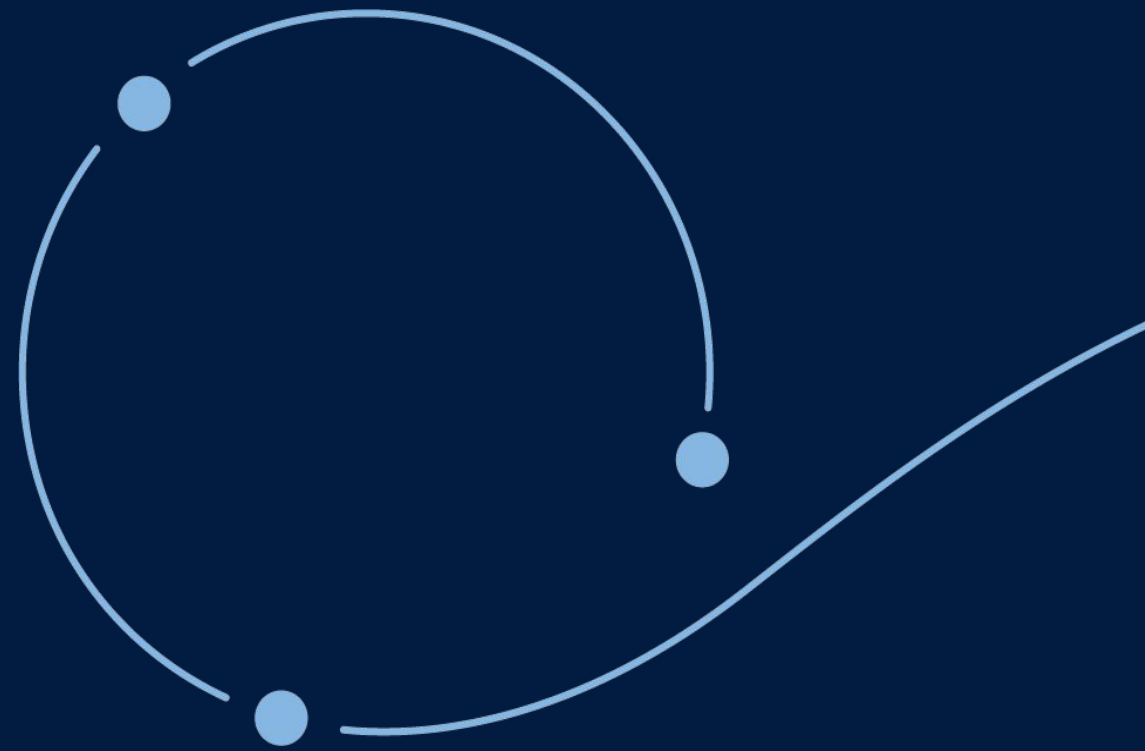
Presentation Attack Detection Improved by Face Image Quality Assessment

Marian Beszédeš



INNOVATRICS

Agenda

- Innovatrics
- Passive Liveness (PL) check applications
- SER-FIQ for face image quality assessment
- Face image quality for passive liveness
- Biases of PL quality
- PL Quality as trigger for actionable feedback
- How to deal with hard spoofs

INNOVATRICS

We are an independent provider of biometric solutions for governments and enterprises.

INNOVATRICS

Achievements

1 Billion+ Enrollees

500+ Projects

3 Biometric Modalities
Fingers / Iris / Face

80+ Countries

17 Years on the Market

~150 Employees

Elections
Africa

Trusted Voter Registration

7 million applicants enrolled

250 applicant registrations per minute

Criminal Investigation Southeast Asia

Law Enforcement ABIS
Automated Biometrics identification System

180 million records

Over 3 000 stations

3 modalities

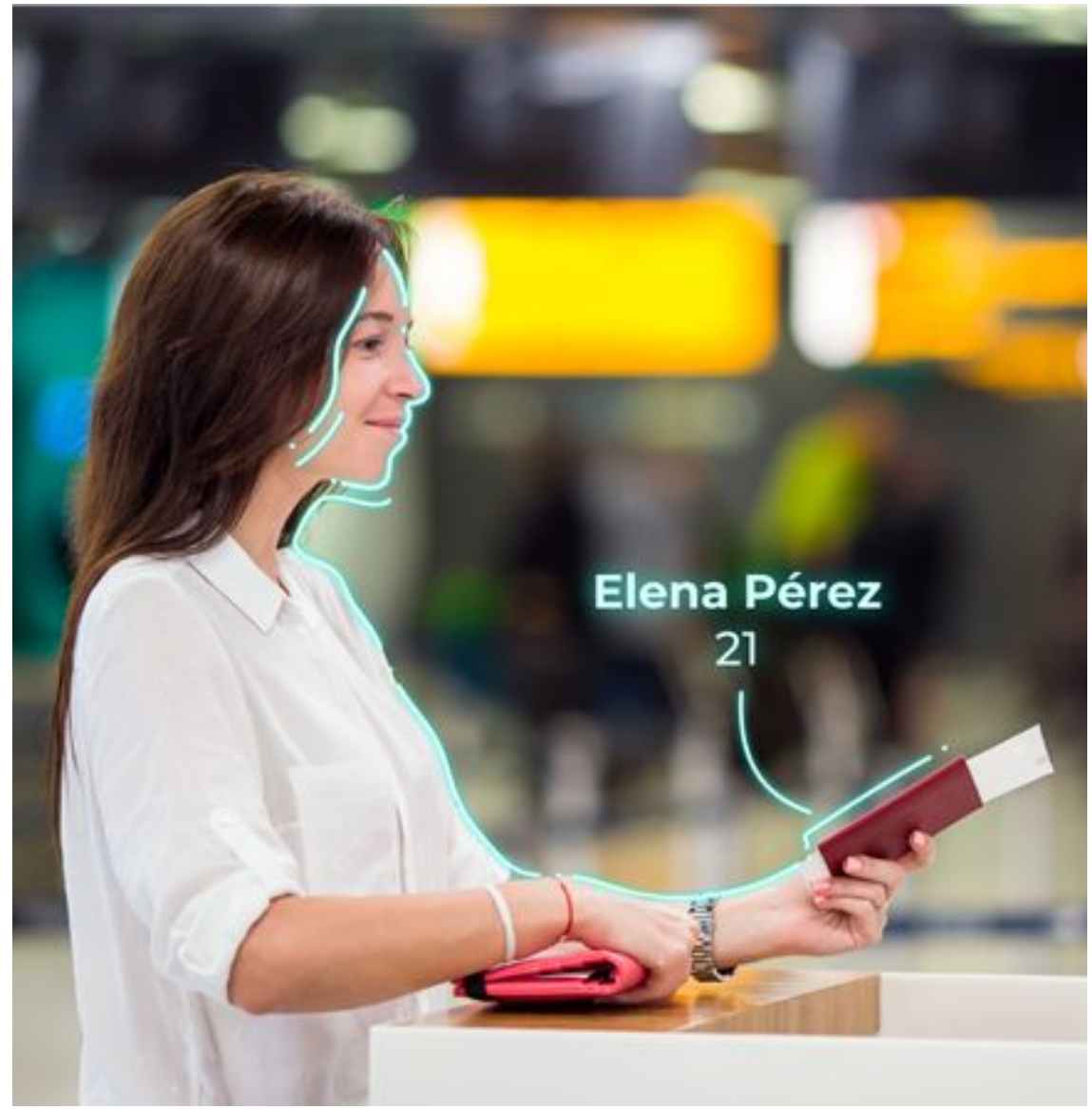
Border Control Middle East

Law Enforcement ABIS
Automated Biometrics identification System

80 million records

100 000 border crossings a day

24/7 onsite support



Digital Onboarding Banking

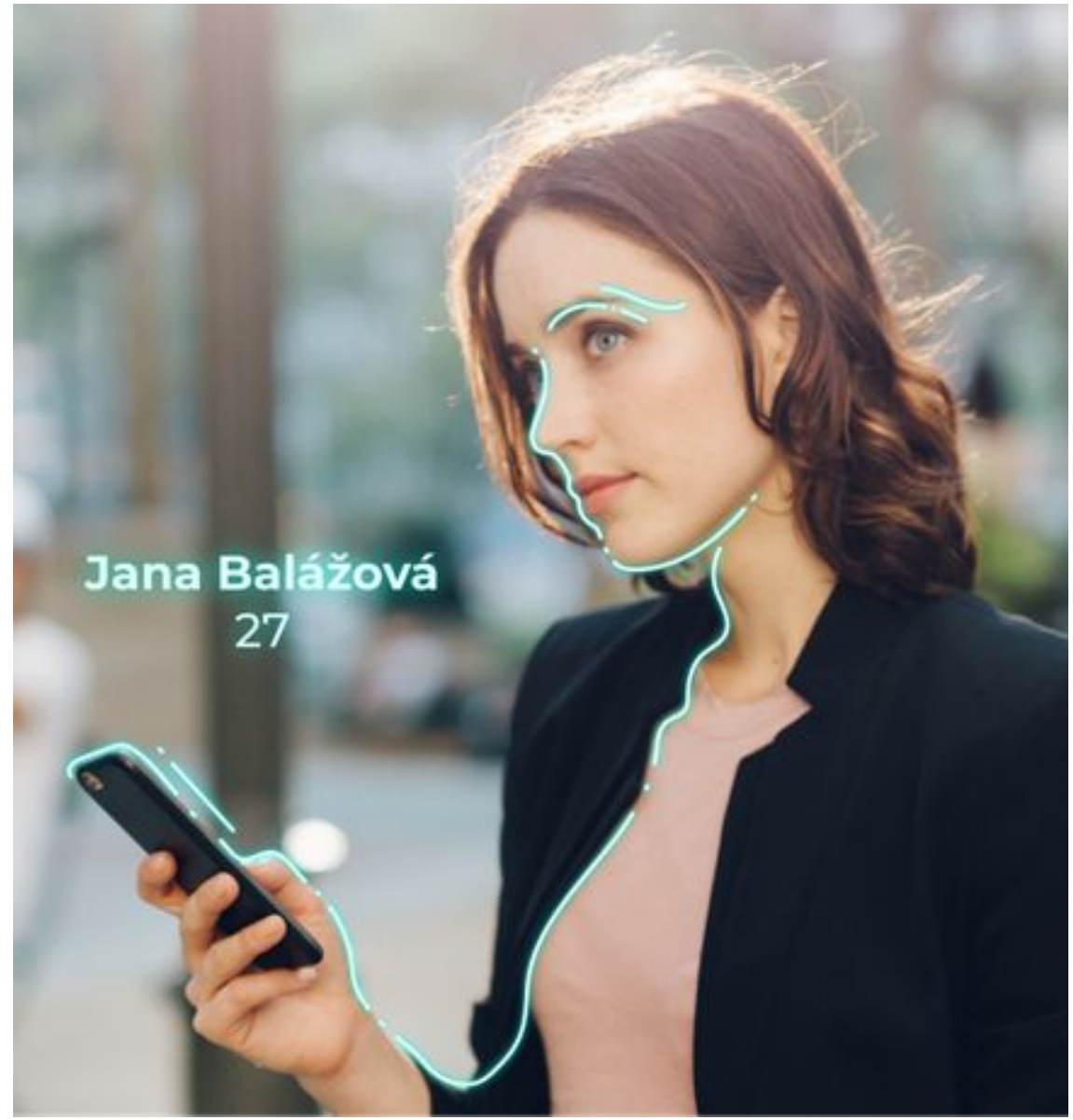
Digital Onboarding & ABIS

70% time saved

30% new accounts

50% student accounts

3 simple steps



Passive Liveness Check

For digital onboarding

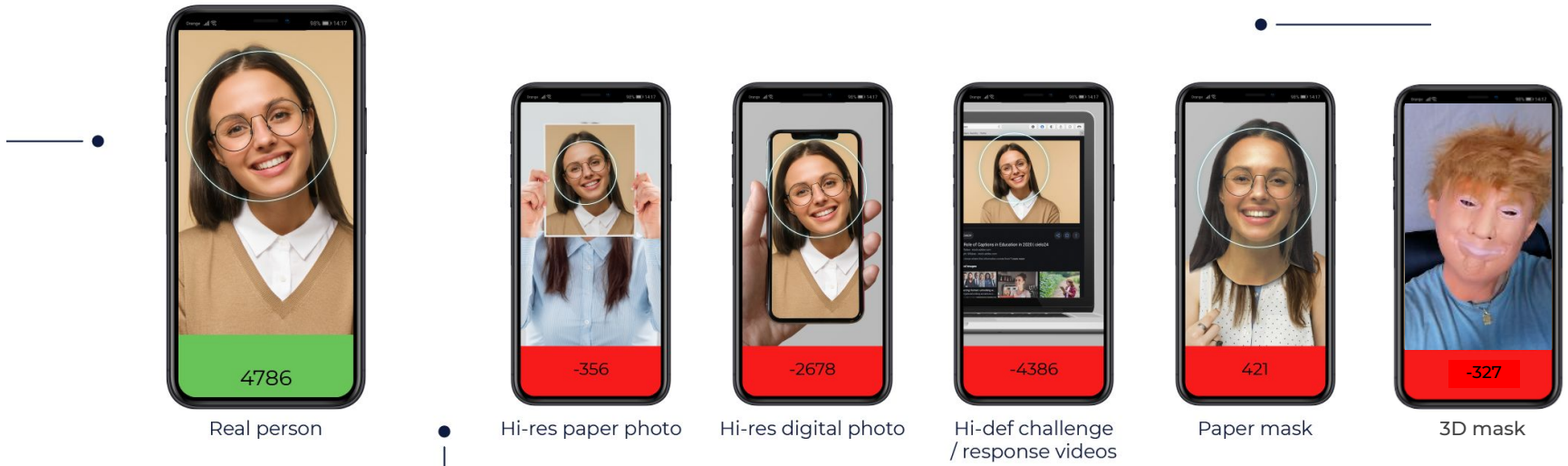
Passive liveness (PL)

What ?

