Convolutional Neural Network for identifying glaucoma: using optical coherence tomography angiography (OCTA) vascular scans

NCBI North Texas Codeathon 2021

Team Introductions

Meet The Team

- *Team Leader*: Dr. Karanjit Kooner, MD PhD, Ophthalmology
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- *Flex*: Binh Vu, University of Dallas
- *Flex*: Jacob Akwal, University of Texas at Dallas
- *Flex*: Sumanth Kumar Kotareddy, University of Texas at Dallas
- *Flex:* Vikas Deo, University of Texas at Dallas

Introduction

Importance of Glaucoma Research

- Glaucoma is the **second leading cause** of blindness worldwide.
- Primary open angle glaucoma (POAG): Progressive neurodegenerative disease of the **retinal ganglion cells** with characteristic features of the **optic disc**, usually accompanied by corresponding **visual field** (VF) **defects**, with or without **elevated intraocular pressure** (IOP).
- Multifactorial risk factors for glaucoma include:
  Increasing age
  Elevated IOP
  Family history
  Systemic hypertension
  Diabetes
  Racial disparities in the prevalence of glaucoma

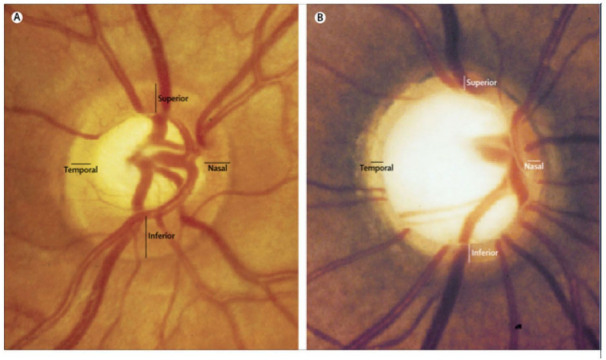
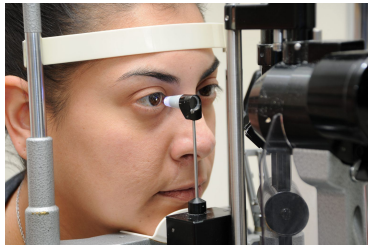


Figure 3. Ophthalmic photographs of healthy (A) and glaucoma patients optic nerve heads (B) (discs). (A) the optic disk is a normal shape with a normal size neuroretinal rim (superior, inferior and nasal and temporal) In B the neuroretinal rim is thinner and the optic disc is larger with a deep cup.

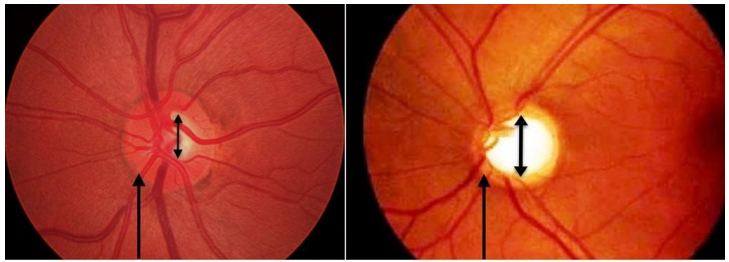
https://webvision.med.utah.edu/book/part-xii-cell-biology-of-retinal-degenerations/what-is-glaucoma/

Need for an objective method to diagnose glaucoma

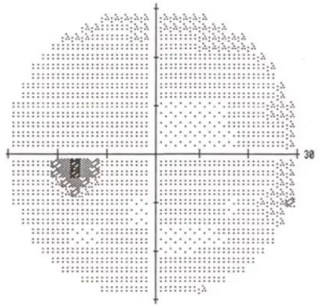
- *Measurement of IOP*:



- *Evaluation of optic nerve*:



- *VF testing*:



All three of these methods to diagnose glaucoma and its progression are inconsistent, variable and inherently subjective!

