Candidate Handcrafted Face-QAA for ISO/IEC IS 29794-5:202x

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EAB WORKSHOP ON FACE IMAGE QUALITY - Nov, 2021
Nov 16, 2021

NORWEGIAN BIOMETRICS LABORATORY

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Candidate Handcrafted Face-QAA for ISO/IEC IS 29794-5:202x

- Proposal based on work published in 2017
  - Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In *5th International Workshop on Biometrics and Forensics (IWBF)*, pp. 1-6. IEEE, 2017.

Assessing Face Image Quality for Smartphone based Face Recognition System

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***Abstract*—In recent years, the popularity of smartphones has increased massively as a personal and authentication device. Face based biometrics is being used to secure the device and control access to several different services via smartphones such as payment gateways etc. Thus, to maintain the reliability and to obtain better verification performance, there is a need to adopt the standards recommended for face sample quality. In this paper, we present an evaluation of face image quality assessment using well-established ISO standards on the images collected using smartphones. In this work, we constructed a new database of 101 individuals with 22 frontal face images with different facial pose angles, illumination and at five different distances between the subject and the mobile device. We evaluate the existing quality metrics and further propose a new quality metric based on vertical edge density that can robustly estimate the pose variations and improves the quality estimation of a face image. The proposed method is evaluated for reliable estimation of the quality for smartphone face biometrics.**

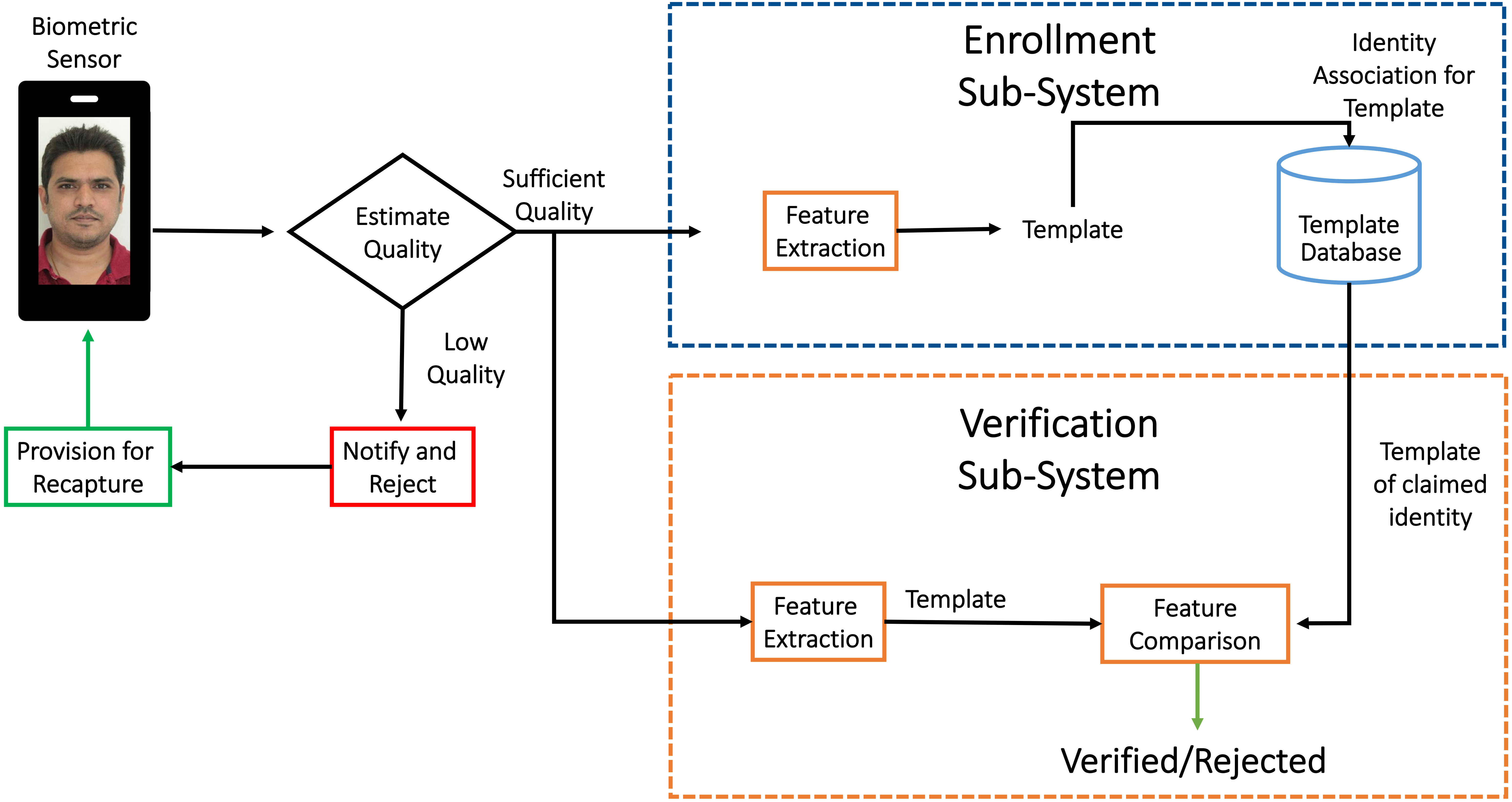
Keywords: Biometrics, Smartphone based biometrics, face recognition, image quality assessment

Fig. 1: Face images with different pose angles and illumination

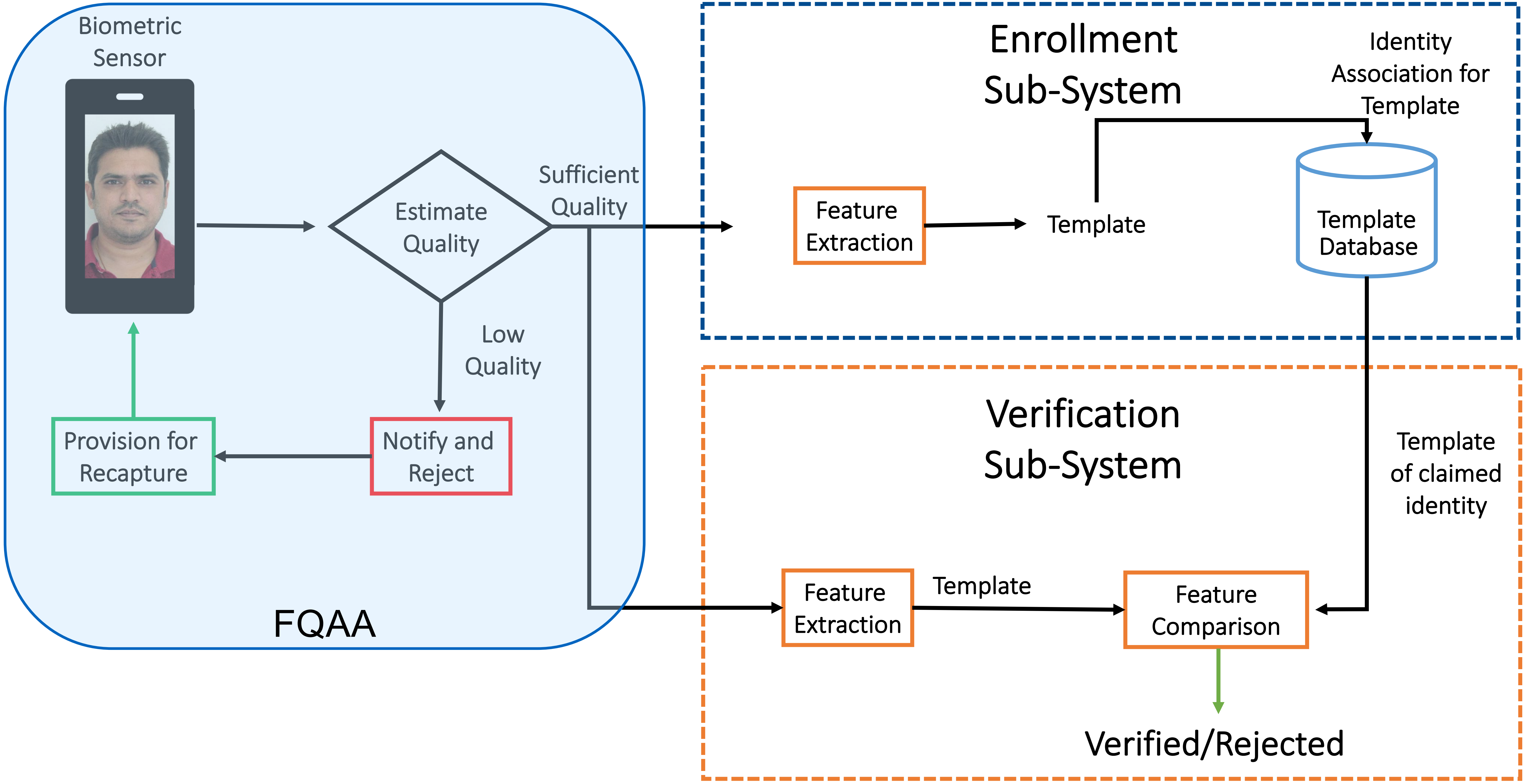
I. Introduction

Major finance applications on smartphones such as Apple-Pay and GooglePay have actively started to employ biometrics for verifying the customers. Similarly, face recognition is being used in different types of mobile applications such as mobile device security, mobile payment gateways, etc. In this kind of applications user's face image is captured in a relaxed or unconstrained environment. The number of factors such as ambient illumination, pose due to different ways of interacting with mobile device and distance of imaging results in varying quality face images. The quality factors of face images obtained using smartphones can be closely correlated to quality factors seen with traditional Face Recognition System *(FRS)*. Hence they are prone to the similar problems confirmed by series of face recognition vendor tests such as an uncontrolled variation of illumination, pose, and age variations. These are three major problems which can reduce the performance of FRS drastically [1], [2], [3]. Further, the technical report `ISO/IEC TR 29794-5` [4] defines different measures to observe the objective quality of an input image. These measures should be applied at the time of enrolment and if possible also for recognition attempts, to achieve optimal recognition performance. Most of the state-of-art commercial biometric systems in today's world are well equipped with quality assessment techniques to achieve good biometric performance. The technical report `ISO/IEC TR 29794-1` [5] describes the methods for calculating the quality scores using different approaches such as "bottom-up", "top-down" and "combined" manner. The proper understanding of the quality score calculations respecting the character of the source (i.e. the biometric characteristic) as well as the concepts of fidelity and utility can be achieved using the defined standards. The report `ISO/IEC TR 29794-4` [6] generalizes the methodologies for fingerprint images. Further, the report `ISO/IEC TR 29794-5`[4] describes the methodologies for facial images to control the sample quality during the enrolment process for many of the commercial applications. It also gives insights about the calculations of pose and illumination symmetry of the input image. In the prior studies on face image quality, most of the work is based on image properties such as brightness, contrast, and sharpness, etc.[7]. In [8] the authors have proposed methods for illumination and pose calculations which are also adopted in `ISO/IEC TR 29794-5`[4]. The quality of biometric images using different image degradations is evaluated in [9]. Further, in [10] authors have proposed a novel approach to assess the face image quality for automatic border control systems. Although there are many works on facial image quality assessment operating in conventional FRS, there are no such image quality evaluations and detailed studies carried out for face samples captured using smartphones to analyze the behavior of FRS operating on smartphone. The key contributions of this work

