Project-1
Classification of Diabetic Macular Edema and Dry Age-Related Macular Degeneration from OCT Images with Convolutional Neural Networks

Problem Statement

- To design a system for the identification and classification of OCT Scans of patients suffering from Age-Related Macular Degeneration (AMD) and Diabetic Macular Edema (DME) from Normal Patients

Objectives

- To develop a classification system that could identify retinal information through OCT images.
- To identify the disease by scanning images of AMD, DME affected and normal patients.
- The system will be able to classify images at patient level using CNNs.
- To help doctors and experts in identification of maculopathy at early stage in a much speedy way than previously used CADs.

INTRODUCTION

Diabetic Macular Edema (DME)

- **Diabetic Macular Edema (DME)**

It is an accumulation of fluid in the macula—part of the retina that controls our most detailed vision abilities—due to leaking blood vessels.

- **Causes**

High blood sugar weakens the blood vessels in eyes. That can make them leak or grow out of control in your retina, the light-sensitive area at the back of your eye. This is called diabetic retinopathy.

When fluid seeps into your retina, it can cause diabetic macular edema. The leaking makes retina swell, which hampers the work of your macula, the special, sensitive part that gives sharp vision.

Diabetic Macular Edema (DME)

Symptoms

- Have images directly in front of eye appear blurry or wavy
- See colors that seem “washed out”.

Getting Diagnosis

A thorough eye exam, which includes:

- **A visual acuity test:** Check how well a patient sees at different distances.
- **A dilated eye exam:** The doctor will use drops to widen pupils and look at the inside of eyes. He'll look for signs of disease, including damaged or leaking blood vessels and swelling on the retina.

If doctor thinks a patient has Diabetic Macular Edema, following tests are needed:

- **A Fluorescein Angiogram (FA)** takes pictures of retina using a special dye that helps finding any leaking blood vessels. The dye is injected into arm, but travels quickly to eye.
- **Optical coherence tomography (OCT)** uses a special camera to photograph retina which is sensitive and can find small amounts of fluid and swelling.

Age-Related Macular Degeneration (AMD)

Age Related Macular Degeneration (AMD)

- AMD is the leading cause of severe, irreversible vision loss in people over age 60.
- It occurs when the small central portion of the retina, known as the macula, deteriorates.
- The retina is the light-sensing nerve tissue at the back of the eye. Because the disease develops as a person ages, it is often referred to as age-related macular degeneration (AMD).

Types of AMD:

1. Dry form:

The "dry" form of macular degeneration is characterized by the presence of yellow deposits, called drusen, in the macula. As drusen grow in size, they lead to a dimming or distortion of vision that people find most noticeable when they read. In more advanced stages of dry macular degeneration, there is also a thinning of the light-sensitive layer of cells in the macula leading to atrophy, or tissue death. In the atrophic form of dry macular degeneration, patients may have blind spots in the center of their vision. In the advanced stages, patients lose central vision.

1. Wet form.

The "wet" form of macular degeneration is characterized by the growth of abnormal blood vessels from the choroid underneath the macula. This is called choroidal neovascularization. These blood vessels leak blood and fluid into the retina, causing distortion of vision that makes straight lines look wavy, as well as blind spots and loss of central vision. These abnormal blood vessels and their bleeding eventually form a scar, leading to permanent loss of central vision.

Age-Related Macular Degeneration (AMD)

Symptoms:

- Decreased quality/resolution of vision with blurriness and difficulty with reading fine print, driving, etc.
- Dark, blurry areas in the center of vision
- Diminished or changed color perception

