A novel method for automatic segmentation and identification of closed-contour structures in images

Unmet Need

Fast, accurate, and objective detection and quantification of imaging biomarkers is crucial for the study and diagnosis of ophthalmic diseases. In recent years, considerable work has been done to automate segmentation of ocular layer structures seen on optical coherence tomography (OCT) images. A technique based on graph theory and dynamic programming (GTDP) has been developed to segment layered structures in OCT images of retina and cornea. However, in addition to layered structures, there is a need to automatically segment and quantify closed-contour features in ophthalmic images. Examples of such closed-contour anatomical and pathological structures are cysts in diabetic or pediatric retina with edema, retinal pigment epithelium (RPE) cells or cone photoreceptors. Existing techniques, including active contours, have been demonstrated to segment closed-contour features; however, they have limited accuracy and cannot be optimally extended to linear features, such as retinal layers. Therefore, there is a need for improved techniques and systems for segmenting and identifying closed-contour features in images.

Technology

Duke researchers have developed a novel extension of GTDP technique that segments closed-contour structures in images. Their algorithm is based on the observation that a closed-contour in Cartesian coordinates can be represented as a line in polar domain using an appropriate transform. While a simple polar transform is sufficient to map a circle into a line, an arbitrary shaped closed-contour requires more sophisticated “quasi-polar” transform that, in its simplest form, is a polar transform followed by a flattening step. The parameters for flattening are attained from a pilot estimate of the features of interest. Once the feature is flattened, the GTDP method is used to segment the object as if it were a layered structure. Due to the robustness of the GTDP segmentation technique only a rough estimate of the feature is needed to attain sufficient flattening. This rough estimate can either be generated automatically or provided by a user.

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Finally, the segmented feature is back-transformed into Cartesian coordinates to accurately indicate the outline of feature on the image. This method was experimentally demonstrated to automatically segment biomarker cells in confocal microscopy images of an age-related macular degeneration (AMD) in mouse model. It was also successfully implemented to segment closed-contour features for other ophthalmic features, including cysts on OCT retinal images of a premature infant or diabetic eye with macular edema.

Advantages

- Will be extremely useful for imaging studies or diagnostics that use cell morphology as a biomarker for the onset and progression of disease.
- Reduces the time and manpower required for segmenting closed-contour features in ophthalmic and other imaging.
- Has been successfully tested experimentally

Publications

- Validated automatic segmentation of AMD pathology including drusen and geographic atrophy in SD-OCT images (Invest Ophthalmol Vis Sci, 2012)
- Automatic segmentation of closed-contour features in ophthalmic images using graph theory and dynamic programming (Biomedical Optics Express,2012)
- Automatic cone photoreceptor segmentation using graph theory and dynamic programming (Biomedical optics express , 2013)
- Automatic segmentation of up to ten layer boundaries in SD-OCT images of the mouse retina with and without missing layers due to pathology (Biomed Opt Express, 2014).
- Kernel regression based segmentation of optical coherence tomography images with diabetic macular edema (Biomed Opt Express, 2015)
- Validation of Macular Choroidal Thickness Measurements from Automated SD-OCT Image Segmentation (Optom Vis Sci. 2016)
- Length-adaptive graph search for automatic segmentation of pathological features in optical coherence tomography images (J Biomed Opt, 2016)
- Platform-Independent Cirrus and Spectralis Thickness Measurements in Eyes with Diabetic Macular Edema Using Fully Automated Software (Transl Vis Sci Technol, 2017)
- Automatic segmentation of nine retinal layer boundaries in OCT images of non-exudative AMD patients using deep learning and graph search (Biomed. Opt. Express, 2017)
- Patent (9,940,722)

Patents

Patent Number: 9,940,722

Title: SEGMENTATION AND IDENTIFICATION OF CLOSED-CONTOUR FEATURES IN IMAGES USING GRAPH THEORY AND QUASI-POLAR TRANSFORM

Country: United States of America