Diabetic Retinopathy (DR) is one of the significant causes of blindness amongst working-age adults throughout the world. It is an effect of prolonged Diabetes, which eventually weakens the retinal blood vessel walls, further leading into leakage of blood and other fluids into the eye. These leakages appear in the form of bright or red lesions in the retinal image. The disease progresses with changes in vessel structures, which in severe stages may cause irreversible damage to the retina.

Diagnosis of DR, especially in its early stages, can help in halting the progression of disease (by following proper clinical measures like, good control of blood sugar) and preserving the patient's vision. Moreover, if automated, then such tool can assist the medical experts for large scale, community-level screening.

In this thesis, we propose a segmentation-based approach to diagnose DR using 2-D fundus images. Here, we target the detection of initial symptoms of DR, which helps in DR diagnosis at any stage, including the challenging early stages. To begin with, we extract the retinal blood vessels, which is one of the most crucial and vulnerable features of a DR-affected retina. Though blood vessel is a typical feature of the retina, its segmentation is vital to understand the presence of abnormalities. We target this retinal vessel extraction in two ways. The first proposed method is unsupervised, based on conventional image processing techniques. In this pipe-line based method, we use multi-scaling (wavelets and curvelets) to target the varying width of blood vessels. This algorithm made us analyze and understand the fundus images in a subjective manner. Using the observed analysis of fundus images, we propose a combined approach in which the input fundus image in pre-processed in unsupervised manner and further fine-tuned to target vessel detection.

Red lesion based DR detection helps in screening out of DR patients even in the early stages. This is reportedly the initial abnormality that starts appearing on the retina due to swelling and leakage of blood from the retinal capillaries. We combine five handcrafted intensity features along-with deep-model extracted features to segment red lesions. Further, we use the presence of red lesions to predict the DR.

To summarize, the thesis proposes the extraction of retinal blood vessels and red lesions by analyzing 2-dimensional fundus images. Further, we use these extracted retinal features for the DR screening. We have explored various conventional image processing and deep learning methods to understand the retinal layer. Experimentation with a variety of datasets, has helped in developing robust and generic algorithms. The proposed screening algorithm is segmentation-based, which is more reliable and supposed to fill the gaps between machines and professionals by locating the abnormality. The analysis and observations stated in the thesis are meant to facilitate the medical community.