0.000	0.0578	0.037	0.624
150	farfaces-001	2021-04-09	0.3707	0.000	0.870	0.540	0.000	0.3885	0.000	0.262
151	fiberhome-nanjing-002	2020-08-10	0.0387	0.000	0.982	0.623	0.000	0.0066	0.000	0.728
152	fiberhome-nanjing-003	2021-03-12	0.0042	0.000	0.992	0.728	0.015	0.0041	0.000	0.765
153	fiberhome-nanjing-004	2021-09-14	0.0025	0.000	0.991	0.707	0.022	0.0027	0.000	0.811
154	fincore-000	2021-06-07	0.0118	0.000	0.985	0.656	0.000	0.0204	0.000	0.679
155	fujitsulab-000	2020-02-04	0.0061	0.000	0.991	0.688	0.022	0.0145	0.004	0.727
156	fujitsulab-001	2020-09-30	0.0067	0.000	0.990	0.678	0.000	0.0053	0.000	0.797
157	fujitsulab-002	2021-02-24	0.0060	0.000	0.994	0.696	0.000	0.0069	0.000	0.766
158	fujitsulab-003	2021-07-12	0.0038	0.000	0.991	0.783	0.015	0.0043	0.000	0.795
159	geo-000	2020-06-29	0.0446	0.000	0.979	0.667	0.029	0.0595	0.000	0.630
160	geo-001	2020-10-30	0.0028	0.000	0.993	0.793	0.000	0.0040	0.000	0.783
161	geo-002	2021-04-01	0.0026	0.000	0.995	0.696	0.000	0.0035	0.000	0.816
162	geo-003	2021-09-15	0.0087	0.000	0.991	0.670	0.000	0.0064	0.000	0.722
163	geo-004	2022-02-10	0.0023	0.000	0.994	0.779	0.029	0.0024	0.000	0.832
164	glory-002	2019-11-12	0.0087	1.000	0.000	0.000	0.000	0.0084	0.014	0.740
165	glory-003	2021-01-15	0.0052	0.705	0.098	0.036	0.000	0.0058	0.000	0.740
166	glory-004	2022-02-08	0.0050	0.016	0.497	0.460	0.353	0.0055	0.000	0.745
167	gorilla-004	2019-11-07	0.0104	0.000	0.991	0.685	0.029	0.0074	0.000	0.715
168	gorilla-005	2020-03-11	0.0060	0.000	0.990	0.656	0.029	0.0065	0.000	0.715
169	gorilla-006	2020-07-31	0.0050	0.000	0.990	0.710	0.000	0.0054	0.000	0.739
170	gorilla-007	2021-06-28	0.0034	0.000	0.990	0.710	0.000	0.0042	0.000	0.747
171	gorilla-008	2021-11-08	0.0029	0.000	0.991	0.721	0.000	0.0039	0.000	0.750
172	graymatics-001	2022-01-28	0.0586	0.000	0.448	0.351	0.346	0.0750	0.000	0.626
173	griaule-000	2021-08-20	0.0036	0.000	0.991	0.750	0.029	0.0129	0.003	0.752
174	hertasecurity-000	2021-01-05	0.0229	0.000	0.990	0.649	0.000	0.0341	0.016	0.710
175	hertasecurity-001	2022-01-18	0.0065	0.000	0.994	0.793	0.000	0.0165	0.000	0.738

Table 18. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
176	hik-001	2019-03-01	0.0053	0.000	0.993	0.804	0.029	0.0051	0.000	0.801
177	hisign-001	2021-09-30	0.0027	0.000	0.991	0.754	0.015	0.0063	0.000	0.808
178	hyperverge-001	2020-12-13	1.0000	0.000	0.000	0.000	0.000	1.0000	0.005	0.000
179	hyperverge-002	2021-05-27	0.0026	0.000	0.991	0.699	0.015	0.0032	0.000	0.793
180	hzailu-001	2022-01-27	0.0049	0.000	0.991	0.696	0.000	0.0040	0.000	0.784
181	icm-002	2020-11-13	0.0073	0.000	0.990	0.688	0.000	0.0108	0.000	0.731
182	icm-003	2021-09-06	0.0070	0.000	0.989	0.670	0.000	0.0103	0.000	0.738
183	icthtc-000	2020-11-13	0.0119	0.059	0.905	0.681	0.000	0.0151	0.004	0.721
184	id3-005	2020-08-04	0.0048	0.000	0.989	0.681	0.015	0.0121	0.002	0.735
185	id3-006	2020-12-17	0.0034	0.000	0.992	0.721	0.000	0.0051	0.000	0.757
186	id3-007	2021-05-19	0.0049	0.620	0.156	0.091	0.000	0.0247	0.001	0.664
187	id3-008	2021-11-10	0.0026	0.000	0.992	0.757	0.015	0.0063	0.000	0.792
188	idemia-005	2019-10-11	0.0057	0.000	0.995	0.714	0.029	0.0064	0.000	0.740
189	idemia-006	2020-07-06	0.0033	0.000	0.991	0.717	0.044	0.0036	0.000	0.791
190	idemia-007	2020-12-04	0.0028	0.000	0.995	0.815	0.088	0.0029	0.000	0.825
191	idemia-008	2021-07-07	0.0022	0.000	0.996	0.783	0.059	0.0025	0.000	0.845
192	iit-001	2019-07-05	0.0067	0.000	0.989	0.692	0.000	0.1141	0.060	0.604
193	iit-002	2019-12-04	0.0052	0.001	0.988	0.652	0.022	0.0117	0.002	0.732
194	iit-003	2020-12-01	0.0033	0.000	0.991	0.710	0.029	0.0060	0.000	0.776
195	imperial-000	2019-03-01	0.0047	0.000	0.990	0.685	0.000	0.0043	0.000	0.769
196	imperial-002	2019-08-28	0.0036	0.000	0.991	0.725	0.000	0.0042	0.000	0.790
197	incode-005	2019-10-17	0.0071	0.000	0.984	0.641	0.000	0.0065	0.000	0.723
