Automatic Detection of Capillary Vessels in OCT data

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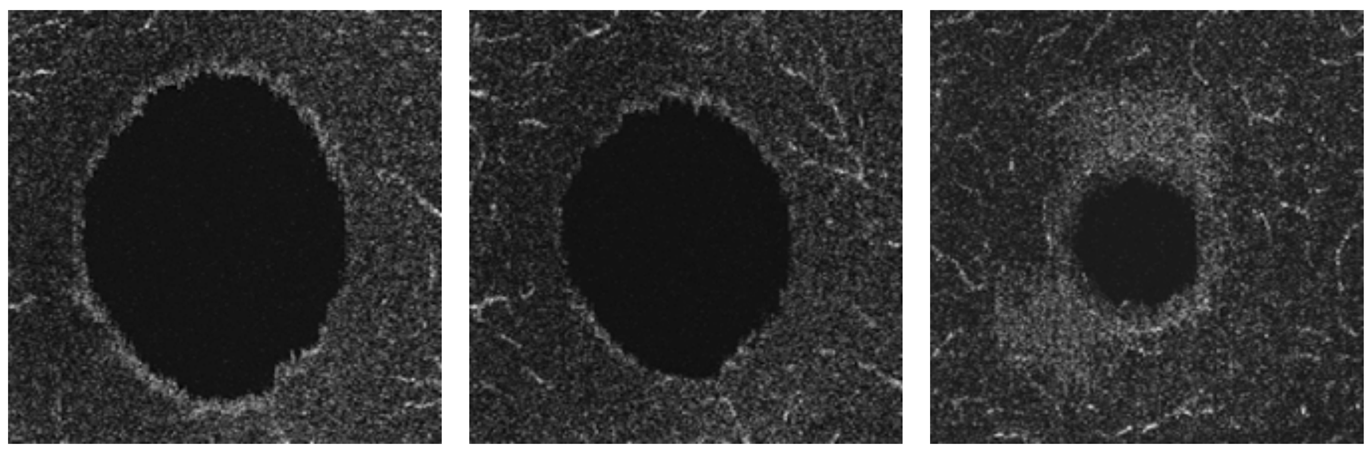
Motivation



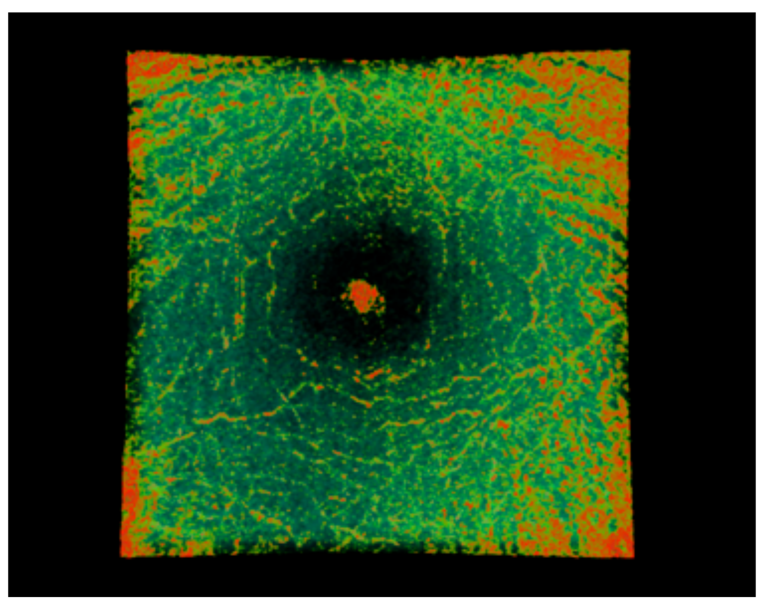
Discovering changes in retinal blood supply before damage to large vessels occurs, can act as early **indicator for vision loss**. **Optical coherence tomography** has become a standard imaging technology in ophthalmology.

