Cataract Detection and Classification using Machine Learning and Transfer Learning

Submitted in partial fulfillment of

the requirements For the degree of

Bachelor of Engineering
in
Information Technology

by

Kamaljit Kaur 17IT2039

Piyush Jha 17IT1027

Kaushal Chande17IT1012

Supervisor

Mr. Swapnil Shinde

Department of Information Technology

Dr. D. Y. Patil Group's

Ramrao Adik Institute of Technology

Nerul, Navi Mumbai

400706. (Affiliated to

University of Mumbai)

(2021)

Ramrao Adik Institute of Technology

(Affiliated to the University of Mumbai)

Dr. D. Y. Patil Vidyanagar, Sector 7, Nerul, Navi Mumbai 400706.

CERTIFICATE

This is to certify that, the Project titled

"Cataract Detection and Classification using Machine Learning and Transfer Learning"

is a bonafide work done by

Kamaljit Kaur 17IT2039

Piyush Jha 17IT1027

Kaushal Chande17IT1012

and is submitted in the partial fulfillment of the requirement for the degree of

Bachelor of Engineering
in
Information Technology
to the
University of Mumbai

Supervisor

Mr. Swapnil Shinde

Project Co-ordinator	Head of Department	Principal
(Mrs. Reshma Gulwani)	(Dr. Ashish Jadhav)	(Dr. Mukesh D. Patil)

Project Report Approval for B.E.

This is to certify that the project entitled *"Cataract Detection and Classification using Machine learning and Transfer Learning"* is a bonafide work done by *Kamaljit Kaur, Piyush Jha, and Kaushal Chande* under the supervision of *Mr.Swapnil Shinde.* This project has been approved for the award of a *Bachelor's Degree in Information Technology, University of Mumbai.*

Examiners:

1. . . . .

2. . . . .

Supervisors:

1. . . . .

2. . . . .

Principal:

. . . .

Date :

Place:

Declaration

I declare that this written submission represents my ideas in my own words and where other's ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Kamaljit Kaur	17IT2039	( )
Kaushal Chande	17IT1012	( )
Piyush Jha	17IT1027	( )

Abstract

According to the World Health Organization report, one of the world's leading causes of blindness is reported to be due to cataracts. Even though cataract majorly affects the elderly population however now they can be seen among minors too. Among the various types, the prominently three types of cataract affect masses in high numbers which are nuclear, cortical, and post-subcapsular cataract. Conventional methods of cataract diagnoses include slit lamp image tests by doctors which do not prove to be effective in classifying cataracts in the early stages and can also have inaccuracies in identifying the correct type of cataract. Existing work to automate the process has worked on classification based upon binary detection only or has considered only one type of cataract among the mentioned types for further expanding the system. Further less amount of research has been done in the field of classification of cataract types. Our system works on the detection of cataracts and type of classification on the basis of severity namely; mild, normal, and severe, in an attempt to reduce errors of manual detection of cataracts in the early ages. Our proposed system has successfully classified images as cataract affected or as a normal eye with an accuracy of 96% using combined feature vectors from the SIFT-GLCM algorithm applied to classifier models of SVM, Random Forest, and Logistic Regression. The effect of using SIFT and GLCM separately has also been studied which leads to comparatively lesser accuracies in the model trained. For the type classification, our system has obtained 97.66% using deep convolutional neural network models, in particular SqueezeNet, MobileNet, and VGG16.

Contents

List of Figures

Chapter 1

Introduction

A cataract is a white cloud formation that gradually hardens and forms a yellow sheet on the normally transparent lens of the eye. This condition which leads to a decrease in the vision of a healthy eye is caused as the light does not reach the retina as the eye lens is covered by a hardened white cloud. The World Health Organization conducted a survey on world sight day 2019 under which 36 million people were identified as lined and 217 million had moderate or severe distance vision impairment (MSVI), out of these cases of blindness and MSVI about 65 million people were affected by cataract [1]. Thus, cataract is responsible for or 48% of blindness cases.

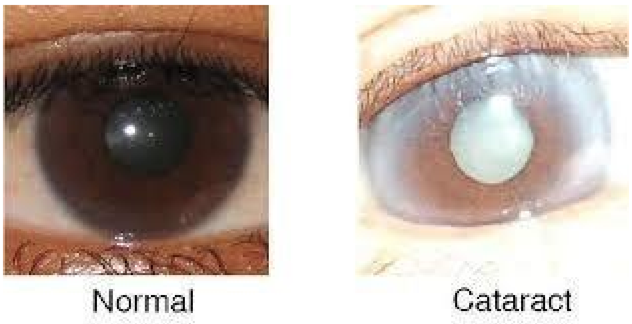

Fig 1.Normal Eye vs Cataract Eye [2]

As per the statistics given by the National Blindness and Visual Impairment Survey India 2015-19, cataracts are responsible for 66.2% of blindness cases, 80.7% severe visual impairments, and 70.2% moderate visual problems for an age group of above 50 years of year.

