Detecting Intraocular Pressure Using CNN on Frontal Eye Images

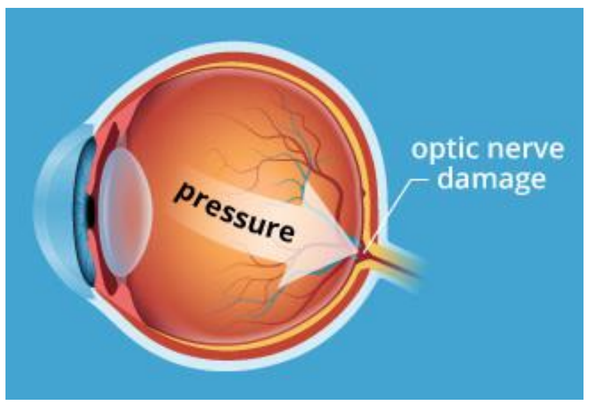
Afrooz Rahmati, Mohammad Aloudat, Abdelshakour Abuzneid and Miad Faezipour
Department of Computer Science and Engineering
University of Bridgeport, Bridgeport, CT 06604, USA

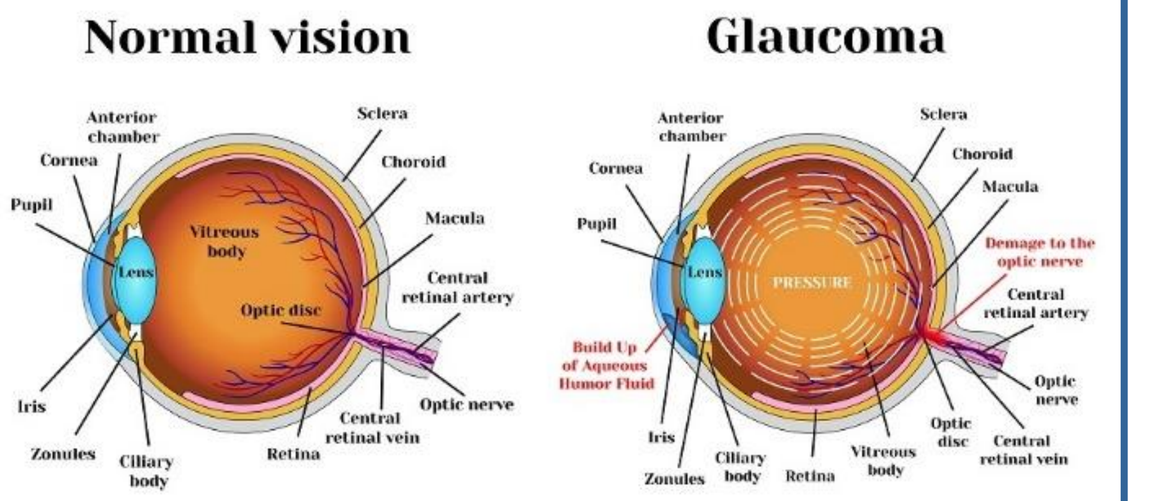
Abstract

Glaucoma is an international disease causing vision loss for many patients around the world. A gradual increase of intraocular pressure (IOP) and missing early diagnoses might cause blindness forever. Observing IOP requires the patient's presence at a healthcare facility where ophthalmologists or nurses evaluate the eye pressure through different medical tests. In some cases, the healthcare professional anesthetizes the eye by dropping a numb liquid which would take at least 6 hours to totally wear off from the eyes and irritate the patient. We are proposing a novel technique applied on the patient's frontal eye images using a convolutional neural network (CNN) to extract common features of high IOP and glaucoma cases automatically. This is a research work in-progress built upon our previous related work in which pre-determined features were extracted from eye images to distinguish healthy eye images from high IOP cases. The dataset used in this work contains 473 normal and high IOP eye images. However, in order to increase our data accuracy, we are working closely with few hospitals in the Middle East. The result of this study has the potential to minimize the patient's presence at healthcare facilities and offer patients' safety by preventing glaucoma causes at the very early stages.

What is Glaucoma?

Glaucoma mainly occurs due to the expansion of pressure inside the eye (IOP) and damaging the entire optic nerve. This damage might cause eventual blindness. Accessing regular eye checkup services would decrease the risk of developing glaucoma. The eye fluid called aqueous humor builds up in the front layer of the eye. This extra fluid develops eye pressure and progresses into the anterior chamber between the iris and cornea [1].





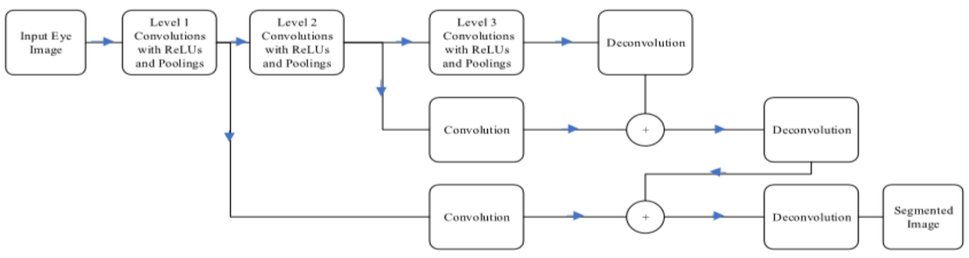
Diagnosing IOP:

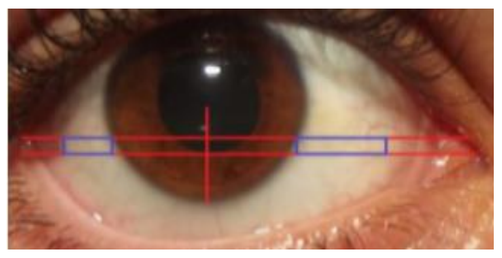
IOP is generally diagnosed by a healthcare professional at health facilities through different examinations such as the Tonometry test, Gonioscopy test, etc. [2]. All these tests require the patient's presence. Sometimes ophthalmologists anesthetize the eyes by numb drops to gently touch the iris surface and measure IOP. This action irritates the patients' eye.

