Chapter 3
Role of Machine and Deep Learning Techniques in Diabetic Retinopathy Detection

Jagan Mohan Nagula
https://orcid.org/0000-0003-0978-4633
National Institute of Technology, Silchar, India

Murugan R.
National Institute of Technology, Silchar, India

Tripti Goel
National Institute of Technology, Silchar, India

ABSTRACT

Machine learning (ML) and deep learning (DL) techniques play a significant role in diabetic retinopathy (DR) detection via grading the severity levels or segmenting the retinal lesions. High sugar levels in the blood due to diabetes causes DR, a leading cause of blindness. Manual detection or grading of the DR requires ophthalmologists' expertise and consumes time prone to human errors. Therefore, using fundus images, the ML and DL algorithms help automatic DR detection. The fundus imaging analysis helps the early DR detection, controlling, and treatment evaluation of DR conditions. Knowing the fundus image analysis requires a strong knowledge of the system and ML and DL functionalities in computer vision. DL in fundus imaging is a rapidly expanding research area. This chapter presents the fundus images, DR, and its severity levels. Also, this chapter explains the performance analysis of the various ML DL-based DR detection techniques. Finally, the role of ML and DL techniques in DR detection or severity grading is discussed.

INTRODUCTION

The human eye is a perplexing system that allows individuals to identify one of their most essential detections. Our ability to comprehend and investigate our surroundings is based on our vision. Our eyes

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always take in light when we look around us, which is crucial for the visual process.

The retina is a thin layer of the receptive layer that surrounds 66 percent of the eyeball, and it is the light stimulus that gives the sensation of visibility (Jagan Mohan et al., 2020b). The retina expands the brain, which is formed by zygotes from neural cells and is appropriately linked to the cerebrum by the optic nerve. The retina captures light and converts it into the object's liveliness. The liveliness of concussions activates neurons that carry electrical information from the eye to the brain's higher centers.

Diabetic retinopathy (DR) is a severe diabetic complication that causes retinal damage and blindness. It damages the retina vessels, resulting in fluid leaks and sensory abnormalities. According to (Steinmetz et al., 2021), DR is one of the most frequent ailments in the United States, the United Kingdom, and Singapore, alongside blinding conditions including cataracts and glaucoma.

This book chapter discusses the fundus image and publicly available databases associated with DR. In addition, this chapter covers the DR with clinically evident retinal feature symptoms, grading or categorization, and risk factors. This chapter describes various Machine Learning (ML) and deep learning (DL) techniques utilized in DR grading. It also explains how to increase ML and DL performance by preprocessing the fundus images. The chapter compares DR detection strategies utilizing ML and DL to other techniques in a quick comparison. It describes the role of ML and DL techniques and their potential for detecting or segmenting the DR stages. Finally, the conclusion concludes the chapter.

The Fundus Image

The fundus image is a 2-D image captured with the reflected light of 3-D retinal tissue. In 1850, H V H Savant invented the ophthalmoscope to capture fundus images. Fundus imaging aids in diagnosing and treating visual and chronic infections such as DR, hypertension, glaucoma, leukemia, and systemically malignancies with visual metastases, to name a few (Senior, 2010). The fundus imaging methods include digital fundus photography, autofluorescence, infrared reflectance, and contemporary fundus imaging technology developments (Chowdhary et al., 2016, Das et al., 2020).

Fundus image capturing uses the same principles as traditional imaging techniques (Mohan et al., 2020). Each image pixel is stored by turning the light into an electrical signal using a sensor. The image resolution can be improved by increasing the number of sensors on the camera.

As shown in Figure 1, the fundus image analysis aids in identifying DR retinal characteristics. Microaneurysms (MA) (Jagan Mohan et al., 2020a), exudates (EX) (Mohan et al., 2021b), hemorrhages (HEM), and Cotton-wool-spots (CWS) (Mohan et al., 2021a) are all DR retinal characteristics.

Table 1 lists the publicly accessible fundus databases and the # of images with a field of view (FOV), resolution, and purpose.

Diabetic Retinopathy

Diabetes patients are increasing at an astonishing rate worldwide due to various causes, including age, lack of physical activity, population growth, overweight, and urbanization. The number of diabetes patients is expected to rise to 366 million by 2030, up from 300 million in 2025 (Zhao & Jiang, 2020). Diabetes is the most common cause of visual impairment in laborer (working age) persons, according to (Pearce & Sivaprasad, 2020). The coronary arteries in the retina are disrupted in DR, leading them to spill liquids or fluids and distorting vision.