Bachelor/Master theses   Advisor: Univ.-Prof. Dr. Andreas Uhl

(1) Synthesis of cross-sensor sample data for vascular biometrics

Vascular biometrics uses the layout of human blood vessels for biometric recognition
(e.g. Amazon One and various Asian ATM producers rely on this biometric trait). As
this biometric technology is relatively recent, no standardised sensor hardware does
exist, thus samples produced by different sensors do vary a lot. This represents a major
challenge for cross-sensor recognition techniques, which should be tackled by
employing generative image synthesis methods like GANs and diffusion models.
The differences in image properties as generated by different sensors are interpreted
as domain gap which should be resolved by domain adaptation techniques – implemented
by image-to-image translation (I2I) techniques like CycleGANs or more recent diffusion-based
I2I translation methods. Additionally, the concept can be adjusted to conduct cross-sensor presentation
attack detection (PAD), in which a vascular biometric system is trained to detect attempts to fool the
sensor with an artefact generated particularly for this purpose. While many techniques exists for single
sensor situation, the extension to a cross sensor setting requires the same techniques as described before
for cross-sensor recognition.

Additional Information: Datasets containing sample data taken by different sensors are available,
as well as biometric recognition software to assess the quality of the generated data.

Recent publications on related topics done by the group:

* Andreas Vorderleitner, Jutta Hämmerle-Uhl, Andreas Uhl. Hand Vein Spoof GANs: Pitfalls in the
Assessment of Synthetic Presentation Attack Artefacts. In Proceedings of the 2023 ACM Workshop on
Information Hiding and Multimedia Security, pp. 133–138, New York, NY, USA, IH&MMSec '23,
Association for Computing Machinery, 2023.
Open Access: https://dl.acm.org/doi/10.1145/3577163.3595107

* Michael Hafner, Aleksandar Radovic, Moritz Langer, Stefan Findenig, Andreas Vorderleitner and
Andreas Uhl. Difficulties in using Synthetic Data for Presentation Attack Detection in Fingervein
Recognition: The Role of Model Fingerprints. International IEEE/IAPR Joint Conference on
Biometrics (IJCB 2024), Buffalo, NY, USA, September 2024.

(2) Learning-based decryption of partially encrypted data

In recent years, lightweight encryption techniques have been developed based on
a partial encryption of visual data termed "partial encryption". It has been questioned
for years if these techniques would be secure. In case of protecting
datasets of similar images with such an approach (e.g. medical data, biometric data),
learning-based techniques like impainting networks, denoising networks, Image2Image
translation techniques in general can be used to attack these encryption schemes. The
aim of the thesis is to exhibit weaknesses in the protection strength in case of applying
learning-based attacks.

Additional Information: We will provide partially encrypted datasets resp. techniques to

apply different types of partial encryption.

Recent publications on related topics done by the group:

* Lukas Lamminger, Heinz Hofbauer, Andreas Uhl. First Learning Steps to Recognize Faces in the Noise. In *Proceedings of the 2023 ACM Workshop on Information Hiding and Multimedia Security*, pp. 139–144, New York, NY, USA, IH&MMSec '23, Association for Computing Machinery, 2023. Open Access: https://dl.acm.org/doi/10.1145/3577163.3595105

* Heinz Hofbauer, Yoanna Martínez-Díaz, Luis Santiago Luevano, Heydi Méndez-Vázquez, Andreas Uhl. Utilizing CNNs for Cryptanalysis of Selective Biometric Face Sample Encryption. n *Proceedings of the 26th International Conference on Pattern Recognition (ICPR)*, pp. 8, August 21 - August 25, 2022.

(3) Understanding Imaging in Vascular Biometrics

The classical way to image human blood vessels for vascular recognition is to apply near-infrared (NIR) illumination and to capture NIR sample data. Various commercial sensor producers have claimed (i) high relevance of NIR light polarisation and (ii) to be able to extract vascular information from white-light colour band differences, respectively. In this thesis, corresponding experiments and evaluations wrt. recognition accuracy have to be conducted in comparison to classical imaging techniques for this data.

Additional Information: We will provide NIR cameras and polarisation filters and will acquire additional optical hardware if required during the thesis.

Publications on related topics done by the group:

* Luca Debiasi, Christof Kauba, Bernhard Prommegger, Andreas Uhl. Near-Infrared Illumination Add-On for Mobile Hand-Vein Acquisition. In *2018 IEEE 9th International Conference on Biometrics Theory, Applications and Systems (BTAS)*, pp. 1-9, Los Angeles, California, USA, October 22 - October 25, 2018.

* Christof Kauba, Bernhard Prommegger, Andreas Uhl. Focussing the Beam - A New Laser Illumination Based Data Set Providing Insights to Finger-Vein Recognition. In *2018 IEEE 9th International Conference on Biometrics Theory, Applications and Systems (BTAS)*, pp. 1-9, Los Angeles, California, USA, October 22 - October 25, 2018.

(4) Synthesis of NIR Iris / Vascular Biometric Samples from RGB Imagery

Iris and vascular biometrics rely on near-infrared (NIR) illumination and data acquisition. NIR cameras are often expensive or/and produce low quality imagery only. Therefore, it would be highly beneficial to be able to learn to generate / synthesize NIR data from RBG images, such that finally iris or vascular recognition can be done employing RBG data. The idea is to use pairs of NIR and RGB images (preferably in paired, i.e. aligned form) and train a system to generate a NIR image upon presentation of a RGB image. Techniques for paired data include the pix2pix network and more recent diffusion based schemes.

<u>Additional Information</u>: We will provide NIR and RGB cameras and software to test recognition on generated samples.

Publications on related topics done by the group:

* Georg Wimmer, Rudolf Schraml, Lukas Lamminger, Alexander Petutschnigg, Andreas Uhl. Cross-Modality Wood Log Tracing. In *Proceedings of the 23rd IEEE International Symposium on Multimedia (ISM 2021)*, pp. 191-195, 2021.

* Georg Wimmer, Michael Gadermayr, Andreas Vécsei, Andreas Uhl. Improving Endoscopic Decision Support Systems by Translating Between Imaging Modalities. In *Simulation and Synthesis in Medical Imaging (SASHIMI'20)*, pp. 131–141, Cham, Switzerland, LNCS, **12417**, Springer International Publishing, 2020.