Morphing Attack Detection - State of the Art and Challenges

Christoph Busch

copy of slides available at:
https://eab.org/events/program/209
more information at:
https://christoph-busch.de/projects-mad.html
latest news at:
https://twitter.com/busch_christoph

EAB webinar, May 18, 2020

ATHENE

European Association for Biometrics
eab
Human Identity in Europe

NTNU

Principles

Principle of equality - in our society

- One individual - one job

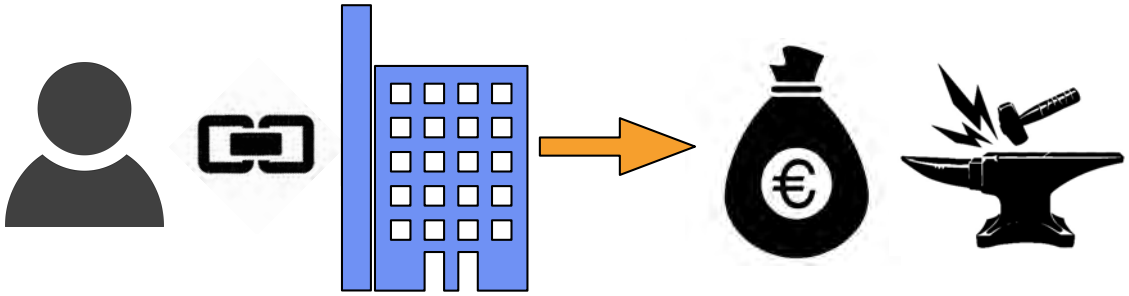


image source: https://de.freepik.com/freie-ikonen
image source: https://pixabay.com

Principles

Principle of equality - in our society

- One individual - one passport

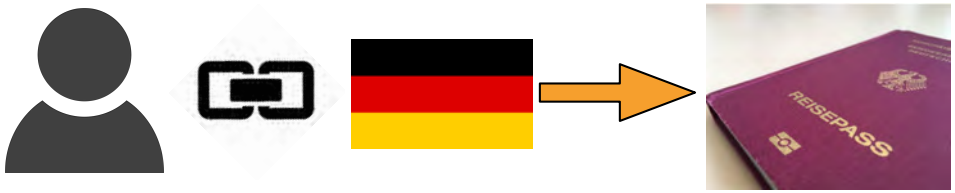


image source: https://pixabay.com

Principles

Principle of equality - in our society

- One Carlos Ghosen - multiple passports

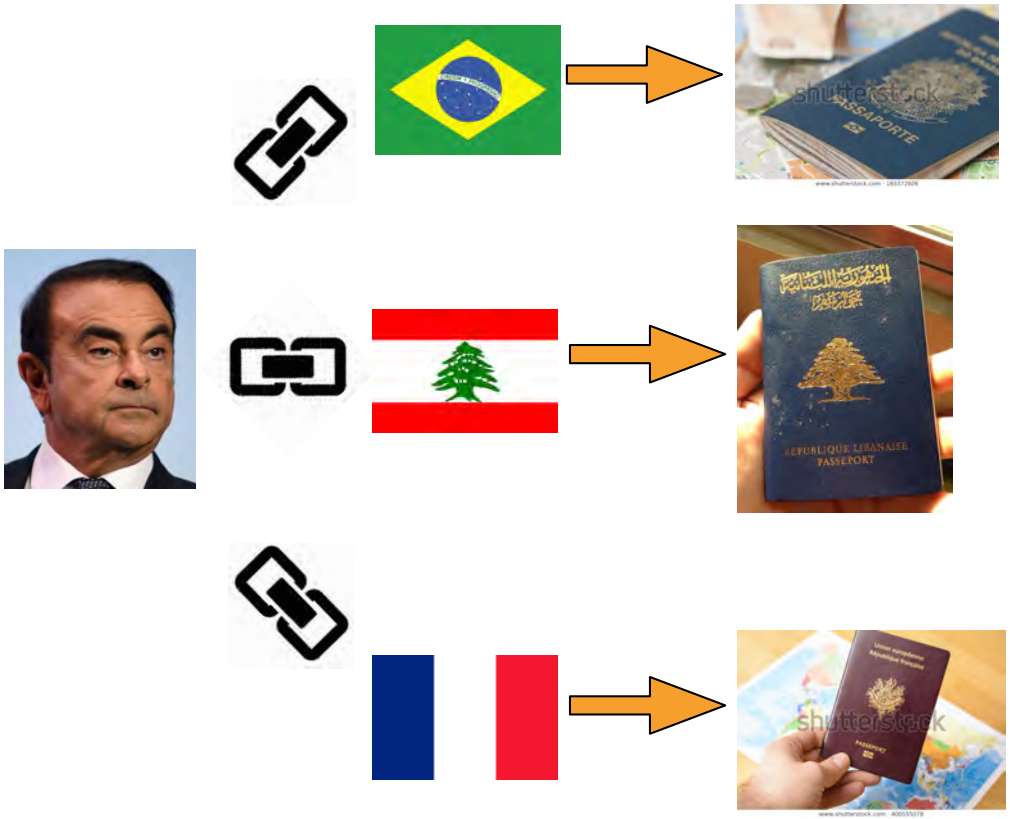
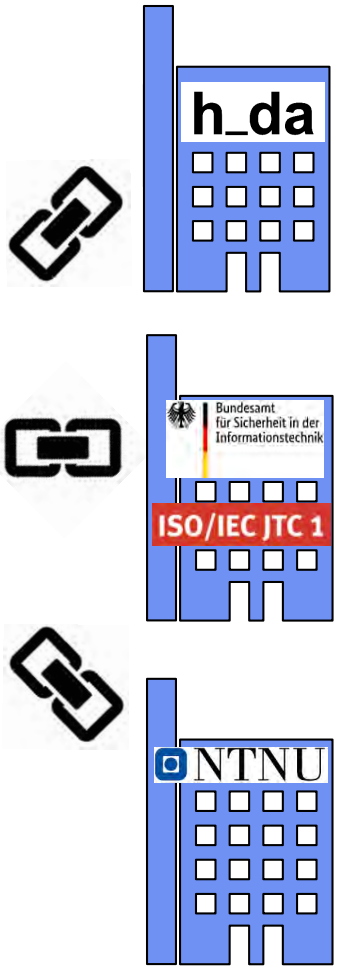


image source: https://www.shutterstock.com/image-photo/passport-hand-worlds-maps-background-400555078
image source: https://stateofmind13.com/2016/01/06/everything-you-need-to-know-about-the-new-lebanese-passport-rules/
image source: https://www.shutterstock.com/image-photo/brazilian-passport-above-map-governmentissued-document-165372926
image source: https://www.stern.de/wirtschaft/carlos-ghosn--die-filmreife-flucht-des-frueheren-star-managers-9069770.html

Principles

Principle of equality - in our society

- One Christoph - multiple jobs (two research groups)



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Darmstadt Research Team

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  - Christoph Busch
  - Christian Rathgeb
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  - Thomas Göbel
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  - Lorenz Liebler
  - Jannis Priesnitz
  - Ulrich Scherhag
  - Torsten Schlett
  - Janier Soler

2019

- Key-factors - since 2009:
  - 3 European funded projects,
    10 German funded projects
    5 research projects funded by the German BSI,
    2 industrial projects,
  - cooperated with > 30 research partners

https://dasec.h-da.de/

IT-Security in Darmstadt

National Research Center for Applied Cybersecurity (ATHENE)

- 400+ scientist from 47+ countries

TECHNISCHE UNIVERSITÄT DARMSTADT

CYSEC research group at TU Darmstadt

CYSEC Cybersecurity TU Darmstadt

Fraunhofer SIT

Fraunhofer Institute for Secure Information Technology SIT

Fraunhofer IGD

Fraunhofer Institute for Computer Graphics Research IGD

h_da HOCHSCHULE DARMSTADT UNIVERSITY OF APPLIED SCIENCES

da/sec research group at Hochschule Darmstadt

da/sec BIOMETRICS AND INTERNET-SECURITY RESEARCH GROUP

Darmstadt in the Rhine Valley

Darmstadt in the Rhine Valley

Darmstadt in the Rhine Valley

Gjøvik Research Group
@Norwegian University of Science and Technology

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  - Parisa Borj
  - Pawel Drozdowski
  - Sushma Venkatesh
  - Tobias Scheer

2020

- keyfactors - since 2008:
  7 European funded projects,
  2 Norwegian funded projects
  2 US-government funded projects,
  3 research projects funded by the German BSI,
  4 industrial projects

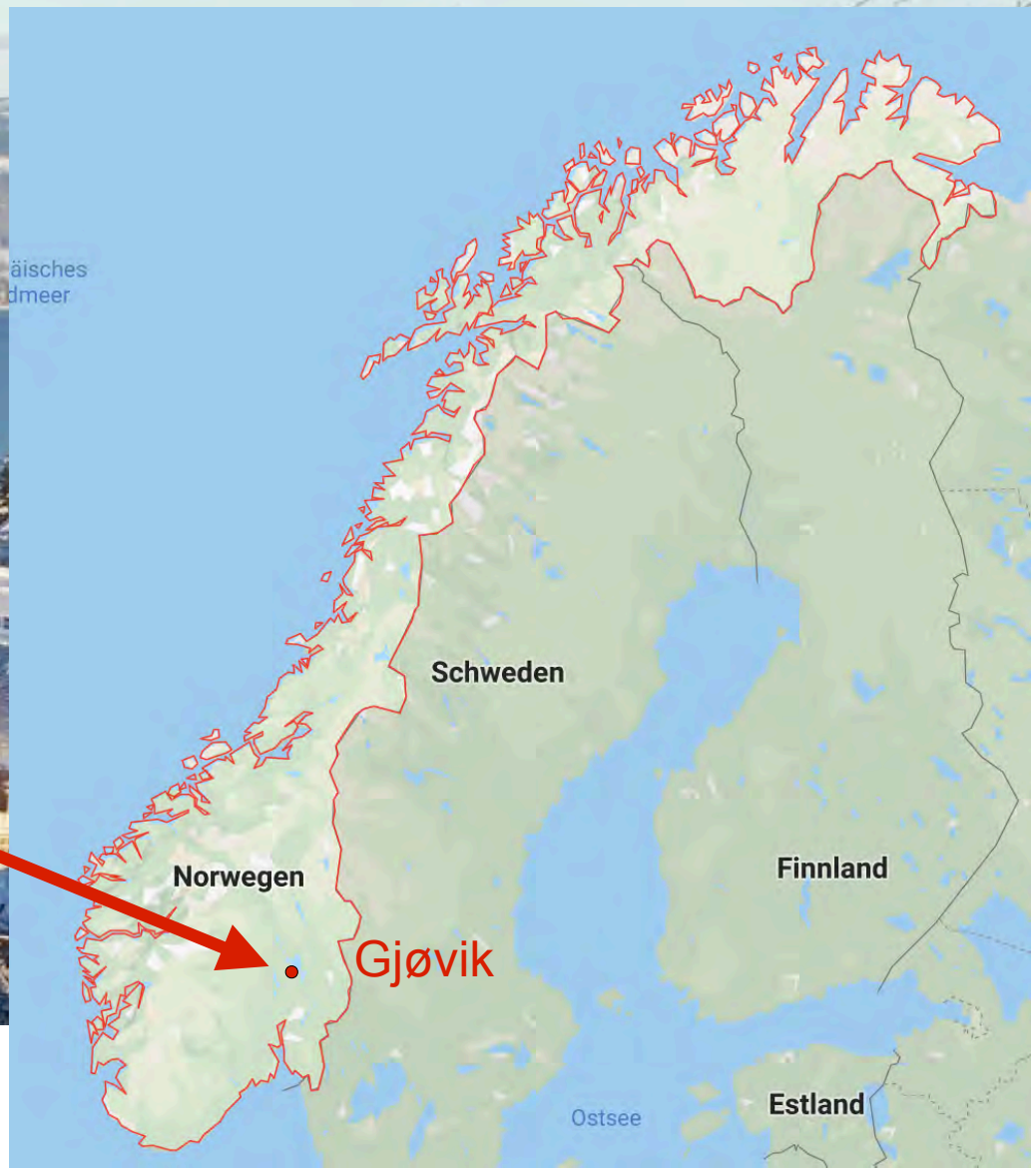
https://www.ntnu.edu/nbl

Gjøvik at Lake Mjøsa

Gjøvik at Lake Mjøsa

- Gjøvik is at the western shore of lake Mjøsa
  - the largest fresh water lake in Norway
    117 km long and 440m deep
- Gjøvik was part of the 1994
  winter olympic games
  - that took place in the triangle:
    Lillehammer - Hamar - Gjøvik
  - Since those days Gjøvik has the famous fjellhalle

