UNIVERSITÄT SALZBURG

PROTECT

Perspective Multiplication for Multi-Perspective Enrolment in Finger Vein Recognition

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Introduction I

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

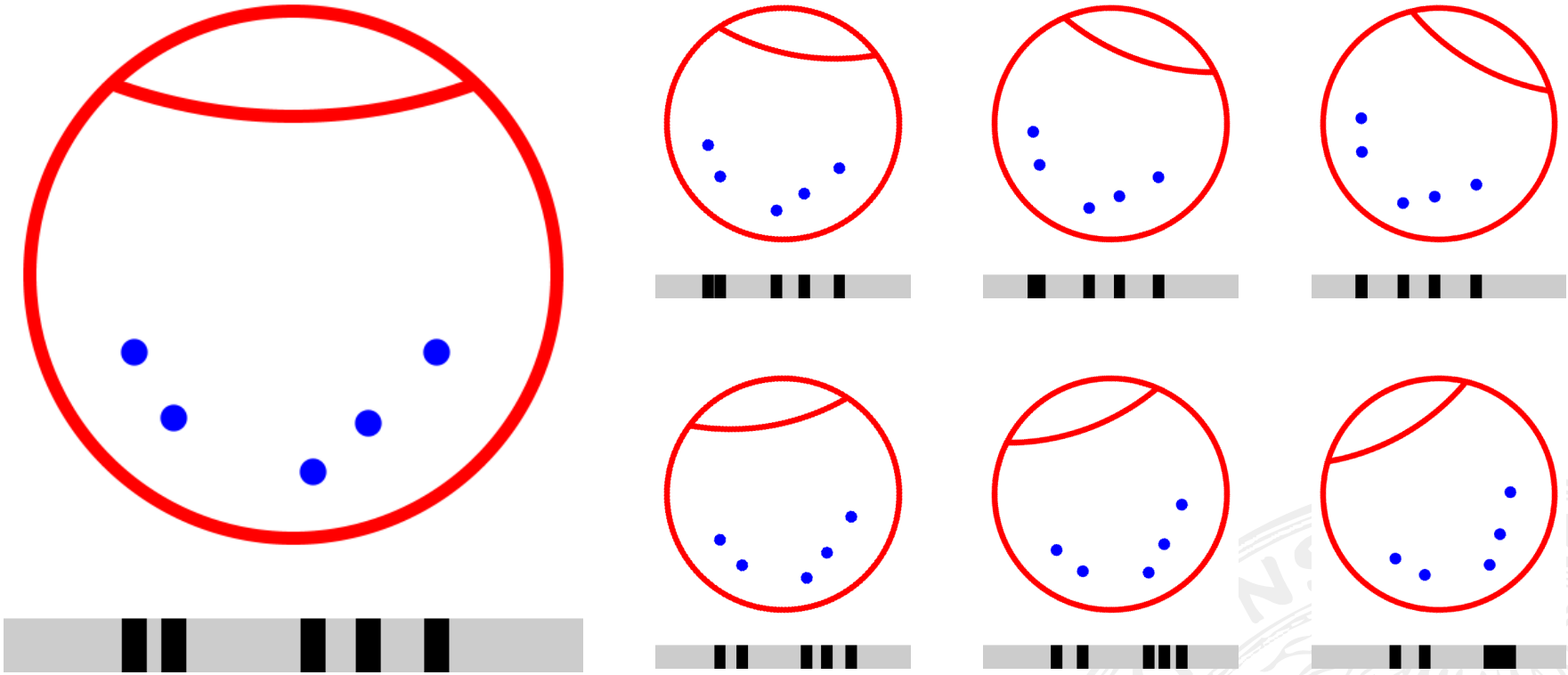


Figure: Longitudinal finger rotation principle: a schematic finger cross section showing five veins (blue dots) rotated from -10° to -30° (top row) and 10° to 30° (bottom row) in 10° steps. The projection of the vein pattern is different according to the rotation angle following a non-linear transformation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

Introduction III

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])

