

Palm Vein Biometrics Based on Infrared Imaging and Complex Matched Filtering

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Research is supported by:



ESF project Nr.
1DP/1.1.1.2.0/09/APIA/VIAA/0
20, co-financed by EU

Latvian State research
program in innovative
materials and technologies

The 12th ACM Workshop on Multimedia and Security
September 9-10, Rome, Italy



Motivation

Problem

- Identity fraud
- Linking physical person to a digital identity

Solution

- Biometrics



Why Palm Veins?

- Invisible in daylight
- Hard to falsify
- Unique structure
- Allow distinguish twins
- Easy to use



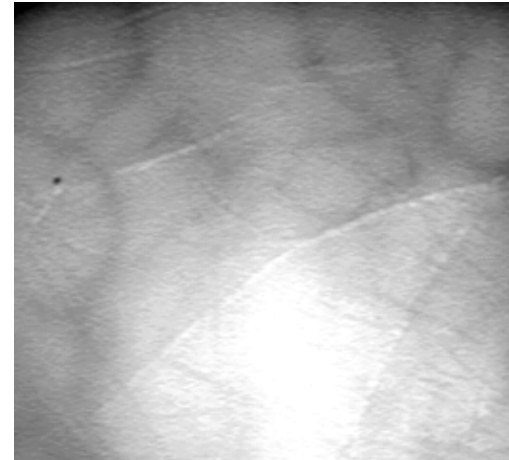
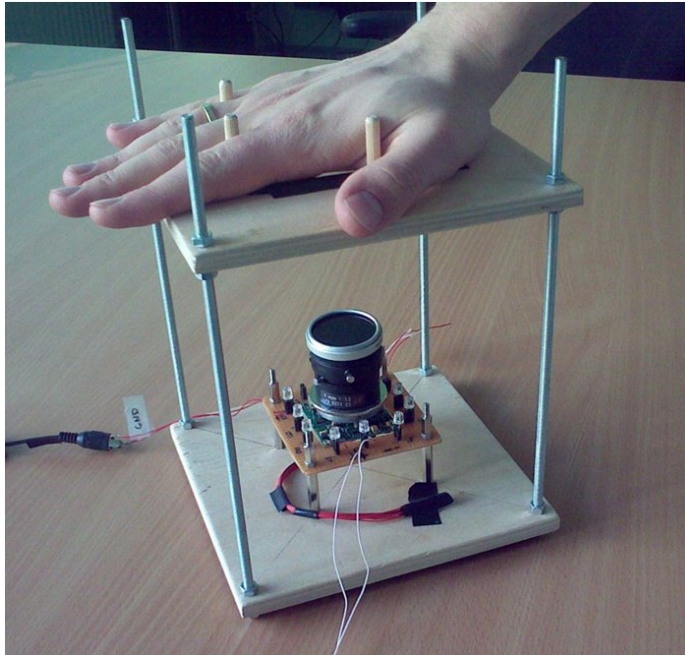
Outline

Image acquisition

Processing

Recognition

Results



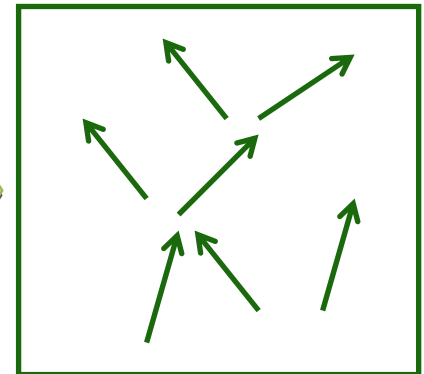
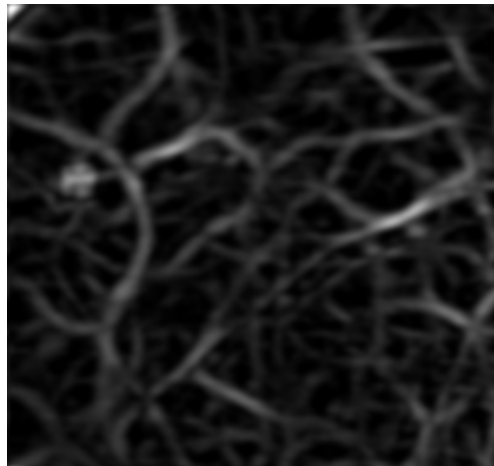
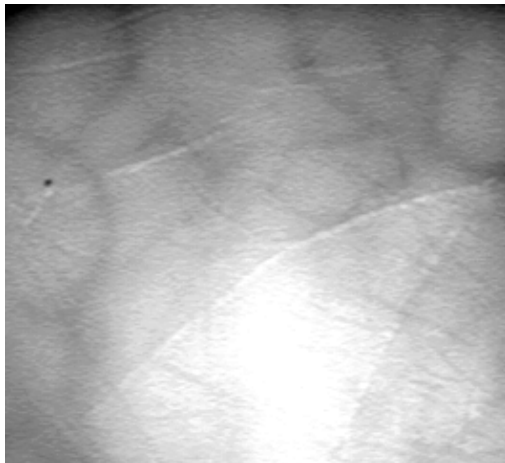
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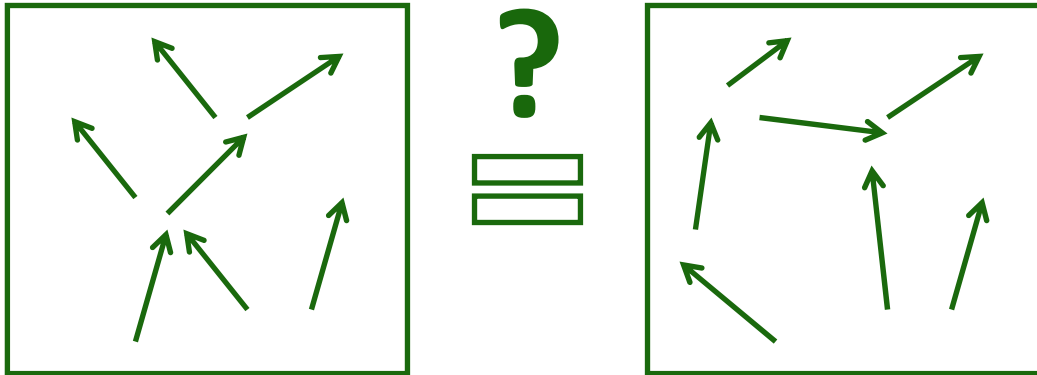
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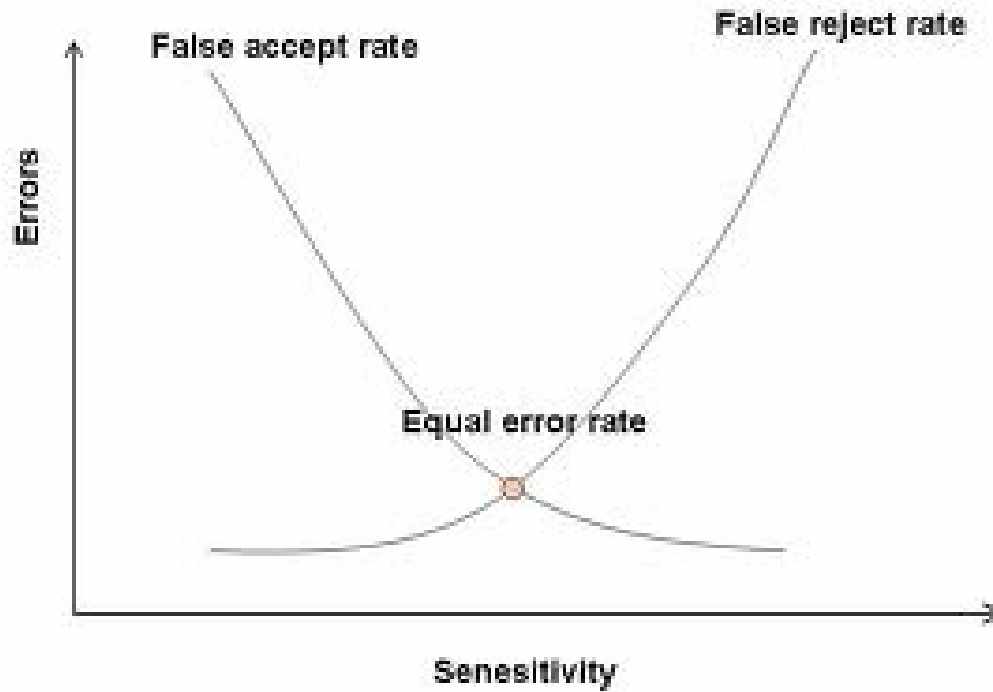
Outline