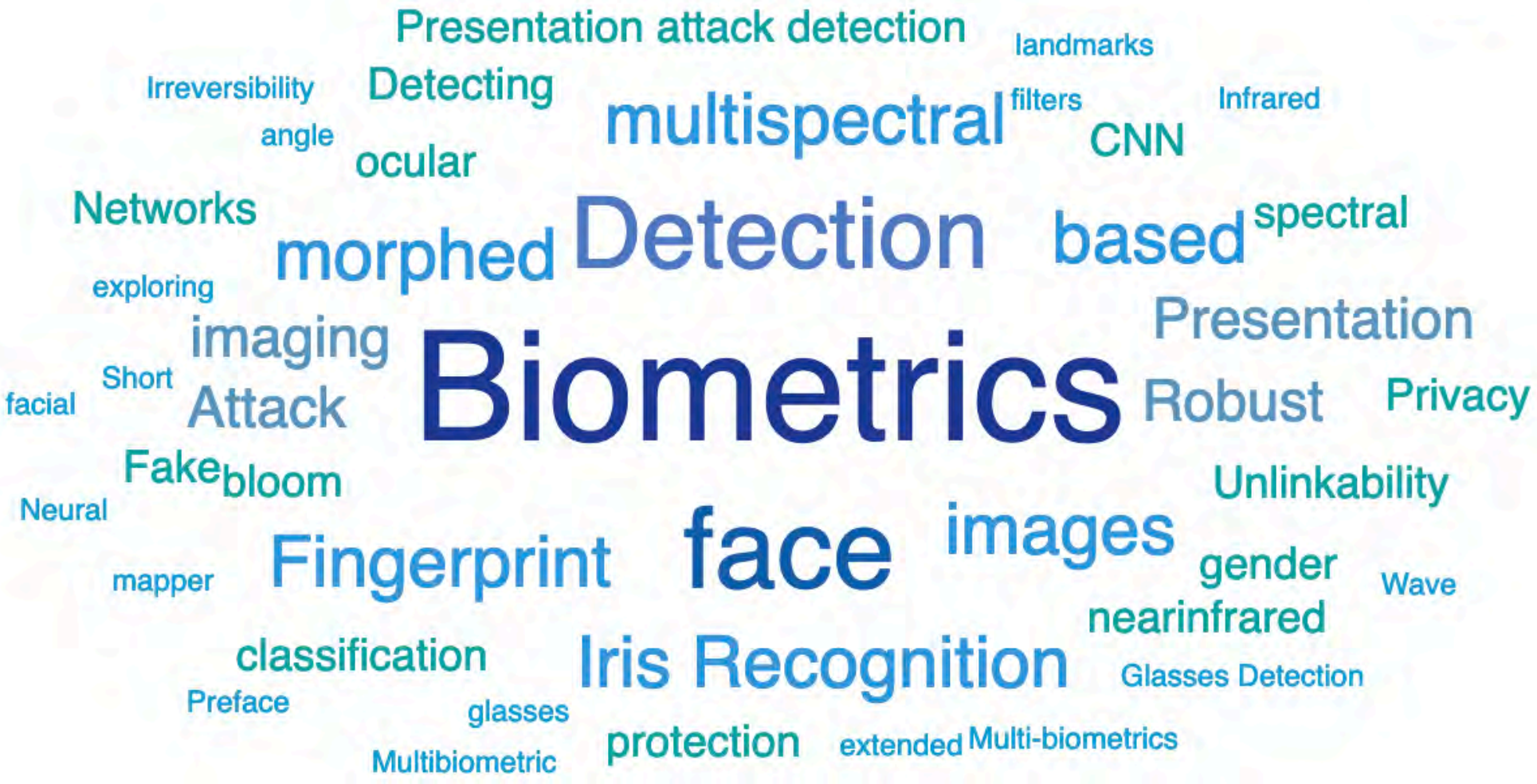
Gjøvik at Lake Mjøsa



There are Days with Sunshine in Norway

Our Research Topics

Our publication tag cloud



Passports

Standardised Travel Documents

ICAO - International Civil Aviation Organisation

- A specialised UN agency (Headquarter Montreal)
- 193 member states
- ICAO's mandate for standards development
  - The Convention on International Civil Aviation - Doc 7300 signed in December 1944 ("Chicago Convention")
  - ICAO works to achieve its vision of safe, secure and sustainable development of civil aviation through the cooperation of its Member States
- Technical Advisory Group on Machine Readable Travel Documents (TAG/MRTD)
- Cooperation with International Organisation for Standardisation (ISO/IEC JTC1)
  - SC17 and SC37

Biometrics and ePassports

- ICAO - New Orleans Resolution - March 2003
  - *“ICAO TAG-MRTD/NTWG recognises that Member States currently and will continue to utilise the facial image as the primary identifier for MRTDs and as such endorses the use of standardised digitally stored facial images as the globally interoperable biometric to support facial recognition technologies for machine assisted identity verification with machine-readable travel documents.*

ePassport Data Group Details

Data stored on the chip (LDS)

- DG1: Information printed on the data page
- DG2: Facial image of the holder (mandatory)

- DG3: Fingerprint image of left and right index finger

- DG4: Iris image

....

- DG15: Active Authentication Public Key Info
- DG16: Persons to notify

Document Security Object

- Hash values of DGs

				DATA ELEMENTS
REQUIRED	ISSUING STATE OR ORGANIZATION DATA	Detail(s) Recorded in MRZ	DG1	Document Type
				Issuing State or organization
				Name (of Holder)
				Document Number
				Check Digit - Doc Number
				Nationality
				Date of Birth
				Check Digit - DOB
				Sex
				Data of Expiry or Valid Until Date
				Check Digit DOE/VUD
				Optional Data
				Check Digit - Optional Data Field
				Composite Check Digit
		Encoded Identification Feature(s)	Global Interchange Feature	DG2 Encoded Face
			Additional Feature(s)	DG3 Encoded Finger(s)
				DG4 Encoded Eye(s)
OPTIONAL	ISSUING STATE OR ORGANIZATION DATA	Displayed Identification Feature(s)	DG5	Displayed Portrait
			DG6	Reserved for Future Use
			DG7	Displayed Signature or Usual Mark
		Encoded Security Feature(s)	DG8	Data Feature(s)
			DG9	Structure Feature(s)
			DG10	Substance Feature(s)
			DG11	Additional Personal Detail(s)
			DG12	Additional Document Detail(s)
			DG13	Optional Detail(s)
			DG14	Security Options
			DG15	Active Authentication Public Key Info
			DG16	Person(s) to Notify

Source: ICAO 9303 Part 10, 2015

ePassport Details

Data to be stored in the RFID-Chip

- Alpha-numeric data: 5 Kbyte
- Facial image: ISO/IEC 19794-5:2005
  - 12 Kbyte (JPEG, JPEG2000)
- Fingerprint images: ISO/IEC 19794-4:2005
  - 2* 10 Kbyte (JPEG, JPEG2000, WSQ)

- Facial image: ISO/IEC 39794-5:2019
  https://www.iso.org/standard/72155.html
- Fingerprint images: ISO/IEC 39794-4:2019
  https://www.iso.org/standard/72156.html
  - ICAO will adopt its 9303 specification in 2020 and refer to ISO/IEC 39794 and its Parts 1, 4 and 5 by December 2020.
  - Passport reader equipment must be able to handle ISO/IEC 39794 data by 2025-01-01 (5 years preparation period).
  - Between 2025 and 2030, passport issuers can use the old version or the new version of standards (5 years transition period).

New in 2020

Principles Revisited

Is the Principle valid on the left Side?

Principle of equality - in our society

- One individual - one passport

Principle of unique link of ICAO

- One individual - one passport
- ICAO 9303 part 2, 2006:
  *„**Additional security measures:** inclusion of a machine verifiable biometric feature linking the document to its legitimate holder“*

image source: https://pixabay.com/de/vectors/tick-sternchen-kreuz-rot-gr%C3%BCn-40678/

Is the Principle valid on the left Side?

Principle of unique link of ICAO

- One individual - one passport

We don’t want this principle of unique link to be broken

- Multiple individuals - one passport

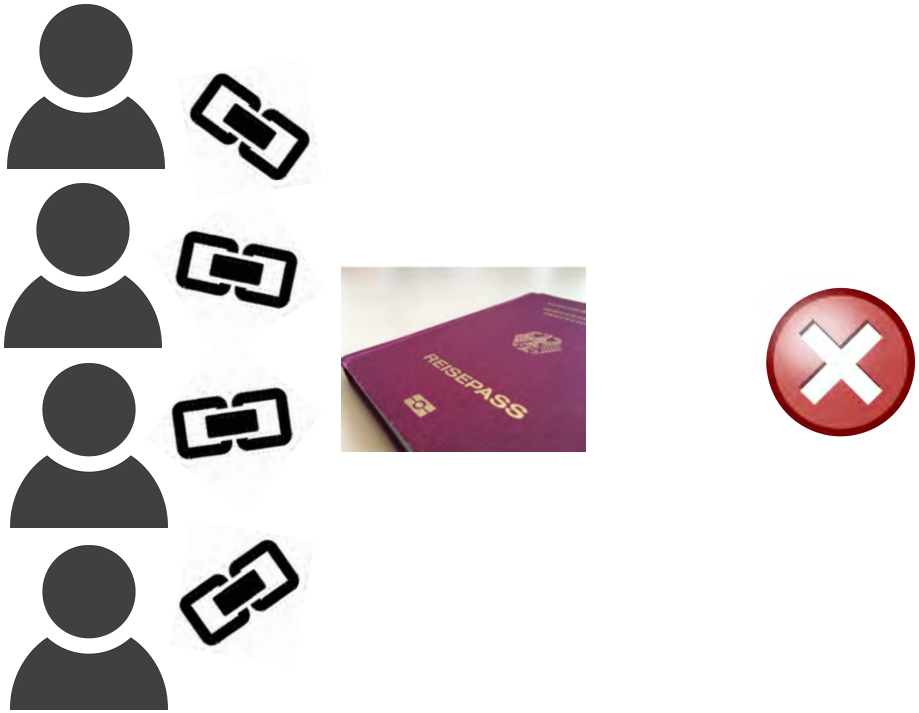


image source: https://pixabay.com/de/vectors/tick-sternchen-kreuz-rot-gr%C3%BCn-40678/

What is Morphing?

What is Morphing?

In our real world morphing can become a threat

- with a criminal and an accomplice as actors
- take the criminal
- and the accomplice
- morphing can transform one face image into the other
- and you can stop half way in the transformation

What is Morphing?

