

ArcFace: Additive Angular Margin Loss for Deep Face Recognition

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Outlines

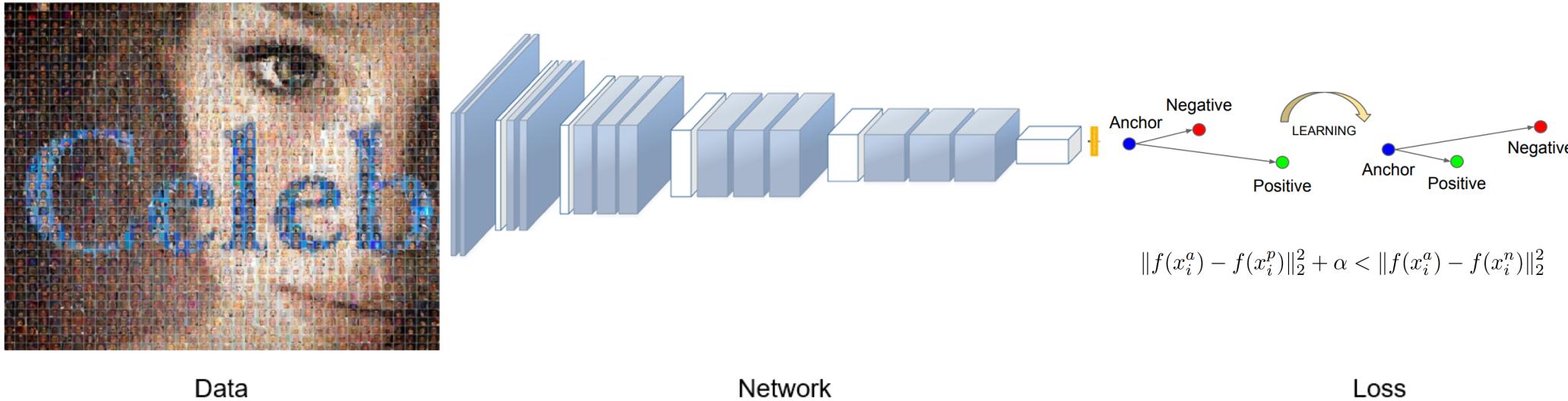
- ArcFace
 - Motivation
 - Method
 - Results
- RetinaFace
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- Image/Video Demo
- FRVT 1:1 Verification
- LFR Challenge/Workshop 2019

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Triplet-Loss

Embedding Target: Intra-class Compactness + Inter-class Discrepancy



Triplet-Loss:

“Margin” is useful

But, Image2image comparison is difficult:

- Combinatorial explosion
- Semi-hard sample mining

Triplet-Loss

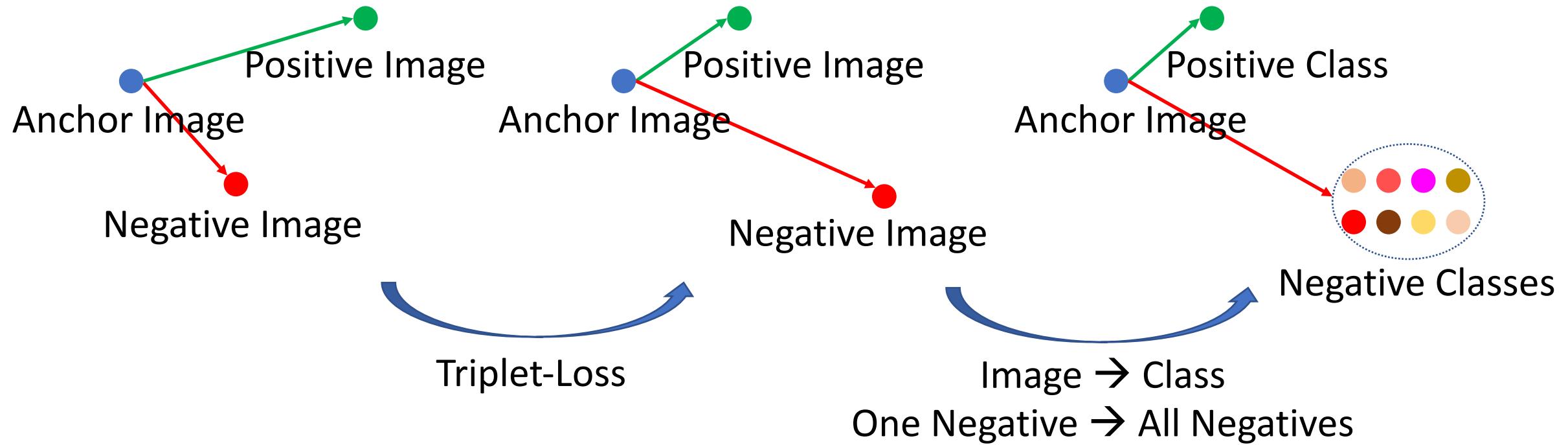
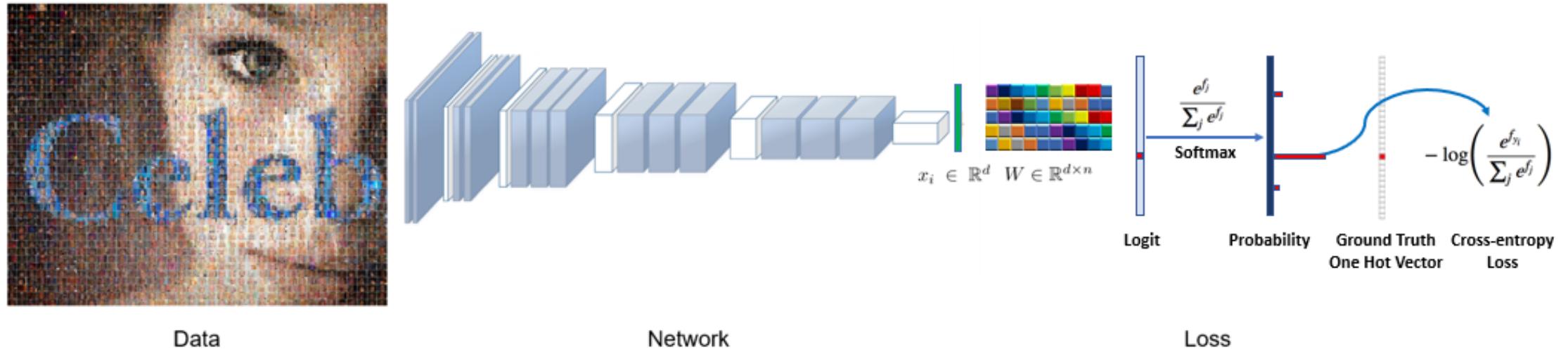


Image2class comparison is easier:

- Class number << Image number
- No semi-hard sample mining (all negative classes are used)

But, online class feature embedding is not efficient.

Softmax-Loss



Softmax-Loss:

Image2class comparison ($W^T x$) is efficient.

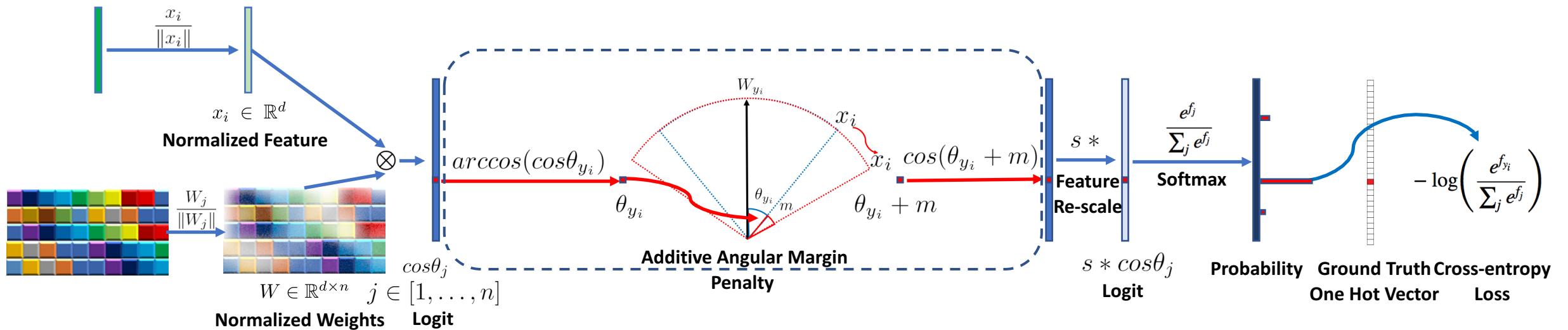
- But, (1) there is no “Margin”;
- (2) W can be very large.

$$L_1 = -\frac{1}{N} \sum_{i=1}^N \log \frac{e^{W_{y_i}^T x_i + b_{y_i}}}{\sum_{j=1}^n e^{W_j^T x_i + b_j}}$$

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ArcFace



Step1: X and W Normalisation

$$L_1 = -\frac{1}{N} \sum_{i=1}^N \log \frac{e^{W_{y_i}^T x_i + b_{y_i}}}{\sum_{j=1}^n e^{W_j^T x_i + b_j}}$$

$$W_j^T x_i = \|W_j\| \|x_i\| \cos\theta_j \quad \longrightarrow \quad L_2 = -\frac{1}{N} \sum_{i=1}^N \log \frac{e^{s \cos\theta_{y_i}}}{e^{s \cos\theta_{y_i}} + \sum_{j=1, j \neq y_i}^n e^{s \cos\theta_j}}$$

Step2: Additive Angular Margin

$$L_3 = -\frac{1}{N} \sum_{i=1}^N \log \frac{e^{s(\cos(\theta_{y_i} + m))}}{e^{s(\cos(\theta_{y_i} + m))} + \sum_{j=1, j \neq y_i}^n e^{s \cos\theta_j}}$$

ArcFace is Easy

Algorithm 1 The Pseudo-code of ArcFace on MxNet

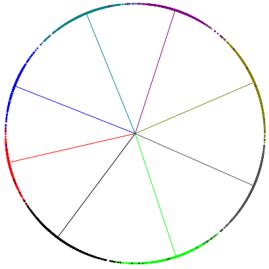
Input: Feature Scale s , Margin Parameter m in Eq. 3, Class Number n , Ground-Truth ID gt .

1. $x = \text{mx.symbol.L2Normalization}(x, \text{mode} = \text{'instance'})$
2. $W = \text{mx.symbol.L2Normalization}(W, \text{mode} = \text{'instance'})$
3. $\text{fc7} = \text{mx.sym.FullyConnected}(\text{data} = x, \text{weight} = W, \text{no_bias} = \text{True}, \text{num_hidden} = n)$
4. $\text{original_target_logit} = \text{mx.sym.pick}(\text{fc7}, gt, \text{axis} = 1)$
5. $\theta = \text{mx.sym.arccos}(\text{original_target_logit})$
6. $\text{marginal_target_logit} = \text{mx.sym.cos}(\theta + m)$
7. $\text{one_hot} = \text{mx.sym.one_hot}(gt, \text{depth} = n, \text{on_value} = 1.0, \text{off_value} = 0.0)$
8. $\text{fc7} = \text{fc7} + \text{mx.sym.broadcast_mul}(\text{one_hot}, \text{mx.sym.expand_dims}(\text{marginal_target_logit} - \text{original_target_logit}, 1))$
9. $\text{fc7} = \text{fc7} * s$

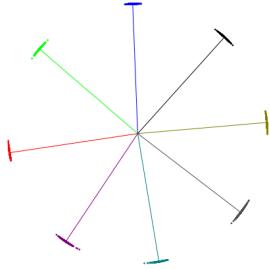
Output: Class-wise affinity score $fc7$.

ArcFace only needs several lines of code.

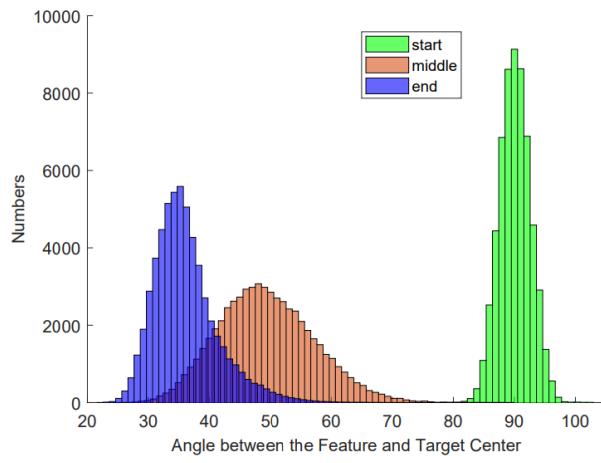
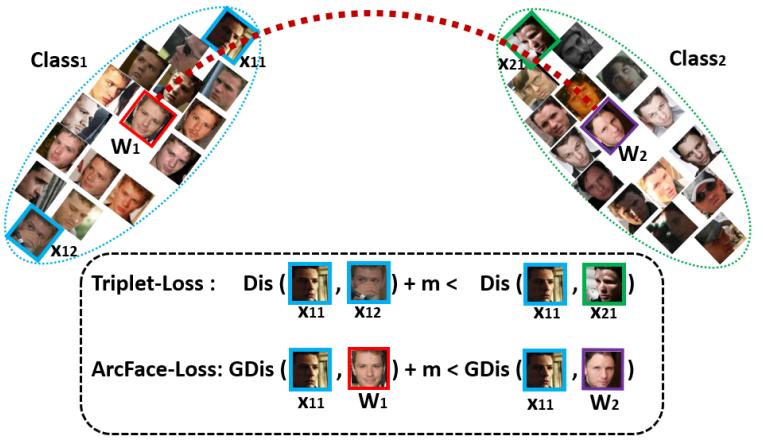
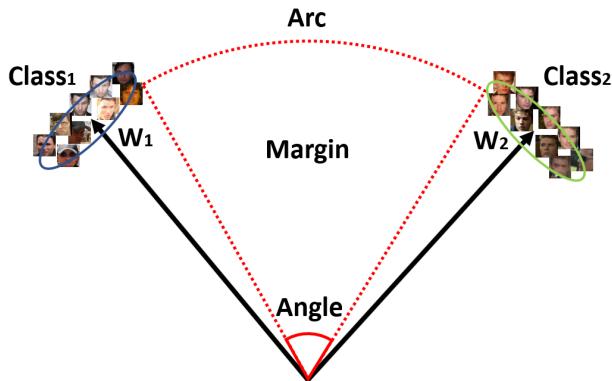
ArcFace is Explicable