Image acquisition

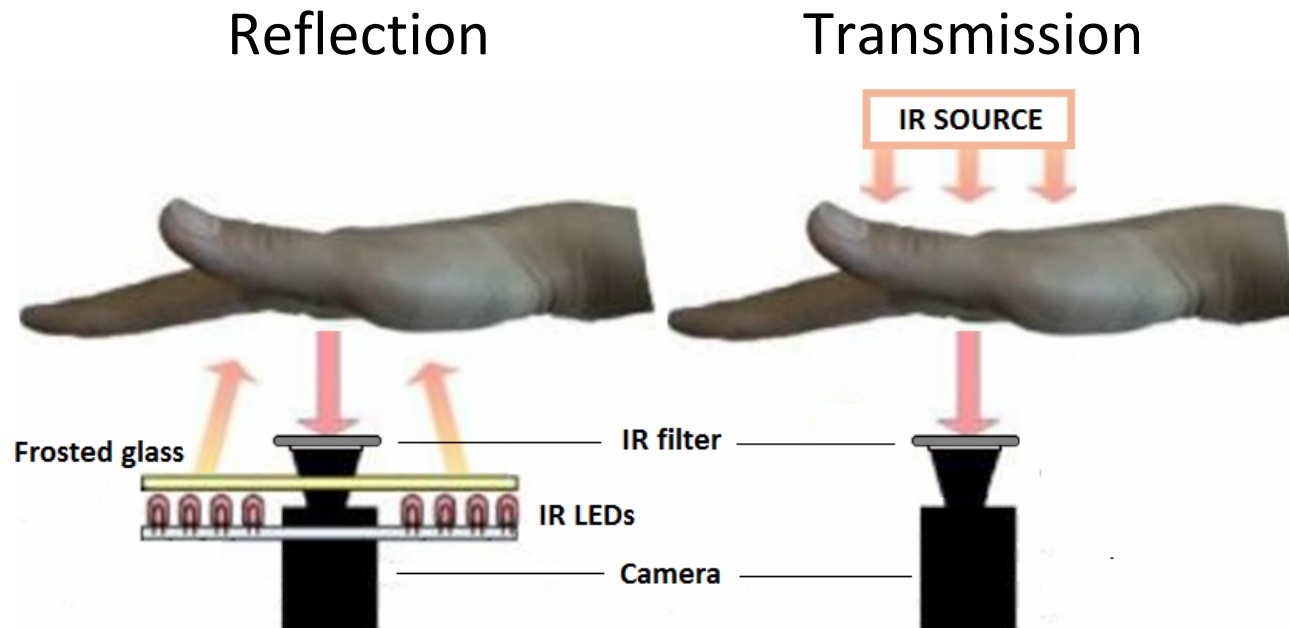
Processing

Recognition

Results



Imaging Methods



Advantages

Low power consumption
Compact design

Disadvantages

Some wrinkles visible

Advantages

Slightly better palm vein visibility

Disadvantages

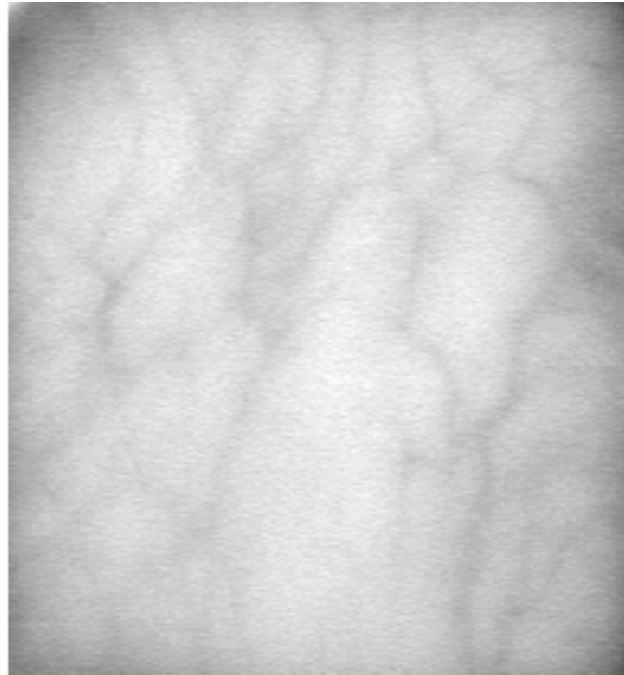
High power consumption
Bulky design



Acquired Images



Visible light



Reflection
method