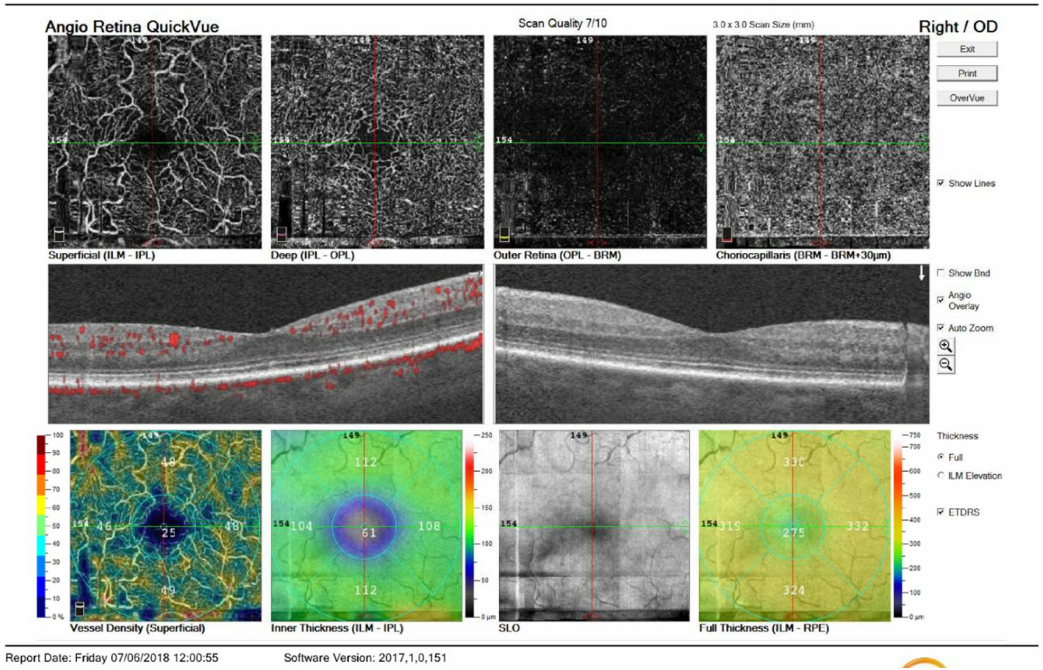
Optical coherence tomography angiography (OCTA)

- Objectively measures both **structural and vascular components** of the optic nerve and retina in a non-invasive manner.

- Interpretation of **over 30** structural, volumetric numerical measures characterizing the optic nerve and retina of each patient can be challenging for clinicians.

https://www.ophthalmologyweb.com/Featured-Articles/184391-Optical-Coherence-Tomography-Angiography-What-You-Need-to-Know/

Image Data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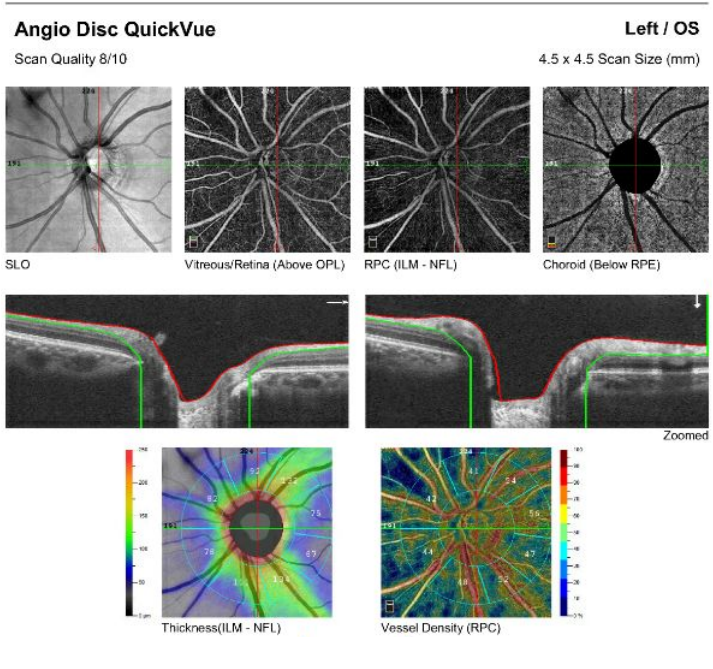
3.0 x 3.0 Scan Size (mm)
Right / OD
Exit
Print
OverVue
Show Lines
Superficial (ILM - IPL)
Deep (IPL - OPL)
Outer Retina (OPL - BRM)
Choriocapillaris (BRM - BRM+30µm)
Show Bnd
Angio Overlay
Auto Zoom
Thickness
Full
ILM Elevation
ETDRS
Vessel Density (Superficial)
Inner Thickness (ILM - IPL)
SLO
Full Thickness (ILM - RPE)
Report Date: Friday 07/06/2018 12:00:55
Software Version: 2017,1,0,151


Angio Disc QuickVue
Left / OS
Scan Quality 8/10
4.5 x 4.5 Scan Size (mm)
SLO
Vitreous/Retina (Above OPL)
RPC (ILM - NFL)
Choroid (Below RPE)
Zoomed
Thickness(ILM - NFL)
Vessel Density (RPC)

Aims of the project

- To develop ML tools using OCTA-derived vascular scans to solve a 4-class problem:

  a. Distinguish between **healthy** (HE) and **glaucomatous** eyes (GE)
  b. Identify if there are **sex-related differences** based on these vascular scans.

