Finger Vein Biometrics: An Analysis from different Perspectives

Bernhard Prommegger • Supervised by: Andreas Uhl

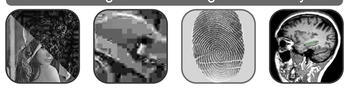
University of Salzburg, Department of Computer Sciences

Jakob Haringer Str. 2, 5020 Salzburg, Austria

PARIS LODRON UNIVERSITY SALZBURG

WAVELAB

Multimedia Signal Processing and Security Lab

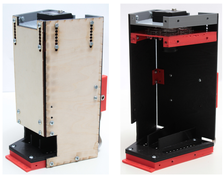


State-of-the-art at the Beginning of the Thesis

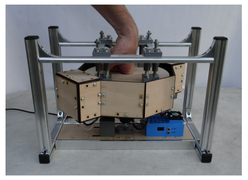
- Commercial and scientific systems use almost exclusively the palmar view
- Some work on dorsal view, all others are ignored
- This thesis wants to analyse also other perspectives than the commonly used ones

Capturing Devices and Data Sets

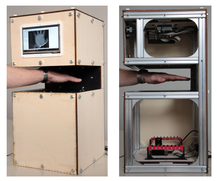
- Development of three different capturing devices
- Acquisition of three publicly available data sets



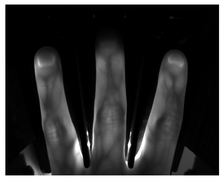
PLUS OpenVein



3D Finger Vein Scanner

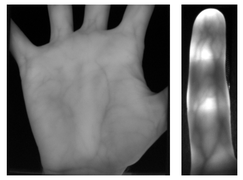


Contactless Scanner



PLUSVein-FV3

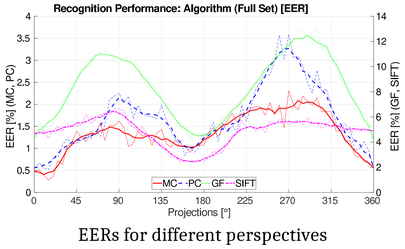
PLUSVein-FR



PLUSVein-CL

Intra Perspective Recognition Performance (IPP)

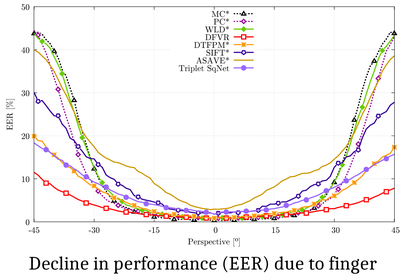
- Analysis of perspectives all around the finger
- Current situation:
  - Typically used: palmar view (0° & 360°)
  - Some work covering the dorsal view
  - All other perspectives are ignored
- Best performance at palmar and dorsal region
- In between the performance is inferior
- Opposite perspectives are independent from each other
- Still good enough to perform recognition



EERs for different perspectives

Effect of Longitudinal Finger Rotation

- Systematic robustness analysis of several finger vein recognition schemes against longitudinal rotation.
- Cross-comparison of the rotated perspectives to the reference view
- Reference view = palmar perspective
- Vein pattern based systems are more vulnerable than more sophisticated ones
- Best performances for DVFR (SIFT based) and CNN based method
- Above $\pm 30°$ a reliable recognition is not possible at all

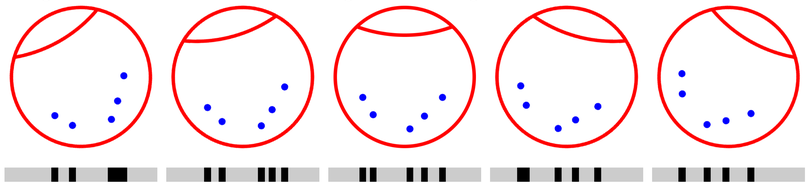


Decline in performance (EER) due to finger rotation for various recognition systems

This thesis has been funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 700259 ("*PROTECT - Pervasive and UseR Focused BiomeTrics BordEr ProjeCT*"), the FFG KIRAS Project under grant 864785 ("*AUTFingerATM - Finger-based Biometrics for Austrian ATMs*") and the Austrian Science Fund (FWF) project no. P32201 ("*Advanced Methods and Applications for Fingervein Recognition*") which was co-funded by the Salzburg state government.

Longitudinal Finger Rotation

- Misplacement of the finger during acquisition
- Can be reduced or prevented by the design of device (e.g. by adding support structures)
- Negative influence can be reduced during pre-processing, feature extraction or comparison

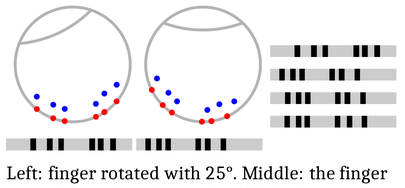


Longitudinal finger rotation principle: a schematic finger cross section showing five veins (blue dots) rotated from -30° (left) to +30° (right) in 15° steps. The projection (bottom row) of the vein pattern is different depending on the rotation angle.

Rotation Correction and Compensation

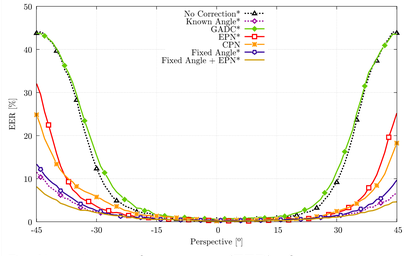
- Systematic analysis to which extent longitudinal finger rotation can be compensated
- Proposal of two rotation compensation approaches
  - using the known rotation angle
  - using predefined fixed angle
- Comparison to state-of-the-art recognition schemes

Knwon-Angle Approach



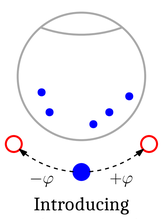
Left: finger rotated with 25°. Middle: the finger rotated into the palmar view. Right (from top to bottom): (1) rotated, (2) corrected, (3) corrected and shifted for the highest correlation to (4) original palmar pattern.

