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PROTECT

Rotation Invariant Finger Vein Recognition

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Introduction I

What is longitudinal finger rotation?

- misplacement of the finger during acquisition

The problem of longitudinal finger rotation:

- causes a deformation of the vein pattern
- negatively effects recognition performance

The vision:

- make finger vein recognition invariant to finger rotation

The idea:

- enrol multiple perspectives
- compare single perspective against enrolled data

The Problem of Longitudinal Finger Rotation

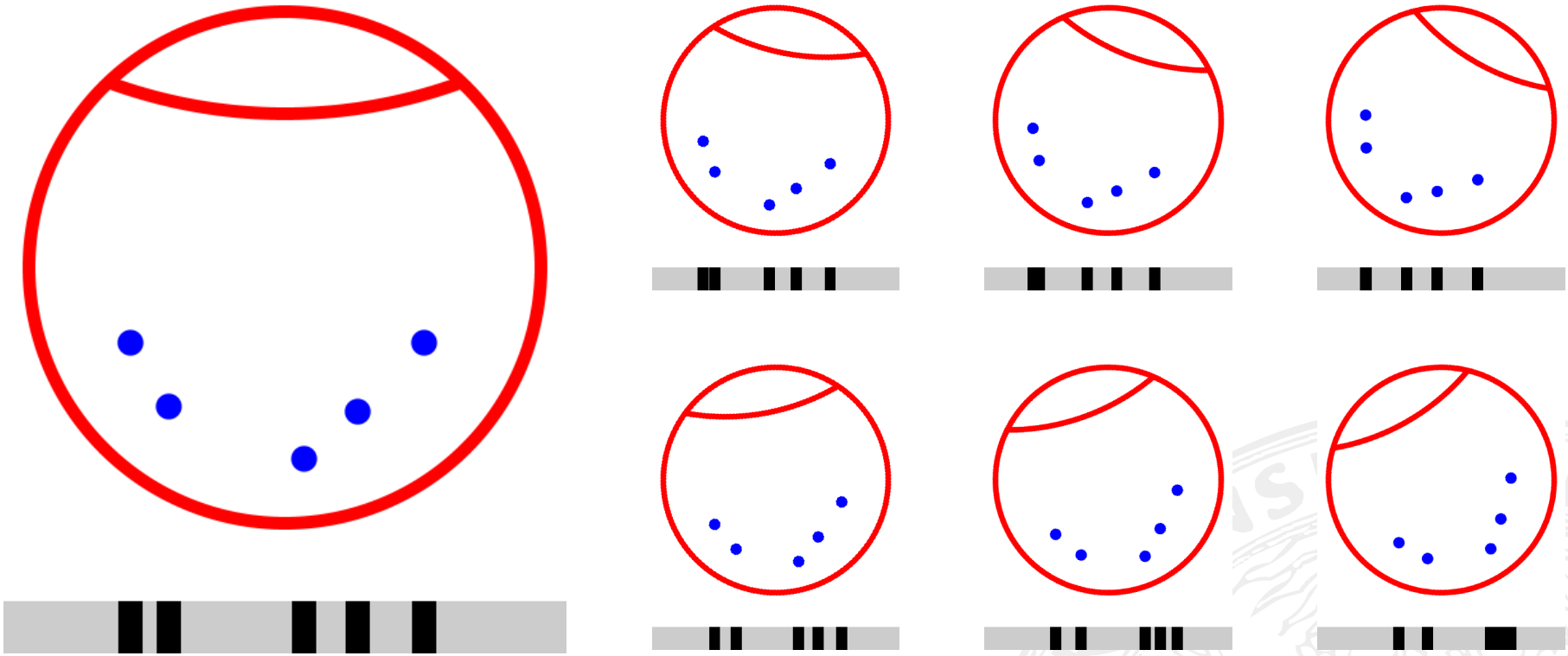


Figure: Longitudinal finger rotation principle: a schematic finger cross section showing five veins (blue dots) rotated from -10° to -30° (top row) and 10° to 30° (bottom row) in 10° steps. The projection of the vein pattern is different according to the rotation angle following a non-linear transformation [1].

