



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA
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From face image ISO compliance to face image quality assessment

*Image quality assessment in electronic ID
documents*

EAB WORKSHOP ON FACE IMAGE QUALITY

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Outline

- From face image ISO compliance...
 - ISO compliance verification: performance assessment
 - FVC-onGoing: FICV benchmark
 - BioLab-ICAO Check
- ...to face image quality evaluation
 - Quality assessment for «high-quality» images
 - Quality features and quality regressor
 - Face sample utility for face verification
 - Preliminary results on digital and P&S images

*Projects in conjunction
with the Italian institute in
charge for the emission of
electronic ID documents
(ISTITUTO POLIGRAFICO ZECCA
DELLO STATO)*

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**From face image ISO
compliance...**

Our previous experience with ISO/ICAO compliance

Need: objectively evaluate and compare the **performance** of SDKs for **ISO/ICAO compliance verification**.

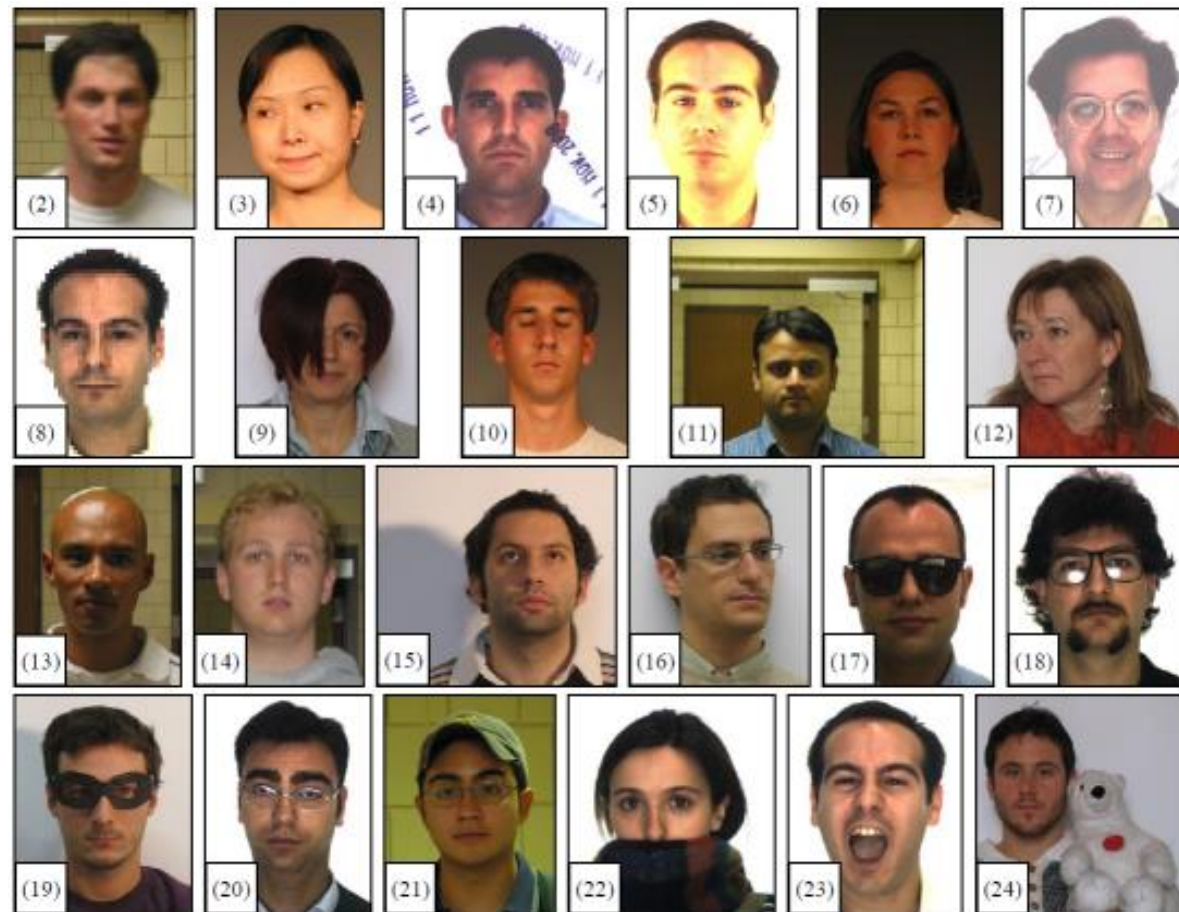
Work done:

- definition of precise and unambiguous **requirements**;
- design of an **evaluation framework** including a proper image database to be used for testing;
- test execution and **performance evaluation**.



Requirements

- 1 Eye center location accuracy
- 2 Blurred
- 3 Looking away
- 4 Ink marked/creased
- 5 Unnatural skin tone
- 6 Too dark/light
- 7 Washed out
- 8 Pixelation
- 9 Hair across eyes
- 10 Eyes closed
- 11 Varied background
- 12 Roll/pitch/yaw rotations greater than a predefined threshold
- 13 Flash reflection on skin
- 14 Red eyes
- 15 Shadows behind head
- 16 Shadows across face
- 17 Dark tinted lenses
- 18 Flash reflection on lenses
- 19 Frames too heavy
- 20 Frame covering eyes
- 21 Hat/cap
- 22 Veil over face
- 23 Mouth open
- 24 Presence of other faces or toys too close to face



FVC-onGoing

FVC-onGoing: on-line evaluation of fingerprint recognition algorithms

FVC-onGoing is a web-based automated evaluation system for fingerprint recognition algorithms. Tests are carried out on a set of sequestered datasets and results are reported on-line by using well known performance indicators and metrics.

The aim is to track the advances in fingerprint recognition technologies, through continuously updated independent testing and reporting of performances on given benchmarks. The algorithms are evaluated using strongly supervised approaches to maximize trustworthiness.

FVC-onGoing is the evolution of FVC: the international Fingerprint Verification Competitions organized in 2000, 2002, 2004, and 2006.