Even though cataract develops very slowly it can cause long-term problems as it moves from covering a very small portion to spreading over the eye lens causing vision loss since light can no longer reach the retina due to the cloud that is formed on the lens.

- **<u>SIGNS AND SYMPTOMS</u>**

1. Blurry Vision.
2. Difficulty to see things at night.
3. Eyes get sensitive to light.
4. Brighter light needed for reading,
5. Halo or circular formation is seen around light sources.
6. The colors appear to be more yellowish.
7. Double vision.

· **CAUSES AND RISK FACTORS**:

1. Ultraviolet radiation
2. Diabetes
3. Hypertension
4. Obesity
5. Smoking
6. Use of corticosteroid medications.
7. Medical history of eye injury or survey.
8. Alcohol consumption.
9. High rate of myopia
10. Previous Family history
11. Age [3]

DIAGNOSIS OF CATARACT:

1. **Visual acuity test.** The current system of conventional practices followed to detect cataracts or other similar diseases includes a visual acuity test under which the eyesight of the patient is checked with the help of a chart or a viewing device that has letters in decreasing order of its size.

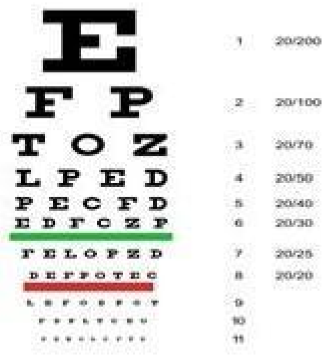

Fig 2.Chart used for acuity test [4]

2. **Slit-lamp examination.** This detection technique helps to check the vision accuracy of the patient another method which is majorly used by the doctors and ophthalmologist is slit lamp examination to see the structure of the front of the eye with the bright illumination of light on the cornea, iris, and lens all under high magnification

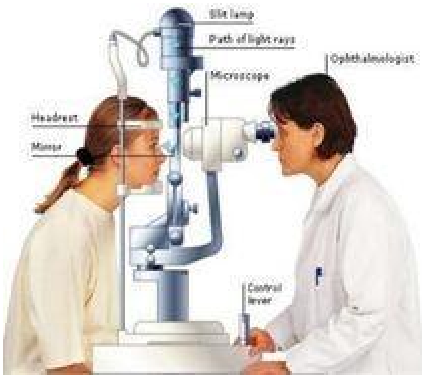

Fig 3.Slit-lamp examination [5]

3. **Retinal exam.** Another method is a retinal exam in which using a slit lamp or an ophthalmoscope, the doctor examines the lens for signs of cataract. The pupil is made to stretch out a little wider than usual by making use of a suitable eye drop[3].

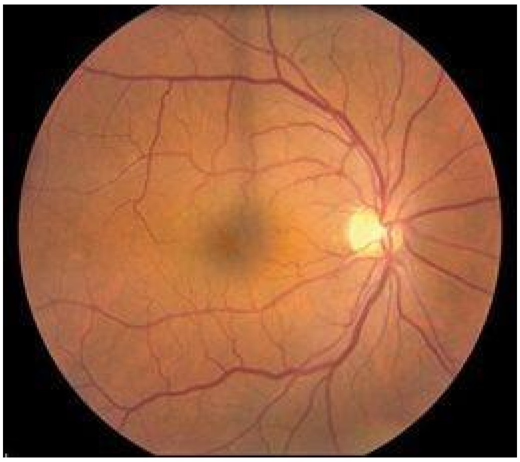

Fig 4. Fundus image [6]

Current work in the field:

As we studied the existing work done on this topic a system which is based on image processing and developed on the MATLAB platform shows an accuracy of about 90% and further suggests using SVM to improve the accuracy [7]. Another project uses fundus images of the retina, the RGB image is first converted into green channel one and by applying image processing techniques, the contrast is enhanced and noise is removed. Binary SVM is implemented to classify the fundus image along with the MDA algorithm. Classification is carried out for two classes i.e. non-cataract and cataract. The grading part consists of three classes i.e. mild, moderate, and severe cataract. The dataset used consists of 261 images [8].

A system was developed using the following approaches 1. computer vision approach of extracting features and using them to develop machine learning models (b) automatic feature generation and classification using convolutional neural networks. A set of six hundred labeled retinal images was used to train the models[9]. A project proposed a method to detect cataracts using smartphones like Android, iOS. The camera detects the eyes, crop the required region of the eyes. When cropping the pupil they are stored in a matrix. They are analyzed with the Native Development Kit on the android platform. The two main features average or mean intensity of image and histogram are used to determine the presence of cataracts in the patient [10].

