INSTITUTE OF ELECTRONICS AND COMPUTER SCIENCE

BIMODAL PALM BIOMETRIC FEATURE EXTRACTION USING A SINGLE RGB IMAGE

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IEGULDĪJUMS TAVĀ NĀKOTNĒ
EIROPAS SAVIENĪBA

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CONTENT

1. Introduction;
2. Palm biometric features in different wavelengths:
   - Model
   - Separation
3. Palm biometric feature difference in size:
   - Model;
   - Separation:
     - NH-CMF;
     - developed calculation module for artifact removal;
4. Results and conclusions:
   - Results;
   - Conclusions;
   - Future work.

MOTIVATION

Existing bimodal biometric systems require acquisition of 2 images to authenticate

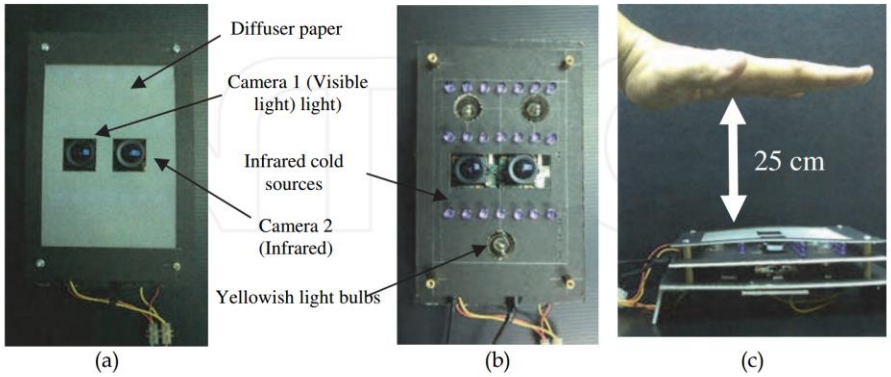


Fig. 6. (a) Image acquisiton device (covered). (b) Image acquisiton device (uncovered). (c) Acquiring the hand images.

Author:

G.K.O. Michael, T. Connie, and A.T.B. Jin. Design and implementation of a contactless palm print and palm vein sensor. In Control Automation Robotics Vision (ICARCV), 2010 11th International Conference on, pages 1268–1273, Dec 2010.

Author:

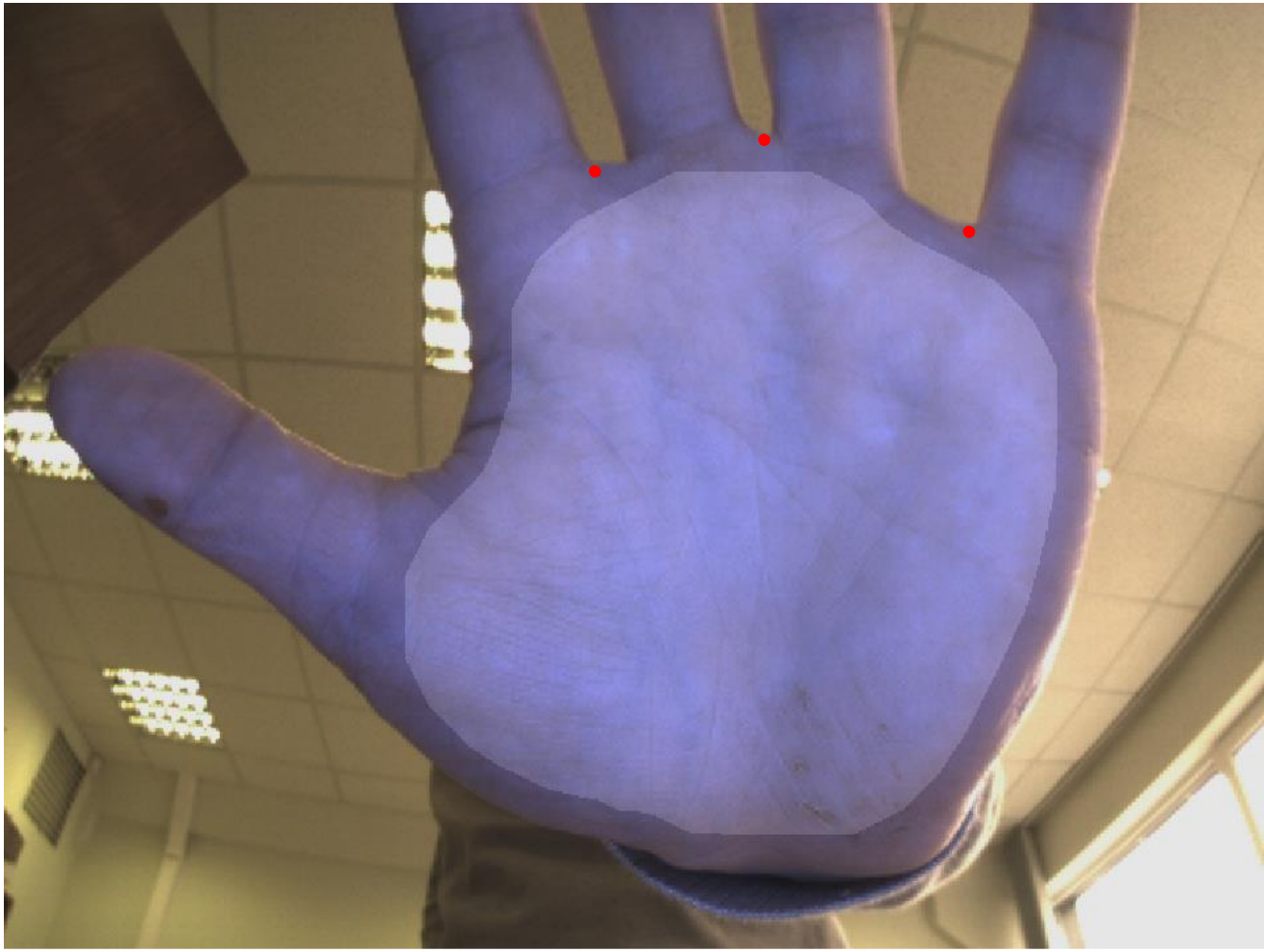
M. Pudzs, R. Fuksis, R. Ruskuls, T. Eglitis, A. Kadikis, and M. Greitans. FPGA based palmprint and palm vein biometric system. In Biometrics Special Interest Group (BIOSIG), 2013 International Conference of the, pages 1–4, Sept 2013.

IDEA

- Acquire palm image

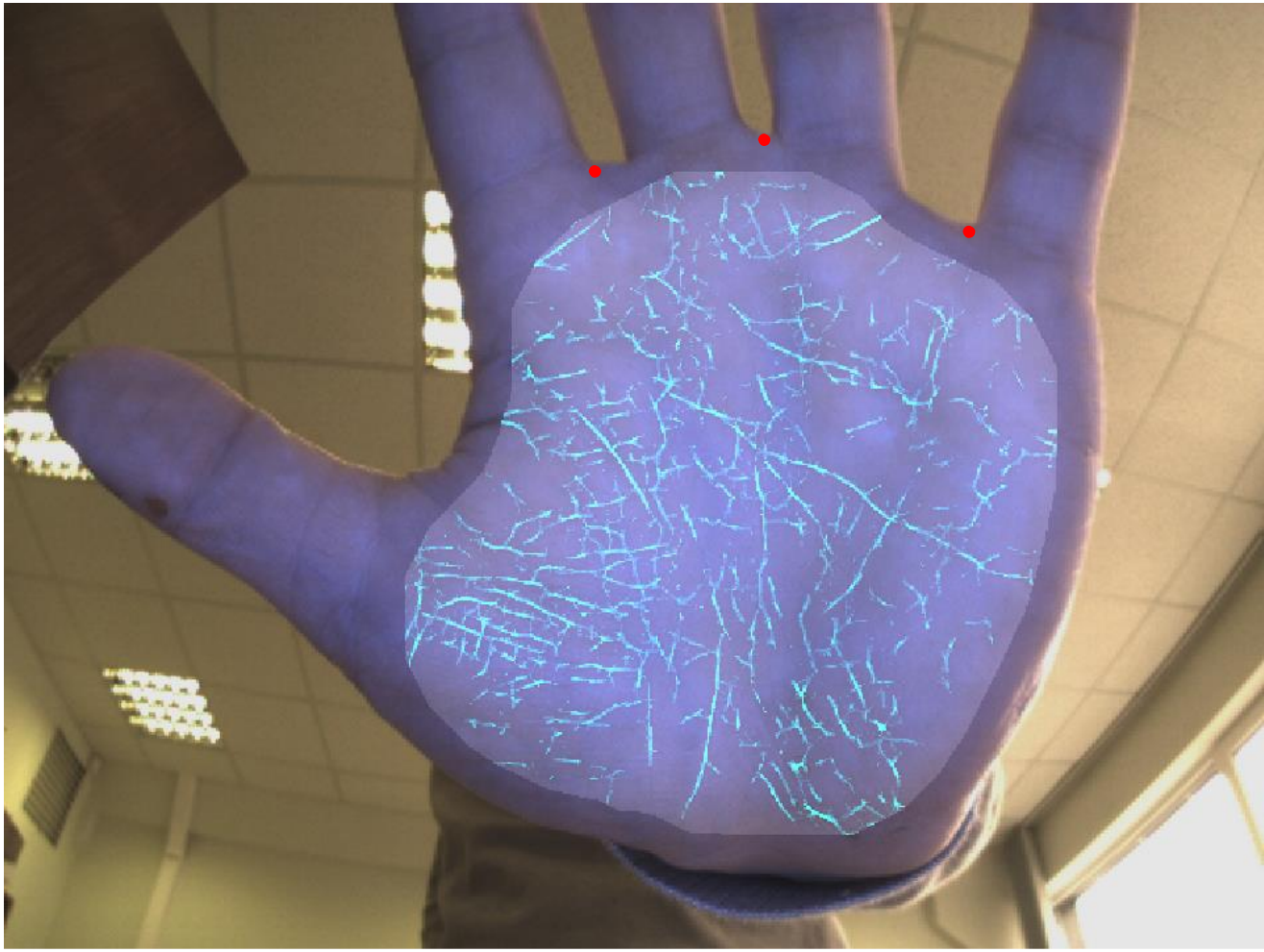
IDEA

- Acquire palm image
- Select ROI



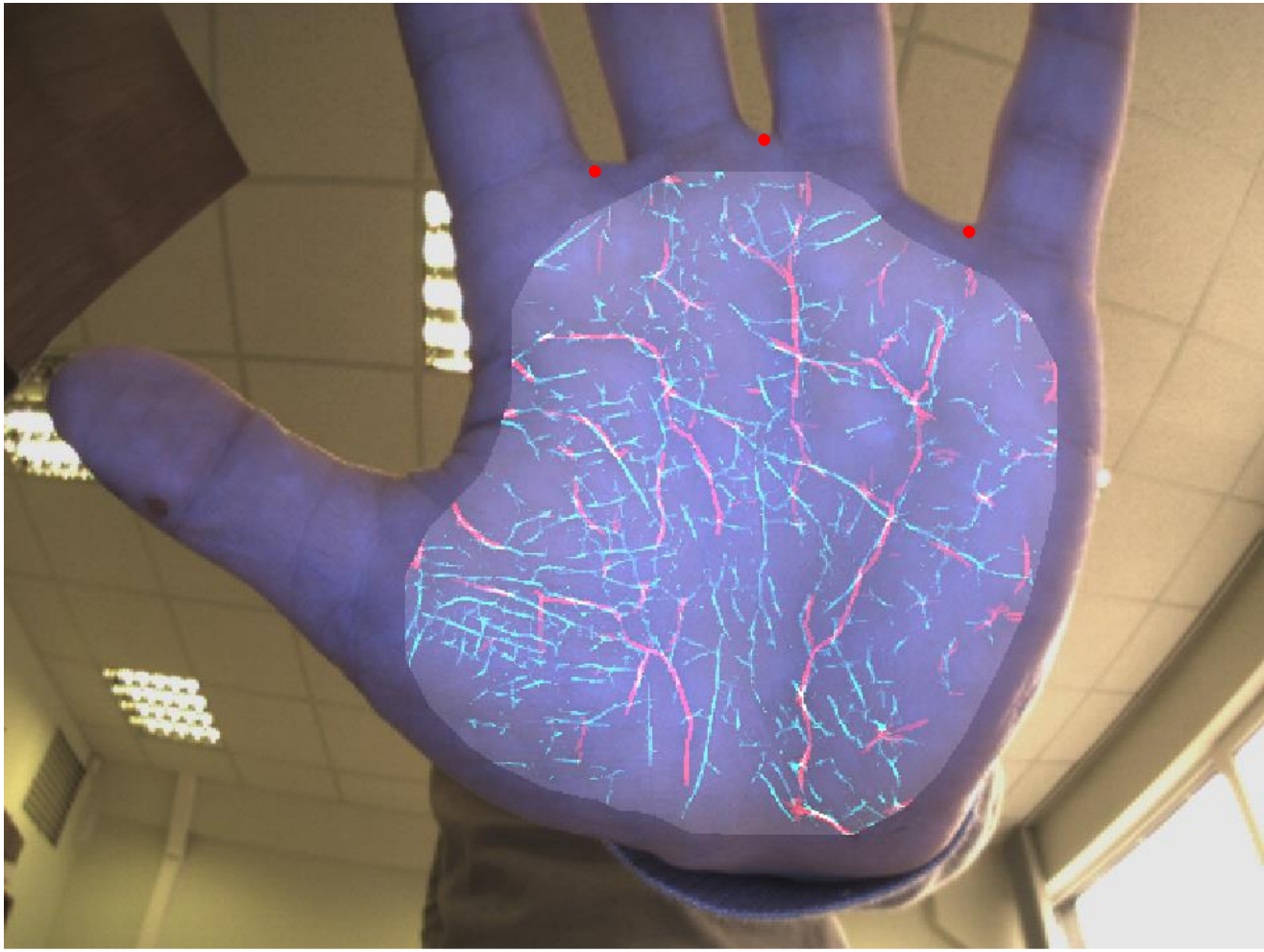
IDEA

- Acquire palm image
- Select ROI
- Extract crease information



IDEA

- Acquire palm image
- Select ROI
- Extract crease information
- Extract vein information

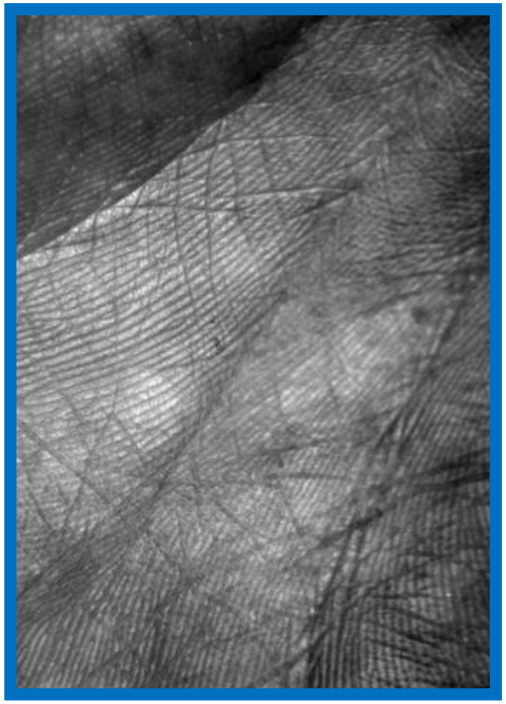


Using single RGB image

PALM BIOMETRIC FEATURES IN DIFFERENT WAVELENGTHS

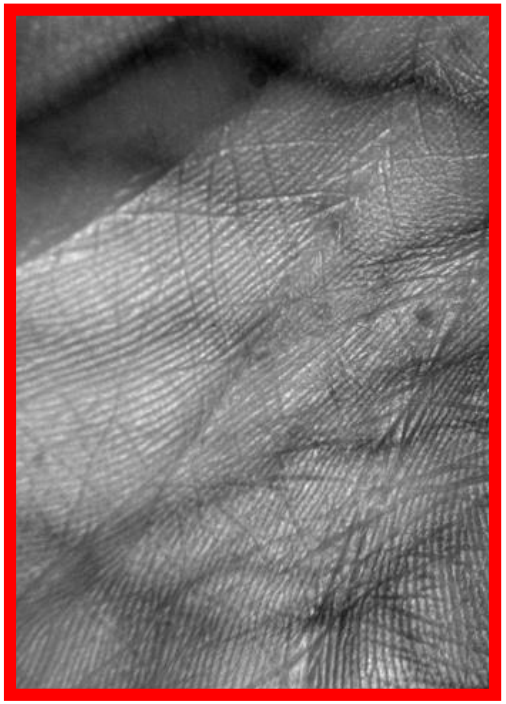
Features of each biometric modality are more pronounced in different wavelength

