AUTOMATED RETINAL IMAGING ANALYSIS FOR ALZHEIMERS DISEASE SCREENING

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ABSTRACT

Alzheimer's Disease (AD), the most common cause of dementia, has increasing prevalence with vast societal and public health implications. There is a critical unmet need to develop biomarkers for early AD diagnosis. Recent scientific advances underscore retinal vascular changes and retinal abnormal protein deposition mirroring the changes in the AD brain. We have previously shown that retinal vascular tortuosity and inflection correlate with neurocognitive dysfunction and may predict AD [1]. Retinal fundus photography is a cost-effective and high-resolution imaging tool to study retinal vascular changes in AD [2] and emerge as a non-invasive biomarker for early AD diagnosis and monitoring. Handcrafted identification of the retinal vascular features on color fundus images is laborious, subjective, and prone to bias. Hence, developing automated retinal imaging tools has attracted strong research interest [3, 4]. Here, we leverage deep neural networks to develop an automatic framework to classify AD and extract AD retinal fundus imaging biomarkers using weakly supervised localization and Gradient-weighted Class Activation Mapping [5].

1 Methods

Our proposed framework is a two-stage system informed by previous research supporting retinal vascular dysfunction in AD. We used non-mydriatic color retinal fundus images from AD patients from Mayo Clinic and cognitively normal controls (NC) from the Eyepacs database [6]. In the first stage, a U-Net based network [7] was applied to raw macula-centered and optic-disc-centered fundus images to produce vascular segmentation. The obtained binary vessel segmentation was subsequently fed into the encoder of the U-Net for feature extraction. The feature extractor is initialized with the weights from the first stage, since the contextual features from the U-Net encoder is useful for classification. The extracted features were fed to an average pooling layer and a fully connected layer with a Softmax activation to output probabilistic prediction.

2 Experimental Results

The U-Net is pretrained on the Digital Retinal Images for Vessel Extraction (DRIVE) dataset [8]. We selected one image with the best segmentation from each subject, which resulted in 40 training images and 16 testing images. The problem is formulated as a binary classification task with positive class (AD) and negative class (NC). Our trained model achieved an area under ROC curve (AUC-ROC) of 0.938 on the testing set (Figure 1(a)). The generated heatmap via Grad-CAM at the last convolutional layer demonstrated that the network mainly pays attention to the medium or distal retinal vascular branches in AD cases, whereas large vessel branches close to optic head are highlighted in NC (Figure 1(d)). Overall, our proposed network identifies retinal blood vessel branches with tortuosity change as potential identifier of AD.

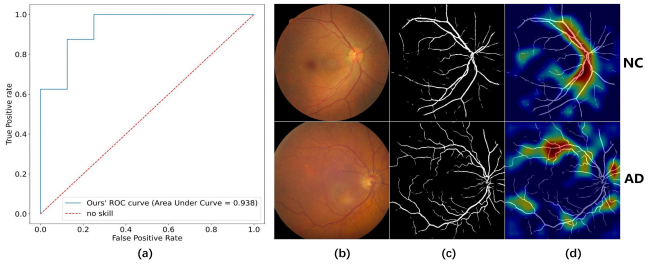

Fig. 1: (a) AUC-ROC curve, (b) original retinal image, (c) vessel segmentation, (d) heatmap result via Grad-CAM.

3 Conclusions

We present a novel retinal imaging-based deep learning analysis framework for AD screening. Our preliminary results in a small data set demonstrated the feasibility of our deep learning model and a strong promise to identify automated retinal imaging biomarkers for AD diagnosis. Future research will include larger datasets of AD and preclinical AD subjects.

4 References

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