Longitudinal Finger Rotation in Vein Recognition Deformation Detection and Correction

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Overview

1 Finger-Vein Biometrics

2 The Problem of Longitudinal Finger Rotation

3 Experiments

4 PLUSVein-Finger Rotation Data Set

5 Results

6 Conclusion and Future Work

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Finger-Vein Biometrics I

- The networks of blood vessel under the skin of the finger are unique
- Therefore, finger-vein characteristics are suitable for biometric applications
- Similar to fingerprints also images of the blood vessels can be used for authentication



Finger-Vein Biometrics II

Biometric finger vein recognition system

Acquisition effected by internal

- NIR light source
- camera module
- sensor configuration
- ...

and external factors

- environmental conditions (temperature, humidity, ...)
- finger misplacements (including longitudinal finger rotation)
- ...

Advantages

- Resistant to forgery as vein structures are inside the finger and only visible in infrared light
- Liveness detection is possible
- No abrasion as with fingerprints
- Insensitive to finger surface conditions

Disadvantages

- Comparatively large capturing device
- Images have in general lower contrast and lower quality than fingerprint images
- Vein structures are influenced by temperature and physical activity
- Vein structure may be influenced by certain diseases or injuries

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The Problem of Longitudinal Finger Rotation I

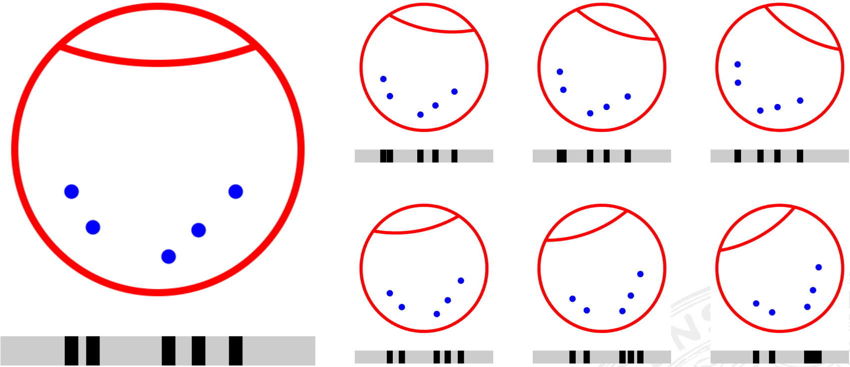

Figure: Finger longitudinal axis rotation principle: a schematic finger cross section showing five veins (blue dots) rotated from -10° to -30° (top row) and 10° to 30° (bottom row) in 10° steps. The projection of the vein pattern is different according to the rotation angle following a non-linear transformation.

Figure: Finger rotation example using an off-the-shelf commercial scanner

The Problem of Longitudinal Finger Rotation III

Prommegger et al., 2018 [1]: Longitudinal Finger Rotation - Problems and Effects in Finger-Vein Recognition (BIOSIG'18)

- commonly used recognition schemes tolerate longitudinal rotations of at least $\pm 10°$

Prommegger et al., 2019 [2]: On the Extent of Longitudinal Finger Rotation in Publicly Available Finger Vein Data Sets (ICB'19, accepted)

Data set	Max rotation between two samples
PLUSVein-FV3 [3]	12.5°
UTFVP [4]	29.5°
FV-USM [5]	41°
SDUMLA-HMT [6]	77°

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Contribution

(i) Systematic analysis to which extent longitudinal finger rotation can be compensated

(ii) Proposal of two rotation compensation approaches

- Rotation compensation using the known rotation angle (provided by the data set)
- Rotation compensation using a predefined fixed angle

(iii) Performance analysis and comparison of the proposed methods against state of the art finger vein recognition methods

Experiments II

Used recognition schemes:

- Vein pattern based feature extraction methods (binarization)
  - Maximum Curvature (MC) [7]
  - Principal Curvature (PC) [8]
  - Wide Line Detector (WLD) [9]
  - Garbor Filter (GF) [10]
  - Anatomic Structure Analysis using Elastic Matching (ASAVE) [11]
- Key-point based methods
  - SIFT [12]
  - Deformation-tolerant feature-point matching (DTFPM) [13]

