SIMULTANEOUS SEGMENTATION OF MULTIPLE STRUCTURES IN FUNDAL IMAGES USING DEEP NEURAL NETWORKS

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ABSTRACT

Fundal imaging is the most commonly used non-invasive technique for early detection of many retinal diseases like diabetic retinopathy. An initial step in automatic processing of fundal images for detecting diseases is to identify the various landmark regions like optic disc, blood vessels and fovea. In addition to these, various abnormalities like exudates that help in pathological analysis are also visible in fundal images. In this work, we propose a multi-tasking deep learning architecture for segmenting optic disc, blood vessels, fovea and exudates simultaneously. Our experimental results on publicly available datasets show that simultaneous segmentation of all these structures results in significant improvement in the performance. For segmentation performance on blood vessels, optic disc, fovea and exudates, we got a Dice score of 78.5%, 94%, 66% and 60% respectively. Proposed simultaneous segmentation approach resulted in a peak improvement of 10% on the exudates segmentation task compared to the individual segmentation using the same network architecture. To the best of our knowledge, we are the first one to evaluate the effectiveness of multi-task learning for segmenting multiple structures in fundal images. We obtained a state of the art Dice score of 78% for blood vessel segmentation on 20 DRIVE test images which is 2% higher than one of the recently reported studies.

***Index Terms*—** Fundal Image Segmentation, Multi-task learning

1. INTRODUCTION

Fundal imaging, capturing images of retina using specialized cameras, is the most widely used non-invasive technique for screening of retinal diseases. These images are used to identify common eye diseases like diabetic retinopathy, which is the most common cause for blindness, and many other cardiovascular diseases. Blood vessels, optic disc and fovea are the major structures visible in a fundal image. However, manual identification and demarcation of fine structures like blood vessels take a lot of time and effort. Hence automatic detection of major landmarks in fundal image has become an active research area.

Figure 1 shows a fundal image with various structures like blood vessels, optic disc and fovea marked. The optic disc is the point of exit of the optic nerves that carry information from the eye to the brain. It is also the point where all the blood vessels enter the eye. Since there are no photo sensors (rods and cones) present in the optic disc, it corresponds to a blind spot in the retina. Fovea is a small region with a lot of cone cells packed together and hence this region is responsible for sharp vision. Blood vessels that carry blood to the eye are spread across the entire region of the retina and vary in thickness and density.

Since the break-through success of deep learning in solving tasks in domains like computer vision for classification [1] [2] and segmentation [3], many deep learning architectures have been tried for segmenting important structures, such as optic disc and blood vessels, in fundal images [4] [5] [6] [7]. One of the challenges of using deep learning architecture for medical images is the lack of annotated training data. Many approaches, like taking multiple training patches from a single image [4] and transfer learning, where a model trained on a dataset such as the Imagenet [8] is fine tuned for the task at hand, are proposed and found to be successful.

In this work, we propose a multi-tasking deep learning architecture for simultaneous detection of blood vessels, optic disc, fovea and exudates. Our results show that a single network that predicts multiple structures performs much better compared to detecting each structure independently using different networks as the single network can make use of the correlation between the two tasks. This correlation is evident from Figure 1, where one can see that near and inside the optic disc blood vessels are thicker and denser. So the knowledge of the optic disc can help the prediction task for blood vessels and vice versa. We perform experiments and report results on three popular datasets DRIVE [9], HRF [10] and IDRID [11].

The contribution of our work are:

1. Propose a multi-tasking model for simultaneous segmentation of blood vessels, optic discs, fovea and exudates.
2. Propose a method for data augmentation of fundal images which enables the training and prediction on whole im-