198	incode-006	2020-02-20	0.0048	0.000	0.987	0.620	0.000	0.0050	0.000	0.720
199	incode-007	2020-08-25	0.0032	0.000	0.992	0.714	0.029	0.0038	0.000	0.751
200	incode-008	2021-01-19	0.0030	0.000	0.991	0.692	0.015	0.0031	0.000	0.816
201	incode-009	2021-06-22	0.0026	0.000	0.990	0.761	0.000	0.0029	0.000	0.808
202	incode-010	2021-10-22	0.0024	0.000	0.995	0.757	0.029	0.0028	0.000	0.850
203	innefulabs-000	2020-09-04	0.0056	0.000	0.987	0.692	0.000	0.0120	0.002	0.725
204	innovativetechnologyltd-001	2019-10-22	0.0202	0.000	0.975	0.649	0.000	0.0150	0.004	0.682
205	innovativetechnologyltd-002	2020-02-26	0.0269	0.009	0.962	0.630	0.000	0.0132	0.003	0.676
206	innovatrics-006	2019-08-13	0.0037	0.000	0.991	0.721	0.007	0.0040	0.000	0.748
207	innovatrics-007	2020-08-19	0.0040	0.000	0.993	0.792	0.044	0.0038	0.000	0.762
208	innovatrics-008	2021-12-15	0.0029	0.000	0.993	0.819	0.081	0.0032	0.000	0.821
209	insightface-000	2021-03-17	0.0026	0.000	0.993	0.837	0.059	0.0032	0.000	0.872
210	insightface-001	2021-09-27	0.0026	0.000	0.995	0.797	0.059	0.0032	0.000	0.844

Table 19. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
211	insightface-002	2022-01-31	0.0026	0.000	0.995	0.819	0.029	0.0032	0.000	0.849
212	intellicloudai-001	2019-08-13	0.0055	0.000	0.990	0.630	0.000	0.0063	0.000	0.739
213	intellicloudai-002	2020-12-17	0.0046	0.000	0.992	0.696	0.029	0.0069	0.000	0.779
214	intellifusion-001	2019-08-22	0.0041	0.000	0.994	0.848	0.074	0.0059	0.000	0.779
215	intellifusion-002	2020-03-18	0.0028	0.000	0.996	0.826	0.037	0.0042	0.000	0.776
216	intellivision-002	2019-08-23	0.0275	0.001	0.987	0.681	0.022	0.0270	0.006	0.694
217	intelresearch-000	2019-07-31	0.0141	0.000	0.987	0.645	0.000	0.0137	0.000	0.712
218	intelresearch-001	2020-01-14	0.0065	0.000	0.994	0.667	0.029	0.0164	0.009	0.723
219	intelresearch-003	2021-01-18	0.0028	0.000	0.996	0.743	0.007	0.0061	0.000	0.803
220	intelresearch-004	2021-08-24	0.0026	0.000	0.996	0.743	0.074	0.0032	0.000	0.827
221	intelresearch-005	2022-02-13	0.0024	0.000	0.996	0.801	0.059	0.0030	0.000	0.825
222	intsysmsu-001	2019-10-22	0.9786	0.000	0.010	0.000	0.000	0.9802	0.000	0.019
223	intsysmsu-002	2020-03-12	0.0069	0.000	0.990	0.717	0.000	0.0054	0.000	0.757
224	ionetworks-000	2021-07-20	0.0032	0.000	0.991	0.688	0.044	0.0049	0.000	0.778
225	iqface-000	2019-06-04	0.0052	0.000	0.990	0.667	0.000	0.0107	0.000	0.752
226	iqface-001	2019-12-11	0.0147	0.000	0.687	0.464	0.033	0.0076	0.000	0.764
227	iqface-003	2021-02-23	0.0044	0.000	0.990	0.750	0.029	0.0096	0.007	0.809
228	irex-000	2020-12-17	0.0035	0.000	0.992	0.743	0.000	0.0033	0.000	0.807
229	isap-002	2020-09-01	0.0047	0.000	0.988	0.699	0.007	0.0062	0.000	0.736
230	itmo-006	2019-03-01	0.0078	0.000	0.991	0.688	0.029	0.0122	0.000	0.723
231	itmo-008	2021-11-19	0.0053	0.000	0.991	0.757	0.029	0.0173	0.032	0.781
232	ivacognitive-001	2021-01-29	0.0057	0.000	0.989	0.645	0.000	0.0054	0.000	0.717
233	iws-000	2020-08-12	0.5110	0.000	0.576	0.217	0.000	0.4703	0.039	0.231
234	kacao-002	2019-06-19	0.0306	0.000	0.881	0.554	0.015	0.0166	0.002	0.684
235	kacao-003	2020-02-26	0.0101	0.000	0.988	0.652	0.000	0.0129	0.000	0.731
236	kacao-004	2020-10-28	0.0033	0.000	0.992	0.714	0.000	0.0111	0.000	0.753
237	kacao-005	2021-03-09	0.0026	0.000	0.992	0.746	0.000	0.0058	0.000	0.787
238	kacao-007	2022-01-12	0.0022	0.000	0.991	0.801	0.000	0.0025	0.000	0.834
239	kakaopay-001	2021-07-06	0.0068	0.000	0.988	0.652	0.000	0.0067	0.000	0.730
240	kedacom-000	2019-06-03	0.0098	0.000	0.993	0.783	0.029	0.0380	0.000	0.741
241	kiwitech-000	2021-03-19	0.0045	0.000	0.990	0.746	0.022	0.0037	0.000	0.775
242	kneron-003	2019-07-01	0.0186	0.001	0.988	0.659	0.015	0.0618	0.036	0.649
243	kneron-005	2020-02-21	0.0067	0.000	0.988	0.688	0.015	0.0248	0.034	0.686
244	knowutech-000	2022-02-13	0.0023	0.000	0.992	0.732	0.044	0.0025	0.000	0.810