FVC-onGoing at 08-Nov-2021

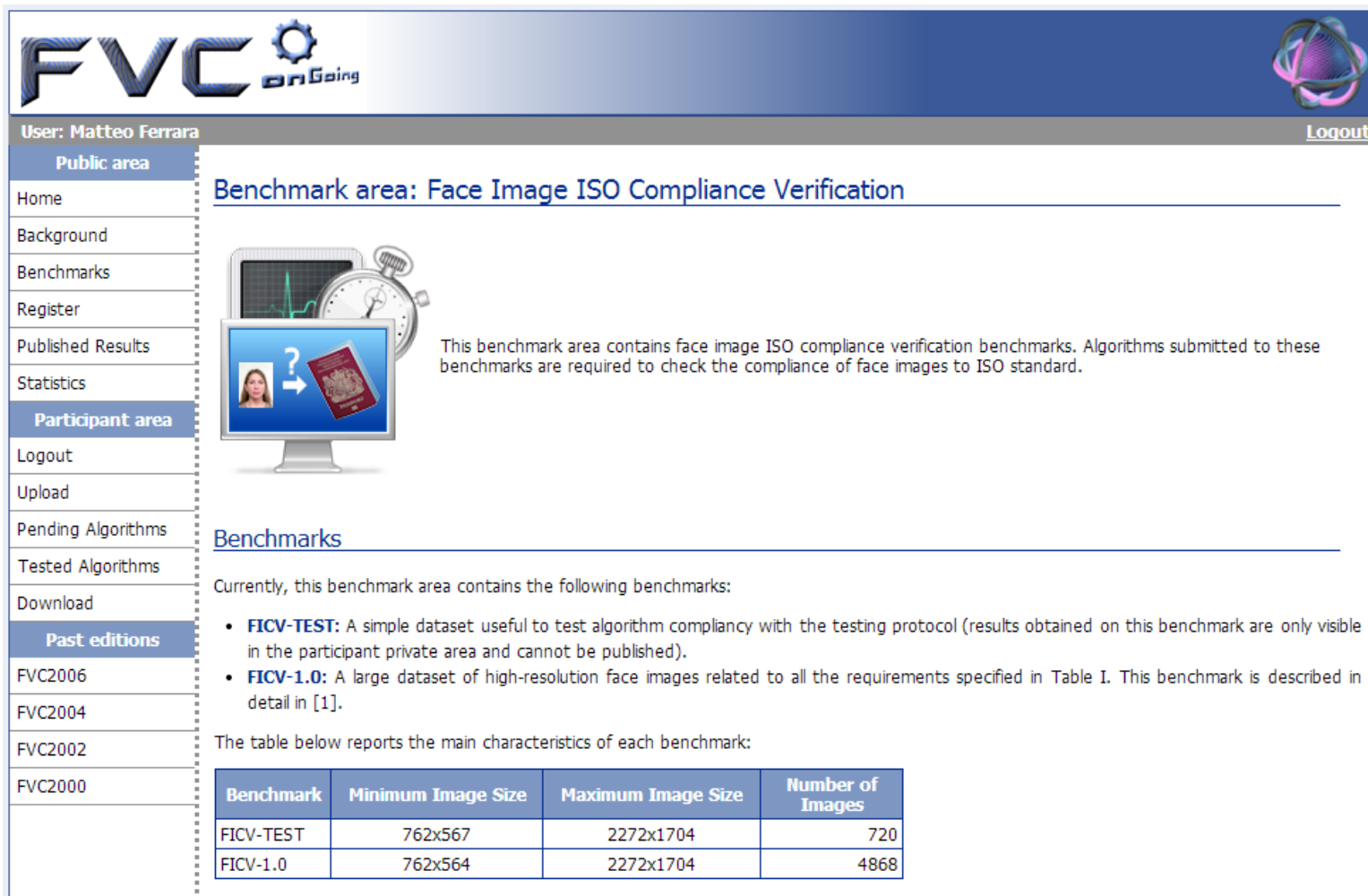
- 1787 Participants Registered
- 7834 Algorithms Evaluated
- 295 Results Published

FVC-onGoing is a **web-based automatic evaluation system**, proposed to test biometric recognition algorithms on a set of sequestered datasets, and to report results using well known performance indicators and metrics.

- The algorithms are evaluated using **strongly supervised** approaches, to maximize trustworthiness of the results.
- FVC-onGoing is:
 - an “**on going competition**” always open to new participants;
 - an **evolving online repository** of evaluation metrics and results.



FICV benchmark area



FVC onGoing

User: Matteo Ferrara Logout

Public area

- Home
- Background
- Benchmarks
- Register
- Published Results
- Statistics


Participant area

- Logout
- Upload
- Pending Algorithms
- Tested Algorithms
- Download

Past editions

- FVC2006
- FVC2004
- FVC2002
- FVC2000

Benchmark area: Face Image ISO Compliance Verification



This benchmark area contains face image ISO compliance verification benchmarks. Algorithms submitted to these benchmarks are required to check the compliance of face images to ISO standard.

Benchmarks

Currently, this benchmark area contains the following benchmarks:

- FICV-TEST:** A simple dataset useful to test algorithm compliancy with the testing protocol (results obtained on this benchmark are only visible in the participant private area and cannot be published).
- FICV-1.0:** A large dataset of high-resolution face images related to all the requirements specified in Table I. This benchmark is described in detail in [1].

The table below reports the main characteristics of each benchmark:

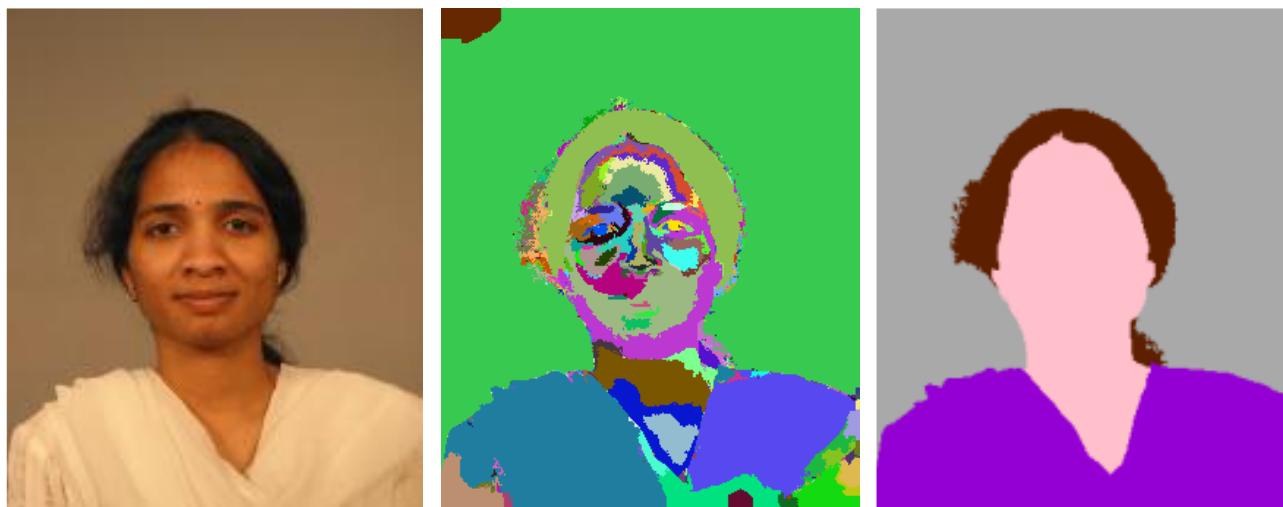
| Benchmark | Minimum Image Size | Maximum Image Size | Number of Images |
|-----------|--------------------|--------------------|------------------|
| FICV-TEST | 762x567 | 2272x1704 | 720 |
| FICV-1.0 | 762x564 | 2272x1704 | 4868 |