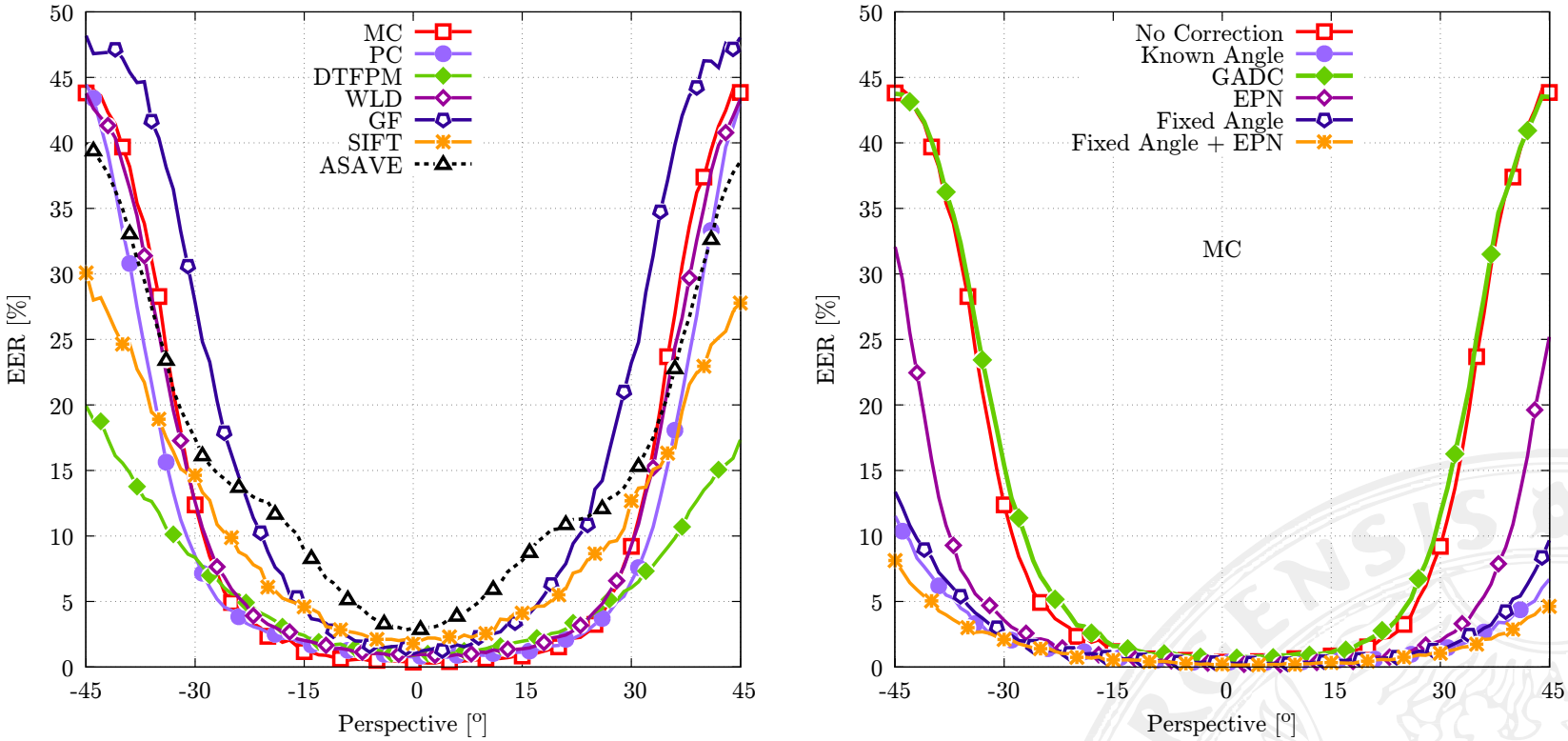


Figure: Trend of the EER across different rotation angles. Left: Performance of different finger vein recognition schemes, right: different rotation compensation approaches for the same scheme (Maximum Curvature)