- No user interaction needed
- Single shot
- On device

Why ?

- Faster
- More reliable
- Better user experience



Passive liveness

Presentation Attack Detection

Level 1 Certification
Level 2 Certification

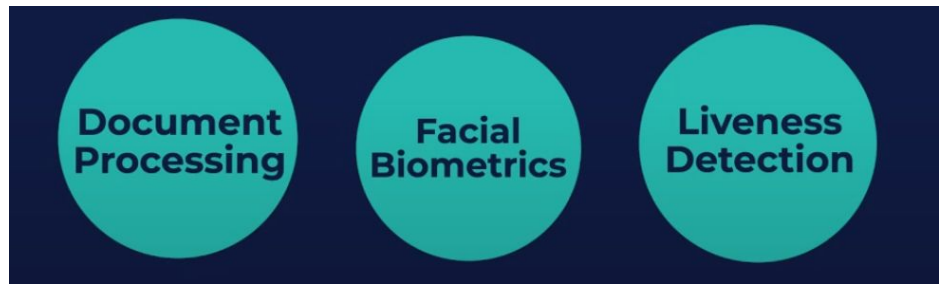
iBeta

	Test Species	Android v3.0.0			iOS v2.1.0(1)		
		PAs	APCE	APCER	PAs	APCE	APCER
1.	3D Curved Paper Mask	150	0 of 150	0%	150	0 of 150	0%
2.	Latex Mask	150	0 of 150	0%	150	0 of 150	0%
3.	Inexpensive Silicone Mask	150	0 of 150	0%	150	0 of 150	0%
4.	Resin Mask	150	0 of 150	0%	150	0 of 150	0%
5.	Layered 2D Transparent Photo	150	0 of 150	0%	150	0 of 150	0%
Total per species			0 of 150	0%		0 of 150	0%
Total for all species			0 of 750	0%		0 of 750	0%

Use cases for passive liveness check

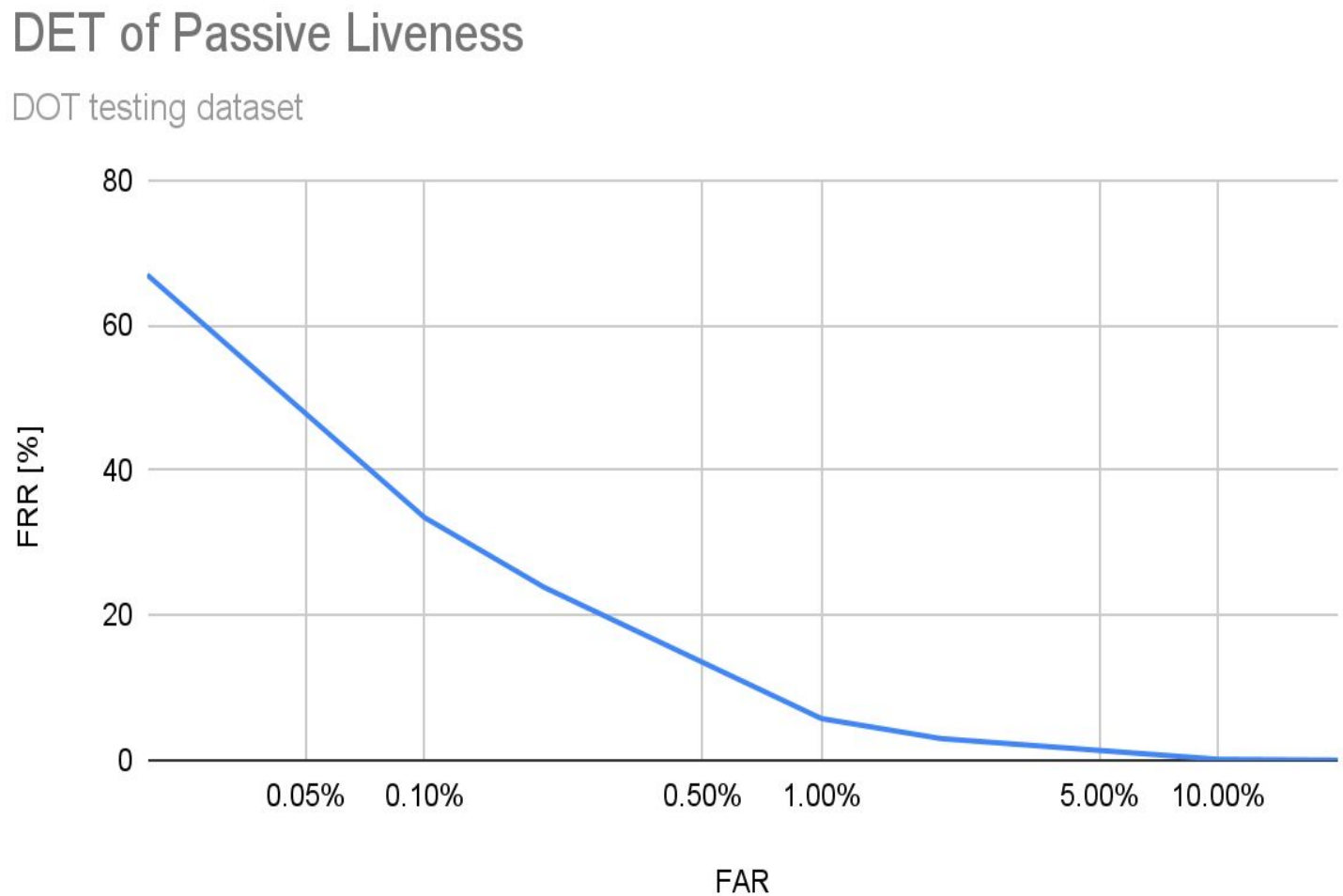
- Integral part of any verification / registration process

- DOT (Digital Onboarding Toolkit) applications
  - Car driver registration
  - eVisa issuance
  - Employee registration
  - Bank account opening
  - eSIM card registration
  - Home quarantine check



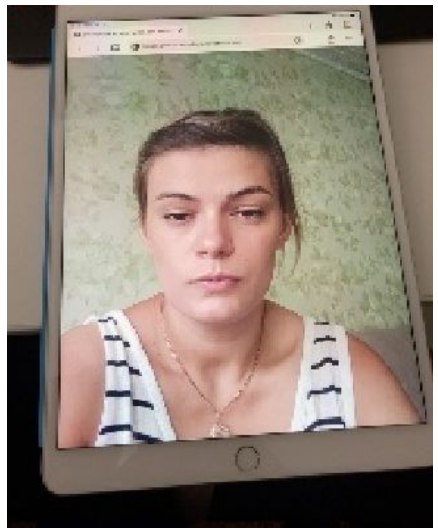
PL Accuracy

- DOT testing dataset
  - Smartphone selfies / Webcams
  - Challenging real world
  - Crowd spoofs hunting
  - 10k Genuines / 19k Spoofs

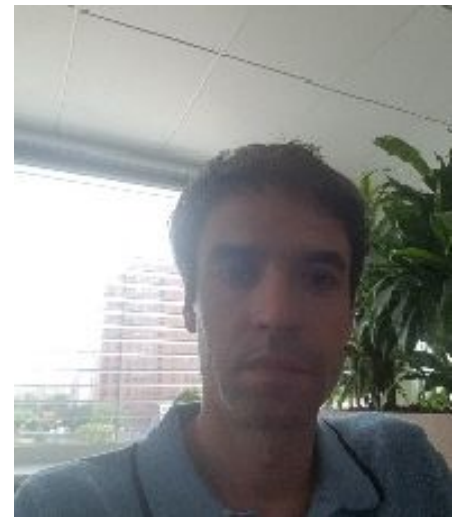
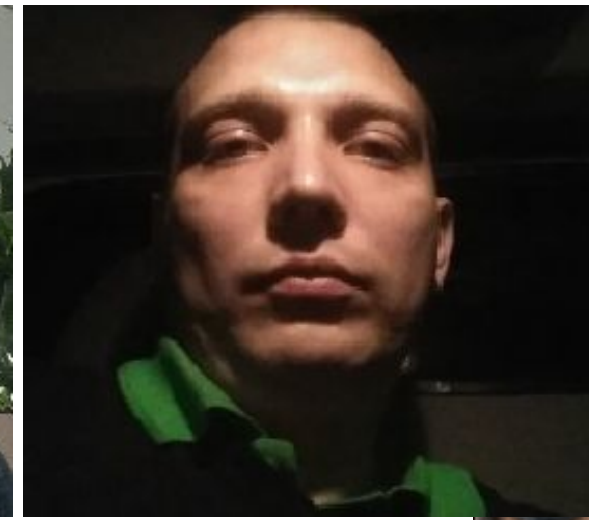
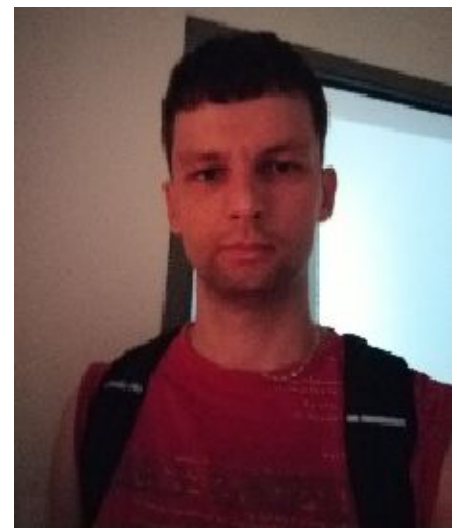