In the FVC-onGoing website a benchmark area named **Face Image ISO Compliance Verification** (FICV) has been created (ISO/IEC 19794-5:2011)



FICV baseline: BioLab-ICAO Check

BioLab basic implementation of algorithms able to check each of the 23 requirements defined in the benchmark.



| Characteristic | SDK1 | | SDK2 | | BioLabSDK | |
|--------------------------|-------------|-------|-------------|------|--------------|------|
| | EER | Rej. | EER | Rej. | EER | Rej. |
| 8 Blurred | 26.0% | 8.9% | 48.1% | 0.6% | 5.2% | 0.0% |
| 9 Looking Away | 27.5% | 7.1% | - | - | 20.6% | 0.0% |
| 10 Ink Marked/Creased | - | - | - | - | 3.4% | 1.2% |
| 11 Unnatural Skin Tone | 18.7% | 4.8% | 50.0% | 0.8% | 4.0% | 0.2% |
| 12 Too Dark/Light | - | - | 3.1% | 0.0% | 4.2% | 0.0% |
| 13 Washed Out | - | - | 40.8% | 0.2% | 9.6% | 0.0% |
| 14 Pixelation | - | - | 0.0% | 0.0% | 1.3% | 0.0% |
| 15 Hair Across Eyes | 50.0% | 81.9% | - | - | 12.8% | 0.0% |
| 16 Eyes Closed | 2.9% | 3.1% | - | - | 4.6% | 0.0% |
| 17 Varied Background | 7.5% | 3.3% | 17.9% | 1.4% | 5.2% | 0.0% |
| 18 Roll/Pitch/Yaw > 8° | - | - | 26.0% | 2.9% | 12.7% | 0.2% |
| 19 Flash Refl. on Skin | 5.0% | 2.7% | 50.0% | 7.5% | 0.6% | 0.0% |
| 20 Red Eyes | 5.2% | 4.5% | 34.2% | 0.0% | 7.4% | 0.0% |
| 21 Shadows Behind Head | - | - | - | - | 2.3% | 0.2% |
| 22 Shadows Across Face | 36.4% | 8.1% | - | - | 13.1% | 0.4% |
| 23 Dark Tinted Lenses | - | - | - | - | 1.9% | 0.2% |
| 24 Flash Refl. on Lenses | - | - | - | - | 2.1% | 0.0% |
| 25 Frames too Heavy | - | - | - | - | 5.8% | 0.0% |
| 26 Frame Covering Eyes | 50.0% | 62.3% | - | - | 6.3% | 0.0% |
| 27 Hat/Cap | - | - | - | - | 14.0% | 0.0% |
| 28 Veil over Face | - | - | - | - | 2.5% | 0.0% |
| 29 Mouth Open | 3.3% | 52.1% | - | - | 6.2% | 0.0% |
| 30 Objects Close to Face | - | - | - | - | 21.6% | 0.0% |

- the SDK does not support the test for this characteristic



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**...to face image quality
evaluation**

Motivations

Face image quality evaluation is in general still an open issue; unlike what happens for other biometric characteristics, **no standard** definitions are yet available.

According to the provisions of ISO/IEC 39794-5, a quality value may be stored in the future in dedicated **quality blocks**.

- to **guide image acquisition**, providing a live feedback on the images acquired by the camera;
- to **monitor the document issuance process** to guarantee a constant quality level for the circulating documents.
- to **improve the face verification process**, possibly exploiting the quality of the document sample.

Face image quality assessment is even harder when applied in the context of electronic ID documents (**high-quality ISO/ICAO compliant images**).



Quality assessment for «high-quality» images

How to assign a **meaningful quality score** to **high quality** images?

State-of-the-art:

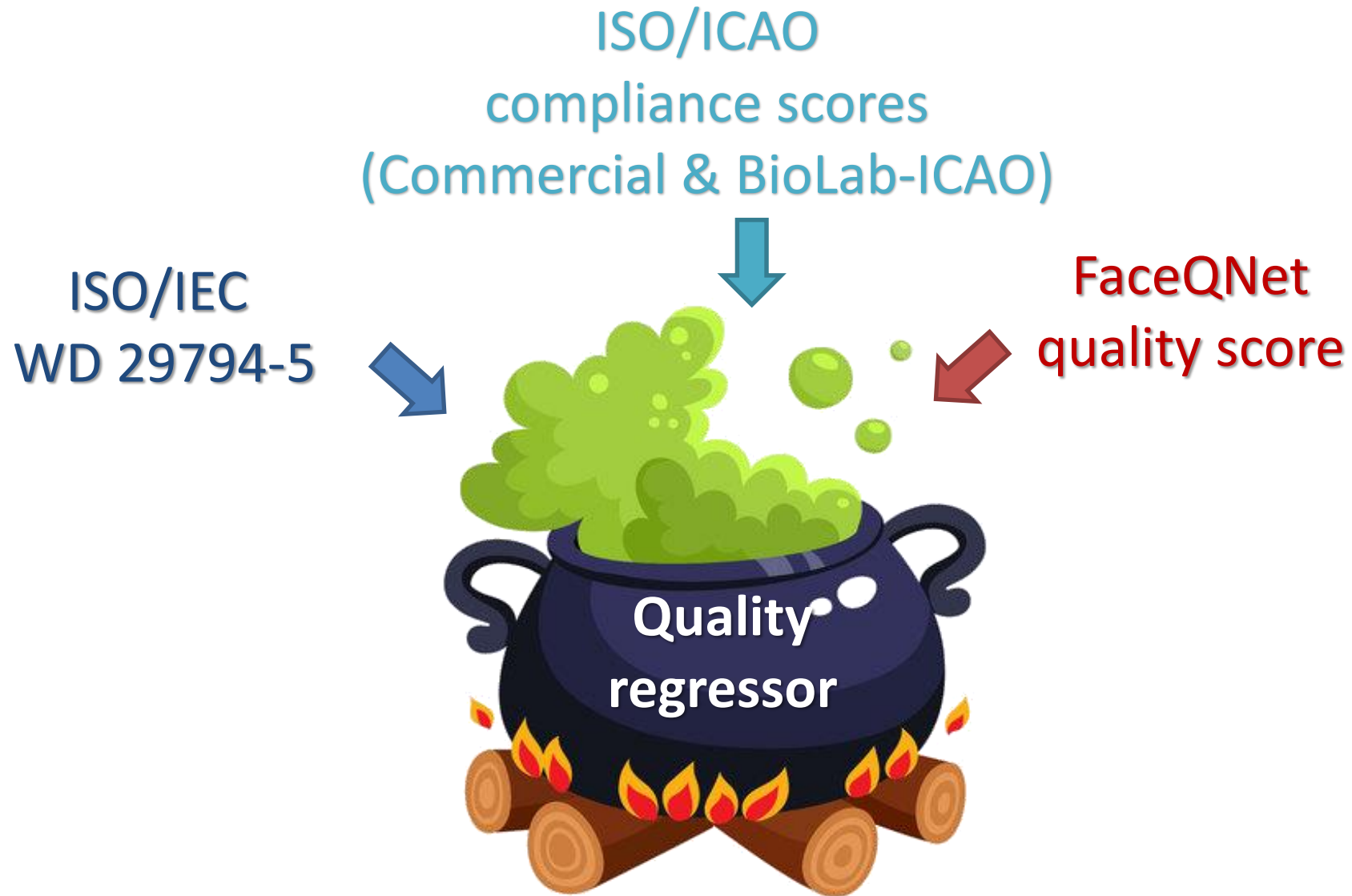
- Hand-crafted features / deep learning-based algorithms
- Most of the quality assessment approaches deal with **general images** (variations in pose, lighting, expression, etc.)

Idea:

- In analogy to NFIQ, and in line with ISO/IEC WD 29794-5, we tried to define a quality score starting from a (large) set of quality features (ISO/ICAO compliance scores and other related indicators).

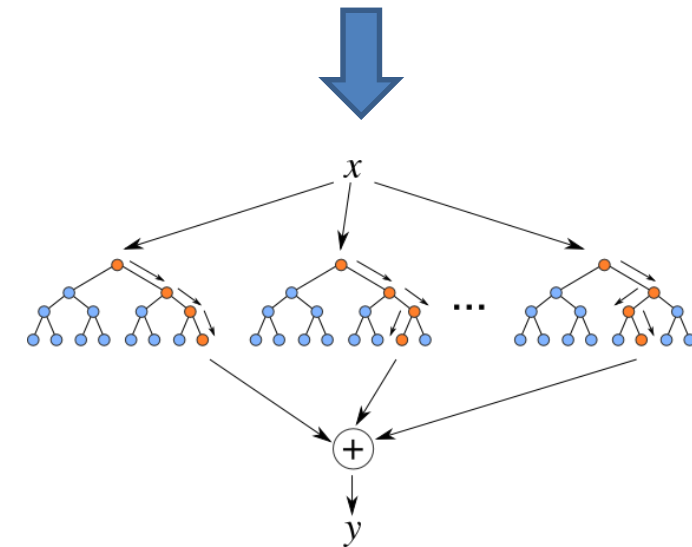


The quality cauldron



| Category | BioLab ICAO | Commercial SDK | ISO/IEC WD 29794-5 |
|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Blurring and mis-focus | Blurred Pixelation | Focus Sharpness | De-focus Sharpness Edge-density |
| Exposure, variation in lightning and shadows | Unnatural skin tone Too dark/light Washed out Flash reflections on skin Flash reflections on lenses Shadows across face Shadows behind head | Saturation Colour control Dynamics Glare Shadows | Under/over-exposure Illumination uniformity Illumination modulation |
| Eyes | Looking Away Hair across eyes Eyes closed Red eyes | Gaze Hair covering left/right eye Left/right eye closed Red eyes Intrapupils distance | Eyes visible Eyes open Inter-eye distance |
| Mouth | Mouth open | Mouth expression | Mouth closed |
| Face image pose, aspect ratio and other faces | Roll/pitch/yaw rotations Presence of other faces or toys | Face pose Face found Horizontal/vertical face posit. Face image width/height ratio | Pose Number of faces present Horizontal/vertical position |
| Accessories | Dark tinted lenses Frames too heavy Frames covering eyes Veil over face Hat/cap | Dark lenses Frames too heavy Frames covering left/right eye Face valid Head coverings | |
| Background | Varied background | Background evaluation | - |
| Other | Ink marked/creased | - | Compression |

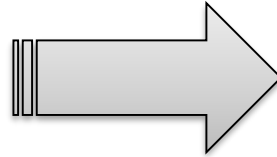
- Blurring and mis-focus
- Exposure, lightning and shadows
- Eyes
- Mouth
- Face image pose, aspect ratio and other faces
- Accessories
- Background
- Other
- FaceQNet



Target quality value for ID documents



GOOD QUALITY



USEFUL FOR FACE VERIFICATION

DLib
VeriLook

Target value computed from genuine and impostor scores

Average genuine score

Average impostor score

$$ns(\mathbf{x}_i) = \frac{\mu_m(s(\mathbf{x}_i, \mathbf{x}'_i)) - \mu_n(s(\mathbf{x}_i, \mathbf{x}_j), j \neq i)}{\sigma_n(s(\mathbf{x}_i, \mathbf{x}_j), j \neq i)}$$

St. dev. impostor scores



Datasets

Digital: 3301 training, 654 testing

- 1637 face image from the AR Face Database
- 220 face image from the CVL Face Database
- 1238 face image from the FERET
- 860 face image from the FRGC

P&S: 396 training, 134 testing

- 530 fully ISO/ICAO-compliant images from FERET and FRGC datasets have been printed by a professional photographer in a document photo format (35×45mm);
- the printed images have been scanned at 300 dpi;
- a final JPG2000 compression has been applied (10Kb).