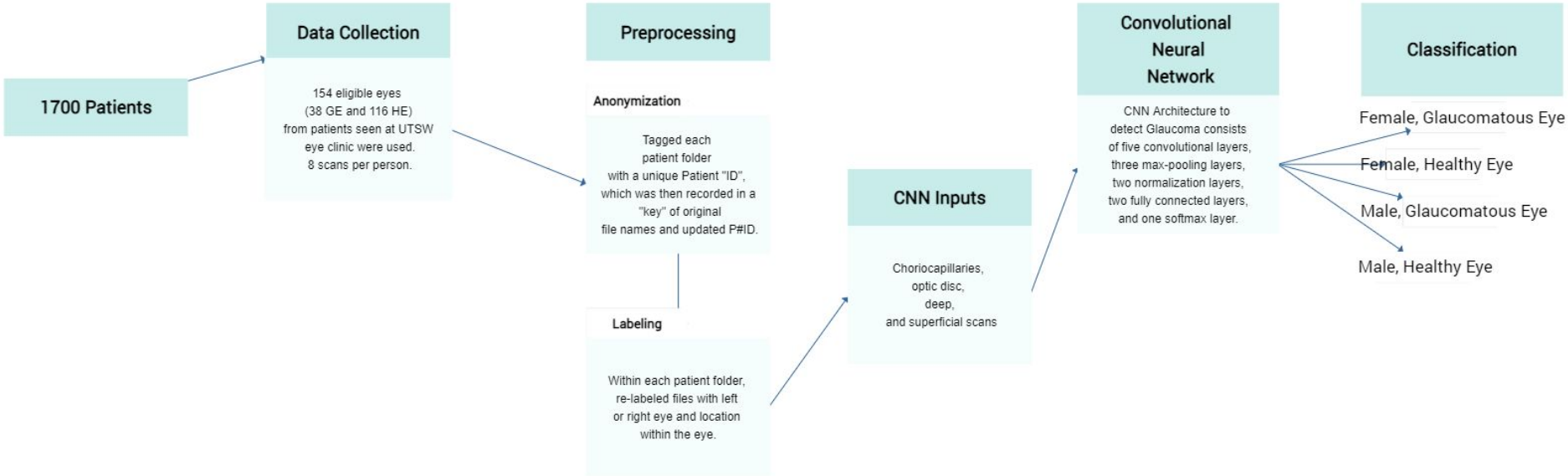
- Build a **database** of OCTA images for further application of deep learning.

Hypothesis

We hypothesize that ML and OCTA vascular scans may help clinicians distinguish between normal versus glaucomatous eyes, in addition to male and female patients.

For this task, we plan to use a Convolutional Neural Network because of its ability to extract and learn from features which may not be easily visible to the human eye.

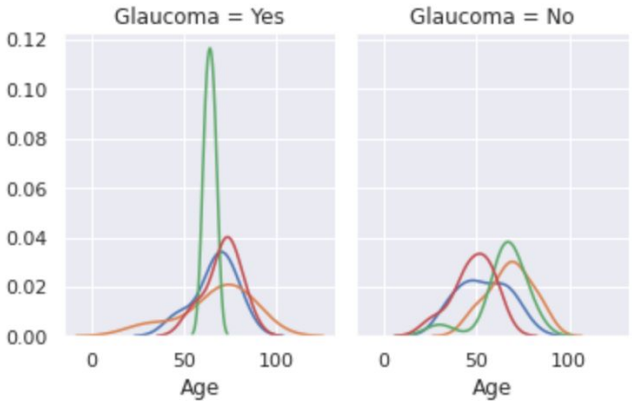
Workflow Diagram

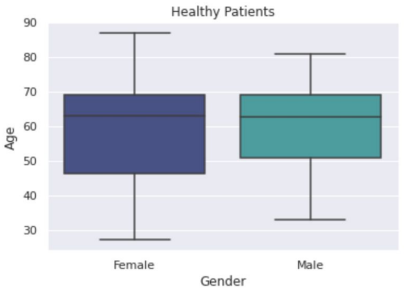


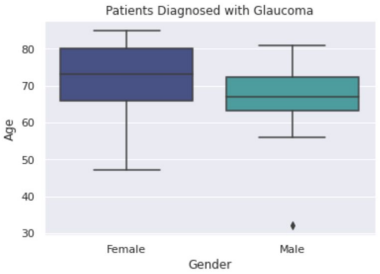
Methodology

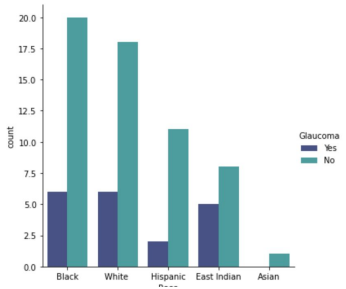
Demographic Data

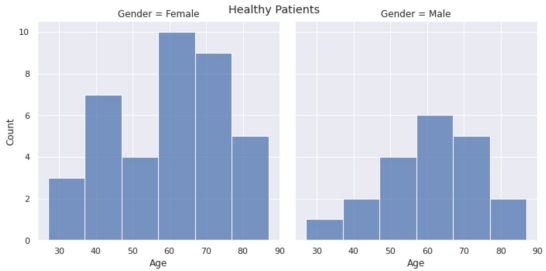
77 patients, with metadata about race, gender, and age.











