Automated Analysis of Retinal Images for Early Diabetes Detection with Sub-Riemannian Methods

Several ocular and systemic diseases such as hypertension and arteriosclerosis cause geometrical and functional changes to the blood vasculature in retinal images, including the change of vessel widths and angles especially at bifurcations and crossings. These diagnostic biomarkers are investigated using the vessel segmentation, junction detections or vessel trackings. We have proposed a fully automatic supervised segmentation method (called Brain-Inspired Multi-Scales and multi-Orientation: BIMSO) for not only the color RGB images, but also the ones taken with laser ophthalmoscope (SLO) imaging cameras. Moreover, we introduced a novel BIfurcation and CRossing detection method using Orientations Scores (BICROS). BIMSO and BICROS are inspired by the pinwheel structure of receptive fields in primary visual cortex. By lifting the 2D image to a joint space of positions and orientations (SE(2)) the vessels disentangle based on their orientations. After using the non-linear enhancement in this space, the blood vessels and junctions are discriminated based on their geometric properties in a supervised manner. Tracking the vessels faces difficulties when the vessel paths are interrupted or junctions are disconnected. We analysed the specific problems at junctions with a connectivity kernel obtained as the fundamental solution of the Fokker-Planck equation, which is usually used to represent the geometrical structure of multi-orientation cortical connectivity. By using the spectral clustering on a large local affinity matrix constructed by both the connectivity kernel and the feature of intensity, the vessels are identified successfully in a hierarchical topology each representing an individual perceptual unit.