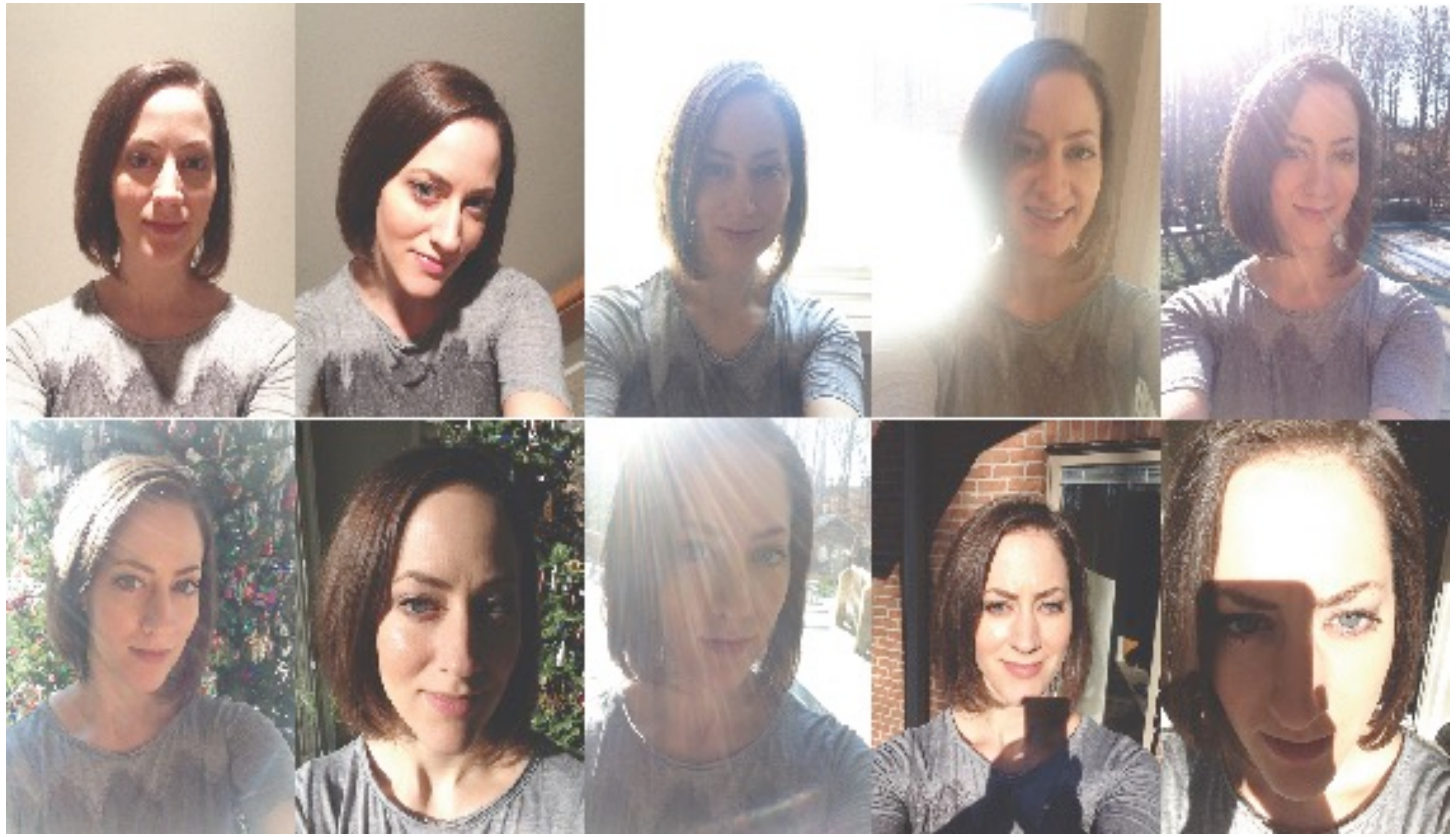
Quality Estimation Before Recognition



Quality Estimation Before Recognition



Sample Quality in Face Recognition



Pose, Illumination and Expression

Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In 5th International Workshop on Biometrics and Forensics (IWBF), pp. 1-6. IEEE, 2017.

Sample Quality in Face Recognition

https://9gag.com/gag/aP72BNg

Quality versus Comparison Score

- Quality is directly proportional to recognition score [Grother2007, Bharadwaj2014]
- Can we use recognition scores to assess the quality assessment algorithms ?
- ERC based predictive performance

[Grother2007] Patrick Grother and Elham Tabassi. Performance of biometric quality measures. 2007.
[Bharadwaj2014] Samarth Bharadwaj, Mayank Vatsa, and Richa Singh. Biometric quality: a review of fingerprint, iris, and face. EURASIP journal on Image and Video Processing, 2014.

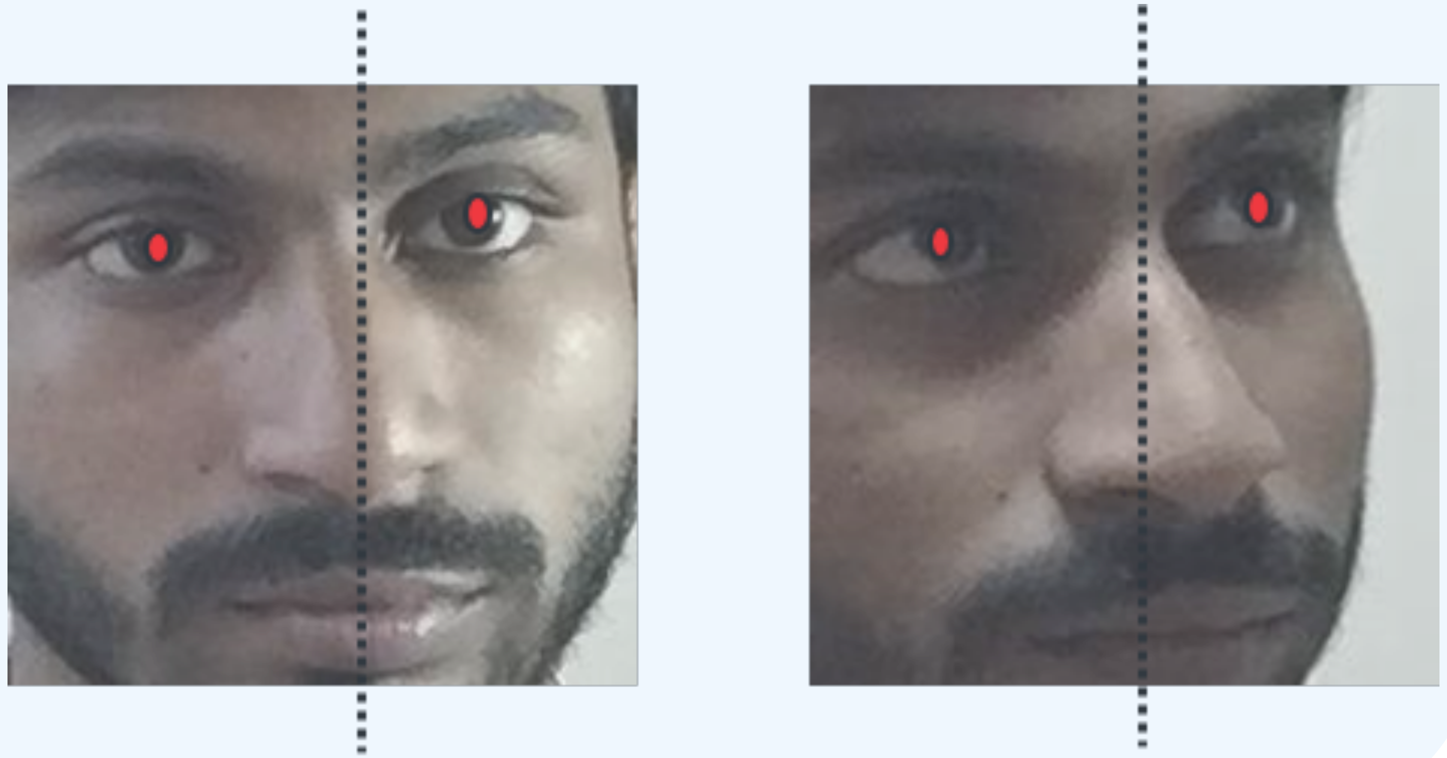
Efforts for face quality estimation using hand-crafted approaches

- Based on image properties such as brightness, contrast, and sharpness [Werner2006]
- Methods for illumination and pose calculations – later adopted in ISO/IEC TR 29794-5 [Gao2007] [ISO29794-5]
- The quality of biometric images using different image degradations is evaluated in [Youmaran2006].
- A face image quality for automatic border control systems using Gray-Level Co-occurence Matrix [Raghavendra2014] .