Introduction V

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

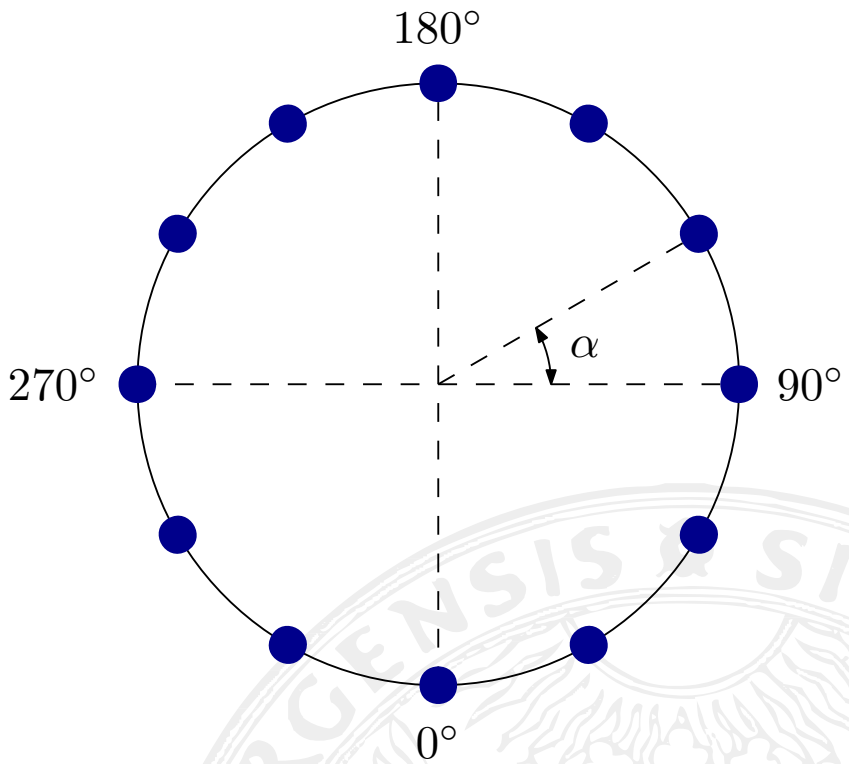


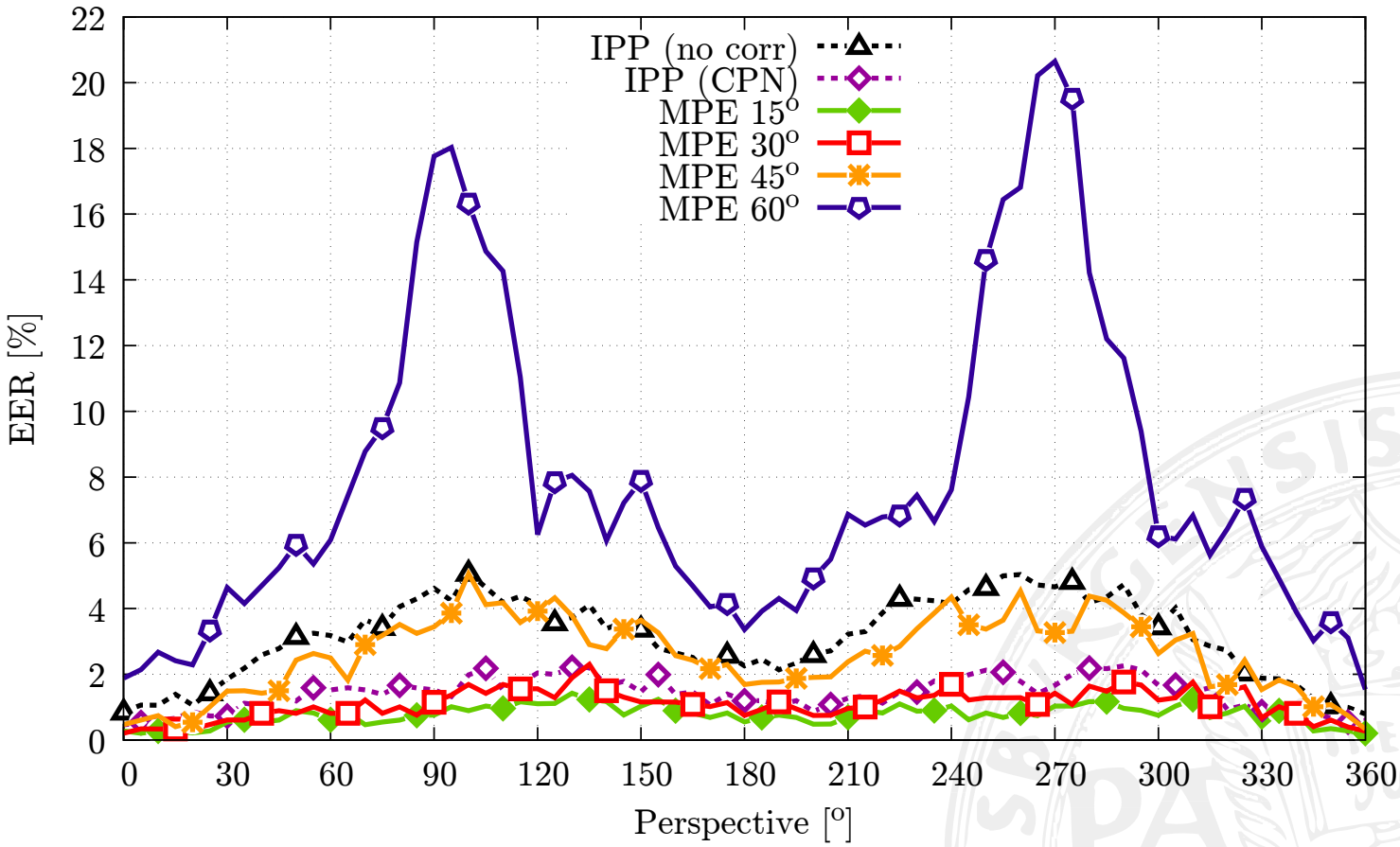
Figure: Camera positioning for MPE for a rotational distance of $\alpha = 30°$ between the enrolment perspectives.

Multi-Perspective Enrolment II

Experiments & Results

- PLUSVein-FR [15] (360°, step size: 5°)
- 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



Multi-Perspective Enrolment IV

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)

Perspective Multiplication for MPE I

Idea of PM-MPE

- Combine MPE [9] with fixed angle compensation [10]