Experiments III

Rotation compensation methods under investigation

- No correction (baseline results)
- Rotation compensation for known rotation angle (proposed)
- Geometric shape analysis based finger deformation detection and correction (GADC) [14]
- Elliptic pattern normalization (EPN) [9]
- Rotation compensation using a fixed angle (proposed)

Rotation Compensation for Known Rotation Angle

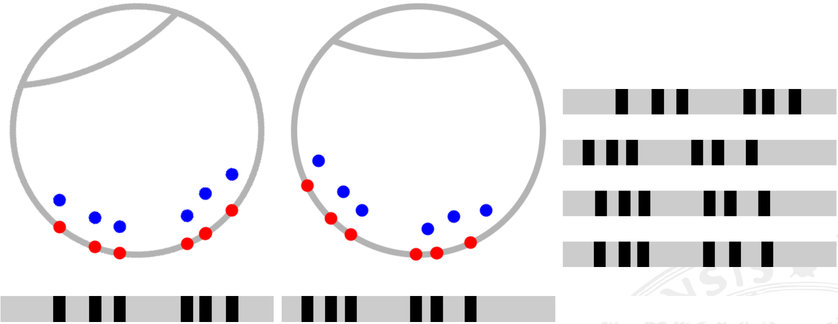

Figure: Principle of rotation correction with known rotation angle. Left: finger rotated with 25°. The blue points depict the veins inside the finger, the red points the veins projected on the finger shape. The bar below is the projected vein pattern. Middle: the finger rotated into the palmar view. The bar below is the rotation corrected vein pattern, which corresponds to the veins estimated on the finger surface. On the right side the vein patterns are visualized below each other. From top to bottom: rotated vein pattern, corrected vein pattern, corrected pattern shifted for the highest correlation to the palmar pattern (bottom row).

Rotation Compensation Using a Fixed Rotation Angle

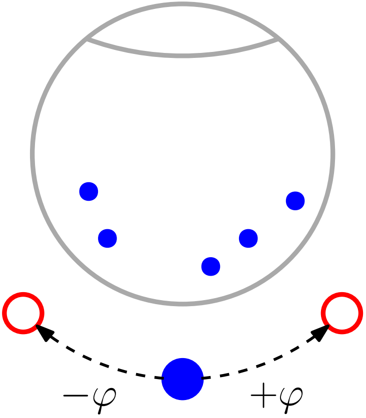

Figure: Rotated camera positions

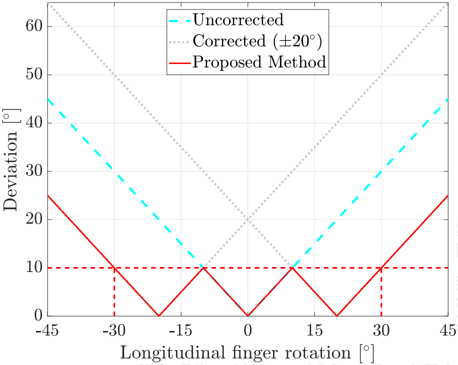

Figure: Deviation of the rotated finger to the palmar view with an correction angle $\varphi_{corr} = 20°$

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- Only data set that provides finger vein images all around the finger
- Enables evaluation of longitudinal finger rotation related problems
- Acquired using our custom build sensor

