

Abstract

Diabetes, being the most common disease worldwide, affects the vision acuity that leads to a condition called Diabetic Retinopathy (DR) where the retinal blood vessels are majorly damaged. Once it is left untreated, the permeability of the retinal capillaries increases, thereby causing Diabetic Macular Edema (DME). DME is a leading cause of central vision loss in person with diabetes. The Early Treatment Diabetic Retinopathy Study (ETDRS) defined DME as retinal thickening at or within one disc diameter of the centre of the macula or definite hard exudates in this region. Routine screening of DR is always recommended for diagnosis on the onset of DME so that the treatment can be started at the earliest to prevent DME. Due to various factors like scarcity of expert ophthalmologists, ambiguity in decision making, intra-observer variation, and time consumption, the clinical investigation of DME gets either delayed and/or less accurate. In view of this, this work motivates for routine retinal screening of DR patients to prevent central vision loss as a consequence.

In this dissertation, we introduced segmentation algorithm for identifying macular region and subsequently quantified the macular area using geometrical and textural features. The image analysis and machine learning algorithms were developed for detecting DME using Fundus Fluorescein Angiogram (FFA) images. Finally the morphological patterns of Spectral Domain-Optical Coherence Tomography (SD-OCT) and FFA images were validated to identify some interesting patterns. To the best of our knowledge, such attempt has been made for the first time using conformal mapping. In order to achieve the goal, at first the macular area from FFA image was segmented using snakes algorithm without optic disc localization. The proposed segmentation methodology achieved an accuracy of 96% as compared to the ground truths generated by two different experts. It was observed to perform better than the standard Otsu's and Chan-Vese algorithms. Next, a computational method was devised for the ophthalmologists for better visualization of the retinal pathologies within the macular area. To achieve this, we enhanced the macular region using super-resolution via sparse representation. The proposed method provided a better magnification of the macular area in comparison with other interpolation techniques like bilinear and bicubic. Thereafter, an attempt was made to quantify the macular region [area of the Foveal Avascular Zone (FAZ)] using geometric and textural measures. These features were statistically evaluated to find the most significant ones in discriminating the DME and healthy groups. Finally, machine learning techniques viz., Naive Bayes, Classification and Regression Trees (CART) and Random Forests (RF) were trained and tested based on the statistically significant feature set. It was observed that CART and RF algorithms performed better with an accuracy of 93.93% and 96.67% respectively for a six-fold cross-validation. The average ROC for RF technique was found to be greater (i.e., 98.6%) than CART (i.e., 85.7%). The Out-of-bag error for RF was evaluated as 0.0303. This thesis is a first-step towards automating the process of DME detection in FFA images. We believe that this system will help the ophthalmologists to study the progression of the disease in multiple patients over a time period.

Keywords: Diabetic Retinopathy, Fundus Fluorescein Angiogram, Diabetic Macular Edema