$460\ nm$



crease

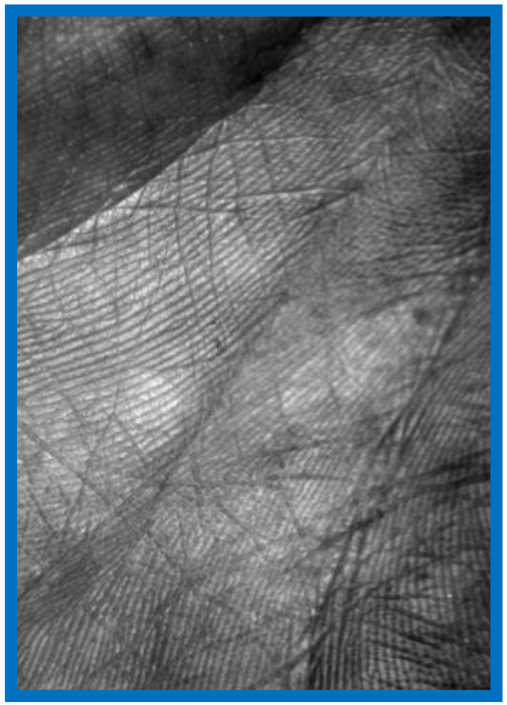
$850\ nm$



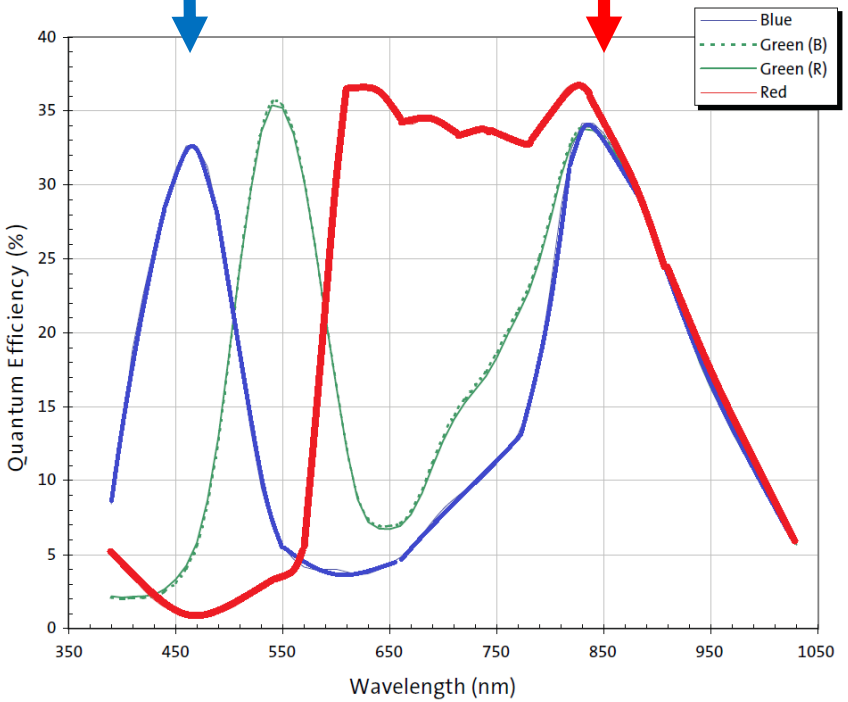
veins

Typical CMOS image sensor with Bayer pattern captures both of used wavelengths.
Both features can be obtained in single image by using appropriate illumination.

$460\ nm$

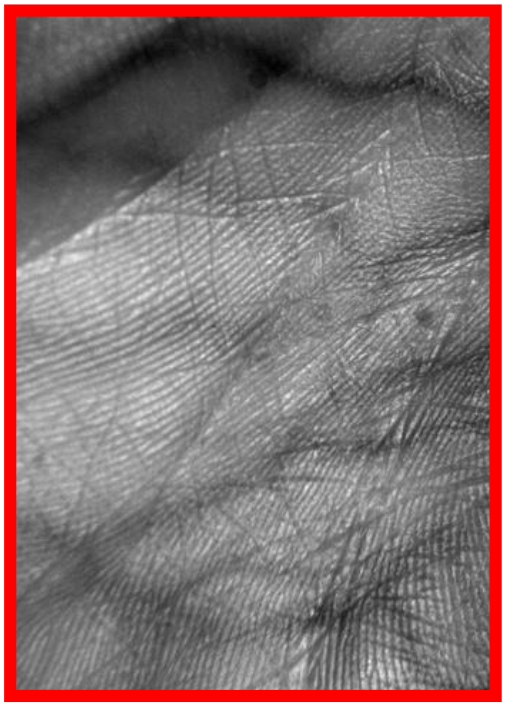


crease

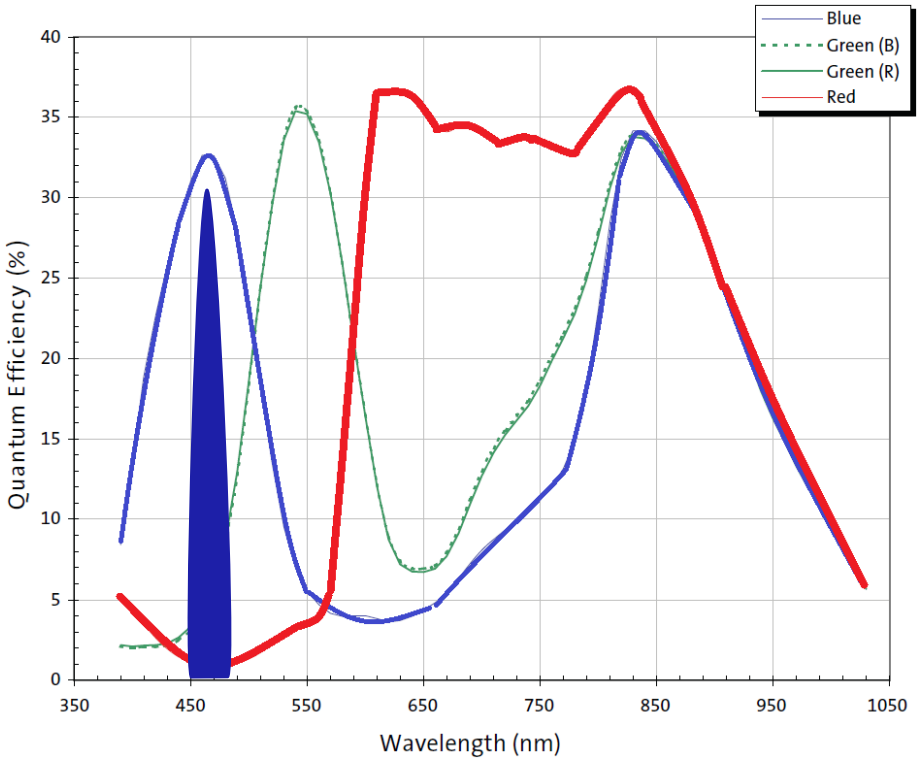


Aptina MT9V032C12STC ES

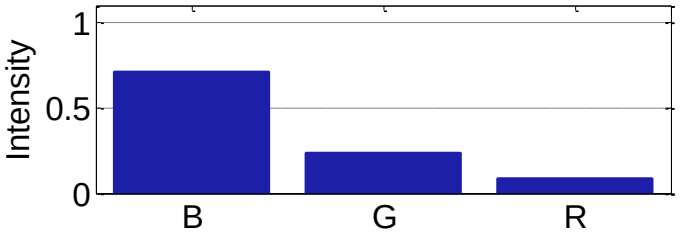
$850\ nm$



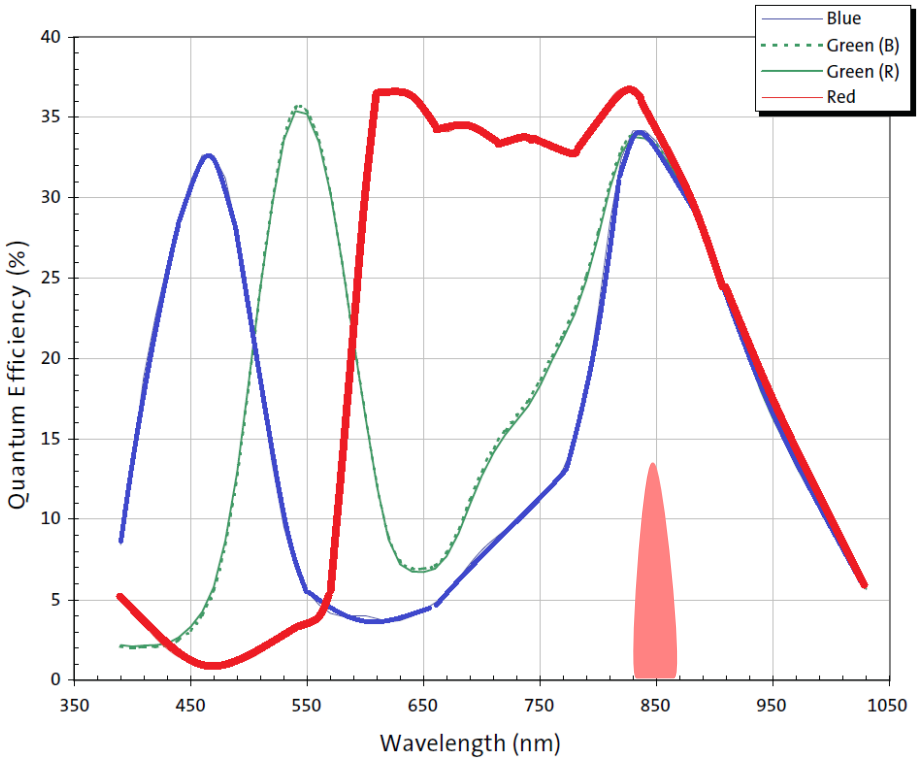
veins



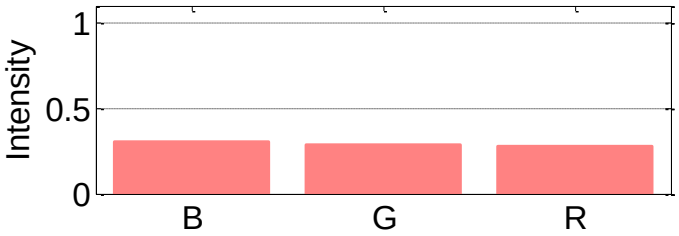
Aptina MT9V032C12STC ES



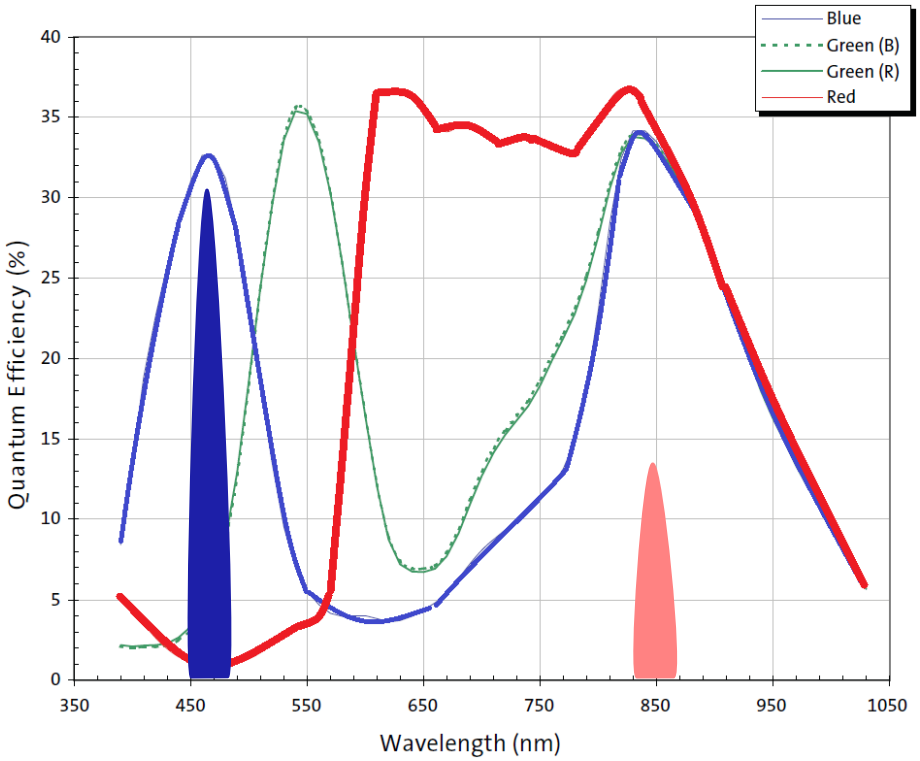
Crease information can be obtained in Blue color channel by using blue color illumination