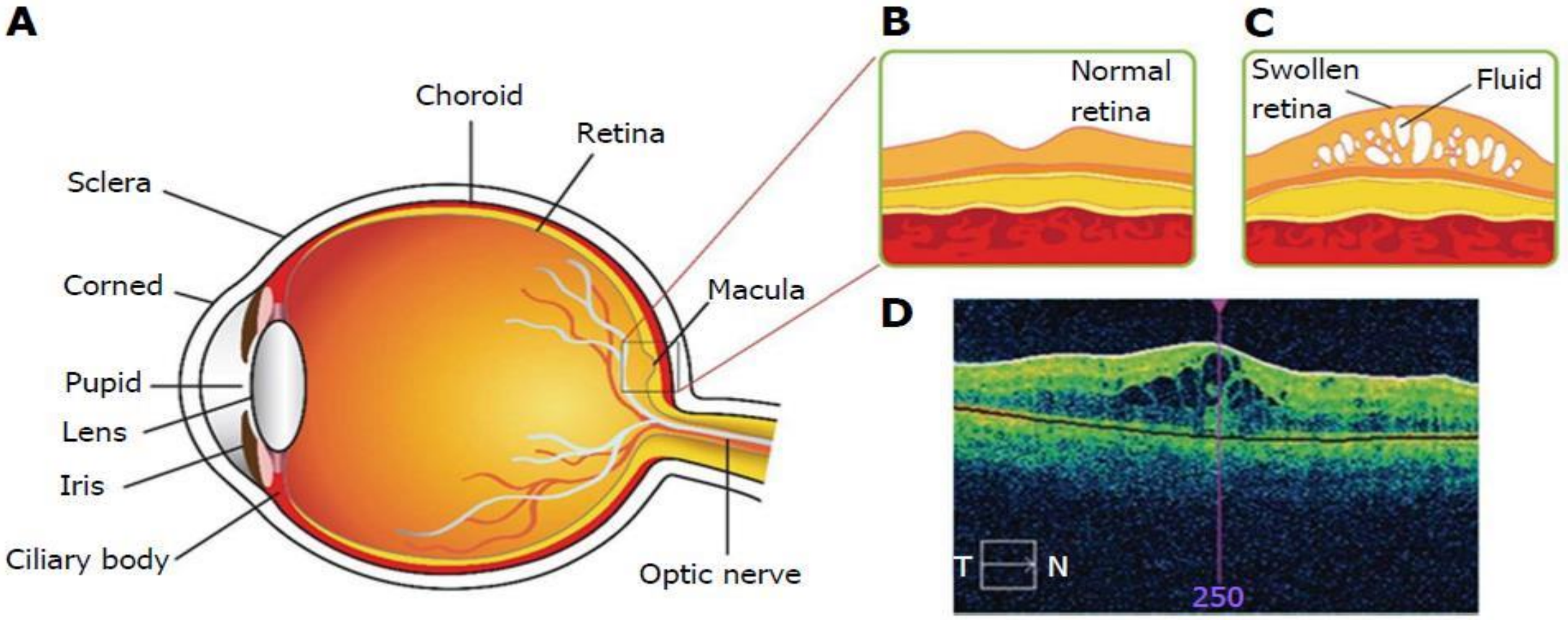
Diagnosis:

- Age-related macular degeneration can be detected in a routine eye exam.
- Early signs of macular degeneration is the presence of drusen -- tiny yellow deposits under the retina -- or pigment clumping.
- Doctors also ask the patients to look at an Amsler grid -- a pattern of straight lines that resemble a checkerboard. Some of the straight lines may appear wavy to patient, or patient may notice that some of the lines are missing.

If doctor detects age-related macular degeneration, following tests are needed:

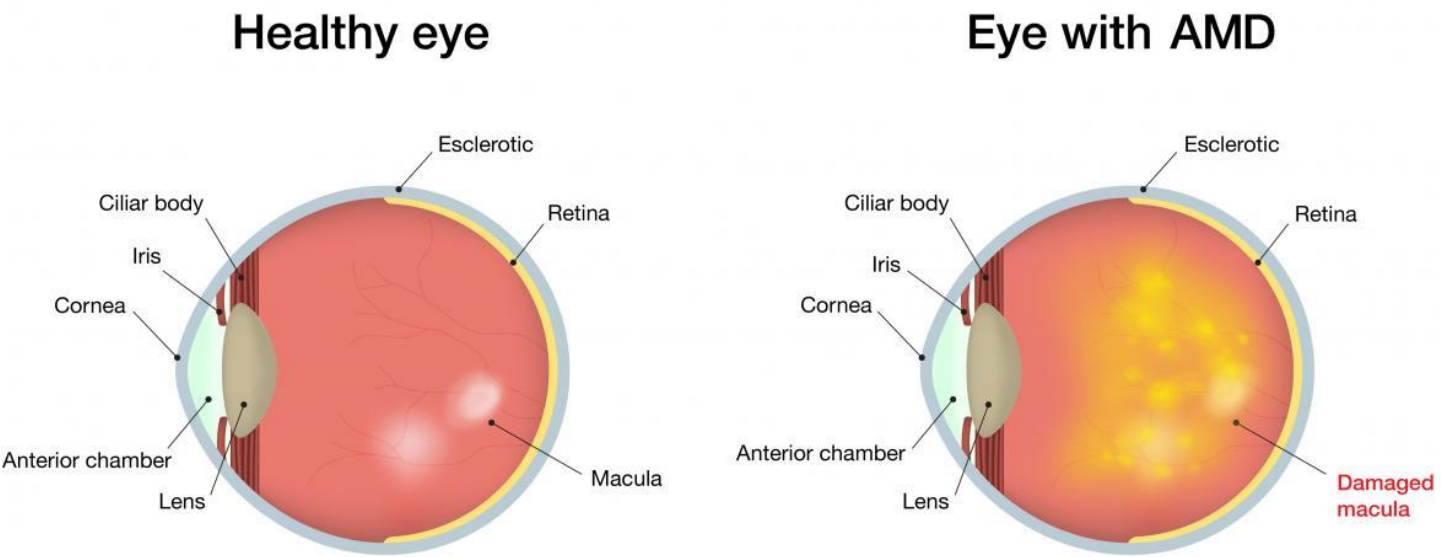
- **A Fluorescein Angiogram (FA)** takes pictures of retina using a special dye that helps finding any leaking blood vessels. The dye is injected into arm, but travels quickly to eye.
- **Optical coherence tomography (OCT)** uses a special camera to photograph retina. It is very sensitive and can find even small amounts of fluid and swelling.