1.1 Problem Definition

At present, there has been a lot of work in the field of detection of various eye diseases and the cataract is one of the most common of them. A cataract is a white cloud formation that gradually hardens and forms a yellow sheet on the normally transparent lens of the eye. The condition of cataracts is responsible for 48% of world blindness.

These problems with existing systems include:

1. Use of small datasets.

2. Heavy algorithms resulting in high efficiency but increased computation power.

Therefore, we are proposing a system which will help in the detection of cataract and their type by considering these above disadvantages.

1.2 Scope of the Project

The aim of this project is to detect the presence/absence of cataracts. The system would provide quick results to the user with great accuracy and efficiency. The user can upload the image on the website and obtain the results any time and based on the results the user can take appropriate actions.

1.3 Objectives

- To build a system that will help to detect the presence of cataracts and also determine the type of cataract.
- To build a system that improves the efficiency of detection
- To build a system that is accessible anywhere and at any time.
- To help save the time of the patient by producing immediate results.

1.4 Relevance and Motivation of project

The condition of cataracts is responsible for 48% of world blindness. There are various works focusing on this idea but they have various issues like the use of small datasets and heavy algorithms which causes an increase in the computation power. Therefore, we are proposing a system that would help in the detection of cataracts by considering the above disadvantages in the existing systems.

1.5 Organization of the report

Chapter 1: The primary objective of this chapter is to introduce problem definition, scope, and motivation behind this project.

Chapter 2: This chapter explains review of literature.

Chapter 3: This chapter deals with planning and formulation of projects.

Chapter 4: This chapter includes the final outcome of the project and different methods used in this project. It also includes the system requirements used in this project.

Chapter 5: This chapter includes a working model and implementation of the project.

Chapter 6: This chapter describes the experimental results and its analysis for the proposed work.

Chapter 7: This chapter describes testing methodology for the proposed system.

Chapter 8: This chapter defines conclusion and future scope of the project

Chapter 2
Literature Review

2.1 Computer-Aided System For Early Detection Of Nuclear Cataract Using Circle Hough Transform. 2019
Authors : Jagadale, A., Sonavane, S., & Jadav, D.V.

In this methodology studied, they proposed a smart computer system to detect and further categorize the cataract using slit-lamp images as their source input.

The proposed system performs the following steps in the given order [11]

A. Lens Localization:

In this method, images are taken through a digital camera that is placed on the eyepiece of a slit lamp. This helped to create a data set of 400 images with classes as early, intermediate, and the mature types of cataracts, which were later cropped for further process. This cropping is done such that the image now contains only the part of the iris. The resizing is done to about 65px and lastly Hough circle detection which is one of the famous algorithms for detecting the region of interest as the circle is used.

B. Detection of Nuclear cataract using SVM.

The images contain intensity values similar to that of a random distribution hence it is expressed by using statistical values of mean, energy, homogeneity, smoothness, and correlation. These features of about 20 images are used as an input to the SVM classifier. This gives the results with an accuracy of 90.25%. The results also state that the score of sensitivity could be enhanced by using some other feature extraction method along with the circle detection algorithm.

2.2 Mobile Application Based Cataract Detection System.

Authors: Agarwal, V., Gupta, V., Vashisht, V.M., Sharma, K., & Sharma, N.

This paper works upon using the algorithms of Machine Learning and Image Processing together [12].

The system's methodology has been divided into four steps shown below:

a) Gathering of Images

b) Pre-processing of Data

c) Classification using KNN

d) Validation of Developed Application

a) Gathering of Images: The data is collected from the google image database. The Google API along with AJAX is being used in the application to download the eye images of cataract and also the images of normal eyes.

b) Pre-processing of Data: The downloaded images are then cropped in order to get only the interesting area of the image. The cropped image is now shown to the user to verify that the image has been cropped appropriately. The image is now fed to the Orange Tool for the process of feature extraction. About 2048 features of the image are extracted with help of this tool. After that, the dataset is classified into 2 categories Cataract and Normal. Both of them are then merged into one .csv file.

c) Classification using KNN: After the feature extraction process, there is no explicit Training phase. The KNN model works on Similarity features which are calculated by making use of distance formulas, for example: Euclidean. The KNN is used in order to decrease the computational work. Based on the similarity, the testing image is classified as either Normal or Cataract.

d) Validation of Developed Application: This is the last stage where the proper working of the mobile application is validated by the users and the Ophthalmologist.The model is implemented using the Orange tool.

Accuracy results of the KNN, SVM, and Naïve Bayes were stated as 83.07%, 72.5%, and 76.67% respectively[5].