Multi Perspective Enrolment I

Idea

- 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

Assumptions

- Circular finger form
- Enrolment perspectives are linearly spaced over the acquisition range

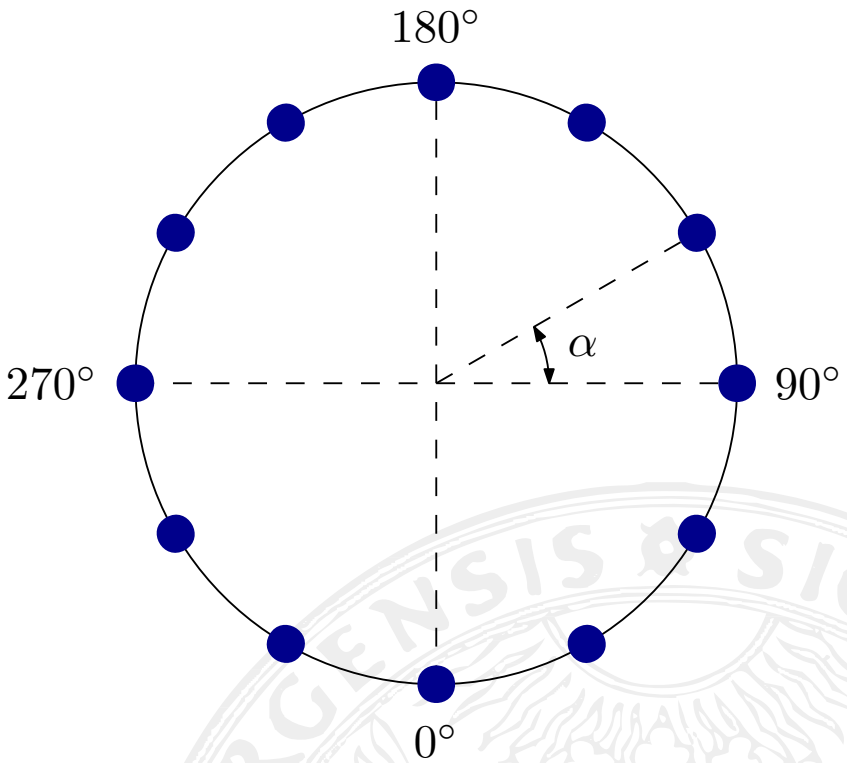


Figure: Camera positioning for MPE for a rotational distance of $\alpha = 30°$ between the enrolment perspectives.

Multi Perspective Enrolment II

Experiments & Results

- PLUSVein Finger Rotation Data Set [2] (360°, step size: 5°)
- Intra-perspective performance results
  - no correction
  - circular pattern normalization (CPN)
- Multi-perspective enrolment (MPE)
  - utilizing CPN
  - $\alpha = 15° \rightarrow$ 24 perspectives
  - $\alpha = 30° \rightarrow$ 12 perspectives
  - $\alpha = 45° \rightarrow$ 8 perspectives
- *n* perspectives enrolled $\rightarrow$ *n* comparisons during verification