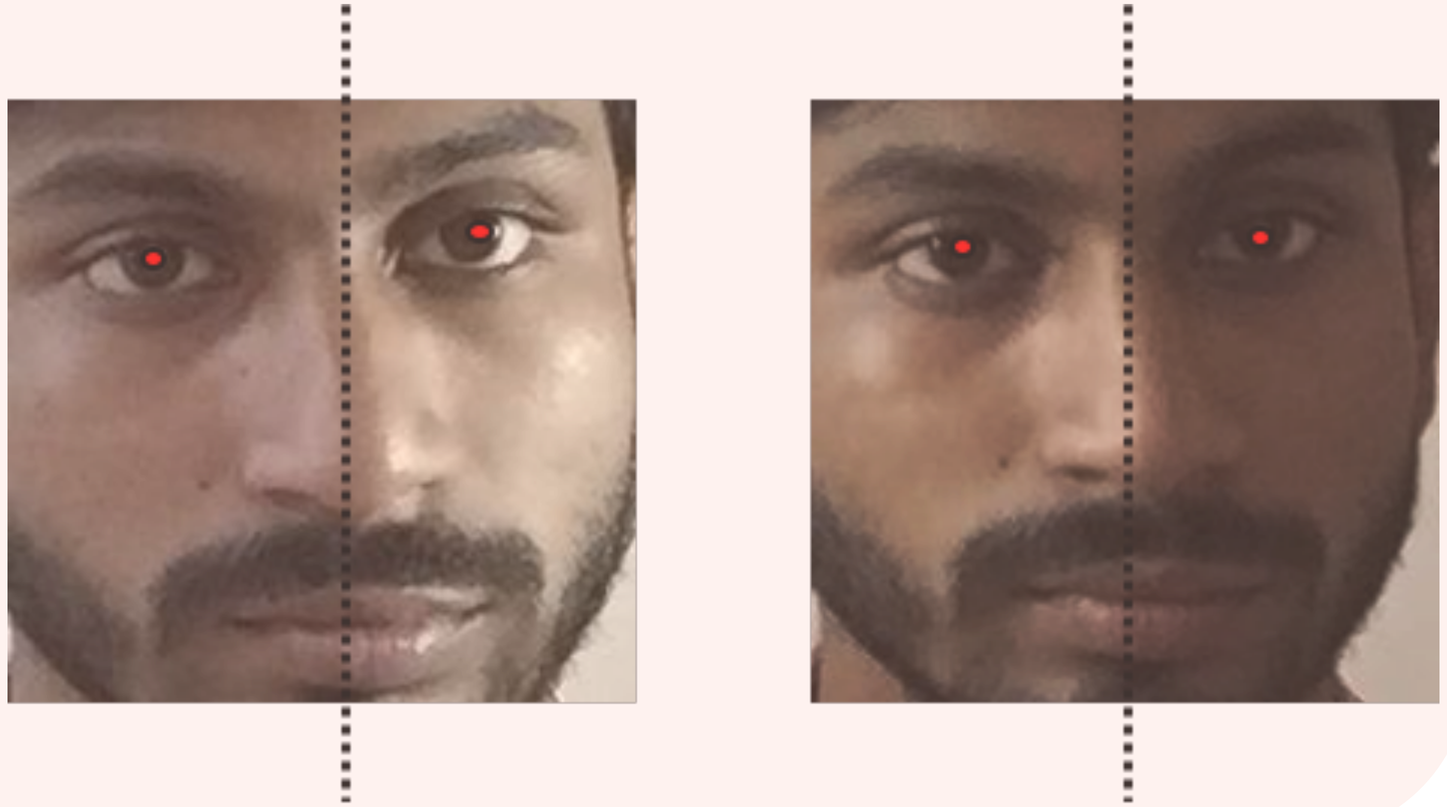
[Werner2006] M. Werner and M. Brauckmann, "Quality values for face recognition," In NIST Biometric Quality Workshop, 2006.
[Gao2007] X. Gao, S. Z. Li, R. Liu, and P. Zhang, "Standardization of face image sample quality." Springer, 2007.
[ISO29794-5] ISO/IEC, ISO/IEC TR 29794-5 Information technology – Biometric sample quality – Part 5: Face image data. ISO/IEC, 2010.
[Youmaran2006] R. Youmaran and A. Adler, "Measuring biometric sample quality in terms of biometric information." IEEE, 2006.
[Raghavendra2014] R. Raghavendra, K. B. Raja, B. Yang, and C. Busch, "Automatic face quality assessment from video using gray level co-occurrence matrix: An empirical study on automatic border control system," 2014, pp. 438-443.

Efforts for face quality estimation using hand-crafted approaches

Pose Symmetry



Lighting Symmetry

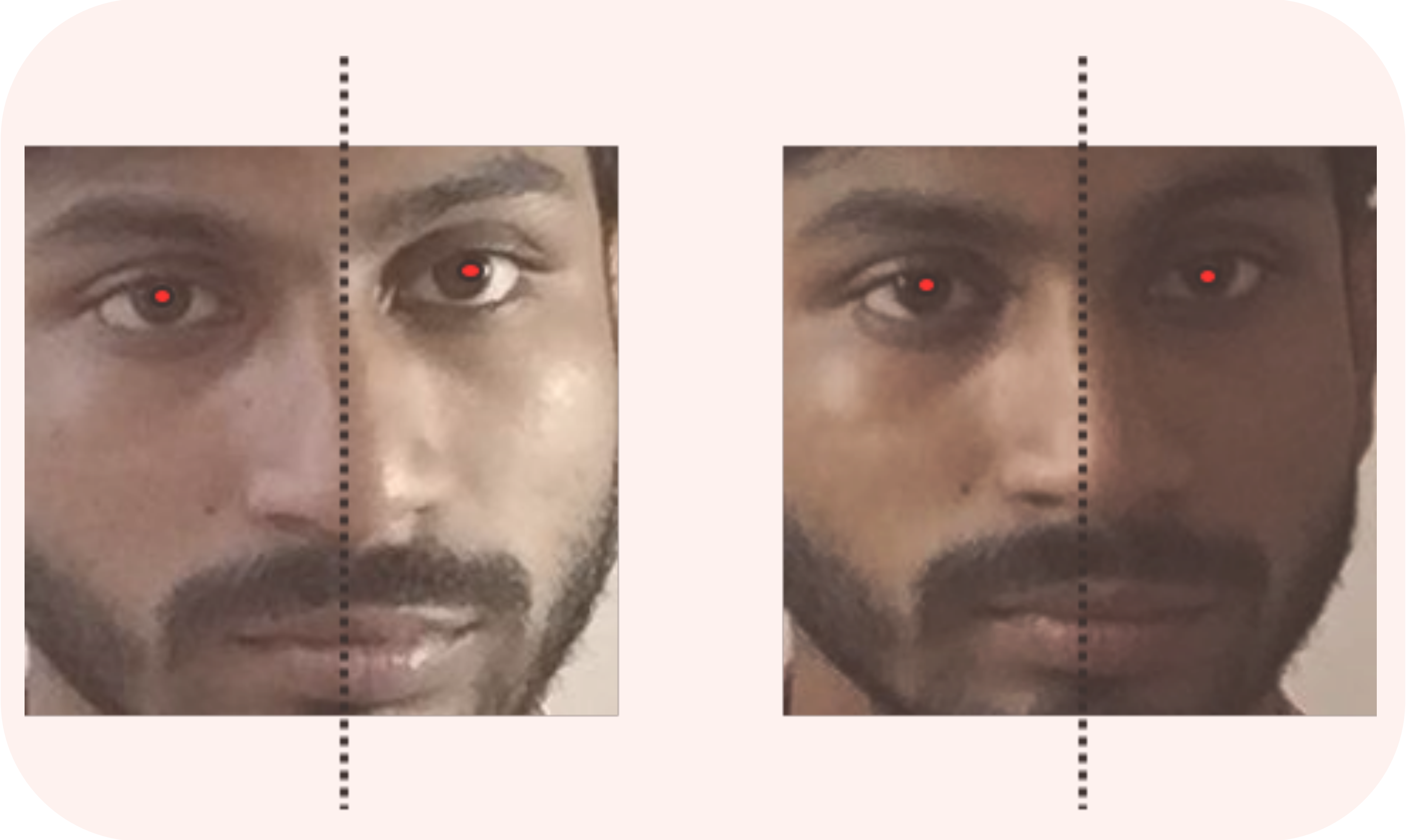


Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In 5th International Workshop on Biometrics and Forensics (IWBF), pp. 1-6. IEEE, 2017.

Lighting Symmetry

$$D_i = \mid H^L_{m*n} - H^R_{m*n} \mid$$

D_i is Earth Mover's Distance (EMD) between H^L_{m*n}, H^R_{m*n} histograms.
Larger values of D_i signifies that image is more asymmetric in nature.

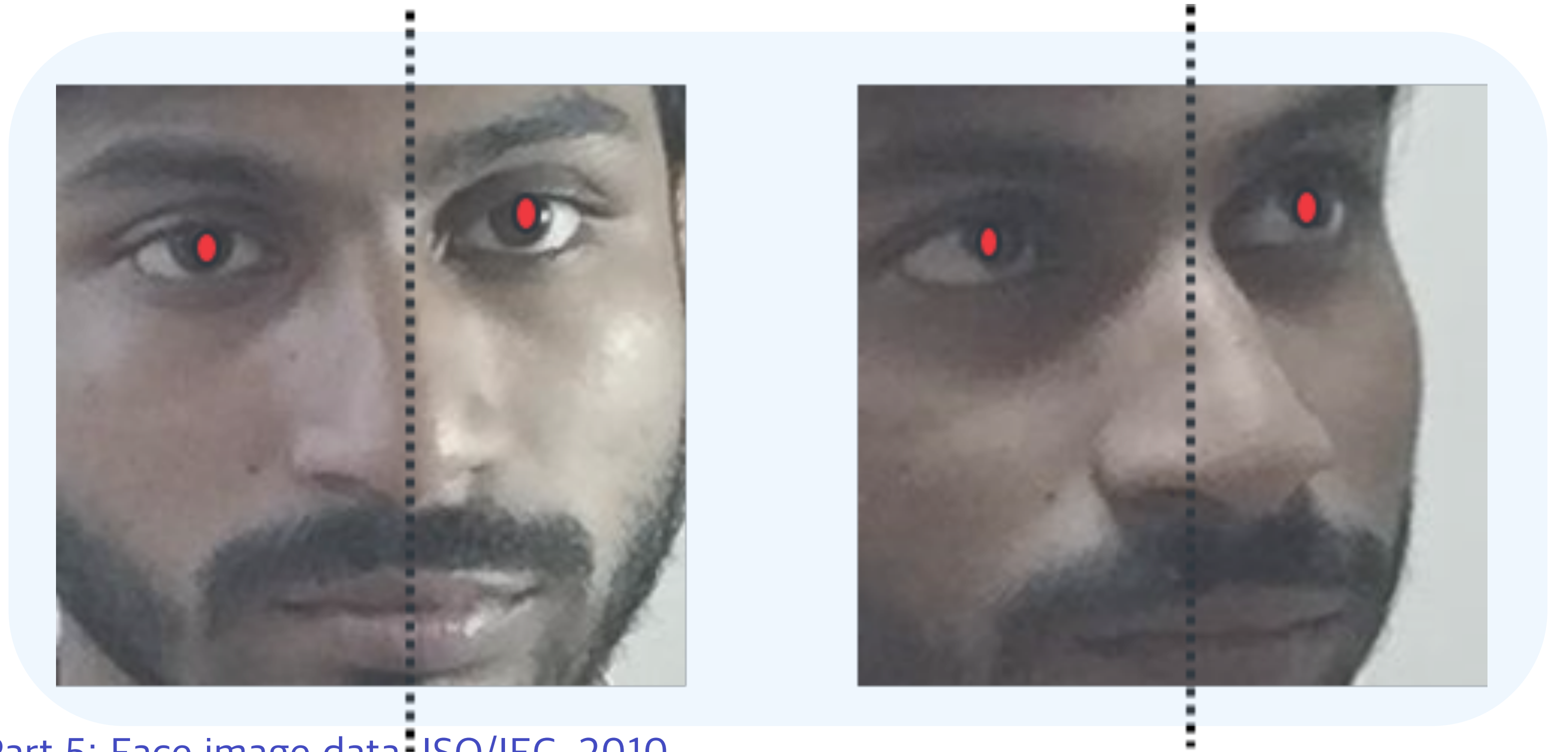


Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In 5th International Workshop on Biometrics and Forensics (IWBF), pp. 1-6. IEEE, 2017.