Softmax

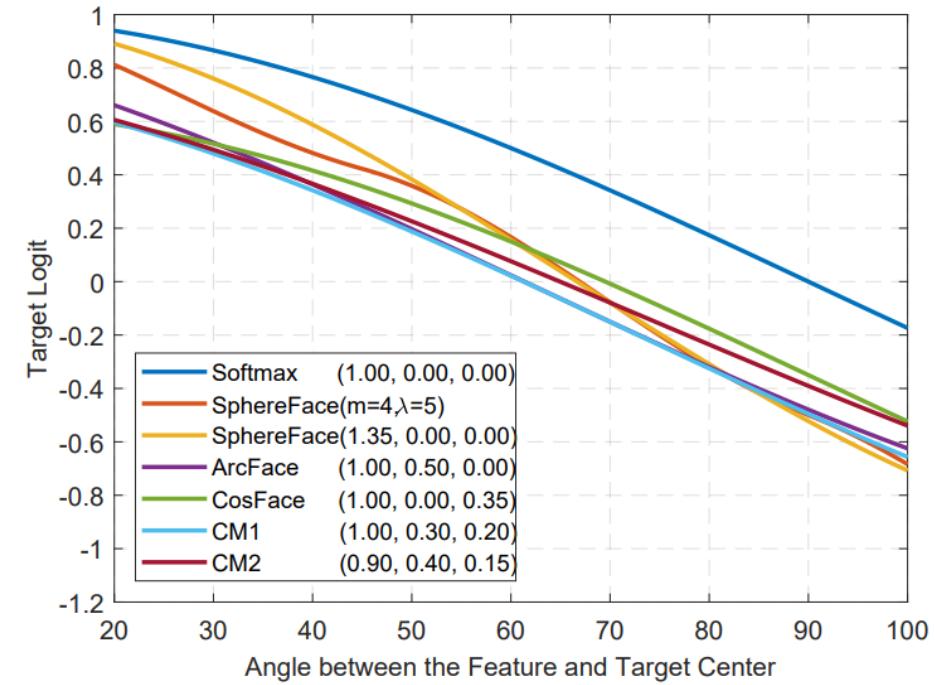
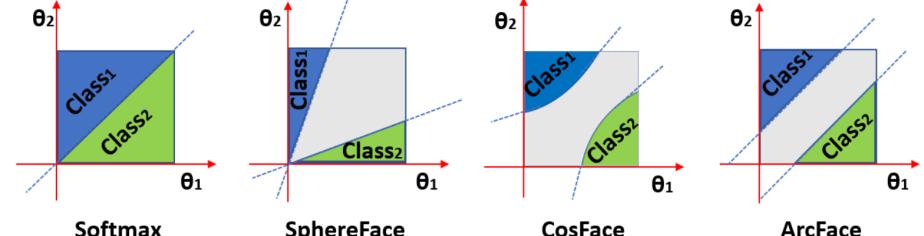


ArcFace

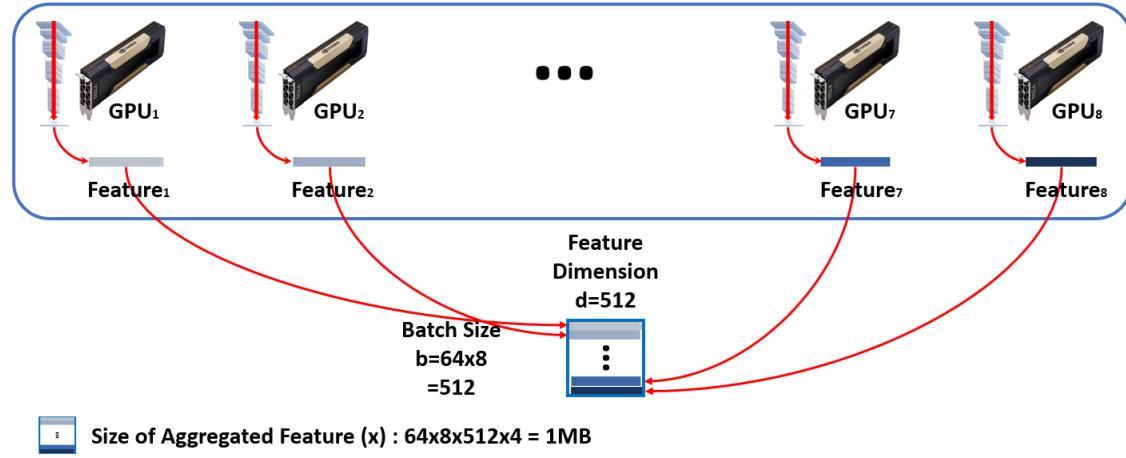


Angle/Arc/Geodesic distance

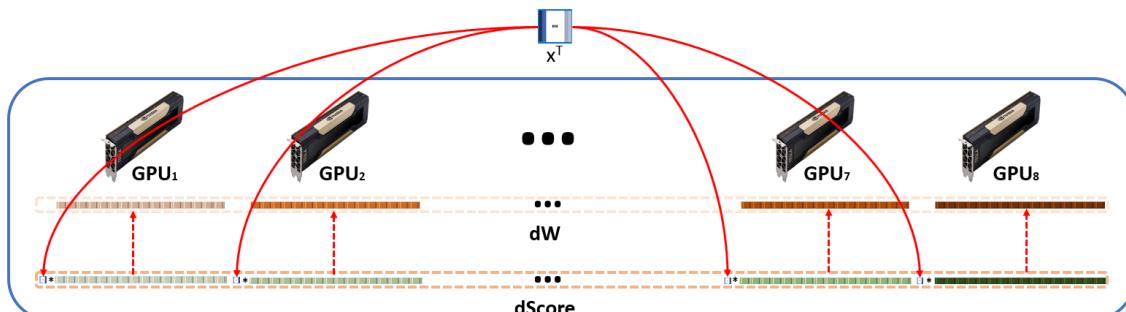
$$L_4 = -\frac{1}{N} \sum_{i=1}^N \log \frac{e^{s(\cos(m_1 \theta_{y_i} + m_2) - m_3)}}{e^{s(\cos(m_1 \theta_{y_i} + m_2) - m_3)} + \sum_{j=1, j \neq y_i}^n e^{s \cos \theta_j}}$$



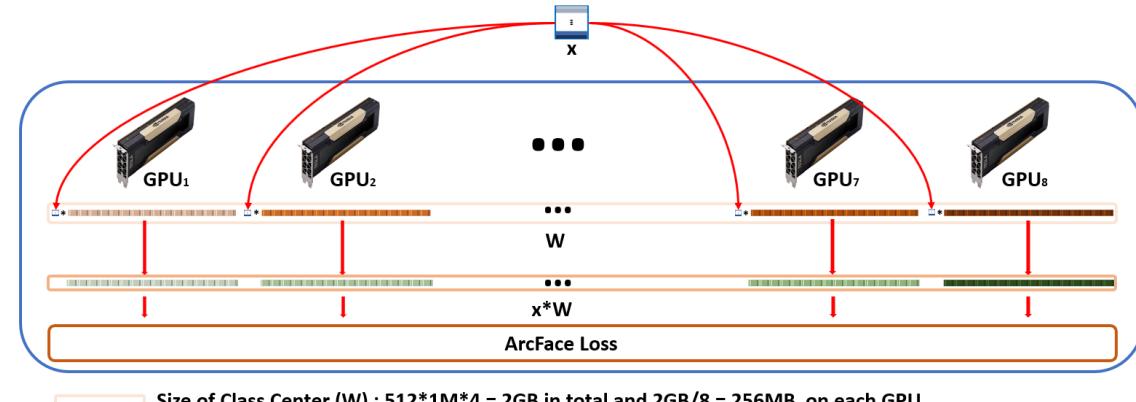
ArcFace is Efficient



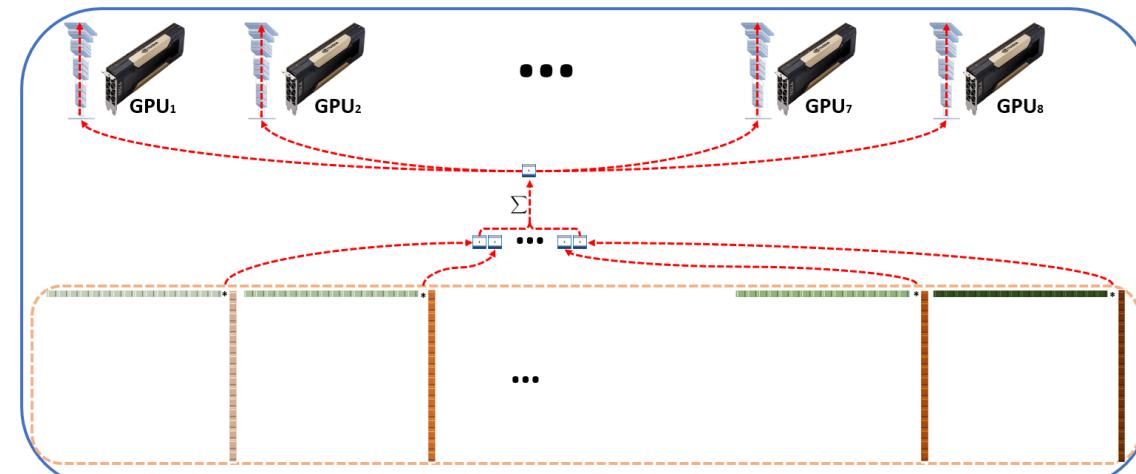
Size of Aggregated Feature (x) : $64 \times 8 \times 512 \times 4 = 1\text{MB}$



Size of Gradient on Similarity Score ($d\text{Score}$): $512 \times 1\text{M} \times 4 = 2\text{GB}$ in total and $2\text{GB}/8 = 256\text{MB}$ on each GPU
Size of Gradient on Class Center (dW): $512 \times 1\text{M} \times 4 = 2\text{GB}$ in total and $2\text{GB}/8 = 256\text{MB}$ on each GPU



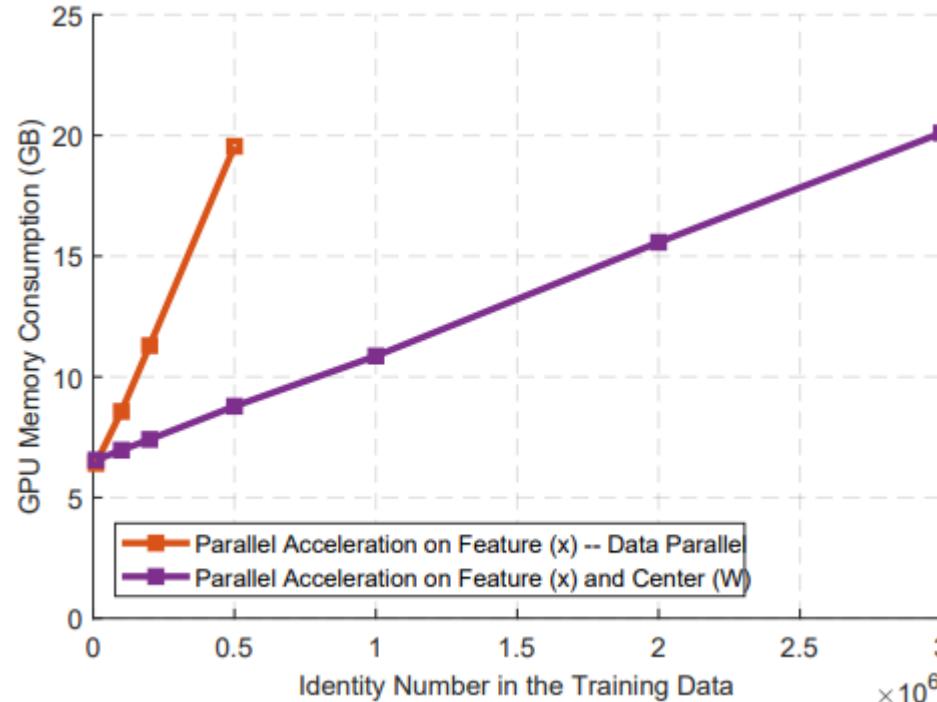
Size of Class Center (W) : $512 \times 1\text{M} \times 4 = 2\text{GB}$ in total and $2\text{GB}/8 = 256\text{MB}$ on each GPU
Size of Similarity Score ($x^T W$) : $512 \times 1\text{M} \times 4 = 2\text{GB}$ in total and $2\text{GB}/8 = 256\text{MB}$ on each GPU



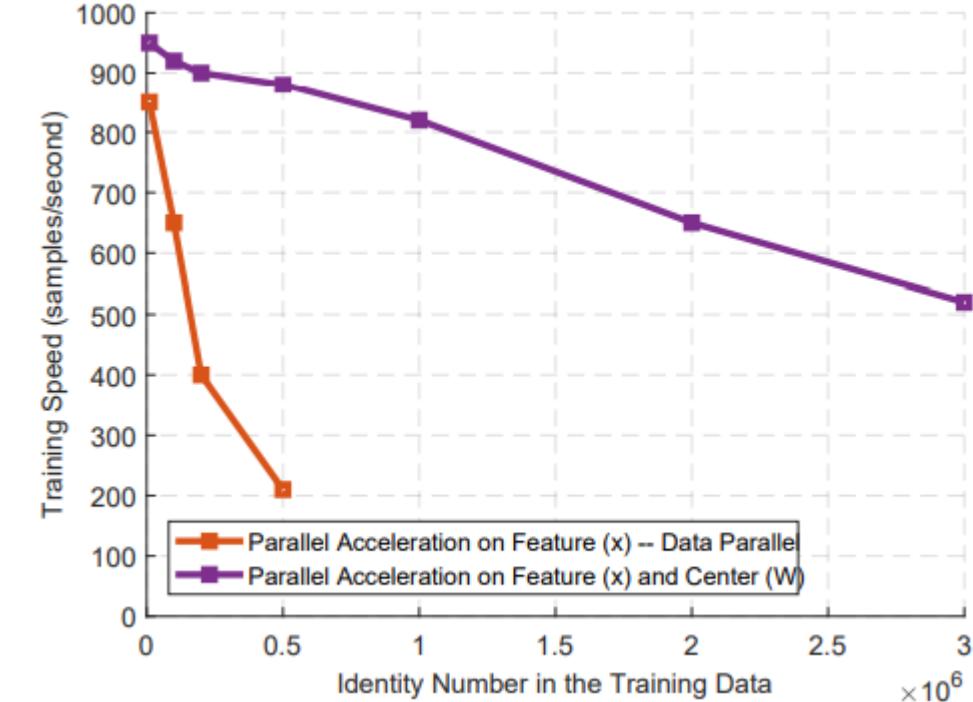
Size of Gradient on Similarity Score ($d\text{Score}$) : $512 \times 1\text{M} \times 4 = 2\text{GB}$ in total and $2\text{GB}/8 = 256\text{MB}$ on each GPU
Size of Class Center (W^\top): $1\text{M} \times 512 \times 4 = 2\text{GB}$ in total and $2\text{GB}/8 = 256\text{MB}$ on each GPU

W is large but we can easily split it.
Parallel acceleration on both x and W.