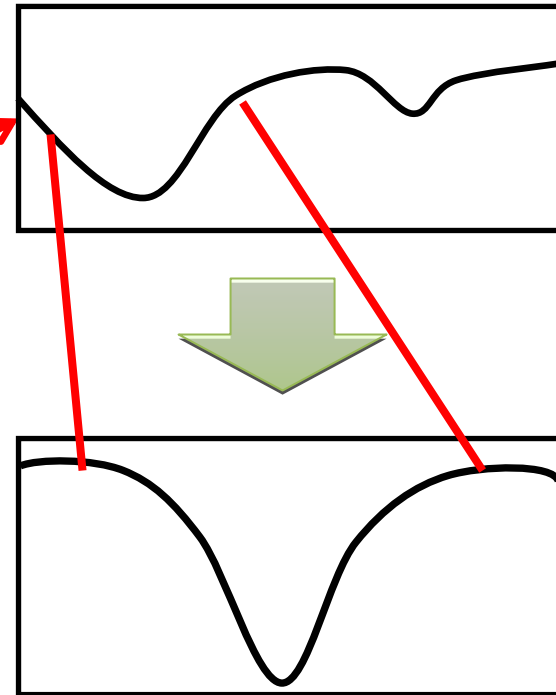
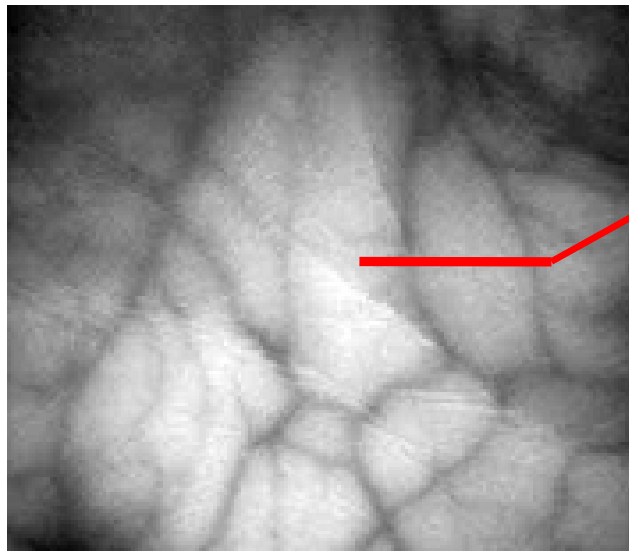


Transmission
method



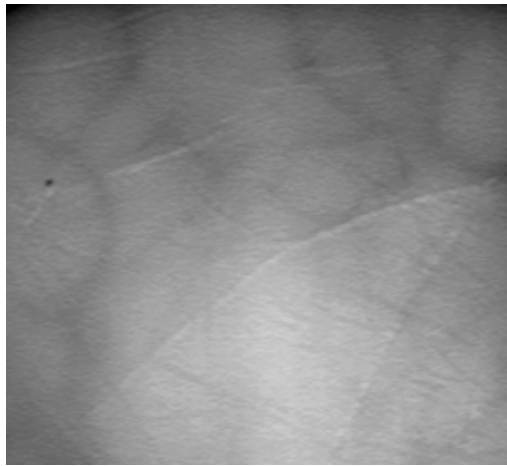
Vessel Analysis

Cross section



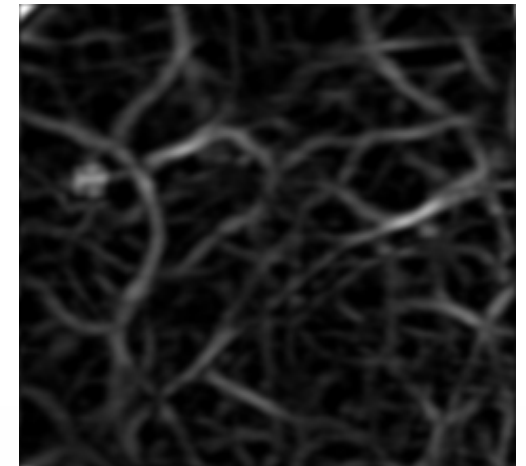
Vessel cross section can be approximated with Gaussian function

Matched Filtering



$$\begin{cases} g_{\phi}(x, y) = -\exp(-x'^2 / 2\sigma_x^2) \\ x' = x \cos \phi + y \sin \phi \end{cases}$$

