

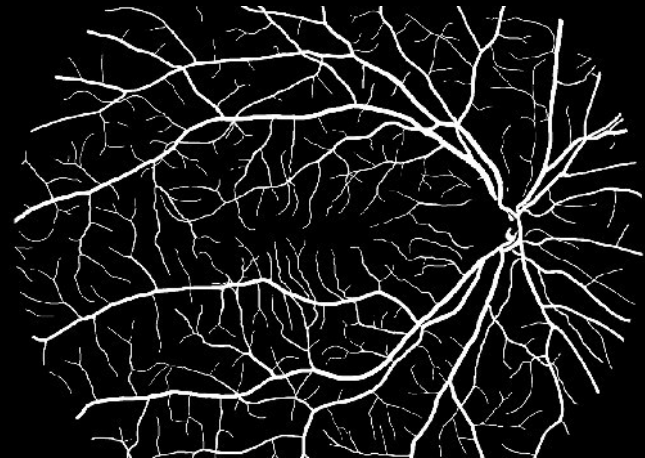
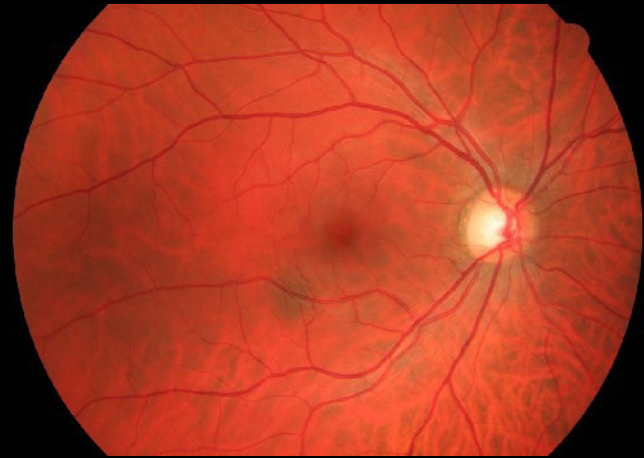
Vessel segmentation of the retina

SSIP 2012, Vienna

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Motivation

- SSIP 2012
- Diagnostics
 - Measurements
 - Abnormalities
 - Laser surgery
- Registration



Difficulties of segmentation

- No universal solution
- Methods depend on:
 - Approach
 - Automatic / semi-automatic
- Specific problems of retinal images
 - Uneven background
 - Damaged / diseased retina
 - Bright center lines

Possible approaches

- Pattern recognition
 - Ridge-based (local gradient peaks)
 - Skeleton-based (centerlines)
 - Region growing (postprocessing, cavities, smoothing)
 - Matching filters (+ centerline detection/thresholding)
- Model-based
 - Explicit models
 - Active contours (requires good initial estimate)
 - Deformable models

Original images

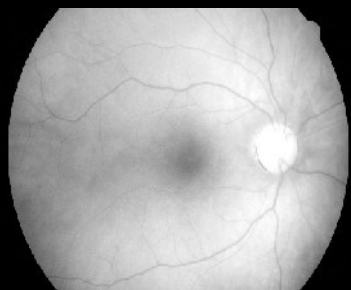


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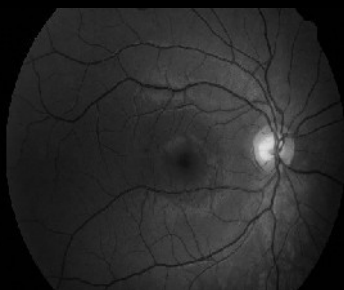