245	kookmin-001	2020-09-28	0.0213	0.000	0.986	0.663	0.000	0.0216	0.000	0.691

Table 20. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES					IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX	VISA-BORDER	TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
246	kookmin-002	2021-03-05	0.0031	0.000	0.991	0.725	0.007	0.0091	0.000	0.768
247	kuke3d-001	2021-10-28	0.0066	0.000	0.994	0.775	0.051	0.0157	0.000	0.749
248	lemalabs-001	2021-04-13	0.0048	0.000	0.990	0.703	0.022	0.0050	0.000	0.737
249	lineclova-000	2021-04-05	0.0054	0.000	0.990	0.659	0.029	0.0087	0.000	0.731
250	lineclova-001	2021-09-29	0.0023	0.000	0.992	0.703	0.015	0.0035	0.000	0.815
251	lookman-004	2019-06-03	0.0103	0.000	0.993	0.768	0.029	0.0383	0.000	0.729
252	luxand-000	2019-11-13	0.2380	0.000	0.896	0.507	0.000	0.1257	0.000	0.536
253	mantra-000	2021-10-28	0.0048	0.000	0.995	0.710	0.029	0.0071	0.001	0.793
254	maxvision-000	2021-10-27	0.0083	0.000	0.992	0.739	0.000	0.0265	0.000	0.716
255	megvii-003	2021-03-08	0.0058	0.000	0.994	0.750	0.000	0.0026	0.000	0.822
256	megvii-004	2021-11-19	0.0024	0.000	0.994	0.815	0.000	0.0032	0.000	0.869
257	meituan-000	2021-05-14	0.0064	0.000	0.746	0.754	0.610	0.0076	0.000	0.764
258	mendaxiatech-000	2021-09-15	0.0025	0.000	0.996	0.790	0.007	0.0024	0.000	0.851
259	minivision-000	2020-10-28	0.0030	0.000	0.991	0.783	0.000	0.0037	0.000	0.805
260	mobai-000	2020-08-26	0.0165	0.000	0.675	0.507	0.029	0.0169	0.017	0.702
261	mobai-001	2021-02-17	0.0036	0.000	0.991	0.750	0.029	0.0063	0.015	0.781
262	mobbl-000	2021-01-28	0.3798	0.004	0.857	0.511	0.000	0.3294	0.063	0.320
263	mobbl-001	2021-06-16	0.3755	0.000	0.839	0.467	0.000	0.2542	0.003	0.374
264	mobbl-002	2021-12-16	0.6749	0.000	0.672	0.377	0.000	0.9999	0.003	0.005
265	mobipintech-000	2021-11-23	0.0028	0.000	0.992	0.739	0.029	0.0084	0.000	0.765
266	moredian-000	2021-02-24	0.9946	0.000	0.023	0.004	0.000	0.9751	0.000	0.230
267	multimodality-000	2021-10-19	0.0029	0.000	0.992	0.732	0.007	0.0059	0.000	0.810
268	mvision-001	2019-11-12	0.0112	0.000	0.986	0.645	0.000	0.0108	0.000	0.724
269	nazhai-000	2020-06-25	0.0028	0.000	0.991	0.772	0.000	0.0036	0.000	0.803
270	neosystems-001	2021-03-02	0.1714	0.000	0.978	0.678	0.000	0.2259	0.100	0.400
271	neosystems-002	2021-07-03	0.1075	0.000	0.987	0.696	0.015	0.1742	0.000	0.511
272	neosystems-003	2021-11-11	0.0986	0.000	0.971	0.601	0.000	0.2201	0.000	0.576
273	netbridgetech-001	2020-01-08	0.2517	0.000	0.860	0.547	0.000	0.1251	0.000	0.513
274	netbridgetech-002	2020-08-11	0.0044	0.000	0.988	0.681	0.015	0.0059	0.000	0.742
275	neurotechnology-008	2020-01-08	0.0048	0.000	0.991	0.761	0.000	0.0074	0.000	0.744
276	neurotechnology-009	2020-07-07	0.0035	0.000	0.993	0.710	0.000	0.0038	0.000	0.766
277	neurotechnology-010	2020-11-26	0.0034	0.000	0.993	0.714	0.000	0.0034	0.000	0.766
278	neurotechnology-011	2021-03-26	0.0041	0.000	0.993	0.703	0.000	0.0037	0.001	0.769
279	neurotechnology-012	2021-07-26	0.0027	0.000	0.991	0.779	0.029	0.0030	0.000	0.772
280	neurotechnology-013	2022-01-07	0.0022	0.000	0.993	0.728	0.029	0.0023	0.000	0.818

Table 21. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
281	nhn-001	2021-03-15	0.0033	0.000	0.993	0.732	0.015	0.0046	0.000	0.776
282	nhn-002	2021-07-15	0.0035	0.000	0.993	0.721	0.015	0.0082	0.000	0.743
283	nodeflux-002	2019-08-26	0.0122	0.000	0.989	0.641	0.007	0.0368	0.010	0.710
284	notiontag-001	2021-03-04	0.2215	0.000	0.886	0.518	0.000	0.3612	0.000	0.273
285	notiontag-002	2021-09-17	0.0032	0.000	0.992	0.703	0.044	0.0045	0.000	0.779
286	nsensecorp-002	2021-05-06	0.5256	0.002	0.364	0.210	0.000	0.4021	0.013	0.276
287	nsensecorp-003	2021-10-29	0.0115	0.000	0.991	0.750	0.000	0.0051	0.013	0.774
288	ntechlab-007	2019-06-25	0.0041	0.000	0.990	0.728	0.015	0.0040	0.000	0.779
