Supervised, hysteresis-based segmentation of retinal images using the linear-classifier percentile

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Photographies of the retina showing the vasculature are used, for example, to support medical diagnosis and for intervention planning. To this end, the retinal vessels need to be segmented to compute measures like vessel area and length, vessel width, abnormal branching, and also to provide a localization of vascular structures. There are several aspects that make vessel segmentation challenging. To name only a few: the contrast of vessels varies with size, small vessels having a weak contrast, the background is usually inhomogeneous and can be locally similar to the vessels.

Considering a pixel as a point in a feature space, image segmentation is similar to a binary (i.e., two-class) pattern classification problem. The hysteresis classification paradigm [Con08], makes explicit use of the prior knowledge about the connectivity of vessels to provide a solution to this binary classification problem. It uses two classifiers: the first one, called the pessimist, works with a practically zero false positives rate, which with overlapping classes implies a high false negatives rate; the second one, called the optimist, works with a practically zero false negatives rate and a high false positives rate. Then, using the connectivity property of vessels, the pessimist results can be used to select true vessels from among the optimist results.

The hysteresis paradigm can be used to construct both supervised and unsupervised classifiers, for scalar and vectorial inputs, which are all accurate and very fast. Hysteresis segmentation can successfully segment objects of inhomogeneous gray-level representation found on an inhomogeneous background, as long as there is a slight difference between object and background at a local level around the object's borders. The linear-classifier percentile-based relative hysteresis classifier was found to be fast and accurate, being slightly better than other hysteresis methods and a lot faster than some other state of the art methods for the problem of retinal-vessel segmentation. Even though we have used the hysteresis classifier to segment vessel images, we believe that it represents a more general image-segmentation tool that can be used as well for other applications afflicted by large class skew and overlap.

[Con08] A. P. Condurache. *Cardiovascular biomedical image analysis: methods and applications.* GCA, Waabs, 2008.