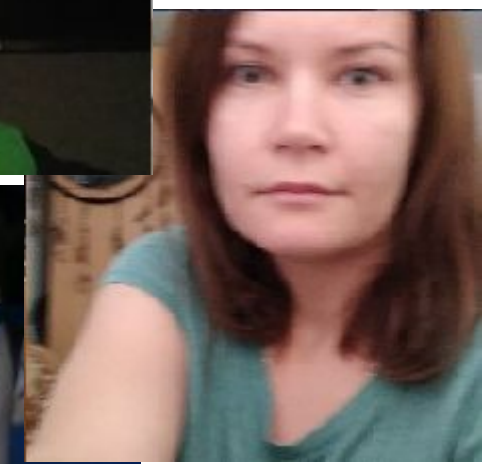
Still some edge case failures

Spoof having **high** PL score




Genuines having **low** PL score

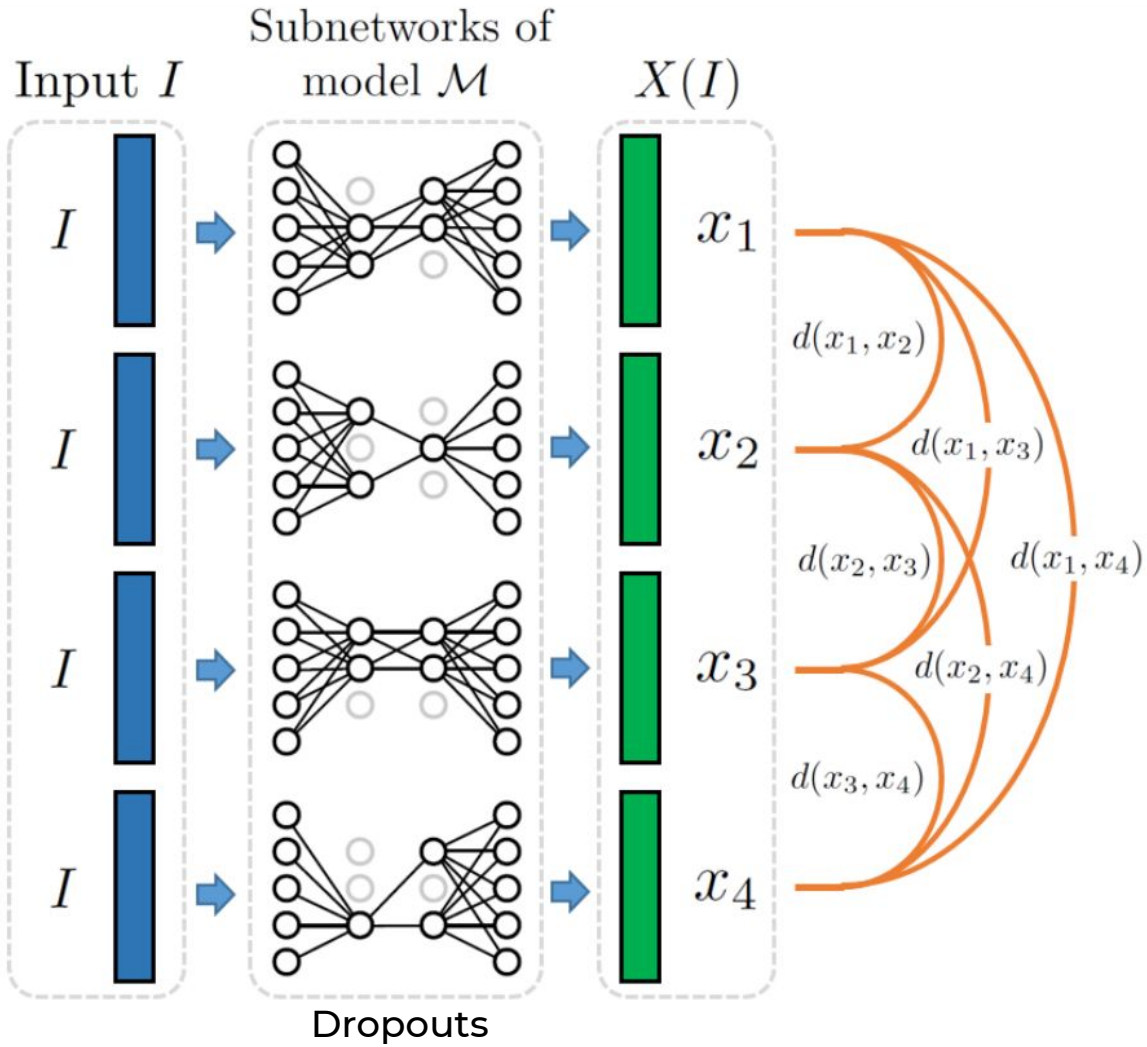


Face Image Quality Assessment

Terhorst, Philipp, et al. "SER-FIQ: Unsupervised estimation of face image quality based on stochastic embedding robustness." CVPR 2020

SER-FIQ

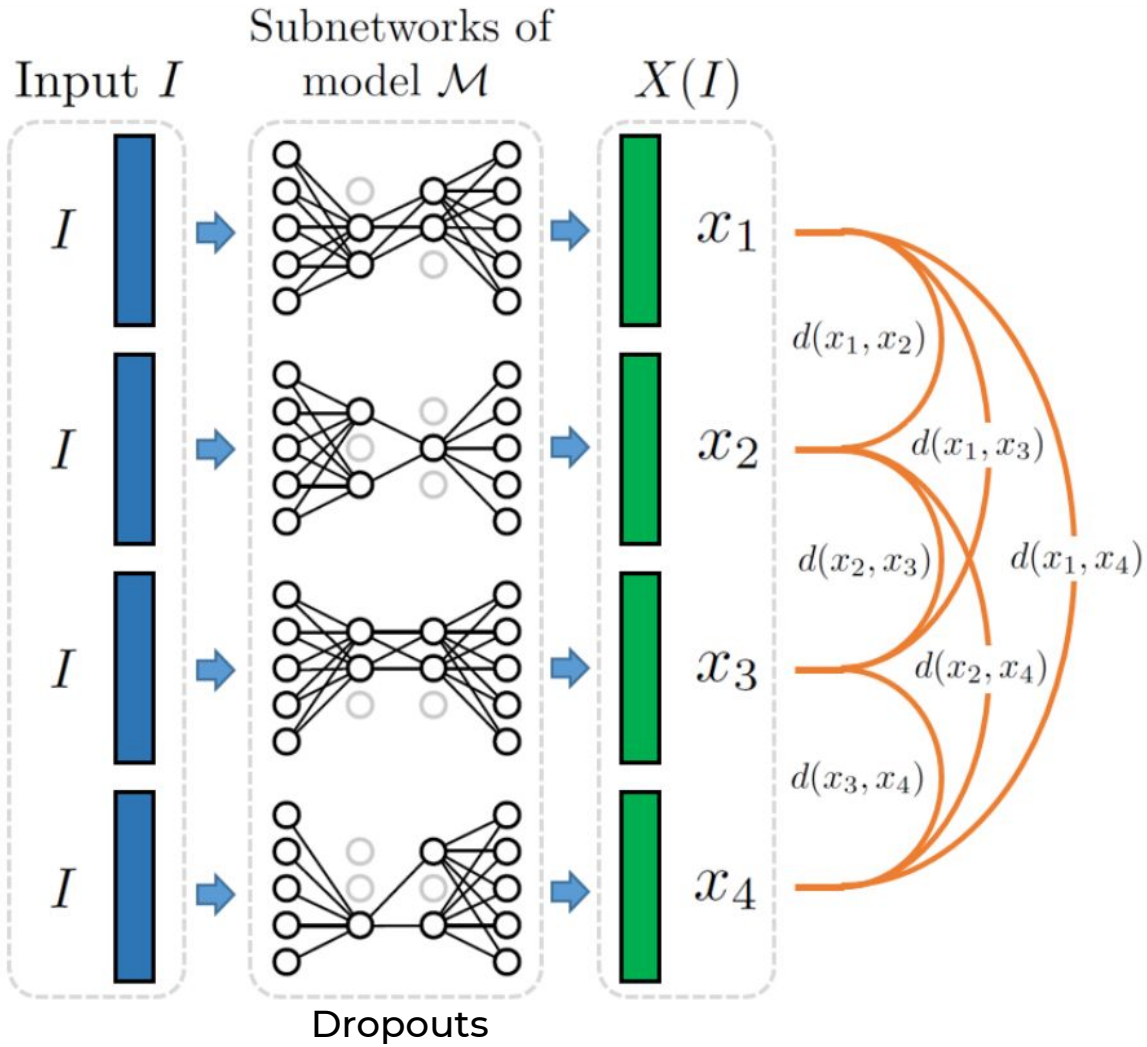
Stochastic Embedding Robustness = Face Image Quality



- Face recognition model should use dropout (at least last layer)
- Face embeddings from subnetworks
  - Small variations = High quality
  - Large variations = Low quality

SER-FIQ

Face Image Quality = Stochastic Embedding Robustness



$$q(X(I)) = 2\,\sigma\Big(-\frac{2}{m^2}\sum_{i<j} d(x_i, x_j)\Big)$$

I - image

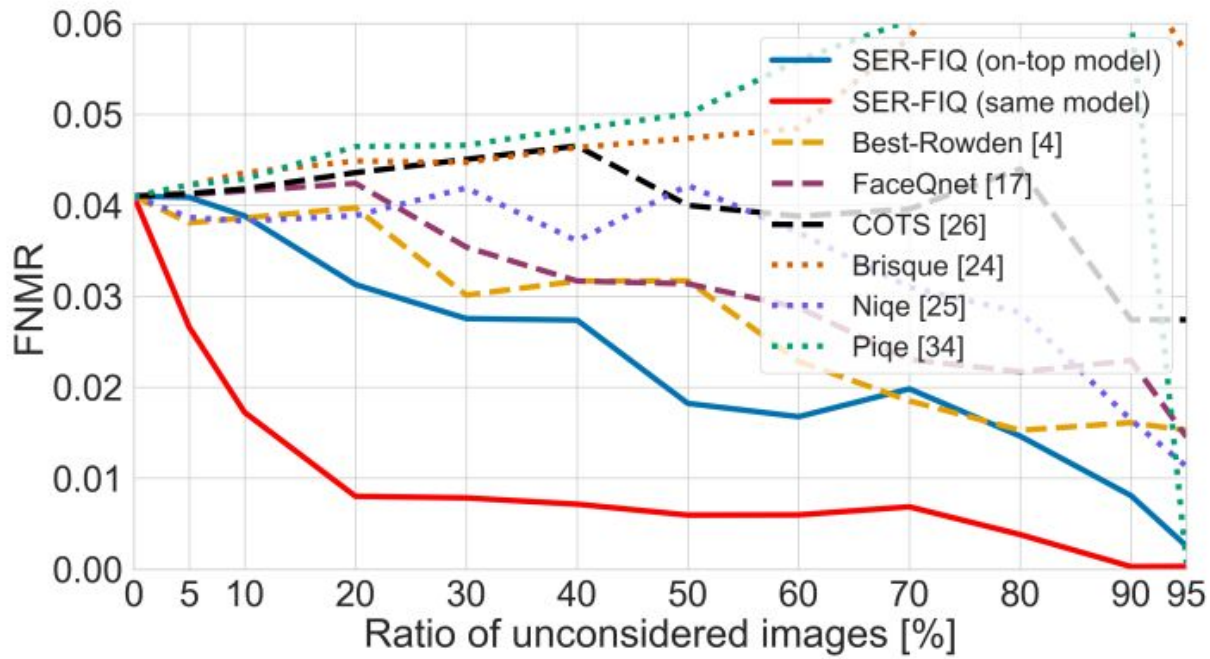
$X(I)$ - set of m stochastic embeddings

q - face quality

$d(x_i,x_j)$ - euclidean distance of embeddings x_i,x_j

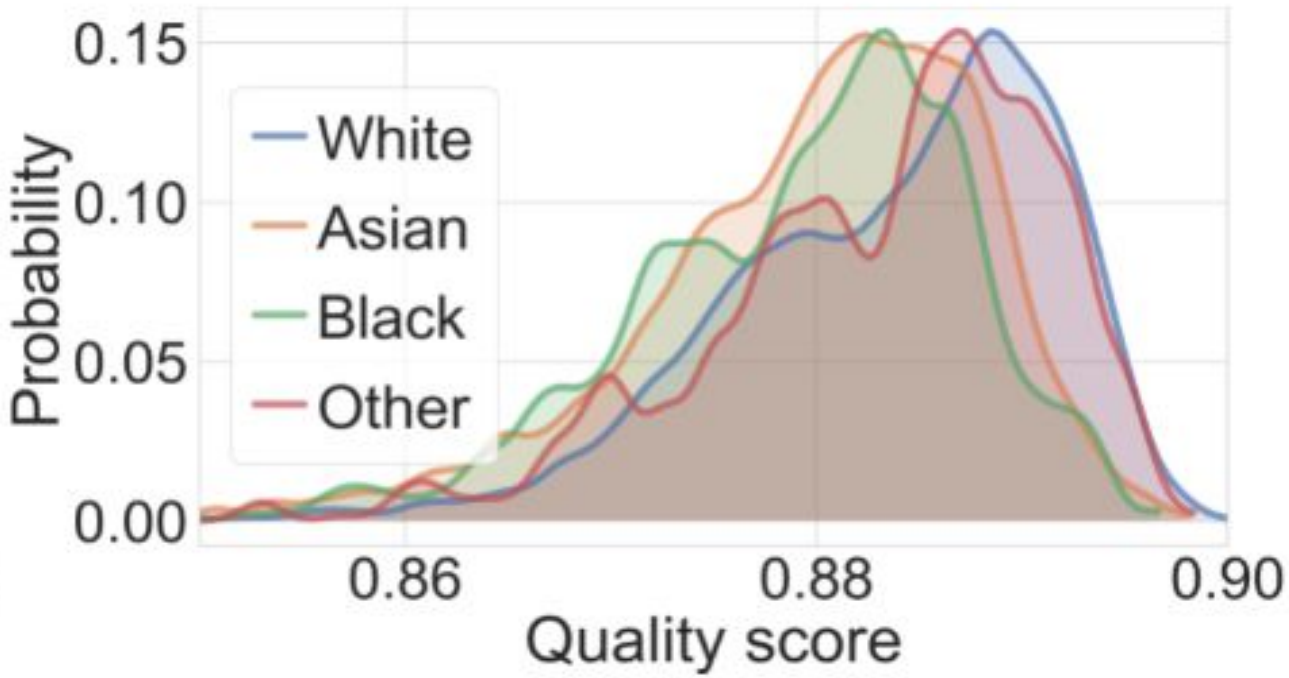
SER-FIQ low face quality filtering

- Filtering out the images with low Face image Quality improves face verification
- Comparison to other methods