Multi Perspective Enrolment III

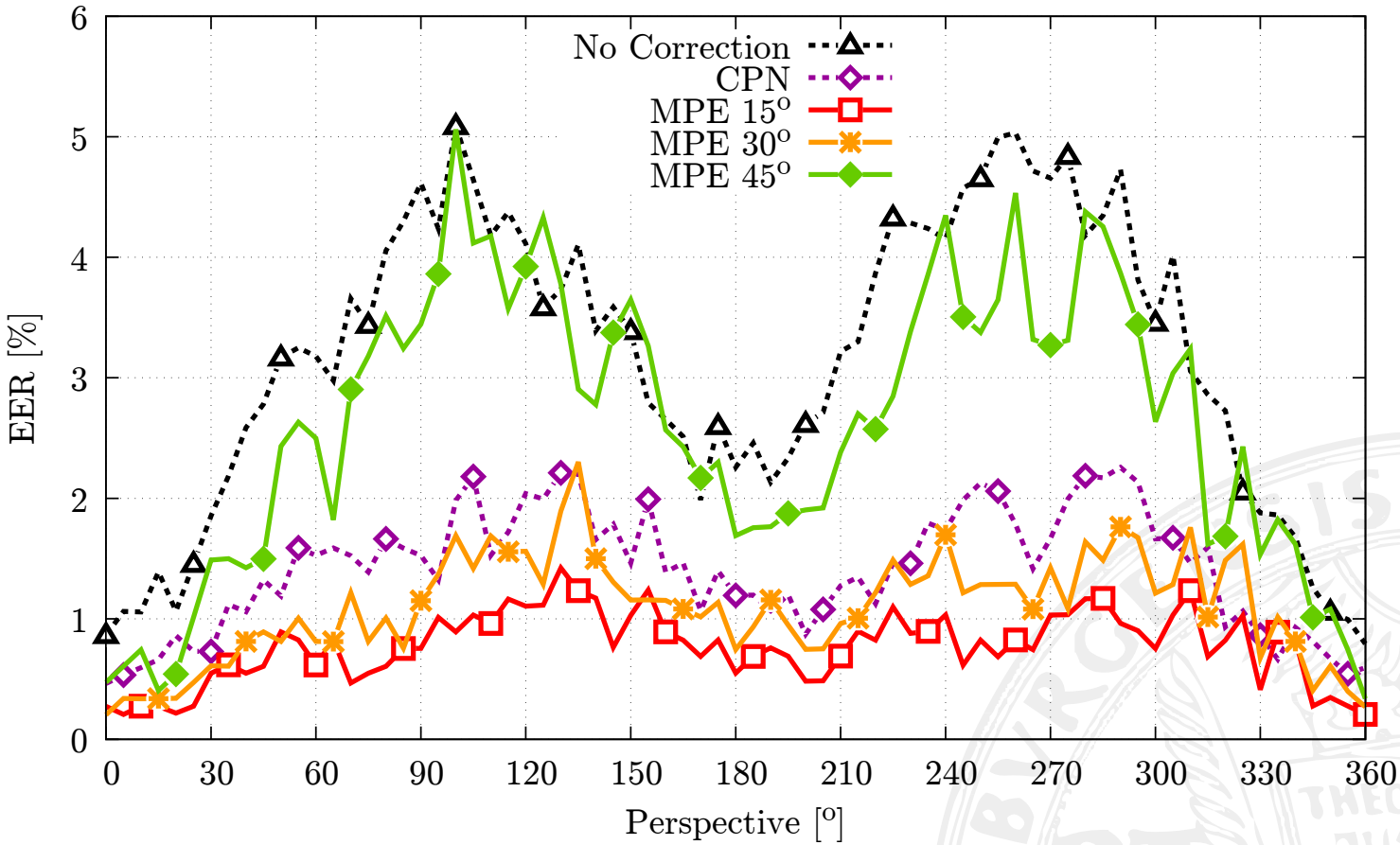


Figure: Recognition performance (EER): in-perspective vs MPE comparisons

Perspective Cumulative Finger Vein Templates I

Idea

- 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 (MC features [3])

Assumptions

- Circular finger form
- Enrolment perspectives are linearly spaced over the acquisition range

Issues

- ”Noise” from knuckles, wrinkles, hair, ...
- Level of detail for PCT generation must be reduced