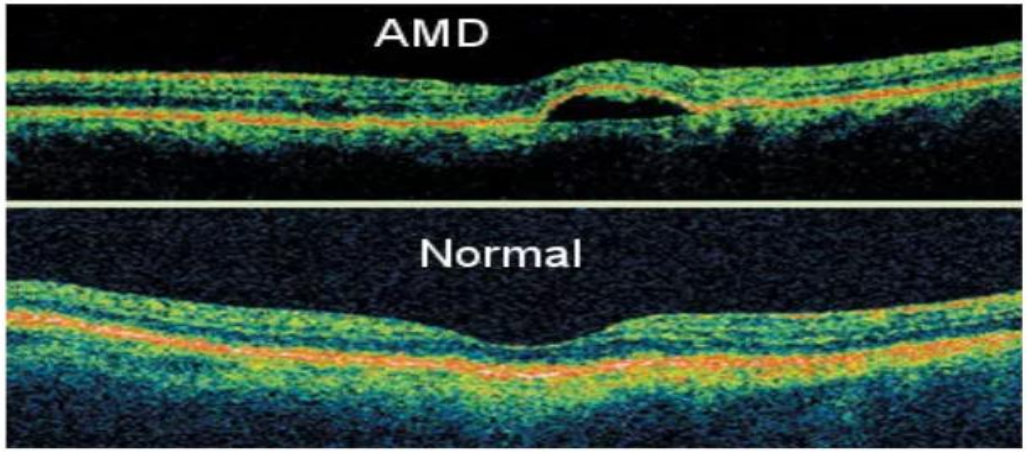
Diabetic Macular Edema

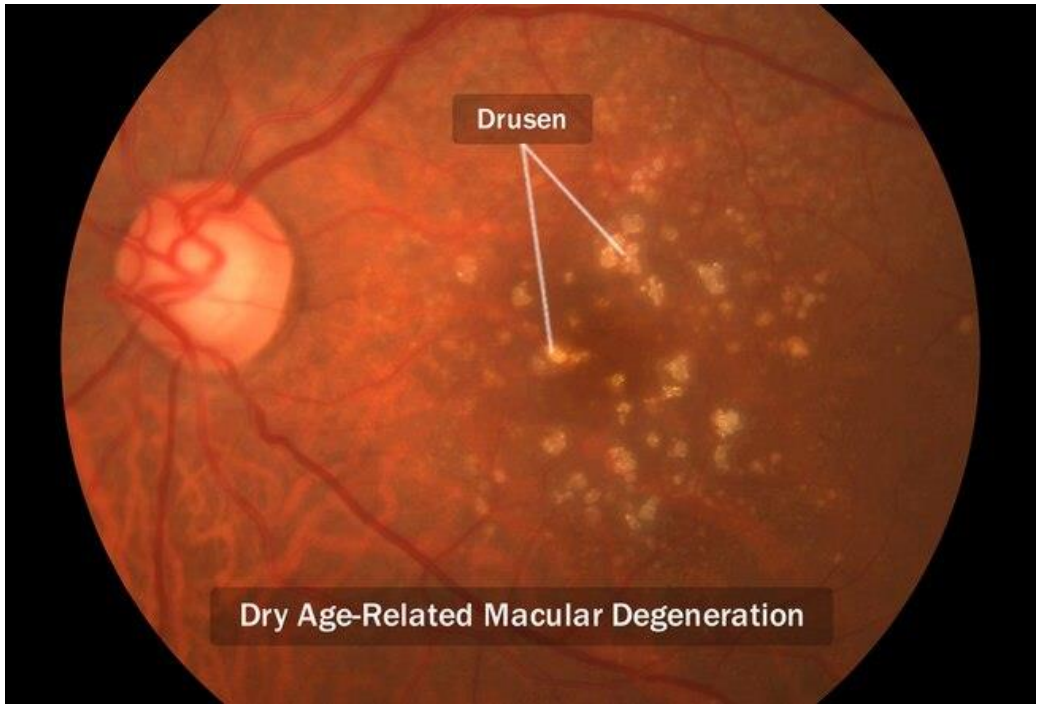


Diabetic macular edema at disease state. A: Structure of human eye; B: Expanded representation of macula region for normal eye; C: Expanded representation of macula region for diabetic macular edema (DME); D: Optical coherence tomography image for DME.

Age-Related Macular Degeneration (AMD)