- Accurate non-invasive and non-contact methods are more convenient.
  - Eye Images and Computer Vision-based techniques

Previous Related Work:

Many computer vision-based studies have been conducted on detecting glaucoma and measuring IOP at an early stage from fundus eye images that reflect the optic nerves. However, there is only one research that is based upon evaluating frontal eye images. Aloudat et al. [3] proposed a novel risk assessment framework of IOP on frontal eye images and applied a fully conventional network (FCN) to separate the iris and sclera area. Six different features were then extracted and a classifier was designed to distinguish eye images with high IOP and glaucoma from the normal eye pressure cases.

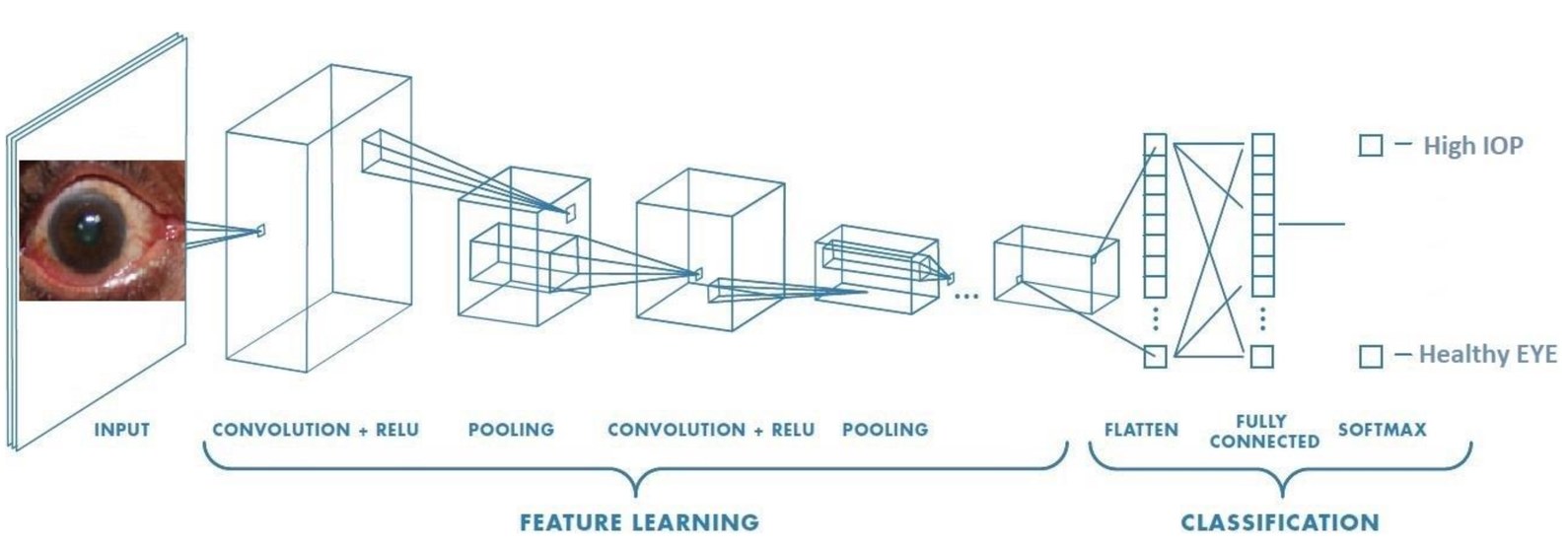




Proposed Solution – CNN:

We are proposing a solution to utilize Convolutional Neural Network (CNN) for the process of extracting eye features and determining high IOP.

- The system receives frontal eye images as input, assigns weights and biases to differentiate eye segments, uses ConvNet to filter images, pool layers to extract dominant features, and finally classifies the output with a regular neural network [4].



Dataset:

Image data was gathered from a hospital in Jordan with 473 patients. 200 frontal eye images were collected from high eye pressure patients and the rest 273 images were taken from healthy patients with normal IOP. In the research work presented here, our training dataset contains 100 images from high IOP and 100 normal eye pressure cases. The remaining 273 images are considered for testing purposes.

- IRB approval was obtained at Princess Basma Hospital for the human subject samples. Authors formally requested access to the dataset.

Expected Outcome:

This research is a work-in-progress and the outcomes are yet to be observed. We anticipate that with the proposed deep learning method using CNN, high IOP cases can be distinguished from normal eye pressure ones with accuracies above 90% using only frontal eye images as the input. The proposed ideas are significant efforts made in an attempt to automate the determination of the onset of high IOP at an early stage from frontal eye images. The ideas can be further personalized for patients by embedding the techniques into smart-phone devices.

References

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