Pose Symmetry

Suggested Approach from ISO/IEC TR 29794-5

1. Perform filtering using LBP filters.
2. Calculate the difference between filtered values for each pixel pair of sub-windows at left-right mirror locations.
3. Calculate a suitable sum of the absolute values of the differences.
4. The total of absolute values provides pose asymmetry.
5. The larger the value, higher is the rotation of image in either of the direction.



[ISO29794-5] ISO/IEC, ISO/IEC TR 29794-5 Information technology - Biometric sample quality - Part 5: Face image data. ISO/IEC, 2010.

Joint Estimation of Lighting and Pose Symmetry

$$I = \begin{bmatrix} I_x \\ I_y \end{bmatrix} = \begin{bmatrix} \partial I / \partial x \\ \partial I / \partial y \end{bmatrix}$$

$$I_g(x, y) = \sqrt{I_x^2 + I_y^2}$$

$$\theta(x, y) = \tan^{-1}\left(\frac{I_x}{I_y}\right)$$

$$E_v(x, y) = \begin{cases} I_g(x, y), & \text{if } 30^\circ \leq \theta(x, y) \leq 120^\circ \\ 0, & \text{otherwise} \end{cases}$$

Margin of 30-120 degrees

$$E_d = \frac{1}{N} \sum_x \sum_y E_v(x, y)$$

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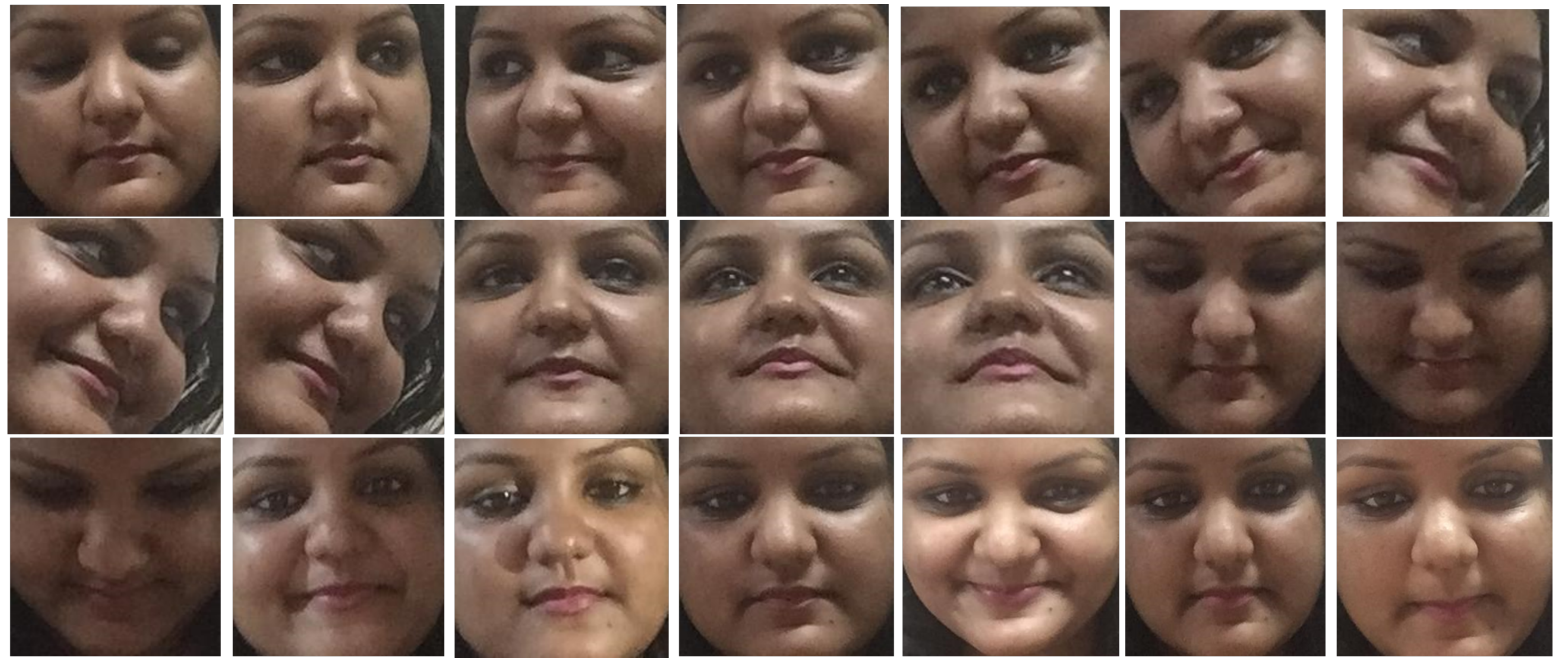
Overall Algorithm

Algorithm 1 Calculate $QualityScore$

Require: $N \geq 1$, *where N is number of comparators used*
  $i \leftarrow N$
  while $i \neq 0$ **do**
    $i \leftarrow i - 1$
    $G_i, B_i \leftarrow C_i$, where G_i and B_i are a set of good and bad images obtained using C_i comparator
  end while
  while $k < len(G_i)$ **do**
    $I \leftarrow G_i(k)$
    if $I \in G_{i+1..N}$ **then**
      $GoodImage(k) \leftarrow I$
      Good Feature Set (k) $\leftarrow$ *(ISO Metric Values) I*
    else
      $Discard\ I$
    end if
  end while
  while $k1 < len(B_i)$ **do**
    $I \leftarrow B_i(k1)$
    if $I \in B_{i+1..N}$ **then**
      $BadImage(k1) \leftarrow I$
      Bad Feature Set (k1) $\leftarrow$ *(ISO Metric Values) I*
    else
      $Discard\ I$
    end if
  end while
  Trained Model $\leftarrow$ *(Random Forest Training) with Good Feature Set and Bad Feature Set*
  Quality Score $\leftarrow$ *(TrainModel) Input Image*

Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In 5th International Workshop on Biometrics and Forensics (IWBF), pp. 1-6. IEEE, 2017.

Experimental Validation of proposed candidate FQAA



Devices	No. Subjects		Total Images	
	Session 1	Session 2	Session 1	Session 2
IPhone 6Plus	101	48	2222	1056
Galaxy S7	101	48	2222	1056

Image Set Details

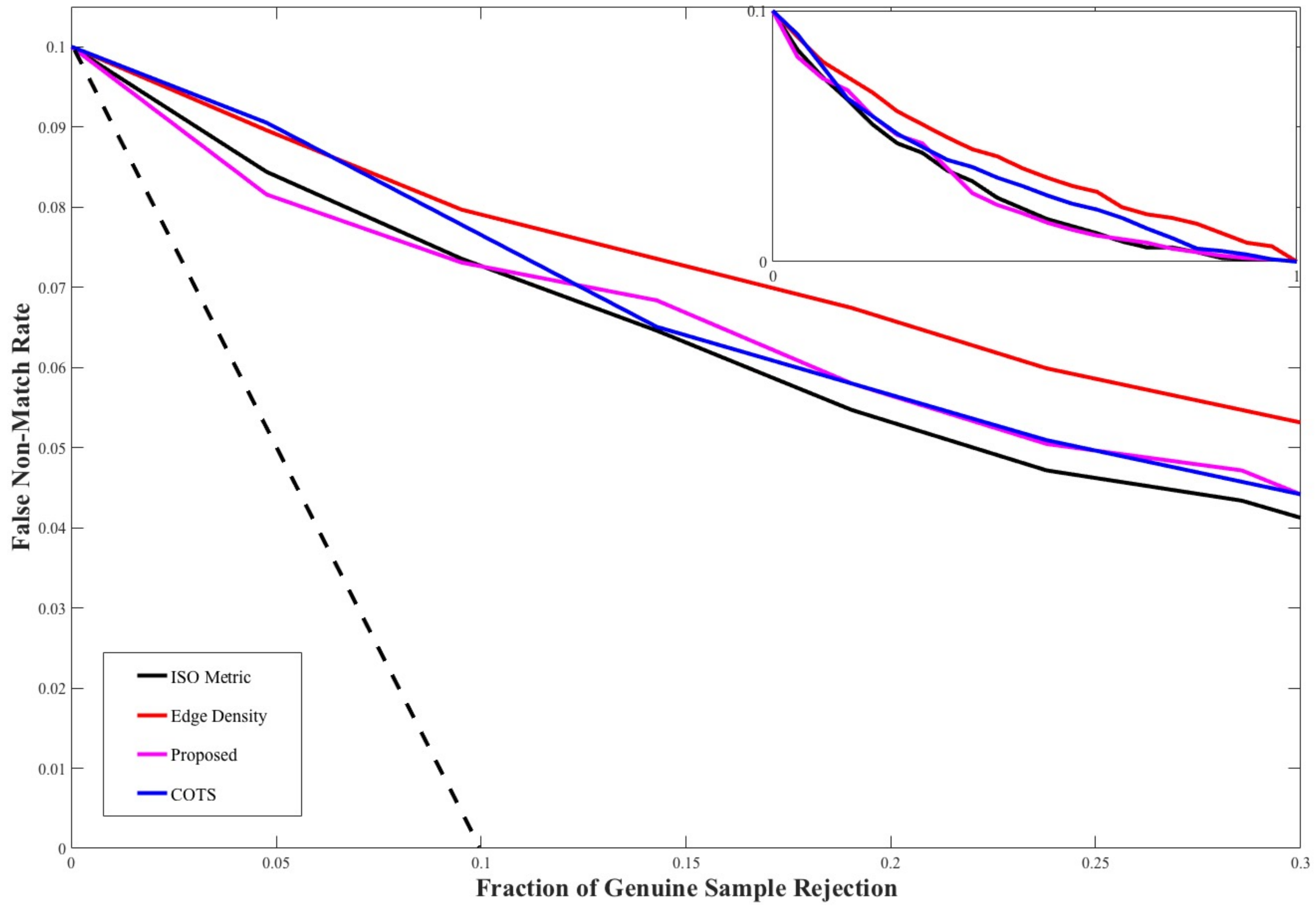
Device	Yaw	Pitch	Roll	I	D
IPhone 6 Plus	2	3	3	2	5
Galaxy S7	2	3	3	2	5

Experimental Validation of proposed candidate FQAA

FNMR decreases rapidly with the fraction of high quality sample rejected [Grother2007, Olsen2015]

$$\eta_{auc}^{erc} = \int_{0}^{1} ERC$$

$$\eta_{pauc20}^{erc} = \int_{0}^{0.2} ERC$$



[Grother2007] Patrick Grother and Elham Tabassi. Performance of biometric quality measures. 2007.
[Olsen2015] M. A. Olsen, V. Smida, and C. Busch, "Finger image quality assessment features-definitions and evaluation," IET Biometrics, 2015.
[Wasnik2017] Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In 5th International Workshop on Biometrics and Forensics (IWBF), pp. 1-6. IEEE, 2017.