Perspective Cumulative Finger Vein Templates II

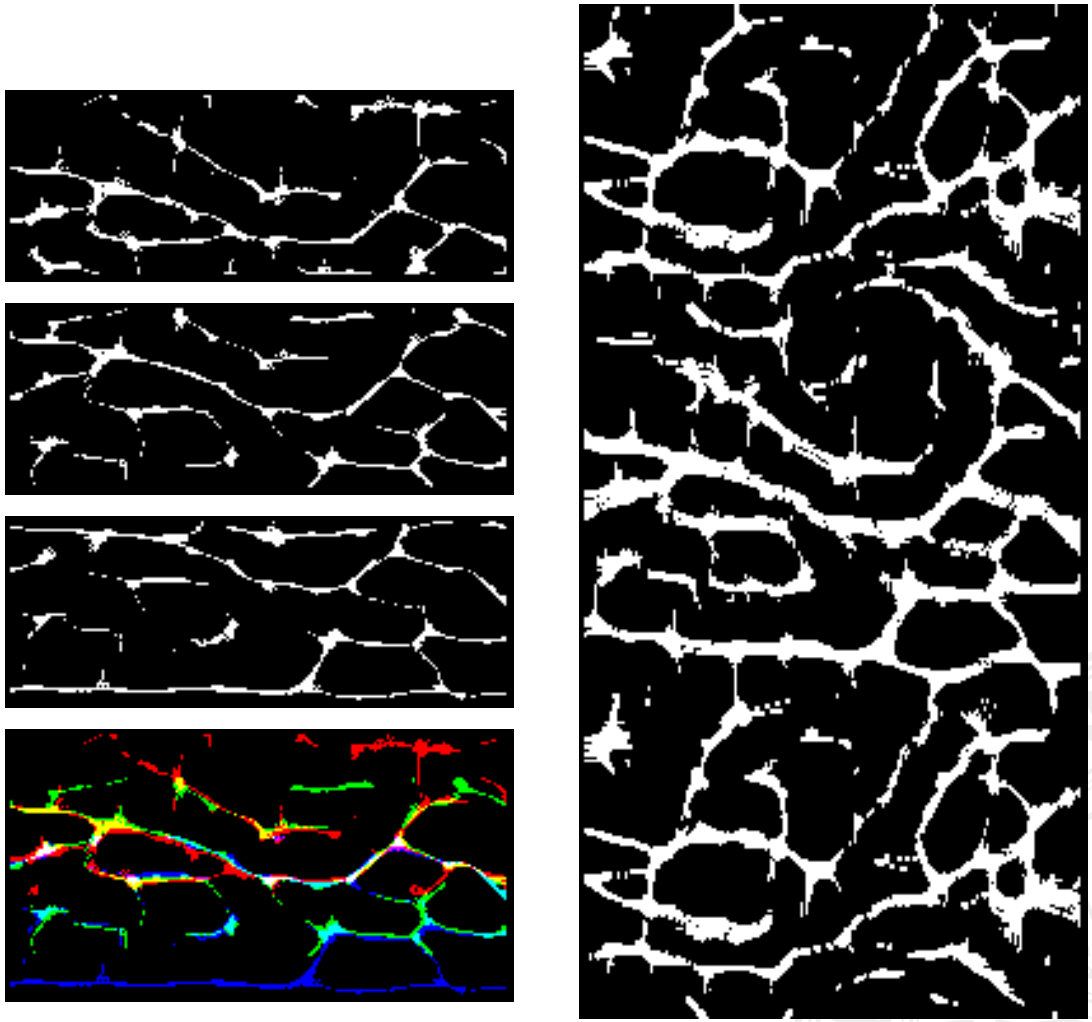


Figure: Example of an PCT. Left: single perspectives (rotation angle 30°) and the combined image of the three samples. Right: a PCT on the range of 360°.