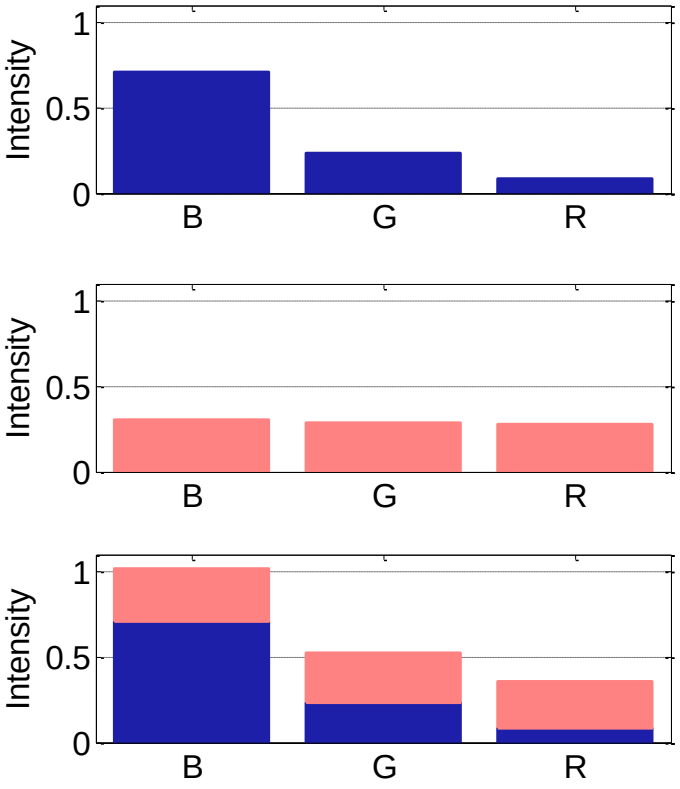
Aptina MT9V032C12STC ES



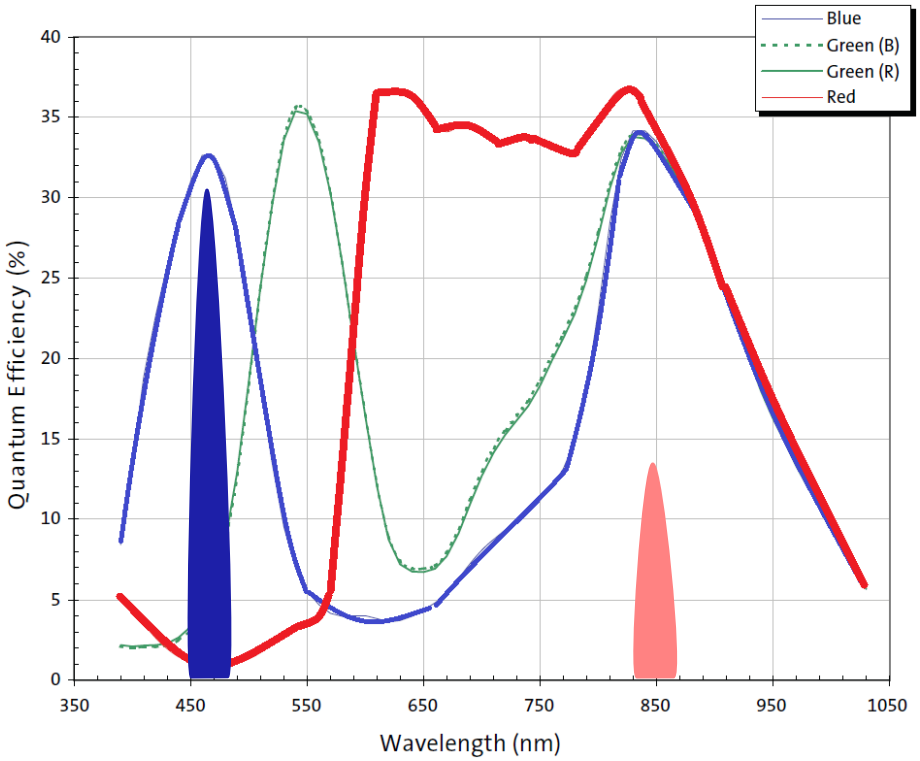
Vein information can be obtained in all color channels by using near-infrared illumination

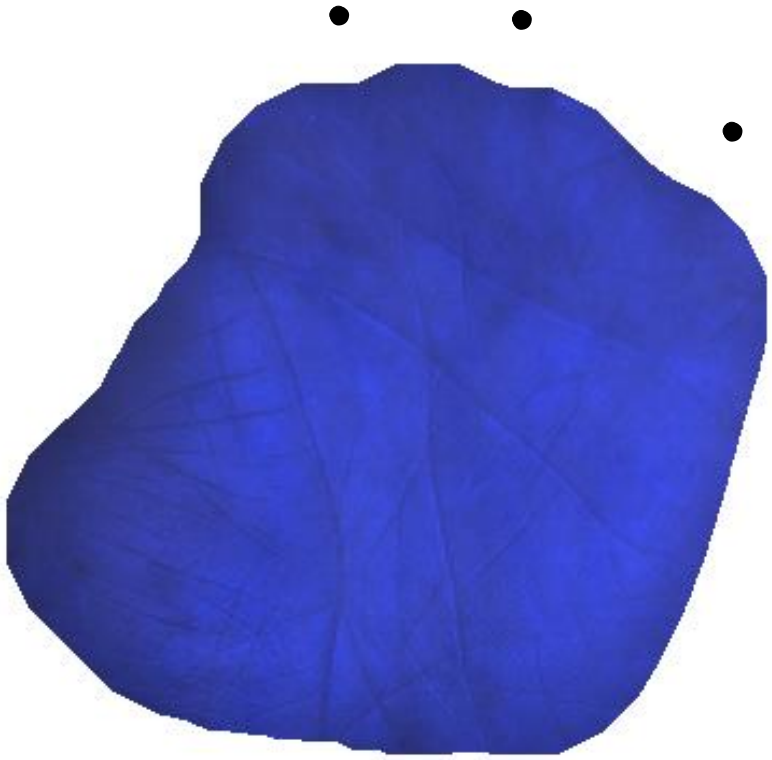


Aptina MT9V032C12STC ES



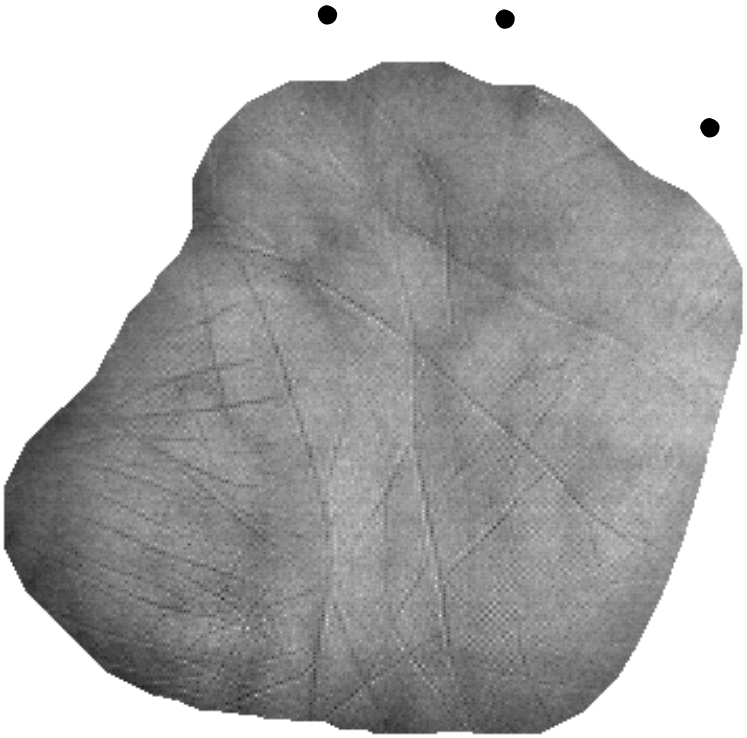
Illumination intensities determine feature information distribution in color channels.
Feature of each modality can be pronounced in its own color channel.



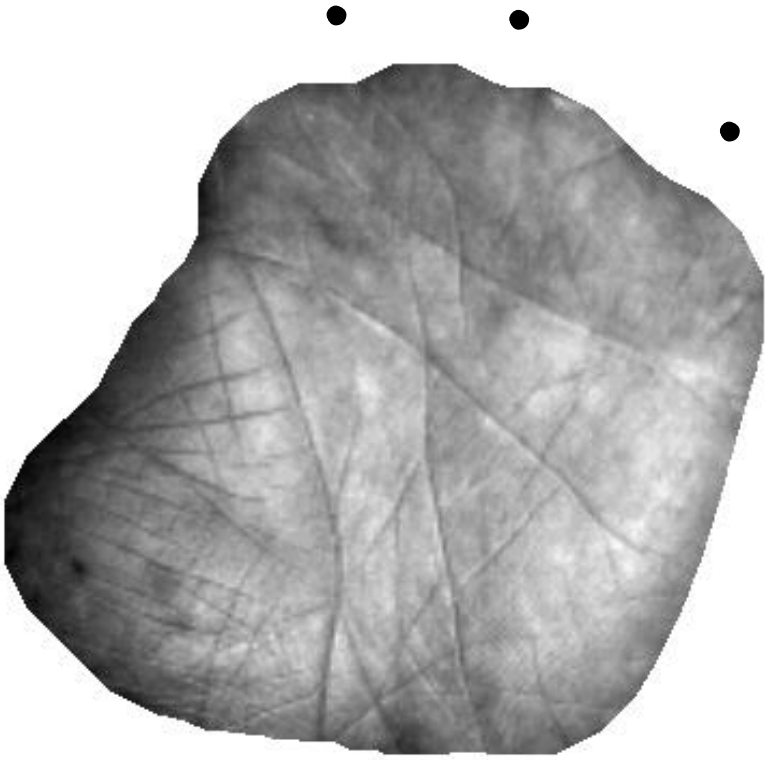


Aptina MT9V032C12STC ES

Illumination intensities determine feature information distribution in color channels.
Feature of each modality can be pronounced in its own color channel.

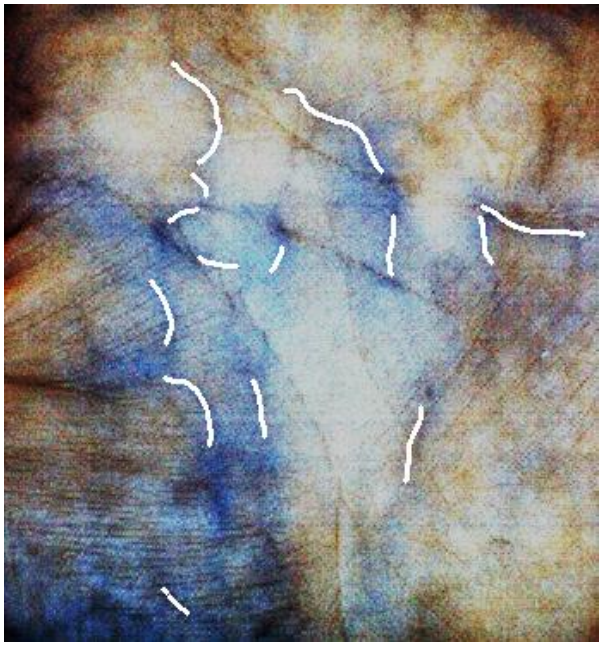


Red color channel
(more pronounced veins)



Blue color channel
(more pronounced crease)

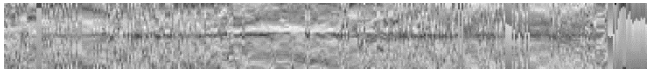
Construction of palm feature model



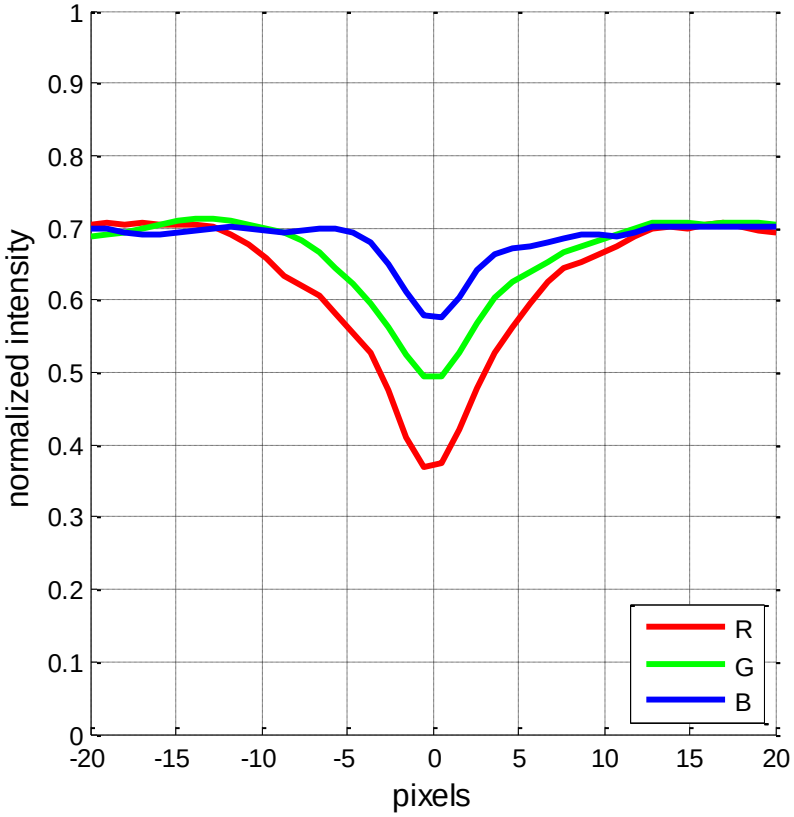
Marked palm veins

Marked palm crease

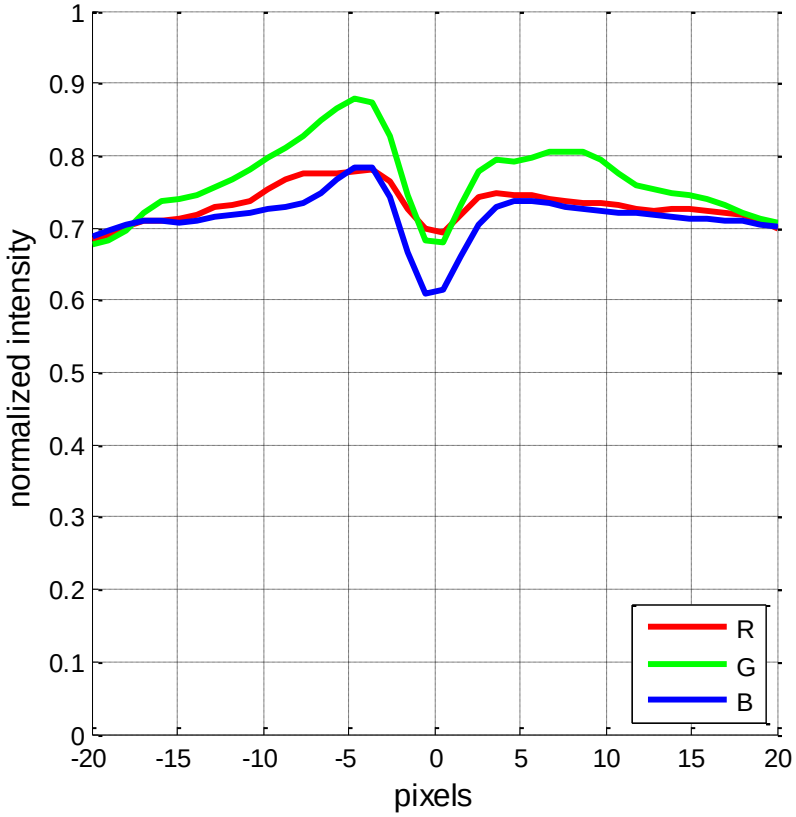
Straightened vein fragment
(R color channel)



Straightened crease fragment
(B color channel)



Vein average continuous feature model



Crease average continuous feature model

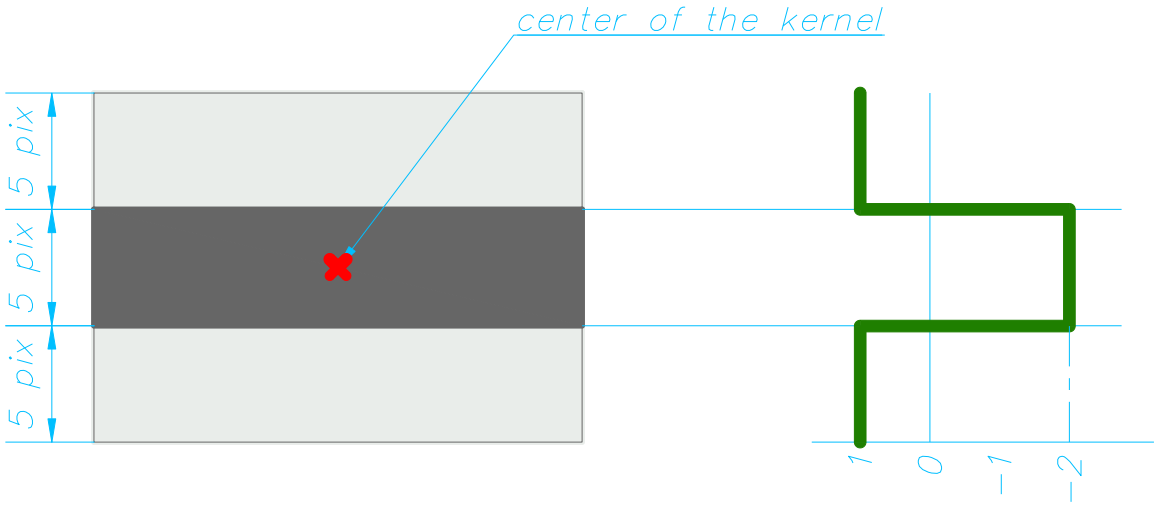
NH-CMF

Non **H**alo – **C**omplex **M**atched **F**ilter

Input image - $f(x, y)$

NH-CMF

Non **H**alo – **C**omplex **M**atched **F**ilter



Matched filter kernel - $M(x, y; \varphi_n)$

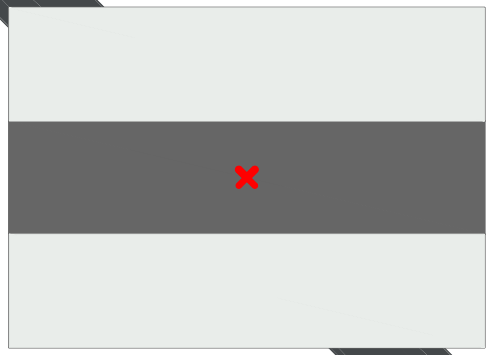
NH-CMF

Non **H**alo – **C**omplex **M**atched **F**ilter

Filtering algorithm:

1. Filter image with matched filter masks

$$s_n(x_0, y_0; \varphi_0) = \sum_D \sum f(x, y) \cdot M(x - x_0, y - y_0; \varphi_0)$$



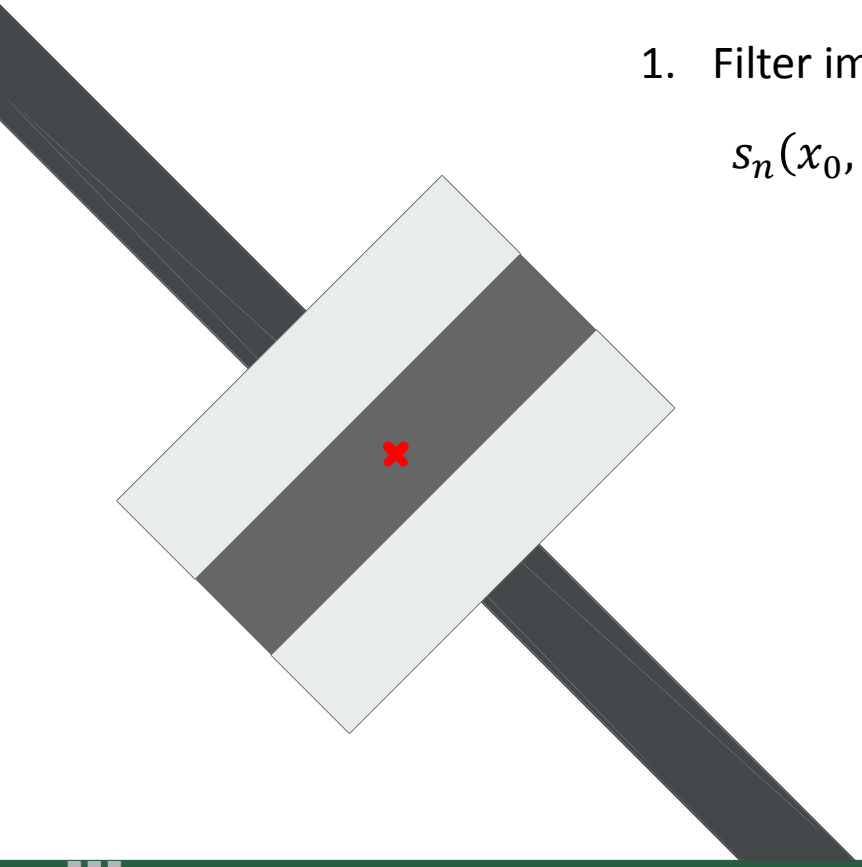
NH-CMF

Non **H**alo – **C**omplex **M**atched **F**ilter

Filtering algorithm:

1. Filter image with matched filter masks

$$s_n(x_0, y_0; \varphi_1) = \sum_D \sum f(x, y) \cdot M(x - x_0, y - y_0; \varphi_1)$$



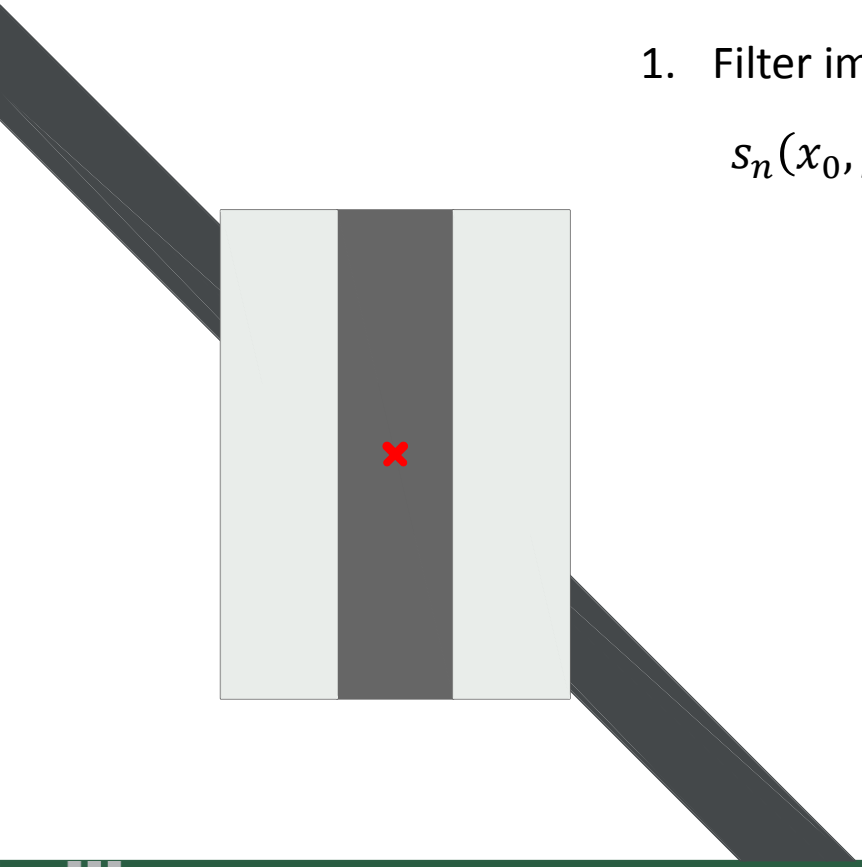
NH-CMF

Non **H**alo – **C**omplex **M**atched **F**ilter

Filtering algorithm:

1. Filter image with matched filter masks

$$s_n(x_0, y_0; \varphi_2) = \sum_D \sum f(x, y) \cdot M(x - x_0, y - y_0; \varphi_2)$$



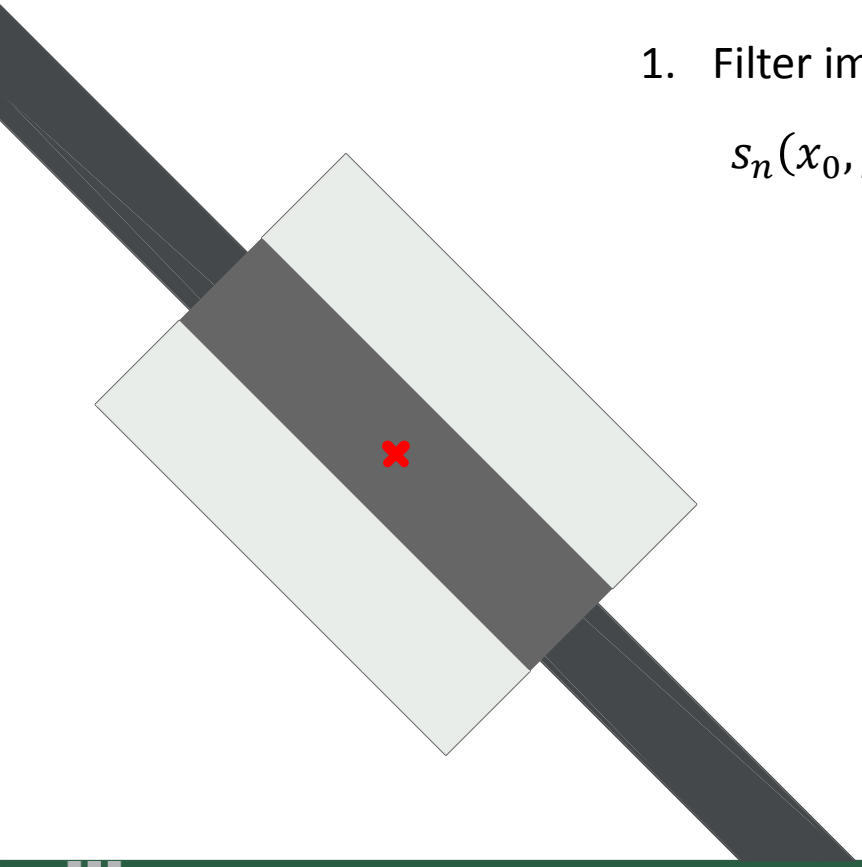
NH-CMF

Non **H**alo – **C**omplex **M**atched **F**ilter

Filtering algorithm:

1. Filter image with matched filter masks

$$s_n(x_0, y_0; \varphi_3) = \sum_D \sum f(x, y) \cdot M(x - x_0, y - y_0; \varphi_3)$$



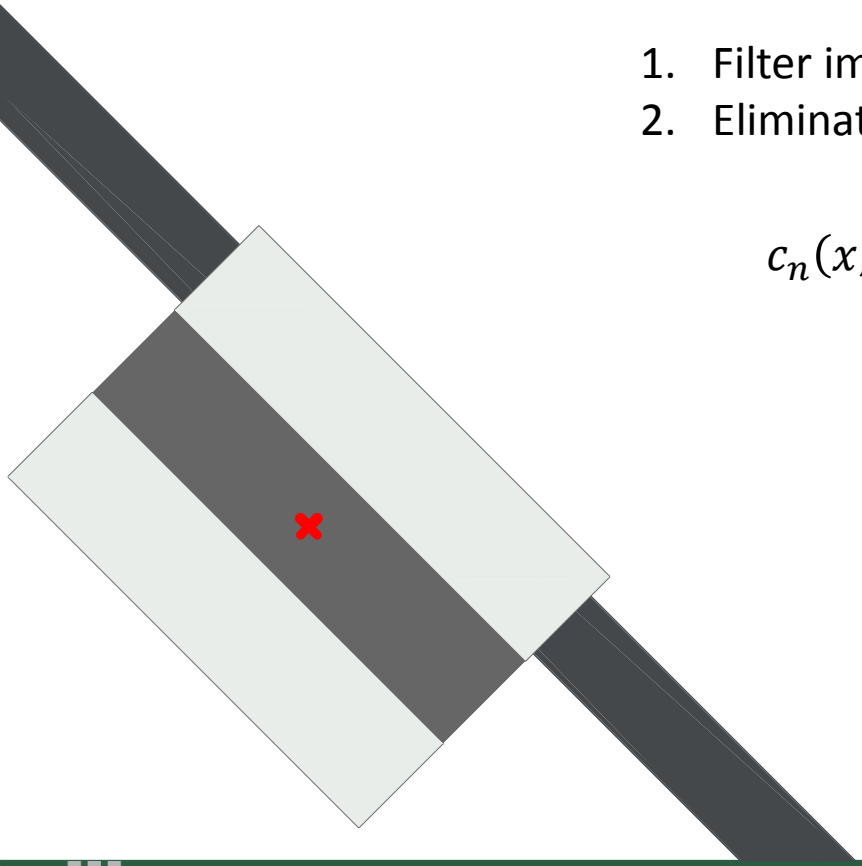
NH-CMF

Non **H**alo – **C**omplex **M**atched **F**ilter

Filtering algorithm:

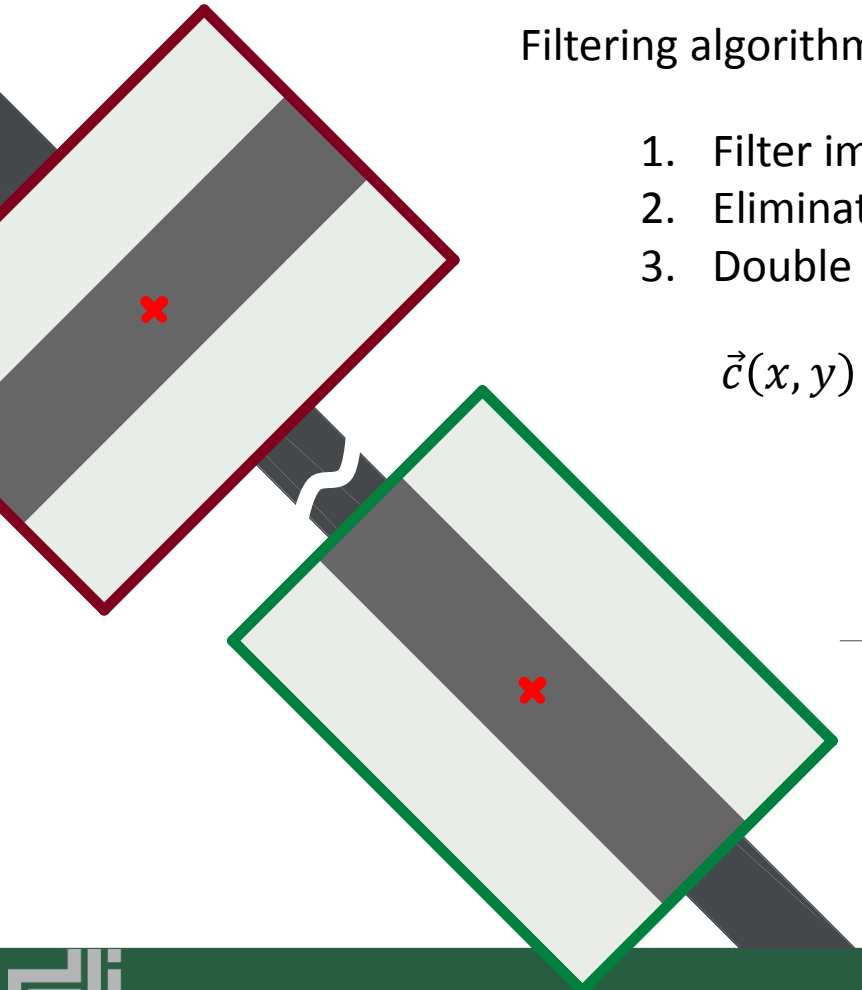
1. Filter image with matched filter masks
2. Eliminate negative values from further processing

$$c_n(x, y; \varphi_n) = \frac{s_n(x_0, y_0; \varphi_n) + |s_n(x_0, y_0; \varphi_n)|}{2}$$



NH-CMF

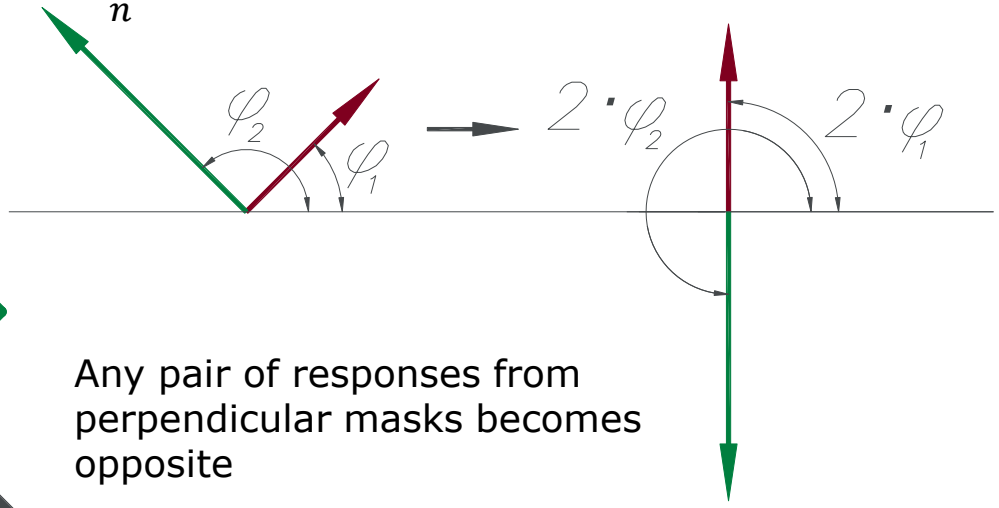
Non **H**alo – **C**omplex **M**atched **F**ilter



