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A Multi-Layer stacked ensemble classifier model for improved classification accuracy of Maculopathy gradation☆

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ABSTRACT

Diabetic Maculopathy (DME) is the serious impediments of diabetes, which may cause permanent blindness unless timely detected. Vision impairment because of diabetes is substantially avoidable with well-timed screening and intervention at primary stages. Presence of most primitive and distinctive signs on the retinal surface is micro-aneurysm and haemorrhage, signify as dark spots and hard and soft exudates signifies as bright lesions. Hence, recognition of all these bright lesions is the first step of automated recognition of DME. In this paper, we present a multi class, multi-layer stacked ensemble classifier-based model with four base learners and one *meta*-learner for improved exudates (EXs) classification accuracy and maculopathy gradation system. The proposed system involves pre-processing, Scale-Space Extrema Detection(SSED) based extraction of clinically significant bright lesions, shape, colour, intensity, and statistical functions-based feature set creation, Minimum Redundancy-Maximum Relevance (mRMR) feature selection, stacking classifier with Bayesian optimization (BO) for hyper-parameter tuning and severity gradation. Information of location of all types of exudates is accounted for to provide the level of severity of DME. At both the image and lesions levels, the proposed system's quantitative assessment is carried out utilising publicly available databases. When compared to other state-of-the-art methodologies, our system's results have achieved competitive performance in three and two class exudates classification and DME gradation.

1. Introduction

DME is a widespread retinal disease due to diabetes mellitus. Diabetes mellitus damages blood-vessel that continues to leak into the retinal surface. This type of permeability ultimately leads to blindness. Number, location and sorts of lesions found on the retina's surface are the irrefutable process of determining the severity of DME. Therefore, regular eye screening is required along with severity gradation to reduce the risk of vision loss. Later-stage treatment is difficult and nearly impossible. As a result, primary identification of DME is critical to avoiding vision loss in patients. For DME identification and treatment, a systematic inspection of the retina of the eye is essential. An automatic screening system is crucial to speed up the DME diagnosis and the system must be sufficiently functional to differentiate DME imagery in order to save costly, time-demanding and resource-intensive manual detection.

Based on retinal appearances, Wilkinson et al. [28] proposed an international clinical diabetic retinopathy (DR) and maculopathy severity scale. This is for the assistance in grading of fundus images into different classes. Yellowish bright spots of random shape, known as hard exudates (HEs), are formed during leakage of lipids and proteins through the irregular blood vessels and are deposited on the retina. Damaged nerve-fibre results in accumulation of axo-plasmic material within the nerve-fibre layer. This causes soft exudates (SEs) which appears as a fluffy, dull whitish lesion on the retina. Macula is one of the important functional centres of the retina with packed photoreceptor cells. Macula is responsible for sharp detailed vision but various diseases such as diabetes exaggerated it. Fovea is the centre of macula. However, if the EXs are localized in the area of macular region, then this type of condition is called clinically significant diabetic maculopathy. Depending on the location of the EXs whether they are at one-disk space or two-disk space distance from fovea, maculopathy is categorized as moderate and severe

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