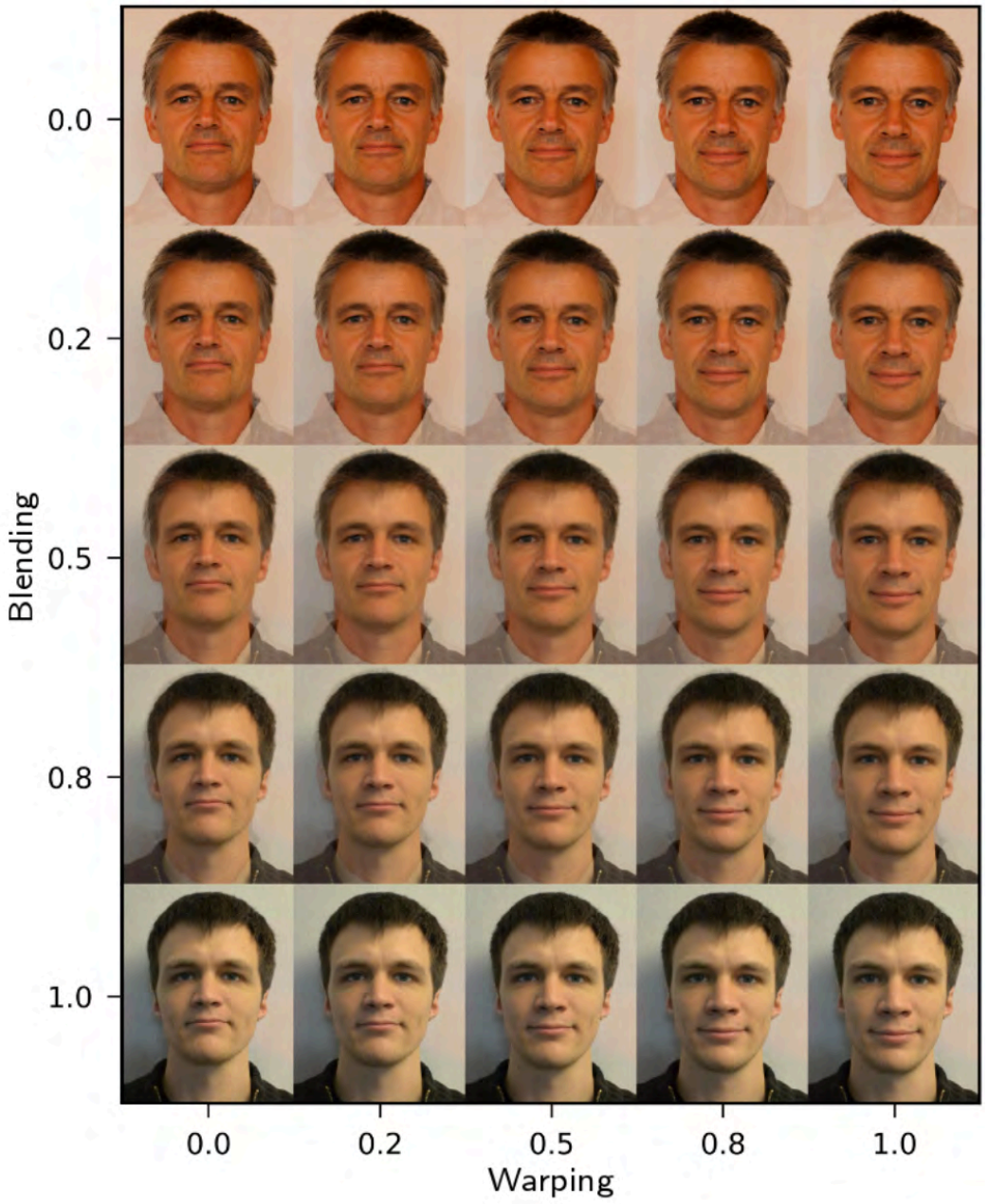
Warping and blending

- controlled by the alpha factor
- Landmark positions

$$\vec{x}_m = (1 - \alpha_w) \cdot \vec{x}_1 + \alpha_w \cdot \vec{x}_2$$

- Colour

$$C_m = (1 - \alpha_b) \cdot C_1 + \alpha_b \cdot C_2$$



Problem Description

History - 2012 to 2016

Integrated Project FIDELITY

http://www.fidelity-project.eu/

- Fast and trustworthy Identity Delivery and check with ePassports leveraging Traveler privacy
- 4 years project (2012-2016)
  - European 7th Framework Programme
- Objectives:
  - To improve the ePassport issuing process
    - Security of birth certificates and other evidence of identity
    - Quality of biometric data in the chip
    - One individual one passport (duplicate enrolment check)
  - To demonstrate solutions that enable faster and more secure and efficient real-time authentication of individuals at border crossing
  - To protect privacy of the travel document holders with a privacy-by-design approach.

[FFM2014] M. Ferrara, A. Franco, D. Maltoni, “The Magic Passport”, in Proceedings IEEE IJCB 2014

Problem: Morphing Attacks

Morphing attack scenario

- Passport application of the accomplice A

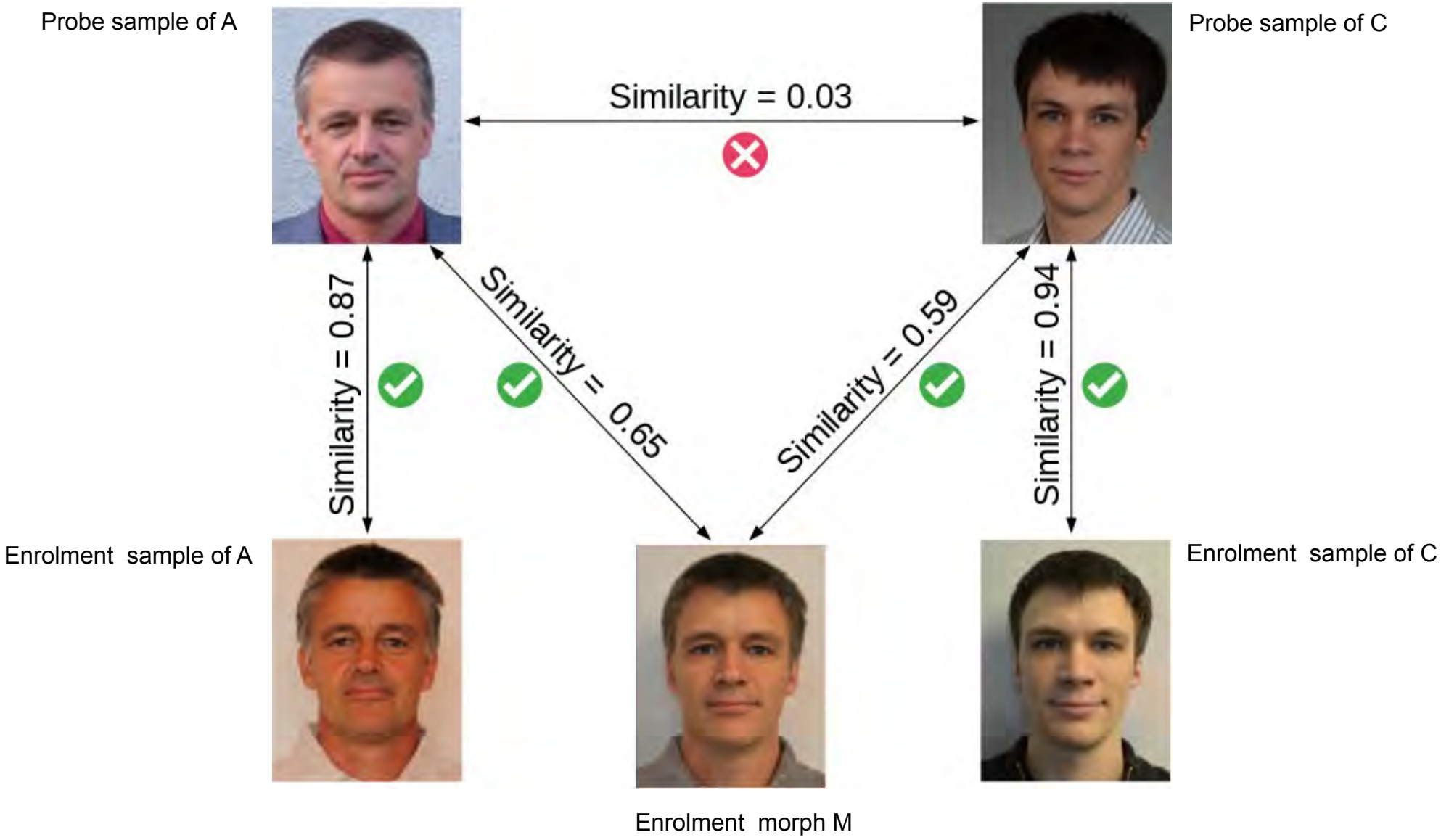
Problem: Morphing Attacks

Morphing attack scenario

- Border control

Problem: Morphing Attacks

Verification against morphed facial images



Problem: Morphing Attacks

Is it a really problem ? - YES!

- In September 2018 German activists
  - used a morphed images of Federica Mogherini (High representative of the European Union for Foreign Affairs and Security Policy) and a member of their group
  - and received an authentic German passport.

Image source: https://www.spiegel.de/netzwelt/netzpolitik/biometrie-im-reisepass-peng-kollektiv-schmuggelt-fotomontage-in-ausweis-a-1229418.html

Problem: Morphing Attacks

Message in December 2015:

- *„Brussels - we have a problem!“*

Proposed solutions to the Morphing Attack Problem:

- 1.) Photo studio should digitally sign the picture taken by Photo Studio and send it to the passport application office
  - this is in progress for Finland
- 2.) Switch to live enrolment
  - that is the case for Norway and Sweden
- 3.) Software-supported detection of morphed face images

Regarding 2.) EU Regulation 2019/1157:

- on strengthening the security of identity cards in recital 32 states: *"... To this end, Member States could consider collecting biometric identifiers, particularly the facial image, by means of live enrolment by the national authorities issuing identity cards."*

What is the vulnerability?

Scale of the Problem: Vulnerability

Human Experts Capabilities - (44 border guards)

[FFM2016] M. Ferrara, A. Franco, D. Maltoni: “On the Effects of Image Alterations on Face Recognition Accuracy”, in Face Recognition Across the Imaging Spectrum, Springer Nature, (2016)

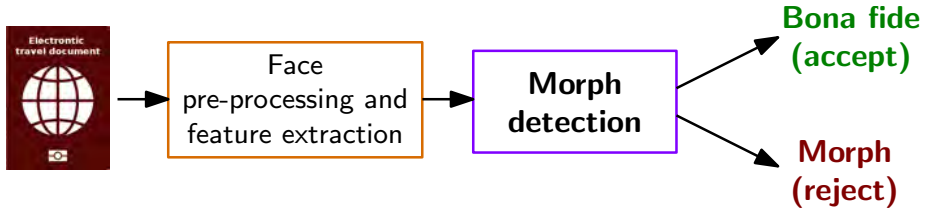
Morphing Attack Detection (MAD)

Scenarios and Methods

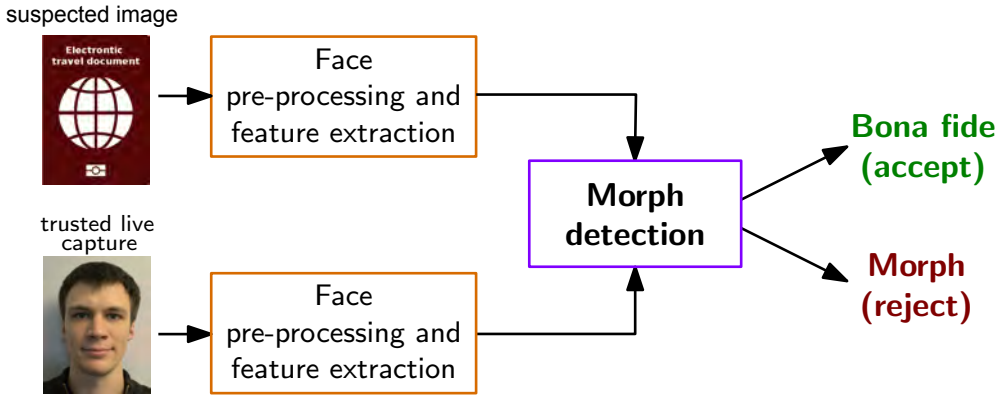
Morphing Attack Detection Scenarios

Real world scenarios

- Single image morphing attack detection (S-MAD)
  - One single *suspected* facial image is analysed (e.g. in the passport application)



- Differential morphing attack detection (D-MAD)
  - A pair of images is analysed - and one is a trusted Bona Fide image
  - Biometric verification (e.g. at the border)