Filtering algorithm:

1. Filter image with matched filter masks
2. Eliminate negative values from further processing
3. Double the angle and sum

$$\vec{c}(x,y) = \sum_{n} c_n(x,y;\varphi_n) \cdot e^{j2\varphi_n}$$



Any pair of responses from perpendicular masks becomes opposite

NH-CMF

Non **H**alo – **C**omplex **M**atched **F**ilter

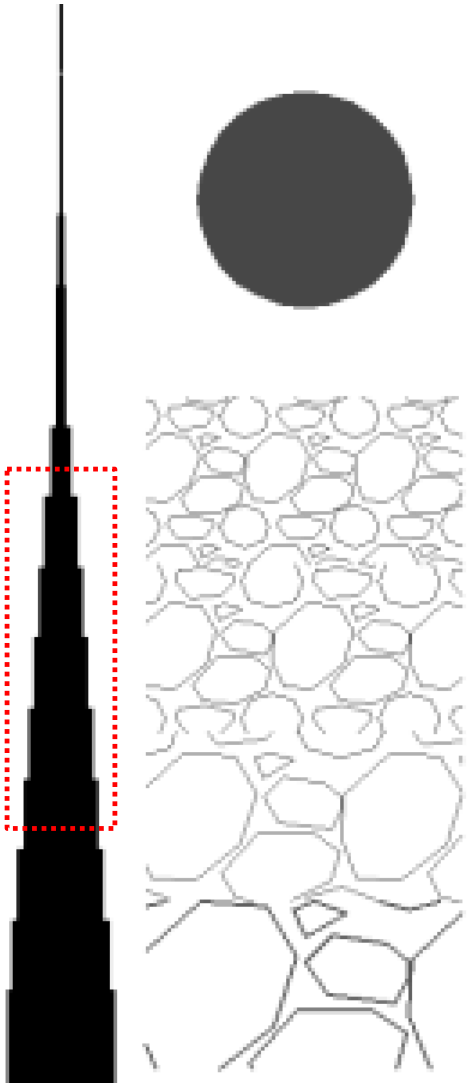
Filtering algorithm:

1. Filter image with matched filter masks
2. Eliminate negative values from further processing
3. Double the angle and sum
4. Reduce the angle and obtain the result

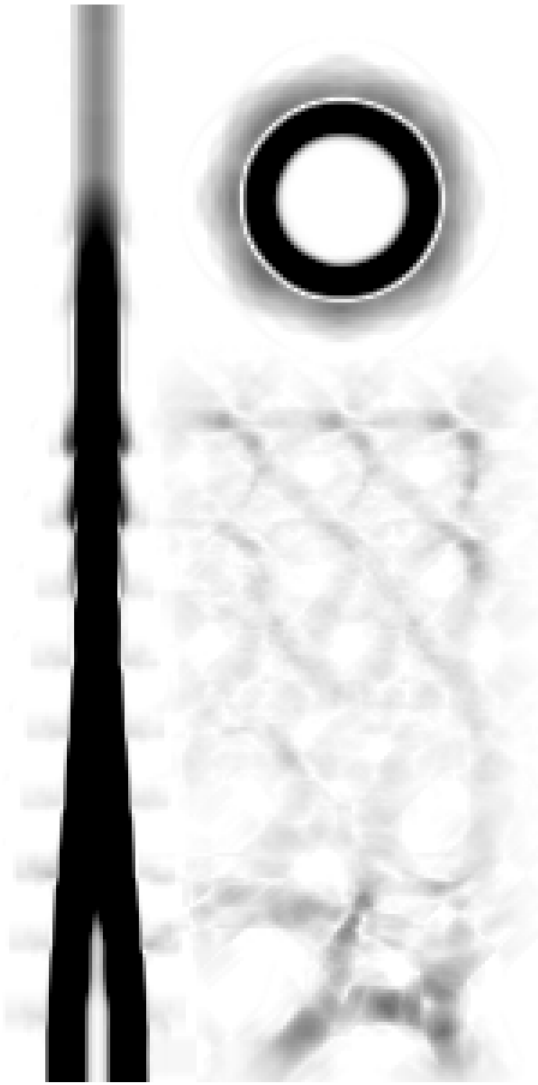
$$\vec{v}(x,y) = |\vec{c}(x,y)| \cdot e^{j0.5 \cdot Arg(\vec{c}(x,y))}$$

Additional information about NH-CMF can be found in:

M.Pudzs, M.Greitans, R.Fuksis. "**Complex 2D Matched Filtering Without Halo Artifacts**", IWSSIP 2011, Bosnia and Herzegovina, June 16-18, 2011, pp. 109-112

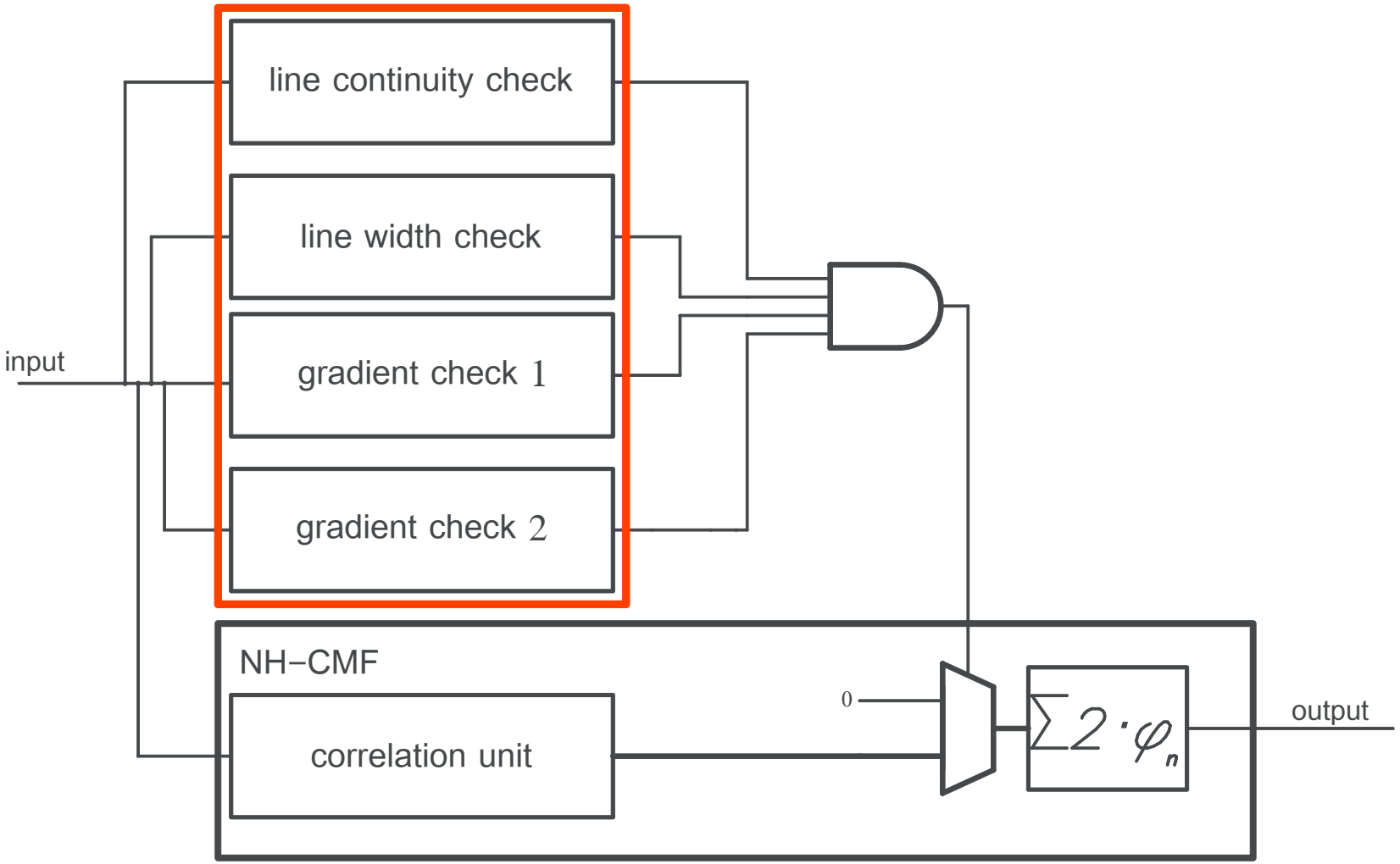


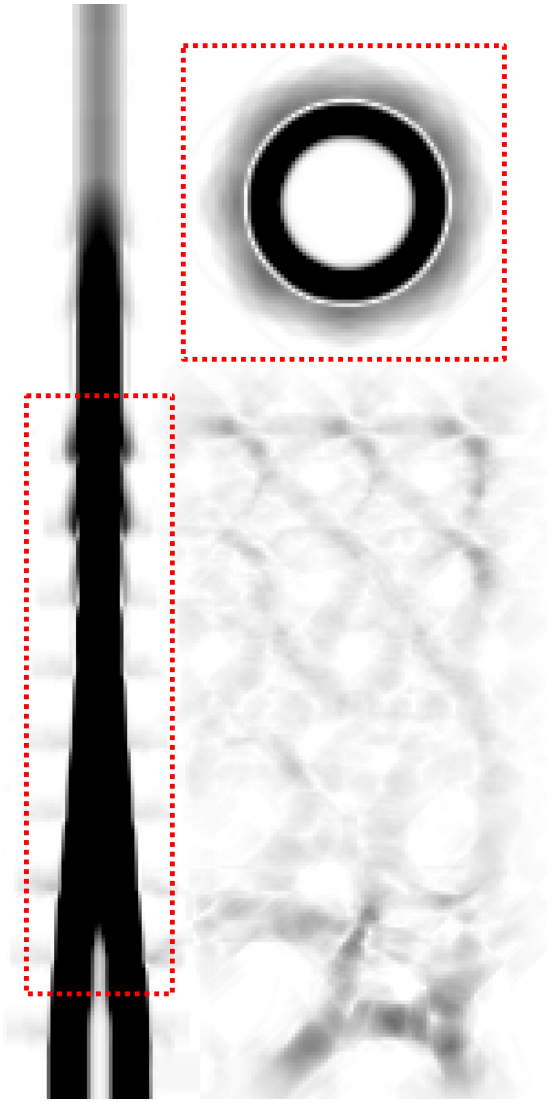
Test image
Marked region – line to extract



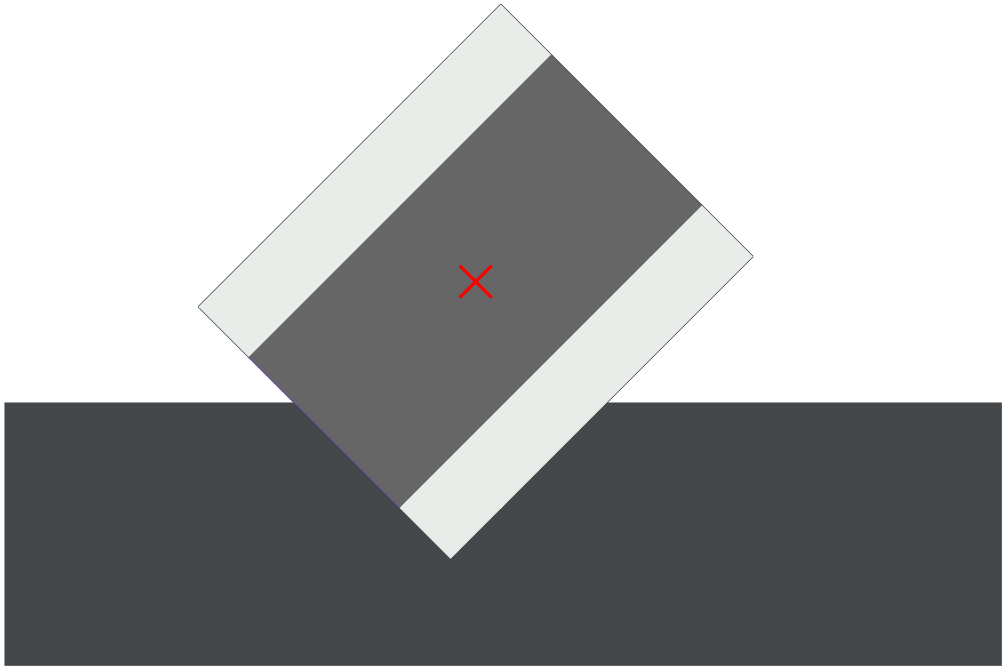
Test image filtered with NH-CMF (inverted)
note that not only line is extracted

Algorithm outline

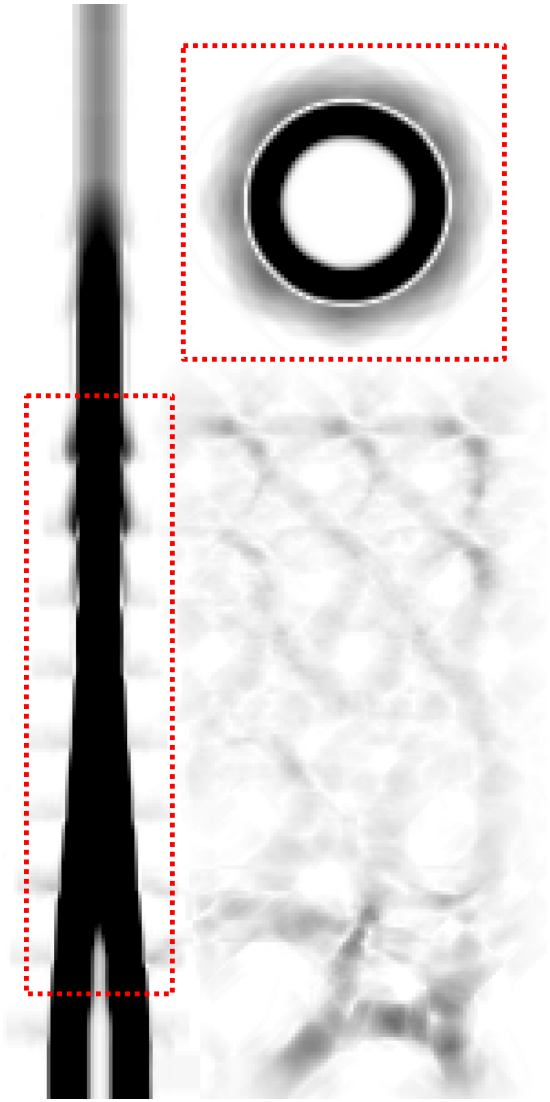




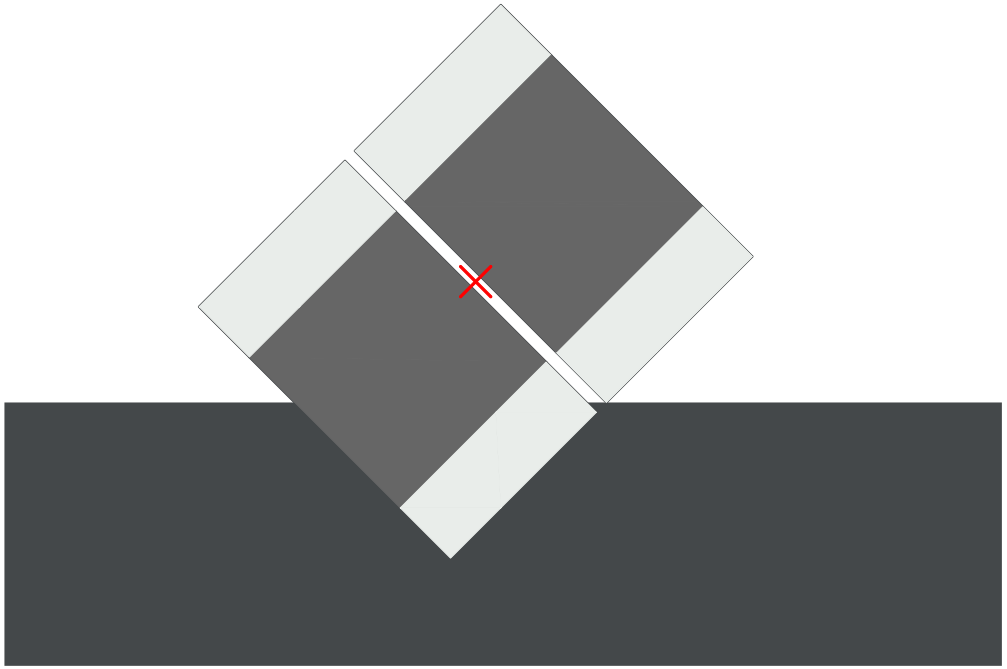
NH-CMF output - marked – line continuity artifacts