289	ntechlab-008	2020-01-06	0.0030	0.000	0.991	0.688	0.000	0.0028	0.000	0.803
290	ntechlab-009	2020-12-30	0.0032	0.000	0.992	0.764	0.000	0.0252	0.003	0.754
291	ntechlab-010	2021-04-30	0.0022	0.000	0.995	0.775	0.029	0.0023	0.000	0.827
292	ntechlab-011	2021-09-13	0.0022	0.000	0.996	0.761	0.029	0.0022	0.000	0.827
293	ntechlab-012	2022-01-20	0.0021	0.000	0.995	0.797	0.000	0.0020	0.000	0.836
294	omface-000	2021-12-15	0.2059	0.000	0.923	0.525	0.000	0.1264	0.000	0.493
295	omnigarde-000	2021-04-05	0.0443	0.000	0.975	0.641	0.000	0.0304	0.000	0.652
296	omnigarde-001	2021-08-23	0.0080	0.000	0.989	0.678	0.000	0.0061	0.000	0.738
297	omnigarde-002	2022-01-19	0.0023	0.000	0.993	0.761	0.029	0.0026	0.000	0.806
298	openface-001	2021-06-15	0.1724	0.000	0.979	0.627	0.007	0.0714	0.008	0.593
299	oz-001	2020-08-04	0.0066	0.000	0.988	0.732	0.044	0.0110	0.000	0.723
300	oz-002	2021-02-05	0.0079	0.001	0.963	0.967	0.971	0.0086	0.000	0.758
301	oz-003	2021-08-13	0.0036	0.000	0.992	0.721	0.022	0.0053	0.000	0.786
302	oz-004	2021-12-13	0.0026	0.000	0.995	0.790	0.000	0.0068	0.000	0.855
303	papsav1923-001	2021-03-10	0.0042	0.000	0.991	0.696	0.000	0.0052	0.000	0.766
304	papsav1923-002	2022-01-20	0.0023	0.000	0.996	0.801	0.029	0.0042	0.001	0.826
305	paravision-004	2019-12-11	0.0027	0.000	0.994	0.754	0.029	0.0085	0.000	0.855
306	paravision-006	2021-02-01	0.0024	0.000	0.994	0.837	0.088	0.0069	0.000	0.853
307	paravision-008	2021-07-01	0.0022	0.000	0.996	0.822	0.088	0.0030	0.000	0.860
308	paravision-010	2022-02-02	0.0021	0.000	0.995	0.783	0.044	0.0024	0.000	0.858
309	pensees-001	2020-08-17	0.0039	0.000	0.990	0.721	0.000	0.0086	0.000	0.757
310	pixelall-003	2019-10-15	0.0041	0.000	0.991	0.732	0.015	0.0071	0.000	0.756
311	pixelall-004	2020-07-02	0.0040	0.000	0.991	0.743	0.026	0.0066	0.000	0.785
312	pixelall-005	2021-02-05	0.0035	0.000	0.991	0.793	0.015	0.0058	0.000	0.811
313	pixelall-006	2021-06-17	0.0028	0.000	0.993	0.772	0.000	0.0051	0.000	0.822
314	pixelall-007	2021-12-01	0.0032	0.000	0.993	0.739	0.051	0.0050	0.000	0.798
315	psl-003	2019-10-03	0.0036	0.000	0.993	0.793	0.037	0.9999	0.000	0.976

Table 22. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES					IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX	VISA-BORDER	TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
316	psl-004	2020-03-03	0.0026	0.000	0.994	0.790	0.059	0.0045	0.000	0.789
317	psl-005	2020-07-06	0.0025	0.000	0.994	0.779	0.059	0.0043	0.000	0.783
318	psl-006	2020-11-13	0.0025	0.000	0.994	0.830	0.125	0.0141	0.000	0.803
319	psl-007	2021-03-19	0.0024	0.000	0.997	0.855	0.147	0.0036	0.000	0.825
320	psl-008	2021-07-21	0.0022	0.000	0.997	0.855	0.147	0.0023	0.000	0.829
321	psl-009	2021-12-08	0.0021	0.000	0.995	0.848	0.162	0.0021	0.000	0.831
322	ptakuratsatu-000	2020-09-11	0.0046	0.000	0.993	0.768	0.029	0.0041	0.000	0.770
323	pxl-001	2020-06-30	0.0258	0.000	0.980	0.638	0.000	0.0255	0.004	0.667
324	qnap-000	2021-08-09	0.0070	0.000	0.994	0.743	0.000	0.0079	0.000	0.732
325	qnap-001	2021-12-09	0.0065	0.000	0.991	0.688	0.022	0.0068	0.000	0.744
326	quantasoft-003	2021-04-19	0.0038	0.000	0.993	0.750	0.029	0.0043	0.000	0.777
327	rankone-009	2020-06-26	0.0052	0.000	0.993	0.793	0.029	0.0053	0.000	0.777
328	rankone-010	2020-11-05	0.0048	0.000	0.992	0.775	0.000	0.0053	0.000	0.775
329	rankone-011	2021-08-27	0.0028	0.000	0.992	0.833	0.044	0.0035	0.000	0.796
330	rankone-012	2021-12-27	0.0025	0.000	0.993	0.793	0.029	0.0030	0.000	0.801
331	realnetworks-002	2019-02-28	0.0213	0.000	0.983	0.630	0.000	0.0101	0.000	0.746
332	realnetworks-003	2019-06-12	0.0227	0.000	0.982	0.605	0.000	0.0100	0.000	0.746
333	realnetworks-004	2021-04-15	0.0042	0.000	0.992	0.743	0.015	0.0054	0.000	0.771
334	realnetworks-005	2021-09-27	0.0040	0.000	0.993	0.768	0.000	0.0041	0.000	0.764
335	realnetworks-006	2022-02-09	0.0403	0.000	0.761	0.743	0.662	0.0036	0.000	0.781