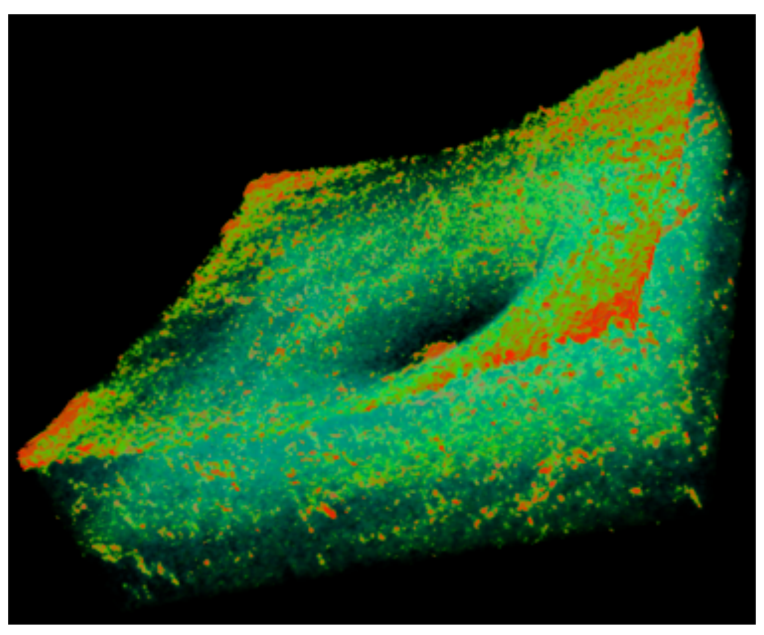
Until now, early manual detection in capillary vessels is impossible due to highly noisy OCT data. Thus there is a need for a computer aided **automatic segmentation**.

Method

1. Optical coherence tomography data

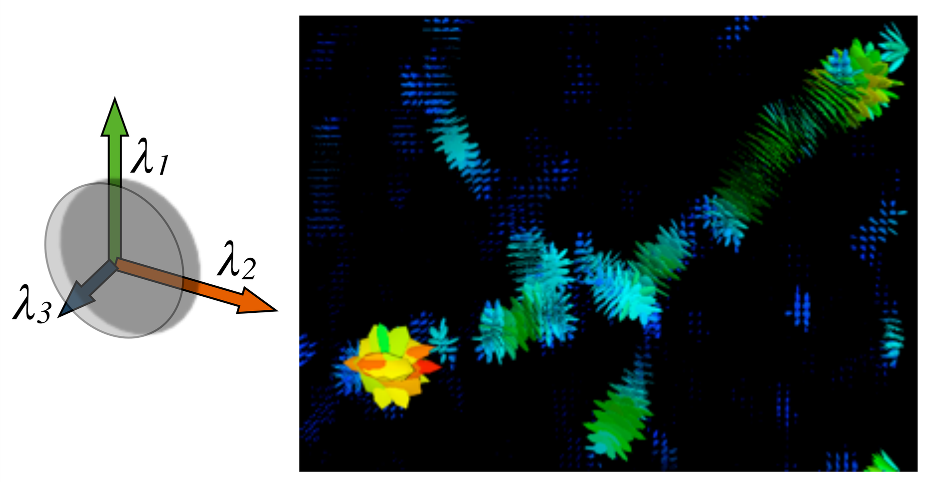
High resolution cross-sectional images of the retina by measuring echoes of backscattered light.