ArcFace is Efficient



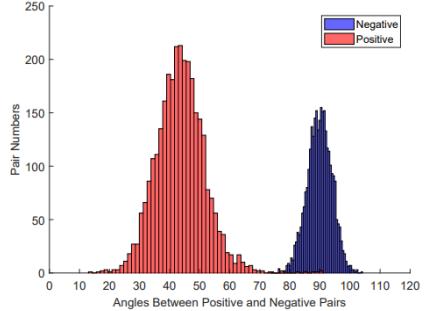
GPU Memory



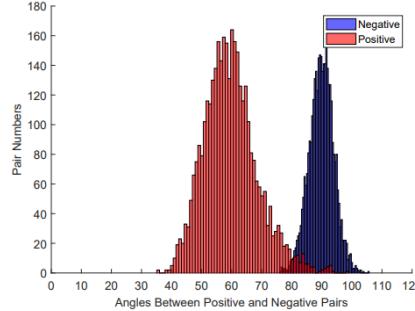
Training Speed

W is large but we can easily split it.
Parallel acceleration on both x and W.

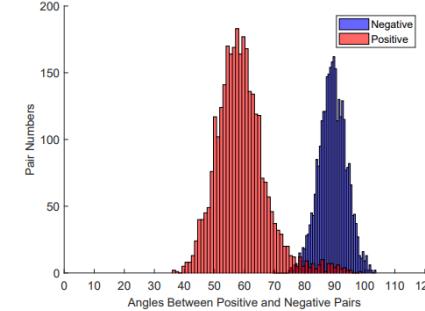
ArcFace is Effective



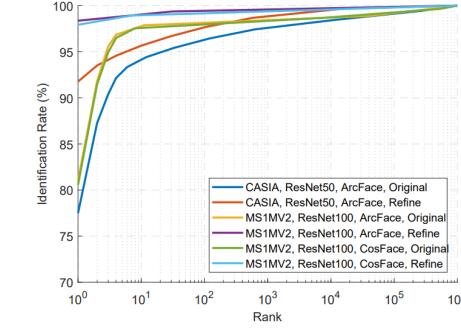
(a) LFW (99.83%)



(b) CFP-FP (98.37%)

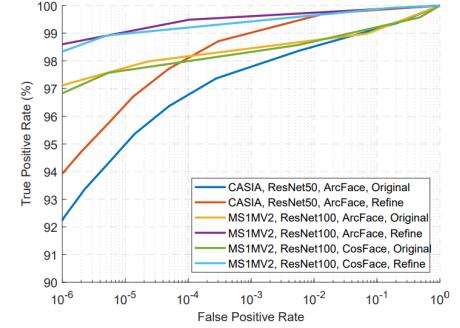


(c) AgeDB (98.15%)

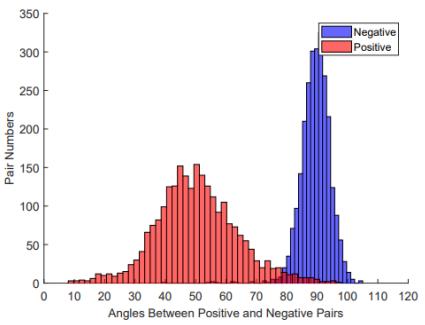


(a) CMC

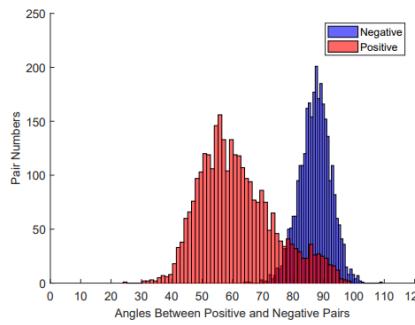
MegaFace



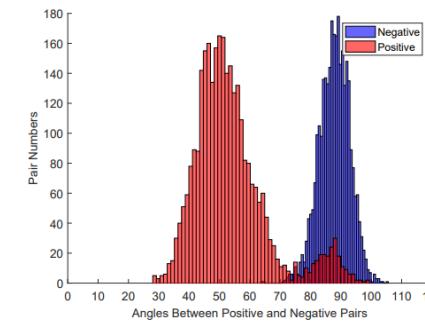
(b) ROC



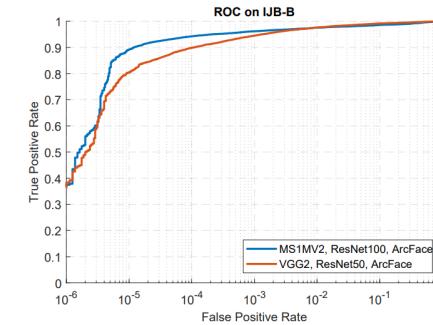
(d) YTF (98.02%)



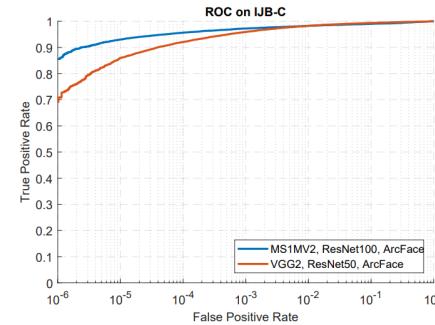
(e) CPLFW (92.08%)



(f) CALFW (95.45%)



(a) ROC for IJB-B



(b) ROC for IJB-C

State-of-the-art on many benchmarks.

ArcFace is Effective

Identification	Verification					
user	description	metric	status	TPR@FPR=1e-3	date	
nttstar	arcface-t2	cos	Finished	0.86125	2019-03-26	
shengxili	r152-emeore	cos	Finished	0.85757	2019-03-05	
deepabc	add_con_v4	cos	Finished	0.85088	2018-12-23	
CIGIT_IRSEC	p1_a31.bin	cos	Finished	0.84917	2018-11-26	
tiandu	facelessvoid	cos	Finished	0.84479	2019-04-01	
FACEX	model-r100-single	cos	Finished	0.84265	2019-03-29	
tuoyuxiang	tpv2a3b80r758-60	cos	Finished	0.84172	2018-12-10	
IrvingShu	r100-m2.0-faceemore	cos	Finished	0.84165	2018-12-06	
xiaoboCASIA	new2	cos	Finished	0.84118	2019-03-13	
hanhao1415	facemodel	cos	Finished	0.84058	2019-03-20	

Trillion-Pairs

State-of-the-art on many benchmarks.

爱奇艺AI竞赛平台					
竞赛介绍	竞赛数据集	讨论组	常见问题	排行榜	报名结束
名次	队伍名称	最优分数	所在组织	提交时间	
1	Witcher	0.8865	InfiniVision	2018-10-13	
2	偏偏我是猫	0.8766	VAR	2018-10-15	
3	周同俱乐部	0.8519	周同科技_北工大	2018-10-15	
4	炸天	0.8505	香港科技大学	2018-10-15	
5	emmm...	0.8252	南京大学	2018-10-12	
6	喜欢爬山的北野绣莹	0.8091	VPP	2018-10-15	
7	188****4098_m1097	0.8087	重庆中科绿色研究院智能安全中心	2018-10-15	
8	dianxin55	0.8076	极链科技	2018-10-14	
9	高贵的宇文玄雅	0.8075	北京邮电大学	2018-10-14	
10	陈少萌萌哒	0.8027	平安科技	2018-10-15	

IQIYI-VID

ArcFace is Enlightening

- AdaCos: Adaptively Scaling Cosine Logit for Learning Deep Face Representation,
X. Zhang, R. Zhao, Y. Qiao, X. Wang, H. Li, CVPR (oral), 2019.
- P2SGrad: Refined Gradients for Optimizing Deep Face Models,
X. Zhang, R. Zhao, J. Yan, M. Gao, Y. Qiao, X. Wang, H. Li, CVPR, 2019.
- GANFIT: Generative Adversarial Network Fitting for High Fidelity 3D Face Reconstruction,
B. Gecer, S. Ploumpis, I. Kotsia, S. Zafeiriou, CVPR, 2019.

.....

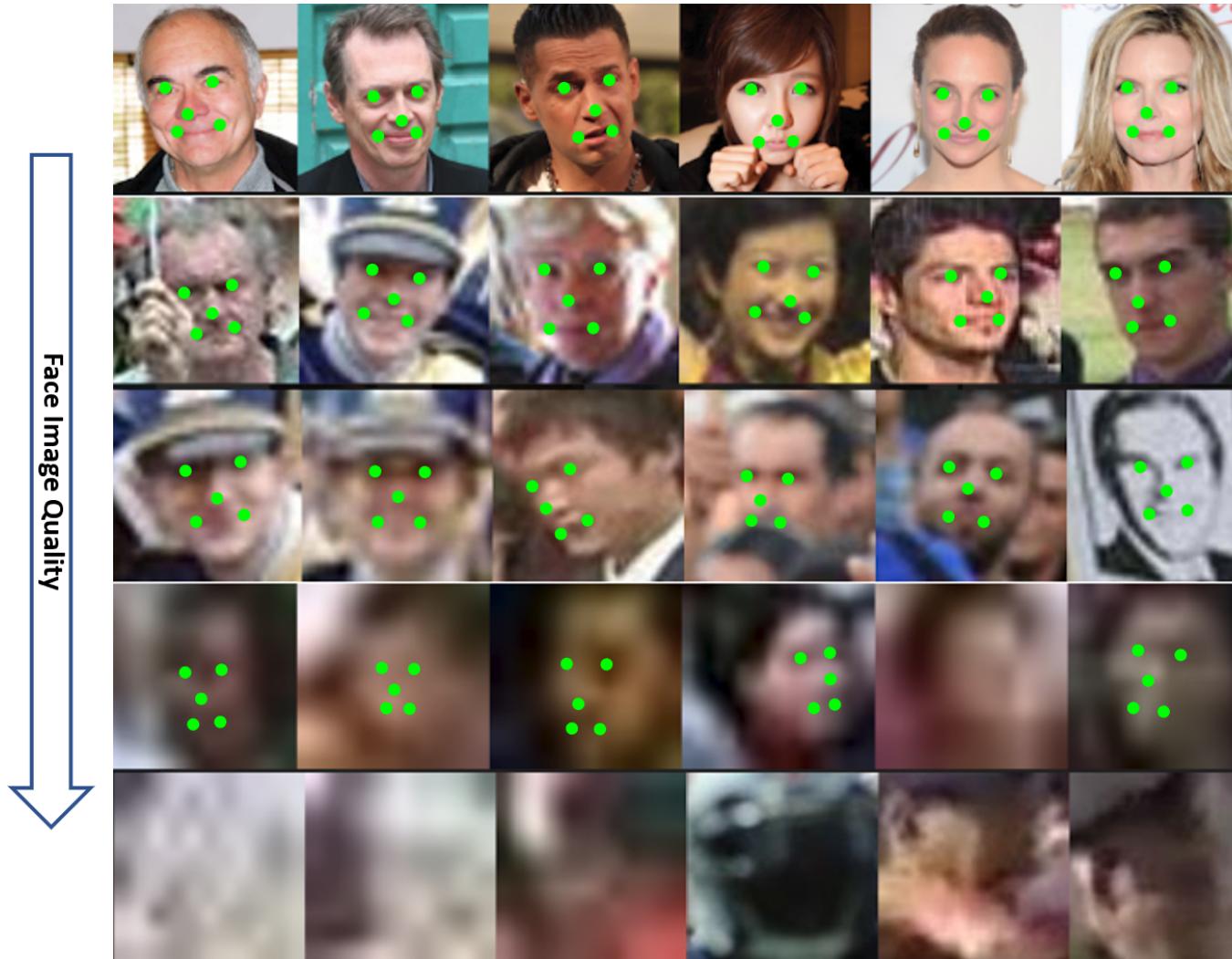
The screenshot shows the GitHub repository page for `deepinsight / insightface`. The repository has 299 stars, 3,534 forks, and 1,229 issues. The `Code` tab is selected. Other tabs include `Issues`, `Pull requests`, `Projects`, `Wiki`, `Security`, and `Insights`. Below the tabs, it says "Face Analysis Project on MXNet" and lists tags: `face-recognition`, `face-detection`, `mxnet`, `face-alignment`, `age-estimation`, `arcface`, and `retinaface`.

Data, code and model are available.

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Joint Face Detection and Alignment

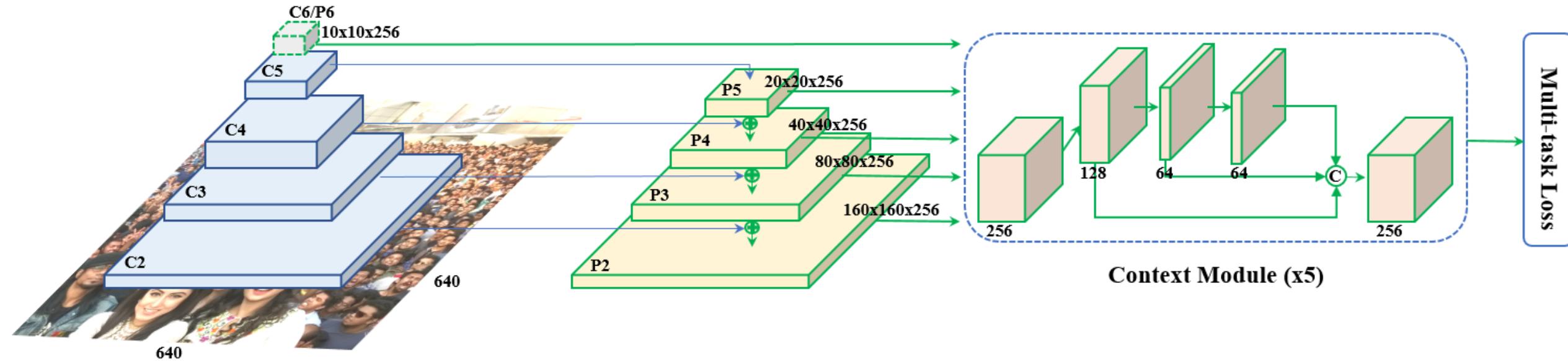


MTCNN, JDA, STN etc.

