On the Extent of Longitudinal Finger Rotation in Publicly Available Finger Vein Data Sets

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Abstract

Finger vein recognition deals with the identification of a subjects based on its venous pattern within the fingers. The majority of the publicly available finger vein data sets has been acquired with the help of scanner devices that capture a single finger from the palmar side using light transmission. Some of them are equipped with a contact surface or other structures to support in finger placement. However, these means are not able to prevent all possible types of finger misplacements, in particular longitudinal finger rotation can not be averted. It has been shown that this type of finger rotation results in a non-linear deformation of the vein structure, causing severe problems to finger vein recognition systems. So far it is not known if and to which extent this longitudinal finger rotation is present in publicly available finger vein data sets.

Contribution

- Evaluation of the presence of longitudinal finger rotation in publicly available finger vein data sets.
- Estimation of rotation angles between samples of the same finger.
- Enhance value of data sets by providing the actual rotation angles.

Results are available for download at:
http://wavelab.at/sources/Prommegger19c

Longitudinal Finger Rotation

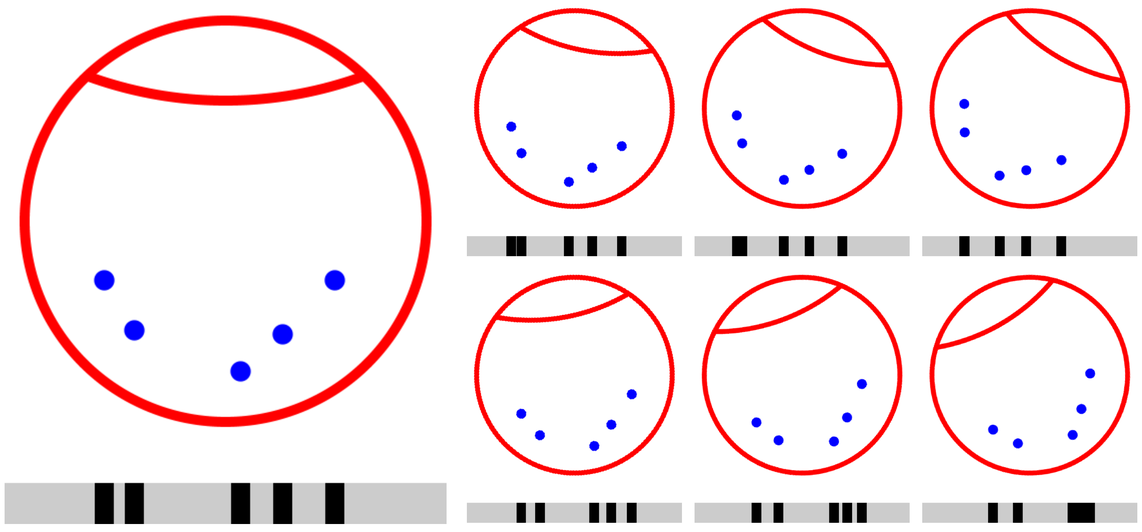

Figure 1: Longitudinal finger rotation principle: a schematic finger cross section showing five veins (blue dots) rotated from -30° (left) to +30° (right) in 10° steps. The projection (bottom row) of the vein pattern is different depending on the rotation angle according to a non-linear transformation.

Data Sets

- 4 publicly available data sets: SDUMLA-HMT, UTFVP, FV-USM, PLUSVein-FV3
- Also visible differences in the extent of longitudinal finger rotation in the data sets
- Data sets do not provide rotation angles between the samples of a finger

Name	Subjects	Finger	Samples	Images	View
SDUMLA-HMT	106	6	6	3816	palmar
UTFVP	60	6	4	1440	palmar
FV-USM	123	4	12	5904	palmar
PLUSVein-FV3	60	6	5	1800	dorsal