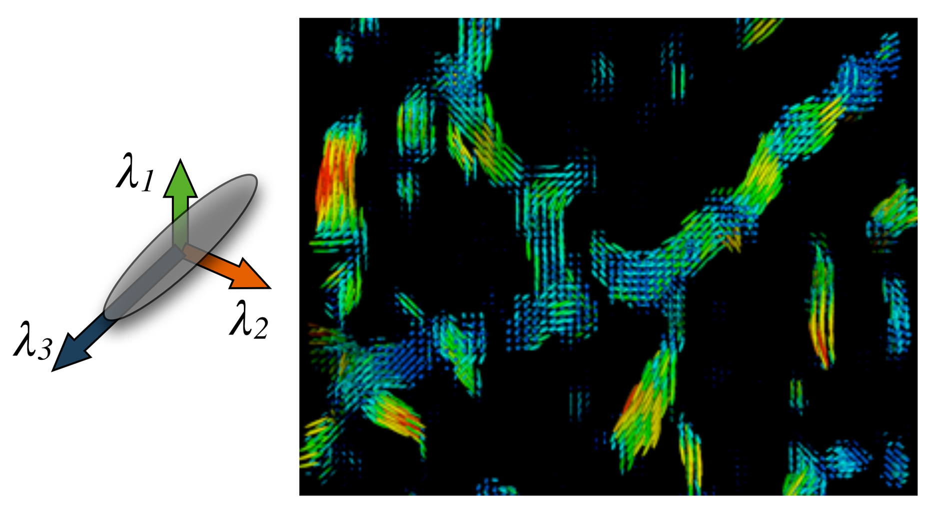


2. Detect and describe candidate points [Sato97]

Perform **eigenvalue decomposition** of Hessian matrix. If $\lambda_1 < \lambda_2 < \lambda_3$, for a bright line: $\lambda_3 \approx 0$; $\lambda_1, \lambda_2 << 0$



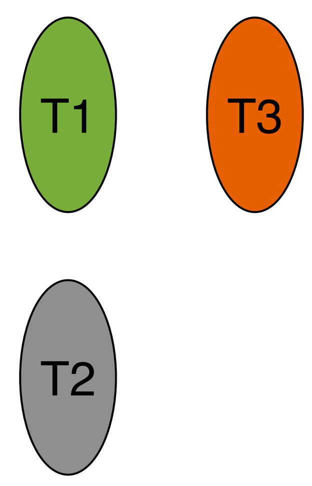
Transform the tensors to represent the vessel structure and local connectivity:



3. Compute a distance measure [Neji08]

Compute distance measure based on a **probabilistic kernel** that contains spatial localization as well as tensor orientation.

In the computed feature space, tensors that point into the same direction, and correspond to locations along this very same direction, will be closer than those that do not lie on the same fiber tract.

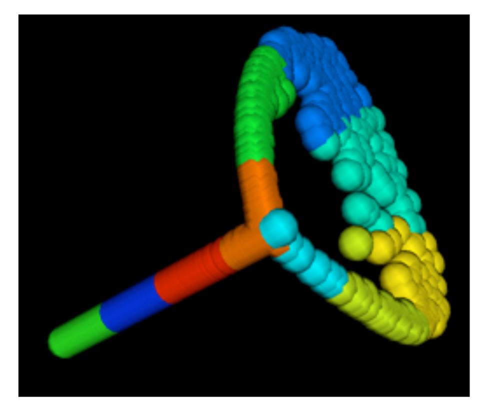


In this case, the connection between tensors T1 and T2 has lower distance than between T1 and T3.

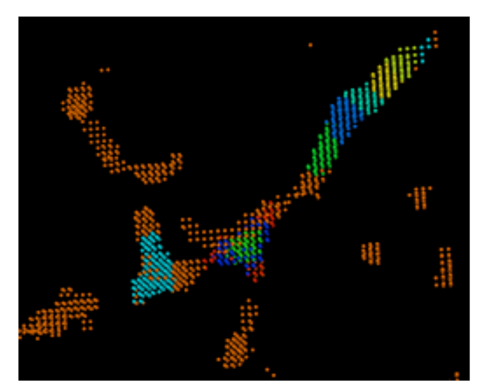
In the subsequent mapping, T1 and T2 appear closer than T1 and T3.

4. Embedding in a feature space

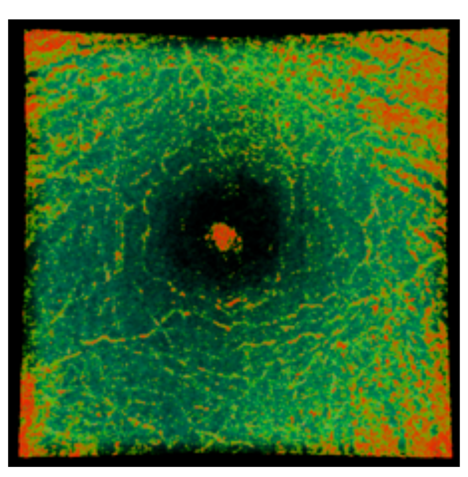
An **embedding** in a feature space based on distance matrix defined by the probabilistic kernel is conducted to represent the global structure.