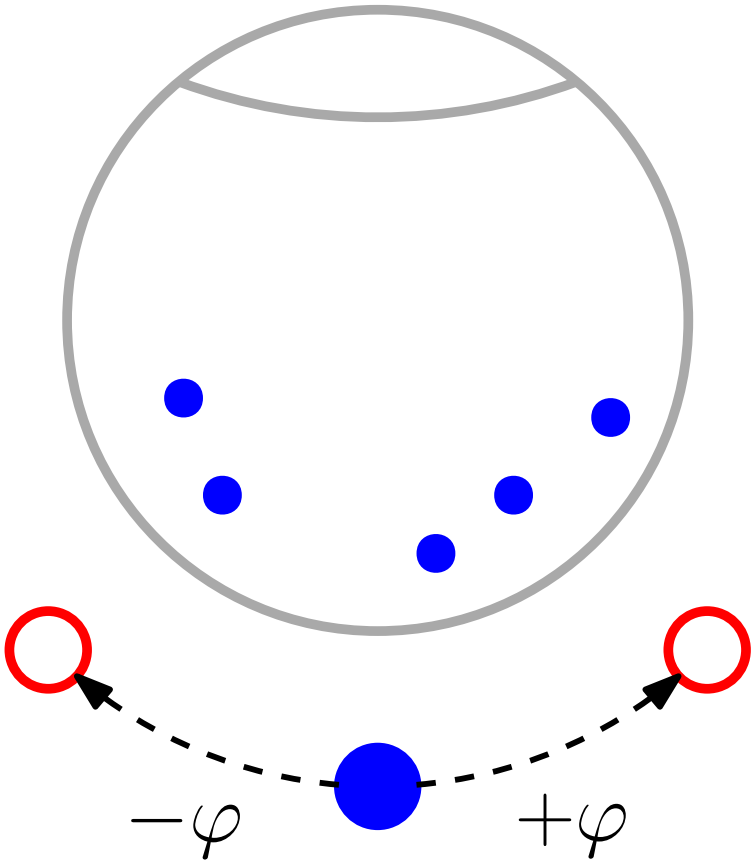


Figure: Rotated camera positions

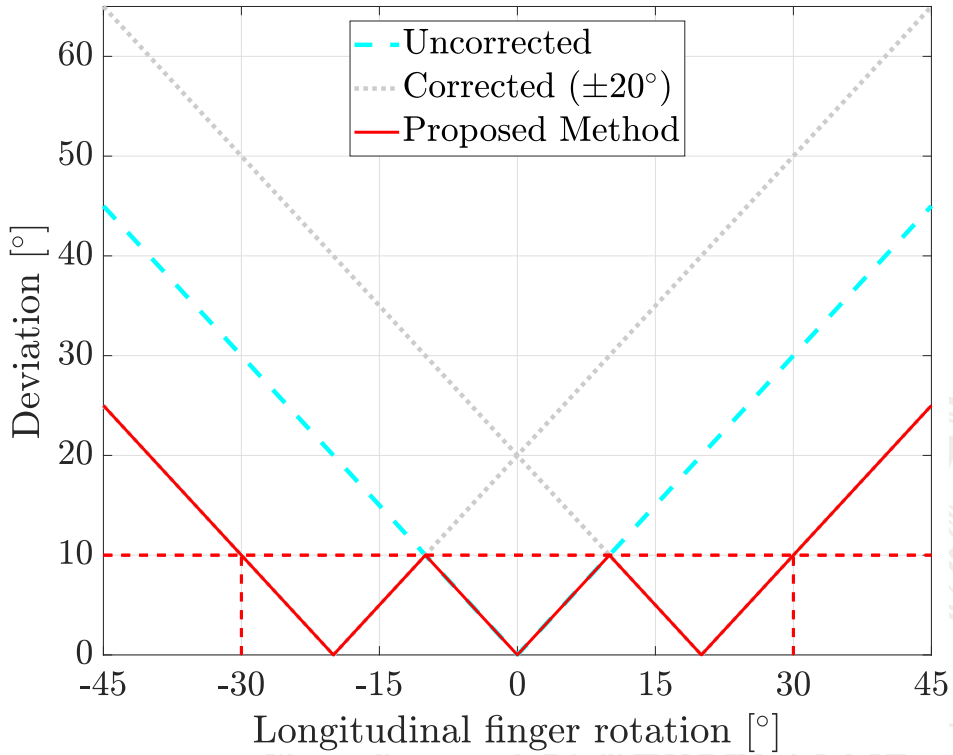


Figure: Deviation of the rotated finger to the palmar view with an correction angle $\varphi_{corr} = 20°$

Perspective Multiplication for MPE II

MPE vs PM-MPE

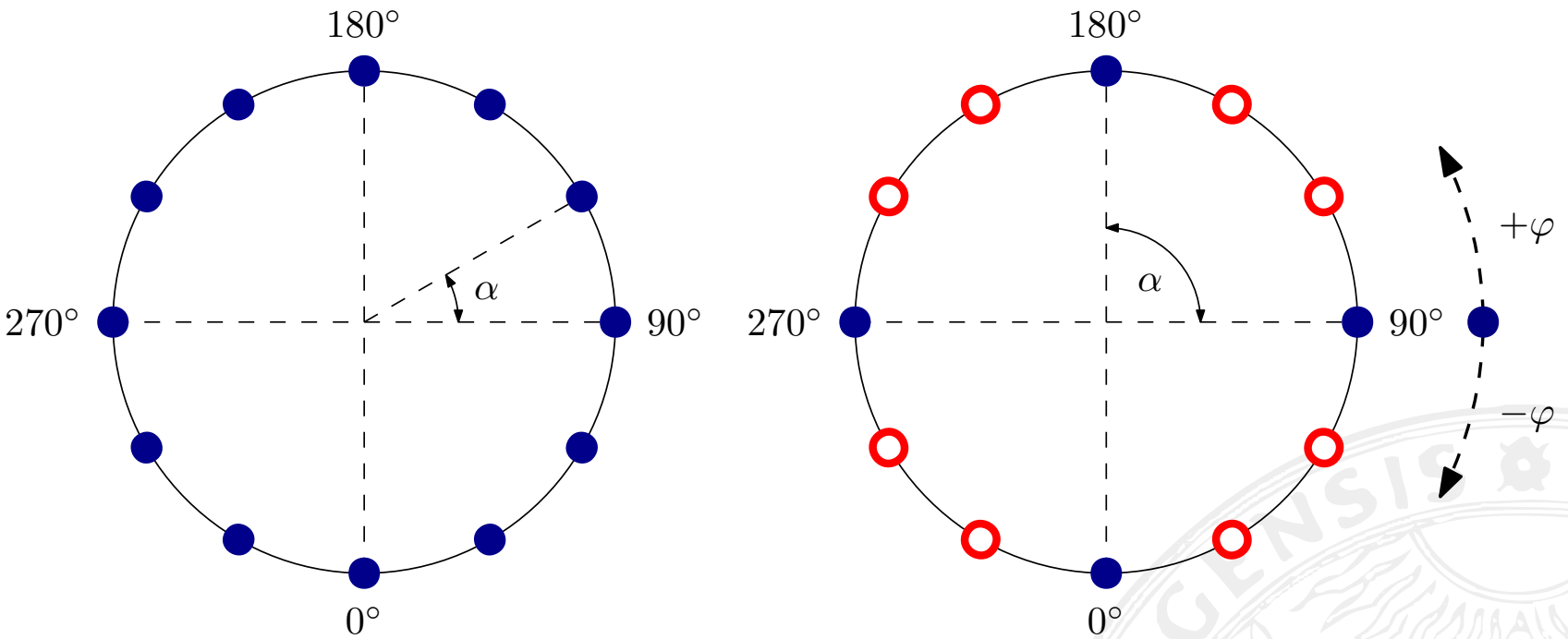


Figure: Camera positioning for MPE (left) and PM-MPE (right) for a rotational distance of 30° between the perspectives. The filled blue dots are cameras, the red circles represent rotated perspectives.