Table 1: Evaluated finger-vein data sets

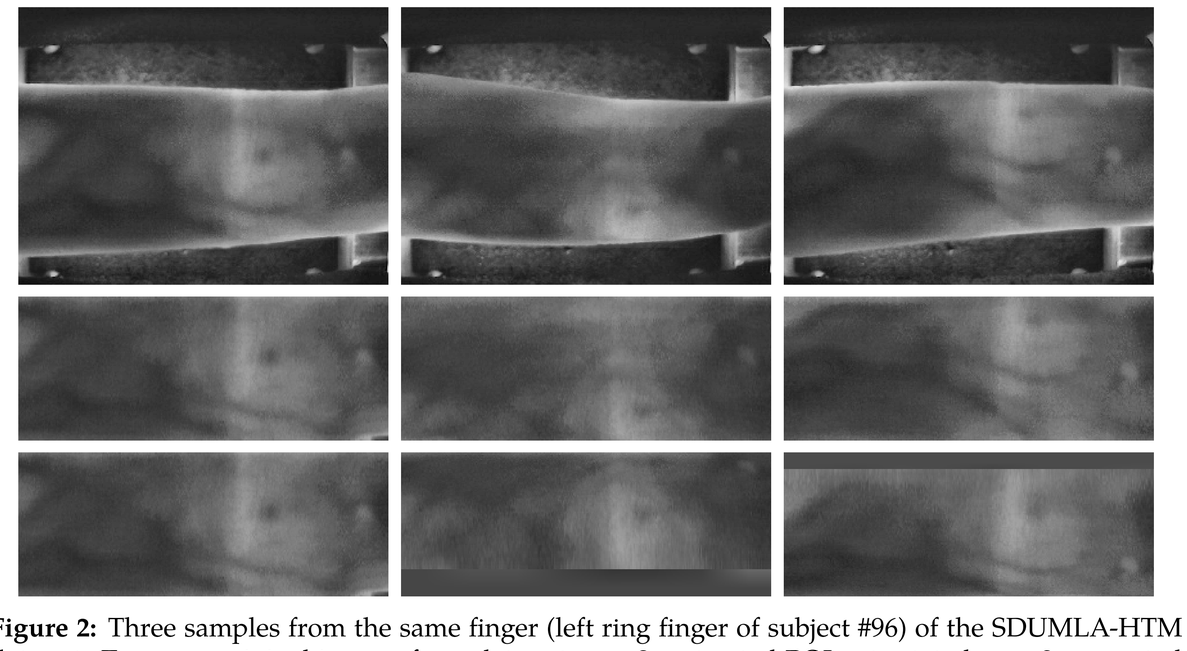

Figure 2: Three samples from the same finger (left ring finger of subject #96) of the SDUMLA-HTM data set. Top row: original images from data set, row 2: extracted ROI not rotated, row 3: corrected ROI. The left column shows sample #1 (reference image), the middle sample #4 (rotation angle: 44°) and the right sample #6 (rotation angle: -32°). All images are enhanced using CLAHE.

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Estimation of Rotation Angle

- Comparison of rotated versions of a sample against reference image
- Maximum curvature features combined with Miura matcher
- Comparison range: ±45°

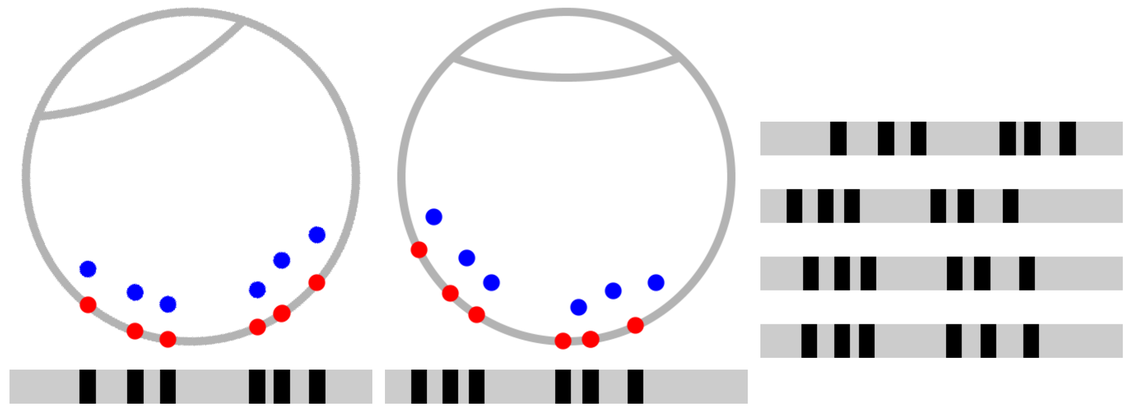

Figure 3: Principle of rotation correction. Left: finger rotated with 25°. The blue points depict the veins inside the finger, the cyan points the veins projected on the finger shape. The bar below is the projected vein pattern. Middle: the cyan points represent the rotation corrected vein pattern on the skin, the blue points represent the veins in the finger in its original position from the palmar view. The bar below is the rotation corrected vein pattern. 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).

$$\begin{bmatrix} x_r \\ y_r \end{bmatrix} = \begin{bmatrix} cos(-\varphi_{rotate}) & -sin(-\varphi_{rotate}) \\ sin(-\varphi_{rotate}) & cos(-\varphi_{rotate}) \end{bmatrix} * \begin{bmatrix} x \\ y \end{bmatrix} \quad (1)$$

$$y = \sqrt{r^2 - x^2} \quad (2)$$

$$\varphi_{i,j} = \underset{-45° \leq \varphi_{rotate} \leq +45°}{arg\ max} score(i, j, \varphi_{rotate}) \quad (3)$$

$$\Phi_{i,1} = \text{avg}\left(\varphi_{i,1} \cdot \varphi_{1,i}\right) \quad (4)$$

x, y	Coordinates in acquired image
x_r, y_r	Coordinates in rotated image
φ_{rotate}	Rotation angle
r	Approximated radius of finger
$\varphi_{i,j}$	Rotation angle between 2 samples
$\Phi_{i,1}$	Rotation angle to first sample