Channel selection

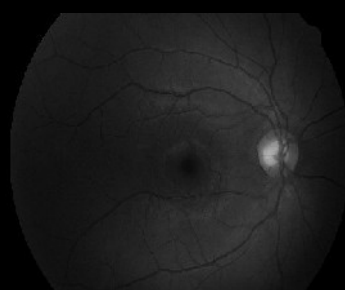
R



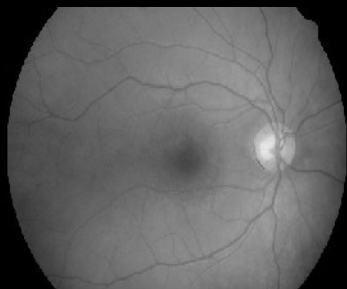
G



B



L



a^*



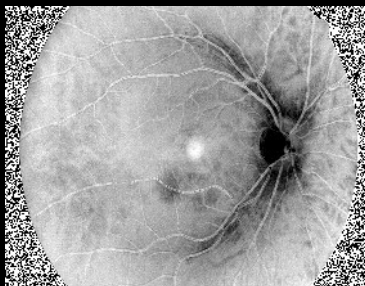
b^*



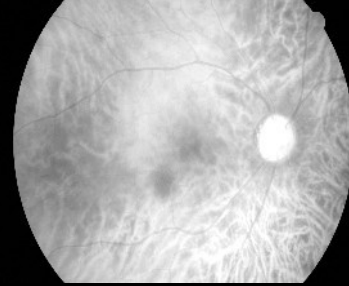
H



S



V



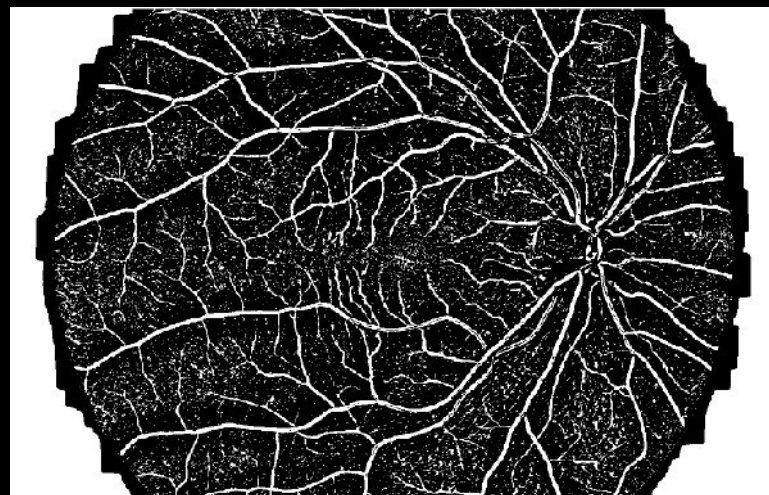
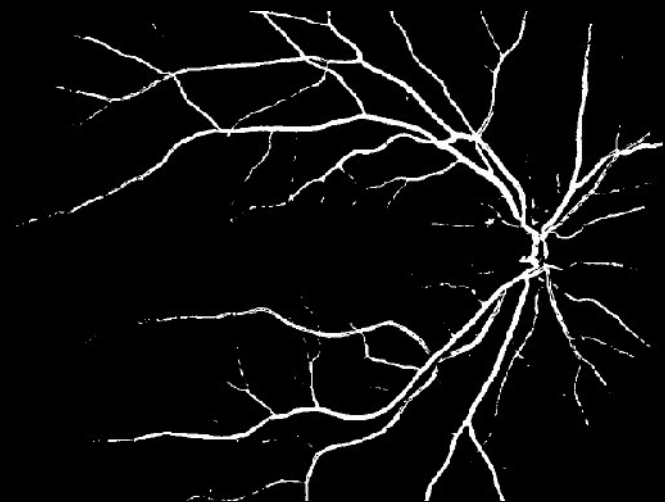
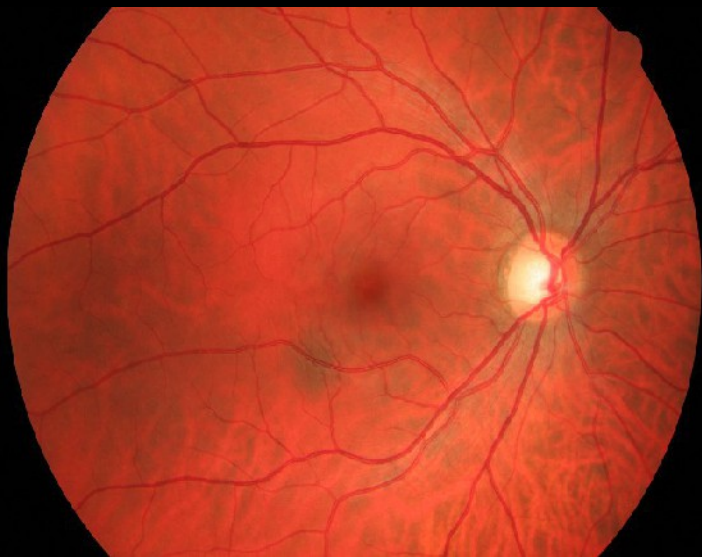
Channel selection – Green



