Rotation Detection in Finger Vein Biometrics using CNNs

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Problem of Longitudinal Finger Rotation

- Recognition accuracy of finger vein recognition systems suffer from misplacements of the finger during acquisition
- Especially longitudinal finger rotation is hard to avoid
- Longitudinal rotation changes the vein pattern in a non-linear matter
- Recognition systems have problems handling rotated images

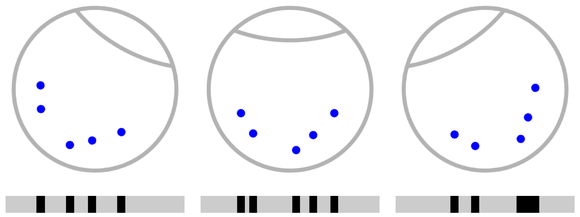

Figure 1: A schematic finger cross section showing five veins (blue dots) acquiered at -30° (left), 0° (middle) and 30° (right).

Proposed solution

Proposal of a CNN based rotation detector that returns the rotational difference between two finger vein samples.

Data Sets

- PROTECT Multimodal Dataset (PMMDB) for CNN training
- PLUSVein Finger Rotation data set (PLUSVein-FR) for evaluation
- SDUMLA-HMT, FV-USM, UTFVP and PLUSVein-FV3 for to verify generalisability of the proposed model.

PMMDB and PLUSVein-FR provide finger vein images all around the finger (360°) in steps of 1°
→ rotational difference between finger vein samples is known.

CNN Training

- **Architecture**: ResNeXt-101 (pre-trained on ImageNet database)
- **Input**: 2-channel input, each channel containing rotated versions of the same finger from PMMDB.
- **Output**: Rotational difference $\hat{\varphi}$ in degree [°]
- **Loss-Function**: Mean squared error (MSE)

$$L = \frac{1}{N}\sum_{i=1}^{N}(\varphi_i - \hat{\varphi}_i)^2$$

- Input images are taken from defined rotational ranges ($\pm\Theta$)

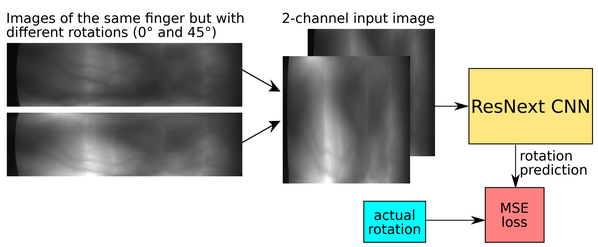

Figure 2: Scheme of CNN training for rotation estimation

Acknowledgement

This project was partly funded from the FFG KIRAS project AUTFingerATM under grant No. 864785 and the FWF project "Advanced Methods and Applications for Fingervein Recognition" under grant No. P 32201-NBL.

Rotation Detection Results

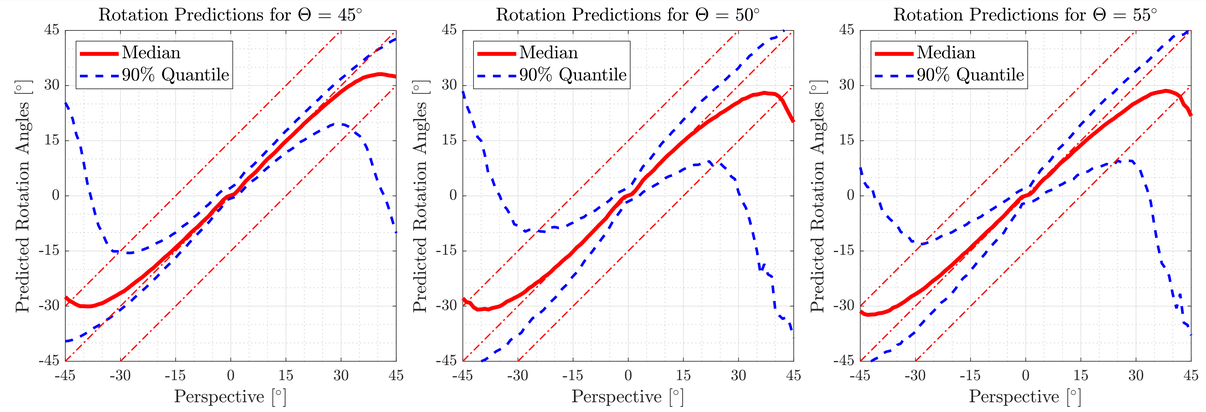

Figure 3: Results of rotation detection on PLUSVein-FR (median and 90% quantile) for different training ranges Θ. From left to right: ±45°, ±50°, and ±55°

- Predicted angle is average of rotation detection in both directions:

$$\Phi_{i(\alpha)} = \text{avg}\left(\hat{\varphi}_{i(\alpha),\text{ref}}, -\hat{\varphi}_{\text{ref},i(\alpha)}\right)$$

- Evaluation range: ±45° around the palmar view
- Best results for $\Theta = \pm 45°$
- Stable results up to ±30°

Verification of the Generalisability of the Presented approach

- Evaluate change (improvement) of recognition performance
- Using 4 publicly available finger vein data sets
- Data sets contain different amount of longitudinal finger rotation
- Predict rotation angles using the proposed method
- Align images ahead of evaluation
- Performance increases for all data sets (up to 263%)
- **CNN was not retrained for evaluated data sets!**

Data Set	Method	EER [%]	RPI [%]
SDUMLA-HMT	original	4.73	-
	aligned	1.30	263.40
FV-USM	original	1.23	-
	aligned	0.52	137.03
UTFVP	original	0.42	-
	aligned	0.18	125.47
PLUSVein-FV3	original	0.08	-
	aligned	0.05	61.23

Table 1: Recognition performance (EER) and relative performance increase (RPI)

Conclusion

- Proposal of a CNN-based rotation detector to estimate longitudinal rotation of two finger vein image samples.
- Fast prediction (approximately 15ms on a GPU system)
- Stable results in the range of ±30°
- Rotation detector is not limited to a single data set (can be reused without retraining)
- Can be used in live systems (rotation detection and correction ahead of every biometric comparison)