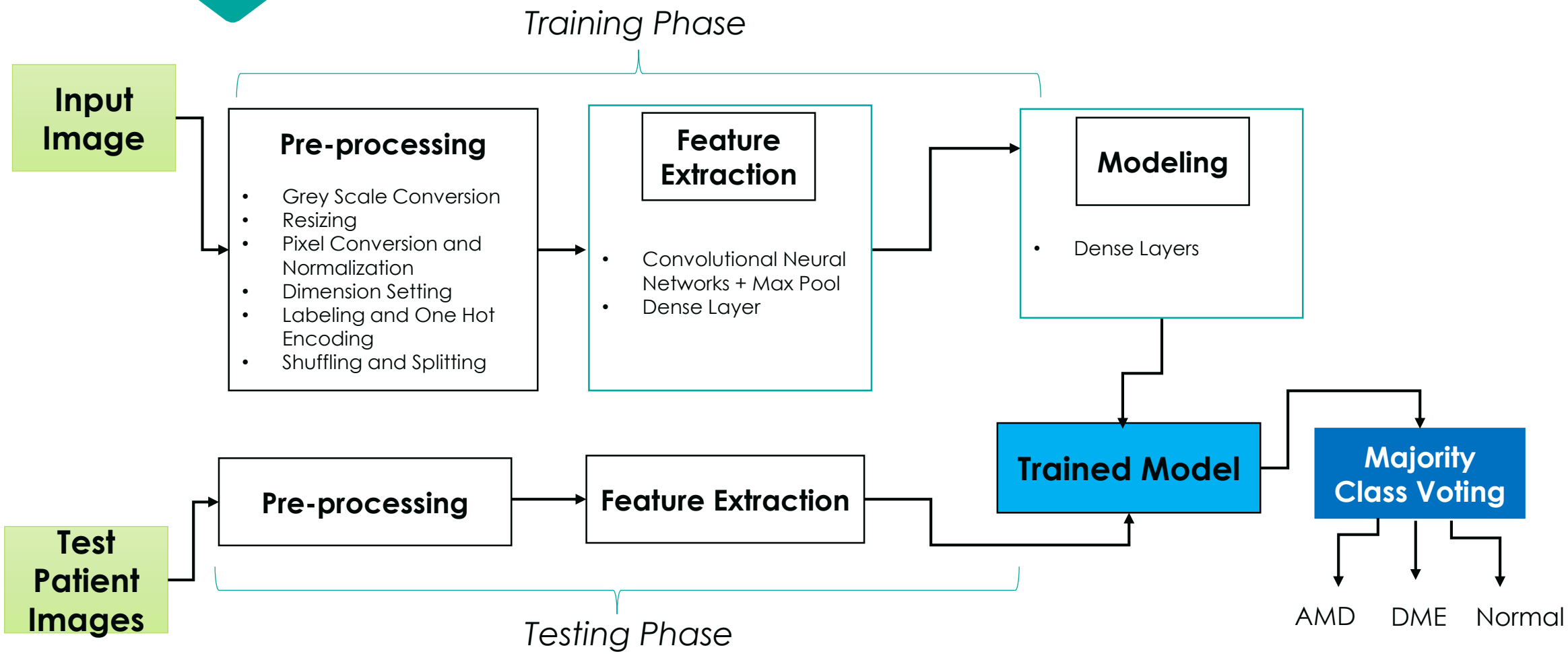
LITERATURE REVIEW

Sr. No	Authors	Method	Type of Maculopathy Disease examined	Dataset	Year	Results
1	E. Mousavi,	Dictionary Learning based Classifiers • COPAL • FDDL • LRSD Final Method: FDDL	AMD DME	Duke University:45 • AMD: 15 • DME:15 • Normal:15	2019	Accuracy: 98.3%
2	Yu Wang,	SMO	AMD DME	Duke University:45 • AMD: 15 • DME:15 • Normal:15	2016	Accuracy: 98 %
3	Ruaa Adeeb Abdulmunem Al-falluji	SVM	DME	Duke University:30 • DME: 15 • Normal:15	2016	Accuracy: 93.33%
4	Guillaume Lemaître	SVM	DME	SERI :32 • 16 DME • 16 Normal	2016	Sp: 93.7%
5	Pratul P. Srinivasan,	SVM	AMD DME	Duke University:45	2014	Cross Val: AMD: 100% DME: 100% Normal: 86.67%
6	S. P. K. KARRI	CNN(GoogLENet)	AMD DME	Duke University:45	2017	Accuracy: 94%

Sr. No	Authors	Method	Type of Maculopathy Disease examined	Dataset	Year	Results
7	Khaled Alsaih	PCA+SVM	DME	SERI :32 • 16 DME • 16 Normal	2017	SP&SE: 87.5%
