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Segmenting 3D Optical Coherence Tomography Images Using a Kalman Filter

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Abstract : Over the past two decades or so, Optical Coherence Tomography (OCT) has been used to diagnose retina and optic nerve diseases. The retinal nerve fibre layer, for example, is a powerful diagnostic marker for detecting and staging glaucoma. With the advances in optical imaging hardware, the adoption of OCT is now commonplace in clinics. More and more OCT images are being generated, and for these OCT images to have clinical applicability, accurate automated OCT image segmentation software is needed. Oct image segmentation is still an active research area, as OCT images are inherently noisy, with the multiplicative speckling noise. Simple edge detection algorithms are unsuitable for detecting retinal layer boundaries in OCT images. Intensity fluctuation, motion artefact, and the presence of blood vessels also decrease further OCT image quality. In this paper, we introduce a new method for segmenting three-dimensional (3D) OCT images. This involves the use of a Kalman filter, which is commonly used in computer vision for object tracking. The Kalman filter is applied to the 3D OCT image volume to track the retinal layer boundaries through the slices within the volume and thus segmenting the 3D image. Specifically, after some pre-processing of the OCT images, points on the retinal layer boundaries in the first image are identified, and curve fitting is applied to them such that the layer boundaries can be represented by the coefficients of the curve equations. These coefficients then form the state space for the Kalman Filter. The filter then produces an optimal estimate of the current state of the system by updating its previous state using the measurements available in the form of a feedback control loop. The results show that the algorithm can be used to segment the retinal layers in OCT images. One of the limitations of the current algorithm is that the curve representation of the retinal layer boundary does not work well when the layer boundary is split into two, e.g., at the optic nerve, the layer boundary split into two. This maybe resolved by using a different approach to representing the boundaries, such as b-splines or level sets. The use of a Kalman filter shows promise to developing accurate and effective 3D OCT segmentation methods.

Keywords : optical coherence tomography, image segmentation, Kalman filter, object tracking
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