Perspective Multiplication for MPE III

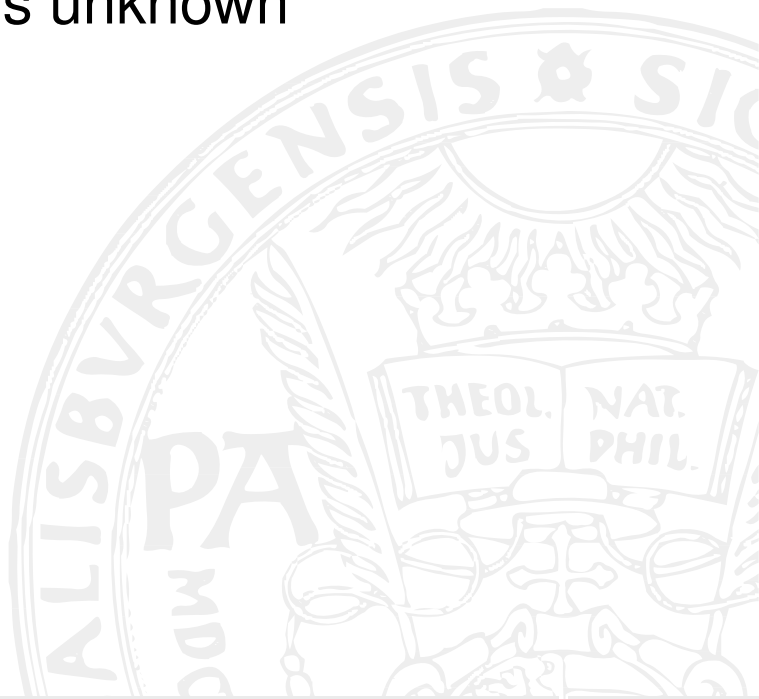
Generation of pseudo perspectives

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



Perspective Multiplication for MPE IV

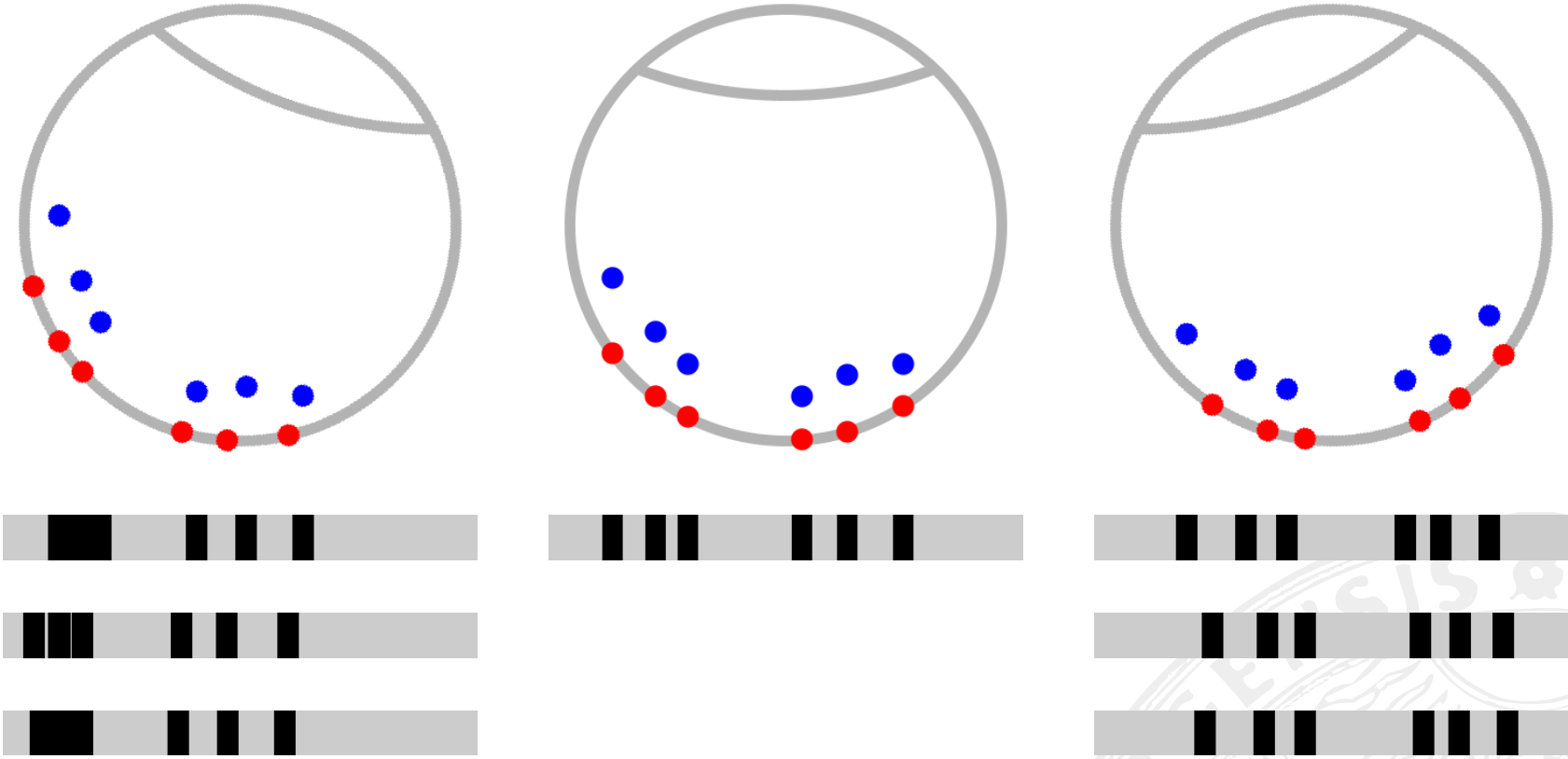


Figure: Principle of pseudo perspective generation. Top: cross sections of a finger acquired during enrolment. The blue points depict the veins inside the finger, the red points the veins projected on the skin surface of the finger. Bottom: projected vein patterns.