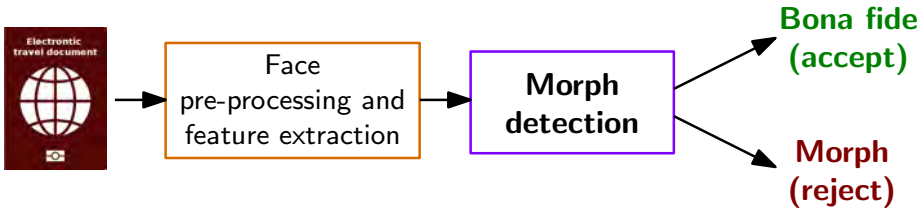


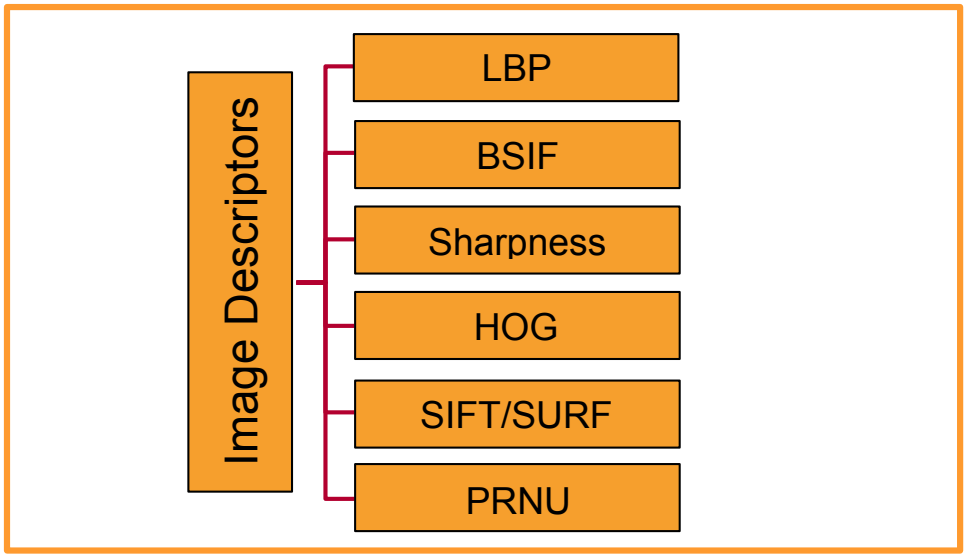
[SRB2018a] U. Scherhag, C. Rathgeb, C. Busch: "Towards Detection of Morphed Face Images in electronic Travel Documents", in Proceedings of the 13th IAPR International Workshop on Document Analysis Systems (DAS), April 24-27, (2018)

Face Pre-processing and Feature Extraction

Morphing Attack Detection (S-MAD) with texture analysis

- Image descriptors as hand-crafted features





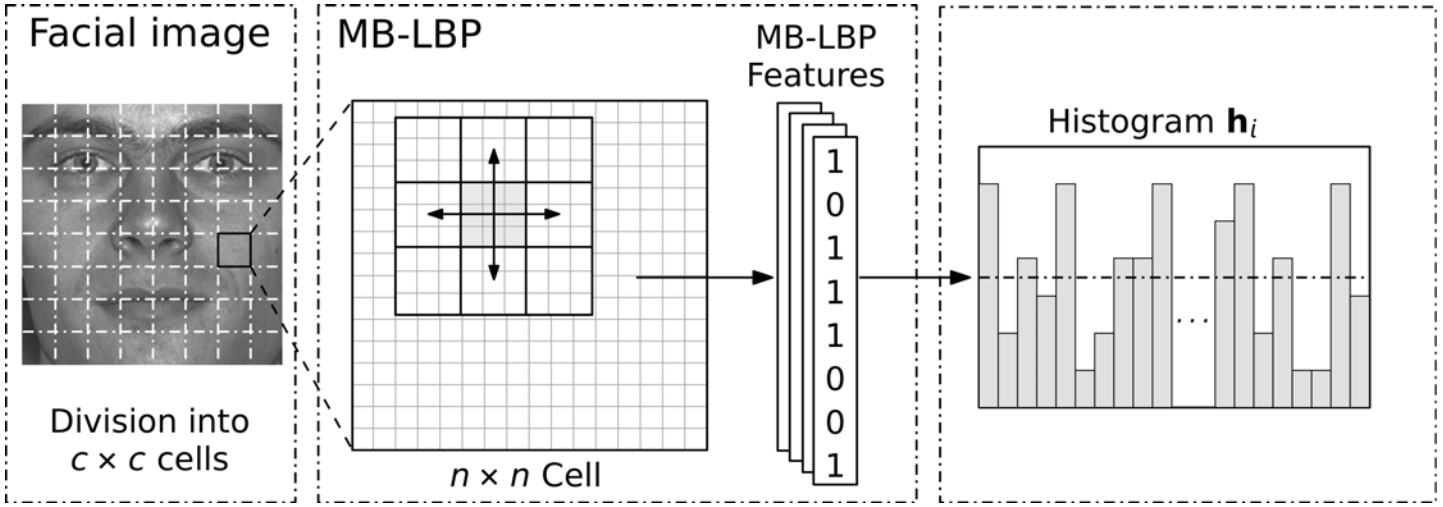
Morph Detection Classifier

[SRB2018b] U. Scherhag, C. Rathgeb, C. Busch: „Detection of Morphed Faces from Single Images: a Multi-Algorithm Fusion Approach“, in Proceedings if of the 2nd International Conference on Biometric Engineering and Applications (ICBEA), Amsterdam, The Netherlands, May 16-18, (2018)

Face Pre-processing and Feature Extraction

S-MAD with image descriptor

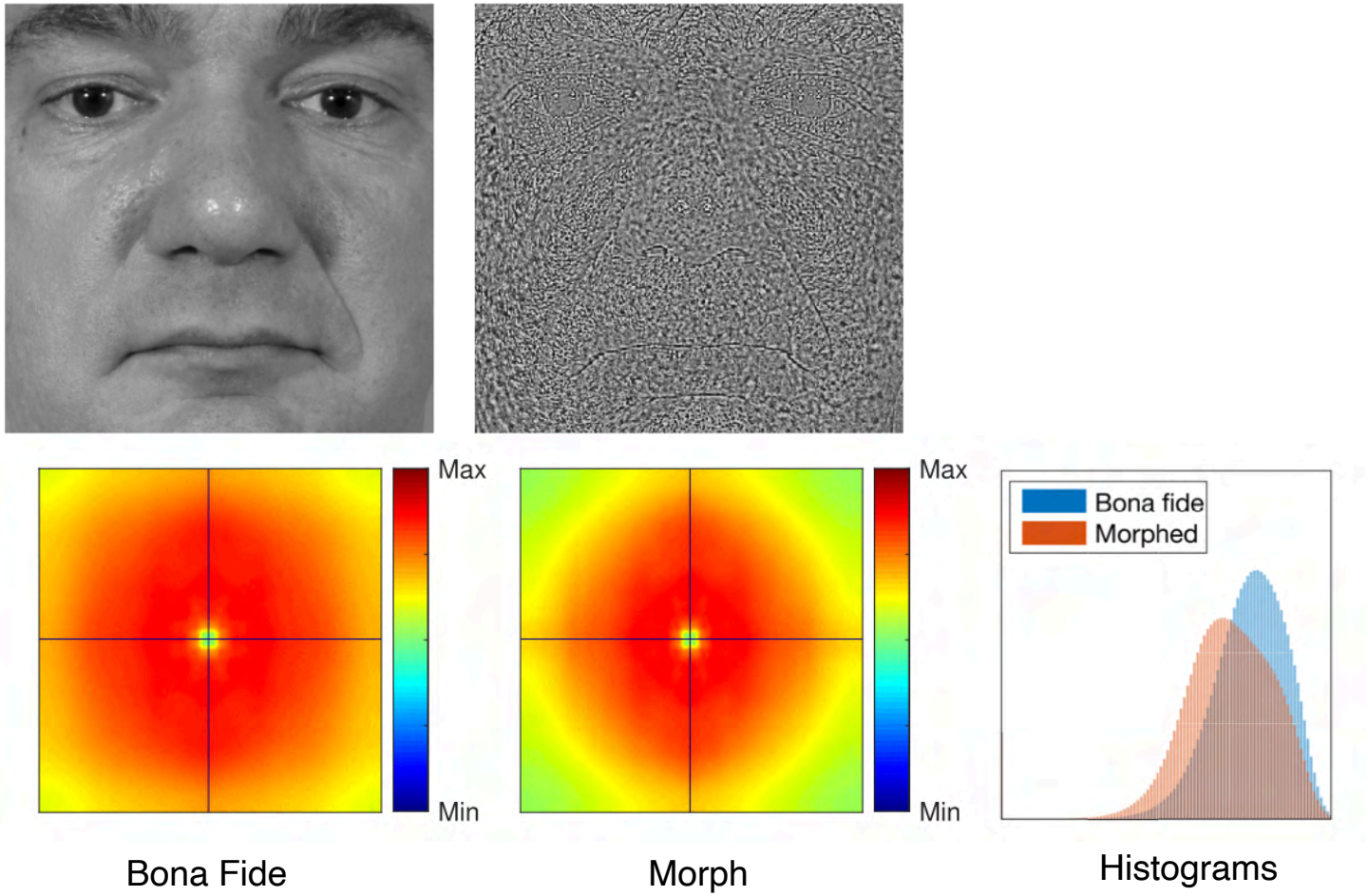
- Local Binary Pattern (LBP)



Face Pre-processing and Feature Extraction

S-MAD with image descriptor / forensic approach

- Photo Response Non-Uniformity (PRNU)

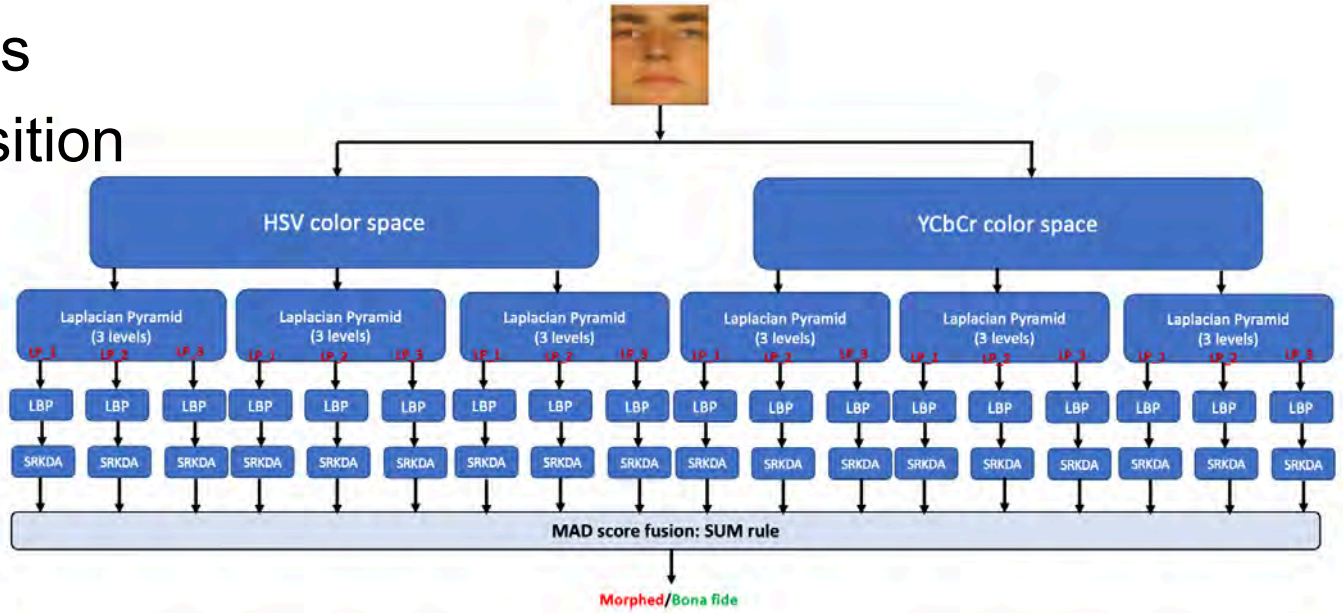


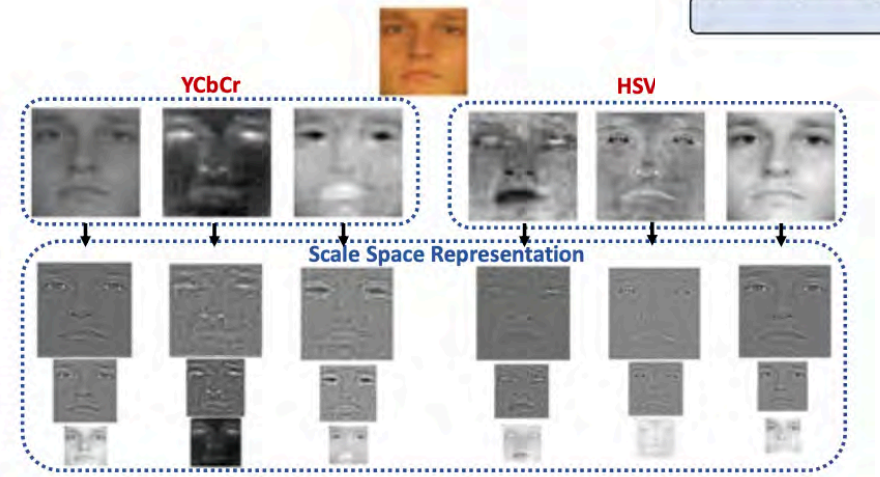
[SDRBU2019] U. Scherhag, L. Debiasi, C. Rathgeb, C. Busch and A. Uhl: "Detection of Face Morphing Attacks based on PRNU Analysis“, in IEEE TBIOM, (2019)