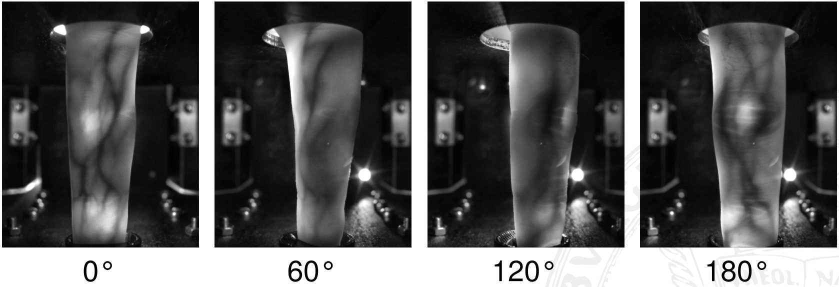

Figure: Example images of the data set acquired from 0° to 180° in 60° steps

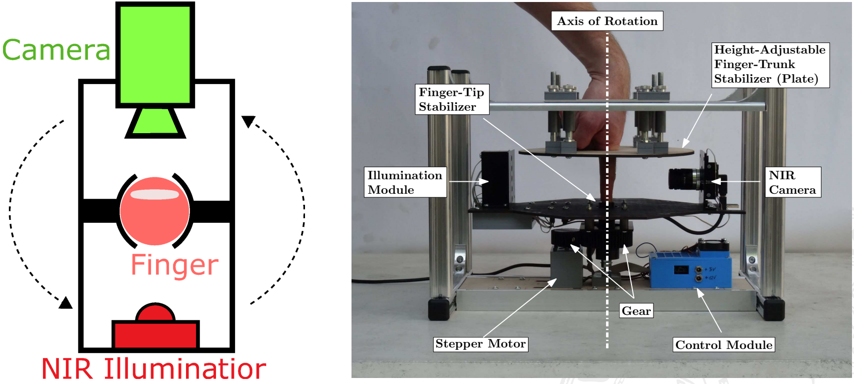

Figure: Left: Principle of the multi-perspective finger vein scanner, right: the scanner itself (originally published in [15], © 2018 IEEE)

PLUSVein-Finger Rotation Data Set III

Statistical data

- 63 subjects (27 female, 36 men)
- 11 nations (Austria, Brazil, China, Ethiopia, Germany, Hungary, Iran, Italy, Russia, Slovenia, USA), but mainly white Europeans (73%)
- Age: 18 (limited by national law) to 79 years
- 252 unique fingers (63 different subjects, 4 fingers per subject)
- Rotational step-size: 1°
- 454.860 images in total.

Used sub-set for this paper

- Range of $\pm 45°$ around palmar view (0°)
- 91 different views
- 114.030 images in total.

PLUSVein-Finger Rotation Data Set IV

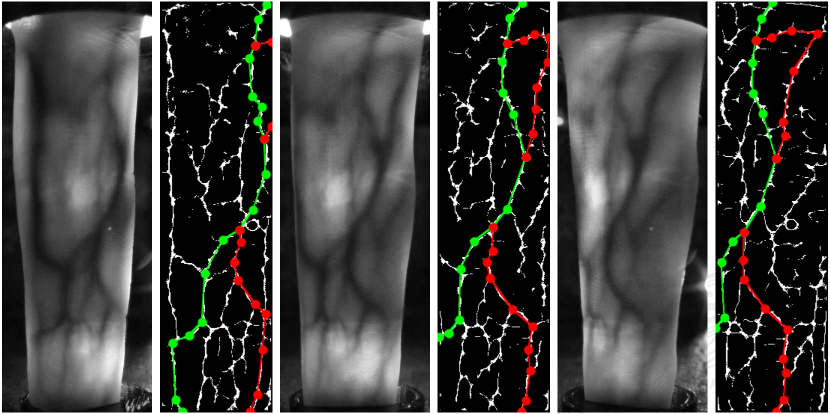

Figure: Examples of finger vein images and extracted MC features acquired at different longitudinal rotation angles. Left: -30°, middle: 0° (palmar view), right: 30°.

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Baseline Results

Feature	EER
MC	0.37 ($\pm$0.09)
PC	0.77 ($\pm$0.13)
DTFPM	0.87 ($\pm$0.14)
WLD	0.92 ($\pm$0.14)
GF	1.02 ($\pm$0.15)
SIFT	1.80 ($\pm$0.20)
ASAVE	2.96 ($\pm$0.25)

Table: Baseline performance results at the palmar view for the different recognition schemes ordered by recognition performance.

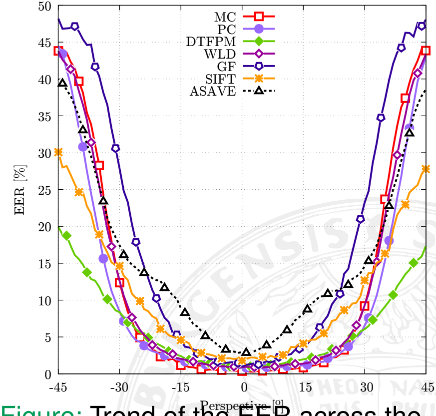

Figure: Trend of the EER across the different rotation angles

Rotation Compensation for Known Rotation Angle

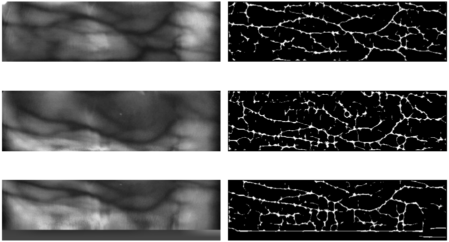

Figure: ROI (left) and extracted MC features (right) of sample images of the PLUSVein-FR. First row: palmar view (0°), second row: 25° rotated view, bottom row: rotation corrected version of the 25° rotated image.