Experimental Validation of proposed candidate FQAA

FNMR decreases rapidly with the fraction of high quality sample rejected [Grother2007, Olsen2015]

Quality Metrics	iPhone 6 Plus Database(ERC)		Samsung S7 Database(ERC)	
	η_{auc}^{erc}	η_{pauc20}^{erc}	η_{auc}^{erc}	η_{pauc20}^{erc}
COTS	**0.015**	**0.00**	**0.0285**	**0.0020**
Blur	0.086	0.013	0.097	0.015
Sharpness	0.068	0.0096	0.074	0.010
Exposure	0.068	0.0097	0.068	0.009
Brightness	0.079	0.011	0.080	0.012
Contrast	0.066	0.0092	0.070	0.01
GCF	0.0664	0.009	0.071	0.010
Pose Symmetry	0.087	0.013	0.089	0.013
Light Symmetry	0.027	0.0015	0.07	0.011
Proposed (ED)	0.0334	0.003	0.03	0.003

AUC and PAUC for at FNMR = 0.1

Quality Metrics	iPhone 6 Plus Database(ERC)		Samsung S7 Database(ERC)	
	η_{auc}^{erc}	η_{pauc20}^{erc}	η_{auc}^{erc}	η_{pauc20}^{erc}
COTS	**0.0196**	**0.0049**	0.033	**0.0069**
Blur	0.0697	0.0149	0.0572	0.0117
Sharpness	0.0503	0.0110	0.0483	0.0106
Exposure	0.0523	0.0114	0.419	0.093
Brightness	0.0618	0.0133	0.0537	0.0117
Contrast	0.0507	0.0111	0.0413	0.0092
GCF	0.0509	0.0111	0.0417	0.0093
Pose Symmetry	0.0706	0.0151	0.0594	0.0128
Light Symmetry	**0.0196**	0.0518	**0.0049**	0.0113
Proposed (ED)	0.035	0.0070	0.039	0.008

AUC and PAUC for at FNMR = 0.01

[Grother2007] Patrick Grother and Elham Tabassi. Performance of biometric quality measures. 2007.
[Olsen2015] M. A. Olsen, V. Smida, and C. Busch, "Finger image quality assessment features-definitions and evaluation," IET Biometrics, 2015.
[Wasnik2017] Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In 5th International Workshop on Biometrics and Forensics (IWBF), pp. 1-6. IEEE, 2017.

Experimental Validation of proposed candidate FQAA

FNMR decreases rapidly with the fraction of high quality sample rejected [Grother2007, Olsen2015]

$$\eta_{auc}^{erc} = \int_0^1 ERC$$

$$\eta_{pauc20}^{erc} = \int_0^{0.2} ERC$$

Quality Assessment Schemes	iPhone 6 Plus Database(ERC)		Samsung S7 Database(ERC)	
	η_{auc}^{erc}	η_{pauc20}^{erc}	η_{auc}^{erc}	η_{pauc20}^{erc}
COTS	**0.015**	**0.00**	0.0285	0.0020
ISO + RF	0.030	0.00236	0.024	0.0010
ISO + ED + RF	0.027	**0.0018**	**0.023**	**0.0010**

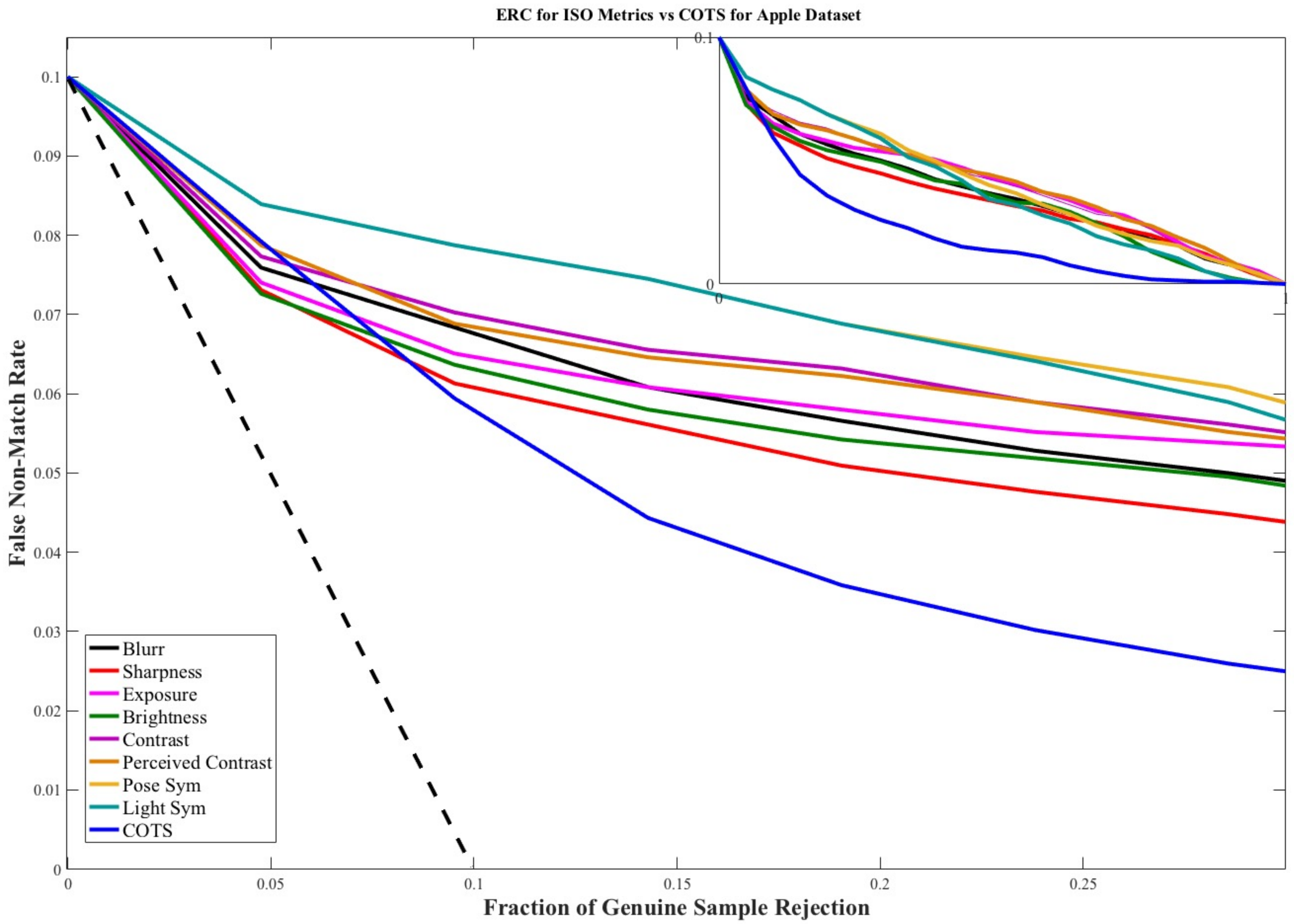
AUC and PAUC for at FNMR = 0.1

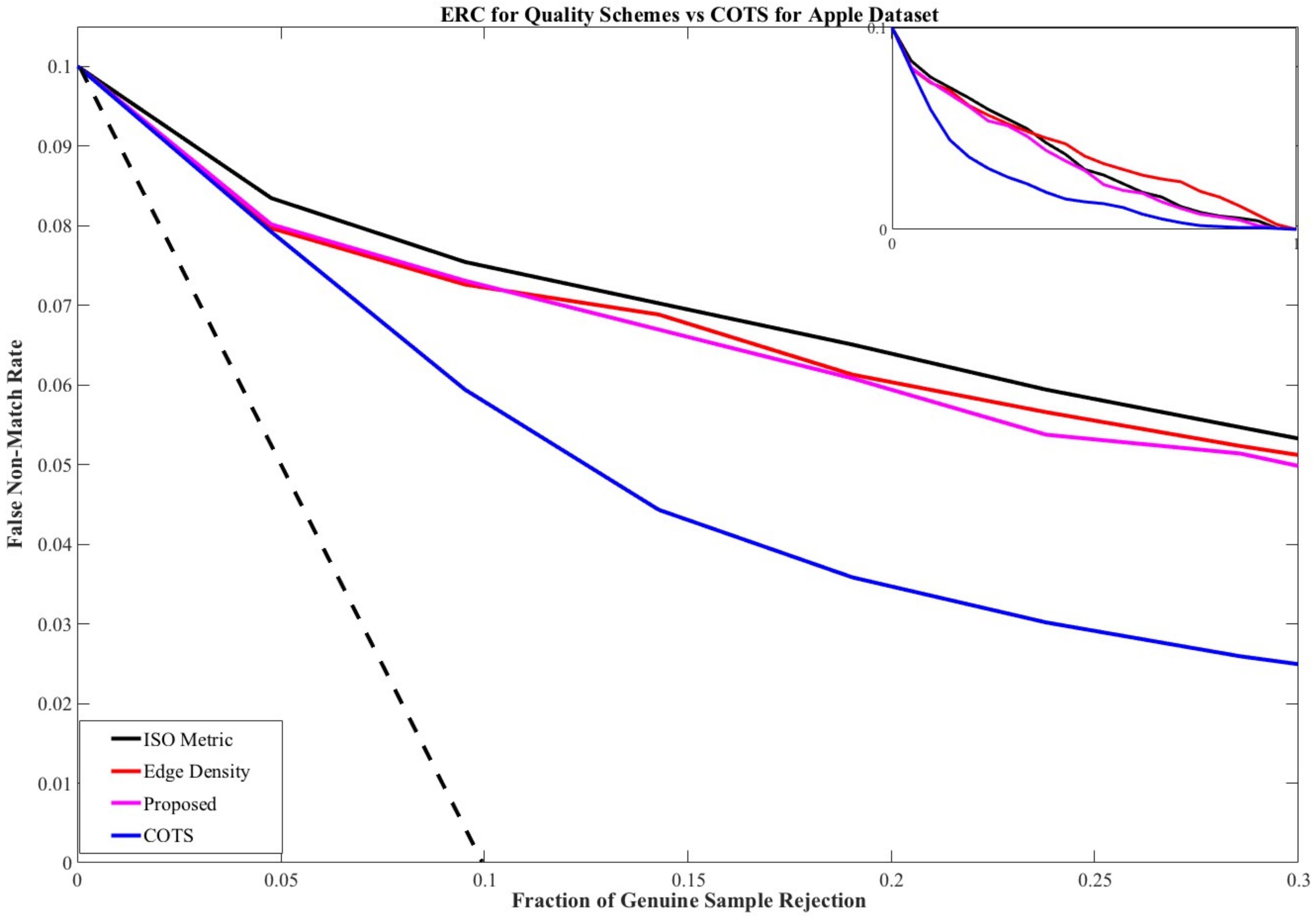
Quality Assessment Schemes	iPhone 6 Plus Database(ERC)		Samsung S7 Database(ERC)	
	η_{auc}^{erc}	η_{pauc20}^{erc}	η_{auc}^{erc}	η_{pauc20}^{erc}
COTS	**0.0196**	**0.0049**	0.0334	0.0069
ISO + RF	0.0697	0.0149	0.0285	0.0070
ISO + ED+ RF	0.032	0.006	**0.0278**	**0.0060**