8	Zhongyang Sun	FCN(ScSPM,V3)	AMD, DME	Clinical Data Dukes Data	2019	Accuracy: Dukes: 100% Clinical:99.69
9	Reza Rasti	WCNN	AMD, DME	Dukes Data Topcon device	2017	Precision: 2-class classification:99.50 % 3-class classification:98.83 %

METHODOLOGY

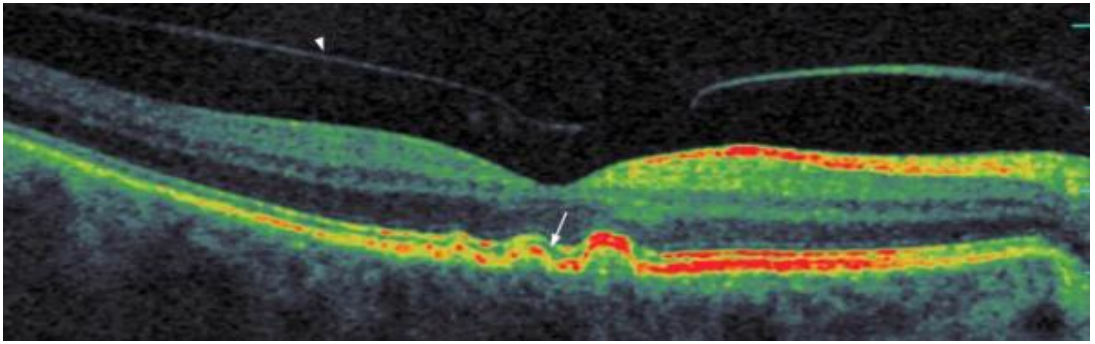
System's Overview

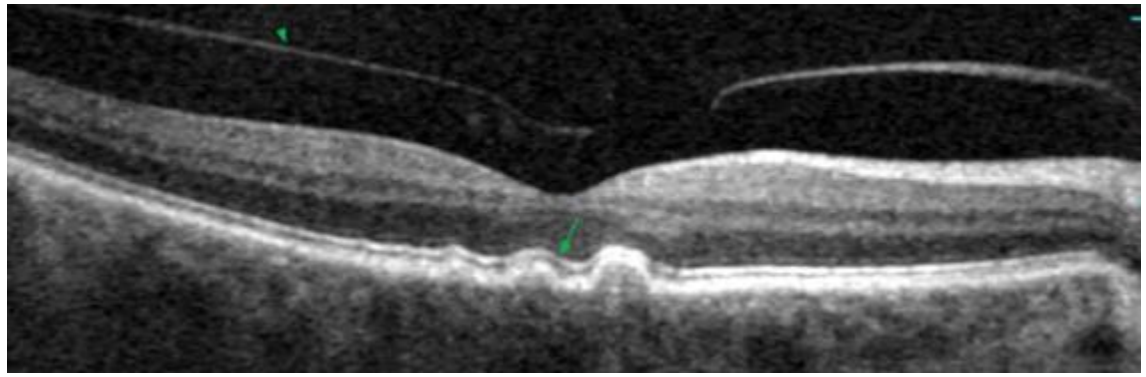


PRE PROCESSING

Pre-Processing

Grey Scale Conversion





- The OCT images initially used for this research was in RGB form.
- A conversion into grey-scale was required for further processing and improved classification results.
- Open CV is used to convert the RGB to Grey Scale

Pre-Processing

Resizing

- Data set from Duke's University comprised of scans which were mostly with the dimensions 512*496
- However some scans were of dimensions 128*128
- All of the scans of patients were resized from various dimensions to the minimum dimensions of the scans:
  i.e. 128*128.