ArcFace NN, LFW dataset, FNMR @ FMR=0.001

SER-FIQ face quality biases



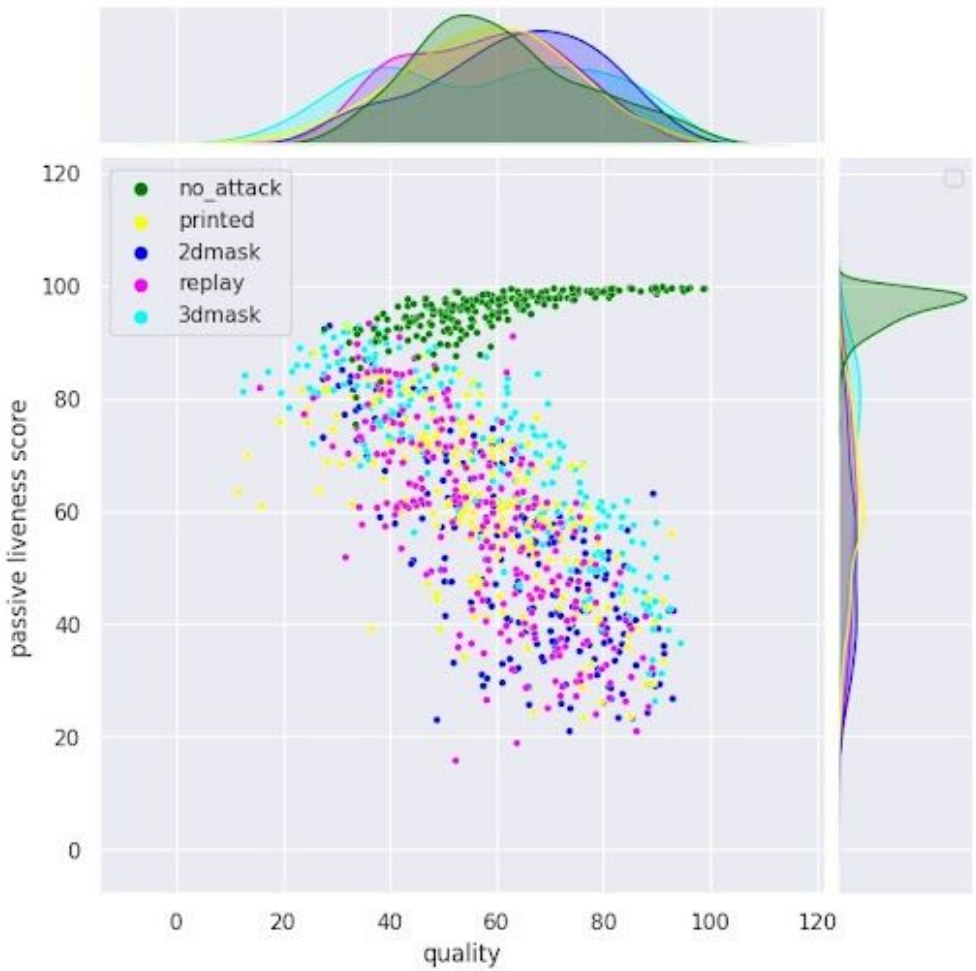
- Asian/Black faces have lower quality than White faces in general = Bias
- It has the same biases as utilized face recognition models

Terhörst, Philipp, et al. "Face quality estimation and its correlation to demographic and non-demographic bias in face recognition." *2020 IEEE International Joint Conference on Biometrics (IJCB)*. IEEE, 2020.

Face Image Quality for Passive Liveness

PL Quality vs PL Score

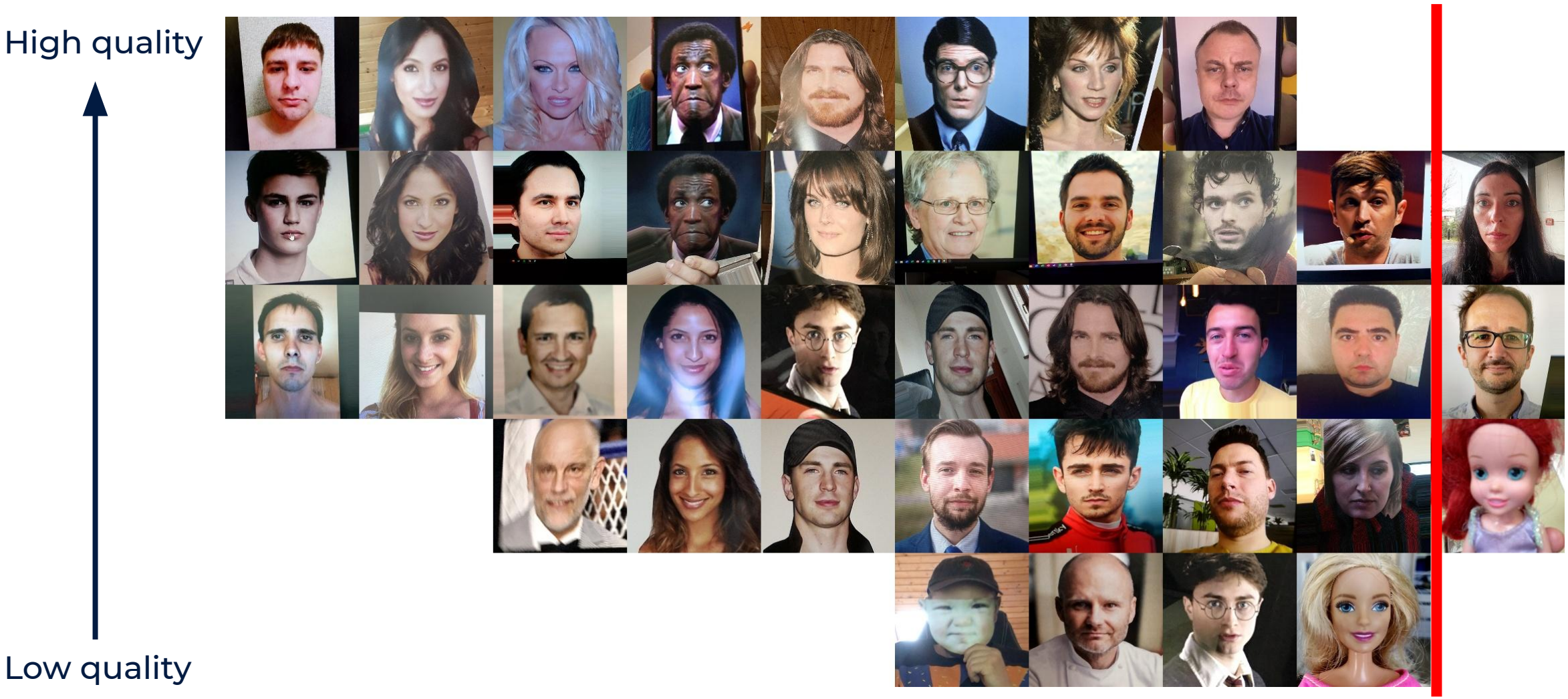
DOT Test DB



- DOT testing dataset
  - Smartphone selfies / Webcams
  - Challenging real world images
  - Crowd spoofs hunting
  - 10k Genuines / 19k Spoofs
- High quality
  - Algorithm has perfect accuracy
- Low quality
  - Algorithm is not sure