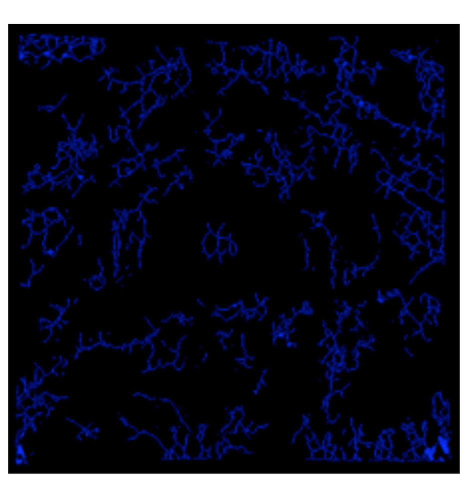
Points close to origin correspond to background points since leading eigenvectors of the Gram matrix are expected to represent the relevant information in the data while the eigenvectors corresponding to the smaller eigenvalues correspond to noisy structures.



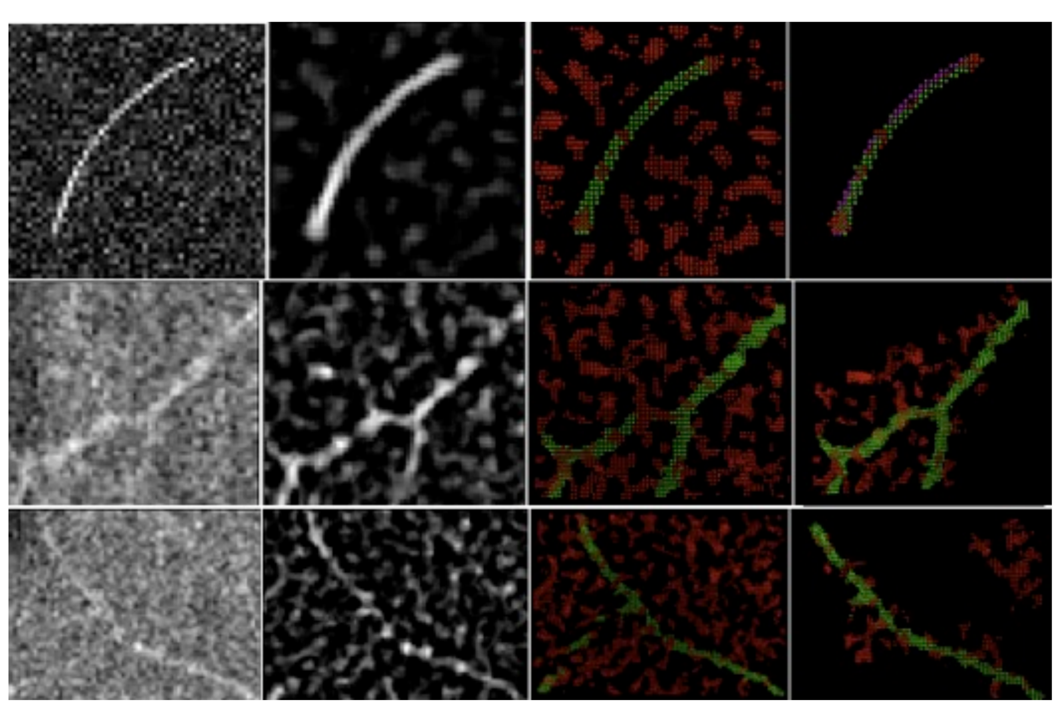
Results



Original Image



Detected Vessels



Comparison of our method to other approach for synthetic (top row) volume and two sections of OCT volumes (middle and bottom row).

Left: original volume. *Middle left:* filtered volume. *Middle right:* result from vessel detector [Sato97]. *Right:* result of our method. Note the reduced background noise. Red points represent FP, green points are TP.

References

[Sato97] Y. Sato, S. Naka jima, N. Shiraga, H. Atsumi, T. Koller, G. Gerig, S. Yoshida, R. Kikinis. *3D Multi-scale Line Filter for Segmentation and Visualization of Curvilinear Structures in Medical Images.* LNCS, vol. 1205:pp. 213–222, 1997.

[Neji08] R. Neji, J.-F. Deux, G. Fleury, M. Maatouk, G. Langs, J.-P. Thiran, G. Bassez, A. Rahmouni, N. Paragios. *A Kernel-based Approach to Diffusion Tensor and Fiber Clustering in the Human Skeletal Muscle.* INRIA Research report, vol. 6686, 2008.

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