Automatic Detection of Microaneurysms in Fundus Images

Jesús Eduardo Ochoa Astorga, Kyoto Institute of Technology, Japan
Linni Wang, Tianjin Medical University Eye Hospital, China
Shuhei Yamada, Kyoto Institute of Technology, Japan
Yusuke Fujiwara, Kyoto Institute of Technology, Japan
Weiwei Du, Kyoto Institute of Technology, Japan*
Yahui Peng, Beijing Jiaotong University, China

ABSTRACT

Early detection and treatment of diabetic retinopathy can delay blindness and improve quality of life for diabetic patients. It is difficult to detect early symptoms of diabetic retinopathy, which is presented by few microaneurysms in fundus images. This study proposes an algorithm to detect microaneurysms in fundus images automatically. The proposal includes microaneurysms segmentation by U-Net model and their false positives removal by ResNet model. The effectiveness of the proposal is evaluated with the public database IDRiD and E-ophtha by the area under precision recall curve (AUPR). 90% of microaneurysms can be detected at early stages of diabetic retinopathy. This proposal outperforms previous methods based in AUPR evaluation.

KEYWORDS

Computer Aided Diagnosis, Deep Learning, Diabetic Retinopathy, Retinal Disease

INTRODUCTION

Diabetic retinopathy (DR) is a complication of diabetes mellitus that may occur if the latter is left untreated. During DR, retina undergoes a group of lesions that gradually deteriorate it, being this condition the most frequent cause of blindness worldwide in individuals aged 20–74 years (Mahendran & Dhanasekaran, 2015). Therefore, detection in early stages is particularly important, as it helps ophthalmologists to administer appropriate treatments that improve patients health condition and hence protecting them from an irreversible damage, such as vision loss. The most common method employed by physicians for detecting DR is through the analysis of fundus photography, in which the disease shows up as hemorrhages, exudations and microaneurysms (MAs), being the last one the most important clinical finding in the diagnosis of DR, as they are the first lesion that appears during the early stages (Selcuk & Alkan, 2019; Sarhan et al., 2019). MAs appear as small red dots, and the main complication in their adequate detection is their similarity to vessel fragments (Bhatia et al., 2016). An example of MA in fundus image is shown in Figure 1.

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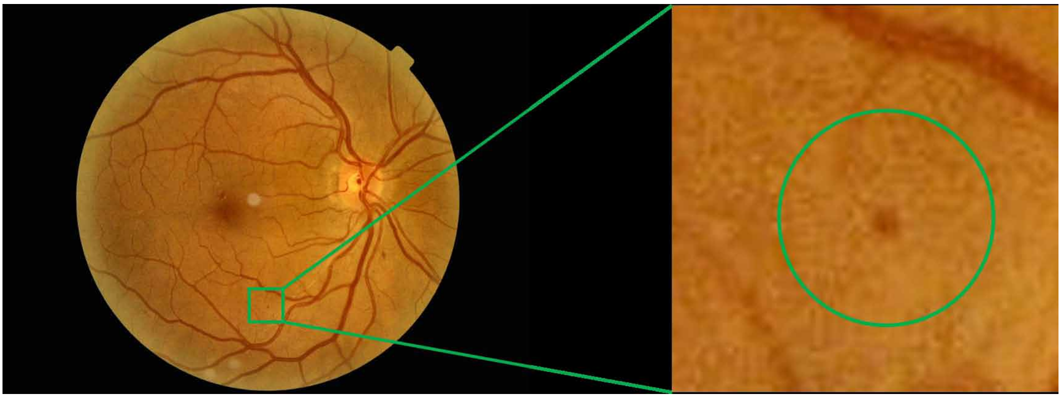
*Corresponding Author

Figure 1. Fundus image with presence of a MA



In common practice, the judgment by physicians is done visually based only on their experience, meaning that this process is time consuming, subjective and, as a result, this gives rise to differences in judgment. Besides, concerning the number of MAs found in fundus during the assessment, this helps to determine the severity of DR, however, the number may turn to be irrelevant, as the sole presence of one single MA is indicative of DR. Due to this, it is essential for computer-aided diagnosis (CAD) systems to detect MAs regardless their position or the amount of these. Inspired in avoiding subjectivity, speeding up the assessment process and increasing the sensitivity of fundus evaluation, several proposals have been suggested for detection and segmentation of MAs in fundus images.

BACKGROUND

Kumar and Kumar (2018) developed a method based on diverse image transformations that include principal component analysis (PCA) and contrast enhancement as pre-processing stage, and subsequently different regions of fundus photography are discarded, namely, exudates, blood vessels, optic disc and fovea, to remain only MAs, which are used to extract features and pass them to a support vector machine (SVM) for DR detection. Similarly, Joshi and Karule (2020) performed MAs detection by implementing image reconstruction over a pre-processed grayscale image obtained from green channel of RGB fundus image. Then, blood vessels and bright artifacts are removed and after connected component analysis, candidate MAs are detected. Lastly, after feature extraction, MAs are detected. The limitation of these approaches lies in the similarity of MAs with blood vessels, and for this reason, it is crucial a satisfactory blood vessels network segmentation. Furthermore, methods primarily based on image processing techniques are highly sensitive to non-uniform illumination occurred during fundus image acquisition, where the geometry of the eye causes internal reflection that contributes to the presence of shading artifacts (Manohar & Singh, 2018). For this reason, other researchers make the most of deep learning to achieve this task.

Jiang et al. (2019) proposed a deep learning lesion-based method for DR disease classification, in which MAs are one of the contemplated lesions. In this study three different deep learning models are used for classification, namely, Inception V3, ResNet152 and Inception-ResNet-V2. Each of these showed favorable results in classification, however, even if separately each model performed satisfactorily, the weights and bias of each fall into local minimums. Thereby, considering the results obtained from each model, a global minimum is searched by using the Adaboost algorithm to create a more robust classifier by associating each individual model. Likewise, Eftekhari et al. (2019) used more than one single deep learning model. In their proposal, fundus pre-processed image is divided in patches that are passed to a basic convolutional neural network (CNN) that returns a probability