Proposed method

- Morphological reconstruction by dilation
- Mask and marker images are prepared in a similar way:
 - Morphological opening to fill the interior of wider vessels
 - Black top-hat to isolate small dark structures (vessels)
 - Coherence enhancing diffusion
(so that the thresholding doesn't break the vessels)
 - Thresholding
 - global for the marker
 - adaptive for the mask
 - Median filtering of the marker

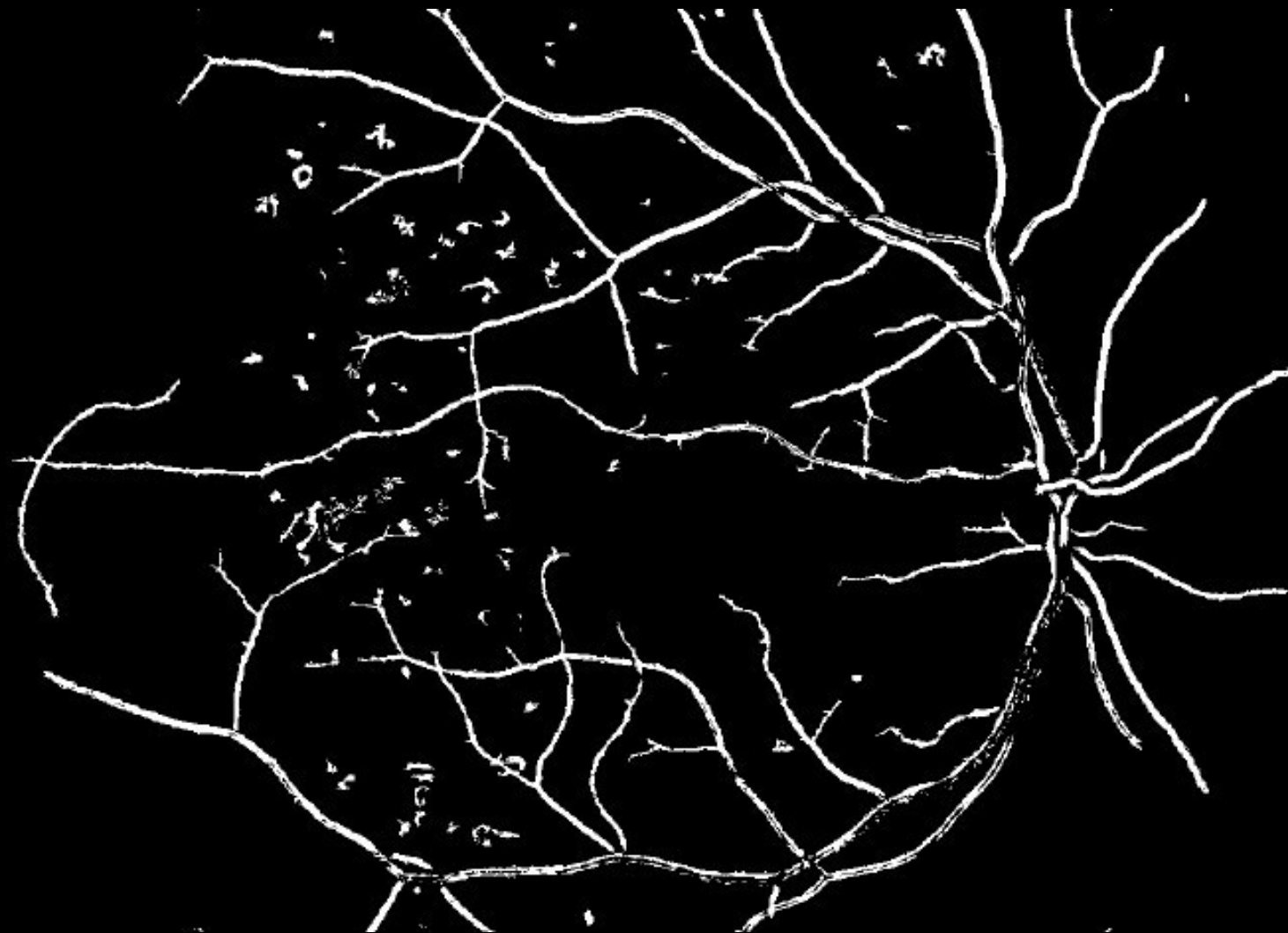
Marker and Mask



Post-processing

- Removal of very small components by area opening
- Removal of larger (but still small) components far enough from other components (retinopathy spots)
 - Sliding window

Post-processing



Post-processing



Comparison to the state of the art

- Adaptive thresholding-based segmentation
 - Thitiporn Chanwimaluang
- Hessian-based “vesselness” filter
 - Alejandro Frangi

Results – healthy

	Adaptive thresholding	Vesselness filter	Proposed method
recall	0.629	0.400	0.713
precision	0.734	0.965	0.816
F1 score	0.677	0.566	0.761
connectivity	0.999	0.995	0.999
area	0.744	0.590	0.791
length	0.730	0.589	0.789

