Evaluation and Improvement of eu-LISA Synthetic Biometric Datasets

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Outline

- Motivation & Project Overview
- Face Age Modification
- Experimental Setup
- Experimental Results
  - Biometric Quality
  - Comparison Score Analysis
- Conclusions

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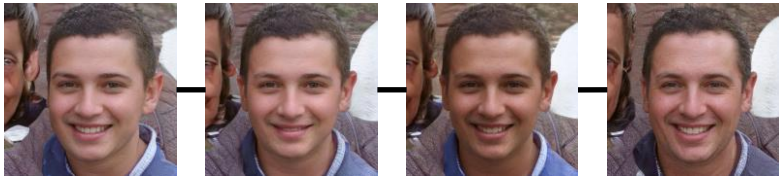
Motivation

- Need:
  - To train and evaluate recognition algorithms in large scale systems
- Problem:
  - Access to data, amount and privacy
- Potential solution:
  - Generate synthetic identities
- Aim of this work:
  - Analyse if synthetically generated (face) samples provide similar characteristic to the bona-fide samples.
  - Evaluate quality and comparison score distributions.

Project Overview

- Evaluate synthetic non-mated face images [Zhang2021]

- Generate synthetic mated samples by editing facial attributes
  - Head Pose [Grimmer2021]
  - Facial expression [Grimmer2021]
  - Illumination [Grimmer2021]
  - **Age** [Alaluf2021]



- Evaluate synthetic mated face images and compare to real data

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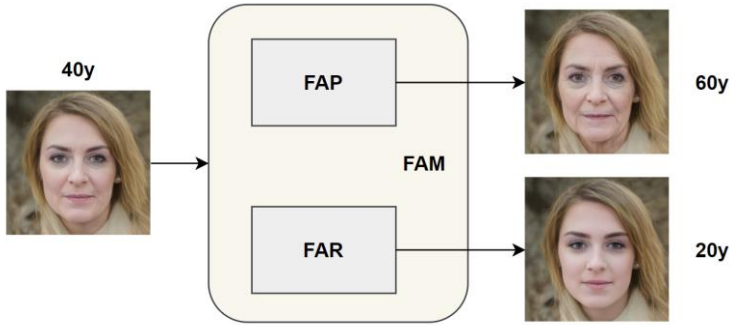
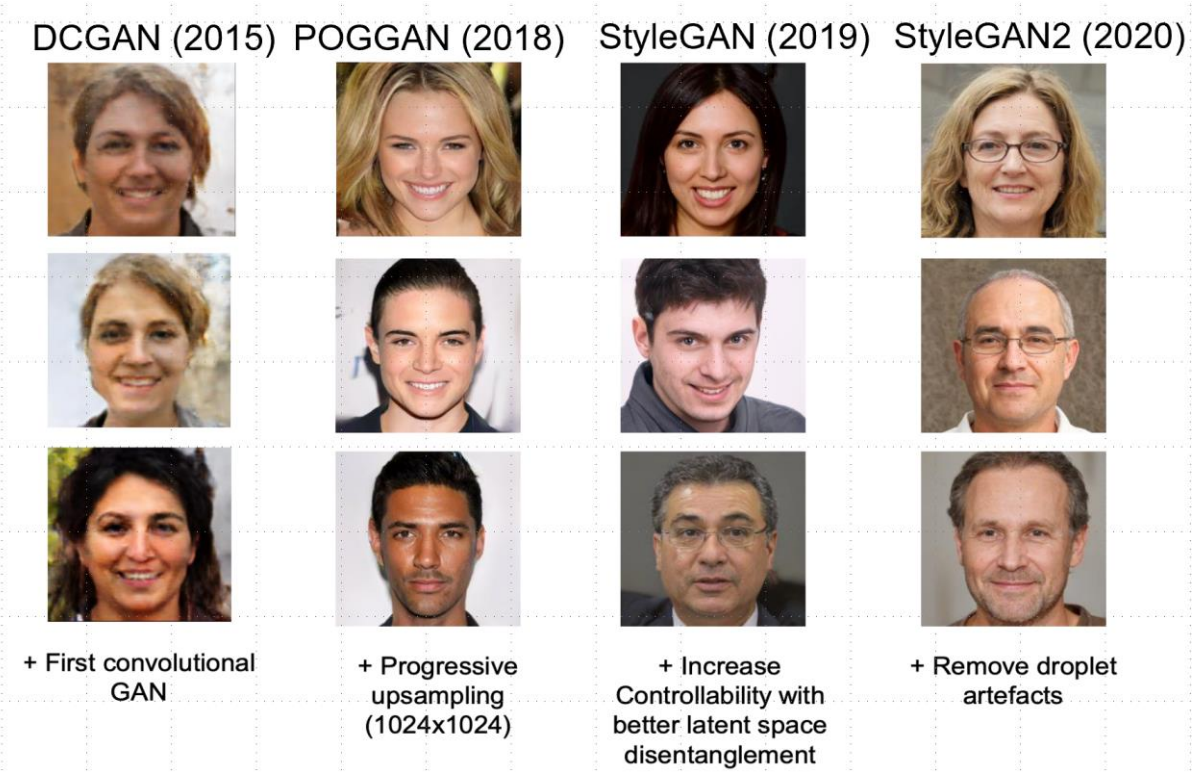
Face Age Modification