336	regula-000	2021-04-13	0.0059	0.000	0.991	0.692	0.000	0.0071	0.000	0.775
337	regula-001	2021-12-14	0.0060	0.000	0.992	0.681	0.000	0.0073	0.000	0.786
338	remarkai-001	2019-03-01	0.0062	0.000	0.989	0.696	0.015	0.0074	0.000	0.732
339	remarkai-002	2019-11-21	0.0051	0.000	0.991	0.681	0.044	0.0051	0.000	0.752
340	remarkai-003	2021-06-22	0.0025	0.000	0.993	0.707	0.000	0.0031	0.000	0.792
341	rendip-000	2021-04-21	0.0037	0.000	0.991	0.750	0.029	0.0049	0.001	0.779
342	revealmedia-005	2021-09-24	0.0038	0.000	0.991	0.764	0.029	0.0049	0.000	0.771
343	revealmedia-006	2022-01-26	0.0029	0.000	0.993	0.750	0.015	0.0031	0.000	0.781
344	rokid-000	2019-08-01	0.0054	0.000	0.990	0.725	0.007	0.0097	0.003	0.745
345	rokid-001	2019-12-19	0.0045	0.000	0.992	0.754	0.000	0.0061	0.000	0.748
346	s1-001	2019-12-06	0.0139	0.616	0.191	0.239	0.051	0.0187	0.182	0.522
347	s1-002	2021-03-24	0.0058	0.000	0.991	0.688	0.000	0.0130	0.005	0.745
348	s1-003	2021-08-24	0.0036	0.016	0.964	0.659	0.029	0.0029	0.000	0.799
349	s1-004	2022-01-04	0.0027	0.000	0.991	0.678	0.007	0.0030	0.000	0.792
350	saffe-002	2019-03-01	0.0065	0.000	0.989	0.670	0.007	0.0122	0.000	0.734

Table 23. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
351	samsungds-000	2021-10-28	0.0125	0.000	0.995	0.768	0.000	0.0080	0.001	0.813
352	scanovate-001	2019-11-12	0.0115	0.000	0.991	0.663	0.059	0.2378	0.152	0.586
353	scanovate-002	2020-06-24	0.0067	0.000	0.989	0.656	0.000	0.0066	0.001	0.757
354	scanovate-003	2021-11-15	0.0040	0.000	0.991	0.728	0.000	0.0283	0.016	0.761
355	securifai-001	2020-10-06	0.4018	0.000	0.815	0.440	0.000	0.3116	0.000	0.377
356	securifai-002	2021-03-19	0.2617	0.000	0.827	0.428	0.000	0.7150	0.000	0.105
357	securifai-003	2021-08-03	0.5155	0.000	0.682	0.346	0.000	0.4681	0.000	0.241
358	securifai-004	2021-12-21	0.0039	0.000	0.991	0.699	0.000	0.0049	0.000	0.752
359	senstime-004	2020-11-20	0.0021	0.000	0.995	0.799	0.029	0.0038	0.000	0.824
360	senstime-005	2021-05-24	0.0021	0.000	0.996	0.790	0.029	0.0018	0.000	0.828
361	senstime-006	2021-12-28	0.0021	0.000	0.996	0.812	0.029	0.0017	0.000	0.833
362	sertis-000	2019-10-07	0.0045	0.000	0.990	0.710	0.000	0.0044	0.000	0.752
363	sertis-001	2020-07-30	0.0086	0.001	0.981	0.638	0.000	0.0148	0.000	0.619
364	sertis-002	2021-05-13	0.0027	0.000	0.993	0.739	0.044	0.0029	0.000	0.778
365	seventhsense-000	2021-06-29	0.0030	0.000	0.991	0.739	0.015	0.0054	0.000	0.777
366	shu-002	2019-12-10	0.0063	0.000	0.992	0.732	0.000	0.9998	0.000	0.977
367	shu-003	2020-06-24	0.0032	0.000	0.991	0.757	0.000	0.0039	0.000	0.779
368	siat-005	2022-02-08	0.0054	0.000	0.994	0.793	0.015	0.0574	0.000	0.798
369	sjtu-002	2020-02-12	0.0054	0.000	0.991	0.627	0.000	0.0039	0.000	0.771
370	sjtu-003	2020-11-02	0.0026	0.000	0.993	0.775	0.029	0.0036	0.000	0.798
371	sjtu-004	2021-05-13	0.0024	0.000	0.997	0.870	0.103	0.0033	0.000	0.822
372	sktelecom-000	2021-07-09	0.0023	0.000	0.994	0.714	0.000	0.0029	0.000	0.808
373	smartengines-000	2021-08-25	0.8649	0.000	0.117	0.051	0.000	0.6165	0.006	0.134
374	smilart-003	2019-03-01	0.0294	0.000	0.985	0.623	0.029	0.0266	0.013	0.673
375	sodec-000	2021-06-02	0.0031	0.000	0.992	0.768	0.000	0.0037	0.000	0.809
376	sqisoft-001	2021-07-27	0.0736	0.000	0.937	0.582	0.000	0.0401	0.000	0.615
377	sqisoft-002	2021-11-03	0.0030	0.000	0.991	0.703	0.000	0.0050	0.000	0.763
378	staqu-000	2020-07-15	0.0073	0.000	0.990	0.685	0.007	0.0085	0.000	0.740
379	starhybrid-001	2019-06-19	0.0054	0.000	0.993	0.808	0.059	0.0078	0.002	0.754
380	sukshi-000	2022-02-13	0.2572	0.000	0.964	0.554	0.000	0.4771	0.000	0.256
381	suprema-000	2021-03-31	0.0059	0.000	0.967	0.986	0.787	0.0104	0.000	0.769
382	suprema-001	2021-09-23	0.0030	0.007	0.980	0.739	0.015	0.0045	0.000	0.803
383	suprema-002	2022-02-11	0.0028	0.000	0.993	0.699	0.022	0.0033	0.000	0.814