AUC and PAUC for at FNMR = 0.01

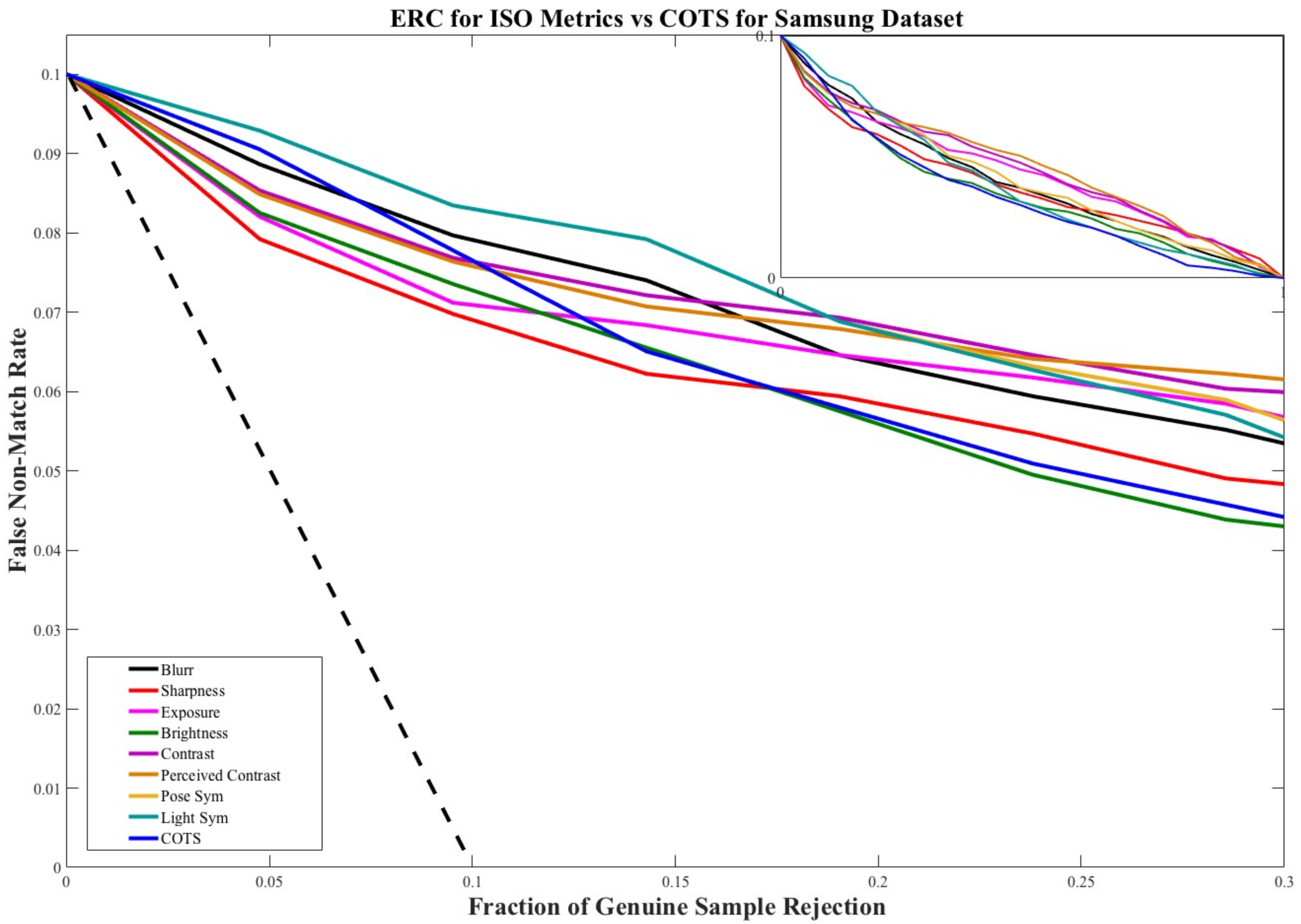
[Grother2007] Patrick Grother and Elham Tabassi. Performance of biometric quality measures. 2007.
[Olsen2015] M. A. Olsen, V. Smida, and C. Busch, “Finger image quality assessment features-definitions and evaluation,” IET Biometrics, 2015.
[Wasnik2017] Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In 5th International Workshop on Biometrics and Forensics (IWBF), pp. 1-6. IEEE, 2017.

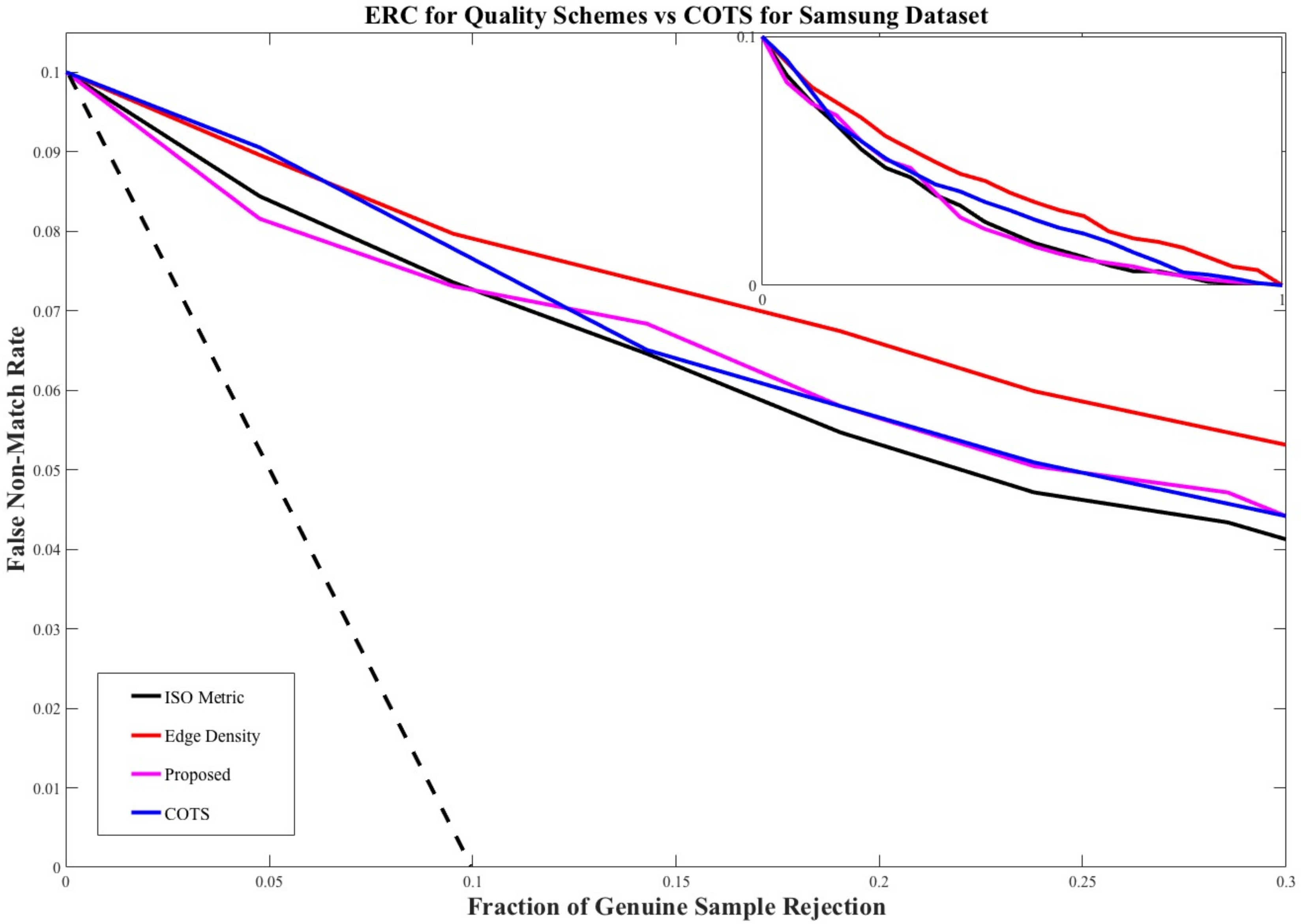
Results from candidate approach



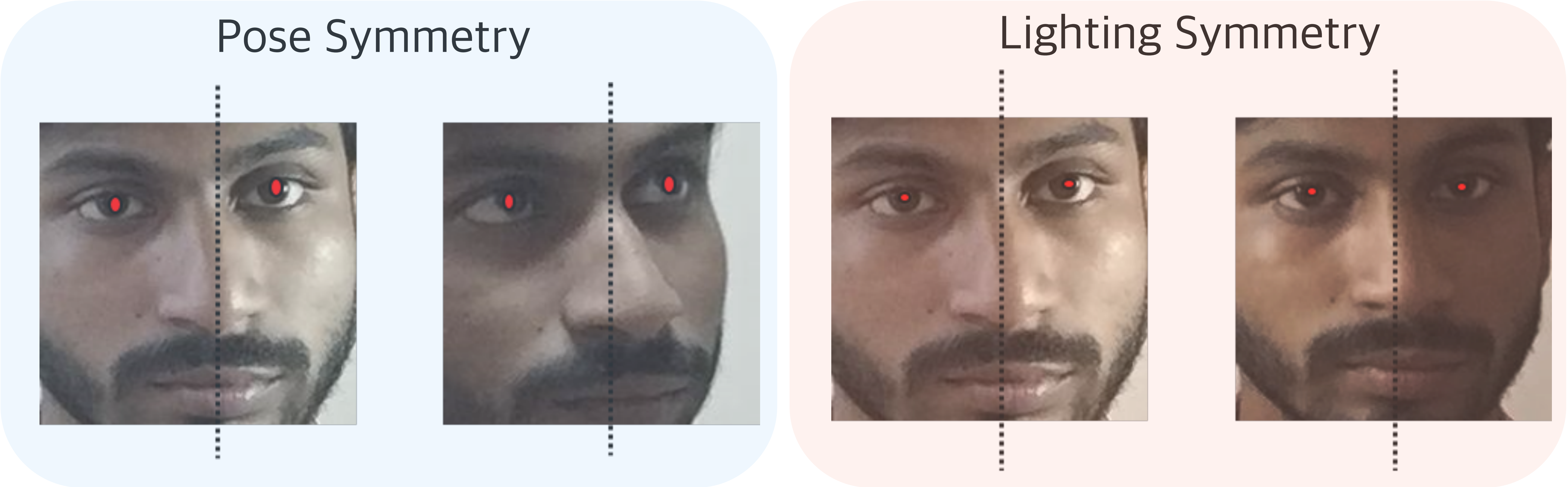


Results from candidate approach





Candidate proposal – Joint estimation of pose and lighting symmetry



Pankaj Wasnik, Kiran Raja, Raghavendra Ramachandra, and Christoph Busch. "Assessing face image quality for smartphone based face recognition system." In 5th International Workshop on Biometrics and Forensics (IWBF), pp. 1-6. IEEE, 2017.