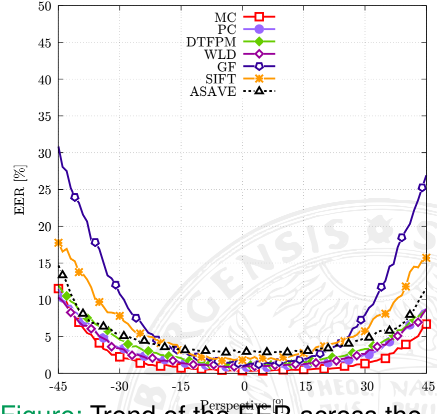

Figure: Trend of the EER across the different rotation angles

Rotation Compensation Using Geometric Shape Analysis [14]

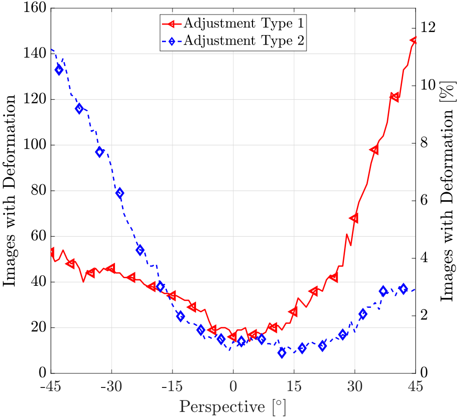

Figure: Number of images with a detected longitudinal finger rotation

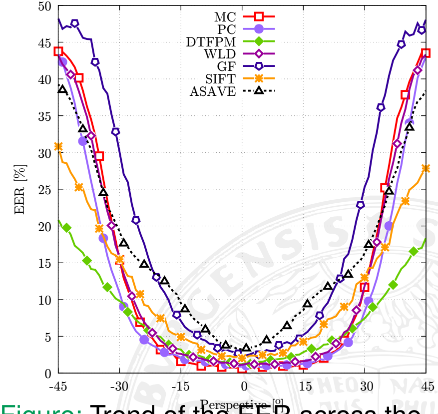

Figure: Trend of the EER across the different rotation angles

Rotation Compensation Using Elliptic Pattern Normalization [9]

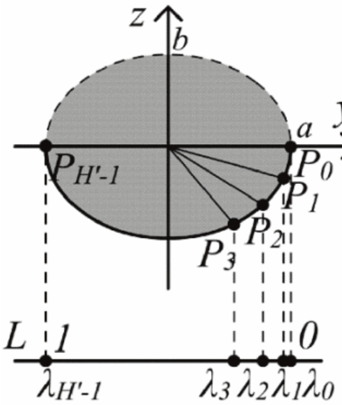

Figure: Ellipse cross section and pattern normalization [9]