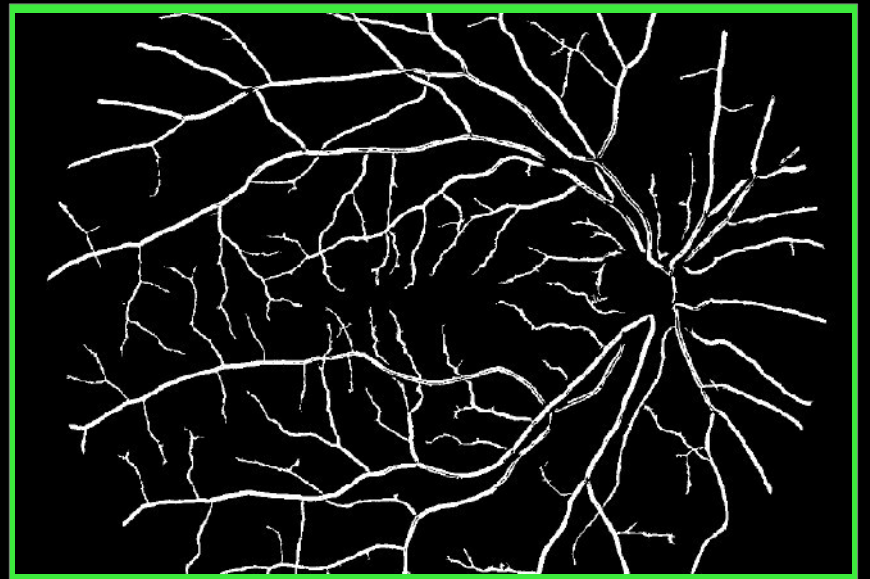
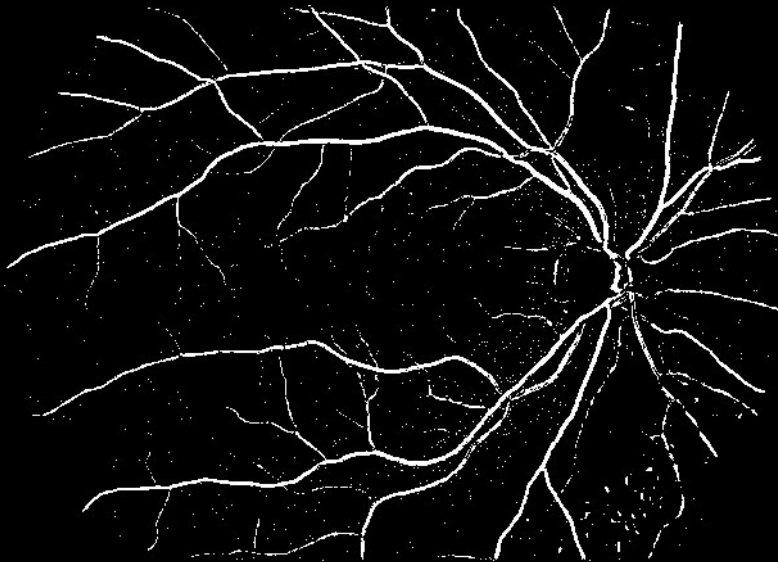
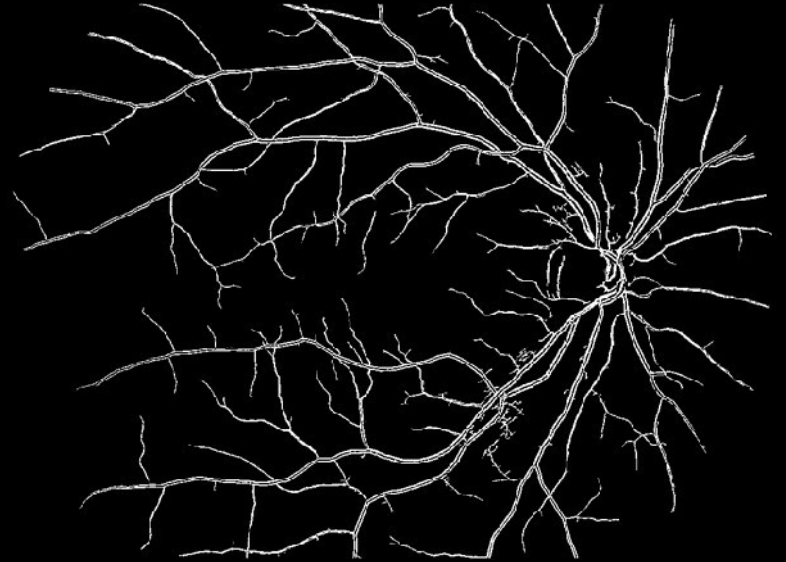
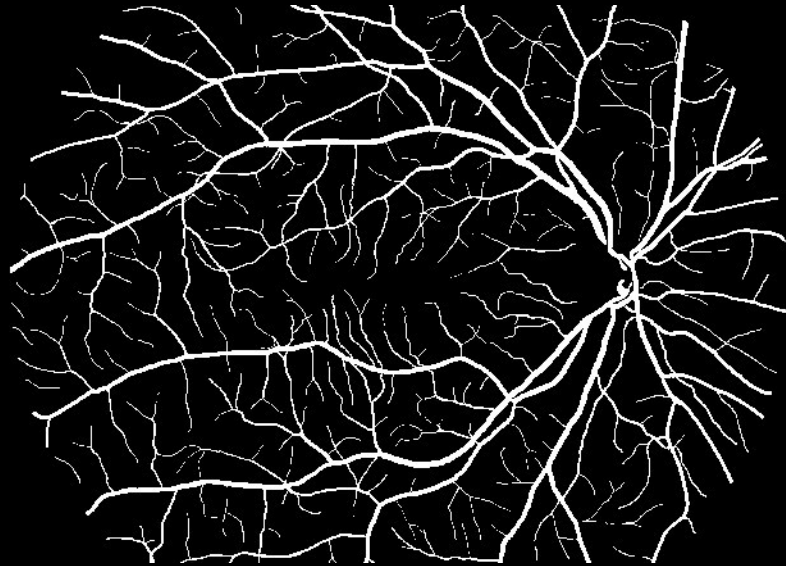
Results – glaucoma

	Adaptive thresholding	Vesselness filter	Proposed method
recall	0.604	0.331	0.708
precision	0.664	0.934	0.668
F1 score	0.633	0.489	0.687
connectivity	0.999	0.997	0.999
area	0.740	0.485	0.745
length	0.725	0.446	0.720

Results – retinopathy

	Adaptive thresholding	Vesselness filter	Proposed method
recall	0.566	0.339	0.607
precision	0.553	0.775	0.650
F1 score	0.559	0.472	0.628
connectivity	0.999	0.976	0.999
area	0.643	0.520	0.671
length	0.651	0.448	0.690

Visual comparison



Conclusion

- No general solution for unhealthy cases
- Many different approaches
- Channel selection, pre- and post-processing are important

Thank you for your attention