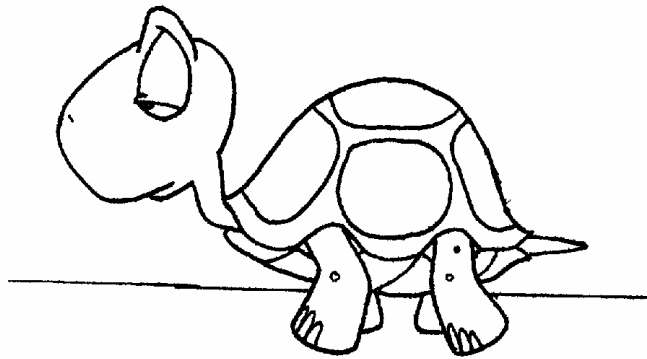
Matched
Filtering



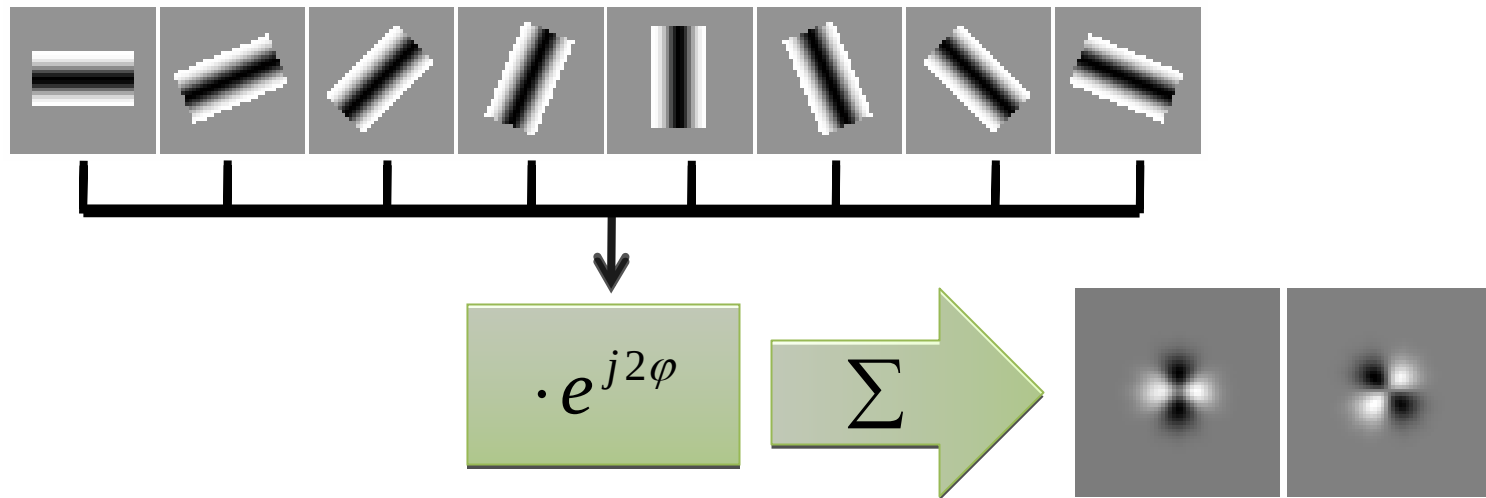
Matched filtering

$$g_{\phi}(x, y) = -\exp(-x'^2 / 2\sigma_x^2)$$

Matched filtering - SLOW



Complex Matched Filtering



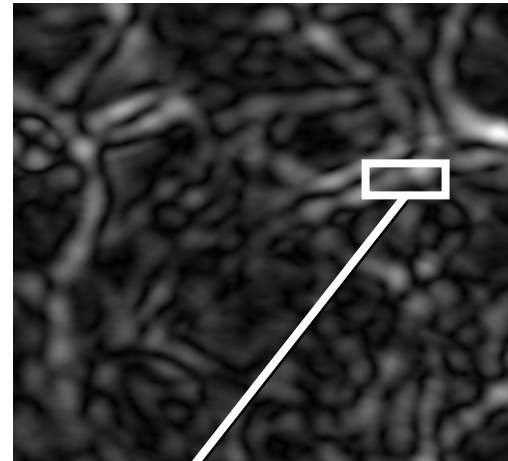
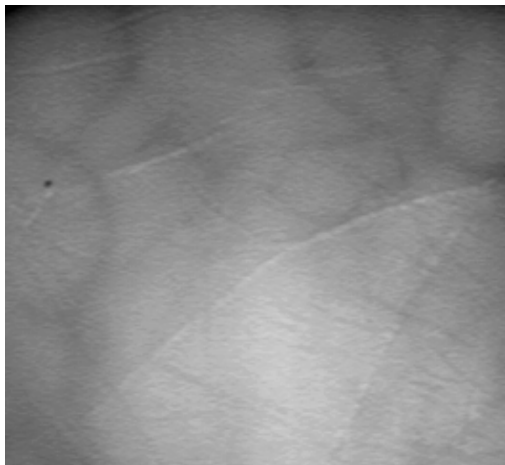
$$CMF(x, y) = \left[\sum_l e^{j2\varphi_l} \cdot G(x, y, \varphi_l) \right]$$

For further information:

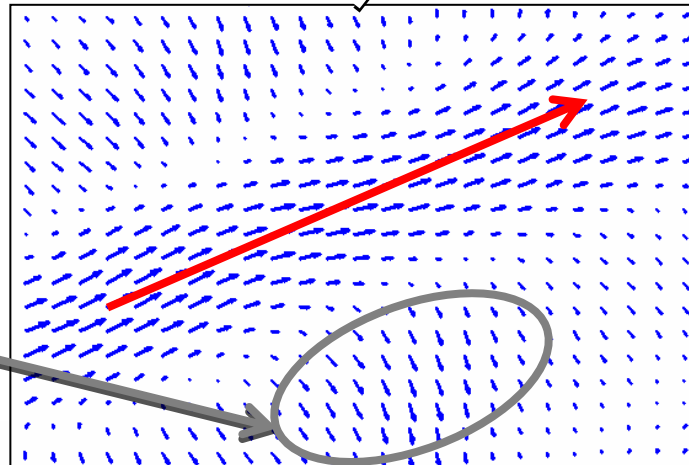
M.Greitans, M.Pudzis, R.Fuksis. „Object Analysis in Images Using Complex 2d Matched Filters”, Proceedings of the IEEE Region 8 Conference EUROCON 2009. Saint–Petersburg, Russia, May, 2009., pp. 1392-1397.