Pixel Conversion and Normalization

- The pixel values of patient scans were on the scale from 0 to 255.
- Therefore, each value was normalized to get the values with in the range of 0 to 1 to get a standard data : $\frac{Xi}{255}$.

Pre-Processing

Labeling and One Hot Encoding

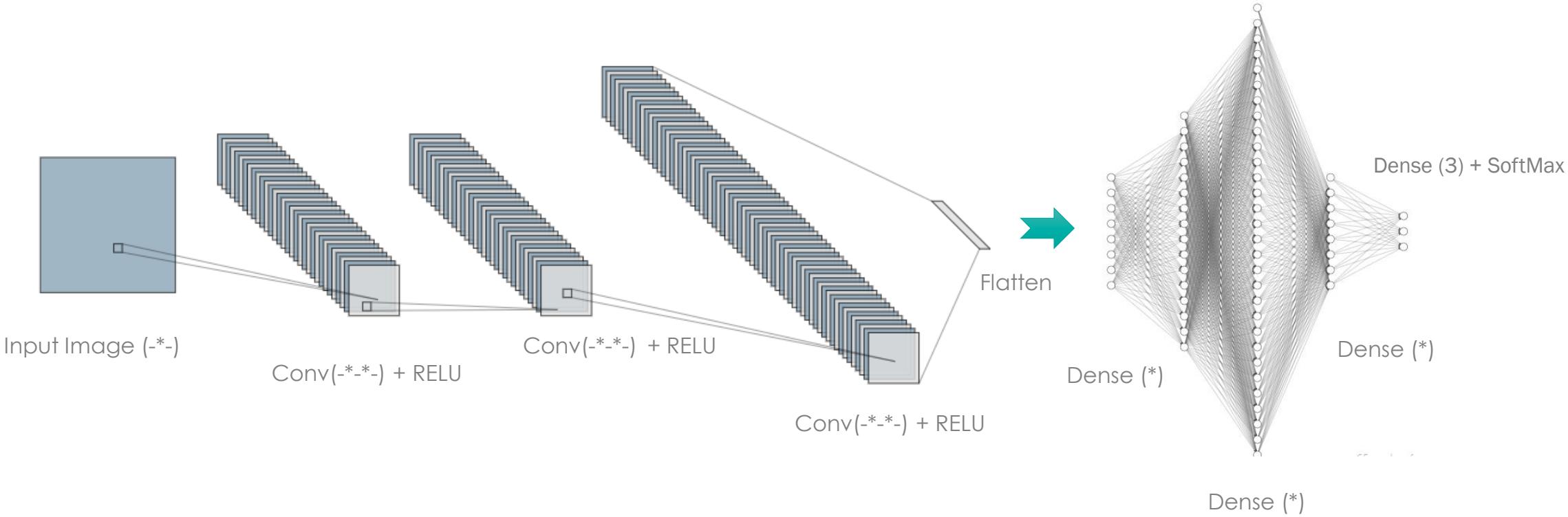
- Duke's University Dataset contained:

- 15 patients of AMD with 723 Scans
- 15 patients of DME with 1101 Scans
- 15 patients of Normal with 1407 Scans

- One hot encoding was done to get the categorical labels (AMD, DME, Normal) into numerical form so that One Hot Encoded Labels can be provided to model while training.