- FAM: Use generative models to predict future (FAP) or past appearance (FAR) of individuals



- Photorealism through concept of adversarial learning
  - Generator: Learns to generate realistic face images
  - Discriminator: Learns to distinguish generated face images from real face images

Example of Synthetic Data



Application in Biometrics

- Face recognition systems must be …
  - Sensitive to inter-identity variation: Twins, doppelgängers, etc..
  - Robust against intra-identity variation:
    expression, head pose, illumination, and age

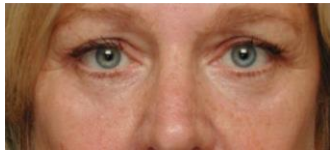
1996 2001 2006 2007 2010 2015

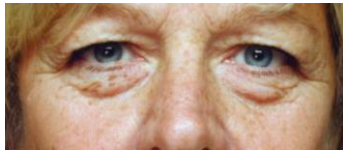
- Lack of available training samples captured over long time spans (>5y)
  - Recognition performance suffers

Application in Biometrics

- Idea: Simulate re-occuring anatomical changes in physiological characteristics with FAM algorithms

Real ageing





Synthetic ageing

- Possible Applications:
  - Increase robustness of face recognition systems through cross-age fine-tuning
  - Compensate age gap between probe and reference sample to reduce false negative identification rate (FNIR)
  - Evaluate impact of face ageing on FRSs → focus of this talk

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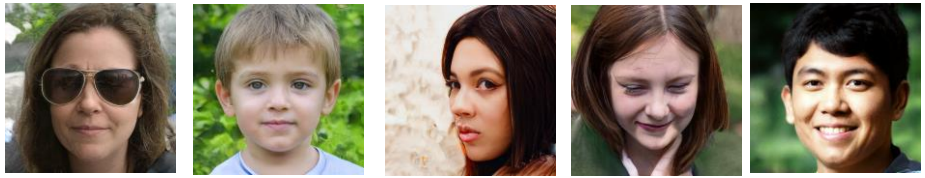
Experimental Setup

- Use StyleGAN [Karras2019] [Karras2020]
  to generate random non-mated face images (Base)
- Use SAM [Alaluf2021]
  for face ageing framework for age progression and regression (Mated Samples)

Experimental Setup

- Filter out images with
  - Inter-eye-distance < 90px
  - Age < 12 years
  - Extreme Yaw and Pitch angles
  - Poor illumination

IED Age Yaw Pitch Illumination



Dataset	# Images before filtering	# Images after filtering
FRGC v2 [Phillips2005]	24,025	17,919
StyleGAN Base	50,000	25,918
SAM (target age = 10)	25,918	18,290
SAM (target age = 20)		22,671
SAM (target age = 30)		23,253
SAM (target age = 40)		23,513
SAM (target age = 50)		22,671
SAM (target age = 60)		17,174
SAM (target age = 70)		10,028

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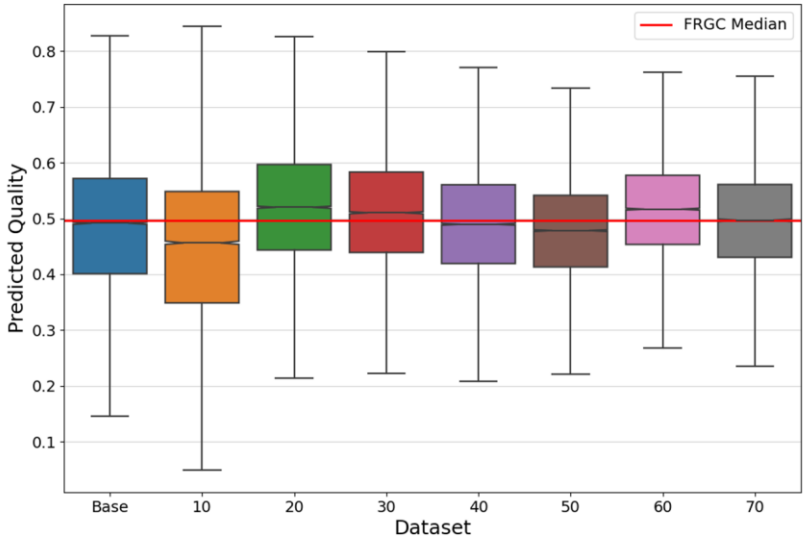
Evaluation