Outlines

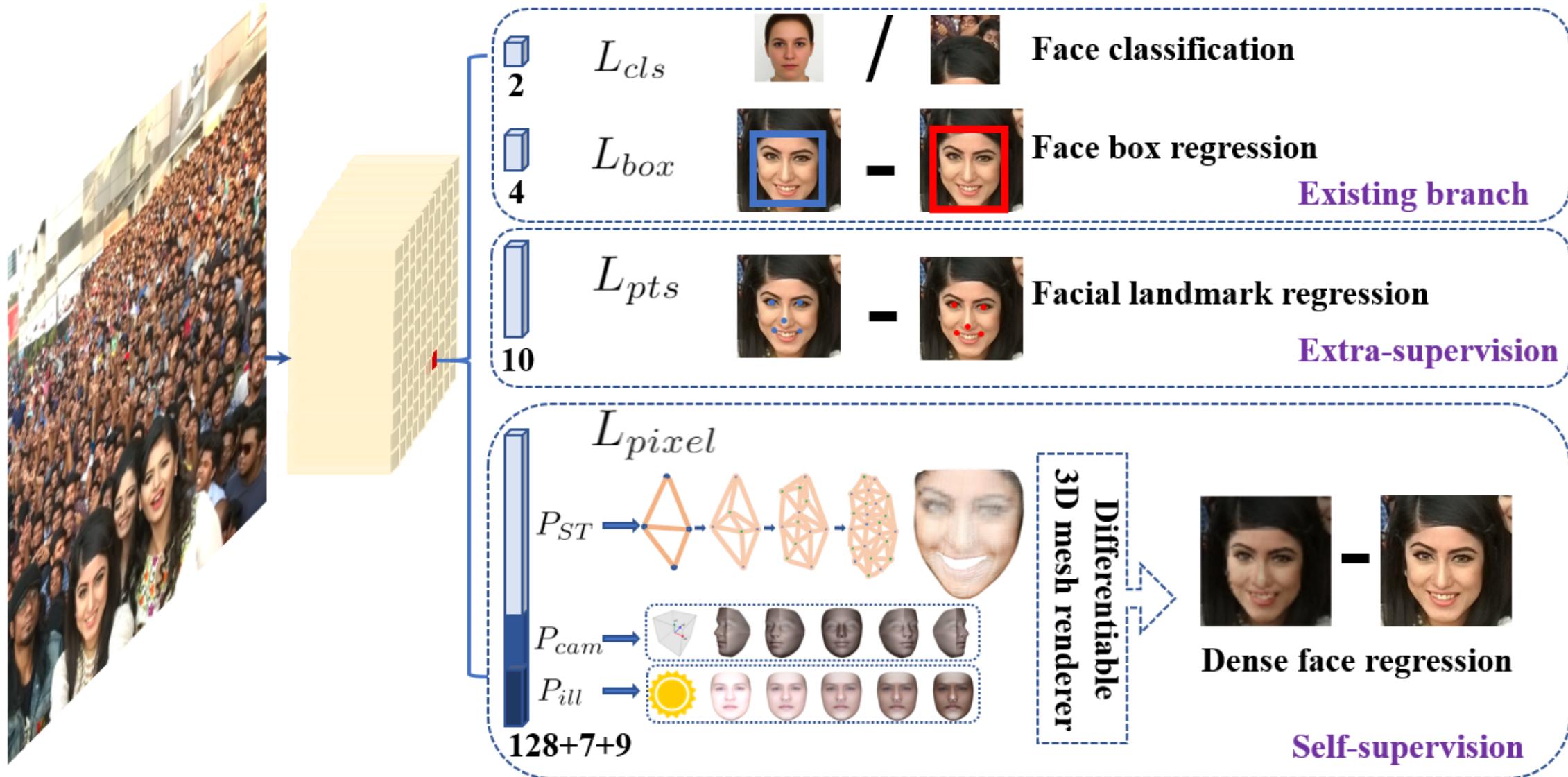
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RetinaFace



- Single-stage on feature pyramid
- Context module (Deformable Conv)
- Multi-task loss

RetinaFace—Multitask Loss



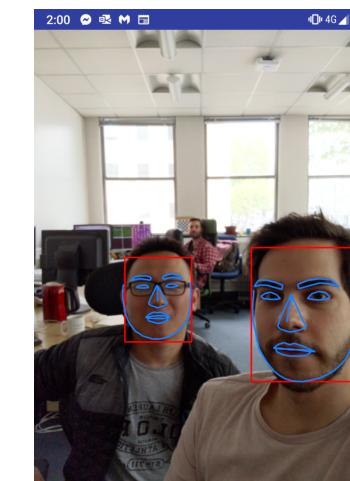
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Ablation Study on Multitask Loss

Method	Easy	Medium	Hard	mAP [33]
FPN+Context	95.532	95.134	90.714	50.842
+DCN	96.349	95.833	91.286	51.522
+ L_{pts}	96.467	96.075	91.694	52.297
+ L_{pixel}	96.413	95.864	91.276	51.492
+ $L_{pts} + L_{pixel}$	96.942	96.175	91.857	52.318

Backbones	VGA	HD	4K
ResNet-152 (GPU)	75.1	443.2	1742
MobileNet-0.25 (GPU)	1.4	6.1	25.6
MobileNet-0.25 (CPU-m)	5.5	50.3	-
MobileNet-0.25 (CPU-1)	17.2	130.4	-
MobileNet-0.25 (ARM)	61.2	434.3	-

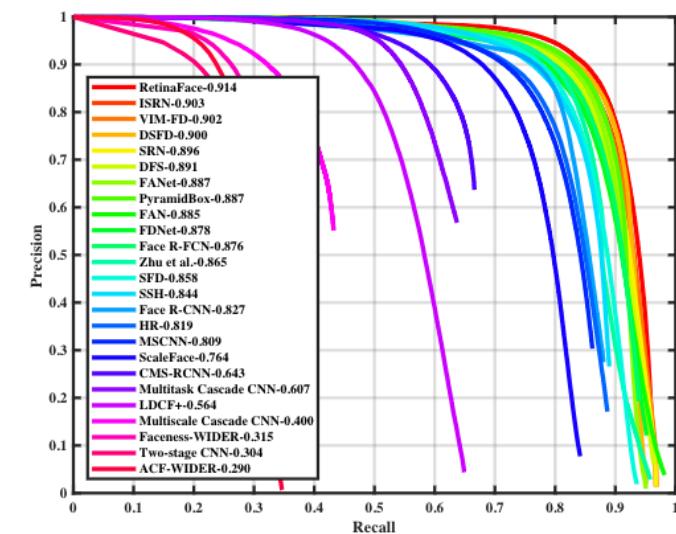
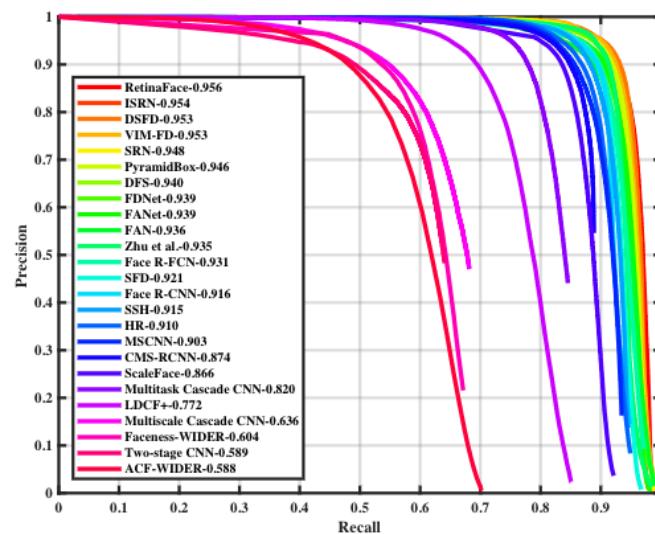
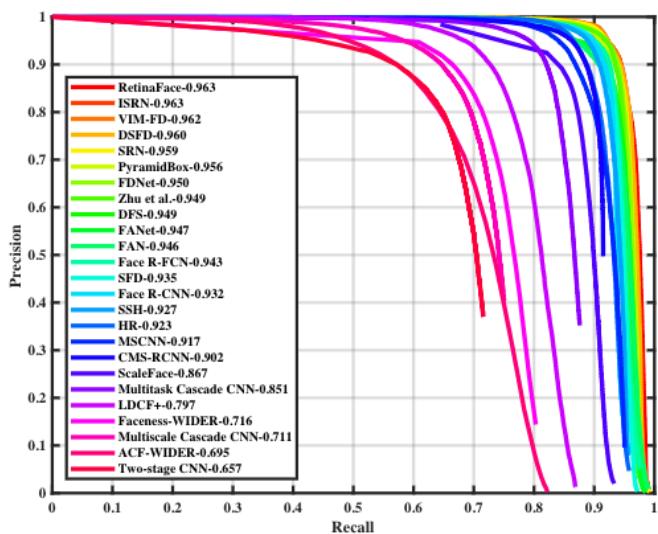
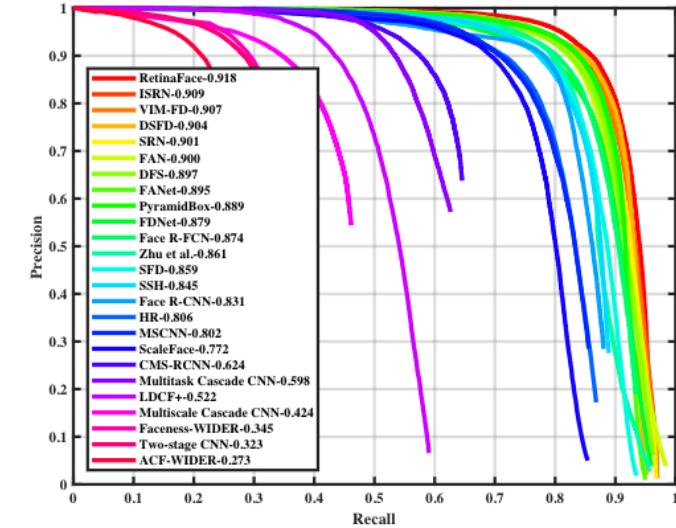
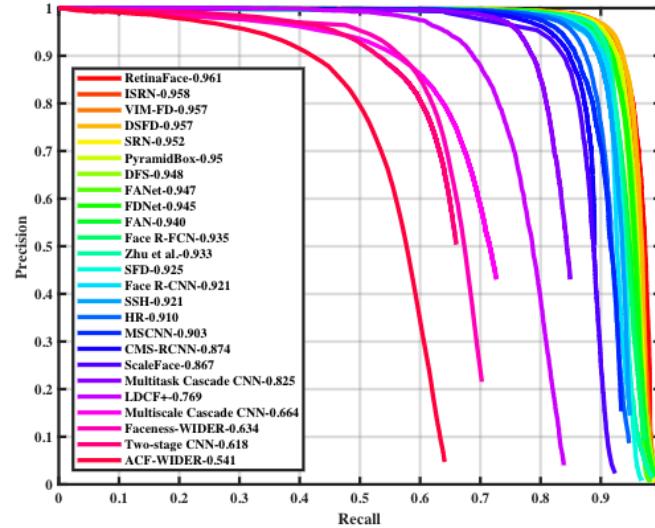
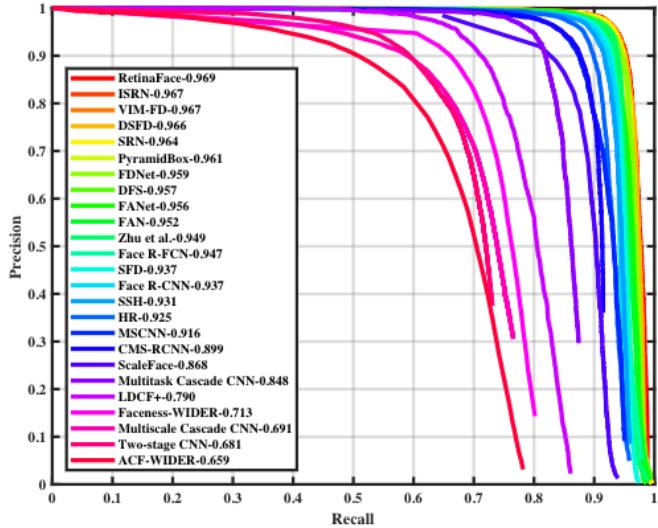


Cost:41 ms ,24 fps

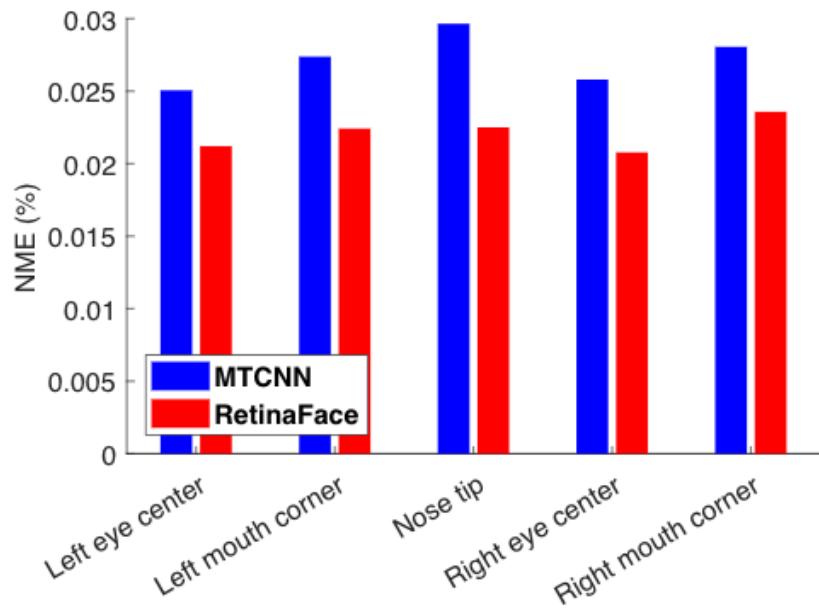
VGA@640x480, HD@1920x1080 and 4K@4096x2160

GPU NVIDIA Tesla P40; CPU Intel i7-6700K; ARM RK3399(A72x2)