Labels	Labels_AMD	Labels_DME	Labels_Normal
AMD	1	0	0
DME	0	1	0
Normal	0	0	1

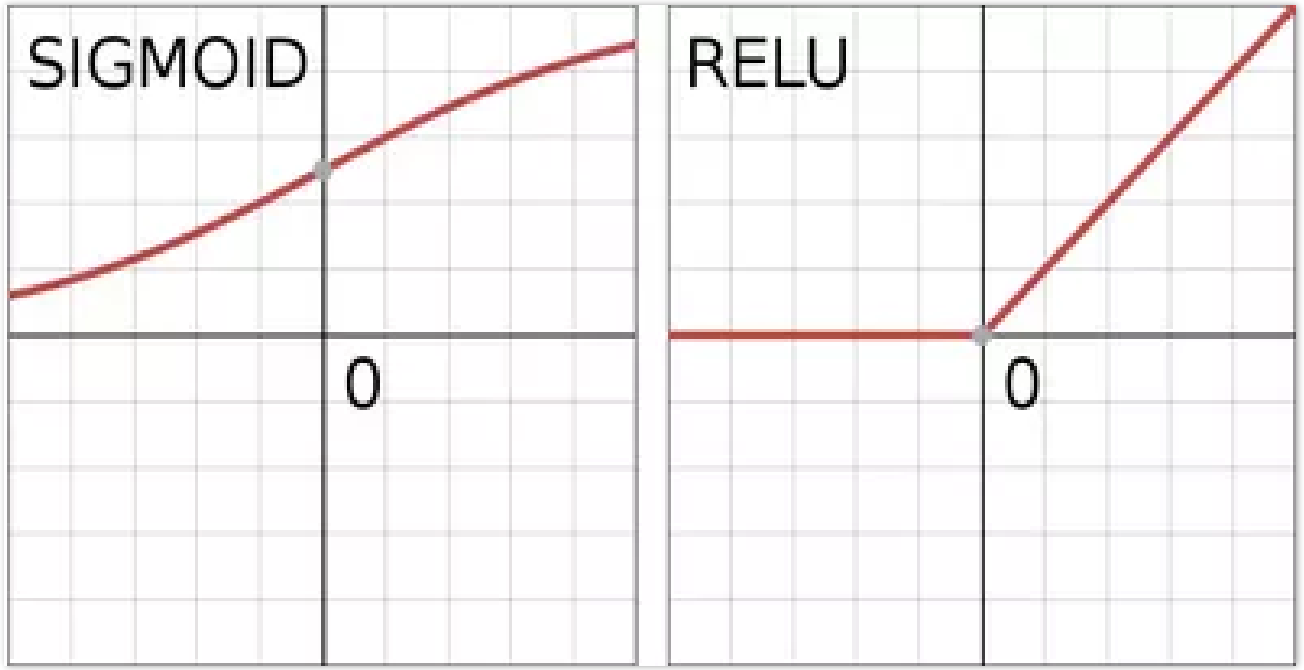
Modeling



Hyper-parameters used for experiments

Name	Value
Input Size	1x128x128
Batch Size	32
Epochs	150

Activation Layer

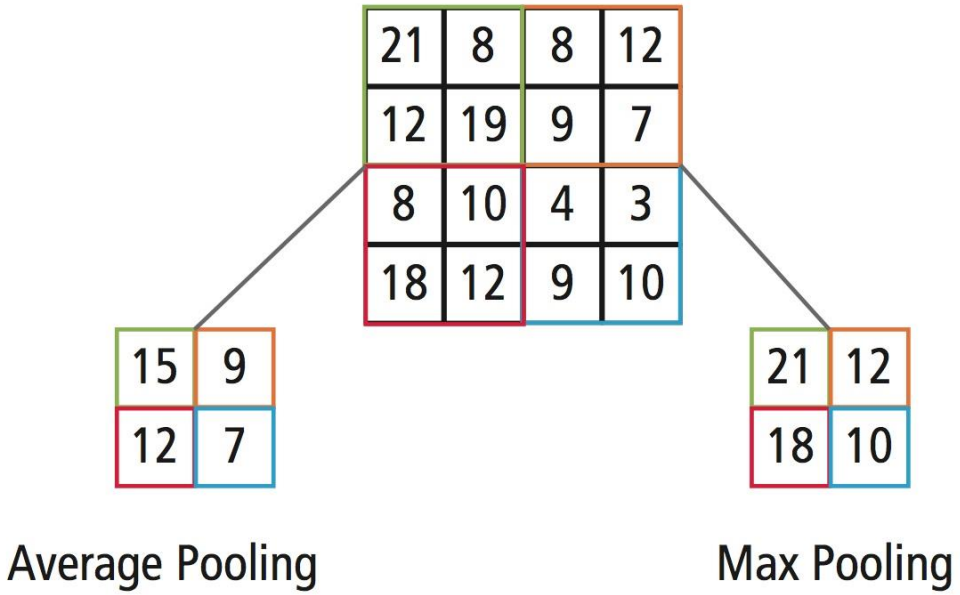


0.0 -1.0 = $(-3)
Wx+b = 0

1/1+1 = ½ = 0.5

Pooling Layer

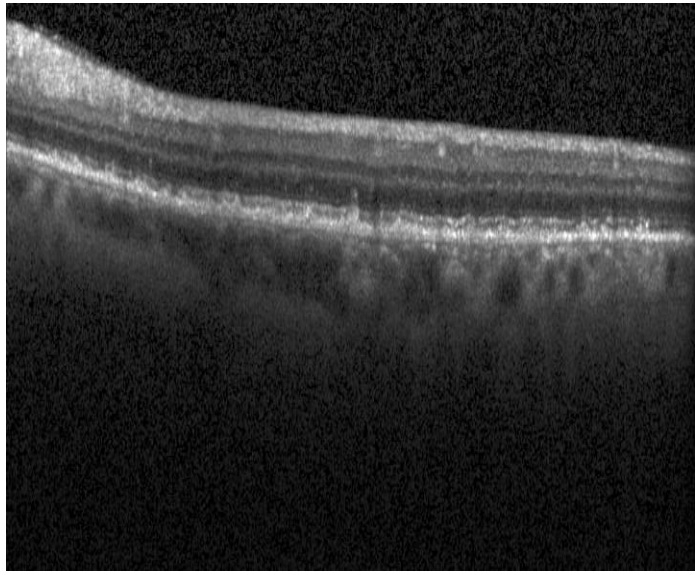