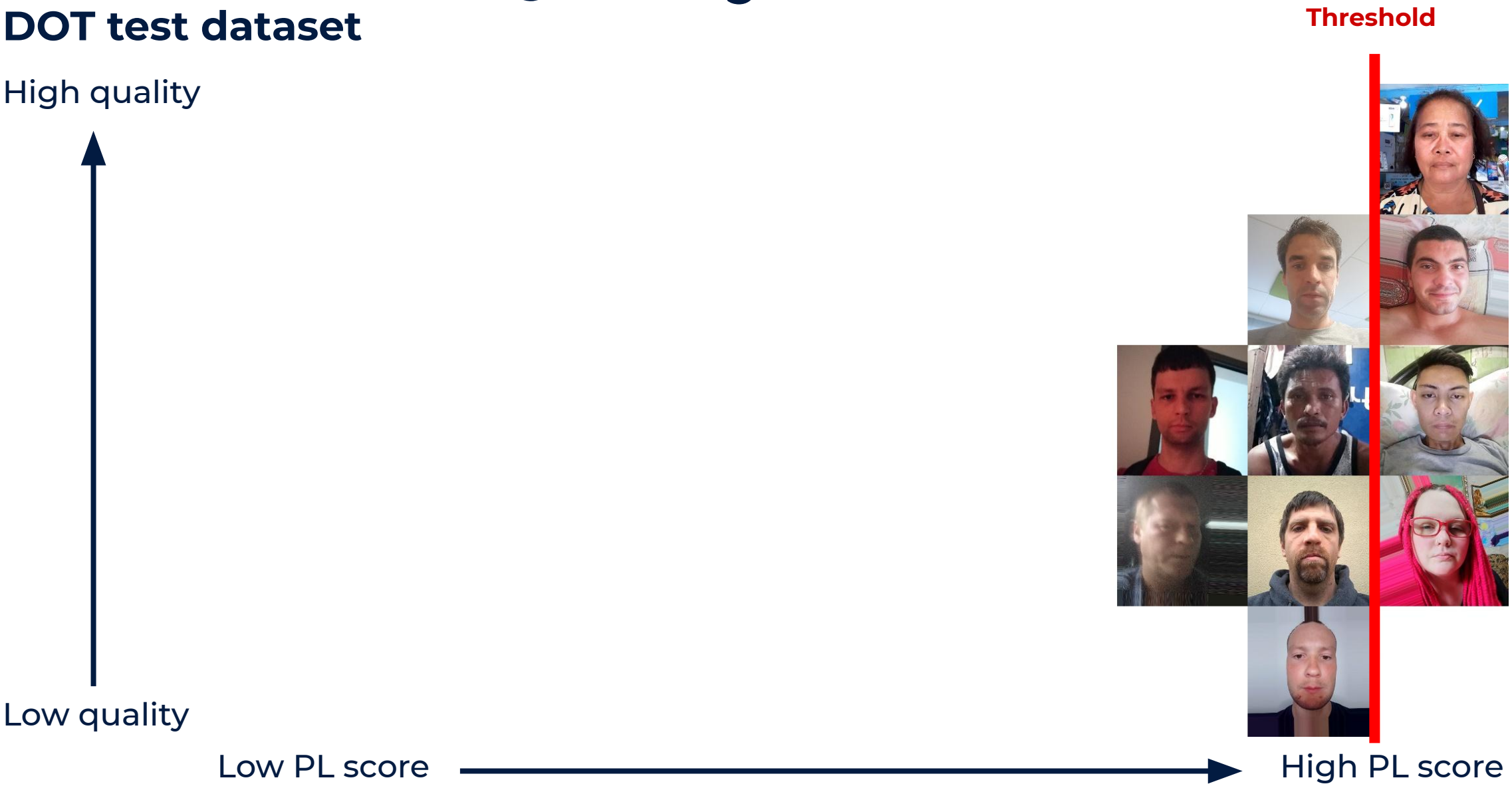
PL score vs Quality - Spoofs

DOT test dataset



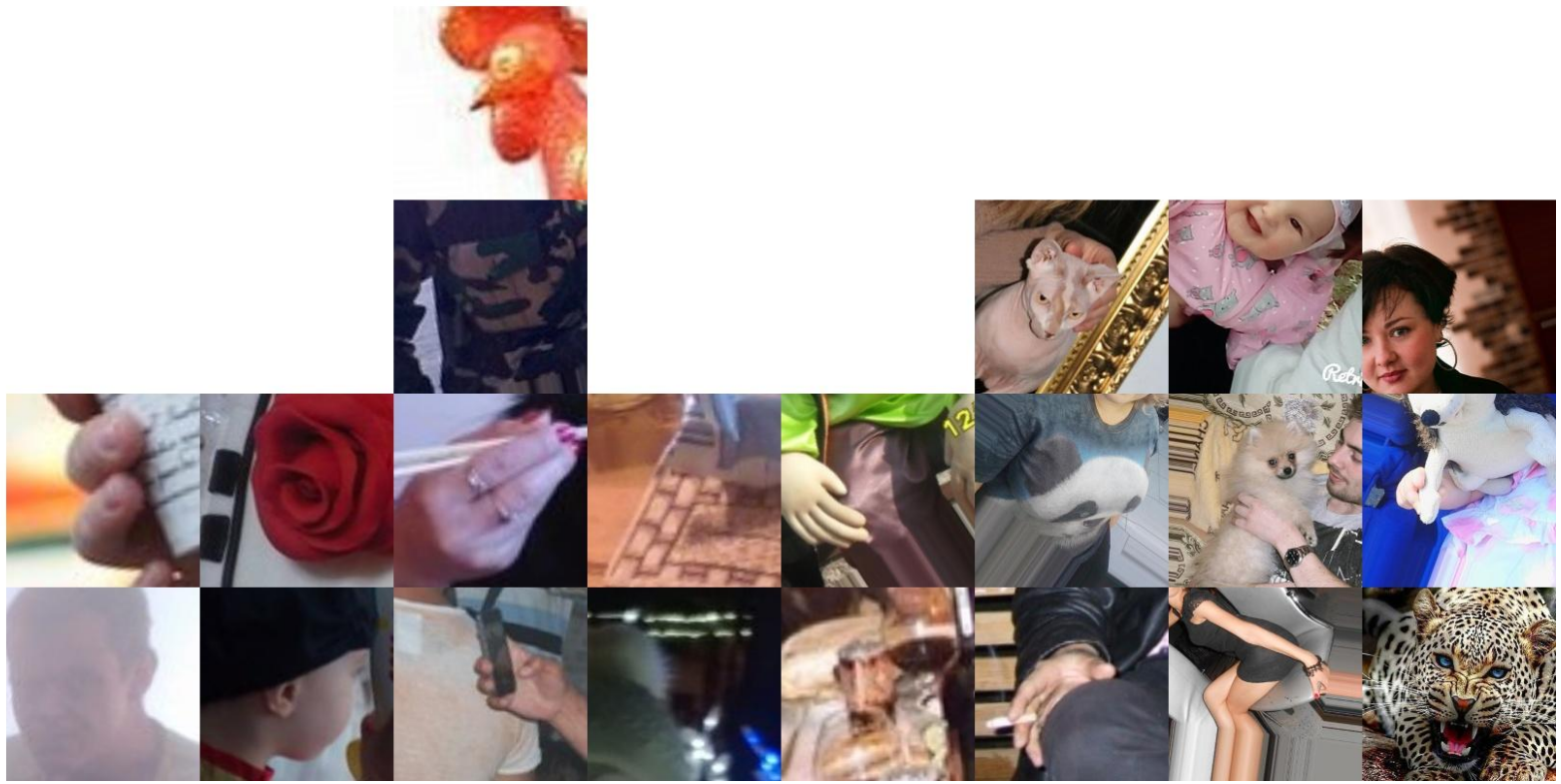
PL score vs Quality - Genuines

DOT test dataset



PL score vs Quality - NonSense

High quality



Low quality

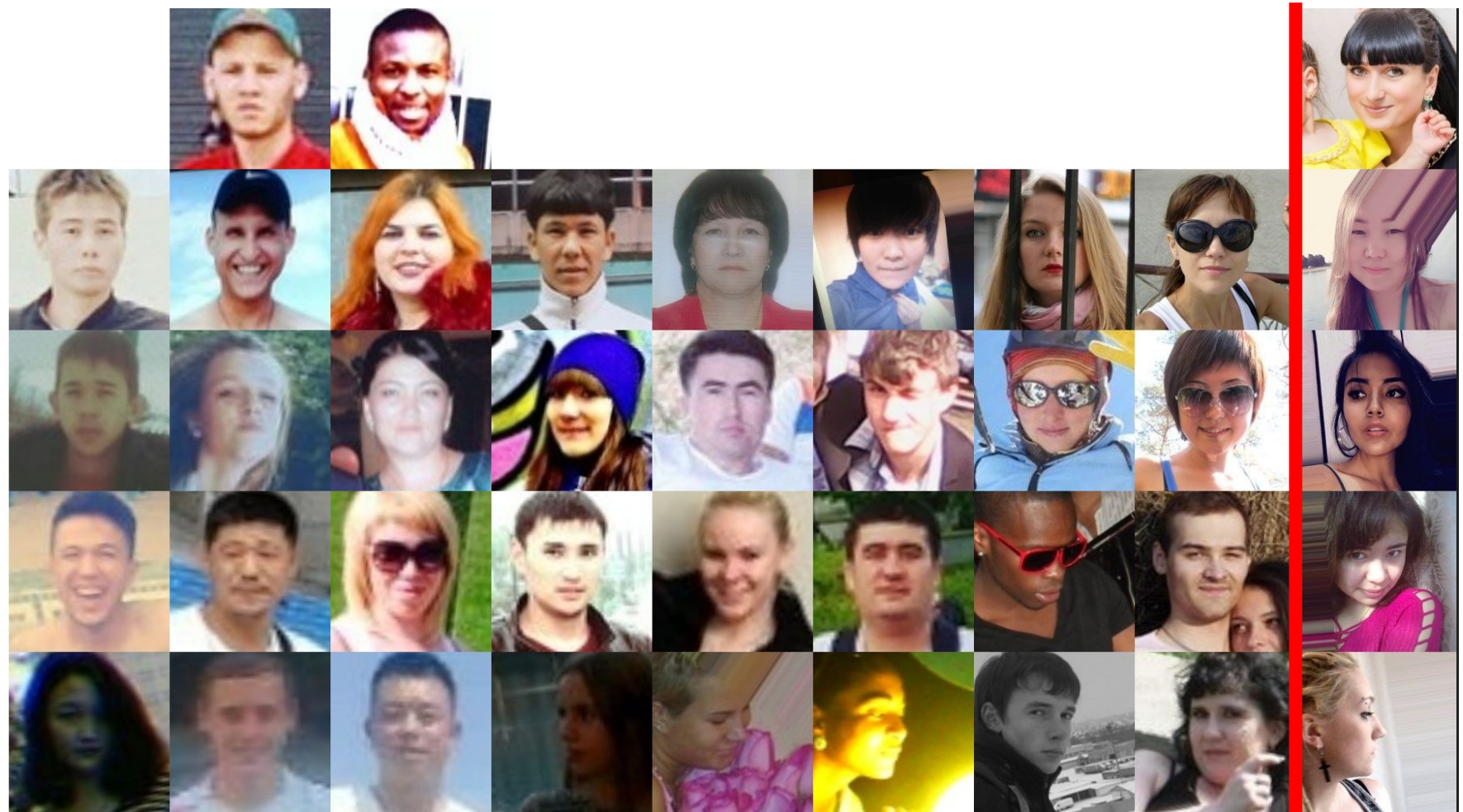
Low PL score

High PL score

PL score vs Quality - Any genuines

Threshold

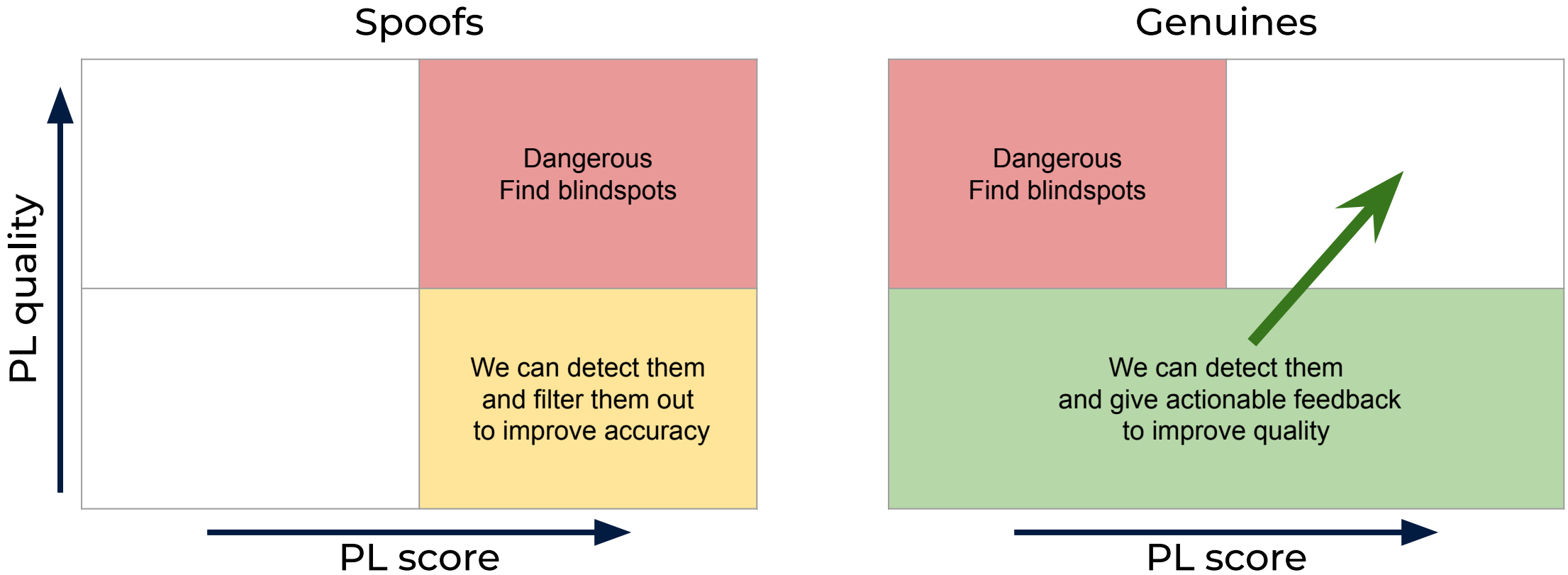
High quality



Low quality

Low PL score → High PL score

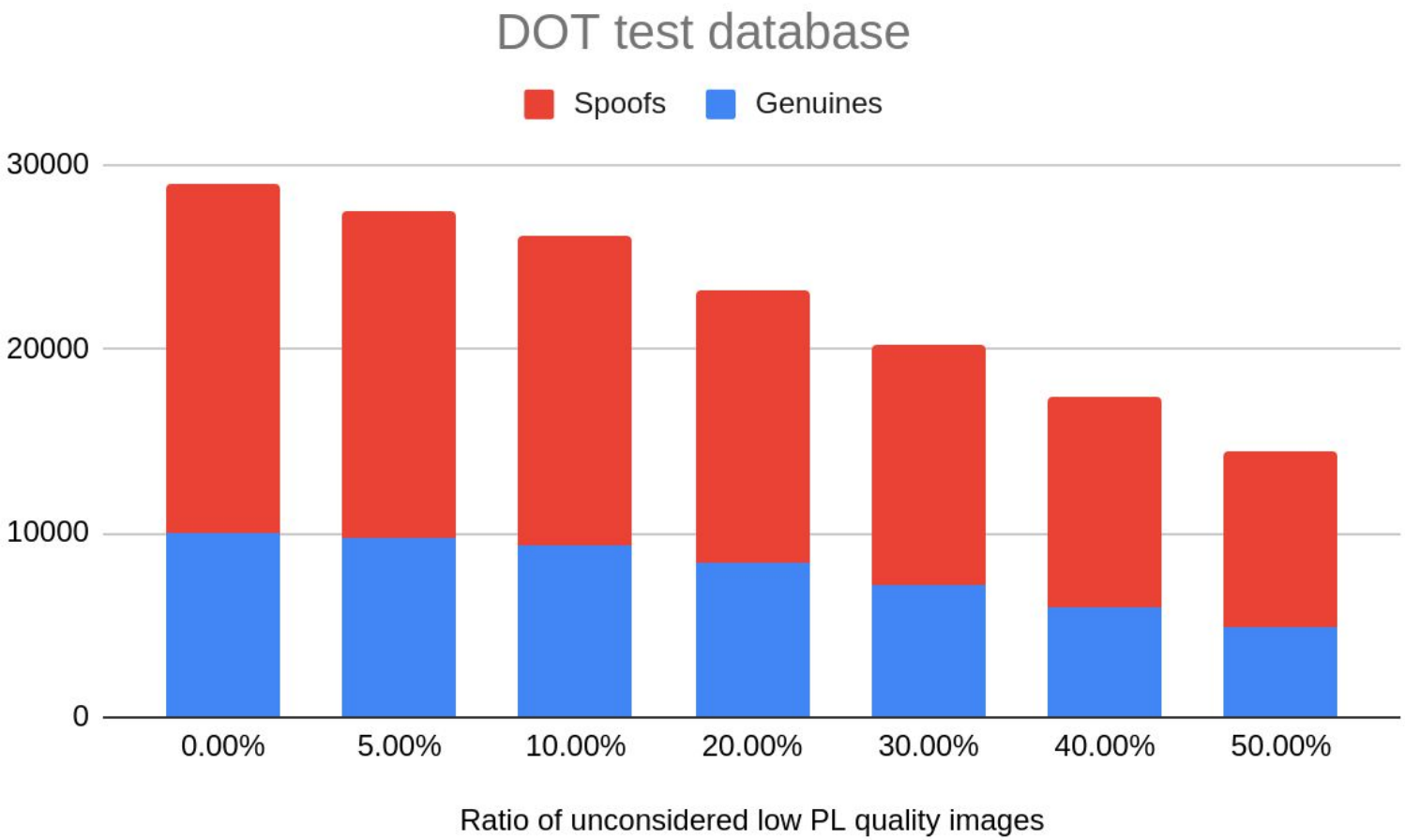
Findings and Hypotheses



PL quality could be good for:

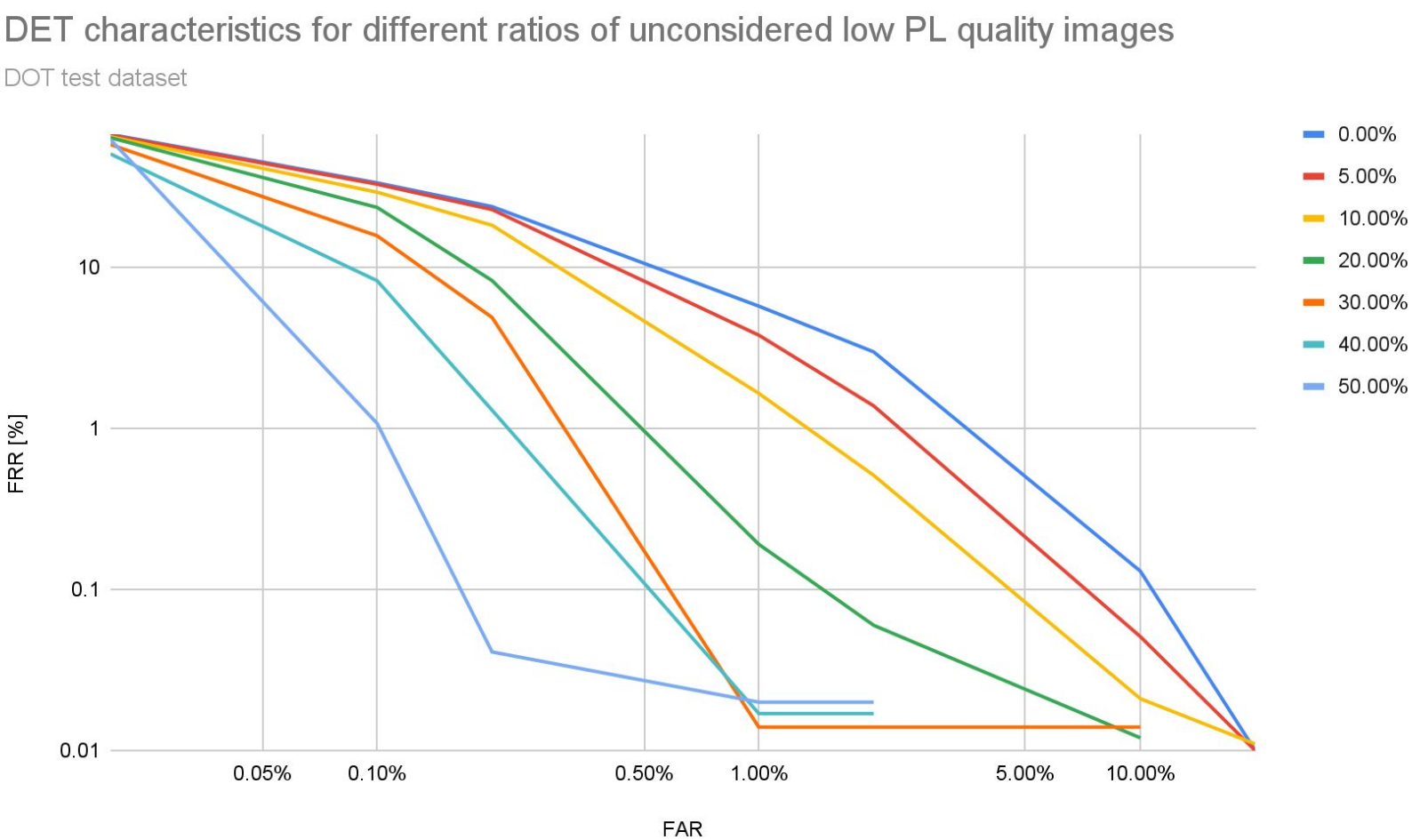
- Improving accuracy of passive liveness algorithm
- Indication of low quality data
- Finding blind spots of PL algorithm

Filtering images with low PL quality



- Ratio of spoofs vs genuines remains the same

Improving accuracy of PL algorithm



- FAR 10^{-1} - 10^{-3}
  - significant FRR improvements
  - Low quality spoofs / genuines filtered out
- FAR < 10^{-3}
  - No FRR changes
  - High quality spoofs are still there

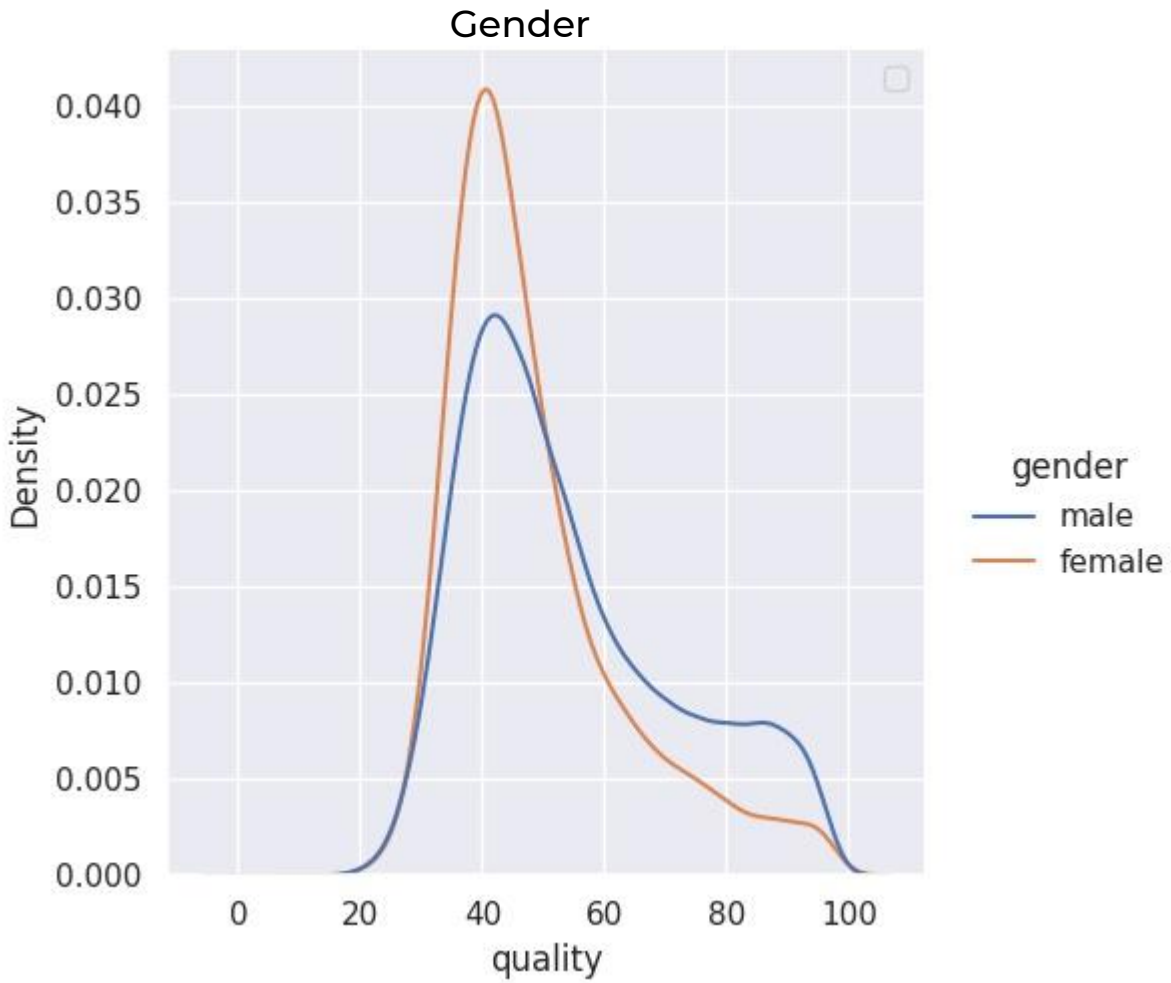
Patterns in low PL quality genuines ⇾ actionable feedback

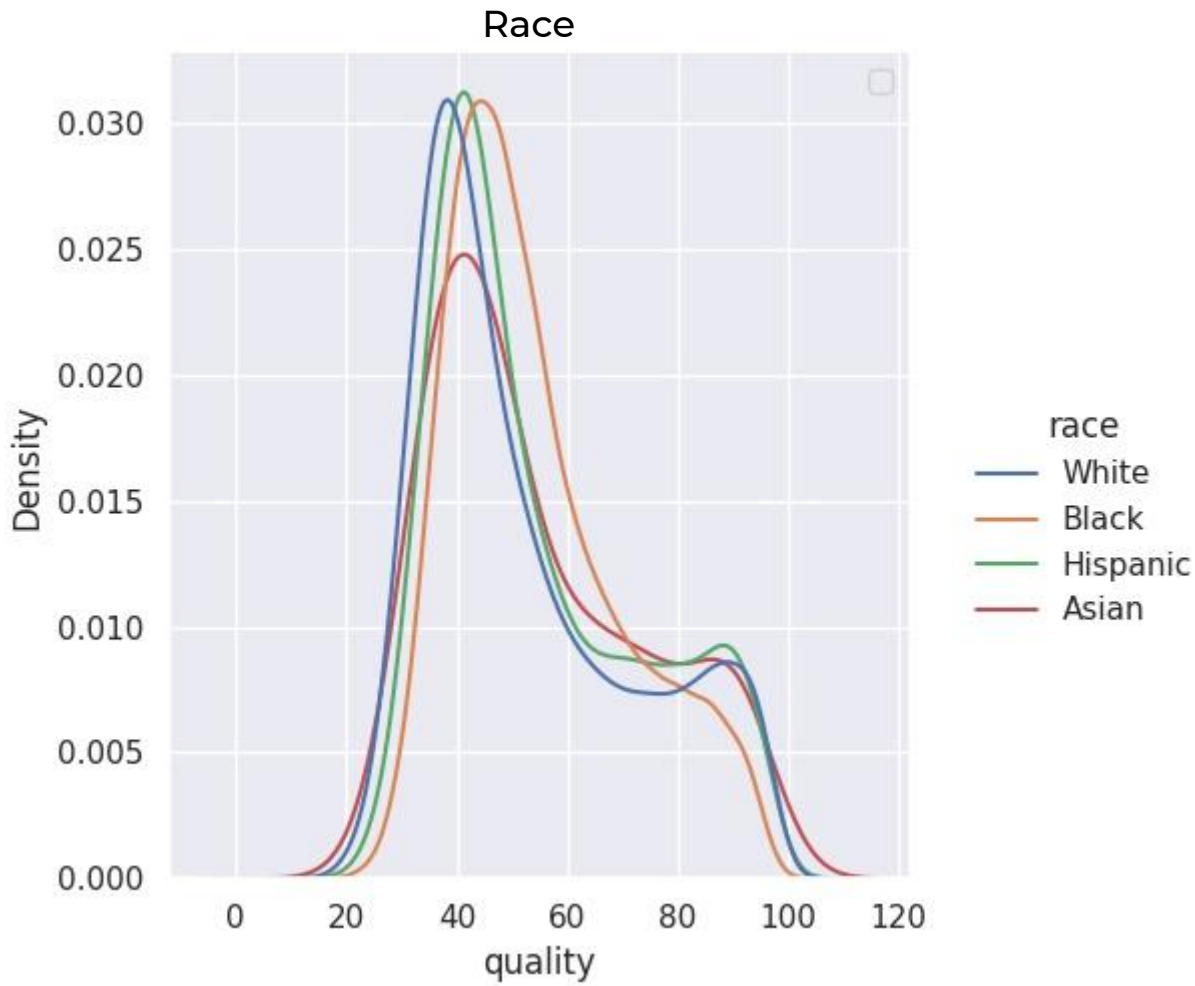
- Images -> Features
  - PL NN as feature extractor
  - Imagenet NN as extractor
  - PCA
- Clustering
  - t-Sne
  - K-Means
- Blind spots
  - Homogenous clusters having some specific property

Are there any biases in PL quality ?

Are there biases in our PL quality ?