Evaluation

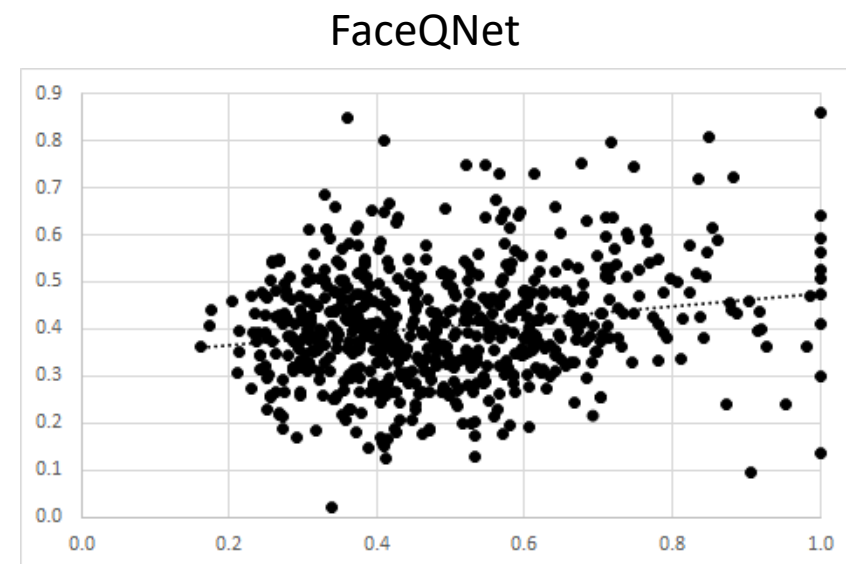
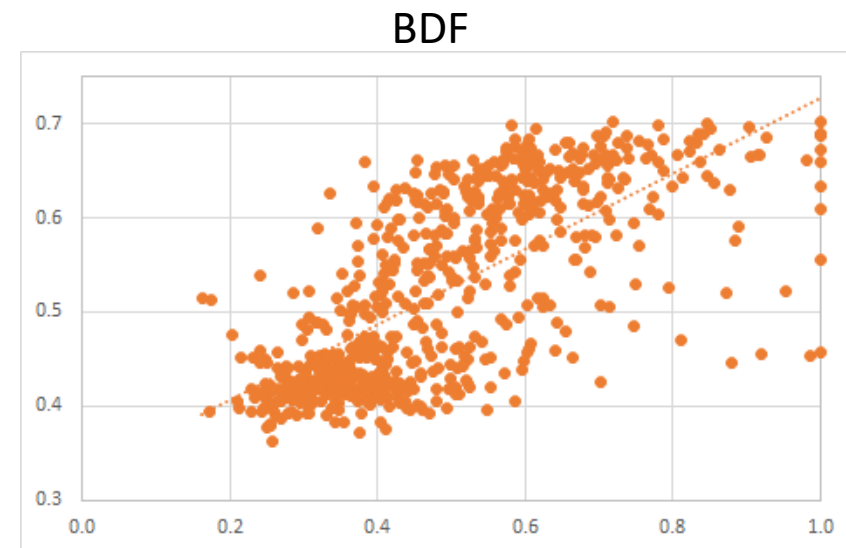
- Different versions of the quality regressor have been trained using different feature subsets
- Performance evaluation based on:
 - **Correlation** between predicted quality score and target value;
 - **Error vs. Discard curves.**



Digital images: correlation quality score/target value

| Combination | Commercial ICAO Check | BioLab-ICAO Check | ISO/IEC WD 29794-5 | FaceQNet |
|-------------|-----------------------|-------------------|--------------------|----------|
| BDF | | ✓ | ✓ | ✓ |
| CDF | ✓ | | ✓ | ✓ |
| BF | | ✓ | | ✓ |
| DF | | | ✓ | ✓ |

| Predictor | Combination | Correlation with target |
|-------------|-------------|-------------------------|
| Regressor | BDF | 0.710146 |
| | CDF | 0.715155 |
| | BF | 0.656530 |
| | DF | 0.709680 |
| FaceQNet QS | | 0.164897 |

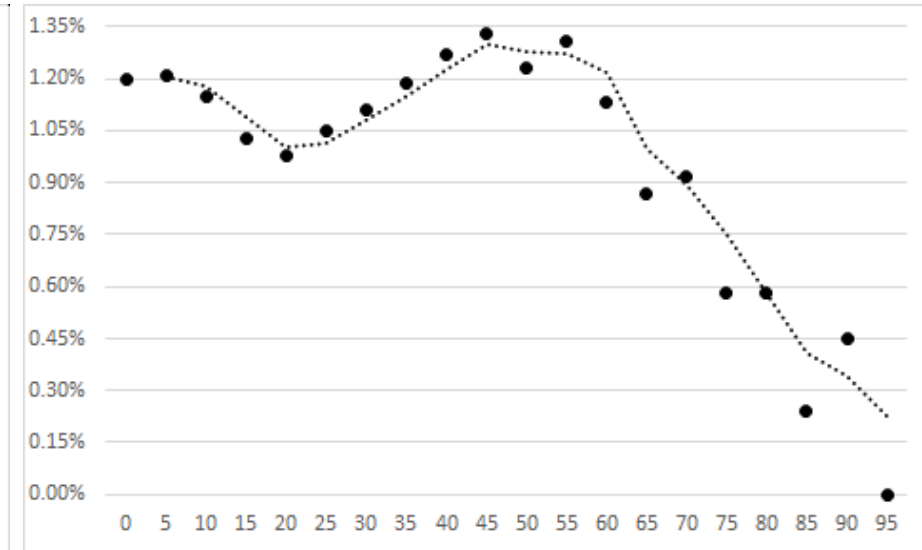
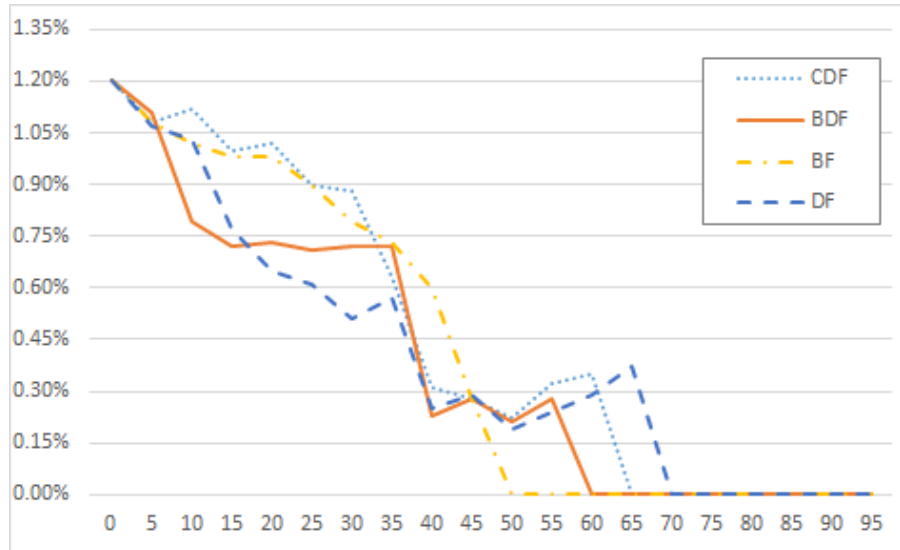