Perspective Cumulative Finger Vein Templates III

Experiments & Results

- PLUSVein Finger Rotation Data Set [2] (360°, step size: 5°)
- Intra-perspective performance results
  - no correction
- Perspective cumulative finger vein templates (PCT) generated using
  - utilizing CPN
  - 24 perspectives ($\alpha = 15°$)
  - 12 perspectives ($\alpha = 30°$)
  - 8 perspectives ($\alpha = 45°$)
- *n* perspectives enrolled $\rightarrow$ 1 comparisons during verification

Perspective Cumulative Finger Vein Templates IV

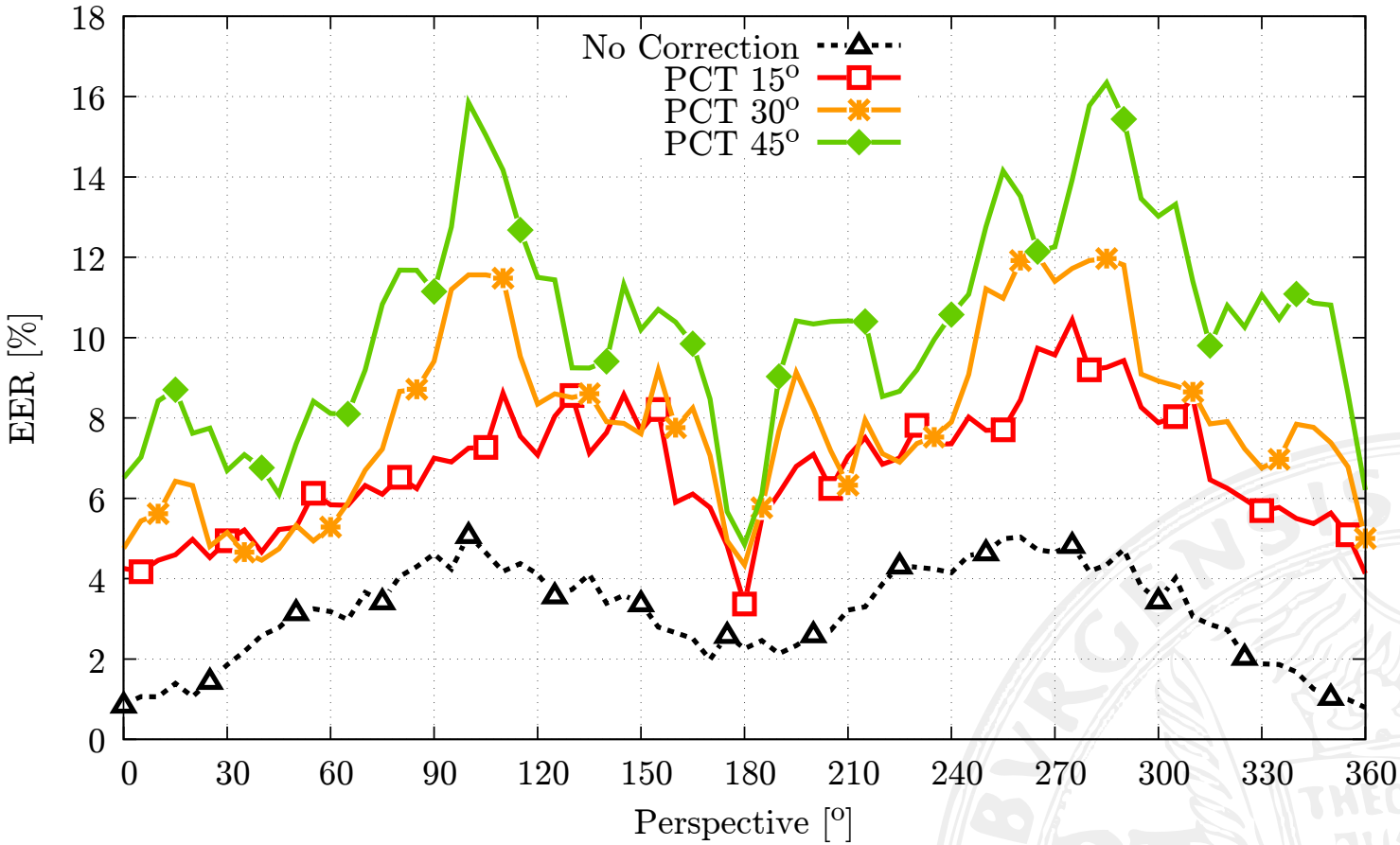


Figure: Recognition performance (EER): in-perspective vs PCT comparisons

Performance Validation I

Comparison to well performing algorithms

- Elliptic pattern normalization (EPN) [4]