- Part A: Biometric Quality
  - Use Face image quality assessment algorithms (FIQAAs)
  - Predict biometric quality in numeric range [0,1]
    - 1: Perfect face recognition utility
    - 0: Worst face recognition utility
  - FIQAA: FaceQnet v1 [HernándezOrtega2020]

- Part B: Comparison Score Analysis
  - Face recognition: ArcFace [Deng2019]
  - Synthetic versus Synthetic
  - Synthetic versus Real (Short-term ageing)

Biometric Quality

- Face Image Quality Assessment Algorithm: FaceQnet v1
- No statistical significant differences between synthetic and real datasets (95% confidence)



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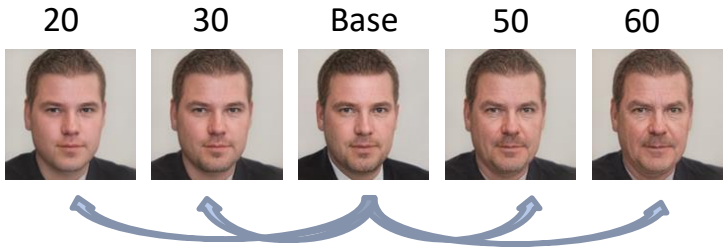
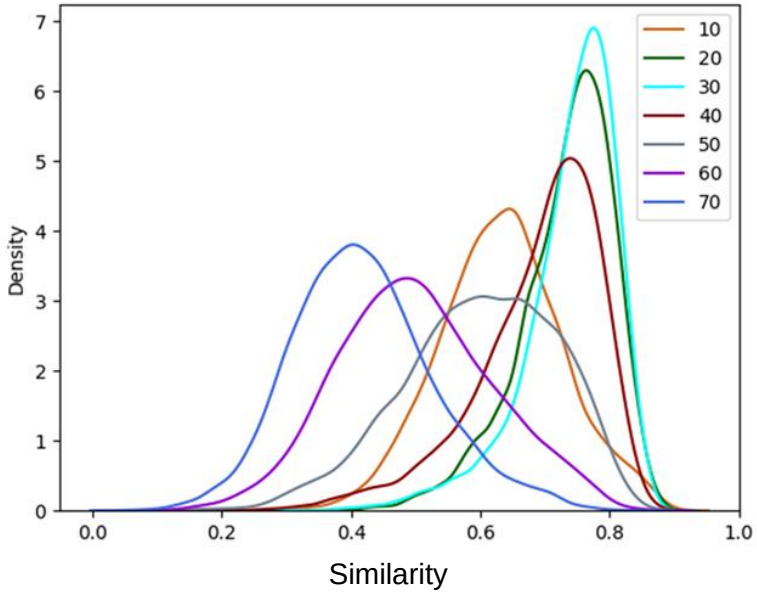
- Part B: Comparison Score (CS) Analysis
  - Face recognition: ArcFace
  - Synthetic versus Synthetic
  - Synthetic versus Real (Short-term ageing)