Samples of generated pseudo-perspectives

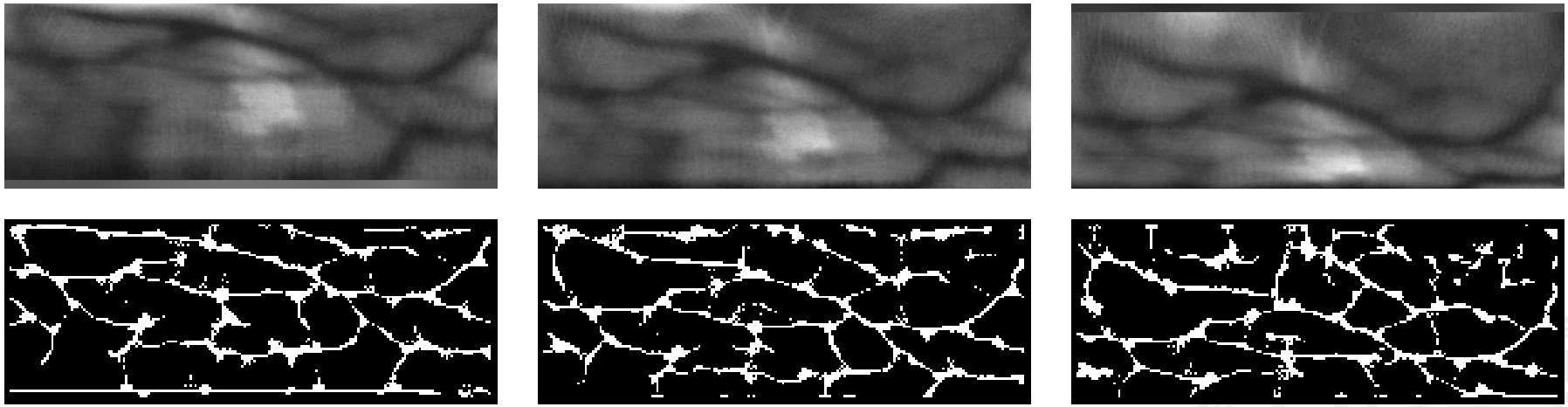


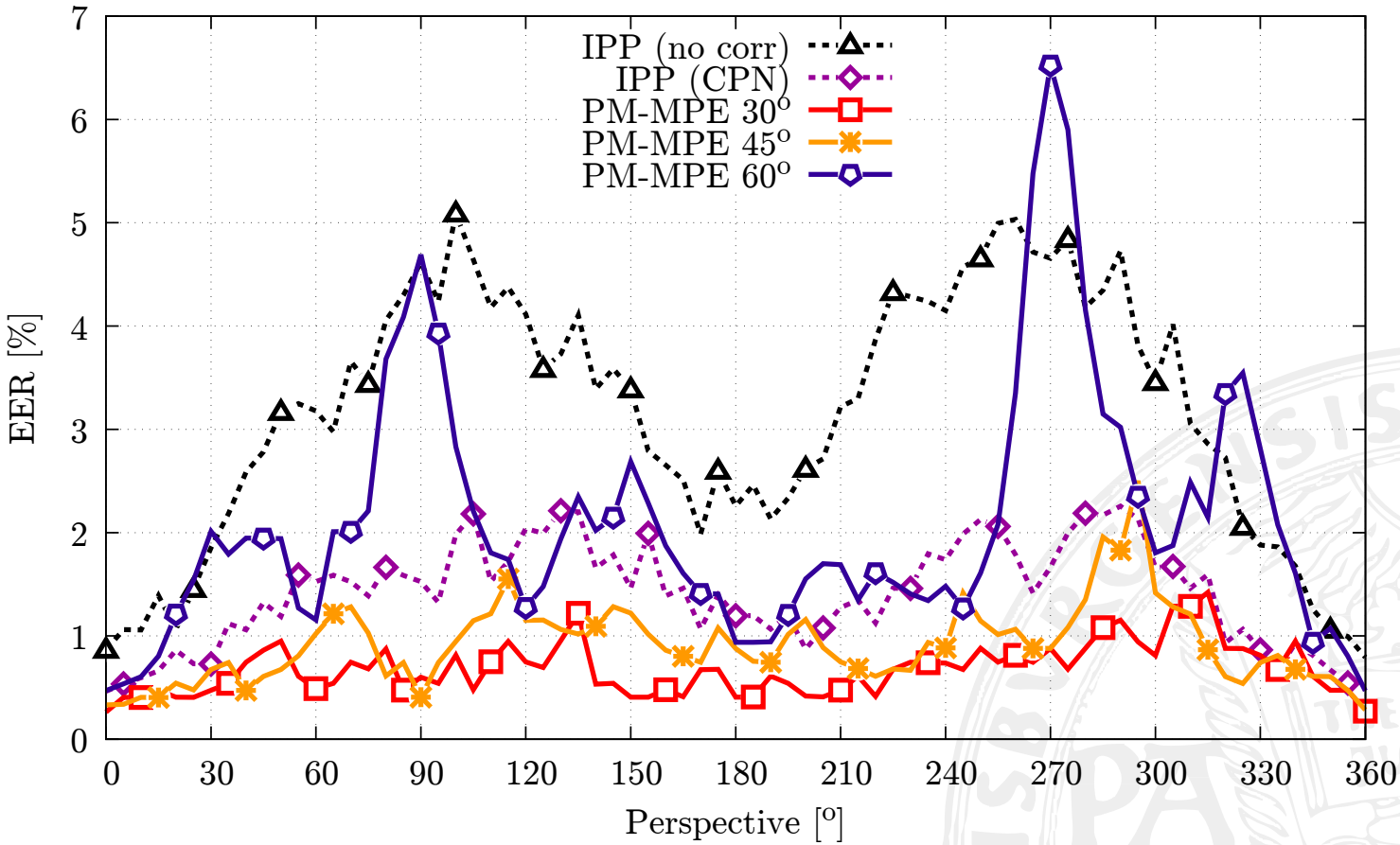
Figure: ROI (top row) and extracted MC features (bottom row) of sample images of the PLUSVein-FR. Middle: enrolment image, left and right: generated pseudo perspectives for $\varphi = \pm 20°$.