Morph Inmates dataset

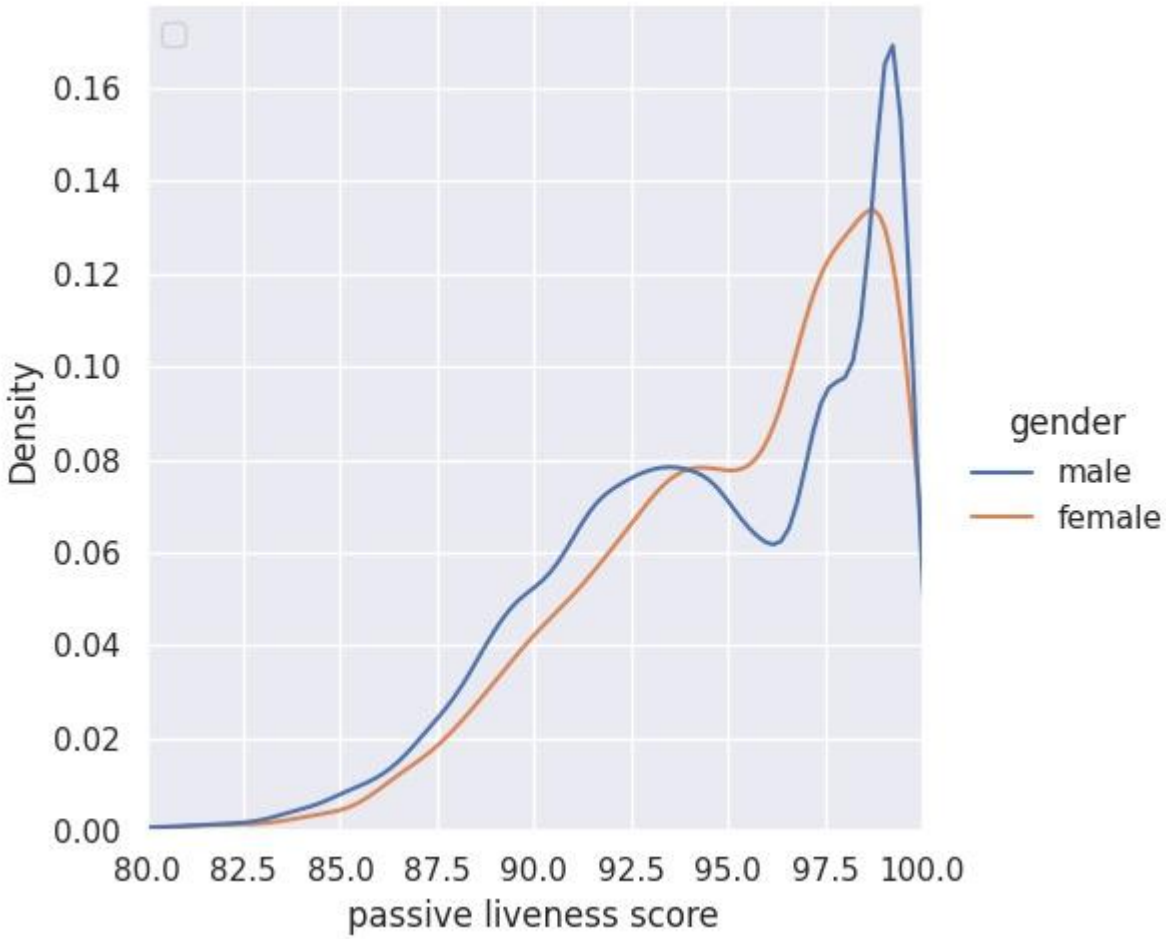




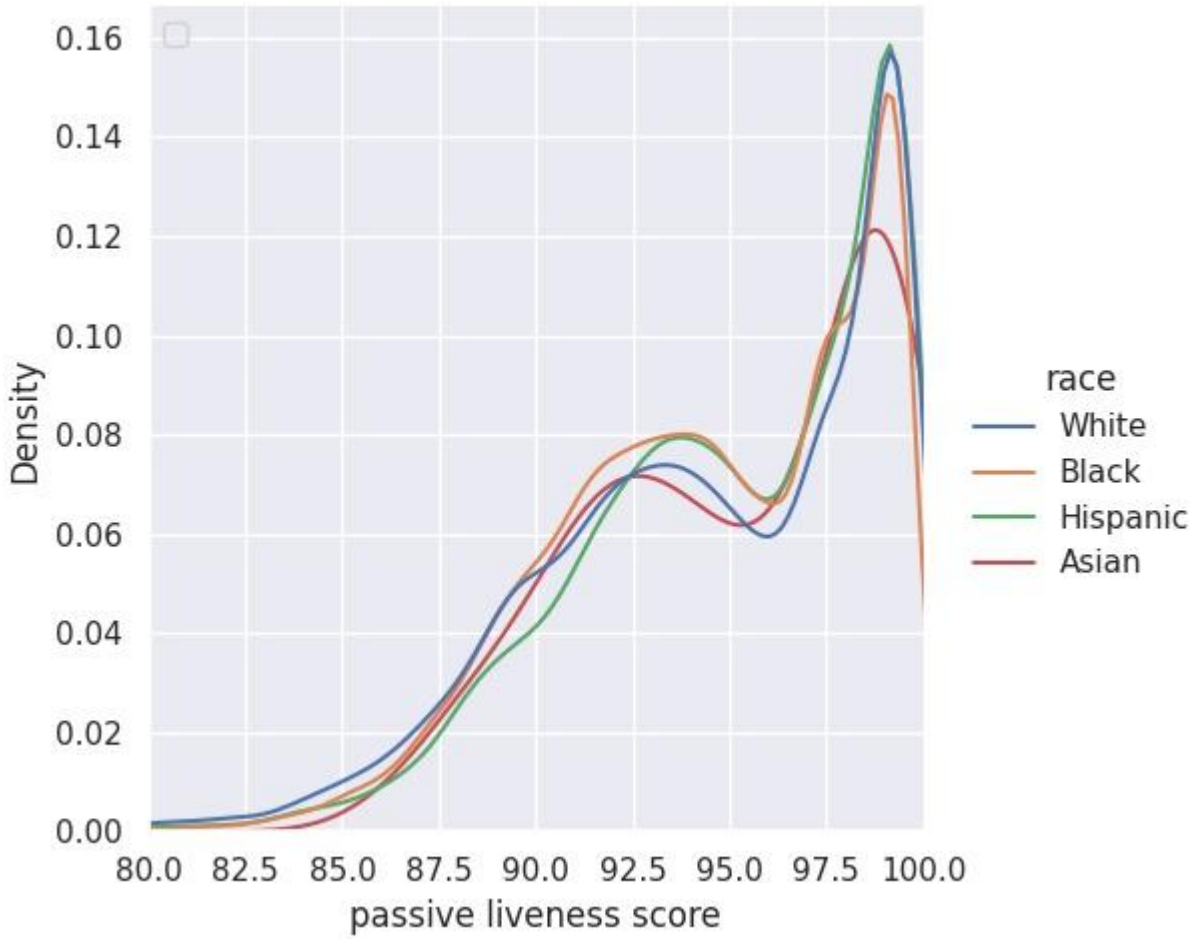
Are there biases in our PL check ?