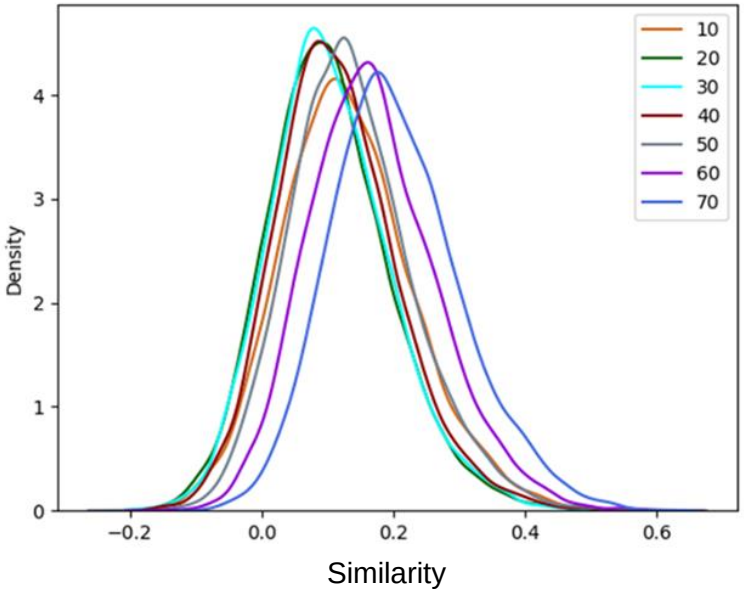


CS Analysis: Synthetic vs Synthetic

Mated Comparisons

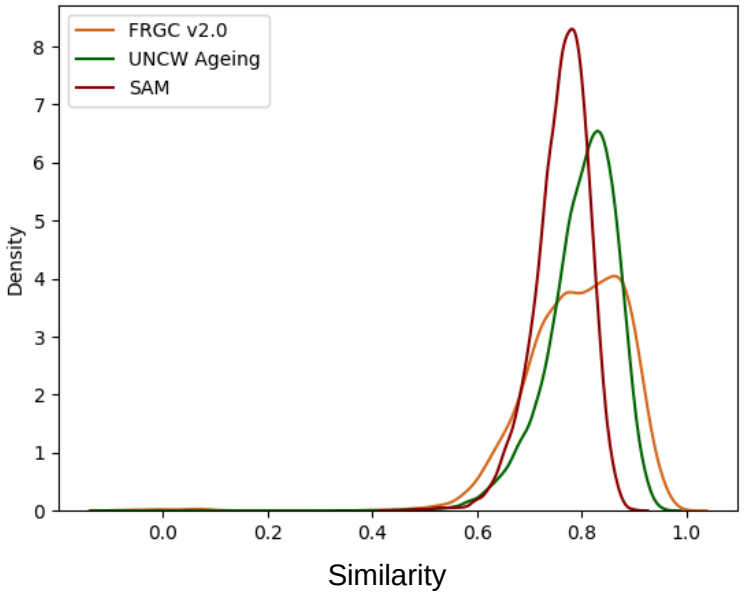


Non-Mated Comparisons



CS Analysis: Synthetic vs Real

Mated Comparison



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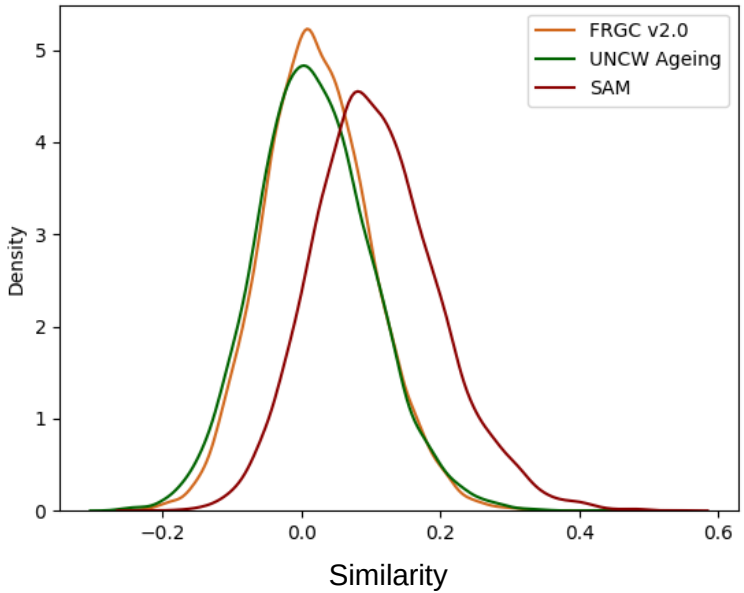

UNCW Ageing Dataset: [Ricanek2006]

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Conclusion

- FAM algorithms based on manipulations in the latent space
  - High visual quality with high resolution (1024x1024)
  - Accurate simulation of age progression and regression
- No statistically significant difference between synthetic and real data in terms of biometric quality (FaceQnet v1)
- Mated comparison score analysis confirms decreasing similarity with proceeding age
- Further experiments reommended to evaluate face recognition robustness to long-term age differences between reference and probe image

Conclusion

- Encouraging as a starting stage
  - more future work and further testing remains necessary

- Not fit for purpose to **completely** assess operational systems
  - We can test workload (i.e. throughput) and workload reduction
  - For biometric performance testing we **shall** report results for synthetic data **and** non-synthetic data (ISO/IEC 19795-1:2021 Cl. 7.4.9)

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Thank you for your attention