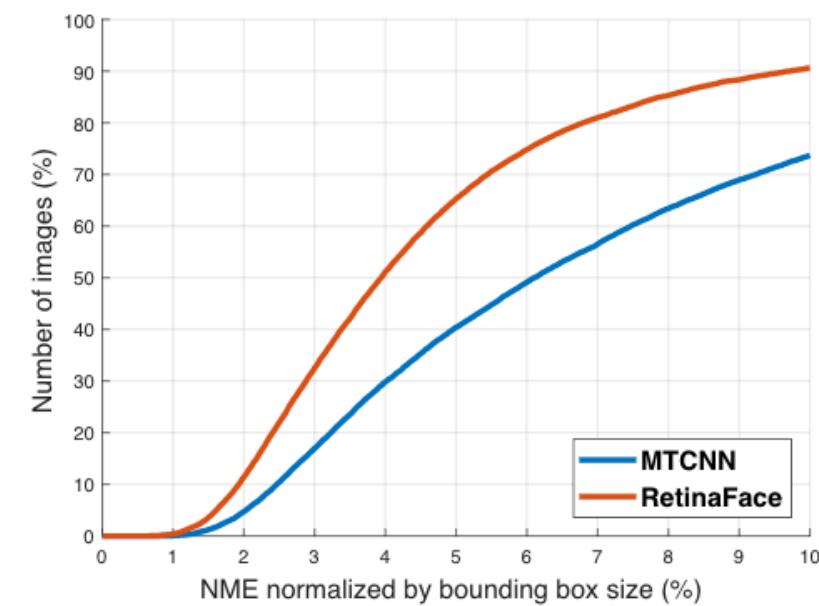
Performance on WiderFace



Five Facial Landmarks

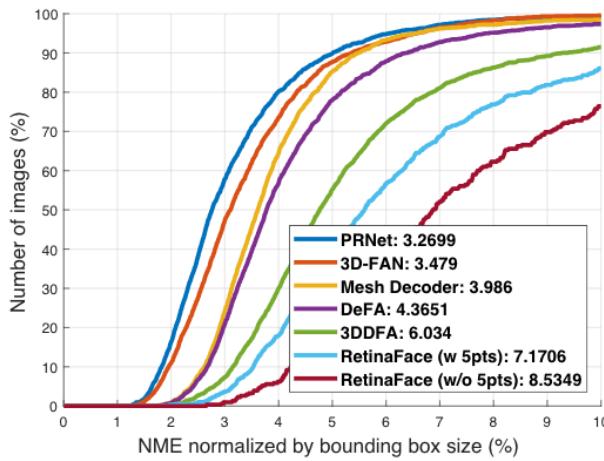


(a) NME on AFLW

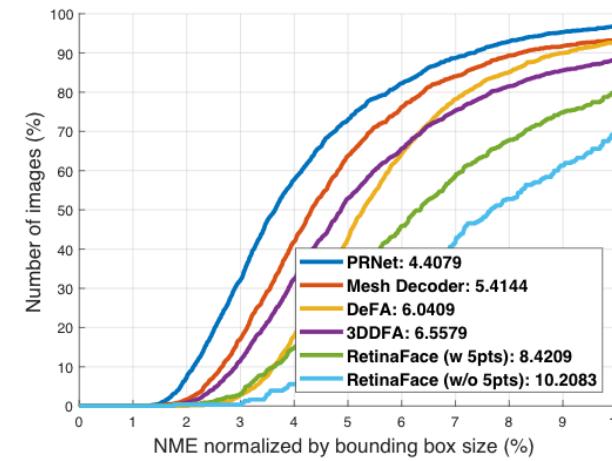


(b) CED on WIDER FACE

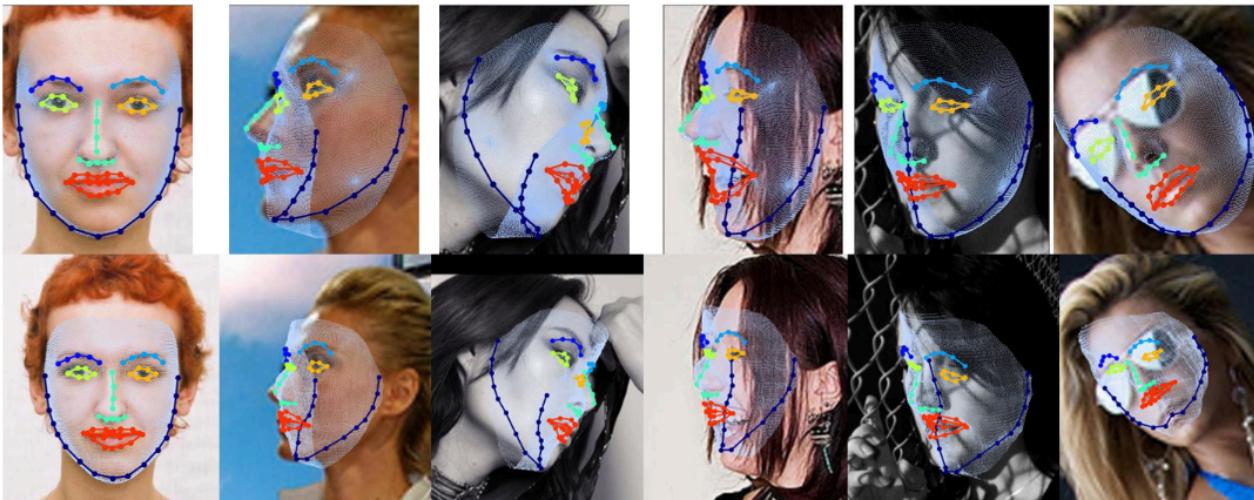
Dense Facial Landmarks



(a) 68 2D Landmarks

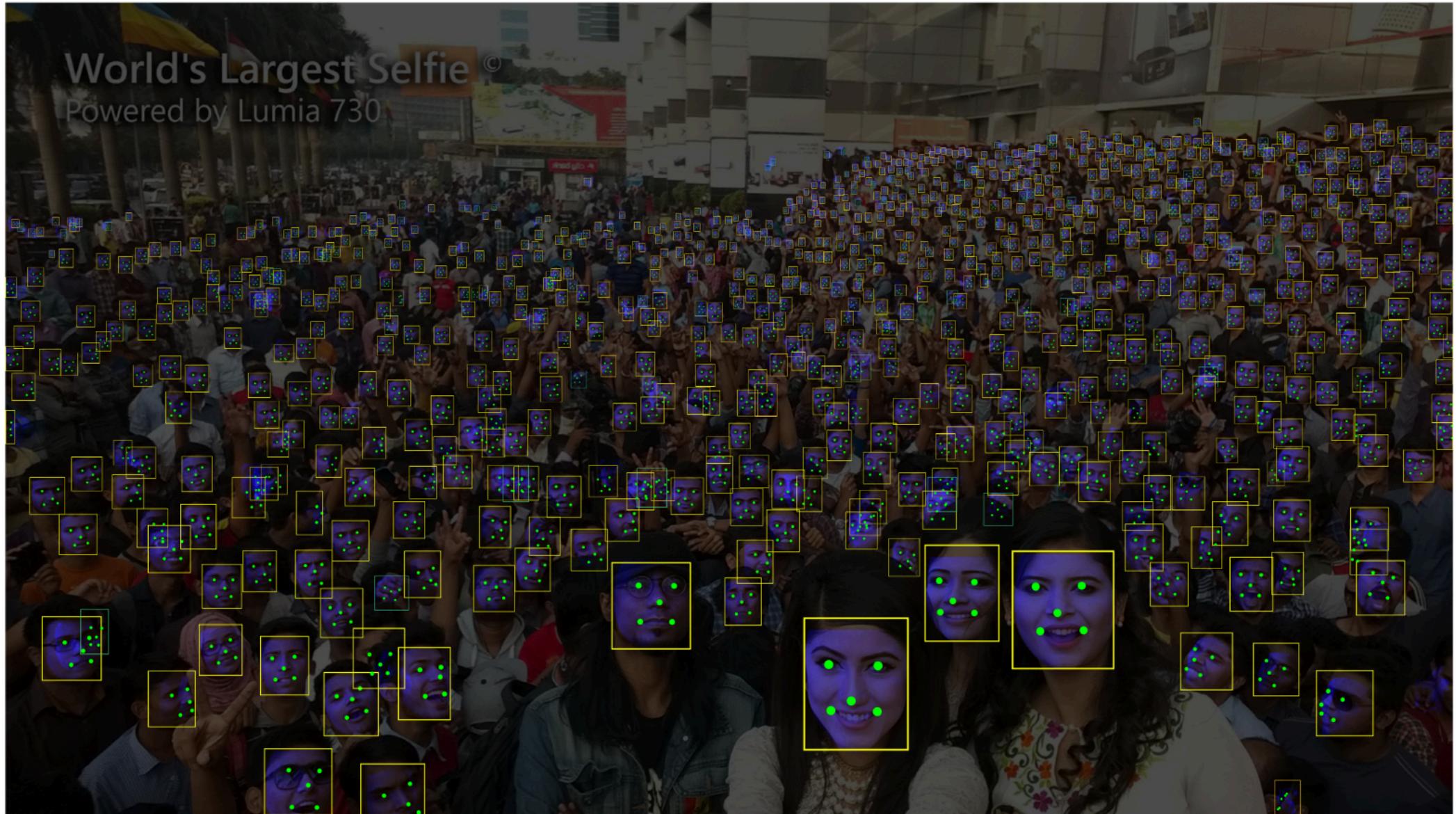


(b) All 3D Landmarks

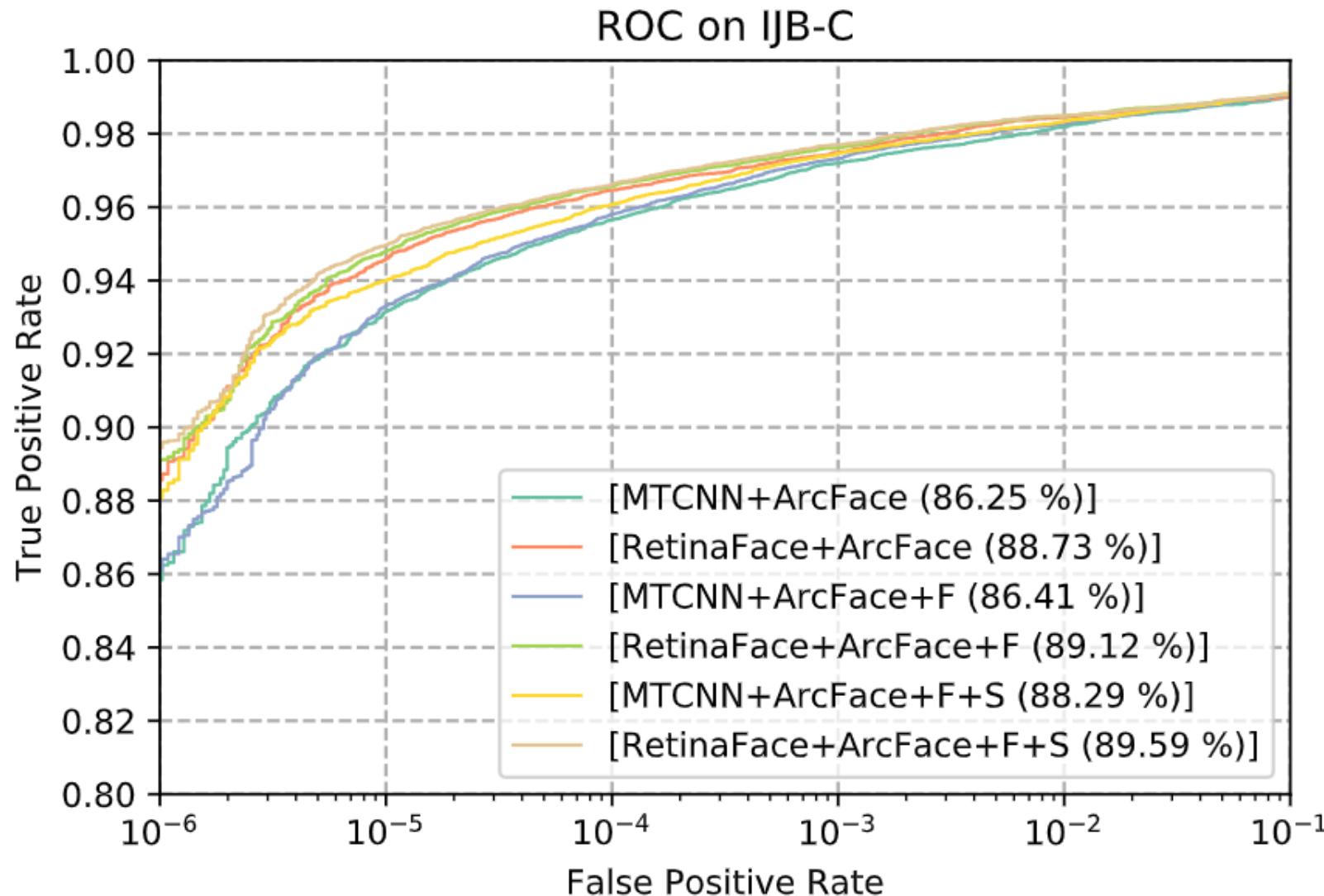


(c) Result Analysis (Upper: Mesh Decoder; Lower: RetinaFace)

Selfie Demo



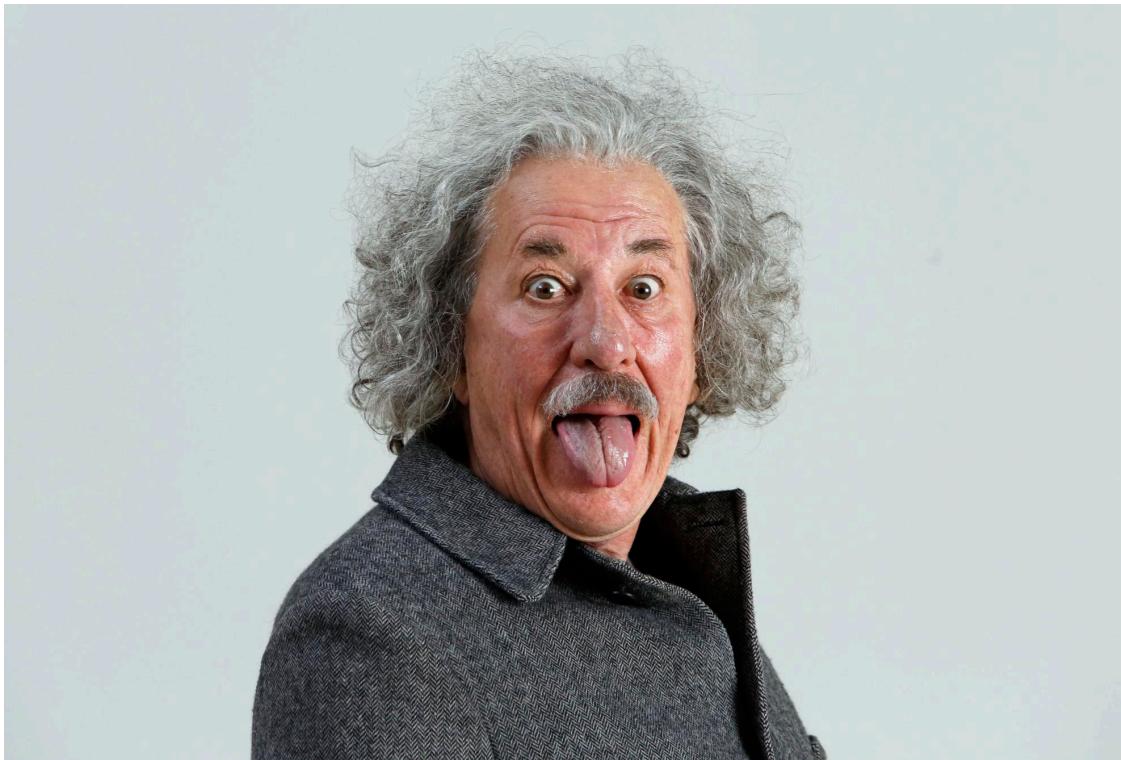
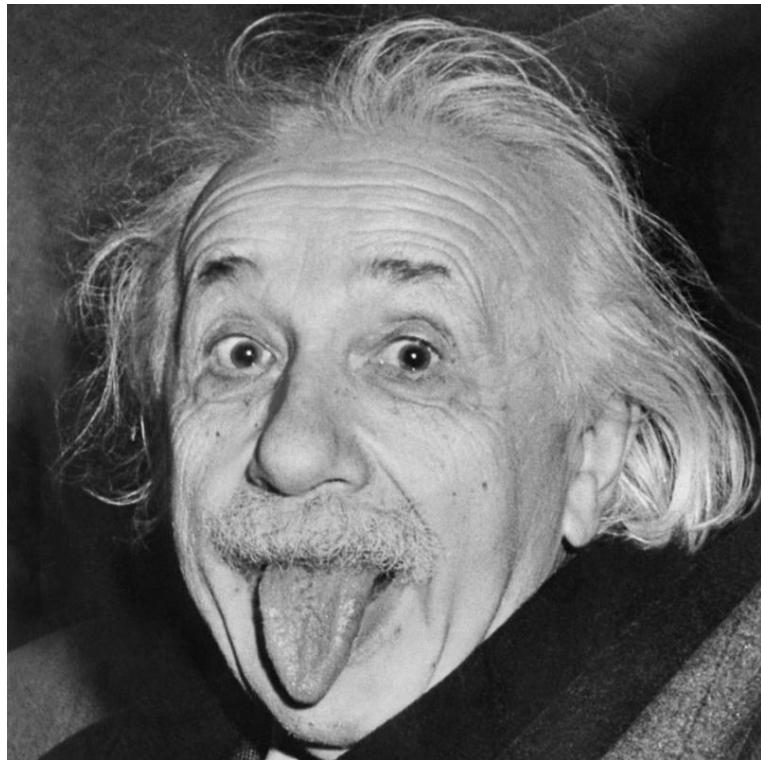
RetinaFace Improves ArcFace