Digital images: Error vs. Discard curves (VeriLook)

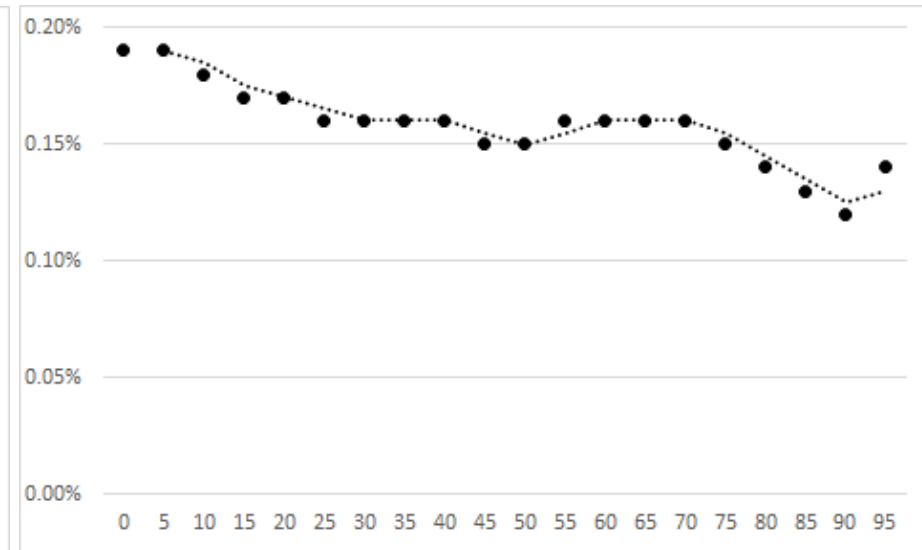
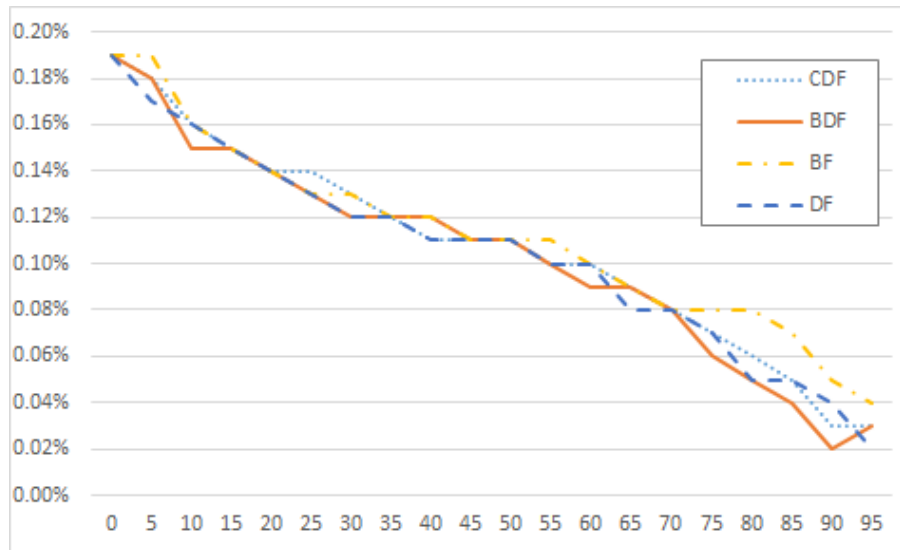
Regressor