384	supremaid-001	2021-05-04	0.0031	0.000	0.991	0.725	0.000	0.0066	0.000	0.773
385	synology-000	2019-10-23	0.0074	0.000	0.989	0.710	0.000	0.0081	0.000	0.722

Table 24. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
386	synology-001	2020-02-26	0.0103	0.000	0.989	0.638	0.000	0.0081	0.000	0.721
387	synology-002	2020-08-20	0.0050	0.000	0.990	0.721	0.007	0.0060	0.000	0.738
388	sztu-000	2020-12-20	0.0040	0.000	0.990	0.692	0.000	0.0052	0.000	0.764
389	sztu-001	2021-07-13	0.0023	0.000	0.995	0.764	0.000	0.0043	0.000	0.830
390	t4isb-000	2022-01-28	0.0028	0.000	0.993	0.732	0.000	0.0040	0.000	0.798
391	tech5-003	2019-08-19	0.0050	0.000	0.993	0.728	0.015	0.0059	0.000	0.815
392	tech5-004	2020-03-09	0.0044	0.000	0.993	0.710	0.000	0.0036	0.000	0.810
393	tech5-005	2020-07-24	0.0037	0.000	0.993	0.761	0.022	0.0027	0.000	0.815
394	techsign-000	2021-08-25	0.0205	0.000	0.989	0.638	0.000	0.0404	0.026	0.684
395	tevia-005	2019-09-27	0.0040	0.000	0.991	0.674	0.000	0.0057	0.007	0.815
396	tevia-006	2020-09-11	0.0032	0.000	0.993	0.725	0.000	0.0034	0.000	0.853
397	tevia-007	2021-08-06	0.0025	0.000	0.991	0.779	0.000	0.0037	0.001	0.844
398	tevia-008	2021-12-06	0.0025	0.000	0.990	0.757	0.044	0.0031	0.000	0.848
399	tiger-004	2020-12-01	0.0168	0.000	0.990	0.634	0.000	0.0145	0.001	0.707
400	tiger-005	2021-07-29	0.0102	0.000	0.990	0.670	0.000	0.0141	0.000	0.727
401	tiger-006	2021-12-13	0.0033	0.000	0.993	0.739	0.029	0.0052	0.001	0.771
402	tinkoff-001	2021-07-08	0.0318	0.000	0.963	0.583	0.000	0.0236	0.001	0.588
403	toppanidgate-000	2021-09-29	0.0024	0.000	0.996	0.772	0.029	0.0033	0.001	0.838
404	toshiba-004	2021-09-27	0.0023	0.000	0.995	0.797	0.007	0.0024	0.000	0.825
405	toshiba-005	2022-02-09	0.0022	0.000	0.996	0.808	0.007	0.0064	0.000	0.828
406	turingtechvip-001	2022-02-03	0.0219	0.000	0.979	0.594	0.000	0.3935	0.002	0.372
407	twface-000	2021-05-14	0.0030	0.000	0.992	0.772	0.007	0.0040	0.000	0.788
408	twface-001	2021-09-14	0.0027	0.000	0.993	0.757	0.022	0.0035	0.000	0.804
409	uluface-002	2019-07-10	0.0051	0.000	0.979	0.674	0.029	0.0056	0.000	0.758
410	unissey-001	2021-11-29	0.0097	0.000	0.764	0.750	0.684	0.0068	0.000	0.742
411	upc-001	2019-06-27	0.0119	0.000	0.990	0.761	0.000	0.0107	0.000	0.727
412	vd-002	2021-04-12	0.0270	0.000	0.969	0.659	0.000	0.0255	0.000	0.658
413	vd-003	2021-10-12	0.0094	0.000	0.992	0.750	0.029	0.0080	0.003	0.752
414	veridas-003	2019-11-27	0.0287	0.000	0.981	0.630	0.000	0.0141	0.002	0.698
415	veridas-004	2020-07-21	0.0136	0.000	0.989	0.652	0.000	0.0101	0.002	0.709
416	veridas-005	2020-12-15	0.0122	0.000	0.992	0.714	0.029	0.0143	0.002	0.690
417	veridas-006	2021-04-15	0.0049	0.000	0.989	0.699	0.007	0.0063	0.002	0.742
418	veridas-007	2021-09-02	0.0034	0.000	0.991	0.714	0.022	0.0055	0.002	0.782
419	verigram-000	2021-09-06	0.0027	0.000	0.994	0.772	0.007	0.0083	0.002	0.811
420	verihubs-inteligensia-000	2021-07-27	0.0031	0.000	0.993	0.721	0.007	0.0050	0.001	0.767

Table 25. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
421	via-000	2019-07-08	0.0094	0.000	0.989	0.707	0.029	0.0094	0.000	0.725
422	via-001	2020-01-08	0.0061	0.000	0.989	0.696	0.007	0.0059	0.000	0.735
423	videmo-000	2019-12-19	0.0083	0.000	0.991	0.699	0.015	0.0089	0.014	0.724
424	videmo-001	2021-12-22	0.0091	0.000	0.989	0.638	0.029	0.0202	0.019	0.724
425	videonetics-001	2019-06-19	0.5855	0.000	0.487	0.138	0.000	0.5038	0.023	0.222
426	videonetics-002	2019-11-21	0.4166	0.000	0.766	0.438	0.000	0.3769	0.018	0.274
427	viettelhightech-000	2021-08-04	0.0058	0.000	0.989	0.649	0.000	0.0062	0.001	0.737
428	vigilantsolutions-007	2019-06-27	0.0077	0.000	0.993	0.739	0.029	0.0112	0.001	0.728
429	vigilantsolutions-008	2020-08-03	0.0069	0.000	0.991	0.739	0.000	0.0117	0.001	0.740
430	vigilantsolutions-009	2020-12-07	0.0060	0.000	0.994	0.772	0.000	0.0091	0.001	0.781