Perspective Multiplication for MPE VI

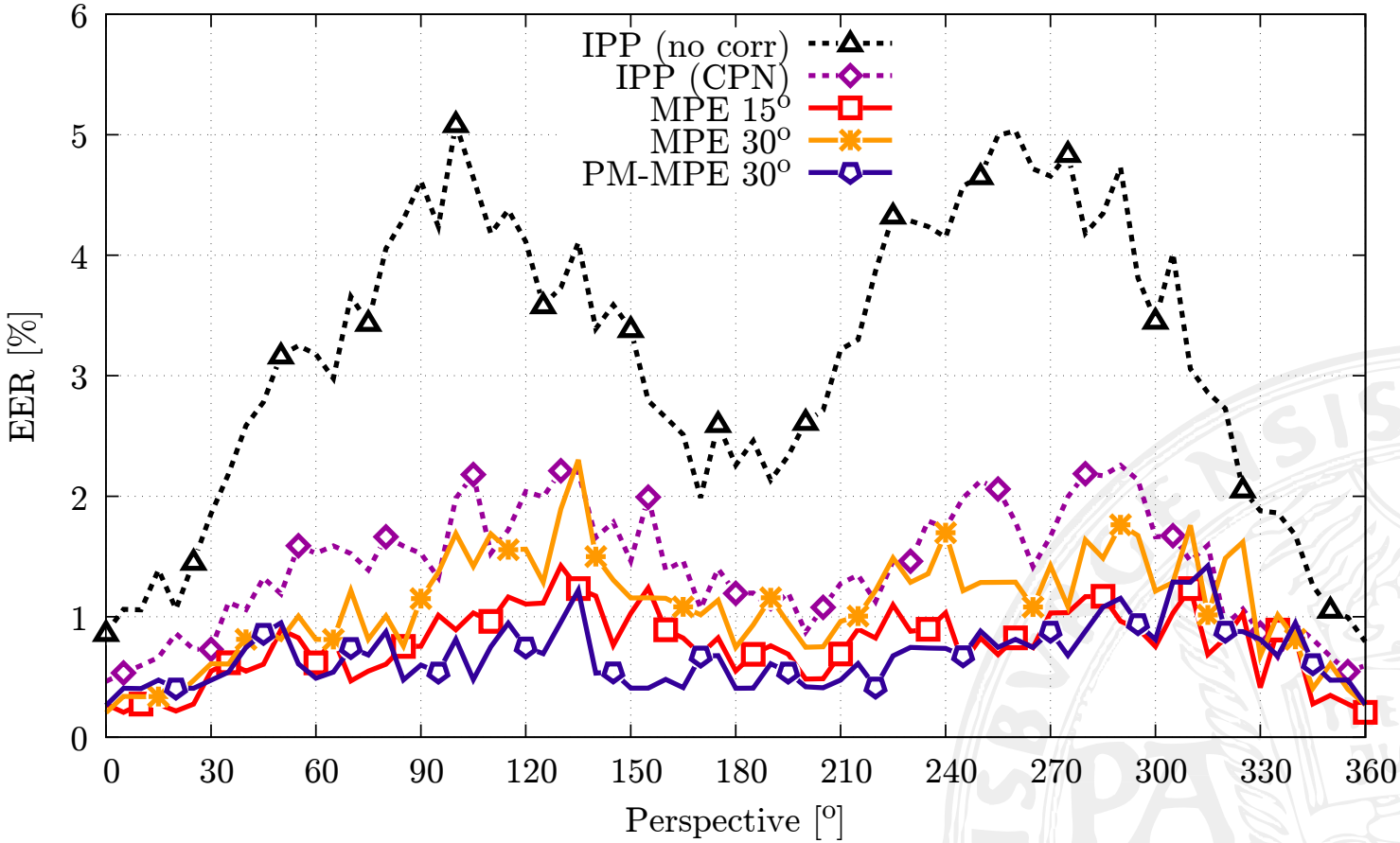
Experiments & Results

- PLUSVein-FR [15] (360°, step size: 5°)
- Intra-perspective performance results
  - no correction
  - circular pattern normalization (CPN)
- Perspective multiplication for MPE (PM-MPE)
  - utilizing CPN
  - $\alpha = 30° \rightarrow$ 12 perspectives
  - $\alpha = 45° \rightarrow$ 8 perspectives
  - $\alpha = 60° \rightarrow$ 6 perspectives
- n perspectives enrolled $\rightarrow 3 \cdot n$ comparisons during recognitions
- reduction of horizontal shift by 50% compared to MPE

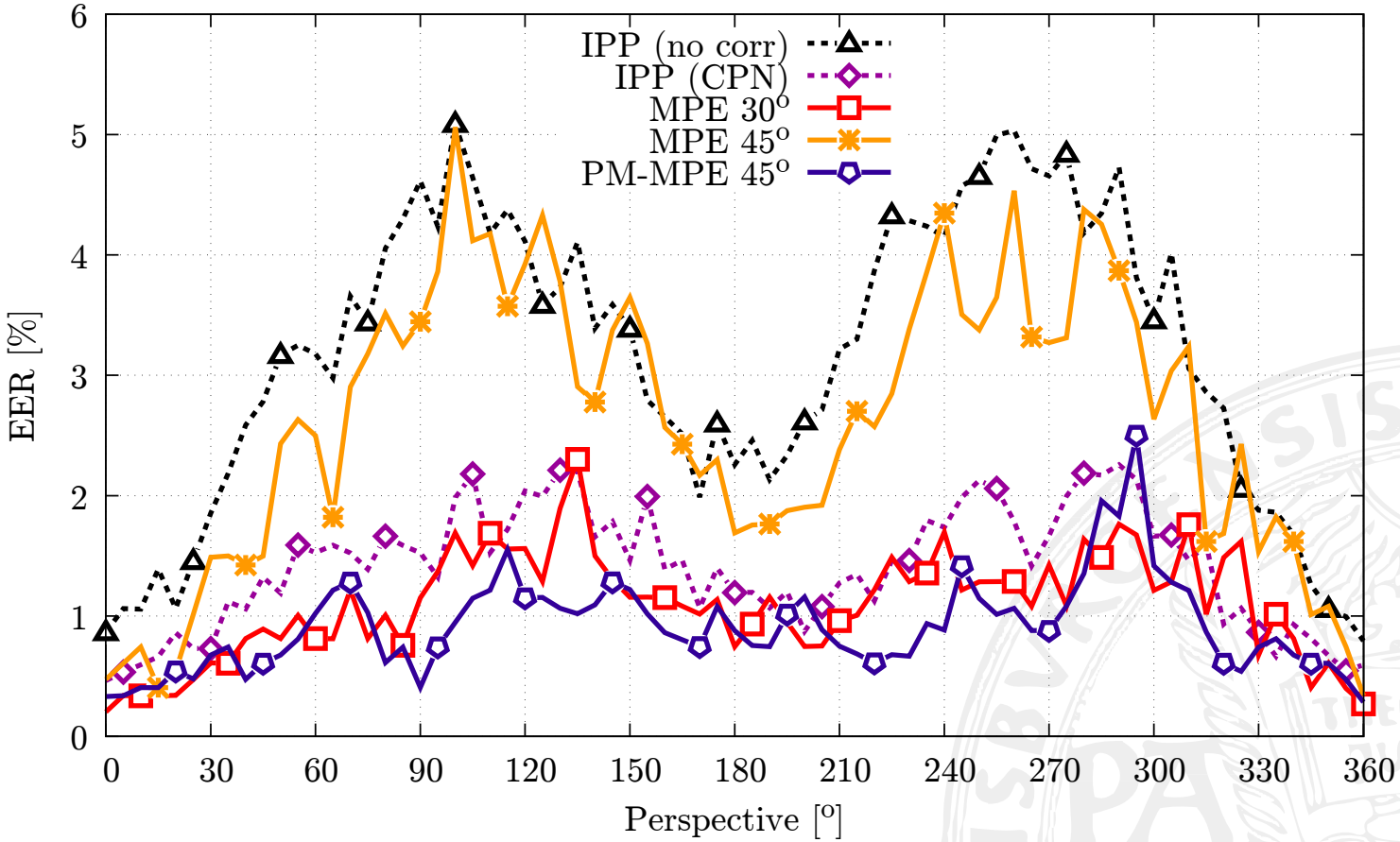
Recognition performance (EER): intra-perspective vs PM-MPE