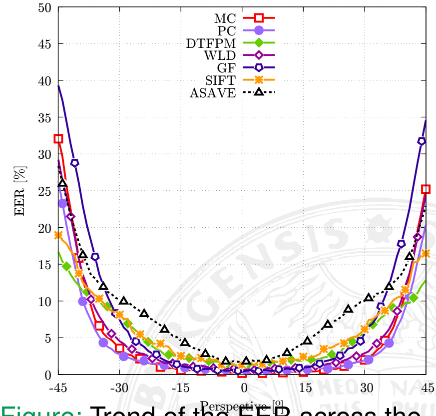

Figure: Trend of the EER across the different rotation angles

Rotation Compensation Using a Fixed Rotation Angle

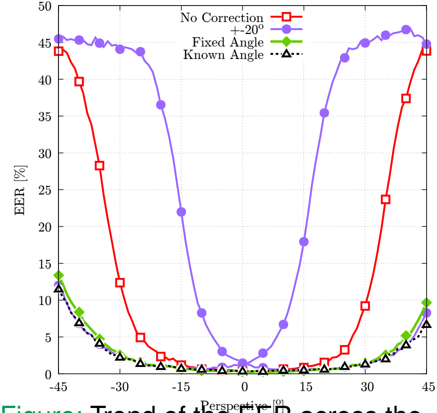

Figure: Trend of the EER across the different rotation angles

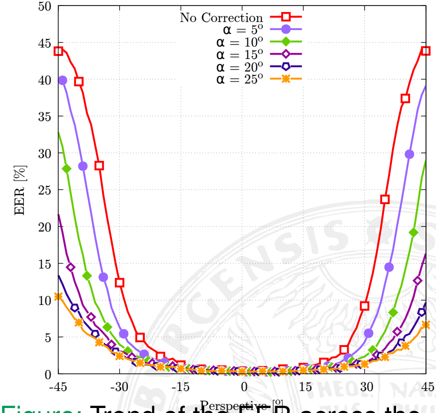

Figure: Trend of the EER across the different rotation angles

Rotation Compensation Using a Fixed Rotation Angle

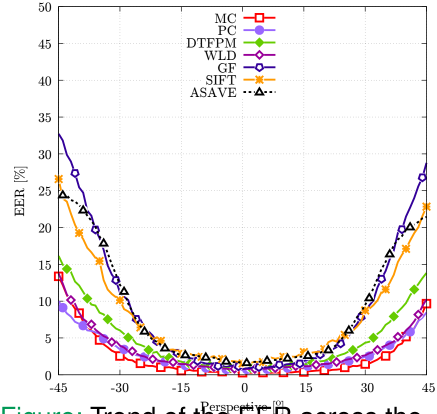

Figure: Trend of the EER across the different rotation angles

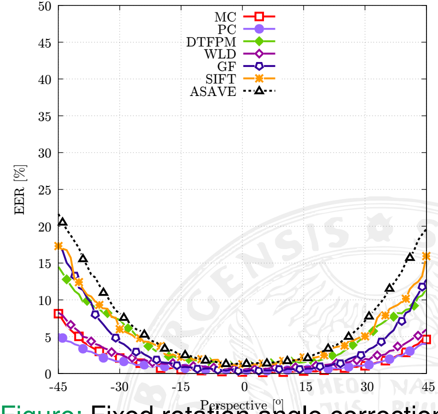

Figure: Fixed rotation angle correction combined with EPN

Comparison of Different Rotation Compensation Approaches

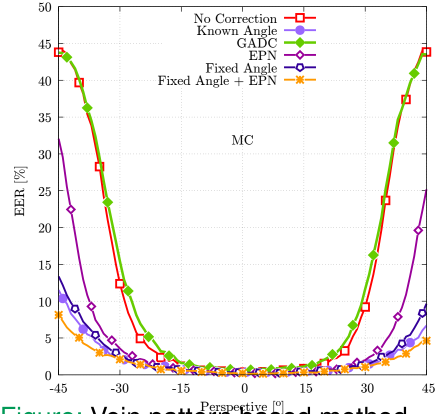

Figure: Vein pattern based method (MC)

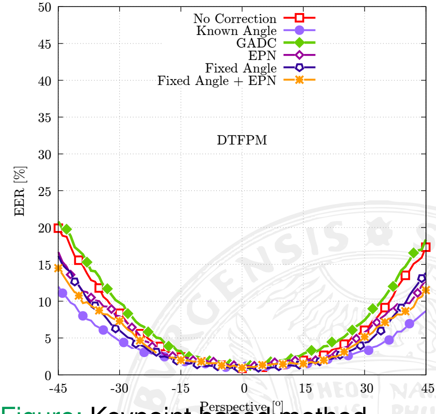

Figure: Keypoint based method (DTFPM)

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Conclusion and Future Work II

Conclusion

- Good performance up to $\pm 30°$ (known & fixed angle approach)
- Known angle approach only applicable if rotation angle is known
- Fixed angle approach applicable on real world data (tested on UTFVP & SDUMLA-HMT)
- Vein pattern based algorithms benefit more from rotation compensation
- GADC does not improve results on our data at all
- Fixed angle correction is suitable for real-time applications
- A combination with EPN further improves the results (computational more expensive)

Future Work

- Analysis of deformations caused by different finger misplacements
- Development of methodologies improving the robustness against finger misplacements
- Contactless finger vein recognition

An implementation of all recognition schemes, the scores and detailed results are available at:
`http://wavelab.at/sources/Prommegger19a`

Thank you!

Q & A

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