In a second experiment, we evaluate our proposed FQA algorithm on still face images by analyzing the ERC plots as explained in section 5. For 103.008 images of 300 subjects from the VggFace2 dataset (?), a high quality reference image is selected using the ICAO compliance scores. The ERC plots in figures 5 and 6 display the FNMR for different fractions of rejected images. The red line with the label “PERFECT” represents a quality measure which correlates perfectly with the distance scores. When an initial FNMR of 0.01 is set, in an ideal scenario, the FNMR will be zero after rejecting 1% of all images. The closer an ERC is to the red line, the better the performance of the used FQA algorithm. For an initial FNMR of 0.01 our approach clearly outperforms FaceQNet, SER and the general image quality assessment program. We hypothesize that SER would perform better when the same type of embeddings were used for verification as quality estimation. In the conducted experiments SER uses ArcFace (?) embeddings to estimate face image quality while the FNMR is calculated using FaceNet embeddings. For an initial FNMR of 0.001, the difference with the other approaches is smaller. It is important to note that our model is considerably smaller than FaceQNet and the resnet-101 model (?) used by SER. FaceQNet comprises 7 times more parameters than our VAE and resnet-101 even 14 times more. Additionally, our method is trained completely unsupervised without the need for ground truth quality values while FaceQNet relies on distance scores as ground truth quality values. The ground truth generation process used by FaceQNet also indicates the dependency on one or more face recognition models. This dependency is even more prominent for SER since a specific face recognition network is used for generating the quality predictions.

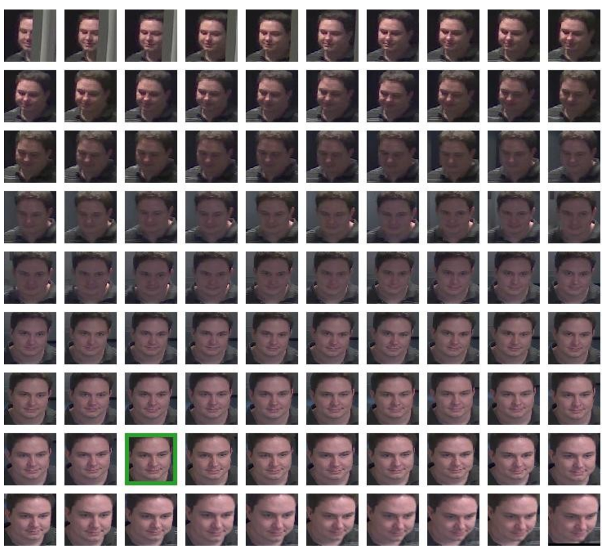

Figure 7: Consecutive face crops from one tracked identity in the ChokePoint dataset. The crop with the green border corresponds with the highest quality calculated by our FQA algorithm.

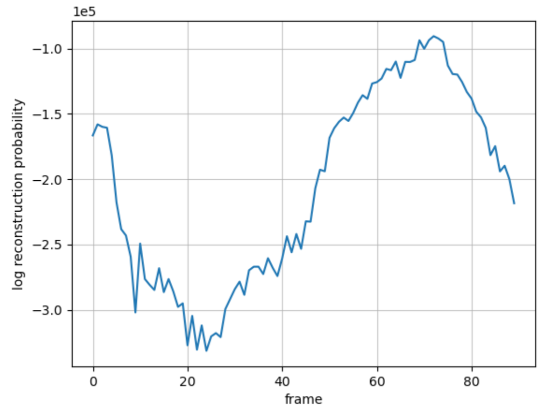

Figure 8: Logarithm of the reconstruction probability (i.e. face quality) for consecutive face crops.

ChokePoint

In a third experiment, we focus on the ChokePoint dataset (?). This dataset is designed for conducting experiments on face identification and verification under real-world surveillance conditions. The dataset consists of 48 videos or 64,204 face images. Both crowded and single-identity videos are included. We now evaluate our system qualitatively on selecting one high quality face crop of each identity in a video stream. Figure 7 shows consecutive face crops of an example video. The crop outlined in green is the frame that corresponds with the highest quality value calculated by our FQA algorithm. Figure 8 shows how the quality score changes over time as the subject moves through the scene. We define the quality score as the logarithm of the reconstruction probability. We can see that initialy the quality score decreases as the person is moving through a darker area looking down. The shades and the angle of the face makes these crops less useful for face recognition. As the person moves closer to the camera, the brightness increases and the subject becomes clearly visible. This is also reflected in an increasing quality score. The highest score is obtained when the person is close to the camera and is looking in the general direction of the camera. As the person turns away, the score again decreases. This qualitative example shows that our model is indeed able to assign understandable and meaningful scores to each frame. We made videos of this and other examples publicly available [1].

Bicycle parking

Finally, we also validated our approach on video data from security cameras in a bicycle parking lot. This to investigate how well the model generalizes to data collected in the real world. Figure 9 shows three example frames with its corresponding frame crop and quality score. Even though these images are very different from the images the VAE was originaly trained on, we can see that the model generalizes well

[1] https://drive.google.com/drive/folders/1GRlFRSxHRfBnfTpI5DG2v2rN3nTCg5Y0?usp=sharing

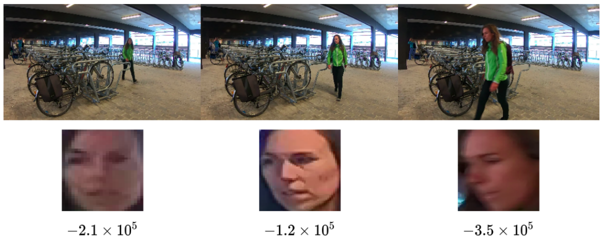

Figure 9: Three frames from the footage of a security camera in a bicycle parking lot. The corresponding frame crops and quality scores are depicted below each frame.

and is able to assign useful scores to each crop.

7 Conclusion and future work

In this study, a novel face image quality assessment method is proposed based on a variational autoencoder's reconstruction probability. This is, by our knowledge, the first time a generative model like a VAE is used to tackle the problem of face image quality assessment. We demonstrate, by quantitative and qualitative results, that our method can be used as a biometric quality predictor. Unlike other data driven approaches, no facial recognition model is used for training and no explicit definition of face quality is given. Our FQA algorithm is used as a building block in a privacy-friendly alternative to large scale facial recognition. Instead of identifying all detected faces in a video stream, our system saves one high quality face crop without revealing the person's identity. This face crop is encrypted and access is only granted after legal authorization. In such a way, the system still supports criminal investigations while not violating the proportionality principle.

In future work, we will further optimize the VAE architecture keeping the constraints on model size and computational complexity in mind as the final goal would be to deploy the model on a stand-alone edge device. It would be interesting to investigate different hardware platforms such as FPGAs that allow the model to process data in real-time with a small energy consumption, making it possible to embed our system in low cost surveillance camera's. Moreover, our method should be evaluated on other datasets and in combination with alternative feature extractors.

8 Acknowledgments

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