2.3 Early Recognition and Grading of Cataract Using a Combined Log Gabor/Discrete Wavelet Transform with ANN and SVM

Authors : Tawfik, H.R., Birry, R.A., & Saad, A.A.

The model for cataract detection, classification, and grading is mainly divided into 3 phases which are described as follows[13]:

a) Pre-processing phase: In this step, the main goal is to remove all the unnecessary information from the image. This is done by resizing the image, cleaning the images. This includes removing glare from the images and also converting them into grayscale form.

b) Feature Extraction phase: The main feature is extracting the image of the eye lens. Therefore, an invisible circle is made and only the part of the image containing the pupil is extracted in this process. After the extraction, it is then given to the wavelet transform with Log Gabor filters to obtain the feature vectors.

c) Classification phase: This is the last phase of the proposed method wherein the feature vectors which are obtained after performing the Wavelet Transform are sent to both the support machines SVM and ANN. Both of these machines classify the images into three classes: normal, early and advanced stage. Here the first-class refers to the normal eyes having no sign of cataract, the second class refers to the eyes which are having cataract but it is in the early stages and the last class refers to the eyes in which the cataract has reached the advanced stage.

Classification results show the accuracy of the SVM classifier as 96.8% and the accuracy of the ANN classifier as 92.3% on a dataset of 120 images.[6]

2.4 Detection, Categorization, and Assessment of Eye Cataracts Using Digital Image Processing.

Authors :Patwari, Professor & Arif, Muammer & Chowdhury, Md Nurul & Arefin, A. & Imam, Md. Ikhwanul

In this research work, the author used digital images of 6 eyes (6 patients) with varying degrees of nuclear cataract, 4 eyes cortical cataracts, and 3 normal eyes. The pictures were converted to grayscale and then to binary formats for finding the relative variations in pixel intensities between healthy and cataractous eyes. The three normal eyes served as a reference.

The lens image is derived from the picture of the patient first. To standardize the comparison and to reduce the calculation load by a third, the RGB image is then converted to a resized greyscale. Compared with the mean grey strength of healthy eyes obtained from 3 natural eyes, the presence of the cataract is then observed. For edge detection and circularity calculation, the image is further converted to black and white. Subsequently, the filtered image is converted to binary format and its circularity ranges from 0.96 to 0.84 for the normal eye and 0.65 to 0.07 for the cataract eye relative to the circularity threshold of the mask. Hence, the software was able to detect the presence of cataracts. The automated cataract detection technique displayed accuracy and repeatability, for NC and CC detection, of 94.96% and 95.14% respectively. [13]

2.5 A Robust Automated Cataract Detection Algorithm Using Diagnostic Opinion Based Parameter Thresholding for Telemedicine Application. Electronics

Authors :Pathak, S., & Kumar, B. (2016).

In this research work, an algorithm is proposed for cataract screening based on texture features: uniformity, intensity and standard deviation.In preprocessing ,images are converted to grayscale image ,applied gaussian filter with image resizing of 256 X 256 . In feature extraction , they calculated the uniformity of image based on histogram which will be further used to compute mean intensity and standard deviation of the image.
Results[14]:

1. Healthy eye-- uniformity value>=1.59 and mean intensity is less than 125.31 and more than 12.93.
2. Mild cataract-- uniformity value in between 0.09 and 0.11 and mean intensity value is between 125.3 and 134.
3. Severe cataract -- uniformity value <0.09 a and mean intensity value is greater than 125.3 .

The proposed method was implemented on MATLAB and gave results with close to 98% accuracy.

2.6 Cataract Detection using Digital Image Processing.

Authors : Jindal, I., Gupta, P., & Goyal, A

Digital image processing is used on eye images in this research paper to assess the existence of a cataract along with its severity. A dataset consisting of images of eyes having differing degrees of cataract is applied to two separate image processing algorithms [16].

The first method uses an automatic detection algorithm based on Feature Extraction. This acknowledges the Image pre-processes it, extracts data on the strength of the mean value, and makes decisions on classification into the healthy eye, mild, and severe cataracts.

In an unhealthy eye, the second method is based on measuring the region of pupil and the cataract. The percentage of cataract is measured as the relative measure of cataracts with respect to the pupil area which is the affected part. Further the image is resized then converted to grayscale version of the original image, also a low pass filter is added and finally by applying a opening of morphological type, the image is preprocessed. The transformation of Hough is then used in the picture to define and isolate circles. The transformation of Hough is then used in the picture to define and isolate circles. For detection of the affected region inside or even near the pupil, contours are used. If the infected region lies within the pupil, a cataract is confirmed by the algorithm.Also the percentage of cataract is measured with the formula: (cataract area / (pupil + cataract area))* 100.