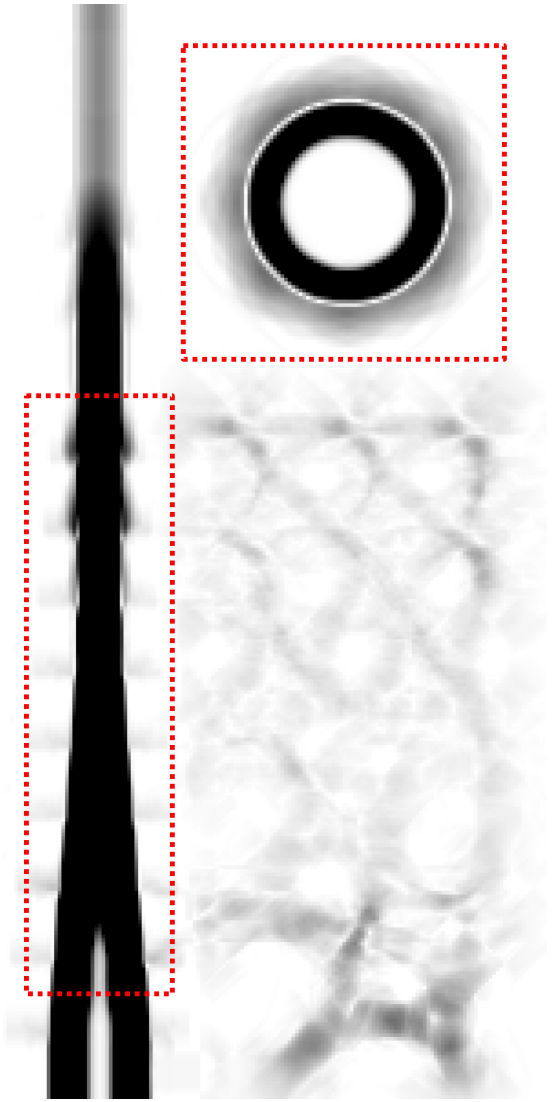
Cause – kernel's partial correlation lengthwise



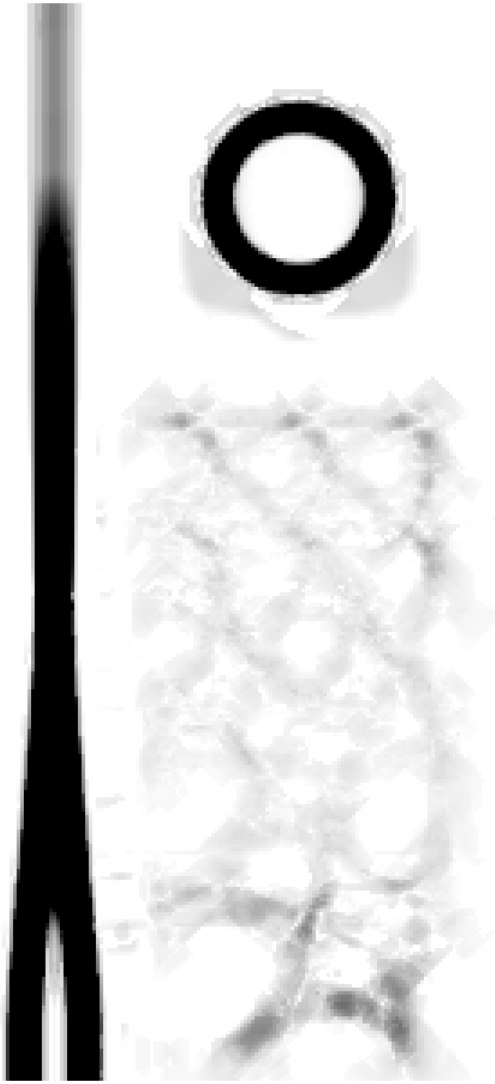
NH-CMF output - marked – line continuity artifacts



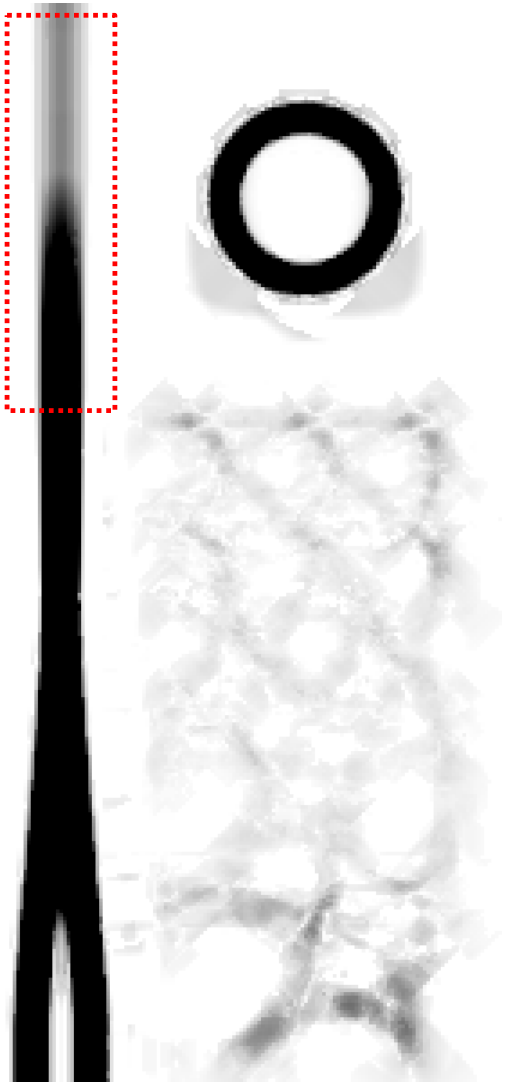
Solution – kernel division lengthwise - line continuity check



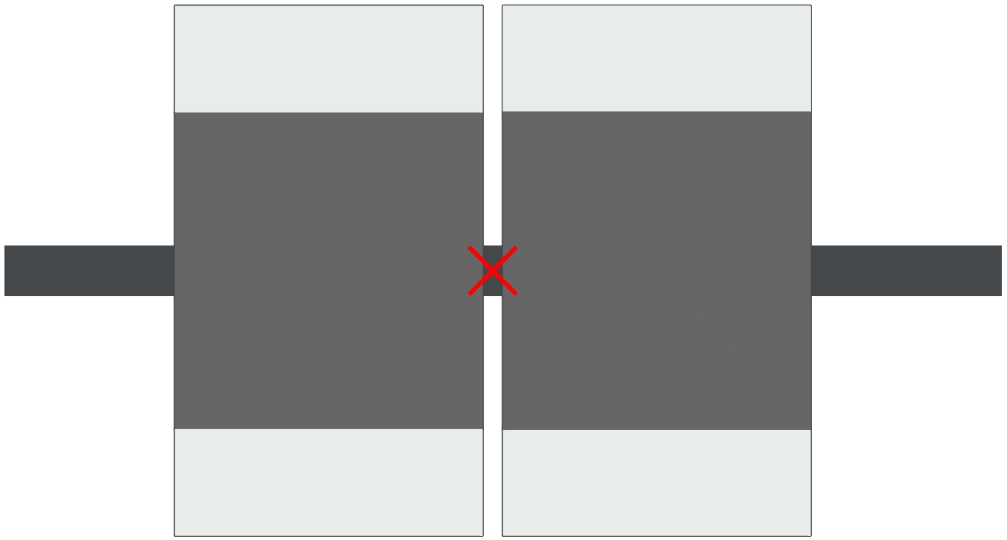
NH-CMF output - marked – line continuity artifacts



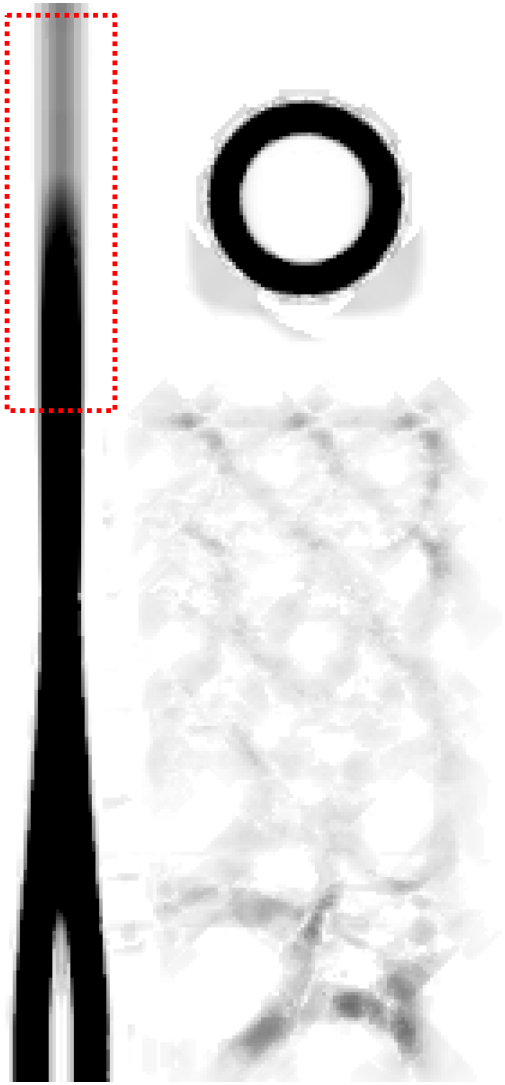
Output after line continuity check



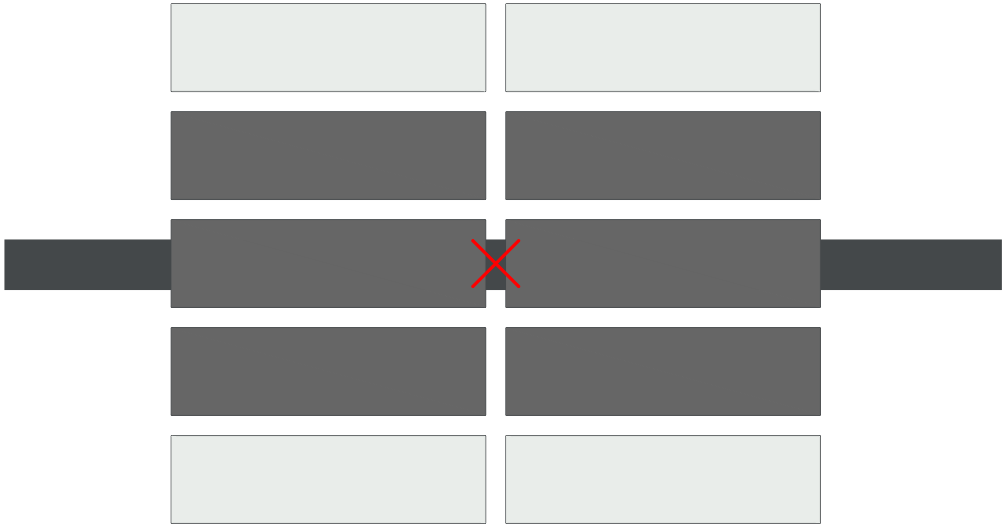
Output after line continuity check – marked - line width artifacts



Cause – narrow line detection

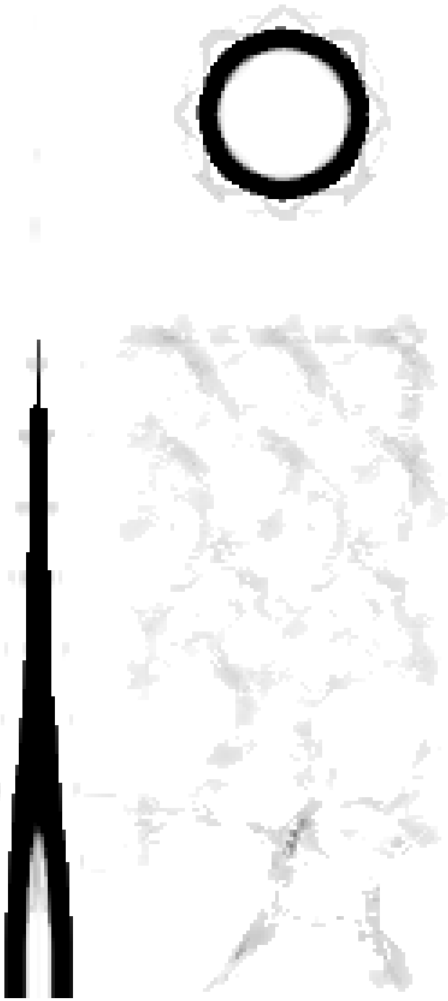


Output after line continuity check – marked - line width artifacts



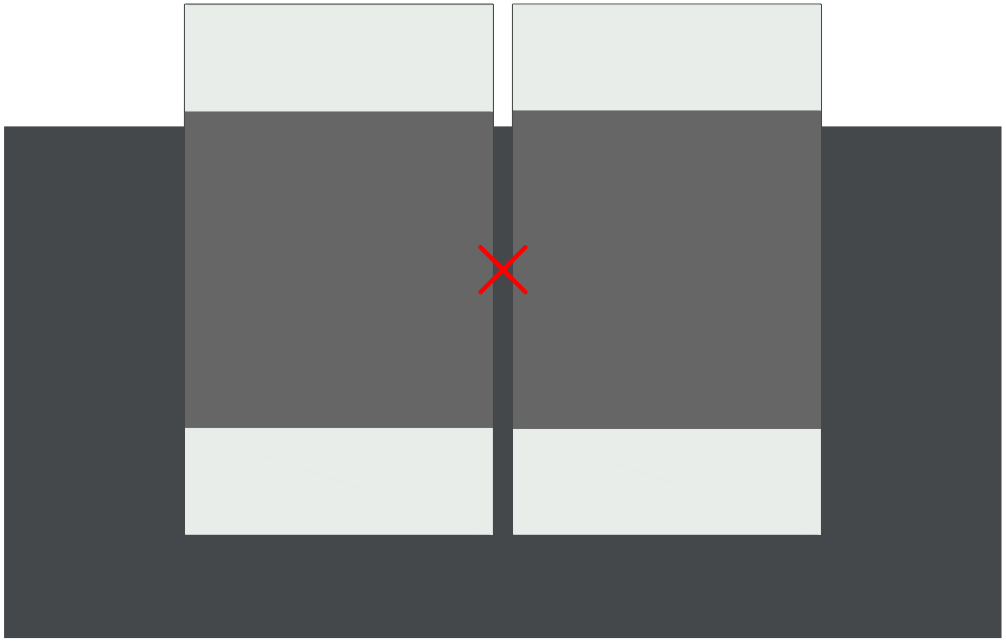
Solution – kernel division widthwise - line width check