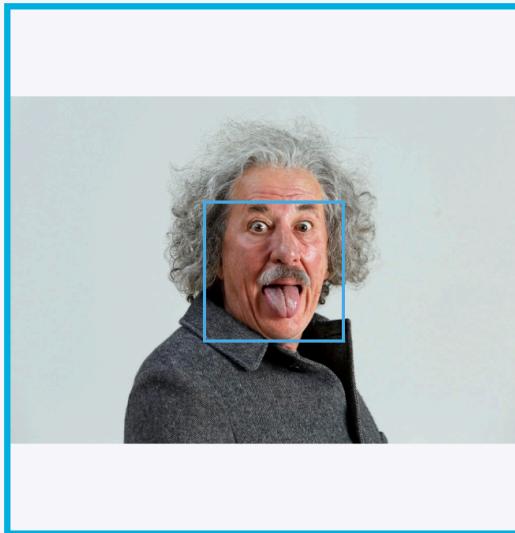
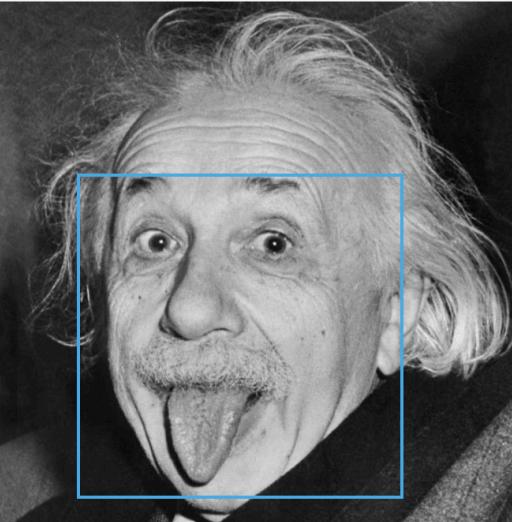
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Test Images



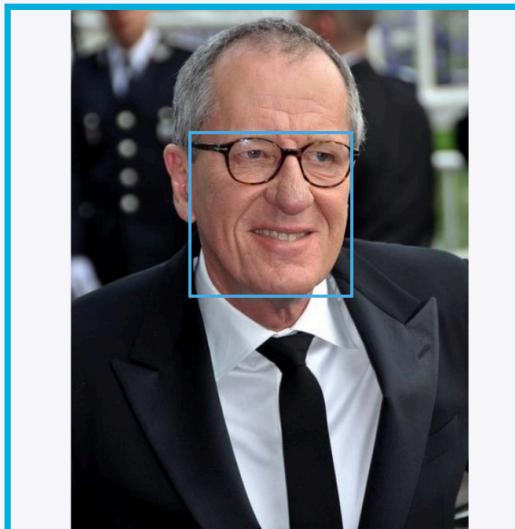
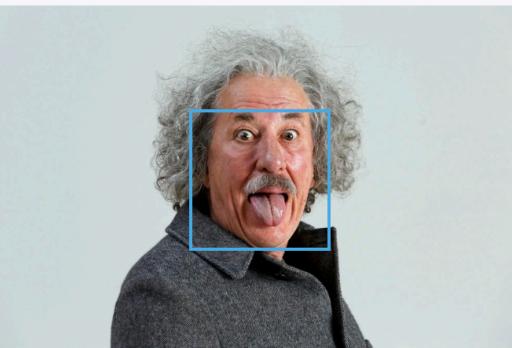
Baseline



Compare Result

Response JSON

Is same person: Probability high.

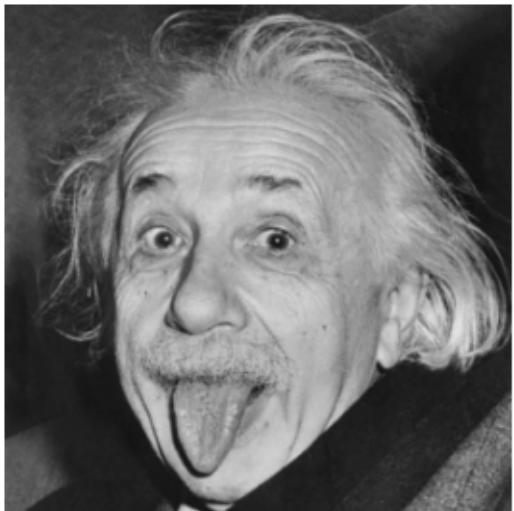


Compare Result

Response JSON

Is same person: Probability normal.

ArcFace



Upload image A

Upload image B

Analyse

Save my images

```
{  
  "match": false,  
  "score": 0.35047  
}
```

[copy to clipboard](#)



Upload image A

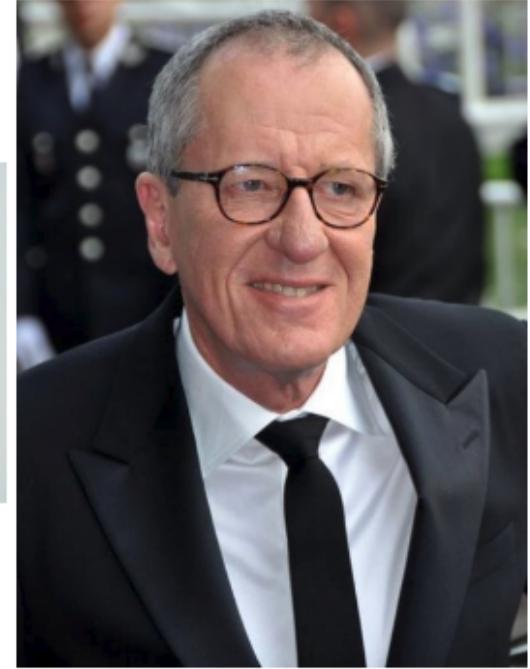
Upload image B

Analyse

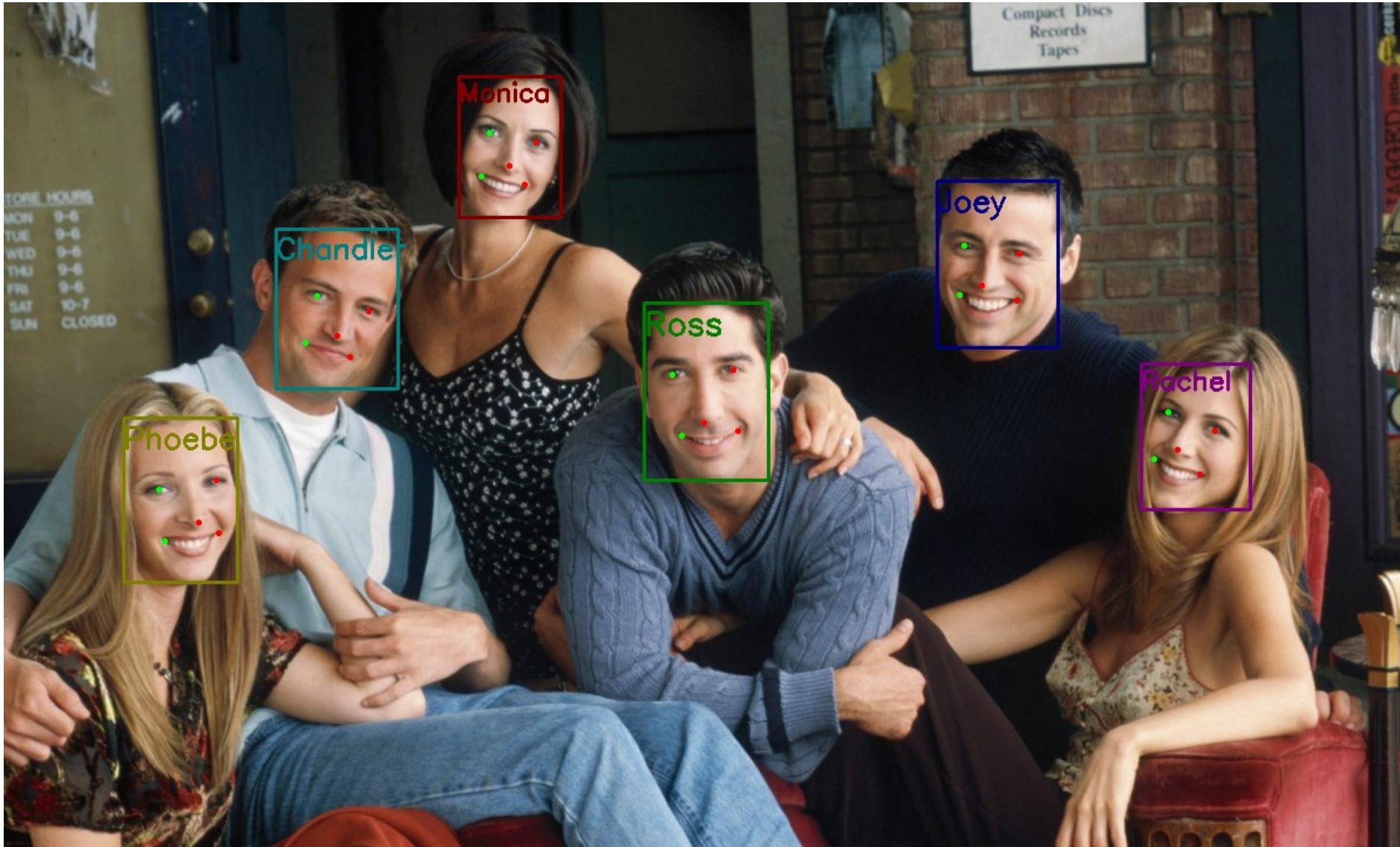
Save my images

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}
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[copy to clipboard](#)



Search Identities



Rachel
Green



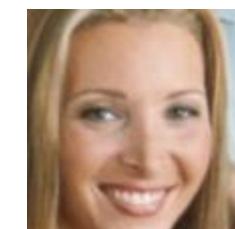
Ross
Geller



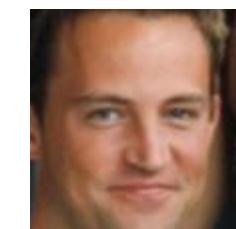
Monica
Geller



Joey
Tribbiani



Phoebe
Buffay

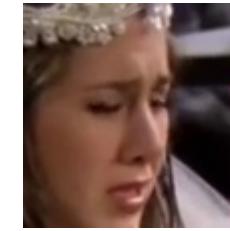
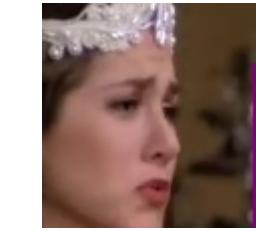
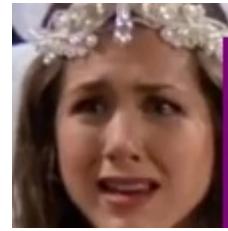
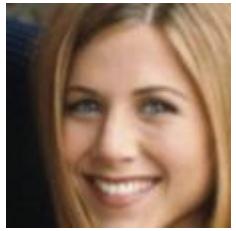


Chandler
Bing

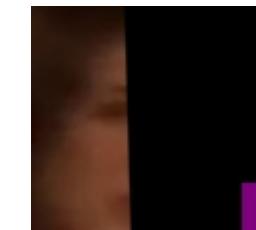
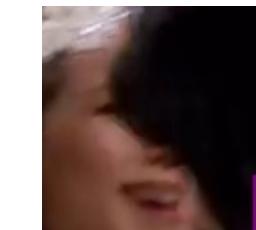
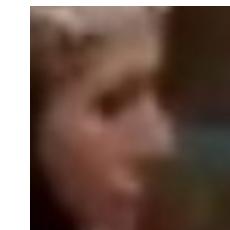
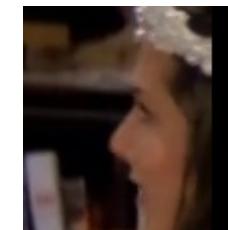
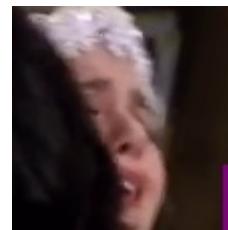
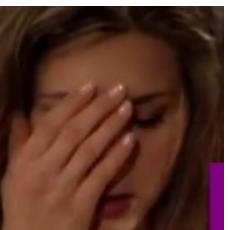
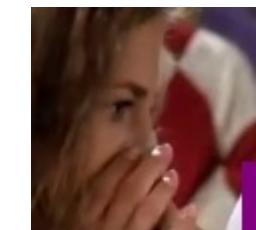
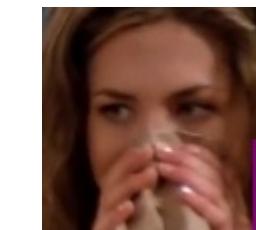
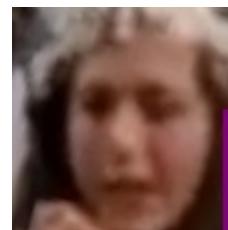
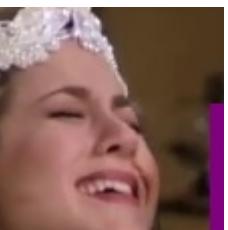
Test Video



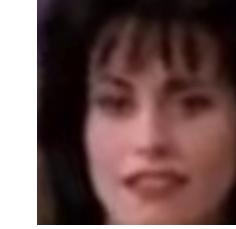
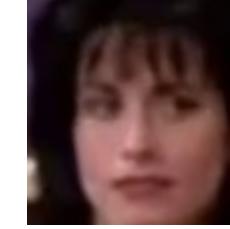
Search Results