Chapter 3
Planning and Formulation

Our system is divided into two phases

1. First phase aims to detect the presence of cataract
2. If cataract is present then the second phase classifies the type of cataract on the severity level: normal,mild and severe.

a) First phase

Our Cataract detection system involves a two stage process :

1) Detection of textural features to form the vector.

2) Input the vector to the classifier to get the results.

After forming the dataset by collecting the relevant images from a stock image website and project source project, to form a simple and better quality dataset the images were manually cropped to the region of the iris and then resized to about 128 pixels. The feature vector is formed by the combination of features extracted from SIFT and GLCM algorithms. SIFT contributed a total of 2303 feature points and GLCM gave 5 features, thus the total size of final feature vector was 2308,

These features were used to train different machine learning classifiers like support vector machine, K-nearest neighbour, random forest and logistic regression. By comparing the accuracies it was concluded that Logistic Regression proved to be better for our work with a score of 96% and thus it was converted into a pickle object file that was later used in our flask web application to give the results when the user would input an image into the system.

b) Second phase

Phase 2 dataset consists of 550 images that are further into three classes namely; 220 mild, 166 normal and 164 severe images. To extract the region of interest i.e pupil of the eye , images were resized to 224 pixels and converted to hsv color space. Pupil color scale mask is applied on the images to retain the pupil part. After this Hough circle transform is applied to find the coordinates of the pupil circular area. Finally the rectangular contour is drawn around the circular area from the coordinate calculated above and the pupil part is extracted. Furthermore for the machine learning part, 2303 SIFT and 5 GLCM features were extracted from the images thus the total size of the final feature vector was 2308.

These preprocessed images are used for training using pre-trained deep convolutional learning models like SqueezeNet, MobileNet and VGG16. By observing the results from these models , we obtained the highest accuracy 97.66% from the SqueezeNet. On the other hand for the machine learning model , 2303 SIFT with 5 GLCM thus a total of 2308 combined features were used to train different machine learning classifiers like support vector machine, XGBoost ,random forest and AdaBoost algorithm . By comparing the results, XGBoost demonstrated the best model with accuracy of 96%.

Finally the Logistic regression model of phase 1 and SqueezeNet model of phase 2 were converted into a pickle object file that was later used in our flask web application to give the results when the user would input an image into the system.

Chapter 4
Methodology

4.1 Proposed System

Project is divided into two phases. First phase aims to detect the presence of cataract, if cataract is present then the second phase classifies the type of cataract on the severity level:normal,mild and severe. The following steps are involved in designing and training the model**.**

1. **Preprocessing:**

a. Phase 1 dataset consists of 97 images that are cropped manually in the initial stage and then they are resized to 128 pixels followed by grayscale conversion of the images which are then used for texture feature extraction.Phase 2 dataset consists of 550 images that are further into three classes namely; 220 mild, 166 normal and 164 severe images.

b. To extract the region of interest: pupil of the eye

The following steps are perform on the dataset to extract the region of interest:

1. Images are resized to 224 X 224 pixels
2. To pull out the pupil part, images are converted into HSV(hue,saturation and value) color space .
3. HSV color space mask is created on the basis of pupil color scale.It returns the range of 0s and 1s of size 224 X 224 in which 1s signify value within the range and 0s outside the range.
4. Above mask is imposed on the step 2 image by bitwise AND operation ,which keeps every pixel in the step 2 img if the corresponding pixel in the mask is 1.
5. Hough circle algorithm is applied on the resultant image to extract the circular area of pupil which returns the coordinate and radius
6. Black color mask of size 224 X 224 is created and a circle is drawn with coordinates and radius we got from step 5.
7. Further Bitwise AND operation is perform and binary threshold is applied to extract the rectangular contour which returns the top-left coordinates ,width and height of the rectangular region around the pupil
8. From the top-left coordinates ,width and height , we cropped the region of interest i.e. pupil of the eye

c. Feature Extraction using GLCM:

Gray Level Co-occurrence Matrix (GLCM) is a statistical method of determining texture by calculating the spatial relationship between the pixels. Characterization of texture of the image is done by GLCM by calculating how frequently pairs of pixels with specific values and a specific relationship occur thereby creating GLCM and finally extracting statistical measures from the resultant matrix [17].