Output after line continuity check – marked - line width artifacts



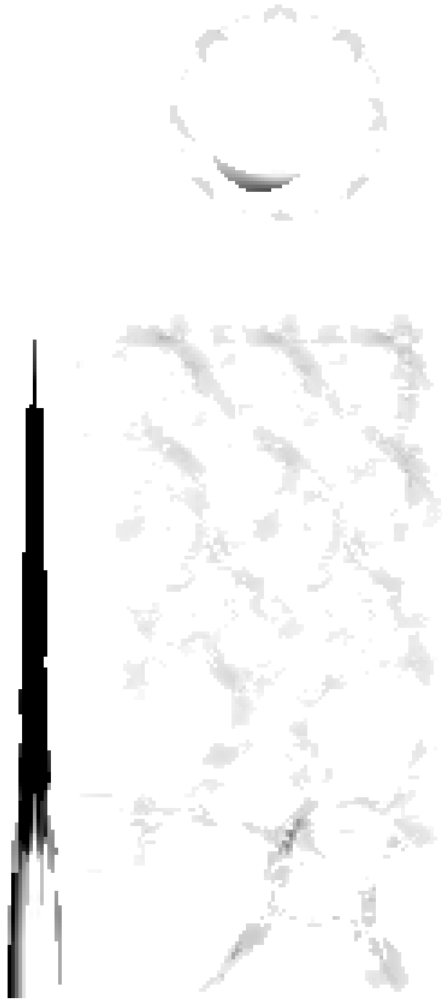
Output after line width check

Output after line width check – marked – gradient formed artifacts

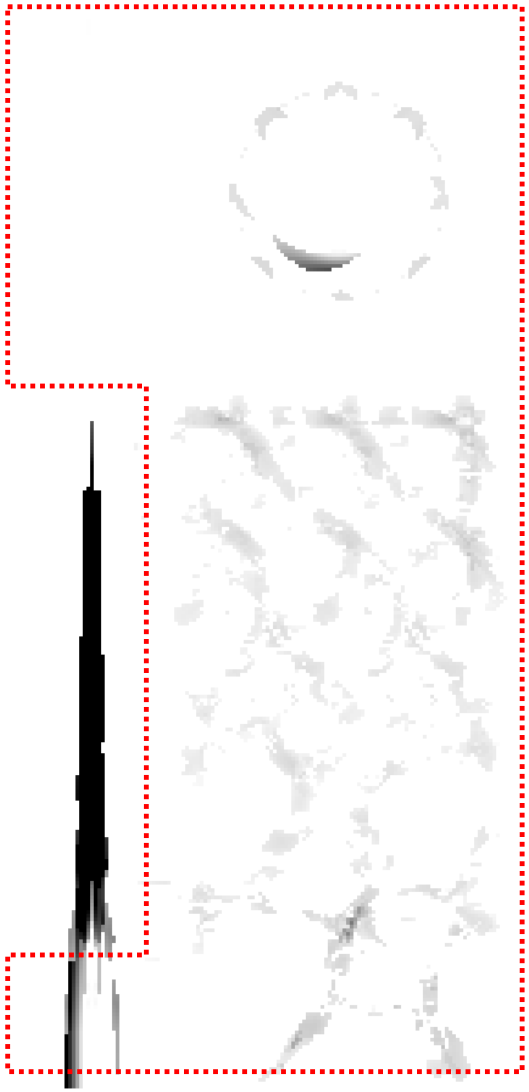


Cause – partial correlation with gradients
Solution – gradient check 1 (4 checks)

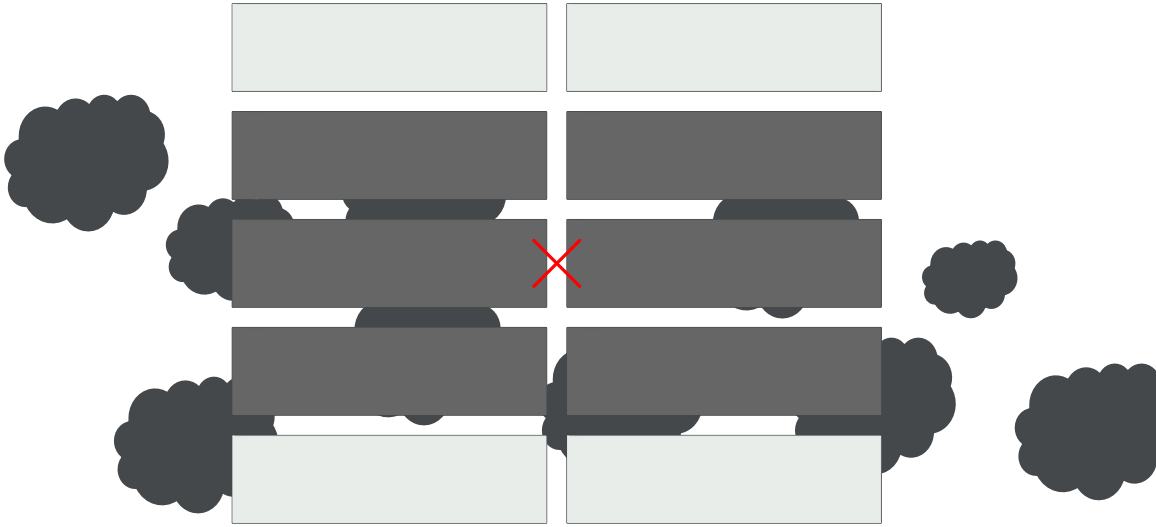
Output after line width check – marked – gradient formed artifacts



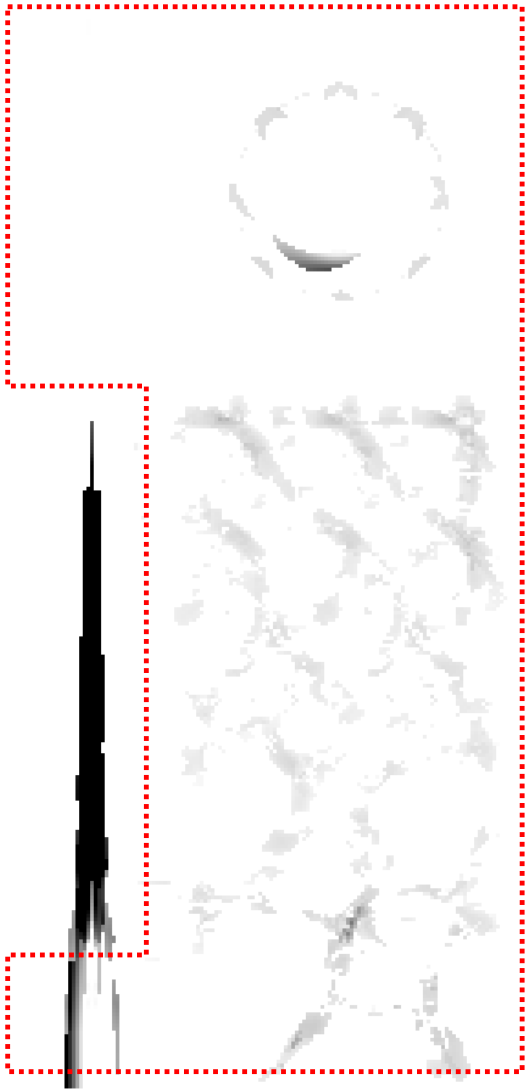
Output after gradient check 1



Output after gradient check 1 – marked – unclassified artifacts



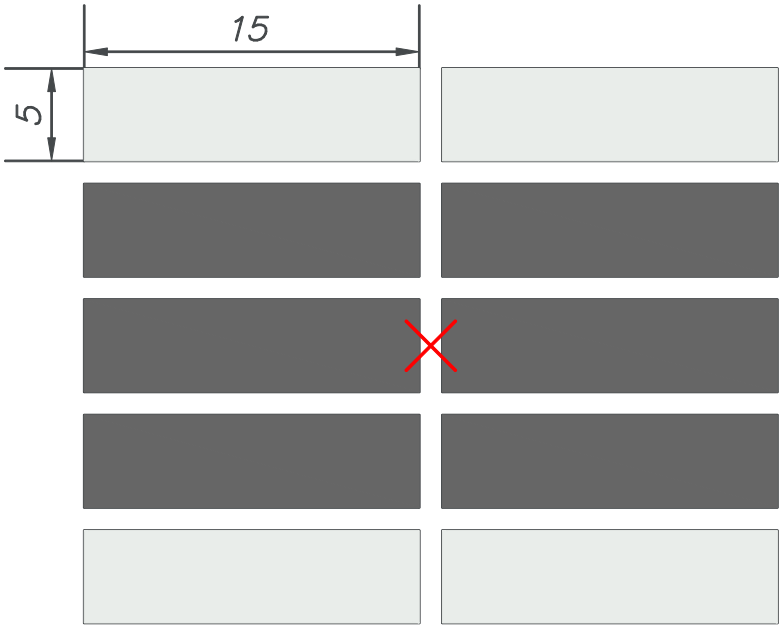
Cause – partial correlation with unclassified artifacts
Solution – gradient check 2 (12 checks)



Output after gradient check 1 – marked – unclassified artifacts

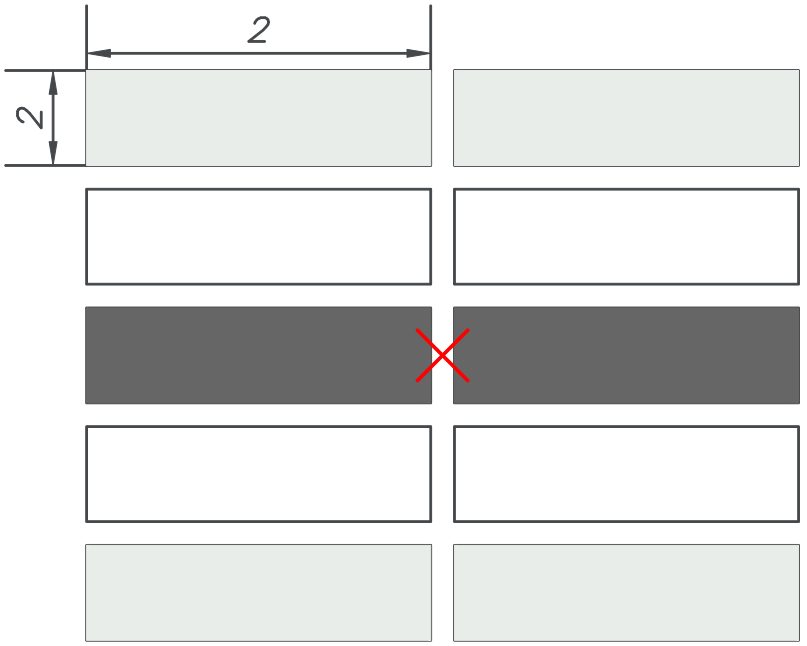
Output after gradient check 2

VEINS

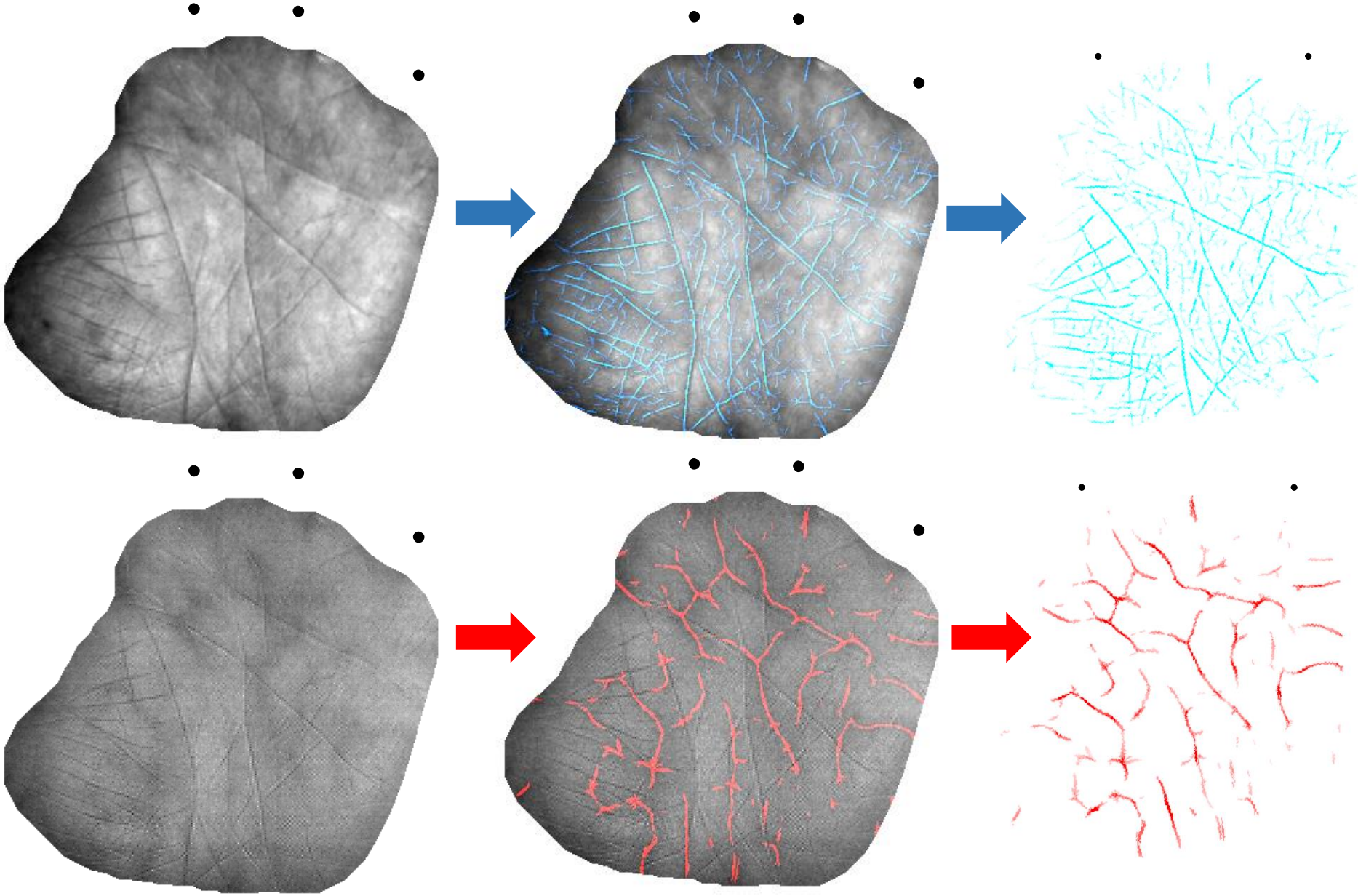


Filter kernel scaled for vein extraction

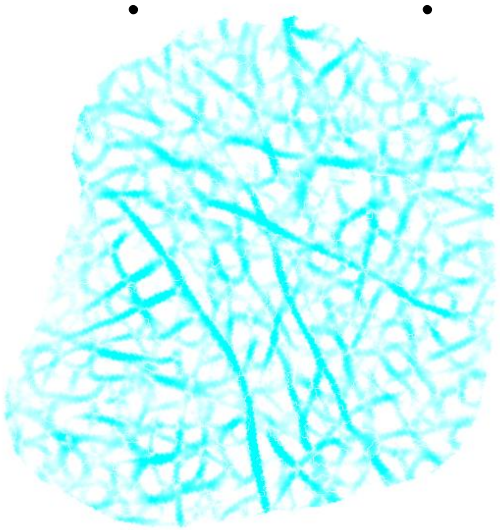
CREASE

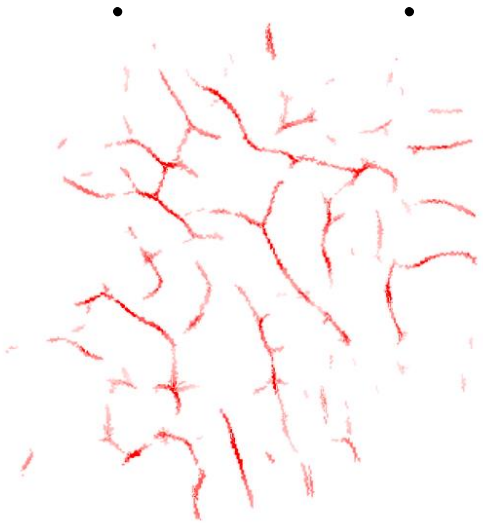


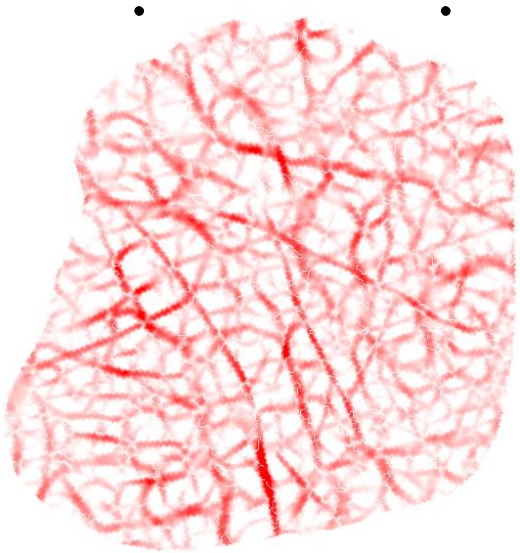
Filter kernel scaled for crease extraction
(notice 2 missing kernel rows for different width line detection)