FaceQNet

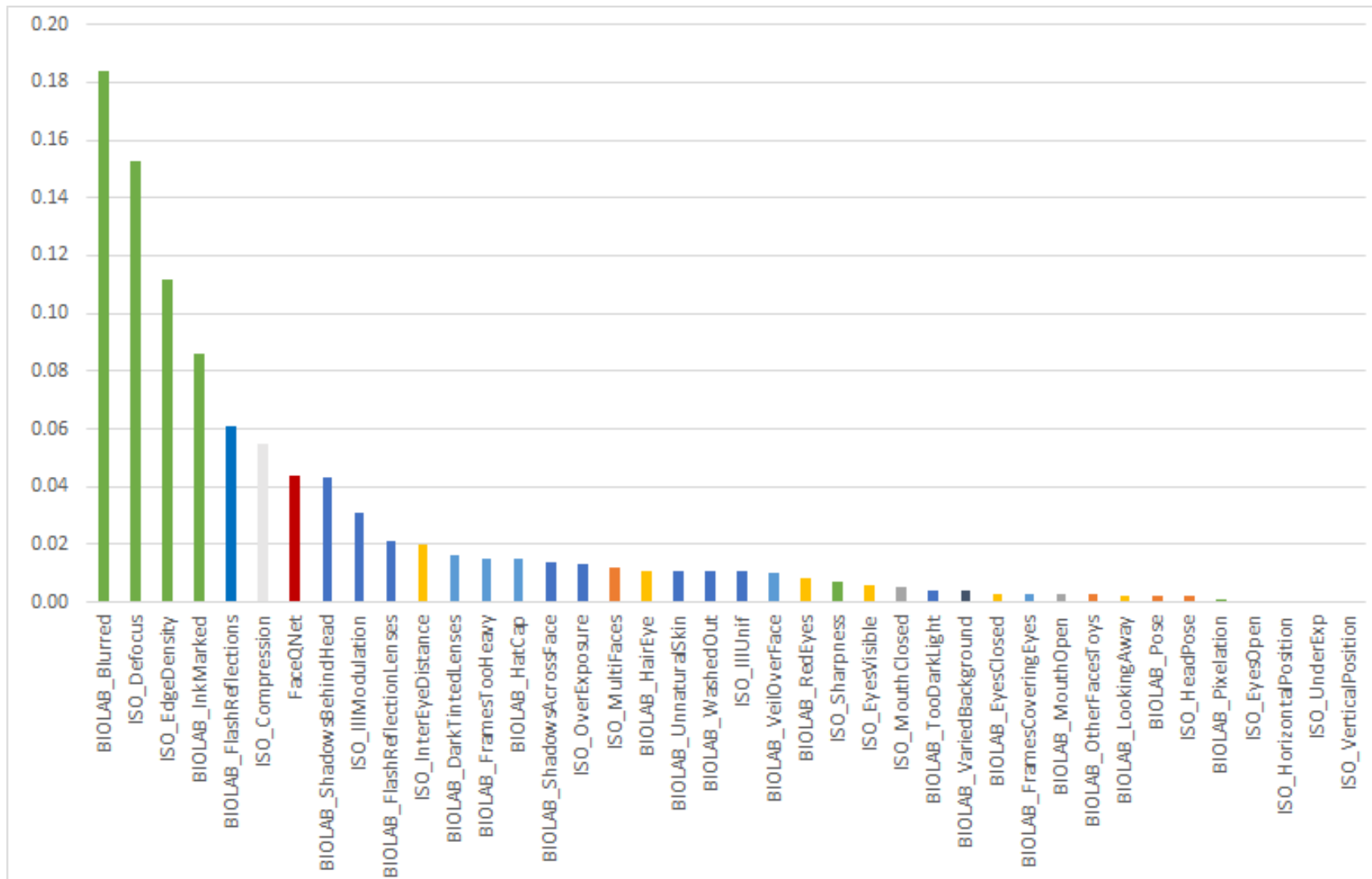
FNMR vs. Discard



FMR vs. Discard



Digital images: feature importance



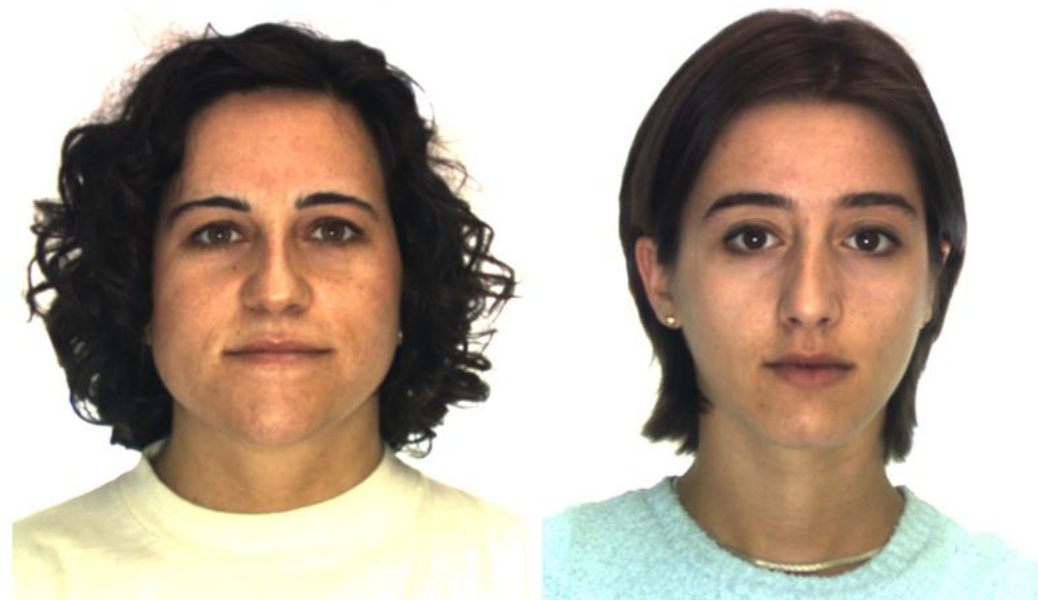
- Blurring and mis-focus
- Exposure, lightning and shadows
- Eyes
- Mouth
- Face image pose, aspect ratio and other faces
- Accessories
- Background
- Other
- FaceQNet



