Perspective Multiplication for Multi-Perspective Enrolment in Finger Vein Recognition

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October 17, 2019
Finger vein sensors

- single finger, palmar perspective
- suffers from different misplacements of the finger during acquisition
- apparatus to avoid finger misplacements

Longitudinal finger rotation

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

Existing solutions

- detect or compensate finger rotation to a certain extent

Aim

- rotation invariant recognition system
The Problem of Longitudinal Finger Rotation

Figure: Longitudinal finger rotation principle: a schematic finger cross section showing five veins (blue dots) rotated from $-10^\circ$ to $-30^\circ$ (top row) and $10^\circ$ to $30^\circ$ (bottom row) in $10^\circ$ steps. The projection of the vein pattern is different according to the rotation angle following a non-linear transformation [1].
Proposed solutions (not complete):

- Physical design of the sensor (e.g. Kauba et al. 2018 [2])
- Pre-aligning of the images (e.g. Lee et al. 2009 [3], Yang 2017 et al. [4])
- Pattern normalization (e.g. Huang et al. 2010 [5])
- Analysis of the geometric shape of the finger (Chen et al. 2018 [6])
- Deformation tolerant matching (e.g. Miura et al. 2004 [7], Matsuda et al. 2016 [8])
- Pre-rotating enrolment perspectives with a fixed angle (Prommegger et al. 2019 [9])
- ...
Rotation detection and correction (Prommegger et al. 2019 [9])

Figure: Trend of the EER across different rotation angles. Left: Performance of different finger vein recognition schemes, right: different rotation compensation approaches for the same scheme (Maximum Curvature)
All approaches have one thing in common:

- Single perspective recognition systems

Prommegger and Uhl: Rotation Invariant Finger Vein Recognition (BTAS’19) [14]

- Acquisition of multiple perspectives during enrolment, and a single one for recognition

- Two approaches
  - Multi-perspective Enrolment (MPE)
  - Perspective Cumulative Finger Vein Templates (PCT)
Multi-Perspective Enrolment I

Idea

- Enrol subject using multiple perspectives
- Recognition: 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 $\alpha = 30^\circ$ between the enrolment perspectives.
Experiments & Results

- Maximum Curvature (MC)
- 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
  - $\alpha = 60° \rightarrow 6$ perspectives
- $n$ perspectives enrolled $\rightarrow n$ comparisons during recognition
Recognition performance (EER): intra-perspective vs MPE
Conclusion

- If enough cameras are used during enrolment, negative effects of longitudinal finger rotation on the recognition performance can be inhibited.

Problem

- Cost and complexity of enrolment device increases with the number of acquired perspectives

Desired improvement

- Reduce number of perspectives needed to be acquired during enrolment
- Perspective multiplication for multi-perspective enrolment (PM-MPE)
Idea of PM-MPE


Figure: Rotated camera positions

Figure: Deviation of the rotated finger to the palmar view with an correction angle $\phi_{corr} = 20^\circ$
MPE vs PM-MPE

Figure: Camera positioning for MPE (left) and PM-MPE (right) for a rotational distance of 30° between the perspectives. The filled blue dots are cameras, the red circles represent rotated perspectives.
Generation of pseudo perspectives

**Problem:** how to calculate the rotated version of the input images

- input images are a 2D projection of the vessels in the 3D space
- finger shape is not known
- depth of blood vessels within the finger is unknown

**Assumptions:**

- circular finger shape
- vessels on skin surface of finger
Figure: Principle of pseudo perspective generation. Top: cross sections of a finger acquired during enrolment. The blue points depict the veins inside the finger, the red points the veins projected on the skin surface of the finger. Bottom: projected vein patterns.
Samples of generated pseudo-perspectives

Figure: ROI (top row) and extracted MC features (bottom row) of sample images of the PLUSVein-FR. Middle: enrolment image, left and right: generated pseudo perspectives for $\varphi = \pm 20^\circ$. 

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Experiments & Results

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- Perspective multiplication for MPE (PM-MPE)
  - utilizing CPN
  - $\alpha = 30^\circ \rightarrow 12$ perspectives
  - $\alpha = 45^\circ \rightarrow 8$ perspectives
  - $\alpha = 60^\circ \rightarrow 6$ perspectives
- $n$ perspectives enrolled $\rightarrow 3 \cdot n$ comparisons during recognitions
- reduction of horizontal shift by 50% compared to MPE
Recognition performance (EER): intra-perspective vs PM-MPE
Recognition performance (EER): MPE vs PM-MPE 30°
Recognition performance (EER): MPE vs PM-MPE 45°
Recognition performance (EER): MPE vs PM-MPE 60°
Conclusion and Future Work

Contribution

- Proposal of a method that effectively reduces the number of perspectives needed to be acquired during enrolment for MPE.

Conclusion

- Performance increase is achieved by
  - introducing pseudo perspectives inbetween two enrolment perspectives
  - additional comparisons during recognition
- PM-MPE allows an increase of the distance between two enrolment perspectives by 15° while still getting similar or superior results compared to MPE.
Future Work

- Possible improvements to (PM-)MPE:
  - Introduction of more than two pseudo perspectives
  - Different positioning of the enrolment cameras (shifted or non-linear positioning)
- Evaluation of (PM-)MPE for other recognition schemes than MC
Thank you!

Q & A