Contact

- Open positions for master thesis (physical and remote)
- Open positions for visiting PhD/Postdocs/faculty

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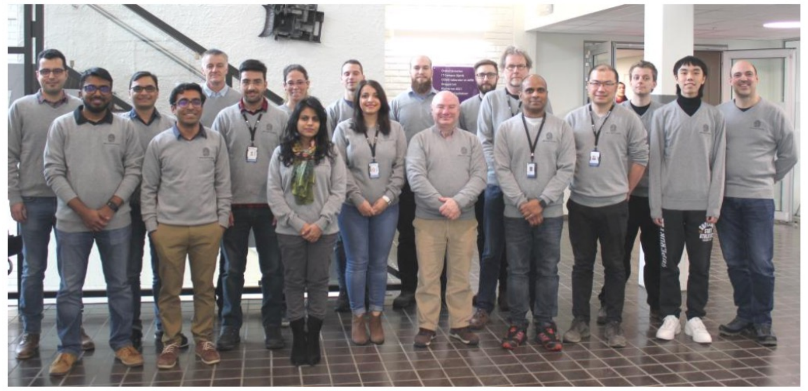
Laboratory

Norwegian Biometrics Laboratory

The biometric research group at NTNU focuses on various biological and behavioral biometrics including 2D- and 3D-face recognition, fingerprint recognition, fingervein recognition, ear recognition, signature recognition, gait recognition, keystroke recognition, gesture recognition and mouse dynamics.

NORWEGIAN BIOMETRICS LABORATORY



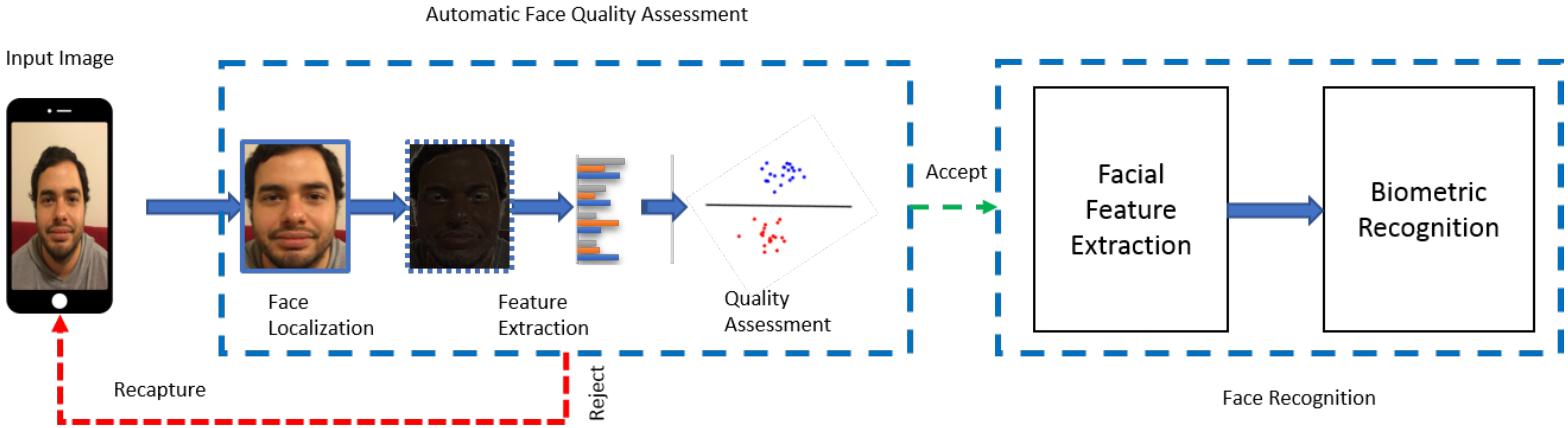
About Publications Tag cloud Network People

Norwegian Biometrics Laboratory is more than just a physical room at the campus. It is a discussion forum to brainstorm, to generate new ideas and projects and to present intermediate results. Thus it is an essential part of the Department of Information Security and Communication at the Norwegian University of Science and Technology (NTNU) and represents an active focus point with many international research projects.

Further, it is the intention of the laboratory to increase the awareness of biometrics in Norway via the Norwegian Biometric Forum and its potential involvement in the Norwegian legislation and to contribute to the international standardization in the field.

Benchmarking against DL Approach

Benchmark against DL Models



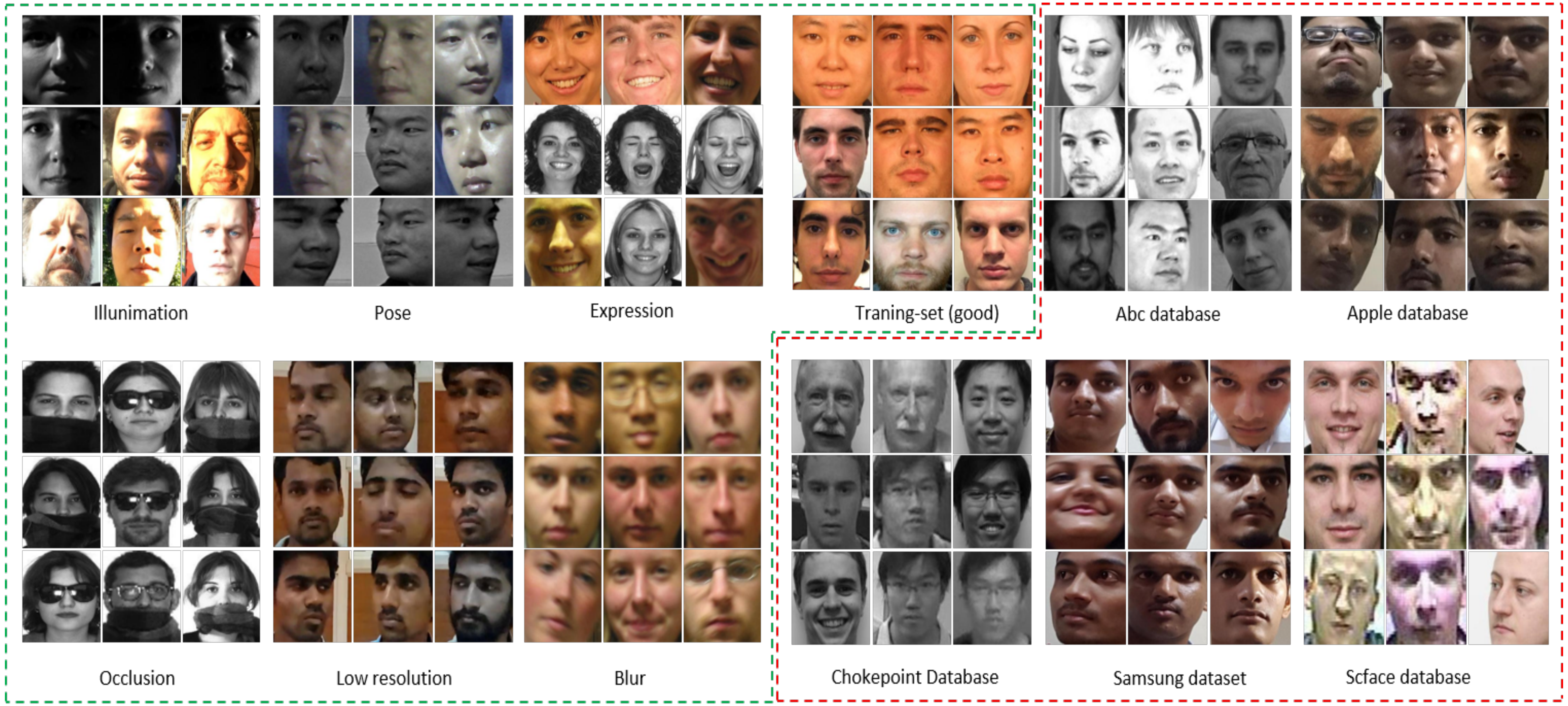
1. Evaluated 14 quality algorithms – 10 CNN based and 4 Non-CNN Based
2. 5 General CNNs, 3 Mobile CNNs, 2 SOTA CNNs [6, 7]
3. 3 General Blind Quality Algorithms
4. 1 Commercial – VeryLook Mobile SDK
5. Evaluated 5 databases – 2 mobile and 3 general

Network Training:

1. Transfer learning
2. Data augmentation: translation in x and y-direction, mirroring along both axes and random cropping.
3. Training Details: Batch size – 64, 412 iterations/epochs.
4. Optimizer: SGD with Momentum = 0.9, Initial Learning Rate = 0.0001.
5. Validation: 10% of total training samples with validation frequency = 3.