For comparison –
NH-CMF results:







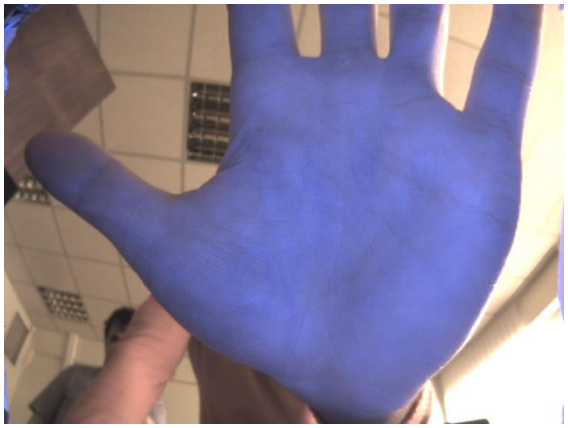
Vein and crease filter results

NH-CMF results

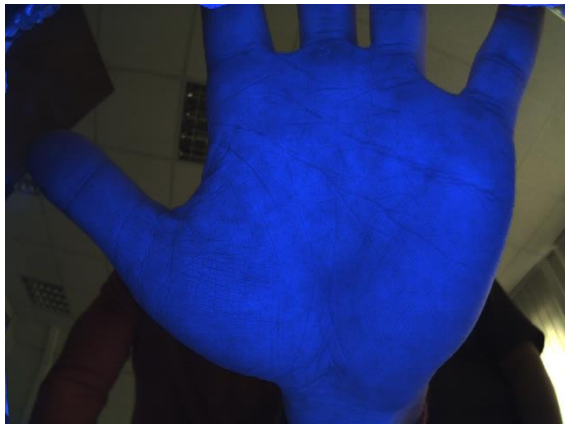
Acquired images for filter performance assessment

Three types of images were acquired to evaluate the performance of proposed filters:

Palm vein images, obtained using 850 nm band-pass filter

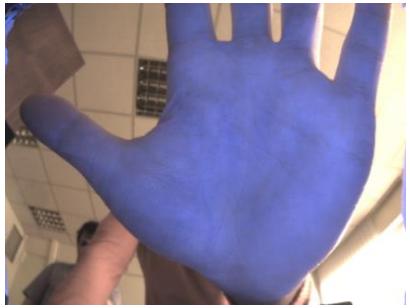


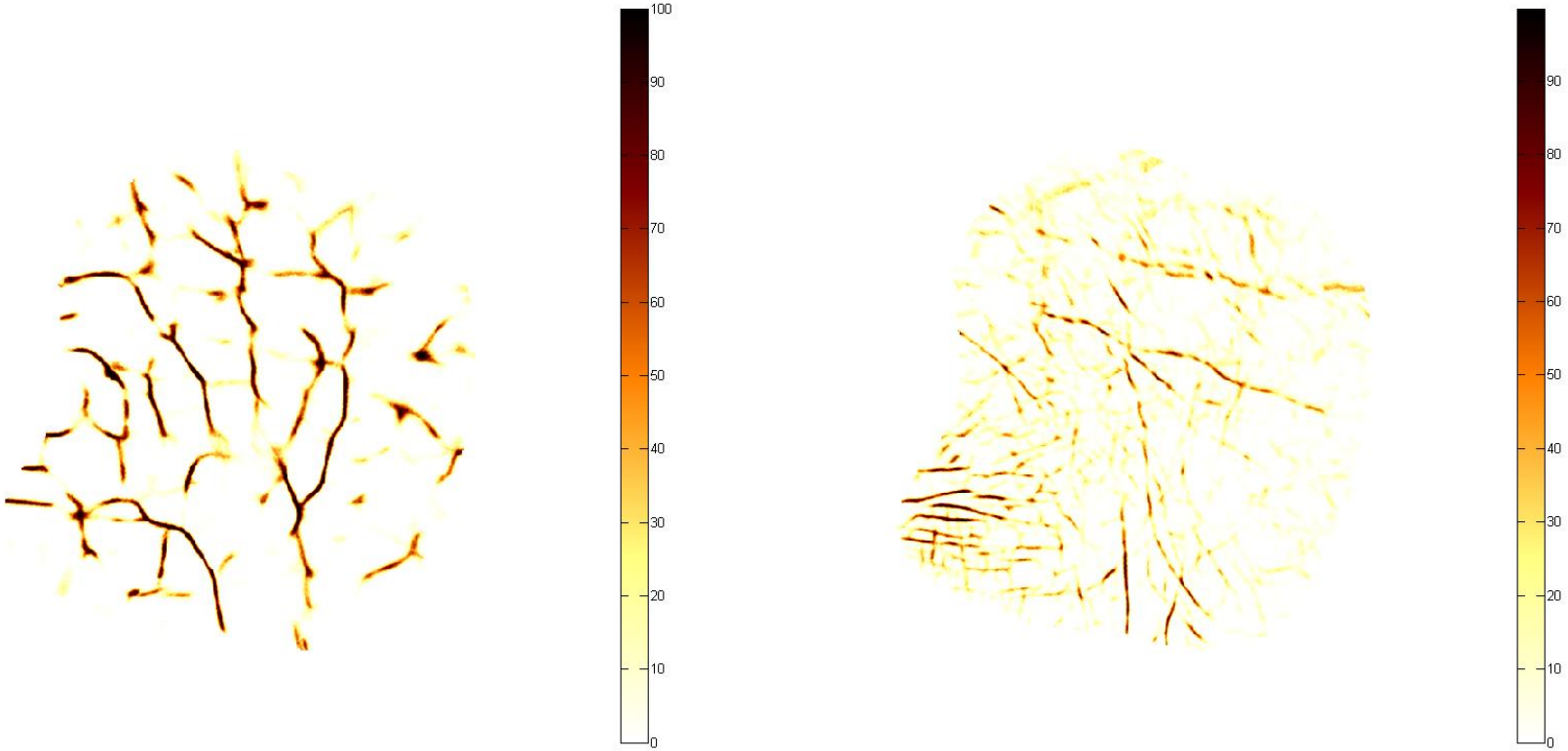
Images containing both palm features



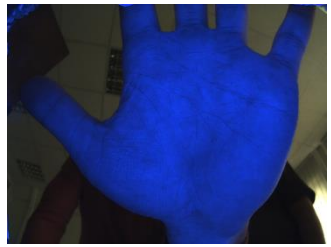
Palm ridge images, obtained using near-infrared light band-stop filter

Ground truth images

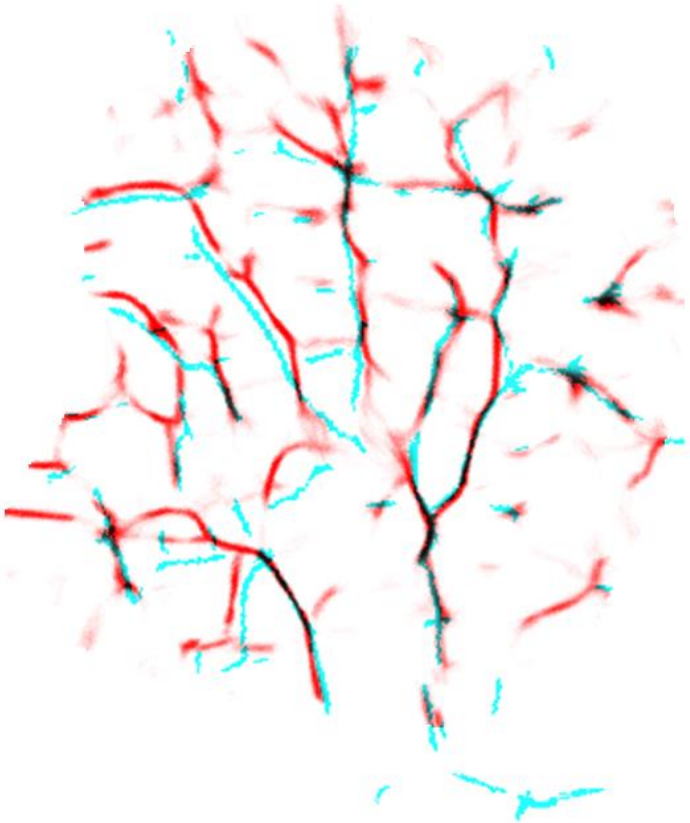


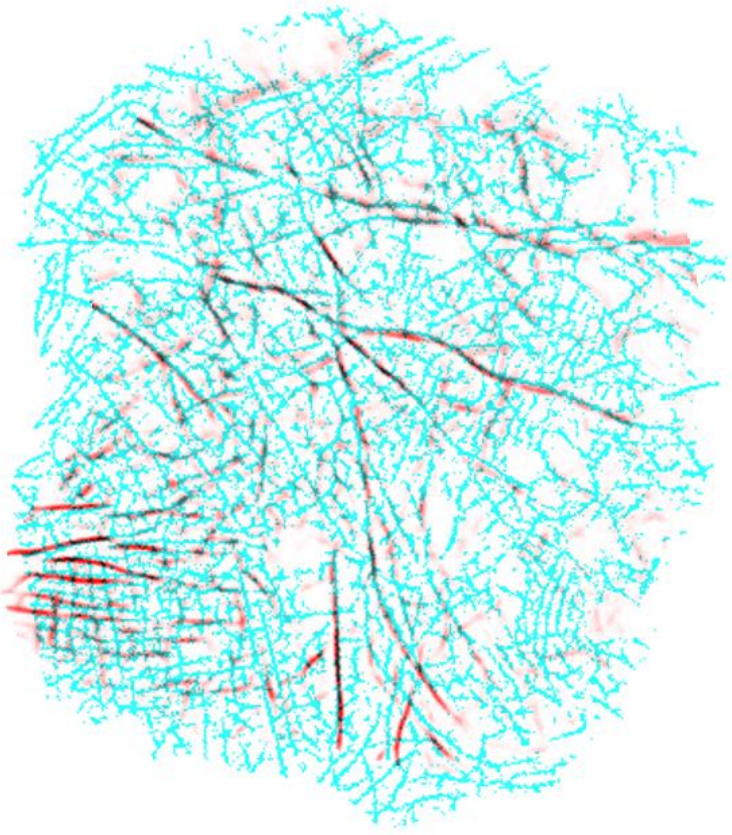


Features of each modality were extracted and summed together from 30 images



Binary ground truth masks were obtained from ground truth images



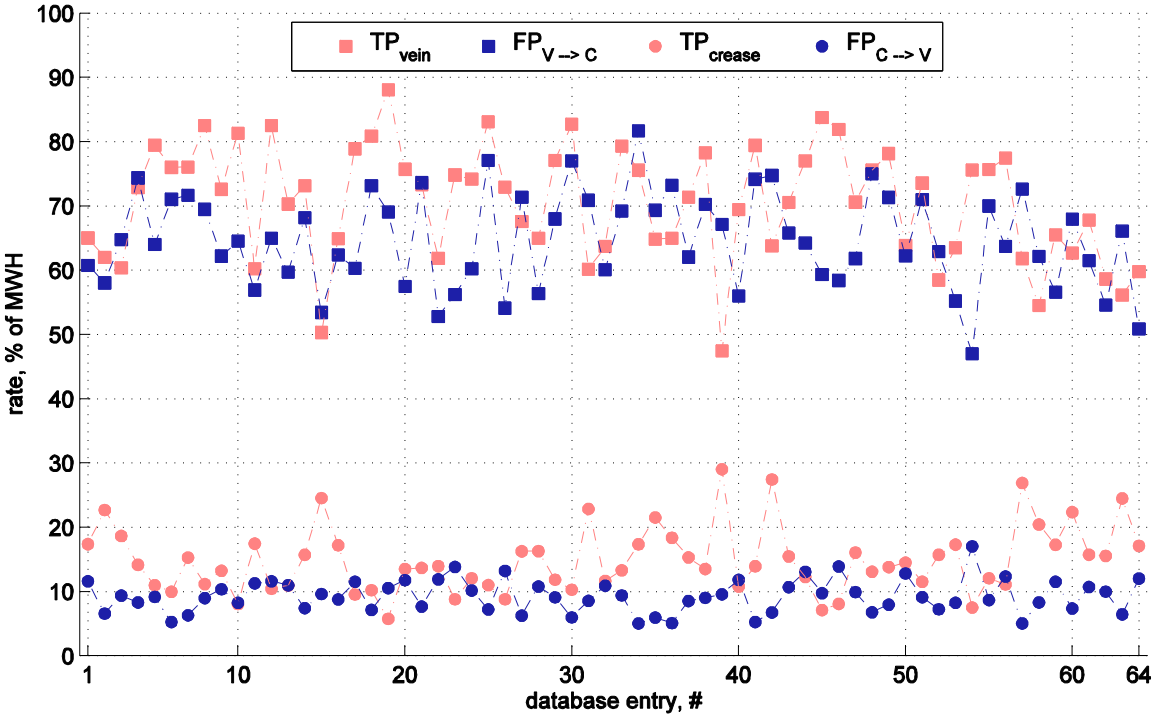


Feature sum image is matched with binary ground truth mask – similarity is evaluated in %

RESULTS

Database: 64 people, aged 22 – 79, palm images.

- veins found correctly – 70.6%;
- crease found correctly – 64.7%;
- veins found as creases – 14.8%
- creases found as veins – 9.29%.



CONCLUSIONS & FUTURE WORK

- It was shown that it is possible to acquire features of both modalities separately using only one RGB image, thus, simplifying biometric device and authentication procedure;
- Crease separation from veins appeared more accurate; palmar and thenar crease sometimes are detected as veins;
- In future we would like to increase recognition accuracy and implement algorithm in embedded system for real-time video processing.

THANK YOU FOR YOUR ATTENTION

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