Results

Data Set	Rotation to mean								
	0° - 5°	5° - 10°	10° - 15°	15° - 20°	20° - 25°	25° - 30°	30° - 35°	35° - 40°	40° - 45°
SDUMLA-HMT	56.4%	21.5%	10.4%	6.2%	2.7%	1.6%	0.8%	0.4%	0.1%
UTFVP	85.2%	13.9%	0.8%	0.1%	-	-	-	-	-
FV-USM	80.0%	15.3%	3.7%	0.8%	0.2%	-	-	-	-
PLUSVein-FV3	98.4%	1.6%	-	-	-	-	-	-	-

Table 2: Distribution of longitudinal finger rotation in classes of size 5°.

Data Set	Absolute Distance to Mean			Maximum Distance		
	Mean	Max	Std	Mean	Max	Std
SDUMLA-HMT	6.43	44.83	6.90	19.40	77.00	15.73
UTFVP	2.65	16.50	2.29	7.95	29.50	4.41
FV-USM	3.04	23.83	3.23	11.32	41.00	7.75
PLUSVein-FV3	1.37	8.60	1.24	4.46	12.50	2.44

Table 3: Statistical data on the degree of rotation present in the data sets.

Data Set	Version	Performance Indicators				
		EER	FMR100	FMR1000	ZeroFMR	RPI
SDUMLA-HMT	ORI	4.73 (±0.22)	6.12	8.09	63.25	-
	ROT	**1.07** (±0.11)	1.13	1.72	59.91	**341.6**
	ROT Mean	1.14 (±0.11)	1.18	1.82	47.77	315.8
UTFVP	ORI	0.42 (±0.12)	0.23	0.65	3.11	-
	ROT	0.19 (±0.09)	0.19	0.23	1.62	124.5
	ROT Mean	**0.09** (±0.06)	0.05	0.09	1.30	**349.1**
FV-USM	ORI	1.23 (±0.08)	1.30	2.34	5.27	-
	ROT	**0.56** (±0.05)	0.48	0.93	2.47	**120.1**
	ROT Mean	0.77 (±0.06)	0.69	1.42	3.93	59.4
PLUSVein-FV3	ORI	0.08 (±0.05)	0.03	0.08	0.39	-
	ROT	**0.06** (±0.04)	0.00	0.06	0.25	**50.0**
	ROT Mean	0.08 (±0.05)	0.00	0.08	0.22	0.9

Table 4: Recognition performance on the evaluated data sets and its corrected versions: ORI = original data set, ROT = rotation corrected to 1st image, ROT Mean = rotation corrected to mean of finger. Best achieved EER and RPI values are highlighted in bold.

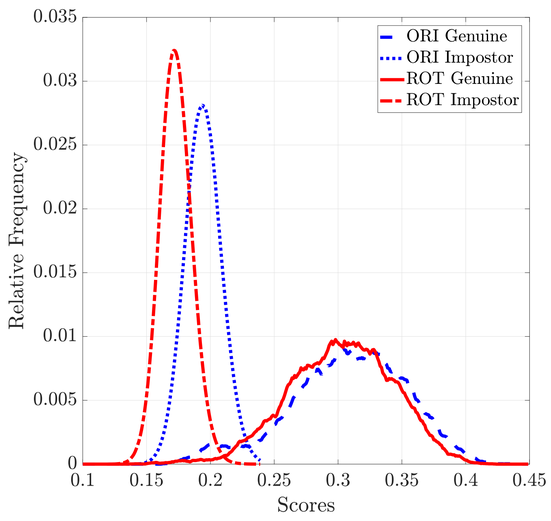

Figure 4: Distribution of genuine and impostor scores for SDUMLA-HMT: ORI = oiriginal data set, ROT = rotation corrected to 1st image

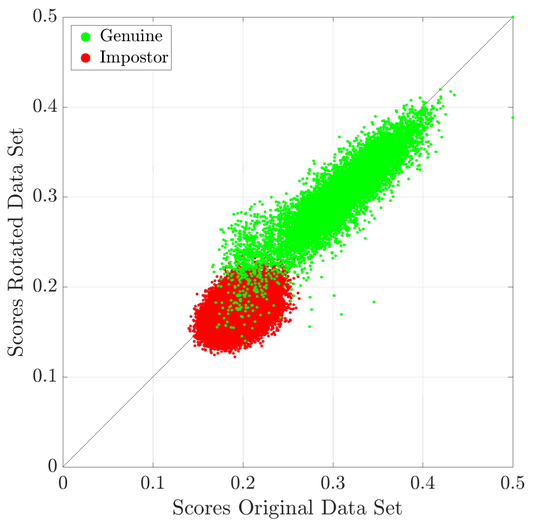

Figure 5: Changes in scores from the original data set to the rotation corrected data set for SDUMLA-HMT