Face Pre-processing and Feature Extraction

S-MAD with Scale-Space features

- Transformation to different color spaces
- Laplacian decomposition



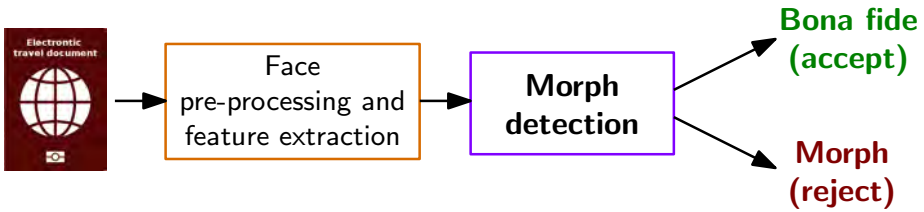


[RVRB2019] R. Raghavendra, S. Venkatesh, K. Raja, C. Busch: "Towards making Morphing Attack Detection robust using hybrid scale-space Colour Texture Features", in Proceedings of the International Conference on Identity, Security and Behavior Analysis (ISBA), (2019)

Face Pre-processing and Feature Extraction

Morphing Attack Detection (S-MAD) with texture analysis

- Image descriptors as Deep features



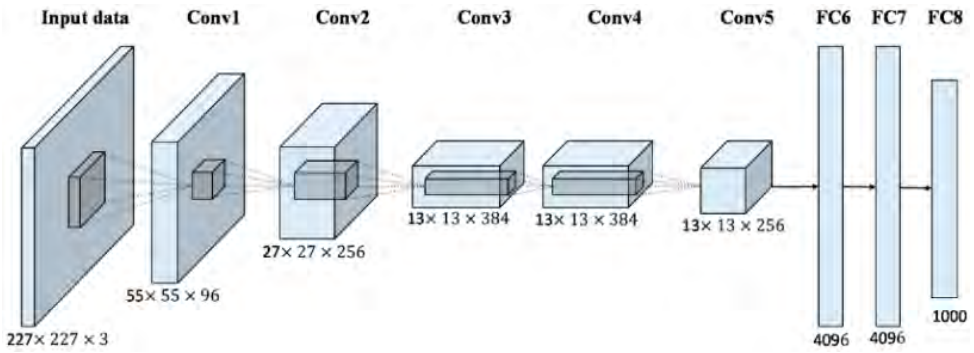
CNN BlackBox

Morph Detection Classifier

Face Pre-processing and Feature Extraction

S-MAD with deep learning

- Feature Representations
  - pre-trained Convolutional Neural Network (CNN)

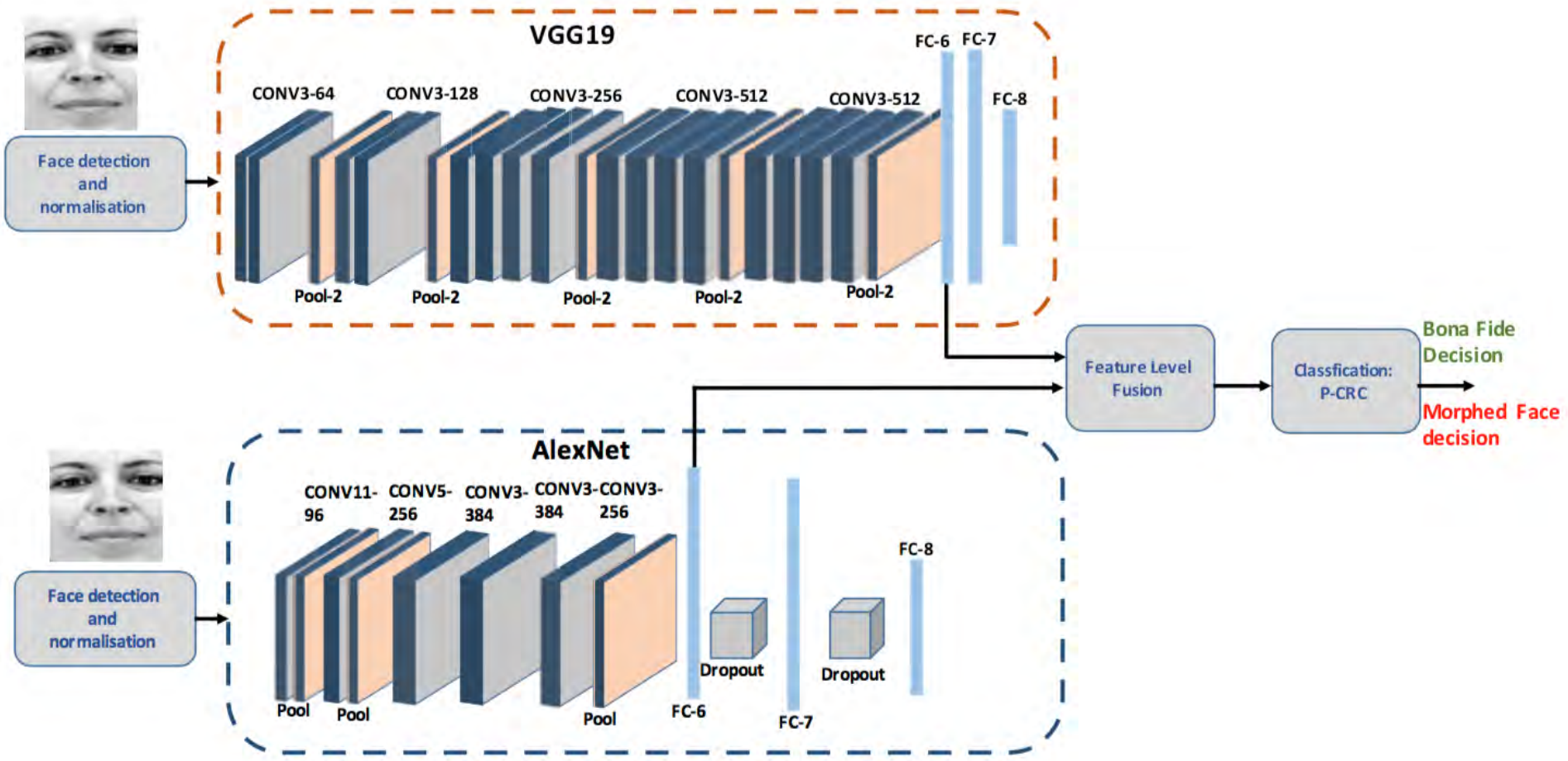


Morph Detection Classifier

Single Image Morphing Attack Detection

S-MAD with deep learning

- Feature level fusion of Deep CNNs

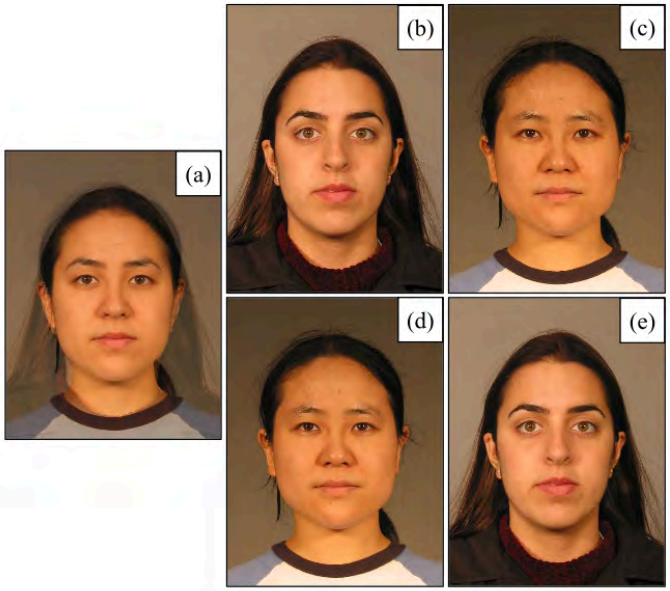


[RRVBu2017] R. Raghavendra, K. Raja, S. Venkatesh, C. Busch: "Transferable Deep-CNN features for detecting digital and print-scanned morphed face images", in Proceedings of 30th International Conference on Computer Vision and Pattern Recognition Workshop (CVPRW), July 21-26, (2017)

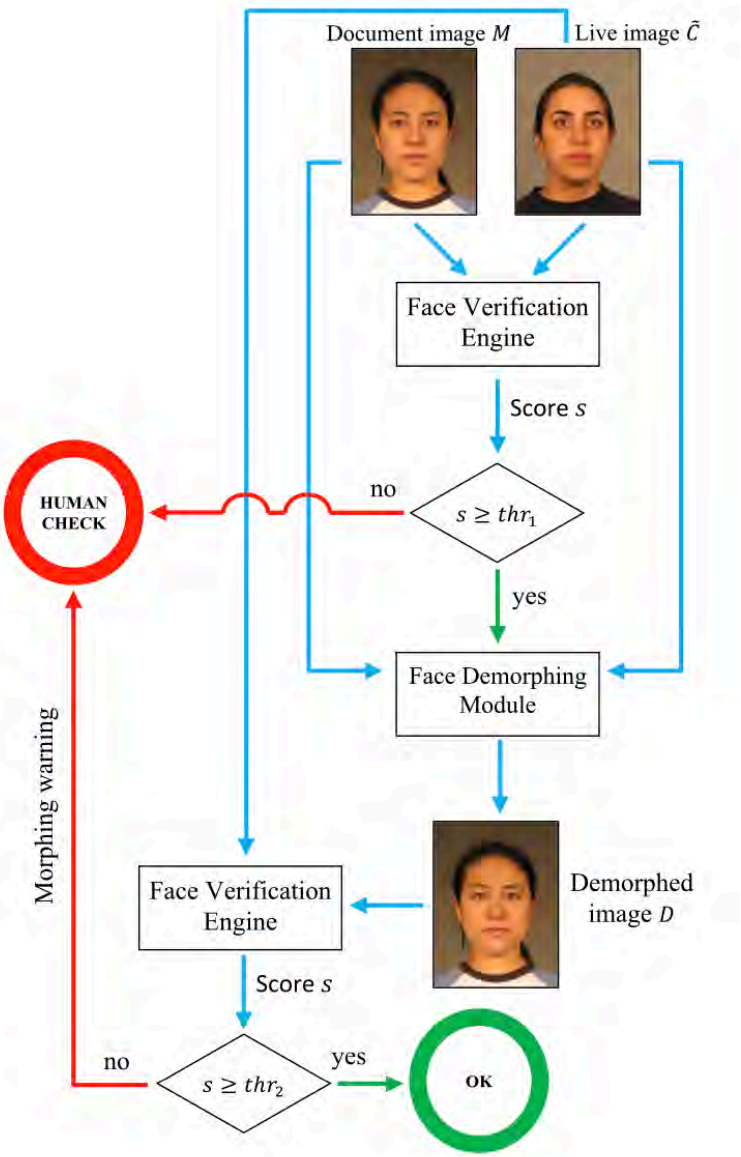
Differential Morphing Attack Detection

D-MAD with Demorphing

- Invert the morphing process
- Then confirm the similarity score



a) suspected image
b) and c): trusted live capture image
d) and e): recovery image

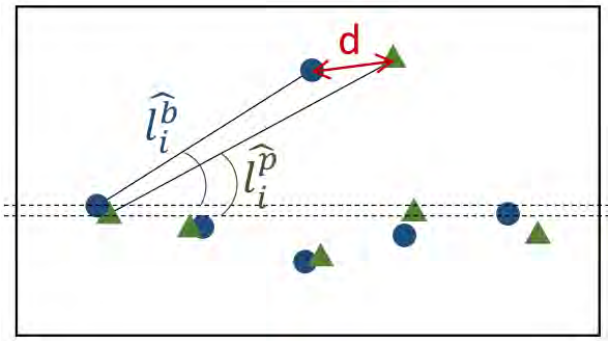


[Ferrara2018] M. Ferrara, A. Franco, D. Maltoni: "Face Demorphing“,
in IEEE Transactions on Information Forencics and Security (TIFS), (2018)