Results

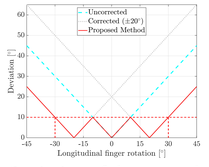


Decline in performance (EER) for *maximum curvature* utilizing different rotation correction/compensation schemes

Fixed-Angle Approach



Introducing pseudo-perspectives



Deviation of the rotated finger to the palmar view with an correction angle $\varphi_{corr} = 20°$

Rotation Detection in Publicly Available FV Data Sets

- Analysis of 4 publicly available FV data sets
- Two approaches for rotation estimation (RE):
  1. Comparison of rotated versions against reference (MC features, highest score wins)
  2. CNN-based estimated (trained with images from PLUSVein-FR)
- Not only scientific problem

Data Set	Abs. Dist. to Mean			Maximum Distance		
	Mean	Max	Std	Mean	Max	Std
SDUMLA-HMT	6.43	44.83	6.90	19.40	77.00	15.73
UTFVP	2.65	16.50	2.29	7.95	29.50	4.41
FV-USM	3.04	23.83	3.23	11.32	41.00	7.75
PLUSVein-FV3	1.37	8.60	1.24	4.46	12.50	2.44

Degree of rotation present in the data sets

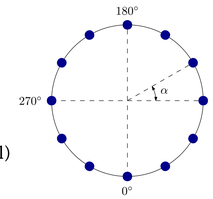
Data Set	Method	EER [%]	RPI [%]
SDUMLA-HMT	original	4.73	-
	score based RE	1.07	341.6
	CNN based RE	1.30	263.4
FV-USM	original	1.23	-
	score based RE	0.56	120.1
	CNN based RE	0.52	137.0
UTFVP	original	0.42	-
	score based RE	0.09	349.1
	CNN based RE	0.18	125.5
PLUSVein-FV3	original	0.08	-
	score based RE	0.06	50.0
	CNN based RE	0.05	61.2

Change in recognition performance after correction

Multi-Camera Recognition Systems

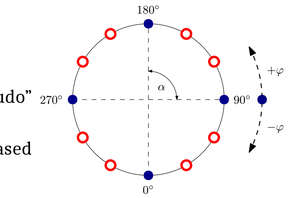
Mulit-Perspective Enrolment (MPE)

- Enrol subject using multiple perspectives
- Verification: single perspective vs all enrolled perspectives
- Max score level fusion for final result
- Invariant to rotation as enrolment covers complete (rotational) range of interest



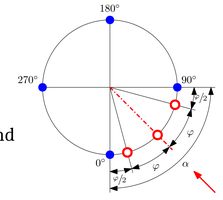
Perspective Multiplication for MPE (PM-MPE)

- Combination of "fixed angle" approach and MPE
- Verification: single probe sample vs all enrolment and "pseudo" perspectives
- Rotational distance between enrolment cameras can be increased while still achieving similar recognition rates



Combined Multi-Perspective Enrolment and Recognition (MPER)

- Multiple perspectives for enrolment and recognition
- Capturing devices for enrolment and recognition differ
- Important: keep max distance between closest enrolment and recognition perspective

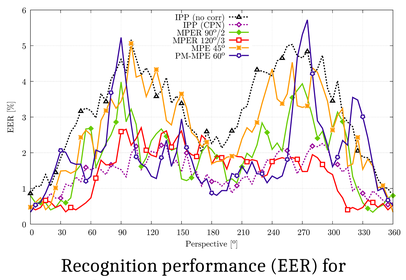


Results

- Invariance to rotation can be achieved with:

Method	Number of cameras involved		
	Enrolment	Recognition	Total
MPE 45°	8	1	9
PM-MPE 60°	6	1	7
MPER-120°/2	4	2	6
MPER-90°/3	3	3	6

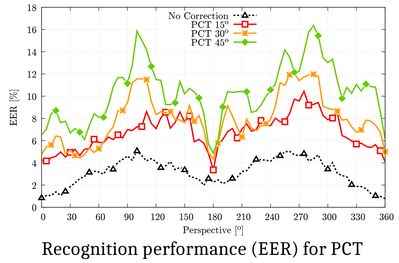
- Use-case dependent decision
- Simulation of capturing devices (PLUSVein-FR)
- Multi-perspective capturing devices have not been built so far



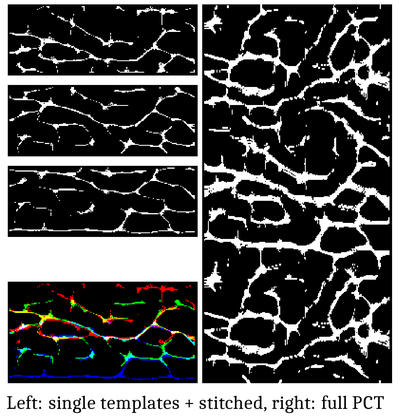
Recognition performance (EER) for multi-camera recognition systems

Perspective Cumulative Finger Vein Templates

- Enrol subject using multiple perspectives
- Combine perspectives to a single PCT
- Verification: single perspective vs PCT
- Invariant to rotation as PCT covers complete (rotational) range of interest
- Applied in the feature space



Recognition performance (EER) for PCT



Left: single templates + stitched, right: full PCT