- Circular pattern normalization (CPN)
- Fixed angle correction ($\varphi = 20°$) [5]
- Known angle correction [5]

Using especially designed data sets

- containing longitudinal rotated finger vein samples
- rotation angle is know
- rotation angles follow a specified distribution
- created from PLUSVein-FR [2]

Performance Validation II

General properties

- 63 subjects, 4 finger, 5 samples
- known rotation angles
- between 0° and ±45°

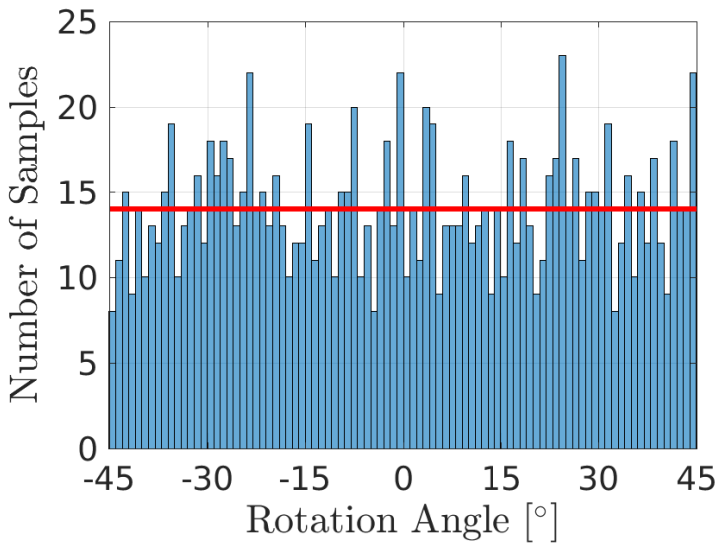
PLUSVein-FR-ED

- equally distributed rotation angles
- rotational distance of samples between 0° and 89°

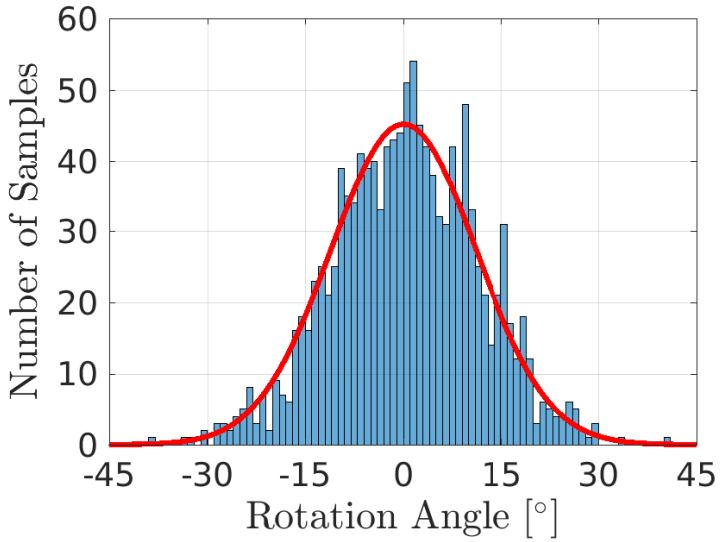
PLUSVein-FR-ND

- normally distributed rotation angles
- $\mu = 0.03, \sigma = 11.12$
- rotational distance of samples between 0° and 55°