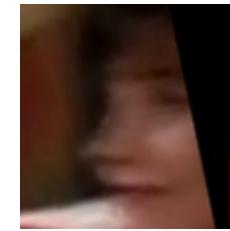
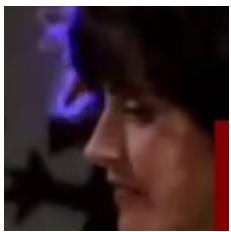
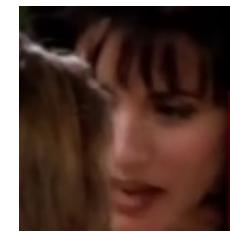
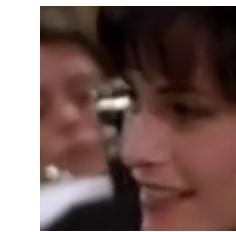
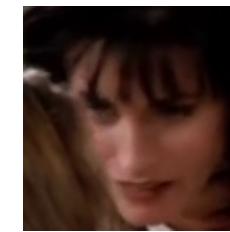
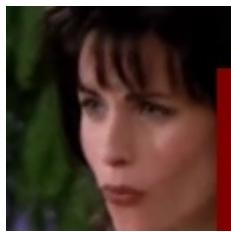
Rachel
Green



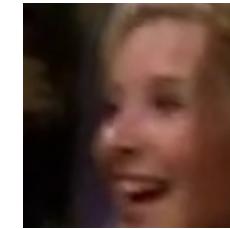
Search Results



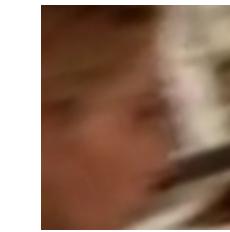
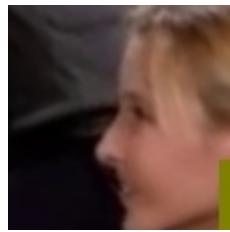
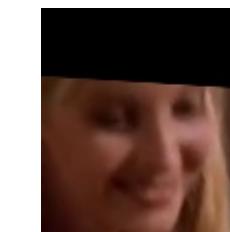
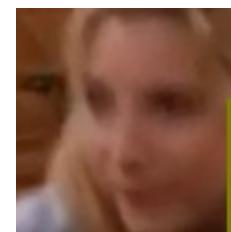
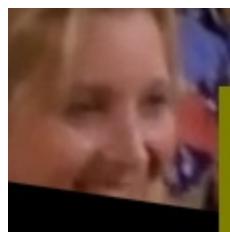
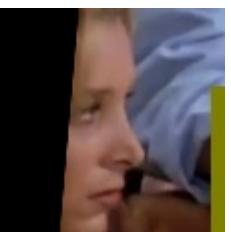
Monica
Geller



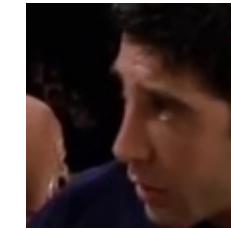
Search Results



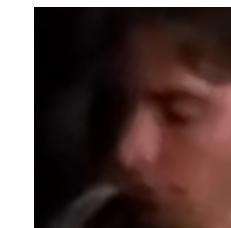
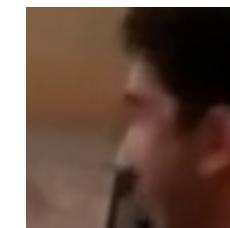
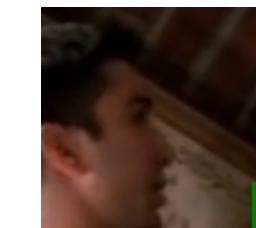
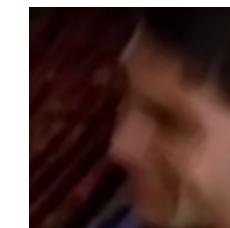
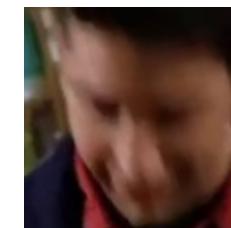
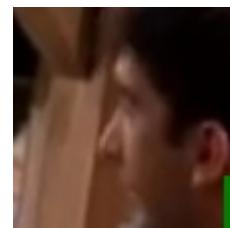
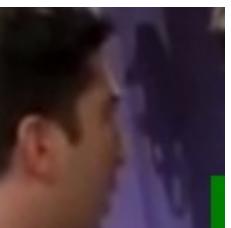
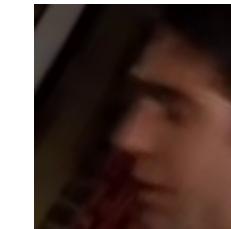
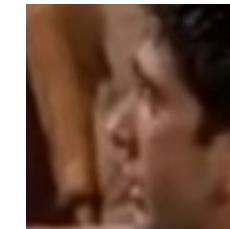
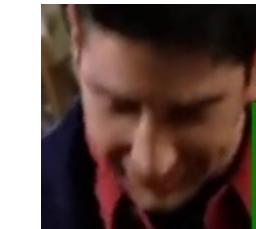
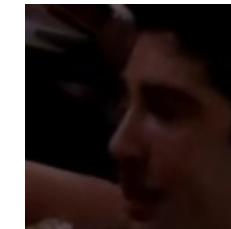
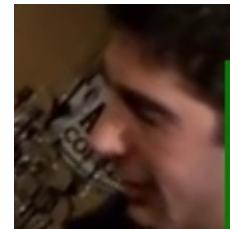
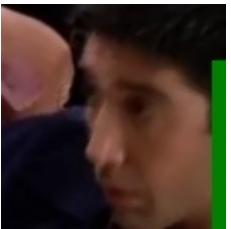
Phoebe
Buffay



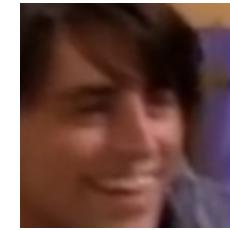
Search Results



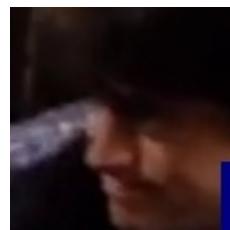
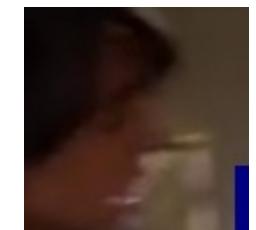
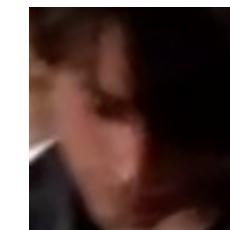
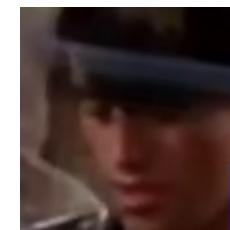
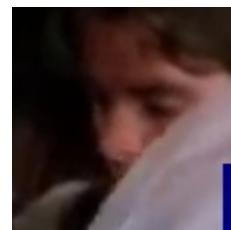
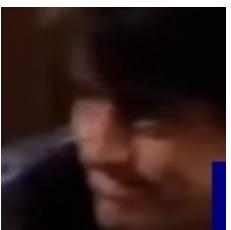
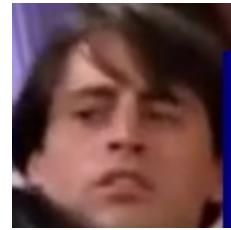
Ross
Geller



Search Results



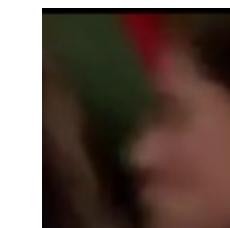
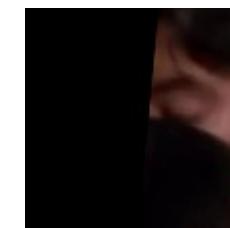
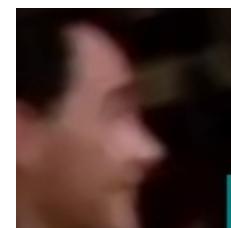
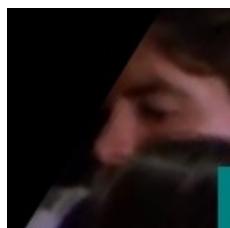
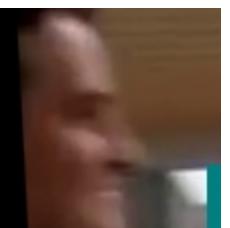
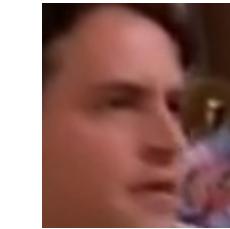
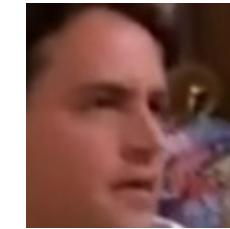
Joey
Tribbiani



Search Results



Chandler
Bing



Outlines

- ArcFace
 - Motivation
 - Method
 - Results
- RetinaFace
 - Motivation
 - Method
 - Results
- Image/Video Demo
- FRVT 1:1 Verification
- LFR Challenge/Workshop 2019

FRVT 1:1 Verification



Demo images for each test set.

FRVT 1:1 Leaderboard

Rank	Submissions	VISA FNMR @FMR \leq 1e-6	VISA FNMR @FMR \leq 1e-4	MUGSHOT FNMR @FMR \leq 1e-5	MUGSHOT FNMR @FMR \leq 1e-5 DT=14 YRS	WILD FNMR @FMR \leq 1e-5
1	visionlabs-006	0.007 ³	0.001 ³	0.004 ¹	0.006 ¹	0.031 ⁵
2	visionlabs-005	0.016 ¹⁷	0.003 ¹⁰	0.005 ²	0.007 ²	0.046 ³²
3	yitu-003	0.003 ¹	0.000 ¹	0.007 ⁴	0.008 ³	0.036 ¹⁸
4	everai-002	0.016 ¹⁹	0.004 ²¹	0.006 ³	0.011 ⁴	0.033 ¹⁰
5	everai-001	0.016 ¹⁶	0.004 ¹⁹	0.007 ⁶	0.011 ⁵	0.032 ⁹
6	cogent-002	0.032 ⁵¹	0.004 ²²	0.009 ¹⁴	0.012 ⁶	0.066 ⁵⁵
7	imperial-001	0.015 ¹⁴	0.003 ¹³	0.007 ⁵	0.012 ⁷	0.031 ⁴
8	psl-002	0.018 ²²	0.005 ²⁸	0.009 ¹⁰	0.012 ⁸	0.033 ¹¹
9	toshiba-003	0.021 ²⁹	0.005 ²⁵	0.009 ⁹	0.013 ⁹	0.032 ⁸
10	cogent-003	0.019 ²⁵	0.003 ¹²	0.010 ¹⁷	0.013 ¹⁰	0.048 ³⁴
11	imperial-000	0.011 ⁸	0.002 ⁶	0.008 ⁷	0.013 ¹¹	0.031 ²
12	vocord-006	0.010 ⁷	0.002 ⁴	0.008 ⁸	0.014 ¹²	0.031 ⁶
13	dahua-002	0.016 ¹⁸	0.009 ⁵⁷	0.012 ²⁸	0.014 ¹³	0.036 ¹⁹
14	psl-001	0.093 ⁷⁹	0.020 ⁷⁷	0.010 ¹⁵	0.014 ¹⁴	0.054 ⁴⁰
15	camvi-002	0.022 ³¹	0.005 ²⁹	0.009 ¹¹	0.014 ¹⁵	0.032 ⁷
16	toshiba-002	0.022 ³²	0.005 ²⁷	0.010 ¹⁶	0.015 ¹⁶	0.116 ⁷¹
17	neurotechnology-005	0.030 ⁴⁷	0.005 ³¹	0.011 ²²	0.015 ¹⁷	0.039 ²³
18	neurotechnology-004	0.030 ⁴⁴	0.005 ³²	0.011 ²⁰	0.015 ¹⁸	0.056 ⁴⁴
19	hik-001	0.012 ¹⁰	0.004 ¹⁷	0.009 ¹²	0.016 ¹⁹	0.031 ¹
20	remarkai-000	0.026 ³⁹	0.006 ³⁷	0.010 ¹⁸	0.016 ²⁰	0.035 ¹⁴

Imperial-000: [RetinaFace, R50; MS1M+Asian, R100, ArcFace]

Imperial-001: [RetinaFace, R50; MS1M, R100, ArcFace]