Differential Morphing Attack Detection

D-MAD with landmark analysis

- Angle based features
- Distance based features

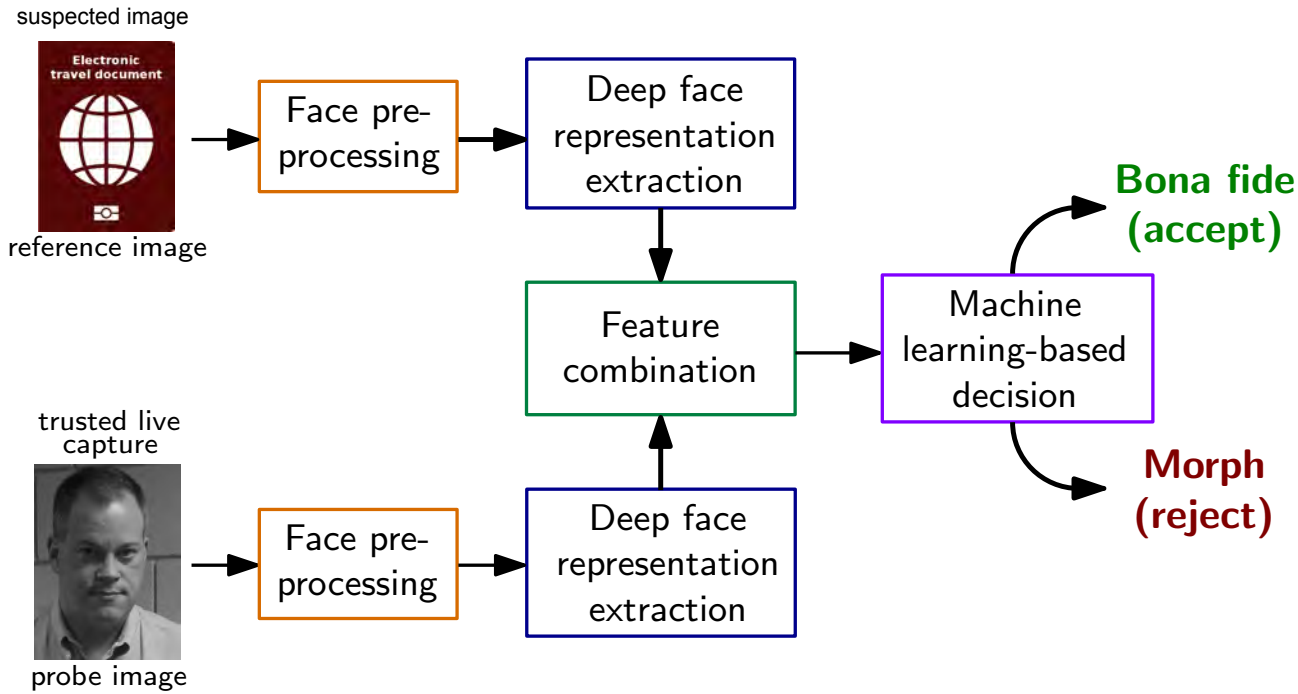


[SDGB2018] U. Scherhag, D. Budhrani, M. Gomez-Barrero, C. Busch: "Detecting Morphed Face Images Using Facial Landmarks“, in Proceedings of International Conference on Image and Signal Processing (ICISP), (2018)

Differential Morphing Attack Detection

D-MAD with deep learning

- Deep Face representations of Deep CNNs

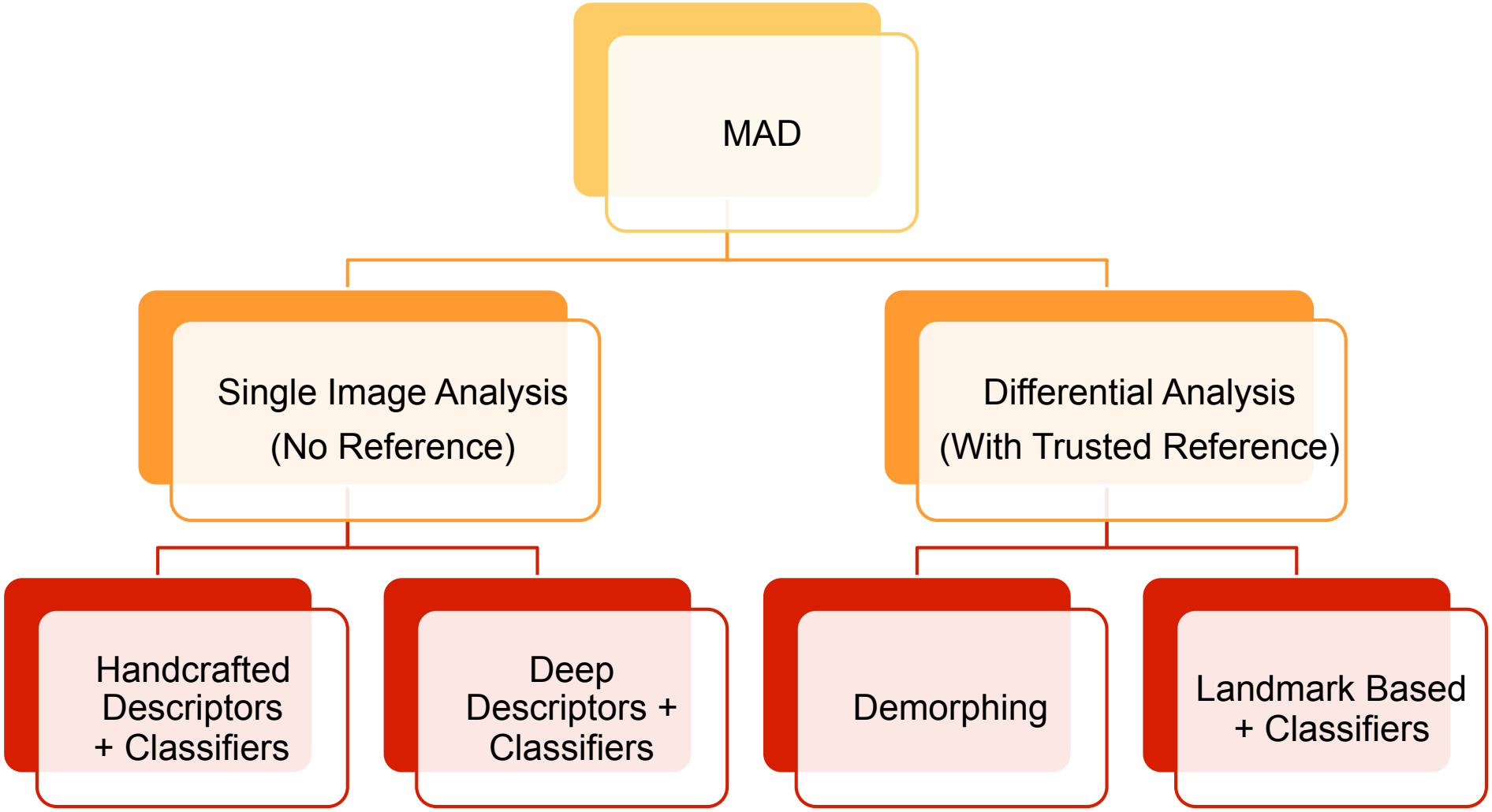


- Deep representations extracted by the neural network (on the lowest layer)
- Feature space with small dimension: 512 (for ArcFace and FaceNet)
- SVM with radial basis function

[SRMB2020] U. Scherhag, C. Rathgeb, J. Merkle, C. Busch: "Deep Face Representations for Differential Morphing Attack Detection", in IEEE Transactions on Information Forensics and Security (TIFS), (2020)

Summary of MAD Algorithms

Taxonomy of Morphing Attack Detection



[SRMBB2019] U. Scherhag, C. Rathgeb, J. Merkle, R. Breithaupt, C. Busch: "Face Recognition Systems under Morphing Attacks: A Survey“, in IEEE Access, (2019)

MAD Evaluation Methodology

Standardized Testing Metrics

Definition according to ISO/IEC 30107-3

- Testing the
  false-negative and false-positive errors:

- **Attack presentation classification error rate (APCER)**
  proportion of attack presentations using the same PAI species incorrectly classified as bona fide presentations in a specific scenario

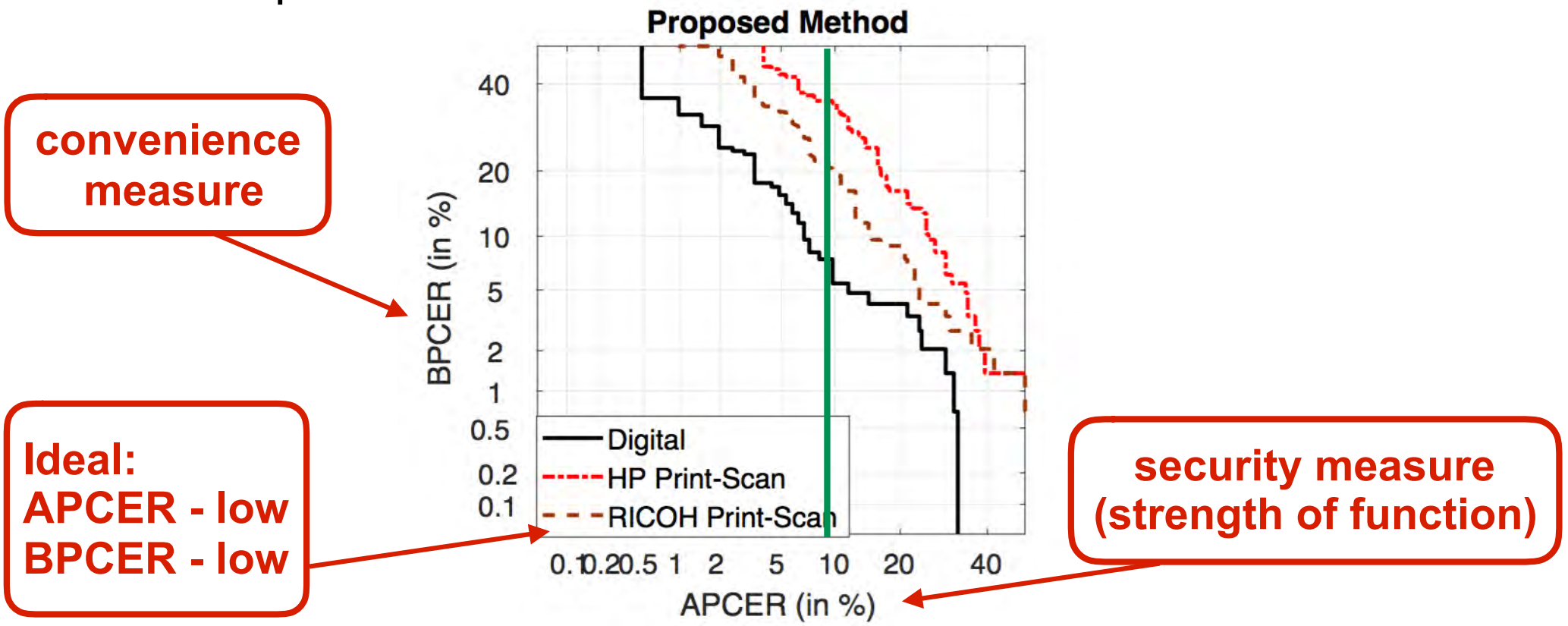
- **Bona fide presentation classification error rate (BPCER)**
  proportion of bona fide presentations incorrectly classified as attack presentations in a specific scenario

source: [ISO/IEC 30107-3] SO/IEC 30107-3, “Biometric presentation attack detection - Part 3: Testing and reporting”, (2017)
https://www.iso.org/standard/67381.html

Standardized Testing Metrics

Definition of metrics in ISO/IEC 30107-3

- DET curve analyzing operating points for various thresholds and plot security measures versus convenience measures
- Example:



Source: R. Raghavendra, K. Raja, S. Venkatesh, C. Busch: "Transferable Deep-CNN features for detecting digital and print-scanned morphed face images", in Proceedings of 30th International Conference on Computer Vision and Pattern Recognition Workshop (CVPRW 2017), Honolulu, Hawaii, July 21-26, (2017)