Several statistics can be computed from the gray co matrix. The computed statistical values provide us essential information regarding the texture of the image. Some of the statistics are listed as below:

1. Contrast - It is used to measure the local changes i.e. the intensity contrast between a pixel and its neighbor over the entire image.
2. Correlation - It determines the gray level linear dependency of the specified pairs of pixels.
3. Energy - It determines Angular's moment i.e. it provides the sum of squares in GLCM.
4. Homogeneity - Evaluates how close the elements are distributed in the GLCM with respect to the GLCM diagonal

b.Feature Extraction using SIFT:

Scale Invariant Feature Transform (SIFT) is mainly used to draw out those features from an image which are independent of the scale of image or any kind of rotation. The SIFT algorithm is divided into 4 steps[18]:

i. Scale-Space Extrema Detection:

This step focuses on identifying those locations and scales which can be identified from different views of the same object. A "scale space" function is used to achieve those results. For this a Gaussian function is used. The scale space is defined by the function:

$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y).$ (1)

Here * is the convolution operator,

$G(x, y, \sigma)$ >Variable-Scale Gaussian and

$I(x, y)$ >Input image.

Different techniques can be used to find the locations of stable key points in the scale space. One of those techniques is Difference of Gaussian, the scale-space extrema can be found, $D(x, y, \sigma)$ by calculating the difference between two images, with one image having scale k times the other image. $D(x, y, \sigma)$ has the following expression:

$D(x, y, \sigma) = L(x, y, k\sigma) – L(x, y).$ (2)

For finding the local maxima and minima, each point has to be compared with its 8 neighbouring points located at the same scale, and its 9 neighbours which are present on above and below scale. If the current value has the least value of all the neighbouring points then this point is the local minima or if it is maximum then this point is local maxima.

ii. Keypoint Localisation:

In this step the main aim is to remove additional points from the collection of keypoints by finding those having less contrast or are present poorly around an edge. The location of extremum, z, is expressed as:

Z = 〖(∂^2 D)/(∂x^2)〗^(-1) (∂D)/∂x… (3)

If the resulting value at z is less than a threshold value then this point is not considered. This eliminates the extreme values having low contrast. To remove extreme values based on poor localization, the difference of Gaussian function is used.

iii. Orientation Assignment:

The main aim of this step is to focus on assigning a uniform orientation to the keypoints based on the image’s local properties. Then the keypoint descriptor can be represented in relation to this orientation, thereby achieving invariance to rotation of the images. The orientation can be found by the steps shown below:

The key points scale is used to select the Gaussian smoothed image L, from above. Orientation histogram is constructed from gradient orientations of sample points. Find the highest peak in the histogram. Using this peak and another local peak having height within 0.8 times of this peak create a keypoint of that direction. Some points may have more than one orientation value. To resolve this, a parabola is to be fitted to the 3 histogram values closest to each peak to interpolate the position of the peak.

iv. Keypoint Descriptor:

Keypoint descriptors can also be created using local gradient data. The gradient information is turned around to have the same direction as that of the keypoint and then weighted by a Gaussian with a variance value of 1.5 times the keypoint scale. A set of histograms are created based on the obtained data over a window centred on the keypoint.

Keypoint descriptors usually use a set of 16 histograms, which are aligned in a 4x4 grid and each grid consists of 8 orientation bins, one is used for the main compass directions and other is used for each of the midpoints of these directions. This helps in generating a feature vector consisting of 128 elements.

v. Making a new Feature Vector:

The features obtained from the above two procedures are then combined together to form the resultant vector which is used in the further steps to train the model. This was done to improve the accuracy of the result by including more features in our vector.

The dataset is then divided into training and testing as 75% and 25% respectively.

3. Detection and Classification:

The classifiers used to obtain the results and for the comparative study are as follows

a.Support vector Machine:

Support vector machines are supervised machine learning algorithms which are more preferred in classification and sometimes used for regression problems in which support vectors are the coordinates of the individual observation.

SVM mainly focuses on dividing the datasets into classes in order to find the most optimistic hyperplane and it can be done in the two steps [20].

- The algorithm will generate hyperplanes repetitively that classify the classes.
- Then, it will select the hyperplane that separates the classes correctly with minimum outliers.

SVM uses a kernel which takes an input data vector and transforms it into a higher dimensional vector .

i. Linear Kernel:

Linear Kernel is used when data is linearly separable i.e. it uses straight lines to classify the classes. The formula of linear kernel is as below [21]

$$LK(x, y) = \text{sum}(x * y). \tag{4}$$

From the above formula, we can see that the product between two vectors says x & y is the sum of the dot product of input values.

ii. Radial Basis Function (RBF) Kernel:

It maps the input space in higher dimensional space like quadratic,cubic,etc. The following formula is used to express it mathematically −

$$LK(x, xi) = \exp(-\text{gamma} * \text{sum}(x - xi^2)). \tag{5}$$

Here, gamma ranges from 0 to 1. We can set gamma values in the SVM algorithm manually. A gamma value of 0.1 is generally preferred [12].

a. Logistic Regression:

Logistic regression is a supervised learning classification algorithm mainly used in binary classification problems[21].