FRVT 1:1 Submission Details

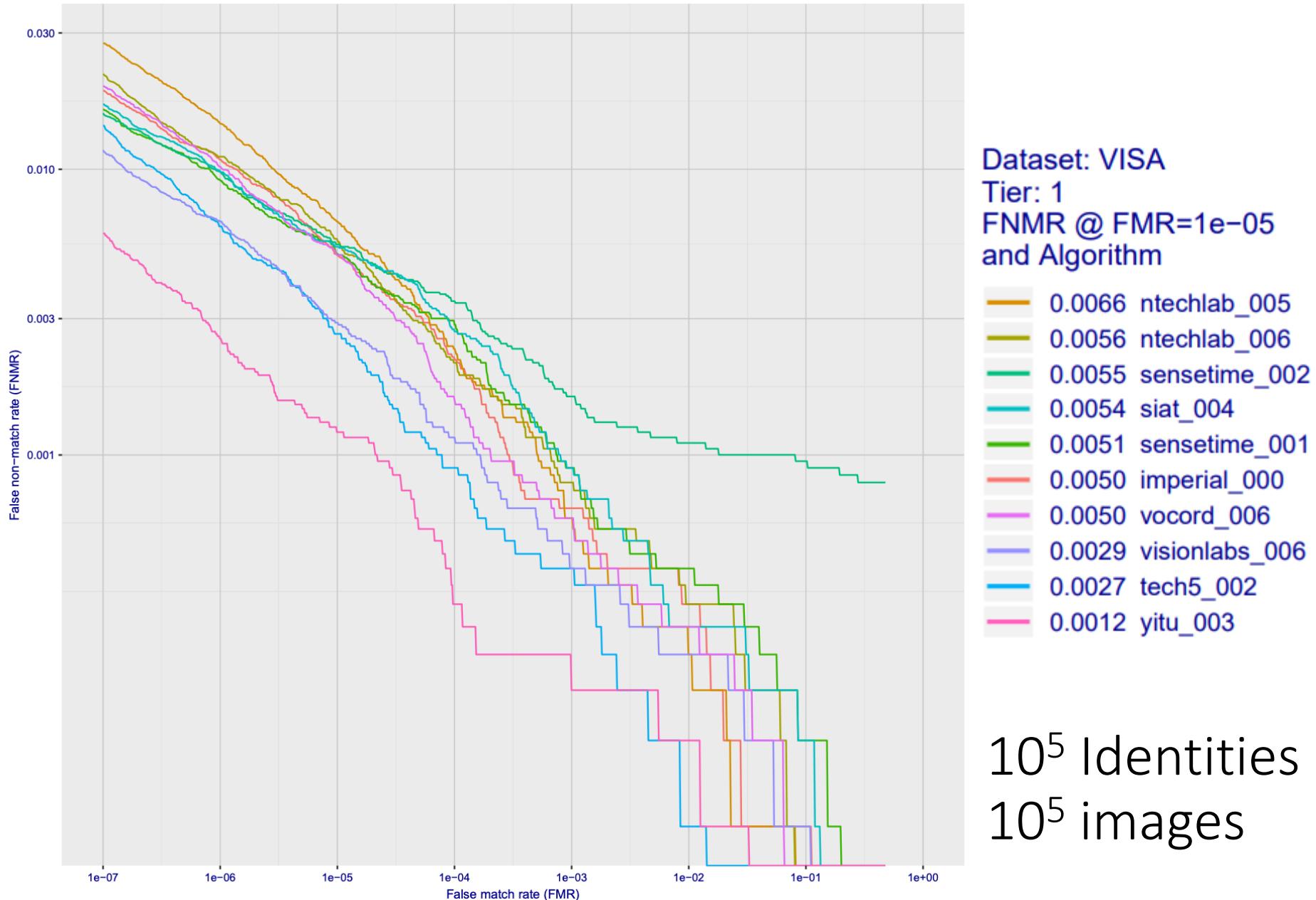
Rank	Submissions	Developers	Date	Model(KB)	Embedding(B)	Time (ms)
1	visionlabs-006	VisionLabs	2019-03-01	353,044	512	270 ± 0
2	visionlabs-005	VisionLabs	2018-10-19	369,602	512	313 ± 0
3	yitu-003	Shanghai Yitu Technology	2019-03-01	1,525,719	2082	860 ± 0
4	everai-002	Ever AI	2019-03-01	561,727	4096	758 ± 0
5	everai-001	Ever AI	2018-10-30	449,149	2048	701 ± 1
6	cogent-002	Gemalto Cogent	2018-10-19	696,959	1979	941 ± 0
7	imperial-001	Imperial College London	2019-03-01	370,260	2048	671 ± 0
8	psl-002	Panasonic R+D Center Singapore	2019-02-28	804,934	2052	888 ± 9
9	toshiba-003	Toshiba	2019-03-01	984,125	1560	540 ± 0
10	cogent-003	Gemalto Cogent	2019-03-01	698,290	973	952 ± 0
11	imperial-000	Imperial College London	2019-03-01	370,120	2048	669 ± 1
12	vocord-006	Vocord	2019-03-01	559,457	768	886 ± 1
13	dahua-002	Dahua Technology Co. Ltd	2019-03-01	526,452	2048	628 ± 7
14	psl-001	Panasonic R+D Center Singapore	2018-10-15	382,035	2056	785 ± 16
15	camvi-002	Camvi Technologies	2018-10-19	236,278	1024	677 ± 7
16	toshiba-002	Toshiba	2018-10-19	813,606	1560	541 ± 0
17	neurotechnology-005	Neurotechnology	2019-03-01	270,450	256	399 ± 0
18	neurotechnology-004	Neurotechnology	2018-10-19	293,384	256	401 ± 0
19	hik-001	Hikvision	2019-03-01	667,866	1408	651 ± 0
20	remarkai-000	KanKan Ai	2019-03-01	240,152	2048	829 ± 7

Intel® Xeon® E5-2630 v4 CPU @ 2.20GHz

FRVT 1:1 VISA

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

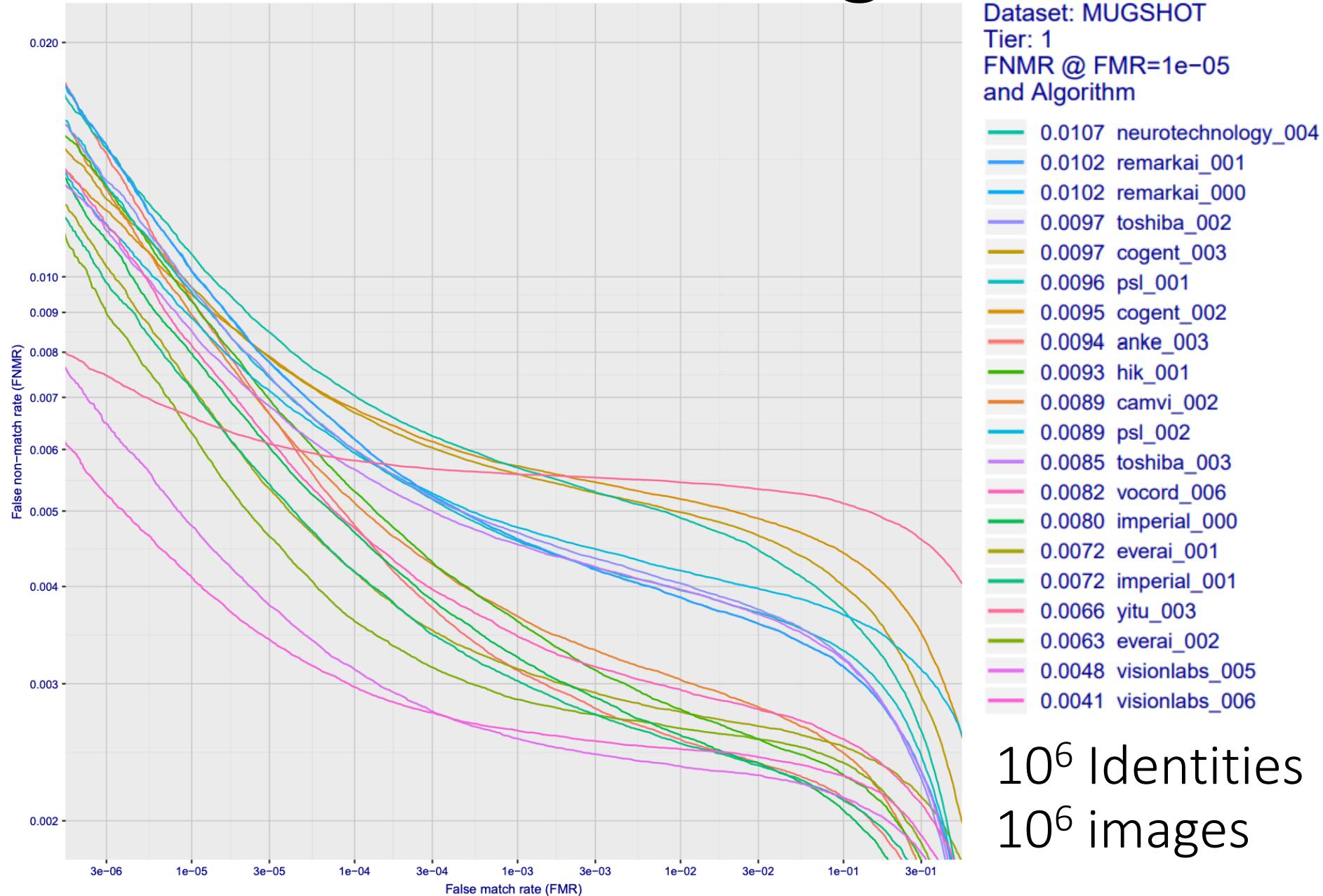
FRVT 1:1 VISA



FRVT 1:1 Mugshot

- ▷ The number of images is on the order of 10^6 .
- ▷ The number of subjects is on the order of 10^6 .
- ▷ The number of subjects with two images on the order of 10^6 .
- ▷ The images have geometry in reasonable conformance with the ISO/IEC 19794-5 Full Frontal image type.
- ▷ The images are of variable sizes. The median IOD is 104 pixels. The mean IOD is 123 pixels.
- ▷ The images are of subjects from the United States.
- ▷ The images are of adults.
- ▷ The images are all live capture.

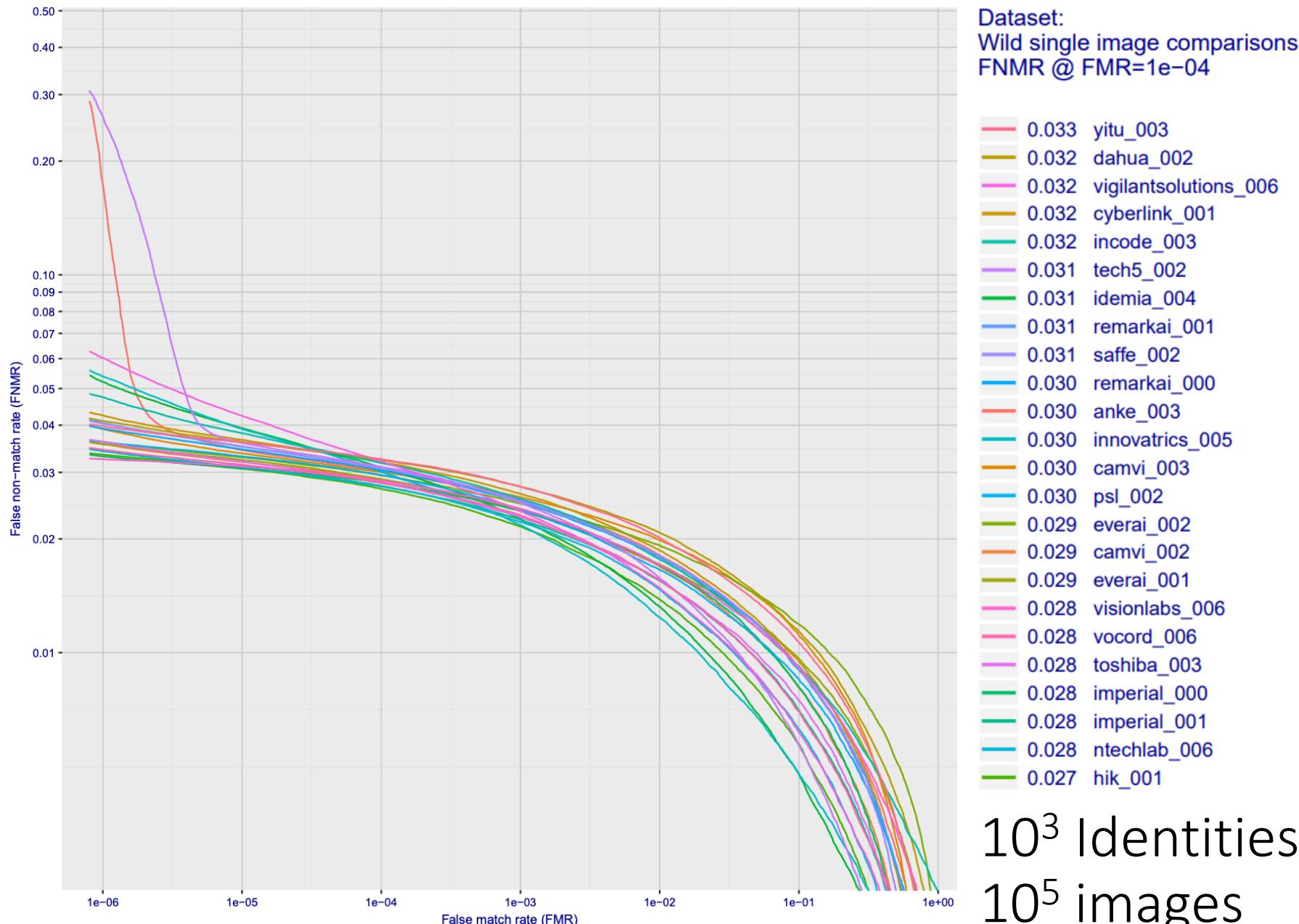
FRVT 1:1 Mugshot



FRVT 1:1 WILD

- ▷ The number of images is on the order of 10^5 .
- ▷ The number of subjects is on the order of 10^3 .
- ▷ The number of subjects with two images on the order of 10^3 .
- ▷ The images include many photojournalism-style images. Images are given to the algorithm using a variable but generally tight crop of the head. Resolution varies very widely. The images are very unconstrained, with wide yaw and pitch pose variation. Faces can be occluded, including hair and hands.
- ▷ The images are of adults.
- ▷ All of the images are live capture, none are scanned.

FRVT 1:1 WILD



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Lightweight Face Recognition Challenge

LIGHTWEIGHT FACE RECOGNITION CHALLENGE & WORKSHOP (ICCV 2019)

Latest News

The Lightweight Face Recognition Challenge & Workshop will be held in conjunction with the International Conference on Computer Vision (ICCV) 2019, Seoul Korea.

Organisers

General Chairs:

Jiankang Deng, Imperial College London, UK

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Sponsors:

The Lightweight Face Recognition Challenge has been supported by EPSRC project FACER2VM (EP/N007743/1)

Huawei (5000\$)

DeepGlint (3000\$)

iQIYI (3000\$)

Kingsoft Cloud (3000\$)

Dynamic funding pool: (14000\$)

Cash sponsors and gift donations are welcome before 20th July 2019.

<http://insightface-challenge.com>

Lightweight Face Recognition Challenge

deepglint-light	deepglint-large	iQIYI-light	iQIYI-large	
user	description	status	TPR@FPR=1e-8	date
coder-james	why_toy_sub_fail_902M	Finished	0.71299	2019-05-13
liujiaheng	Fifth Test	Finished	0.71184	2019-05-21
NothingLC	t512	Finished	0.71168	2019-05-25

deepglint-light	deepglint-large	iQIYI-light	iQIYI-large	
user	description	status	TPR@FPR=1e-8	date
Ihh18	test_559fnc	Finished	0.82854	2019-05-27
trantor	retina-xt-13	Finished	0.81731	2019-05-29
witcher	ww	Finished	0.81041	2019-05-25

Lightweight Face Recognition Challenge

deepglint-light	deepglint-large	iQIYI-light	iQIYI-large	
user	description	status	TPR@FPR=1e-4	date
NothingLC	divideam40c	Finished	0.53406	2019-05-28
hengcherkeng	980_Mflops_distill_100ir	Finished	0.50004	2019-05-21
xfr	70	Finished	0.48956	2019-05-29
deepglint-light	deepglint-large	iQIYI-light	iQIYI-large	
user	description	status	TPR@FPR=1e-4	date
cky	r100_fcat2	Finished	0.66627	2019-05-28
Ihlh18	iqiyi_a486	Finished	0.66610	2019-05-29
emdata	R100SE-baseline	Finished	0.65405	2019-05-11

A large, colorful word cloud centered around the words "thank you" in various languages. The word "thank" is in red, "you" is in orange, and "thank you" together is in yellow. The surrounding words are in different colors and fonts, representing numerous languages from around the world. Some examples include "danke" in German, "спасибо" in Russian, "merci" in French, "gracias" in Spanish, "mānana" in Hawaiian, and "merhaba" in Turkish.