CMF Result

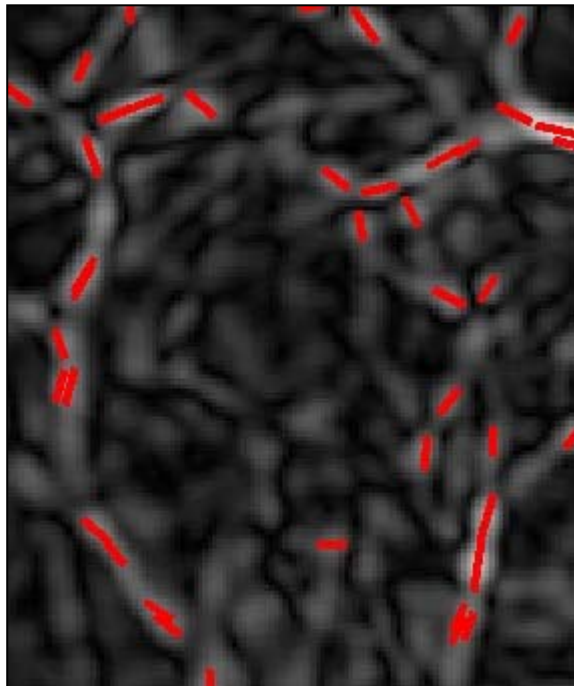


Advantages:
Filtering with one complex mask
Additional information about the vessel's orientation
Drawback: Halo effect

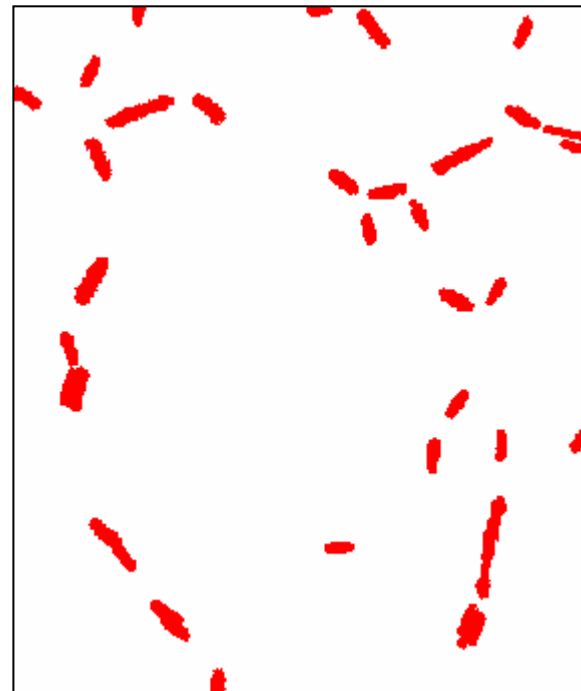


Building Vector Sets

After CMF we can construct the most significant vector set



240x320 pixels



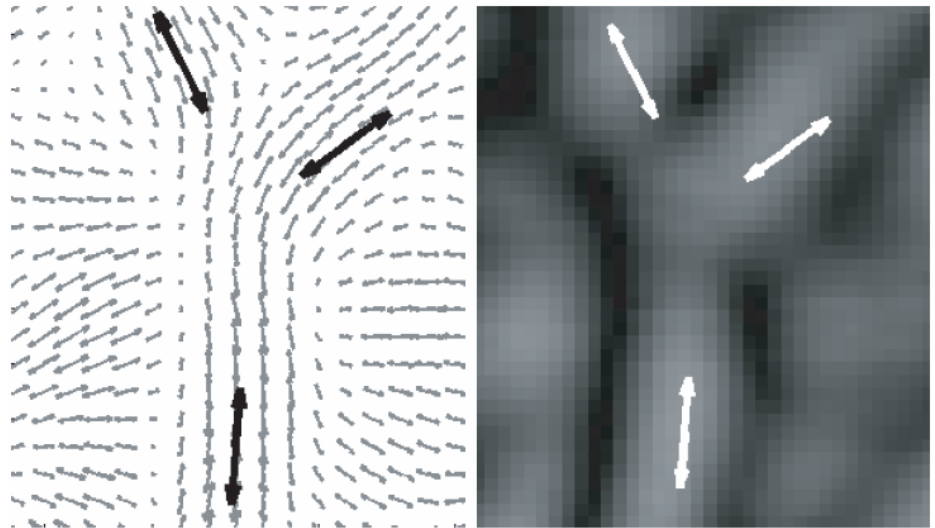
128 bytes



Building Vector Sets

Iterative execution of the following steps:

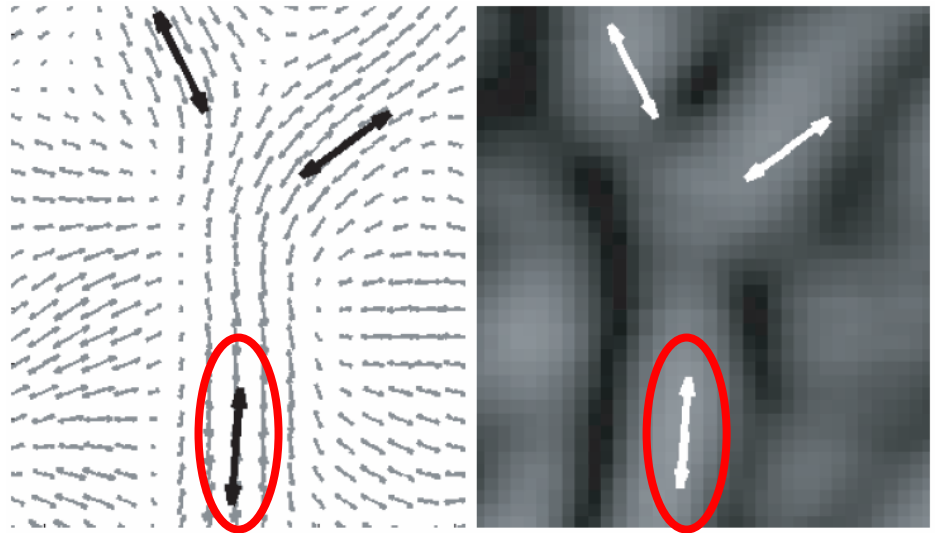
- Find max response
- Save the vector
- Exclude neighbor vectors from further processing
- Continue



Building Vector Sets

Iterative execution of
the following steps:

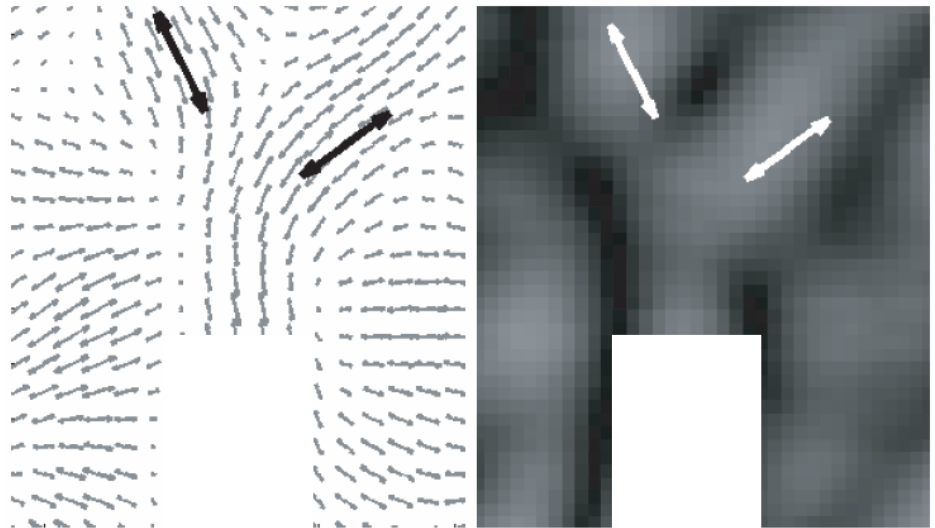
- Find max response
- Save the vector
- Exclude neighbor
vectors from further
processing
- Continue



Building Vector Sets

Iterative execution of the following steps:

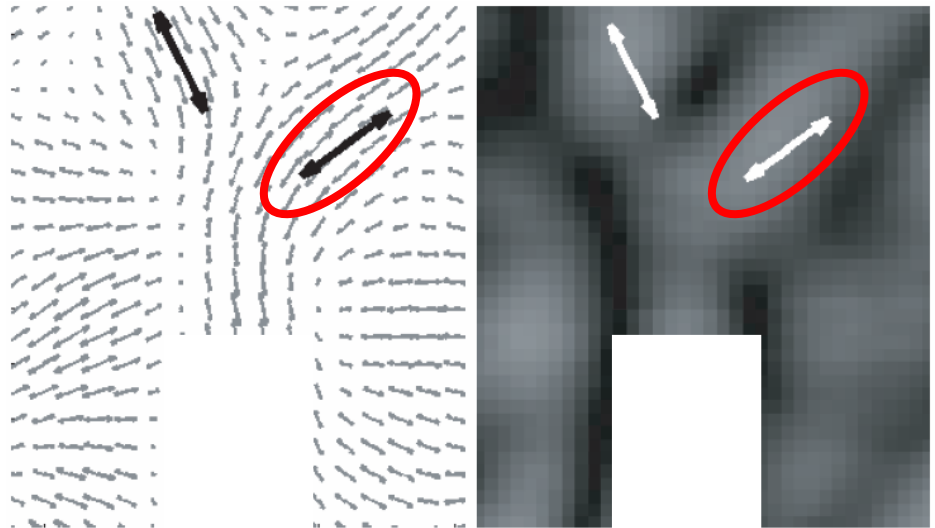
- Find max response
- Save the vector
- Exclude neighbor vectors from further processing
- Continue



Building Vector Sets

Iterative execution of the following steps:

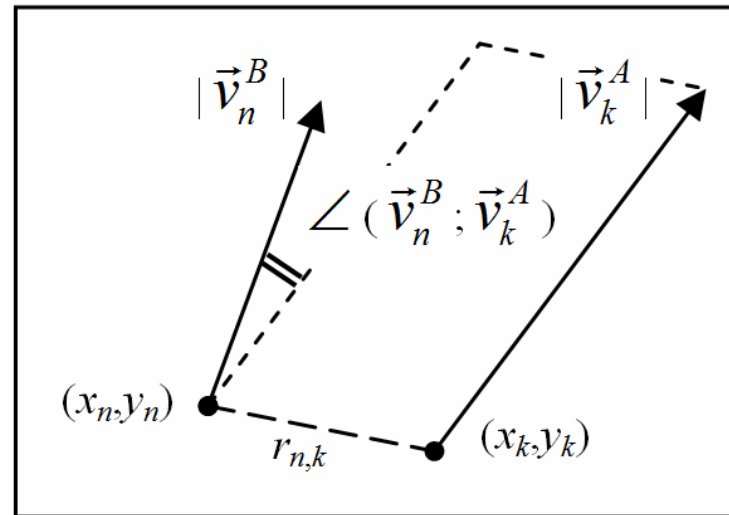
- Find max response
- Save the vector
- Exclude neighbor vectors from further processing
- Continue



Comparison of Vectors

Calculation of similarity:

1. Pair of longer vectors have greater influence on similarity
2. Closely oriented vectors have greater impact
3. Closer the vectors – more considerable contribution



3 Impact factors:

magnitudes

angles

distance

$$s_{nk}^{(AB)} = \overbrace{|\vec{v}_n^B| \cdot |\vec{v}_k^A|}^{\text{magnitudes}} \cdot \overbrace{|\cos \angle(\vec{v}_n^B; \vec{v}_k^A)|}^{\text{angles}} \cdot \overbrace{\exp\left(-\frac{r_{n,k}^2}{\sigma^2}\right)}^{\text{distance}}$$

Comparison of Vector Sets

Similarity index of two vector sets:

$$s(B, A) = \sum_{n=1}^N \sum_{k=1}^K s_{n,k}^{(BA)}$$



Normalization

$$S(B, A) = \frac{s(B, A)}{\sqrt{s(B, B) \cdot s(A, A)}}$$

Drawbacks:

1. Index is influenced by image contrast
2. Neighborhood vessel impact on similarity

Advantages:

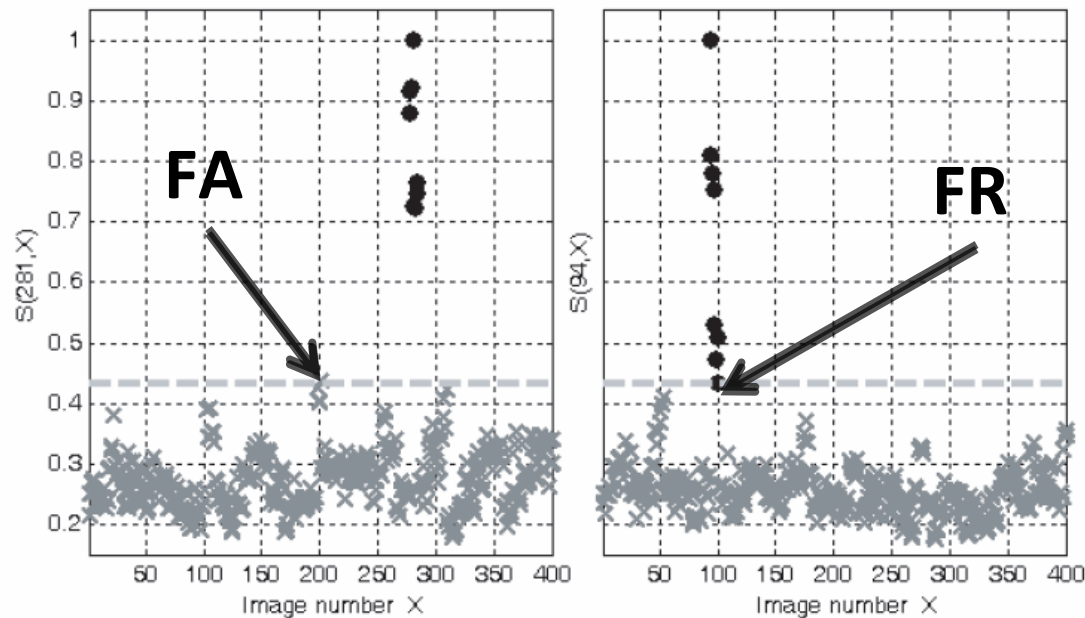
1. Value is normalized between 0 and 1

Algorithm is not rotation and scale invariant – we have used the palm fixing stand for accurate image acquisition without shifts

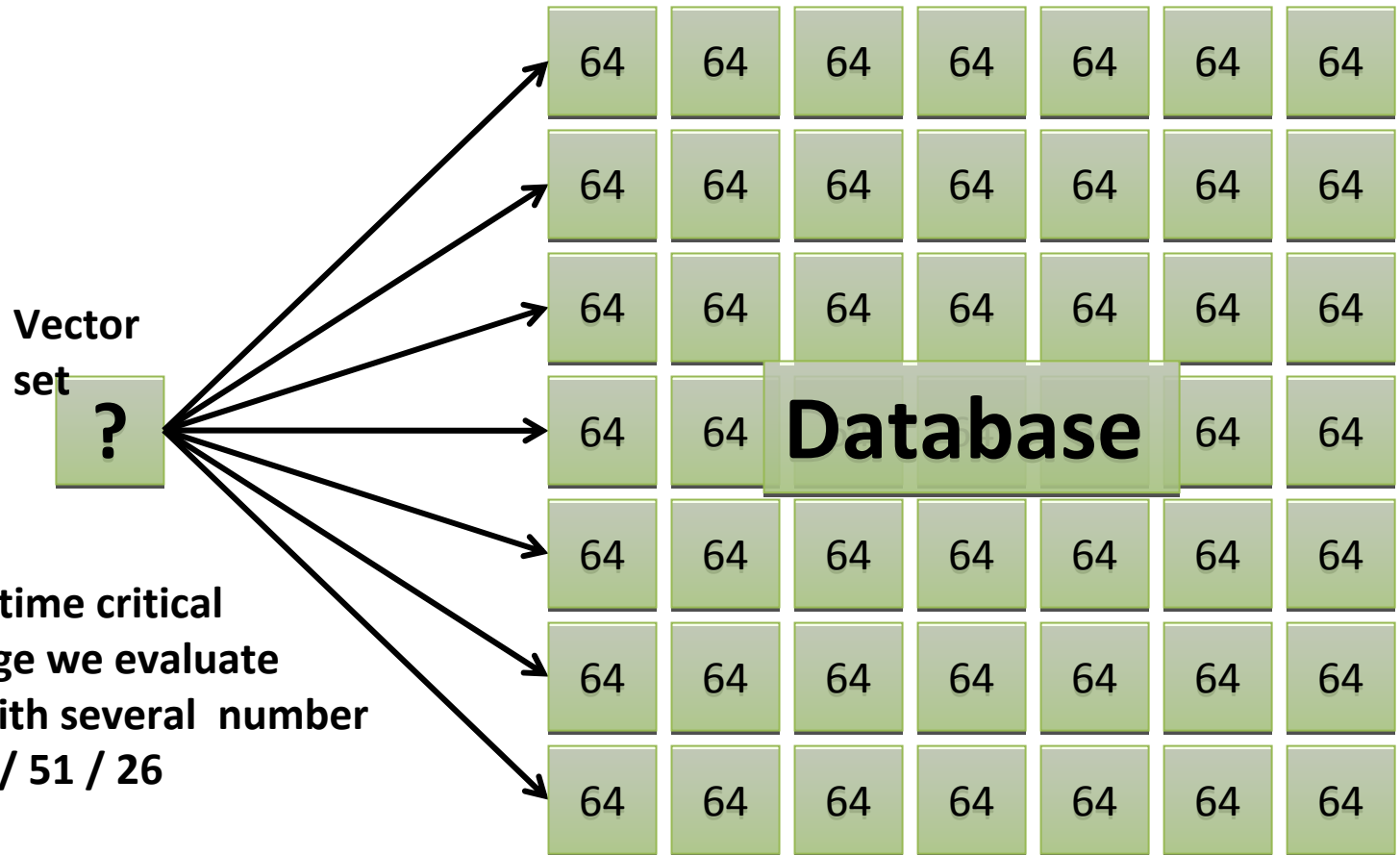


Construction of the Database

- Database of 400 images from 50 persons
- Result of comparison for 2 cases



Comparison with Database



Because of the time critical recognition stage we evaluate performance with several number of vectors - 64 / 51 / 26