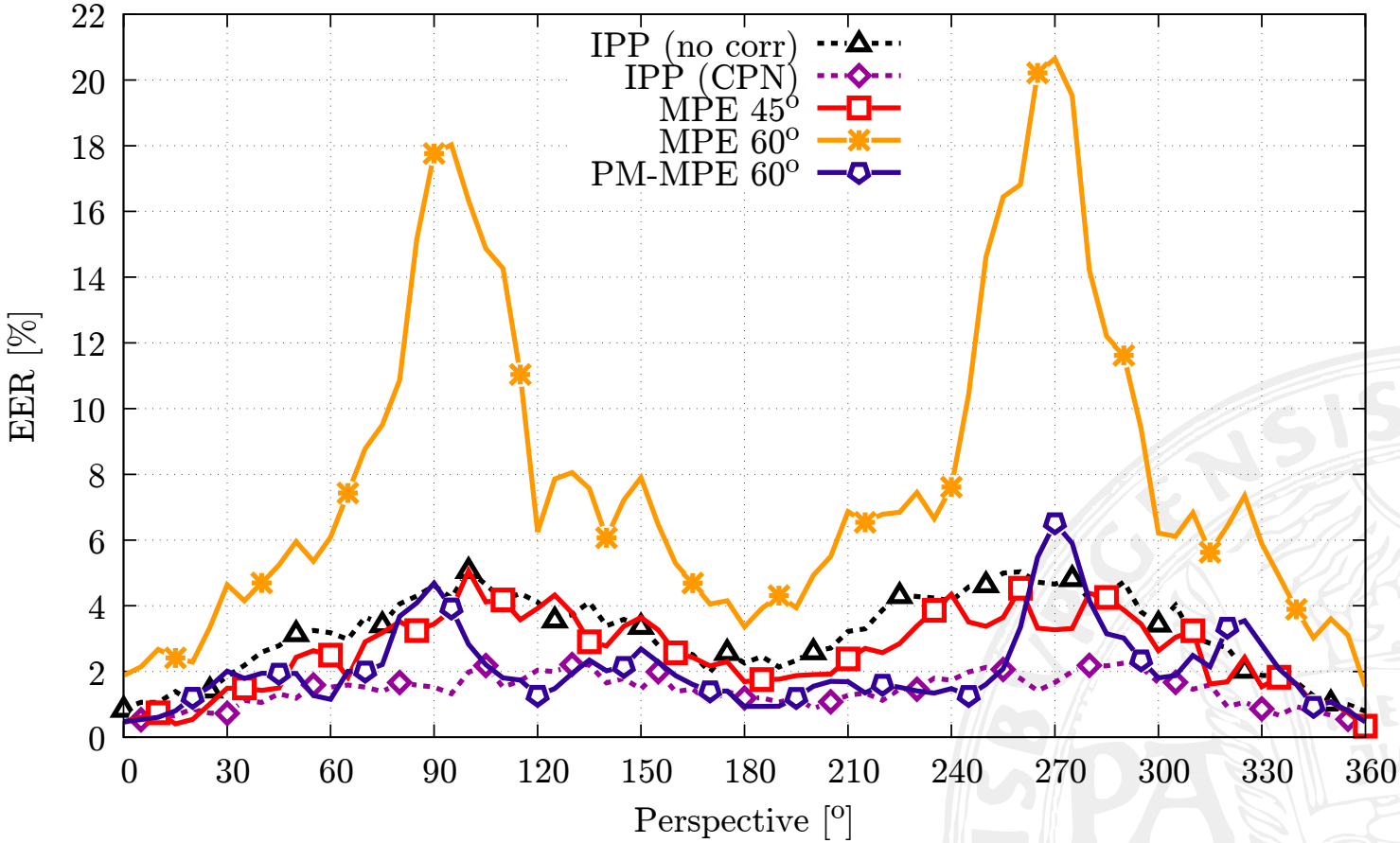
Recognition performance (EER): MPE vs PM-MPE 30°



Recognition performance (EER): MPE vs PM-MPE 45°



Recognition performance (EER): MPE vs PM-MPE 60°



Conclusion and Future Work I

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 allwos an increase of the distance between two enrolment perspectives by 15° while still getting similar or superior results compared to MPE.

Conclusion and Future Work II

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

The End

Thank you!

Q & A

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