Morph Inmates dataset

Gender

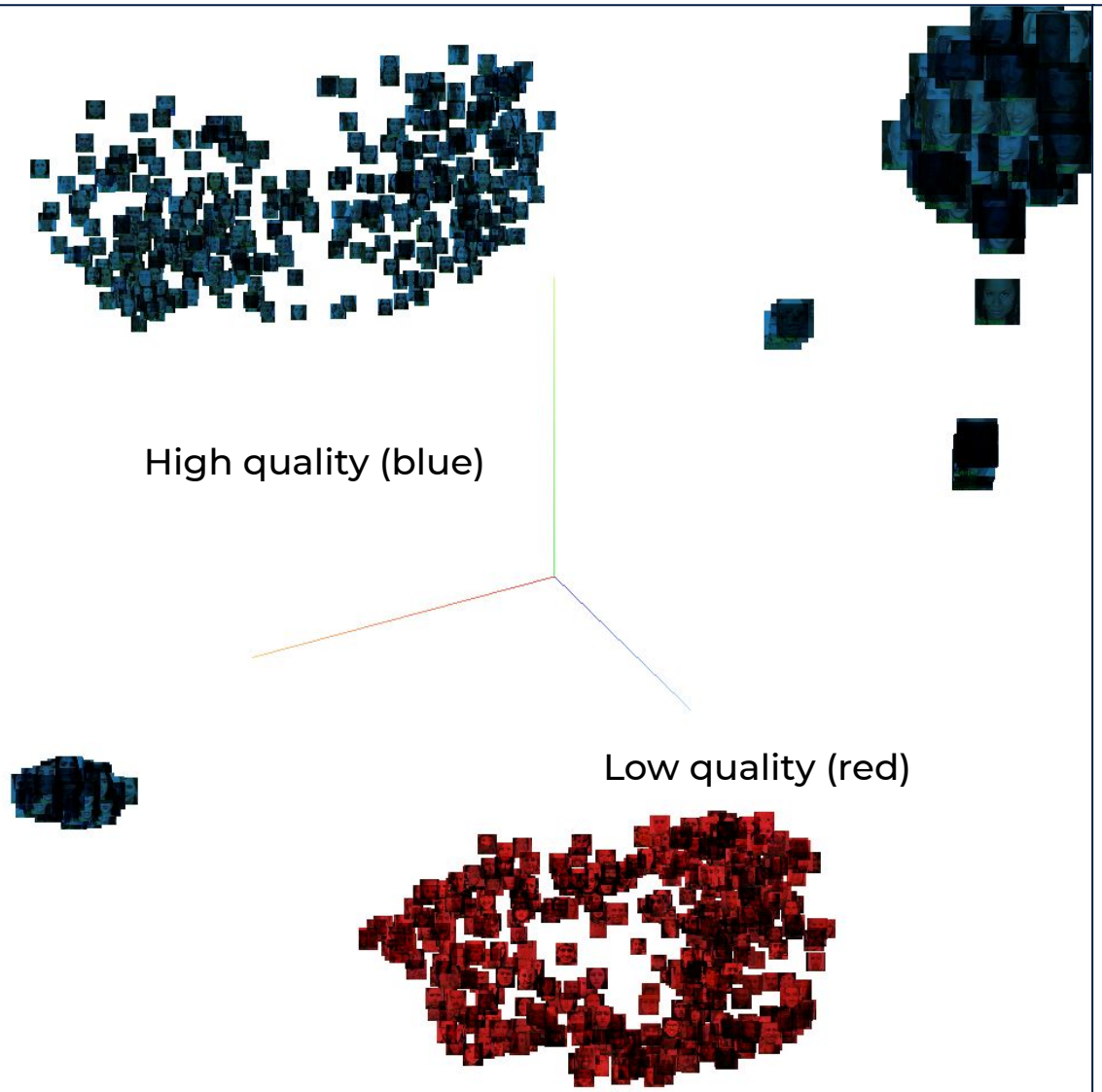


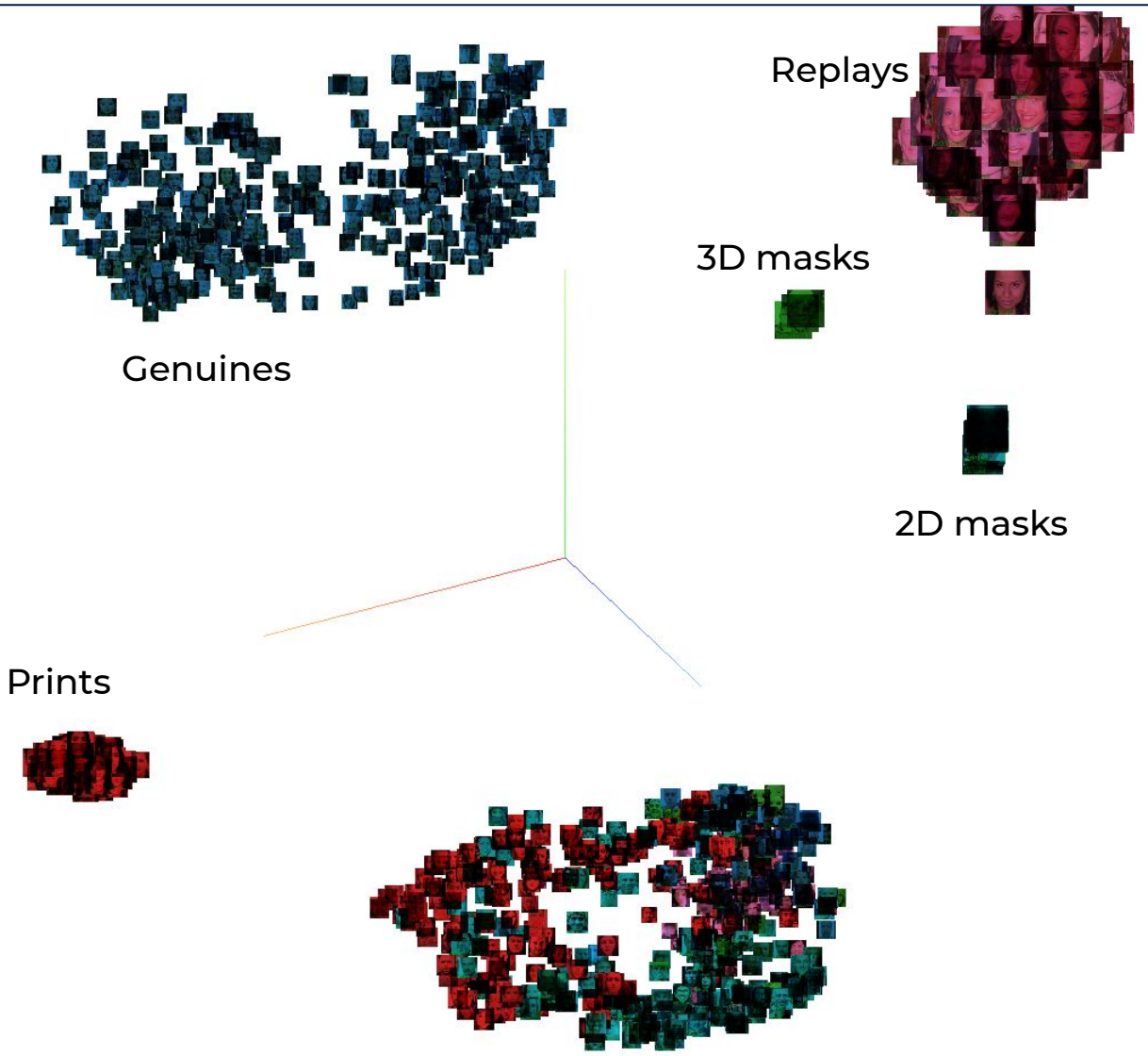
Race



PL Quality as a Trigger for Actionable Feedback

PL Features + t-SNE





ImageNet Features + KMeans

ImageNet

- recognition of 1000 generic classes

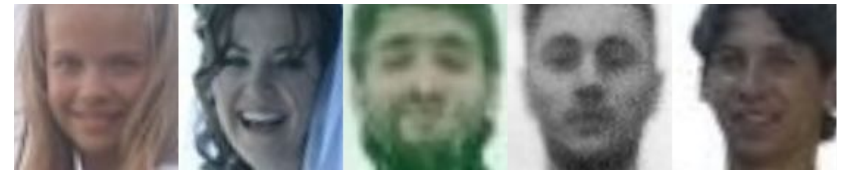
Our case

- fine-grained face type images
- large heterogeneous clusters

PCA + K-Means

- Compact clusters
- Clearly identified problems
- Similarity to the cluster
  - Distance from the cluster centre

Backlight + Low contrast



Low contrast

Over-exposed

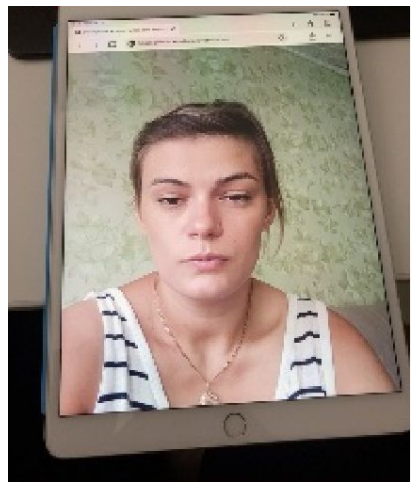
Under-exposed / Blury

White balance / Color shift

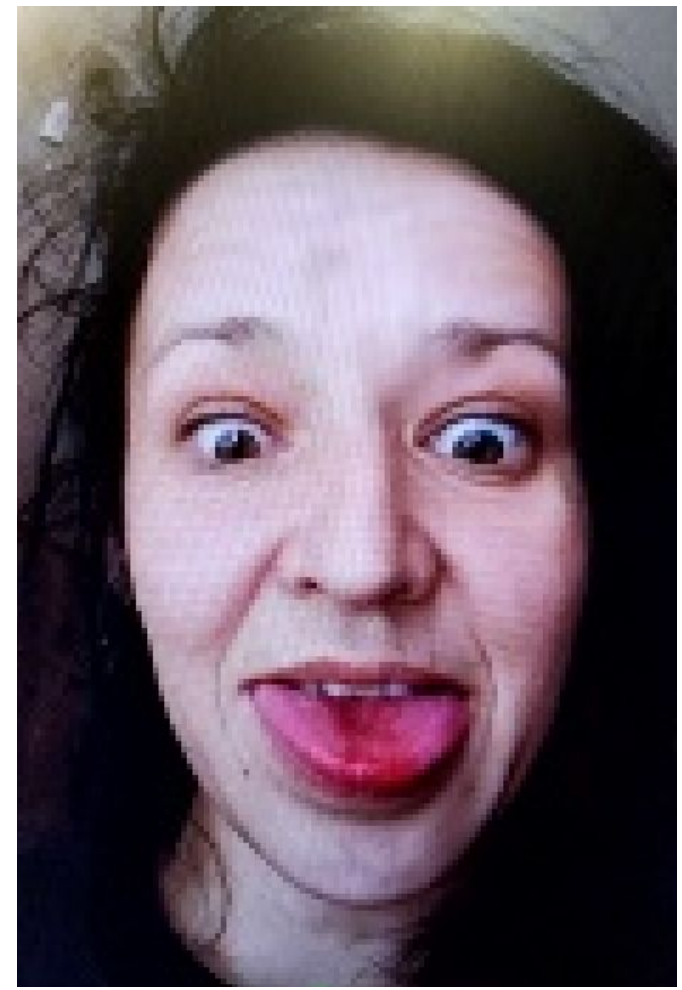
PL (actionable feedback) check workflow

Hard Spoofs

High Quality / Score spoofs





Multimodal Passive Livennes

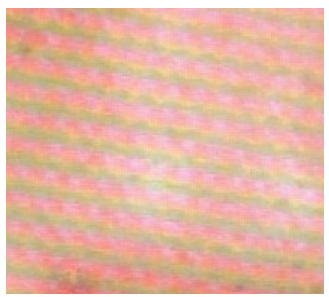
Moire

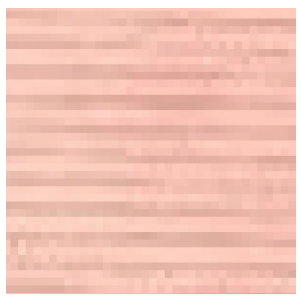
Moire pattern detection

Near to original resolution

Attacks:

- Replay (display)





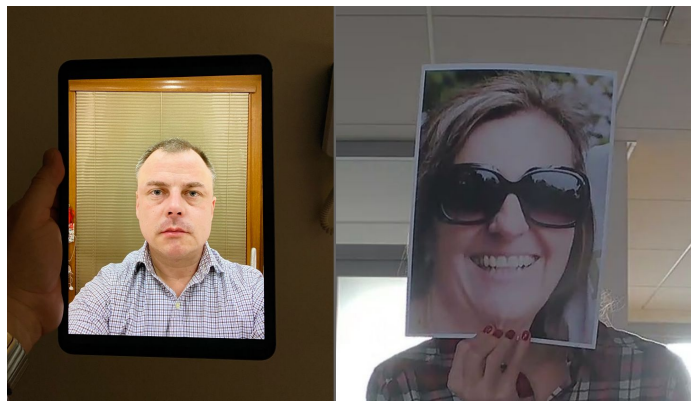
Frames

Face in scene analysis

Zoomed out face crop with lower resolution

Attacks:

- Tablet / Phone (display) attacks
- Printed attacks



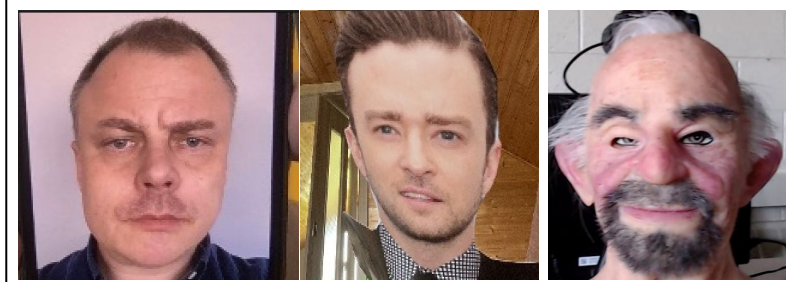
Nearby

Face details analysis

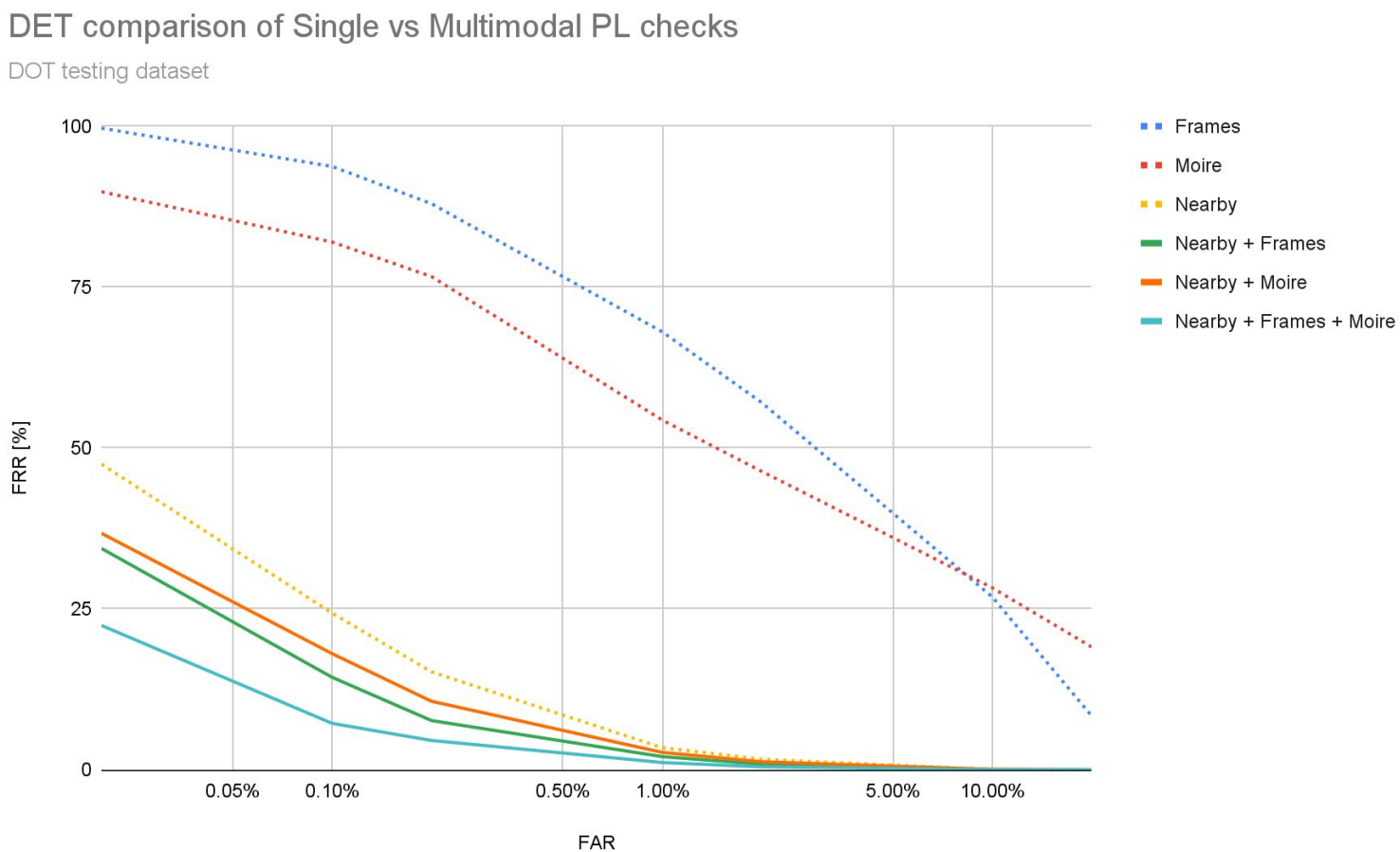
Closed up crop of face with high resolution

Attacks:

- Replay (display)
- 2D masks
- 3D masks
- Printed attacks



Multimodal PL accuracy



Results

- Low PL quality filtering can significantly **improve PL check accuracy**
- PL quality can be used to **find and categorize blind spots** of PL check
- **Actionable feedback** according to low PL quality image clusters similarity

Questions?

Slovakia (HQ)
+421 2 2071 4056

Brazil
+55 11 4210-5185

Singapore
+65 3158 7379

Taiwan (R.O.C.)
+886 2 7741 4036

USA
+1 404 984-2024