As a function of x, the logistic regression model predicts P(y=1). The Logistic regression equation can be derived from the Linear Regression equation. The steps to get Logistic Regression equations are given below:

Equation of the straight line is written as:

$$y = b0 + b1x1 + b2x2 + b3x3 + \ldots + bnxn\ldots \tag{6}$$

In Logistic Regression y can be between 0 and 1 only, so dividing the above equation by (1-y):

$$y/(y-1): 0 \text{ for } y = 0 \text{ and infinity for } y = 1\ldots \tag{7}$$

But we need range between -[infinity] to +[infinity], hence take logarithm of the equation it will become:

$$\text{Log}[y/1 - y] = b0 + b1x1 + b2x2 + b3x3 + \ldots.. + bnxn\ldots \tag{10}$$

The above equation is the final equation for Logistic Regression [22].

c.Random Forest:

Random forest is the supervised learning algorithm that can be used for both classifications as well as regression. Mainly it is used for classification models. The random forest algorithm produces data decision trees and then gets the predictions from all of these trees and eventually chooses the final answer by majority voting technique. It used multiple decision trees for its decision making and that is why it is called an ensemble algorithm, which results in over-fitting reduction [23].

Step 1 - Initially it starts with a selection of random samples from the dataset.

Step 2 - It constructs a decision tree for each sample and gets the forecast from each decision tree.

Step 3 - Performs voting for every forecast result.

Step 4 - Lastly, select the most voted forecast as the final prediction result.

d.K-Nearest Neighbor:

KNN uses 'feature similarity' to predict the values of the latest data points. In simple words, this means that the new data point is assigned a value based on how accurate it is with matches of the points in the training set [24].

Step 1 − Divide the Dataset into training and testing dataset

Step 2 − Next, we need to choose number K i.e number of neighbors.

Step 3 − For each of the data point i algorithm needs to do the following:

3.1 Distance calculation between testing data and each row of training data. Euclidean distance is a commonly used method for calculating distance.

3.2 Sort them in ascending order with respect to their distance.

3.3 Assigning a category to the test point based on which the number of neighbors is maximum.

e. AdaBoost:

This term stands for Adaptive Boosting which is an ensemble modeling method to build a strong classifier by repeatedly increasing the weights of the incorrect classifications of the weak classifier. This boosting technique was initially developed for binary classification problems and the algorithm follows
the following steps[25]:

1. Once we get the dataset, we assign equal weights to each data point.
2. The model is trained on these training examples and misclassified points are identified.
3. Weights of misclassified points are increased.
4. if required results are obtained
    Go to step 5
  else
    Go to step 2
5.End

f. XGBoost classifier algorithm

XGBoost classifier is an extreme gradient boosting algorithm which comes under ensemble based models . This model works by sequentially building decision trees on the features and optimizing the loss/residual function from the previous decision tree. Model work as follows:

1. Constructing the base model - M0
   i. Finding the probability of any class and assigning it to Pr by formula,
      = 1/ total number of unique classes
   in case of a regression problem, Pr = average of all the target values.
   ii. Calculation of the Residual R0 of each data point by subtracting each target value by Pr.
   iii. calculate similarity score using residual score (S.S) = (Summation of residual)^2 /∑(Pr(1-Pr)) + Ɣ
   Ɣ = hyperparameter ,value range from 0 to 1. it is initialized at the start of the algorithm
   iv. Construct the base decision tree using these similarity score and residual
2. Calculate the Information Gain(I.G) of each node = S.S of the immediate child nodes - S.S of the node. Best IG score of the node will be used for the next decision tree root selection.
3. Update log(Pr) = log(Pr/1-Pr) and base model prediction = activation function(log(Pr))
4. Decision Model M1 will have input and target as the loss suffered(residual) in M0 and again it will give new Residual R1
5. repeat step step 1 ii to step 3.
6. New prediction = Previous Prediction + Learning rate * Output
7. This process will continue until IG >Ɣ set at the starting of the algorithm and its subsequent post-pruning[26].

