EyeDiff: Automated Longitudinal Analysis of Lesion Changes in Retinal Images

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Diabetic retinopathy (DR) is the leading cause of vision loss in the working age adults. With an increasing diabetic population there is an urgent need for smarter screening for DR and tracking its progress. Longitudinal analysis of fundus images can potentially be useful to evaluate changes in lesions and therefore helpful in assessing risk for DR progression. This would need precise alignment of retinal fundus images along with lesion identification. We propose EyeDiff – a tool for robust and accurate alignment of retinal fundus images, coupled with lesion identification.

Longitudinal retinal fundus image sets from over 1000 patients were obtained retrospectively from EyePACS. The longitudinal images were aligned using condition number theory based registration in the vesselness transform domain in a multi-scale framework. Regions of interest were determined based on morphological filtering and hessian matrix based computations to limit the pixels that are processed further. Ground truth annotation for DR lesions such as microaneurysms (MA), hemorrhages, and exudates from expert graders from Doheny Eye Institute was obtained on a set of 100 images. Lesion detectors were learnt using novel multi-scale descriptors such as Gaussian derivatives and morphological filterbanks in a support vector machine framework. On a subset of images from 50 patients, lesion analysis was performed.

All longitudinal image pairs were successfully registered even with multiple lesion changes, and different intensities between the images. The detected lesions from the baseline image (red colored border) and the longitudinal image (cyan colored border) were marked on these registered images (Figure 1).

Eyediff enables automated lesion dynamics visualization by resolving two key challenges – robust longitudinal image registration and accurate lesion detection. We can further augment the utility of the tool by computing MA appearance-disappearance rates and quantifying growth of exudates towards fovea across visits.

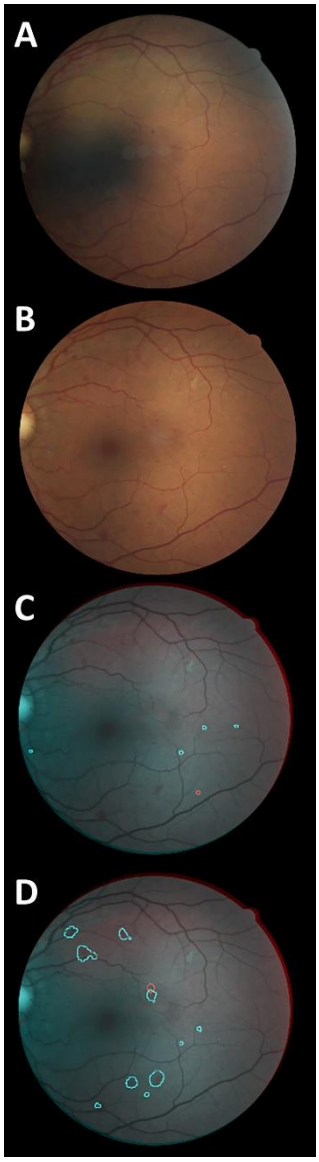

Figure 1: Lesion changes on a pair of longitudinal images from a patient. (A) Baseline RGB color image, (B) Longitudinal image (imaged after 22 months). Registered green channel images from A and B are artificially colored and overlaid in (C, D). (C) Detected MAs marked: baseline image MAs have red border, while those in longitudinal image have cyan border. (D) Detected hemorrhages marked as in (C).