- Max Pooling
- Simplifies the complexity of neural network
- Down samples the image by selecting maximum value from the window



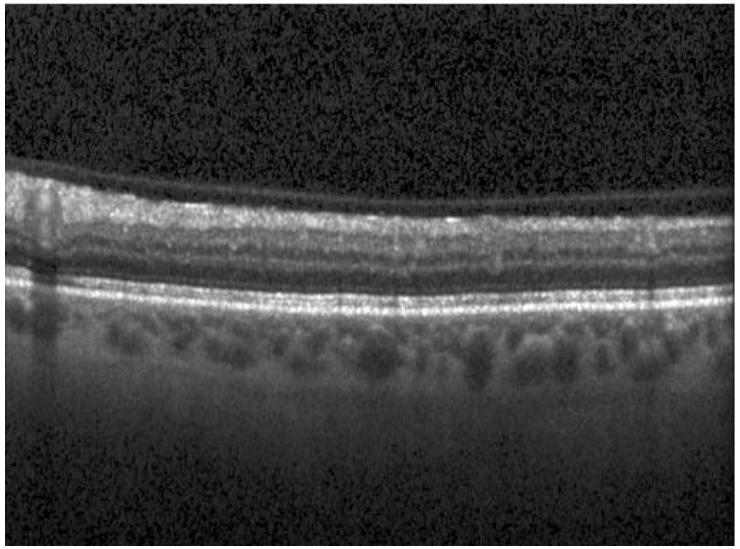
EXPERIMENTAL RESULTS

Duke's Dataset Specifications

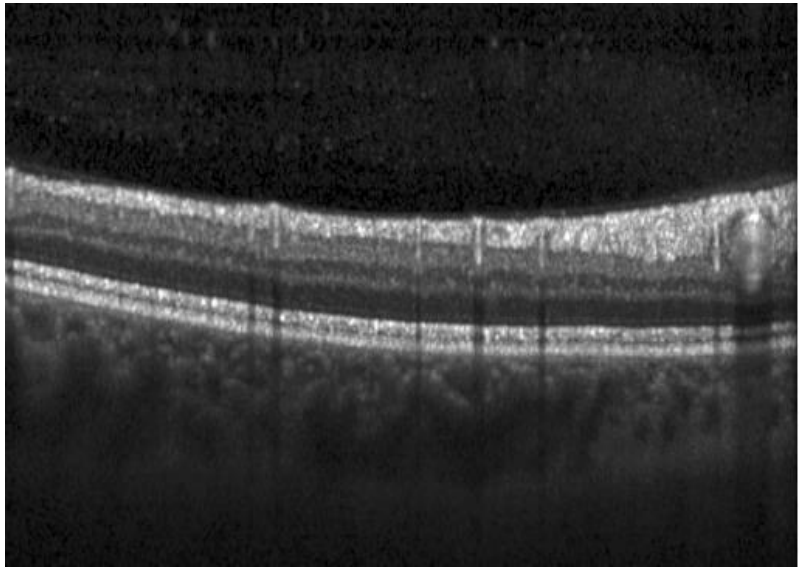
Database	Total Patients	Total Images	Training images	Testing Images
Duke's Dataset	45	3231	2584	647



AMD



DME



Normal