PLUSVein-FR-ED



PLUSVein-FR-ND



Performance Validation III

4 MPE scenarios

- 2 perspectives: $\pm 20°$
- 3 perspectives: -30°, 0° (palmar view), +30°
- 5 perspectives: $\pm 45°$ in steps of 30°
- 7 perspectives: $\pm 45°$ in steps of 15°

3 PCT scenarios

- step size $15° \rightarrow$ 7 perspectives
- step size $30° \rightarrow$ 5 perspectives
- step size $45° \rightarrow$ 3 perspectives

Performance Validation IV

Method	PLUSVein-FR-ED		PLUSVein-FR-ND	
	EER	RPI	EER	RPI
No Correction	21.63	-	3.39	-
CPN	15.34	41.0	1.52	122.3
EPN	15.87	36.3	1.72	96.4
Fixed Angle ($\varphi = 20°$)	5.24	312.5	**0.66**	412.4
Known Angle	5.44	297.6	1.13	200.4
MPE 2 Cameras	1.66	1202.8	0.80	324.0
MPE 3 Cameras	1.13	1807.1	**0.53**	534.1
MPE 4 Cameras	0.60	3513.8	0.67	407.3
MPE 7 Cameras	**0.33**	6379.3	**0.34**	909.9
PCT 15°	3.00	620.3	**2.20**	53.7
PCT 30°	3.53	512.2	**2.72**	24.7
PCT 45°	3.91	452.9	**2.80**	21.0

Table: Performance results for PLUSVein-FR-ED and PLUSVein-FR-ND

Conclusion and Future Work I

Contribution

Proposal of 2 rotation invariant finger vein recognition methods

- Multi-perspective enrolment
- Perspective cumulative finger vein templates

Introduction of 2 publicly available finger vein data sets

- PLUSVein-FR-ED (equally distributed rotation angles)
- PLUSVein-FR-ND (normally distributed rotation angles)

Conclusion and Future Work II

Conclusion

- MPE achieves superior results with respect to all other rotation tolerant schemes
- PCT
  - stable recognition performance over the whole range
  - worse than other recognition schemes (use case dependent)
  - computational less expensive than MPE (template size, comparison)
- Rotation invariant due to additional effort during registration
- If enough perspectives are enrolled $\rightarrow$ negative effects of longitudinal finger rotation are inhibited

Future Work

- Apply PCT in image space
- Reduce number of required enrolment perspectives for MPE and PCT

The End

Thank you!

Q & A

Bibliography I

[1] B. Prommegger, C. Kauba, and A. Uhl, “Longitudinal finger rotation - problems and effects in finger-vein recognition,” in *Proceedings of the International Conference of the Biometrics Special Interest Group (BIOSIG’18)*, Darmstadt, Germany, 2018.

[2] ——, “Multi-perspective finger-vein biometrics,” in *Proceedings of the IEEE 9th International Conference on Biometrics: Theory, Applications, and Systems (BTAS2018)*, Los Angeles, California, USA, 2018.

[3] N. Miura, A. Nagasaka, and T. Miyatake, “Extraction of finger-vein patterns using maximum curvature points in image profiles,” *IEICE transactions on information and systems*, vol. 90, no. 8, pp. 1185–1194, 2007.

Bibliography II

[4] B. Huang, Y. Dai, R. Li, D. Tang, and W. Li, “Finger-vein authentication based on wide line detector and pattern normalization,” in *Pattern Recognition (ICPR), 2010 20th International Conference on*. IEEE, 2010, pp. 1269–1272.

[5] B. Prommegger, C. Kauba, M. Linortner, and A. Uhl, “Longitudinal finger rotation - deformation detection and correction,” *IEEE Transactions on Biometrics, Behavior, and Identity Science*, pp. 1–17, 2019.