MAD Evaluation Methodology

Face Morphing Attack evaluations are complex

- Evaluations must consider a dedicated methodology [SNR2017]
- Evaluations must consider many parameters

$$result = f\,(dataset\text{-}training,\ dataset\text{-}testing,\ morphing\text{-}attack,\ landmark\text{-}detector,\ feature\text{-}extractor,\ classifier,\ scenario\ (S\text{-}MAD\ vs.\ D\text{-}MAD),\ post\text{-}processing,\ printer,\ scanner,\ ageing)$$

[SNR2017] U. Scherhag, A. Nautsch, C. Rathgeb, M. Gomez-Barrero, R. Veldhuis, L. Spreeuwers, M. Schils, D. Maltoni, P. Grother, S. Marcel, R. Breithaupt, R. Raghavendra, C. Busch: "Biometric Systems under Morphing Attacks: Assessment of Morphing Techniques and Vulnerability Reporting", in Proceedings of the IEEE 16th International Conference of the Biometrics Special Interest Group (BIOSIG), Darmstadt, September 20-22, (2017)

MAD evaluation

Evaluations must consider many parameters

- Morphing may require manual interaction

$$result = f(dataset\text{-}training, dataset\text{-}testing, morphing\text{-}attack, landmark\text{-}detector, feature\text{-}extractor, classifier, scenario\ (S\text{-}MAD\ vs.\ D\text{-}MAD), post\text{-}processing, printer, scanner, ageing)$$

Automated face morphing tools may introduce artifacts

Large set of accessible morphing mechanisms at zero or low cost


Fantamorph


openCV


splicing


GIMP

- Fantamorph - http://www.fantamorph.com/index.html
- openCV - http://www.learnopencv.com/face-morph-using-opencv-cpp-python
- splicing - http://www.piviandco.com/apps/mixbooth
- GIMP animation package - http://registry.gimp.org/node/18398

MAD Evaluation in SOTAMD

EU funded project: February 2019 – January 2020

- Partners:
  - National Office for Identity Data, NL, Bundeskriminalamt (BKA), DE
  - University of Bologna (UBO), IT, Hochschule Darmstadt (HDA), DE
  - The University of Twente (UTW), NL, NTNU, NO



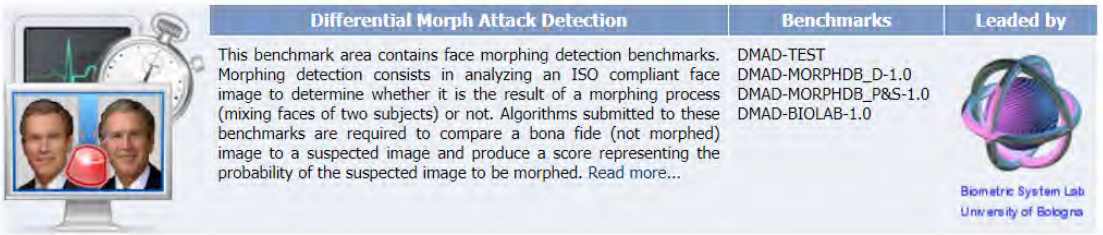

Specific objectives:

- Capture face images from 150 subjects
  - with photo equipment and
  - automated border control gates
- Generate morphed face images with at least 3 algorithms
- Post-process automatically and manually
- Print and scan all morphed face images
- Test the MAD algorithms on the Uni Bologna server
  https://biolab.csr.unibo.it/FVConGoing

D-MAD Evaluation in SOTAMD

SOTAMD achievements

- A new benchmark area for differential morphing attack detection



- Two benchmarks to evaluate different image types:
  - Digital or Printed/Scanned images

- Possibility of analysing results according to specific factors:
  - Manual or automatic morphing
  - Morphing approaches and parameters (e.g., morphing factor)
  - Gender, ethnicity, age, etc.

SOTAMD compliance with NIST-FRVT-MORPH

NIST recently realized FRVT MORPH

- an ongoing independent testing of face morph detection technologies.
  https://www.nist.gov/programs-projects/frvt-morph

The SOTAMD consortium decided to define

- a testing protocol perfectly compatible with the NIST interface,
- in order to minimize the effort for developers and
- promote the submission of algorithms to both evaluation platforms.

NIST only accepts Linux dynamically-linked library file;

- FVC-onGoing accepts both Windows and Linux executables

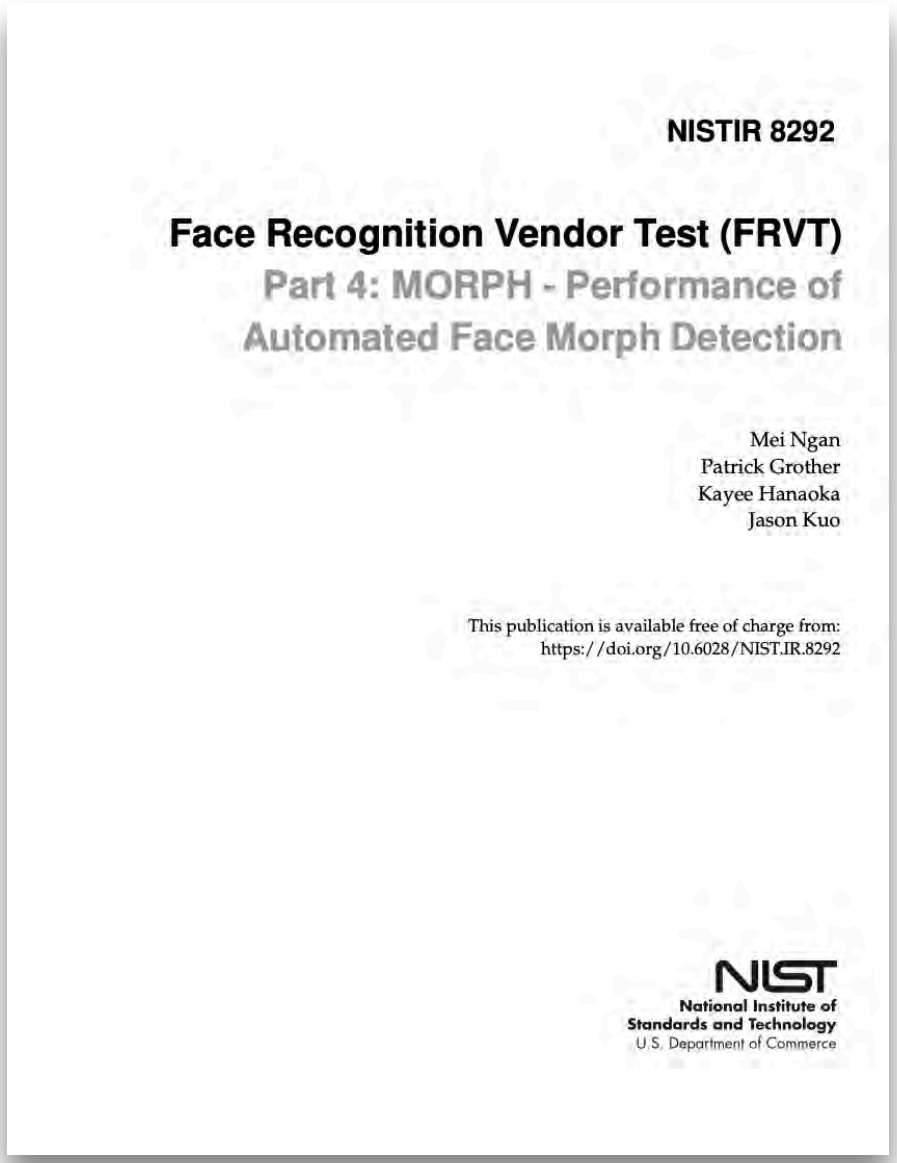
NIST-FRVT-MORPH

NIST IR 8292 report presented March, 2020

FRVT-MORPH

https://pages.nist.gov/frvt/html/frvt_morph.html

- results for MAD algorithms from three research labs:
  - Hochschule Darmstadt (HDA)
  - Norwegian University of Science and Technology (NTNU)
  - University of Bologna (UBO)



NISTIR 8292

Face Recognition Vendor Test (FRVT)
Part 4: MORPH - Performance of Automated Face Morph Detection

Mei Ngan
Patrick Grother
Kayee Hanaoka
Jason Kuo

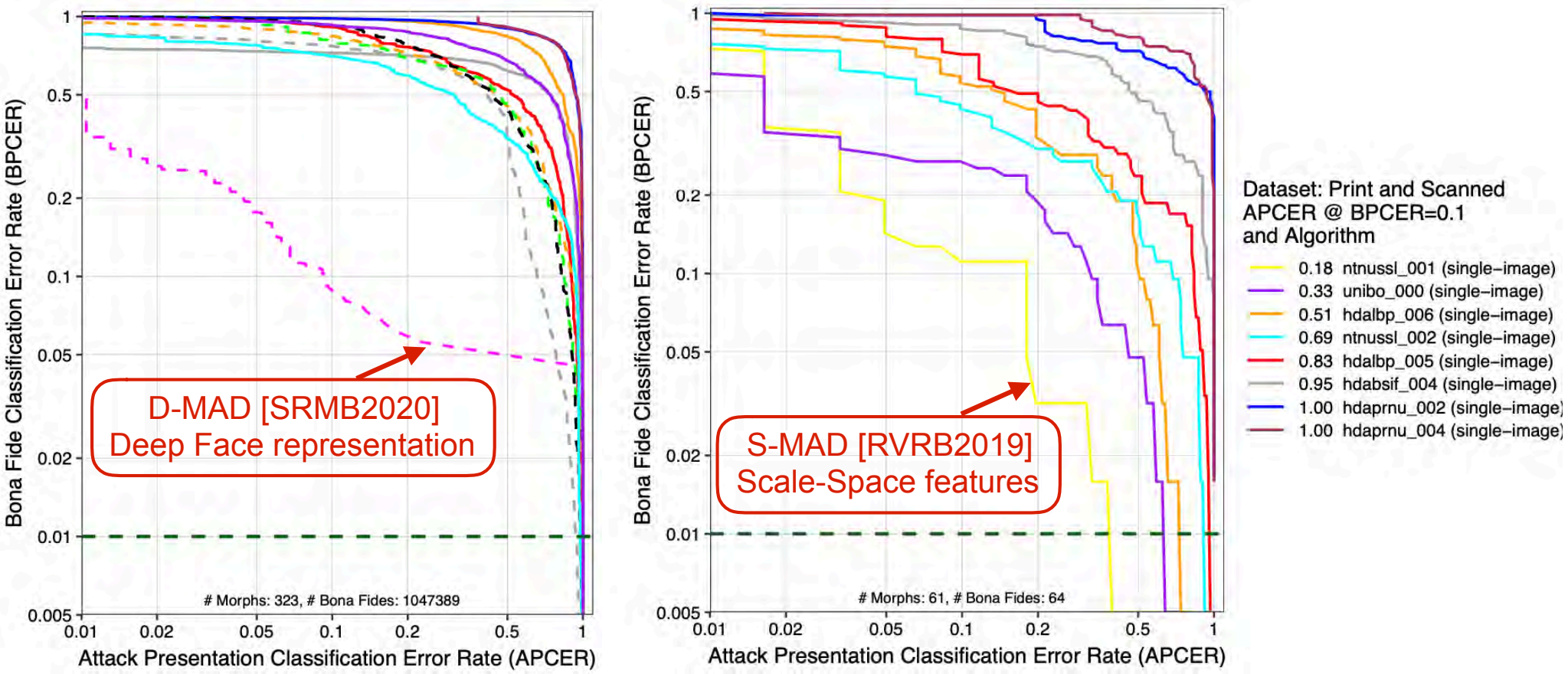
This publication is available free of charge from:
https://doi.org/10.6028/NIST.IR.8292

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

NIST-FRVT-MORPH

NIST IR 8292 report presented March, 2020

- Performance of Automated Face Morph Detection
  https://github.com/usnistgov/frvt/blob/nist-pages/reports/morph/frvt_morph_report.pdf
- results for high quality morphs versus print and scanned
  - note the low number of print and scanned images



What needs to be done?