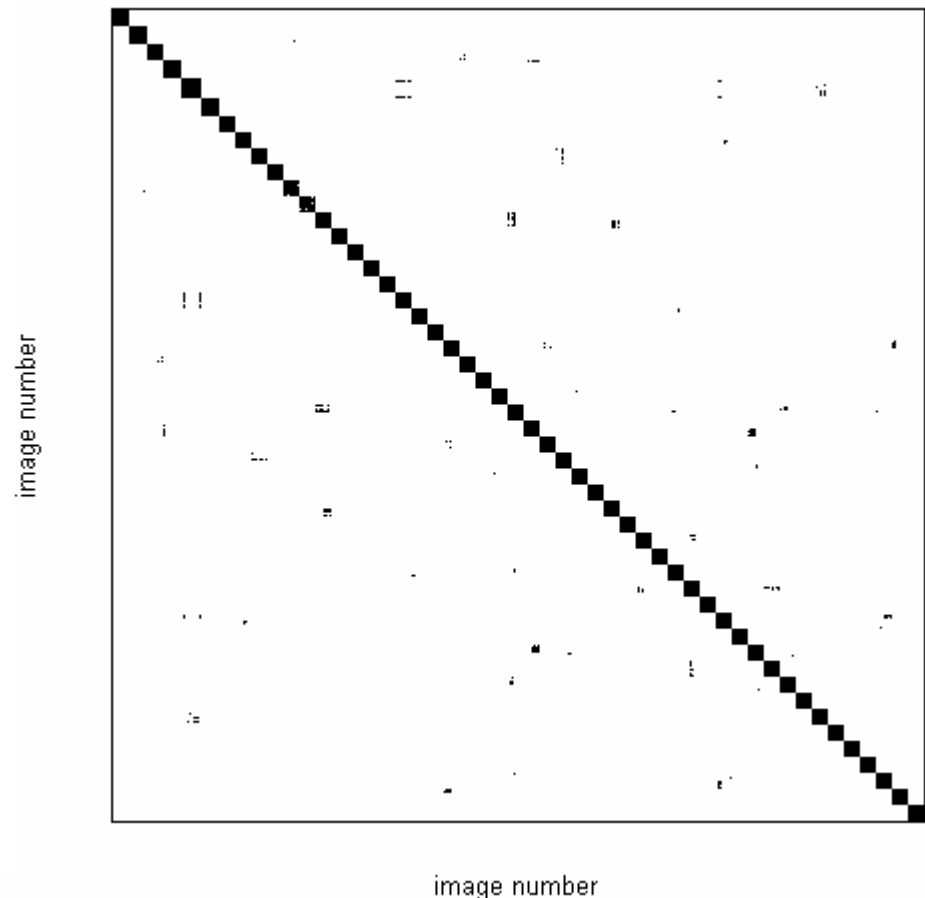
Results of database evaluation

Each image is compared with each other image in database

Each black square represents the 8 images of each person

**Black dots represent the FA
White dots represent the FR**

Thresholded similarity indexes matrix, using 64 of 64 vectors, EER=0.17%



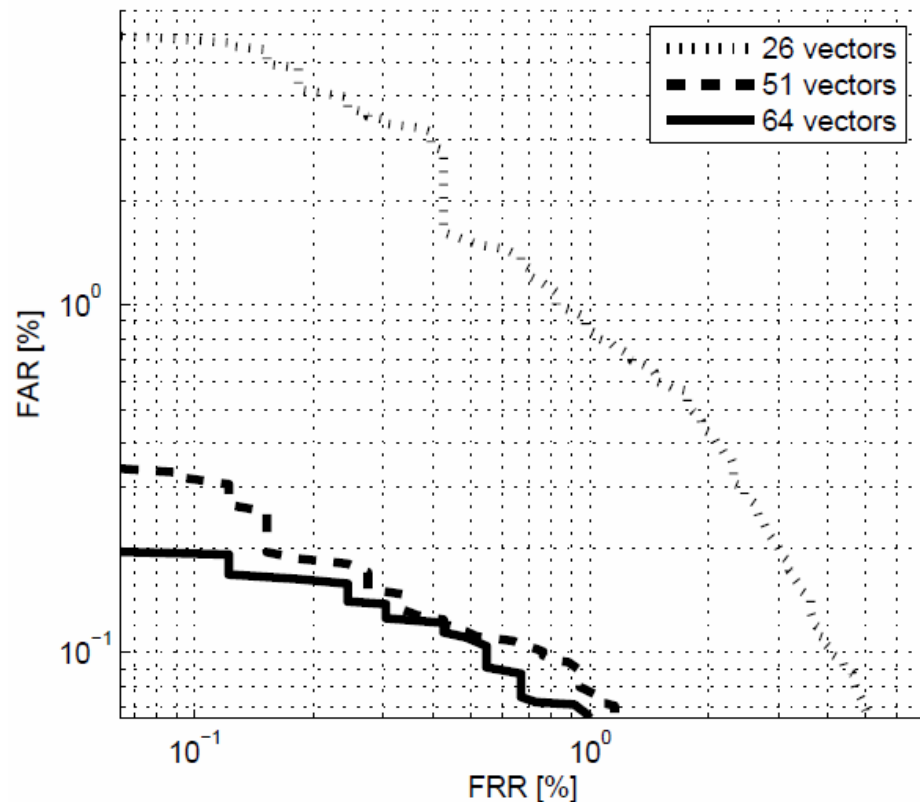
Experimental results

	P2PM	ICPM
EER	2.679%	0.557%

These methods* use binary image comparison and the database of 500 persons

	Our method
EER	0.17%

Our method uses vector set comparison, but database of 50 persons



* H. Chen, G. Lu, and R. Wang. A new palm vein matching method based on icp algorithm. In *ICIS'09: Proceedings of the 2nd International Conference on Interaction Sciences*, pages 1207–1211, New York, NY, USA, 2009. ACM.



Conclusions

Imaging

- Reflection method is more suitable for real system
- Power efficiency can be achieved using IR LEDs

Processing

- CMF is suitable for embedded solutions
- Complexity of CMF can be reduced ~ 200 times

Recognition

- Rotation and scale invariance must be considered
- Further study on efficient vector comparison needed



Thank you!