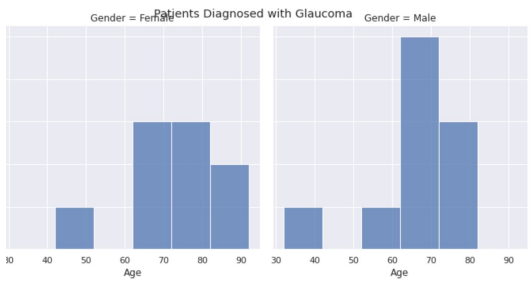
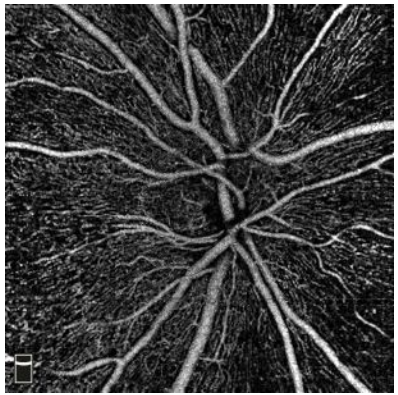
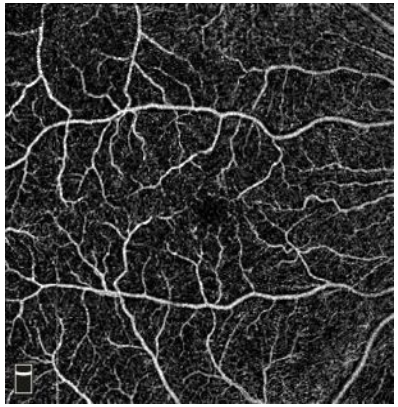


Image Data

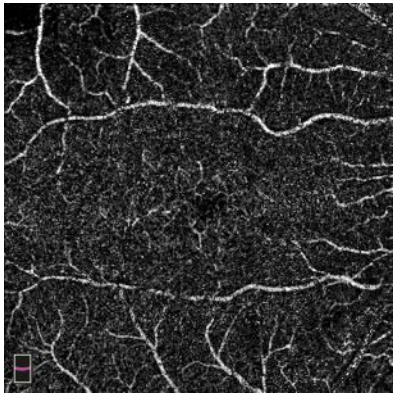
Optic Disc



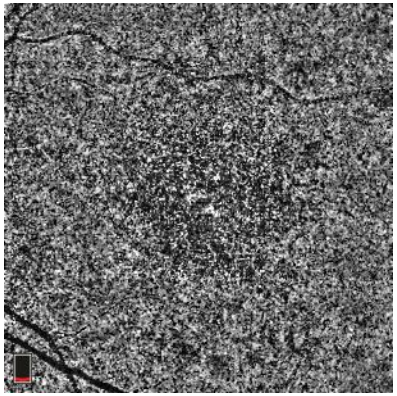
Superficial



Deep



Choriocapillaris



- Input size to the CNN architecture will be of standard size, which workouts to be of size 300x300.

Information about the Model

- Different stack of layers that produces an output function when given an input with the help of a differentiable function is called CNN Architecture.
- Layers generally are:
  Convolutional Layer: associated with a convolutional filter and a nonlinear activation function known as ReLU(Rectified Linear Unit).
  Pooling Layer: max pool function
  Fully Connected Layer
  Activation Function layer.
- In addition to these layers there might also be **Normalization** layer and **Dropout** Layers to improve the accuracy results.
- CNN Architecture to detect Glaucoma consists of five convolutional layers, three max-pooling layers, two normalization layers, two fully connected layers, and one softmax layer.

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Training and Testing Methodology

- The dataset consists of labeled 565 high-resolution images belonging to 2 categories (Glaucoma and Non Glaucoma).
- These images are labeled by human labelers using a python script.
- This dataset consists of variable resolution images, which are down-sampled to a **fixed resolution of 300x300.**
- Dataset is divided into three sets: **Training**, **Validation** (70%) and **Testing** (30%) sets.
- CNN Model is trained with different epochs until we reach an optimum accuracy without any model outfitting.

Conclusion

In Conclusion

- Developed methodology for data organization/anonymization and ML tools for testing and validation.

Future Plans

- Download more images from patient database in order to augment dataset.
- Work on implementing the model with the complete database.