Title: Retinal image analysis with the trainable COSFIRE filtering approach

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Abstract:
Retinal imaging provides a unique opportunity to inspect the health status of a person in a non-invasive way. Besides eye-related diseases, such as glaucoma, age macular degeneration and diabetic retinopathy, in the retina one can find signs that can give indications about the cardiovascular system, such as hypertension and atherosclerosis, and systemic diseases.

The automatic analysis of retinal fundus images is important as it could be used in computer aided diagnosis systems that can assist medical experts, especially in mass screen programs. One fundamental step in the analysis of such images is the segmentation of the vessel tree from the background. This is important, among others, for the analysis of the spatial arrangement of bifurcations, and to allow better analysis of the lesions in the background.

In this talk I will present three methods that we propose for the analysis of retinal fundus images, namely vessel segmentation, bifurcation detection and glaucoma detection. The three methods share a common filtering approach called COSFIRE (Combination of Shifted Filter Responses). A COSFIRE filter is trainable, in that its selectivity is determined by the automatic analysis of a prototype pattern of interest given in the training stage. For instance, when the prototype pattern is an elongated bar structure, we can configure a COSFIRE filter that can be used for the delineation of the vessel tree. If we use a set of typical junctions (Y-, T- and K-type) we can configure COSFIRE filters that are able to detect the bifurcation points in the image. Moreover, we can configure COSFIRE filters that are selective for the divergent point of the vessels that characterizes the location of the optic disk. This is followed by a technique that measures the cup-to-disc ratio, a property that medical experts use to diagnose glaucoma.

Besides retinal image analysis, the COSFIRE approach has proven to be effective in various computer vision applications, ranging from contour detection, machine vision, object recognition and image classification. The main strength of the COSFIRE filtering approach is its trainable character, as a COSFIRE filter can be configured to be selective for any pattern. Such filters achieve tolerance to rotation, scale and reflection. They are conceptually simple and easy to implement. We also made available online the implementations in Matlab and C++.