[Wasnik2018] Pankaj Wasnik, Raghavendra Ramachandra, Kiran Raja, Christoph Busch, "An Empirical Evaluation Of Deep Architectures On Generalization Of Smartphone-Based Face Image Quality Assessment." In the 9th IEEE International Conference On Biometrics: Theory, Applications, And Systems (BTAS 2018) Los Angeles, California, 2018.
[Qi2018] Xuan Qi, Chen Liu, and Stephanie Schuckers. "Boosting face in video recognition via cnn based key frame extraction." In 2018 International Conference on Biometrics (ICB), pp. 132-139. IEEE, 2018.
[Zhang2017] Lijun Zhang, Lin Zhang, and Lida Li. "Illumination Quality Assessment for Face Images: A Benchmark and a Convolutional Neural Networks Based Model." In International Conference on Neural Information Processing, pp. 583-593. Springer, Cham, 2017

Benchmark against DL Models



Train Dataset

Database	Bad Images	Good Images	Data Characteristic
AR Face	2778	-	Occlusion, expressions, illumination
CAS-PEA	1250	-	Pose, illumination
Extended Yale	700	-	Illumination
FRGC	1580	8939	Blur, expression
NCKU face	4580	-	Pose
Our database	5605	7553	Illumination, low resolution

Test Dataset

Database	No of Subject	No of Images	Is smartphone based database?
ABC	58	8950	No
Apple	101	1010	Yes
Chokepoint	29	2900	No
Samsung	101	1010	Yes
Scface	130	3120	No

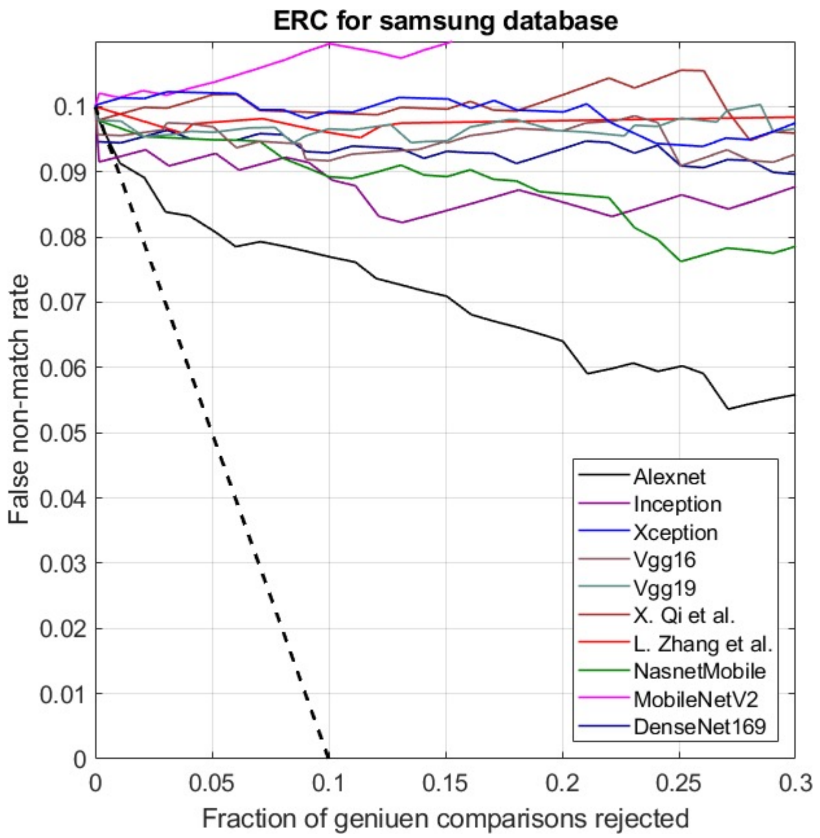
Database:

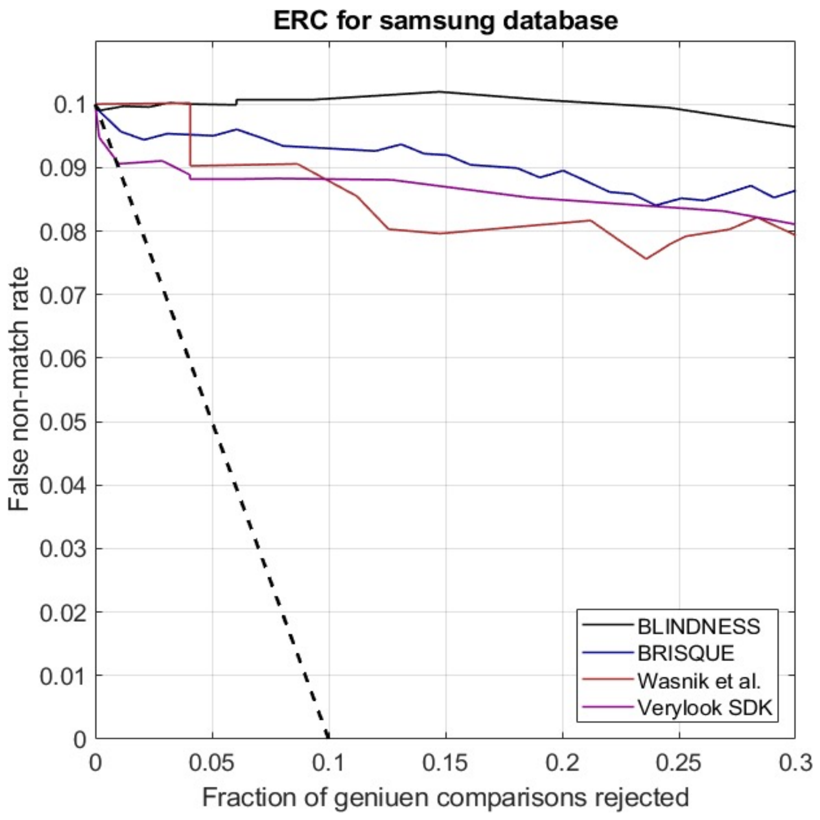
1. Training database Consists of≈33000 good and bad quality images.
2. Evaluation database Consists of≈ 17000 face images from 419 subjects.
3. Most of the used databases are publicly available

Benchmark against DL Models

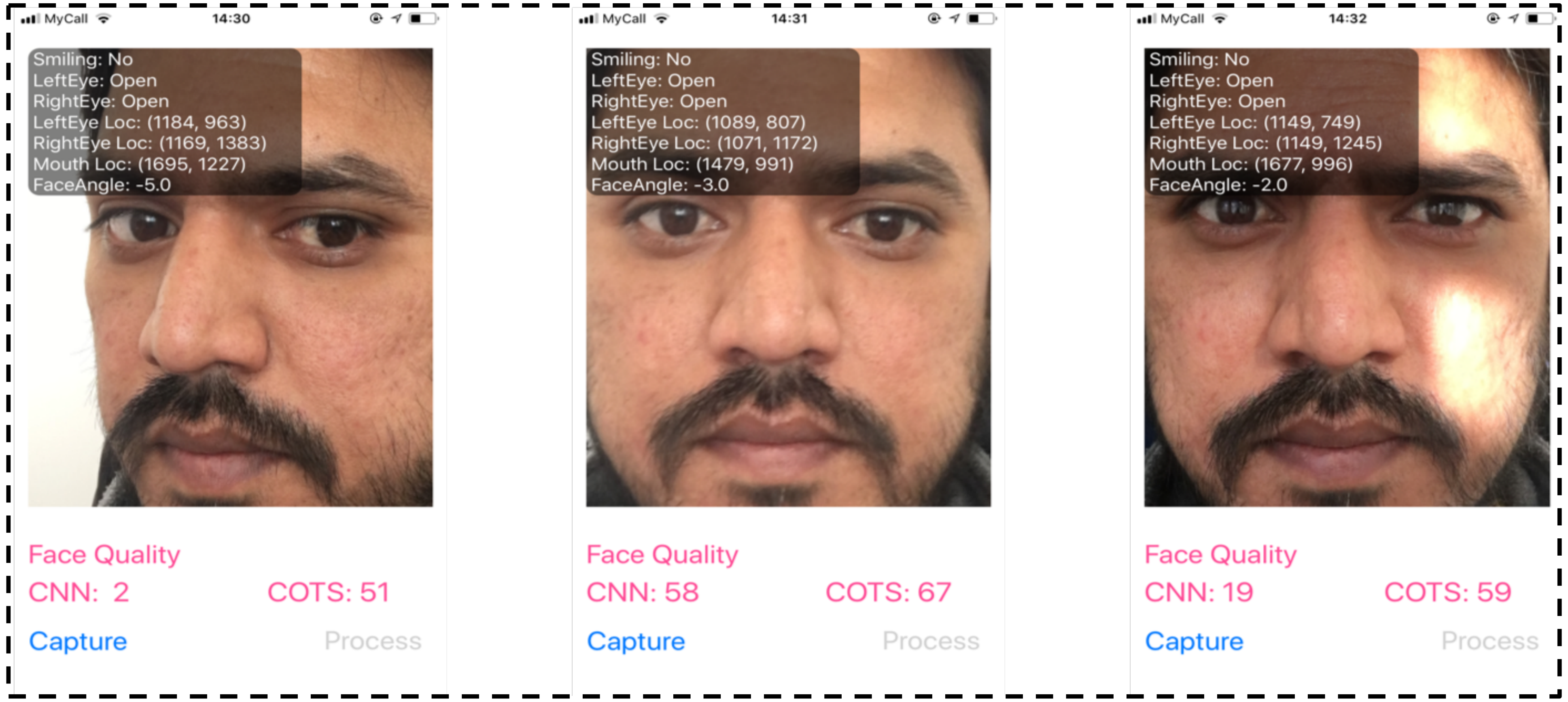
Algorithm	ABC		Apple		Chokepoint		Samsung		Scface	
	η^{erc}_{auc}	η^{erc}_{pauc20}	η^{erc}_{auc}	η^{erc}_{pauc20}	η^{erc}_{auc}	η^{erc}_{pauc20}	η^{erc}_{auc}	η^{erc}_{pauc20}	η^{erc}_{auc}	η^{erc}_{pauc20}
Alexnet	0.064	0.013	**0.057**	**0.011**	**0.027**	**0.008**	**0.054**	**0.010**	0.048	0.012
Inception	**0.035**	**0.009**	0.084	0.012	0.045	0.012	0.072	0.012	**0.027**	**0.008**
Vgg16	0.089	0.013	0.068	0.012	0.072	0.011	0.077	0.013	0.096	0.013
Vgg19	0.072	0.013	0.074	0.014	0.053	0.013	0.074	0.014	0.095	0.014
Xception	0.064	0.011	0.070	0.012	0.071	0.012	0.093	0.014	0.058	0.012
Qi et al.	0.062	0.012	0.089	0.014	0.070	0.012	0.094	0.014	0.084	0.013
Zhang et al.	0.083	0.013	0.083	0.014	0.088	0.014	0.091	0.012	0.083	0.012
MobileNetV2	0.060	0.012	0.104	0.015	0.071	0.012	0.108	0.015	0.053	0.011
Densenet169	0.080	0.014	0.078	0.013	0.065	0.013	0.083	0.013	0.099	0.014
NasnetMobile	0.068	0.013	0.091	0.014	0.060	0.011	0.080	0.013	0.079	0.012
BLINDNESS	0.067	0.013	0.094	0.014	0.069	0.012	0.096	0.015	0.083	0.014
BRISQUE	0.077	0.012	0.067	0.013	0.094	0.012	0.099	0.014	0.087	0.013
Wasnik et al.	0.087	0.015	0.068	0.012	0.082	0.014	0.064	0.013	0.071	0.014
Verylook SDK	0.065	0.013	0.087	0.014	0.101	0.014	0.075	0.013	0.075	0.013

AUC and PAUC for at FNMR = 0.1





Benchmark against DL Models



- Results favor CNN models.
- ERC should be used to select a FQAA
- Generalization is achieved in terms of Different challenges, databases, sensors