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Portable and Affordable Ophthalmic Disease Detection System

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***Abstract*— This paper introduces an ophthalmic disease detection system[2] that allows users to take a fundus image and detect common eye diseases using a smartphone. The detection is based on a convolutional neural network to classify the various retinal diseases by fundus images. The overall accuracy was 74%, and AUC was 0.93. Grad-CAM was generated to provide heatmaps with visual explanations of the prediction.**

***Clinical Relevance*— The results help promote worldwide eye health, helping clinicians diagnose retinal diseases with confusing features more easily.**

I. Introduction

One of the major problems in ophthalmology is that there are regions in the world that lack opportunities to access sufficient eye health services, leading to more prevalent blindness and socioeconomic effects [1]. To resolve this problem, we introduce a product that allows users to take a fundus image using a smartphone and detect common eye diseases from these images using its website. The product consists of 3 subsystems: an image classifier, a device that holds a 20D ophthalmic lens, and a website that provides UI to the users. This work explores the usage of a convolutional neural network (CNN) in creating the image classifier that can detect various ocular diseases by examining retinal photographs.

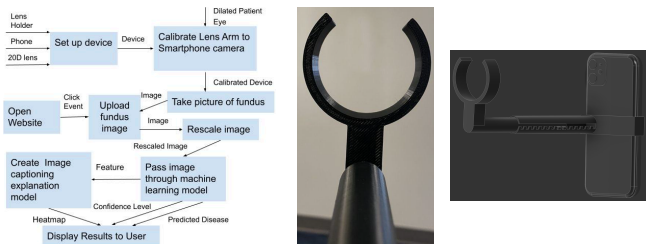

Figure 1. (Left) The function block diagram describes the function between input and output. (Right-top) Complete CAD design for the iPhone 11. (Right-bottom) Real camera view of lens holder.

II. Methods

The device was designed in Fusion360 software and printed with ABS plastic. It consists of 2 pieces connected by a lock and key mechanism to adjust the distance between the smartphone and the condensing lens (Fig. 1).

The image classifier detects five eye diseases (Diabetic Retinopathy, Cataract, Glaucoma, Pathological Myopia, and Age-Related Macular Degeneration) and no disease from fundus images. It was created using Tensorflow and Keras, using Xception pre-trained neural networks. The data were collected from 8 open sources, 354 images were used per class for creating the dataset, and they were later split into train and test datasets with the ratio of 8:2. After training, model accuracy, loss diagrams, ROC curves, and AUC values for each class were used to evaluate the algorithm.The website was hosted on DigitalOcean, providing a simple UI for the users to use easily both on smartphones and PC.

III. Results

The average model accuracy was 74%, and AUC was 0.93. In addition, Grad-CAM was generated to create heat maps that provide visual explanations of the prediction (Fig. 2).

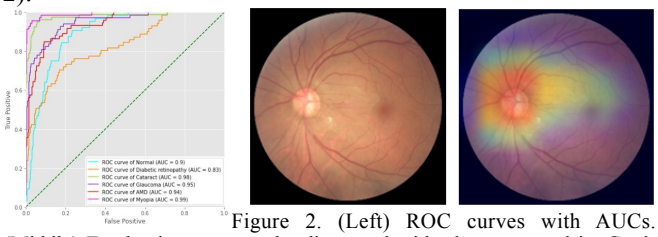

Figure 2. (Left) ROC curves with AUCs. (Middle) Fundus image example, diagnosed with glaucoma, and its Grad-CAM result (Right). It highlights the affected area of glaucoma.

IV. Discussion and Conclusion

The product was tested to ensure that the website displays everything that is supposed to be shown to users. The algorithm detects the diseases with the desired accuracy, followed by corresponding confidence levels and Grad-CAM heatmap. Seven images per class were used for testing, showing high prediction accuracy. A mock fundus examination to collect retinal images took place using an emulated pupil for testing the device. Future work suggests improving algorithm accuracy, especially for Diabetic Retinopathy, by including patient history in the algorithm. Introducing noise to the training set and introducing image segmentation are also points of improvement. Making it compatible with different smartphone models other than the iPhone is a significant task for the device.

The diseases tested are the leading diseases that cause blindness throughout the globe [2]. Given this, the proposed product is a portable and affordable ophthalmic disease detection system and produces acceptable results given the number of classes inputted. Furthermore, it can be implemented to automatically detect various diseases, severely lessening the burden in diagnosing numerous fundus images among clinicians.

References

[1] "Vision impairment and blindness." https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment, Feb. 2021.

[2] J. D. Steinmetz *et al.*, *The Lancet Global Health*, vol. 9, no. 2, pp. e144–e160, Feb. 2021.

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[2]https://github.com/A-EYE-George-Washington-University/Model