431	vigilantsolutions-010	2021-04-07	0.0059	0.000	0.994	0.783	0.029	0.0088	0.001	0.774
432	vigilantsolutions-011	2021-08-07	0.0057	0.000	0.993	0.757	0.000	0.0080	0.001	0.768
433	vinai-000	2020-09-24	0.0028	0.000	0.993	0.681	0.000	0.0041	0.000	0.770
434	vinbigdata-001	2022-01-06	0.0826	0.000	0.540	0.344	0.000	0.0635	0.000	0.606
435	visage-000	2020-12-09	0.0553	0.000	0.961	0.565	0.000	0.0284	0.005	0.634
436	visionbox-000	2019-02-26	0.0105	0.000	0.988	0.696	0.000	0.0115	0.003	0.713
437	visionbox-001	2019-03-01	0.0074	0.000	0.989	0.703	0.000	0.0080	0.003	0.728
438	visionbox-002	2021-04-29	0.0047	0.000	0.993	0.750	0.029	0.0050	0.000	0.780
439	visionlabs-008	2020-01-06	0.0026	0.000	0.995	0.775	0.007	0.0029	0.000	0.793
440	visionlabs-009	2020-07-27	0.0023	0.000	0.995	0.779	0.051	0.0024	0.000	0.810
441	visionlabs-010	2021-01-25	0.0024	0.000	0.996	0.822	0.015	0.0024	0.000	0.811
442	visionlabs-011	2021-10-13	0.0022	0.000	0.996	0.844	0.088	0.0021	0.000	0.826
443	visteam-000	2020-01-14	0.9845	0.000	0.020	0.007	0.000	0.9806	0.003	0.020
444	visteam-001	2021-03-16	0.4269	0.000	0.678	0.370	0.000	0.2090	0.000	0.350
445	visteam-002	2021-08-20	0.0645	0.000	0.951	0.598	0.000	0.0311	0.000	0.634
446	visteam-003	2022-01-31	0.0210	0.000	0.968	0.609	0.000	0.0125	0.000	0.681
447	vixvizion-000	2019-06-19	0.0212	0.041	0.509	0.333	0.000	0.0251	0.005	0.664
448	vixvizion-002	2021-01-08	0.0035	0.000	0.993	0.721	0.029	0.0074	0.001	0.746
449	vixvizion-003	2021-05-18	0.0043	0.000	0.993	0.728	0.037	0.0073	0.000	0.740
450	vixvizion-004	2021-09-20	0.0036	0.000	0.991	0.732	0.029	0.0047	0.000	0.746
451	vnpt-001	2021-01-08	0.3455	0.231	0.659	0.478	0.015	0.3332	0.210	0.439
452	vnpt-002	2021-06-08	0.0110	0.000	0.993	0.728	0.037	0.0338	0.000	0.722
453	vnpt-003	2021-12-01	0.0028	0.000	0.992	0.703	0.007	0.0056	0.000	0.767
454	vocord-007	2019-06-06	0.0041	0.000	0.994	0.757	0.000	0.0498	0.021	0.801
455	vocord-008	2020-01-31	0.0034	0.000	0.995	0.826	0.015	0.0033	0.000	0.828

Table 26. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

	ALGORITHM		MUGSHOT	TWINS DAY IMAGES				VISA-BORDER	IMMIGRATION-RELATED IMAGES	
				TEMPLATES	IDENTICAL TWINS	FRATERNAL SAME-SEX	FRATERNAL DIFF-SEX		TEMPLATES	TWINS
	NAME	SUBMISSION DATE	FNMR	FTE	FMR	FMR	FMR	FNMR	FTE	FMR
456	vocord-009	2020-12-28	0.0030	0.000	0.996	0.826	0.081	0.0041	0.000	0.829
457	vocord-010	2021-12-20	0.0028	0.000	0.995	0.819	0.015	0.0015	0.000	0.836
458	vts-000	2020-11-04	0.0047	0.000	0.990	0.685	0.022	0.0175	0.001	0.712
459	winsense-000	2019-06-17	0.0067	0.000	0.990	0.649	0.000	0.0093	0.000	0.714
460	winsense-001	2019-10-16	0.0045	0.000	0.992	0.775	0.000	0.0040	0.000	0.777
461	winsense-002	2020-11-20	0.0027	0.000	0.991	0.739	0.007	0.0035	0.000	0.787
462	wuhantianyu-001	2021-08-05	0.0098	0.000	0.984	0.612	0.000	0.0152	0.000	0.722
463	x-laboratory-000	2019-09-03	0.0103	0.000	0.991	0.737	0.000	0.0366	0.000	0.744
464	x-laboratory-001	2020-01-21	0.0034	0.000	0.992	0.714	0.029	0.0042	0.001	0.770
465	xforwardai-000	2020-02-06	0.0029	0.000	0.994	0.732	0.000	0.0047	0.000	0.772
466	xforwardai-001	2020-09-25	0.0026	0.000	0.994	0.768	0.029	0.0038	0.000	0.830
467	xforwardai-002	2021-02-10	0.0025	0.000	0.996	0.826	0.059	0.0036	0.000	0.843
468	xm-000	2020-10-19	0.0026	0.000	0.995	0.812	0.051	0.0036	0.000	0.797
469	yoonik-000	2020-06-24	0.0043	0.000	0.990	0.743	0.015	0.0498	0.000	0.656
470	yoonik-001	2020-10-26	0.0032	0.000	0.991	0.710	0.000	0.0276	0.000	0.720
471	yoonik-002	2021-09-06	0.0026	0.000	0.993	0.746	0.029	0.0603	0.000	0.705
472	yoonik-003	2022-01-06	0.0028	0.000	0.991	0.743	0.015	0.0804	0.000	0.684
473	ytu-000	2021-06-16	0.0054	0.000	0.994	0.743	0.000	0.0026	0.000	0.828
474	yuan-000	2020-06-30	0.0044	0.000	0.990	0.670	0.022	0.0106	0.000	0.735
475	yuan-001	2021-01-08	0.0062	0.000	0.991	0.739	0.000	0.0052	0.000	0.742