MAD Action Plan

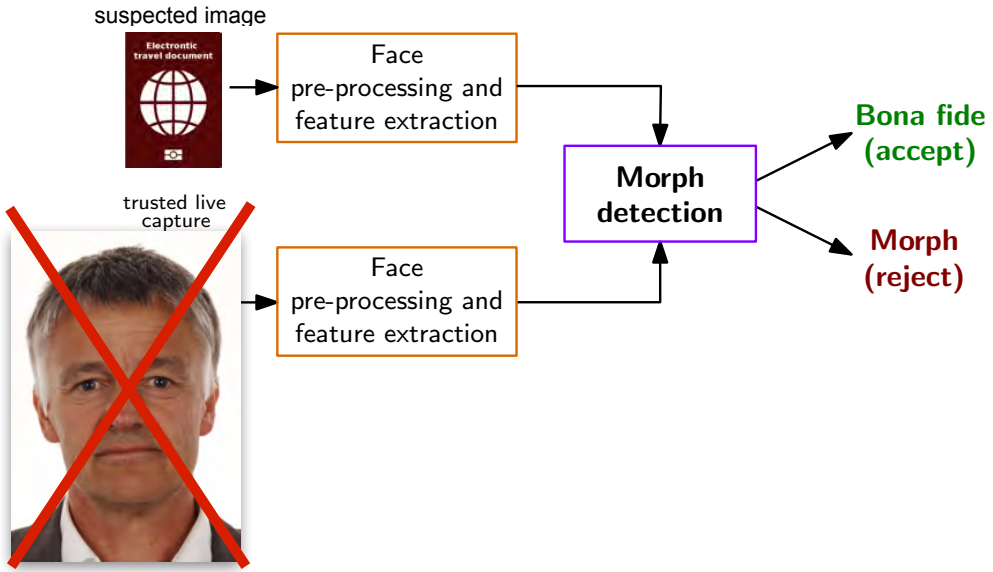
I.) Establish consensus amongst stakeholders

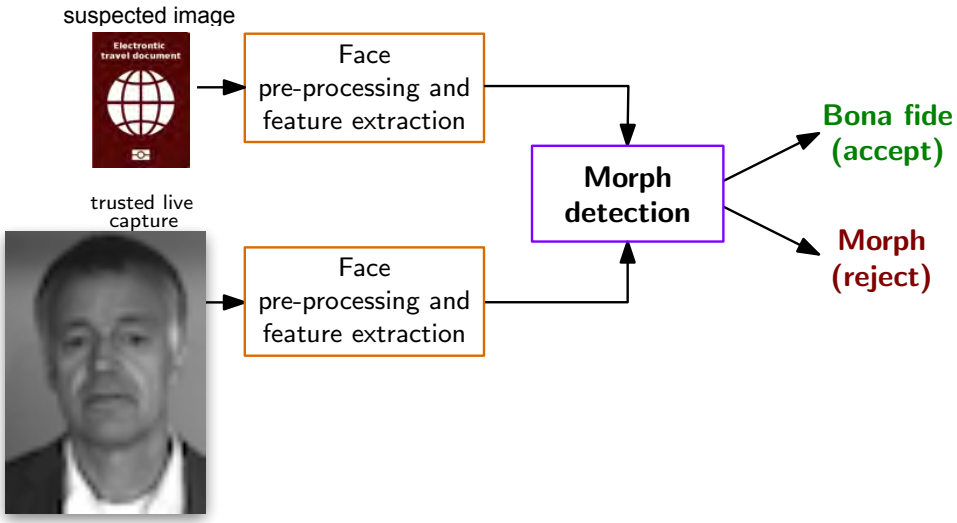
- Europe should immediately start an action to secure
  - the trusted link between a MRTD and the document holder meaning to switch to live enrolment!
  - and to develop and deploy technical mechanisms that can detect a morph passport at borders.
- Support the iMARS-consortium, that is ready to jointly work on the morphing challenges
  - iMARS = image Manipulation Attack Resolving Solutions (H2020 proposal)
  - The iMARS consortium consists of Idemia, NTNU, University Bologna, University Twente, Hochschule Darmstadt, University Leuven, Dutch National Office for Identity Data, German Bundeskriminalamt, Vision-Box, Cognitec, Mobai, IBS, EAB and various end users (border control agencies)
  - iMARS is a pan-European approach that is supported by the European Association for Biometrics (EAB)

MAD Action Plan - iMARS Project

II.) Detect automatically Morph Passports at Borders

- After the completed transition to live enrolment in all MS we must anticipate that European passports - potentially containing a morphed image - are presented at least for the next 10 years.
  - Robust border control processes based on a differential morphing attack analysis, where the quality of probe image varies.
  - Trusted live capture images must be in realistic degraded quality!





- Explicit and implicit D-MAD algorithms

MAD Action Plan - iMARS Project

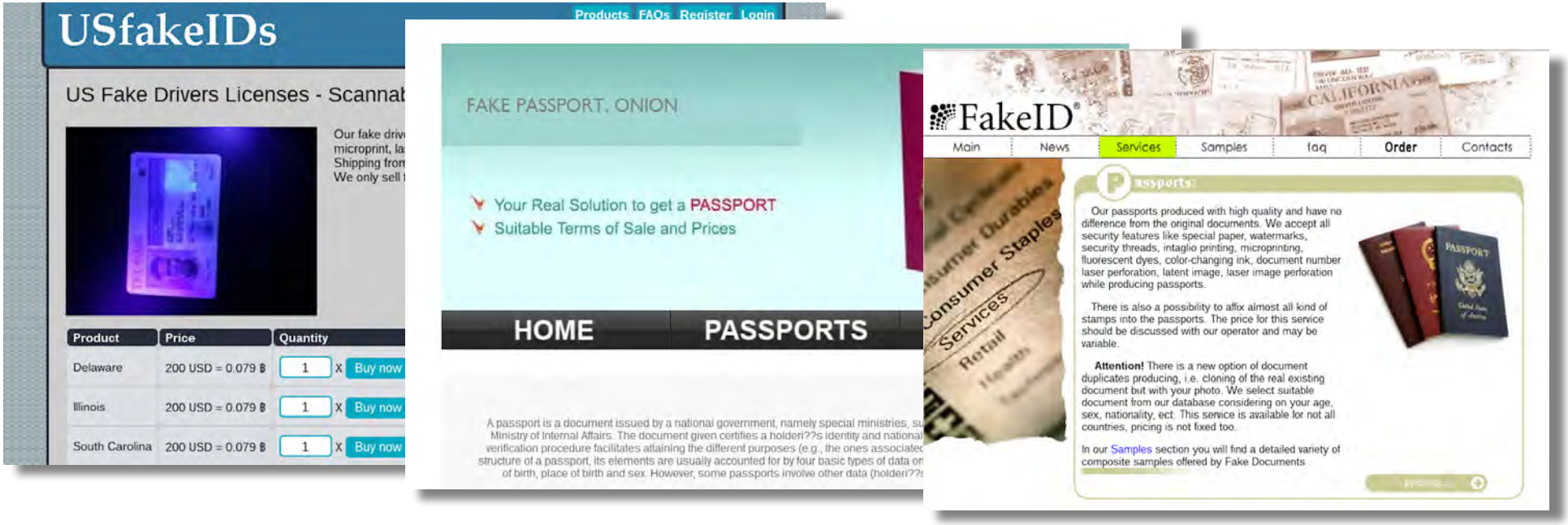
III.) Develop Face Image Quality Metrics

- We need the equivalent to NFIQ2.0 for facial images
- Ensure that captured samples that are sufficiently good in terms of illumination, sharpness, or pose
- Align with the framework for biometric sample quality described in ISO/IEC 29794-1:2016
  - align with ISO/IEC NP 24357 and ISO/IEC 29794-5
- Develop an automatic face image quality assessment software,
  - which can predict recognition accuracy
- Once predictive face quality metrics are available,
  - MAD evaluation can be adapted to the three relevant scenarios (ID Document issuance, border control, and forensic investigation)
  - we can report the impact of face image quality on morphing attack detection

Conclusion

We are facing a situation, where

- Passports with morphs are already in circulation
  - 1000+ reported cases
  - Switch to live enrolment is a good decision, but does not solve the problem
- Passports with morphed face images will have a major impact on border security (GlobalWarming, Information, Services)
- In combination with passport brokers a dramatic problem
  - the darknet offers numerous such opportunities:



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More information

The MAD website

https://www.christoph-busch.de/projects-mad.html

The MAD survey paper

- U. Scherhag, C. Rathgeb, J. Merkle, R. Breithaupt, C. Busch: "Face Recognition Systems under Morphing Attacks: A Survey“, in IEEE Access, (2019)

IEEE Access

Face Recognition Systems Under Morphing Attacks: A Survey

ULRICH SCHERHAG, CHRISTIAN RATHGEB, JOHANNES MERKLE, RALPH BREITHAUPT, AND CHRISTOPH BUSCH

ABSTRACT Recently, researchers found that the intended generalizability of (deep) face recognition systems increases their vulnerability against attacks. In particular, the attacks based on morphed face images pose a severe security risk in face recognition systems. In the last few years, the topic of (face) image morphing and automated morphing attack detection has sparked the interest of several research laboratories working in the field of biometrics and many different approaches have been published. In this paper, a conceptual categorization and metrics for an evaluation of such methods are presented, followed by a comprehensive survey of relevant publications. In addition, technical considerations and tradeoffs of the surveyed methods are discussed along with open issues and challenges in the field.

INDEX TERMS Biometrics, face morphing attack, face recognition, image morphing, morphing attack detection.

I. INTRODUCTION

A. FACE MORPHING ATTACK

Thanks

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  - The content of this presentation represents the views of the author only and is his sole responsibility.
    The European Commission does not accept any responsibility for use that may be made of the information it contains.

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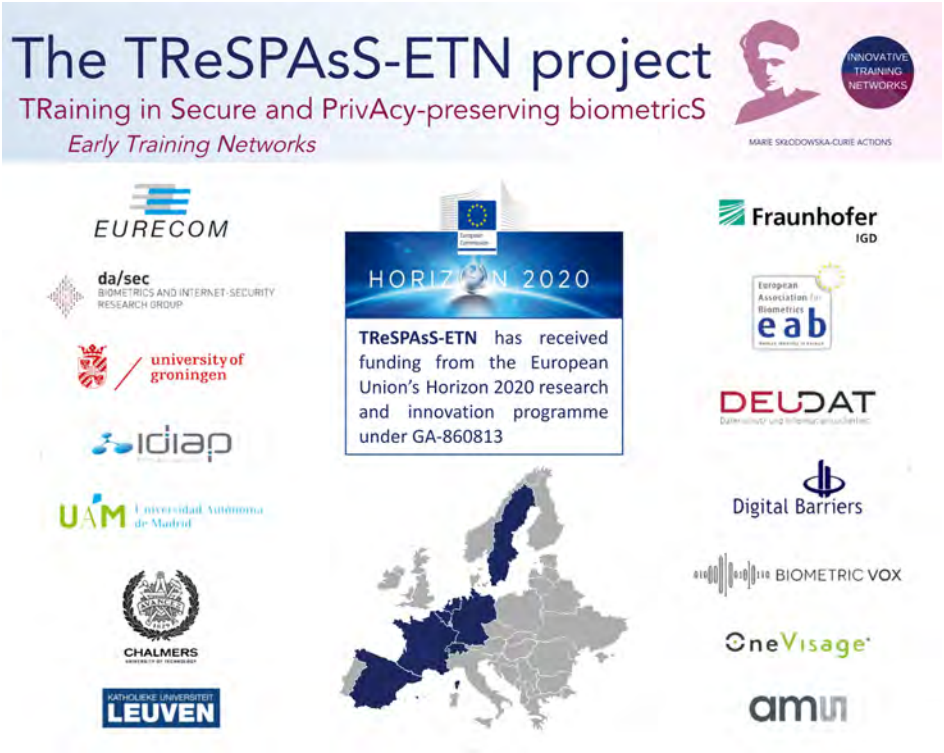
- In the NIST-FRVT-MORPH-Project:
  - Mei Ngan, Patrick Grother

If you are a Master student consider:

We have open positions!

- TReSPAsS: TRaining in Secure and PrivAcy preserving BiometricS
  - contact: christian.rathgeb@h-da.de for a position in Darmstadt
- iMARS: image Manipulation Attack Resolving Solutions
  - contact: christoph.busch@ntnu.no for a position in Gjøvik



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