Digital images: visual examples



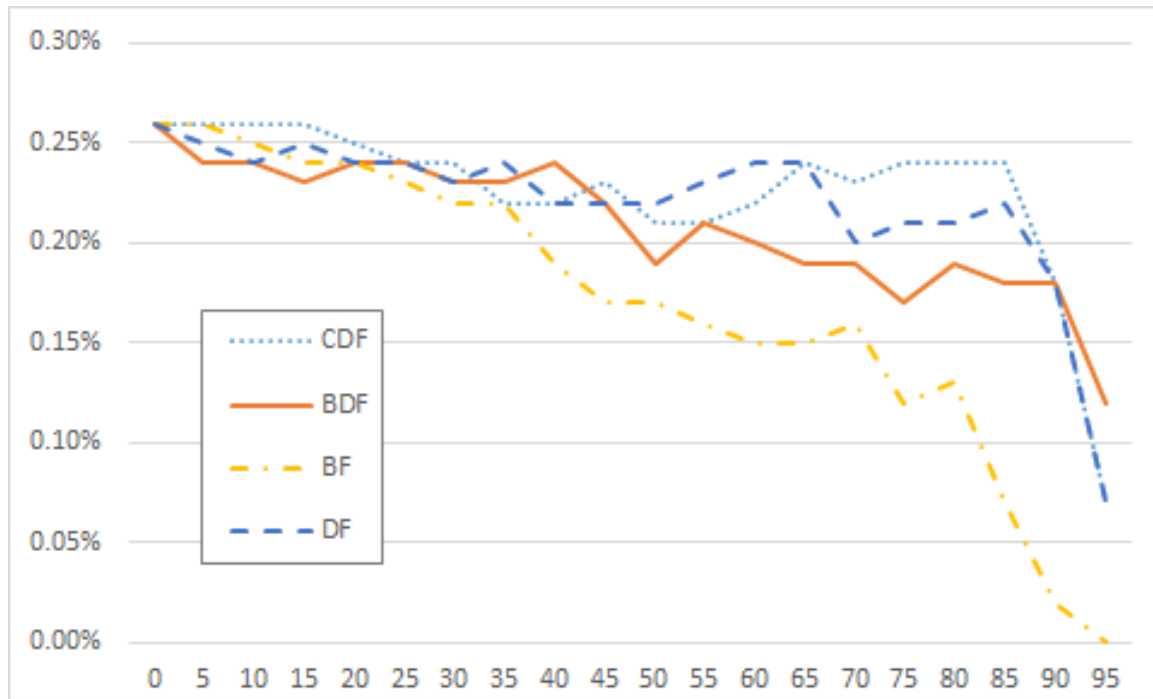
High quality



Low quality

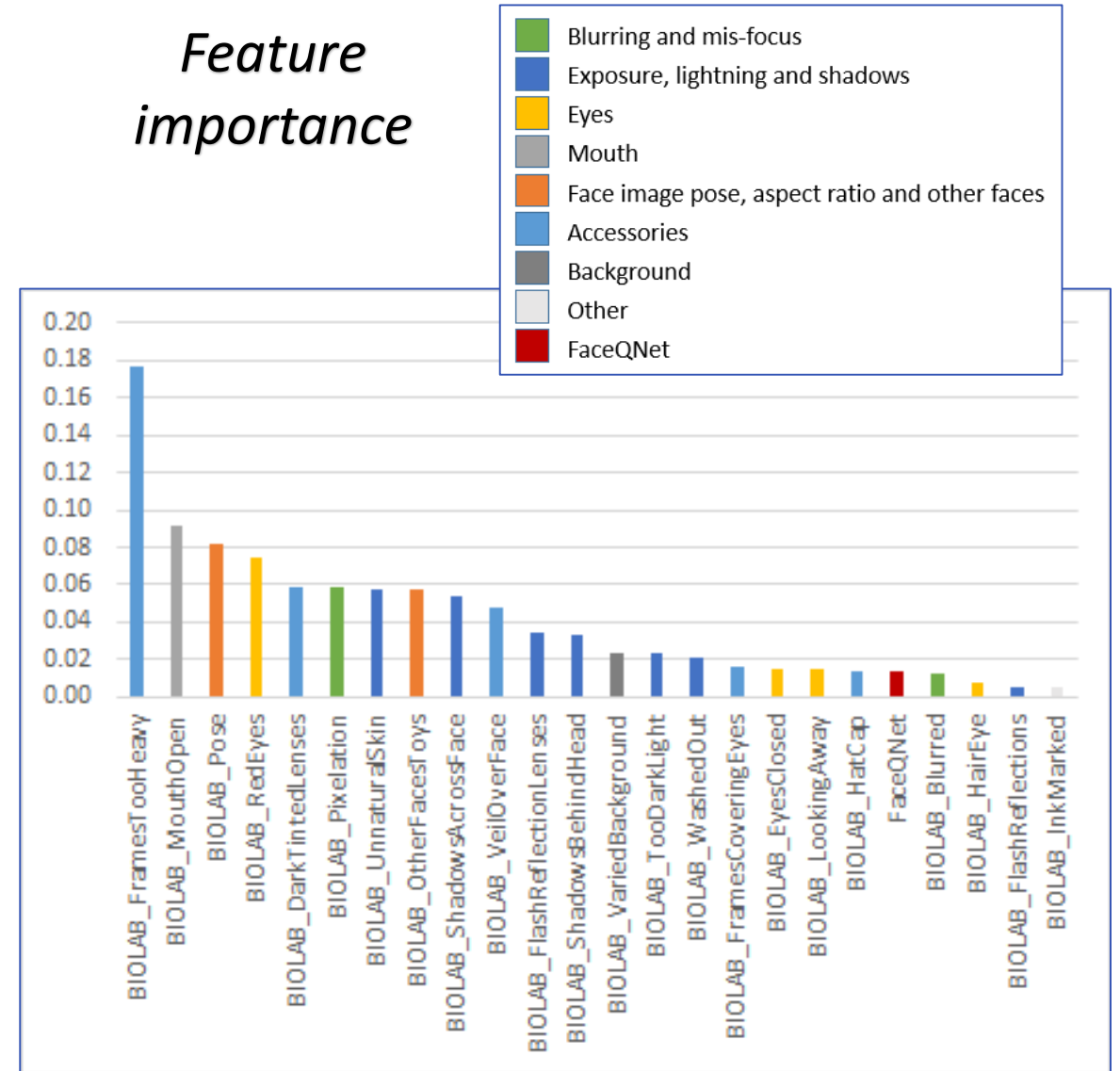


P&S images: preliminary results



FMR vs. Discard

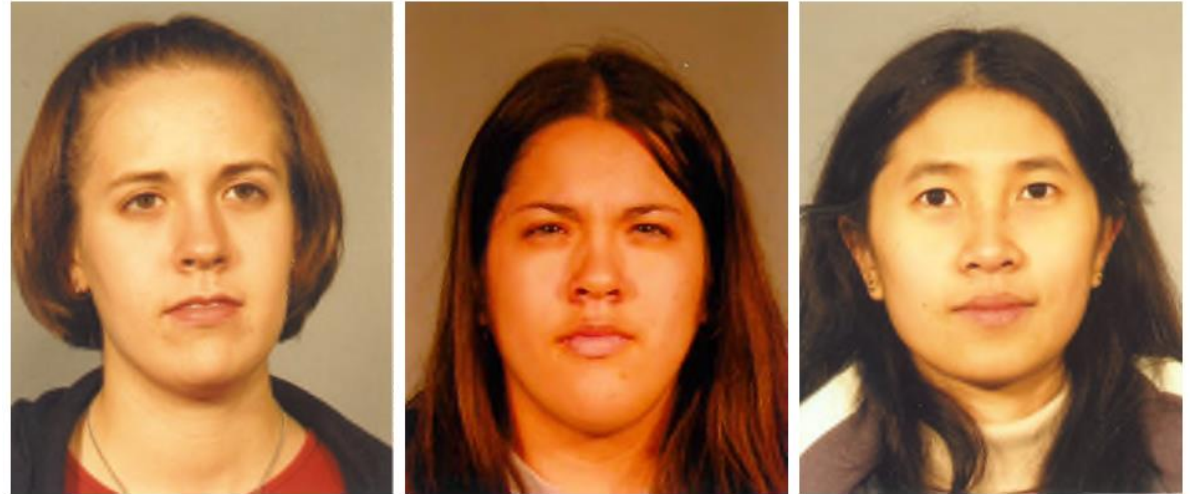
Feature importance



P&S images: visual examples



High quality



Low quality



Conclusions

- Face image quality assessment in electronic ID documents is a **complex task**.
- The preliminary results confirm the effectiveness of a **quality regressor** based on quality features related to ISO/ICAO compliance, coupled with FaceQNet.
- Dealing with **P&S images is more complex**, further investigations on large datasets are needed.

Future work:

- Further **experiments** (other FRs, larger datasets).
- Evaluation in a **real scenario** next year.
- Need to consider further indicators related to possible **alterations** (e.g. geometric distortions, beautification, excessive make-up).
- Use in **iMARS** to evaluate the impact of image quality on morphing attack detection performance.





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