476	yuan-002	2021-05-17	0.0043	0.000	0.991	0.739	0.022	0.0045	0.000	0.736
477	yuan-003	2021-09-17	0.0039	0.000	0.992	0.732	0.037	0.0045	0.000	0.742
478	yuan-004	2022-01-26	0.0029	0.000	0.990	0.728	0.007	0.0155	0.000	0.752

Table 27. This table summarizes False Match Rate (FMR) on twins probe images. FMR is the proportion of twin comparisons at or above a threshold score set to achieve FMR=1e-04 on FRVT 1:1 Mugshot and Visa-Border images. FRVT 1:1 Mugshot and Visa-Border False Non-Match Rate (FNMR) is included to show the performance of the algorithms when mated comparisons are below a threshold set to achieve the same FMR=1e-04. Mugshot is used as a control for Twins Days data, and Visa-Border is used as a control for Immigration-related data.

References

- [1] Fraternal twins. <https://www.genome.gov/genetics-glossary/Fraternal-Twins>.
- [2] Identical twins. <https://www.genome.gov/genetics-glossary/identical-twins>.
- [3] Nist ongoing face recognition vendor test (frvt) 1:1 verification. <https://pages.nist.gov/frvt/html/frvt11.html>.
- [4] Nist ongoing face recognition vendor test (frvt) accuracy with face masks. https://pages.nist.gov/frvt/html/frvt_facemask.html.
- [5] Nist special publication 500-290: American national standard for information systems - data format for the interchange of fingerprint, facial & other biometric information. NIST Special Publication 500-290. https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=910136#page=96.
- [6] Twins day festival, 2010-2018. <https://twinsdays.org>.
- [7] Joyce A., Martin M.P.H., Michelle J.K., and Osterman M.H.S. Is twin childbearing on the decline? twin births in the united states, 2014-2018, October 2019. <https://www.cdc.gov/nchs/data/databriefs/db351-h.pdf>.
- [8] J. M. Dawson and colleagues. Twins day dataset. The twins data used in this paper was originally collected by J. M. Dawson and colleagues, as described in the paper by J. McCauley, S. Soleymani, B. Williams, N. Nasrabadi, and J. Dawson, "Identical Twins as a Facial Similarity Benchmark for Human Facial Recognition," in Proc. 2021 International Conference of the Biometrics Special Interest Group (BIOSIG 2021), Darmstadt, Germany, Sep. 15-17, 2021, pp. 1-5 (published Sep. 2021). <https://biic.wvu.edu/data-sets/twins-day-dataset-2010-1015>.
- [9] Patrick Grother, Mei Ngan, and Kayee Hanaoka. Still face 1:1 verification application programming interface (api). https://pages.nist.gov/frvt/api/FRVT_ongoing_11_api.pdf.
- [10] Patrick Grother, Mei Ngan, and Kayee Hanaoka. Face recognition vendor test (frvt) part 2: Identification. Interagency Report 8271, National Institute of Standards and Technology, September 2019. <https://nvlpubs.nist.gov/nistpubs/ir/2019/NIST.IR.8271.pdf>.
- [11] M.P.H. Joyce A. Martin, Brady E. Hamilton Ph.D., and Michelle J.K. Osterman M.H.S. Three decades of twin births in the united states, 1980-2009, January 2019. <https://www.cdc.gov/nchs/data/databriefs/db80.pdf#page=5>.
- [12] Shun-Cheung Lai, Minna Kong, Kin-Man Lam, and Dong Li. High-resolution face recognition via deep pore-feature matching. In *2019 IEEE International Conference on Image Processing (ICIP)*, pages 3477–3481, 2019.
- [13] Michelle J.K. Osterman, M.H.S., Ph.D. Brady E. Hamilton, M.P.H. Joyce A. Martin, Anne K. Driscoll, Ph.D., Claudia P. Valenzuela, and Division of Vital Statistics M.P.H. Births: Final data for 2020. Technical Report 17, February 2022. <https://www.cdc.gov/nchs/data/nvsr/nvsr70/nvsr70-17.pdf>.
- [14] P. J. Phillips, P. J. Flynn, K. W. Bowyer, R. W. V. Bruegge, P. J. Grother, G. W. Quinn, and M. Pruitt. Distinguishing identical twins by face recognition. In *2011*

IEEE International Conference on Automatic Face Gesture Recognition (FG), pages 185–192, 2011.