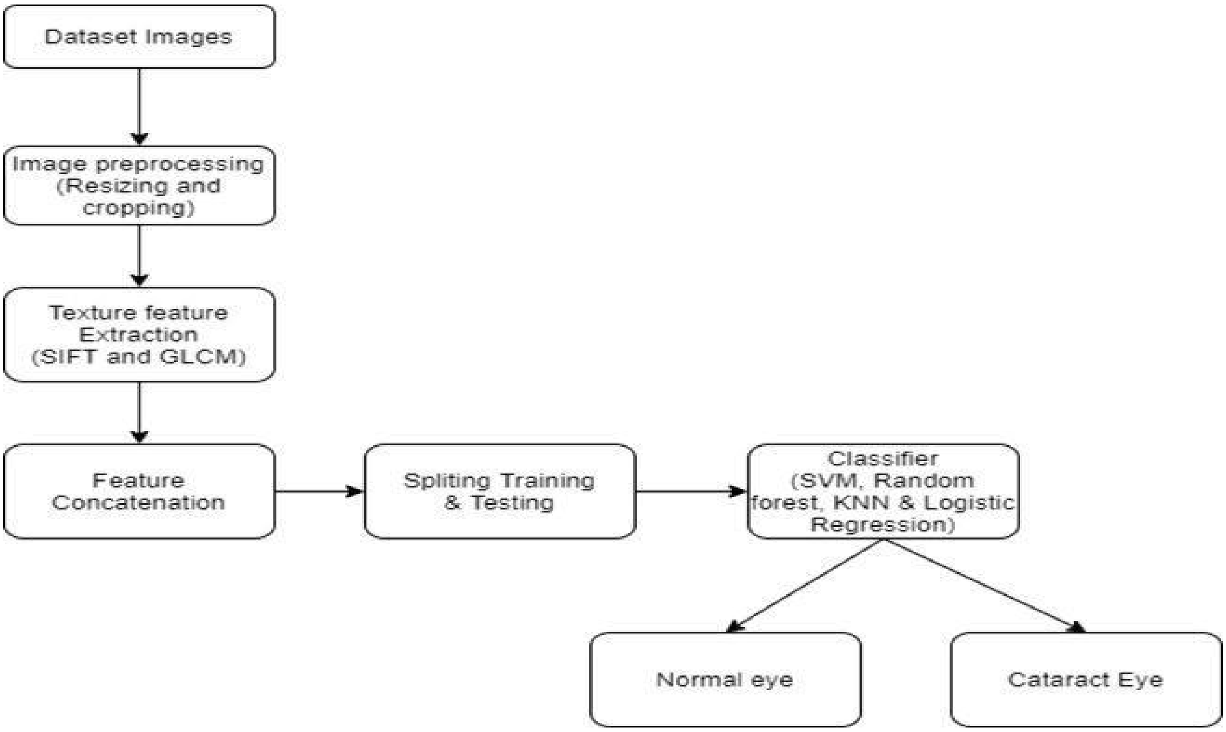

Fig 5. Data Flow binary classification

g . Deep learning convolutional algorithm :

Data Augmentation: Neutral networks require more training data because they extract the features on their own. The performance of CNN highly depends on the data which is fed into the neural network. However in instances where the amount of data available is less, the popular technique of data augmentation is used where in each sample in the data set is changed in response to some categories and new images are generated. These new images can be fed into the neural network as a single batch. The variations that can be made to the image include flip, scale, prop, translation, zoom,Gaussian Noise, etc. In our implementation we have used horizontal flip and zoom of the factor 0.2

The process of multiclass classification is performed using transfer learning and the following pre-trained models have been used to perform multiclass classification on the pre-processed images.

1. **Mobile Net**: This convolution neural network architecture was proposed by Andrew G. Howard. This streamlined architecture was specially designed for mobile and embedded devices with the capability of giving results in a lesser amount of time using less computation power. The architecture follows the principle of depth wise separable convolutions. The main idea was to separate the filter's depth and spatial dimensions which is then followed by point-wise

convolution. The overall architecture of MobileNet consists of 28 layers. It can easily be distinguished from a standard CNN since each 3x3 depth separable layer is followed by batch normalization and ReLU activation function layer. This is again repeated for the point-wise separable layer. This model takes an input of size 224x224x3[27].

2. **VGG-16:** This convolution neural network was initially proposed for the purpose of classification and detection. This model gives an accuracy of 92.7% on the famous imageNet dataset. The motivation behind developing this model was to improve the existing accuracy of the Alexnet model by changing the large kernels into multiple 3x3 kernel-sized filters which are placed in series with each other. The model accepts an input of size 224x224 in RGB format. All the convolution layers have a filter size of 3x3 and all the max pooling layers have pool size of 2x2[28]. In the output layer the model uses softmax activation function. As the name suggests it consists of 16 layers in total and the other variants can have 19 layers with corresponding weights.

3. **SqueezeNet:** This convolution neural network model was specially designed by considering the fact that the same level of accuracy can be obtained by reducing the size and number of parameters that the model uses during the training phase. The Squeezenet model gives alexnet level of accuracy however it uses 15 times less parameters and also the size of the model is less than 0.5 MB[29]. Use of such a compressed and squeezed model helps to run the model on various distributed servers and also in the environment where there is a limitation of the memory available. It replaces the conventional 3x3 filters with 1x1 point wise filters which required processing power 9 times lesser than the former, these reduced filters are termed as fire modules. It consists of 18 layers and uses an input size of 227x227 in the input layer.

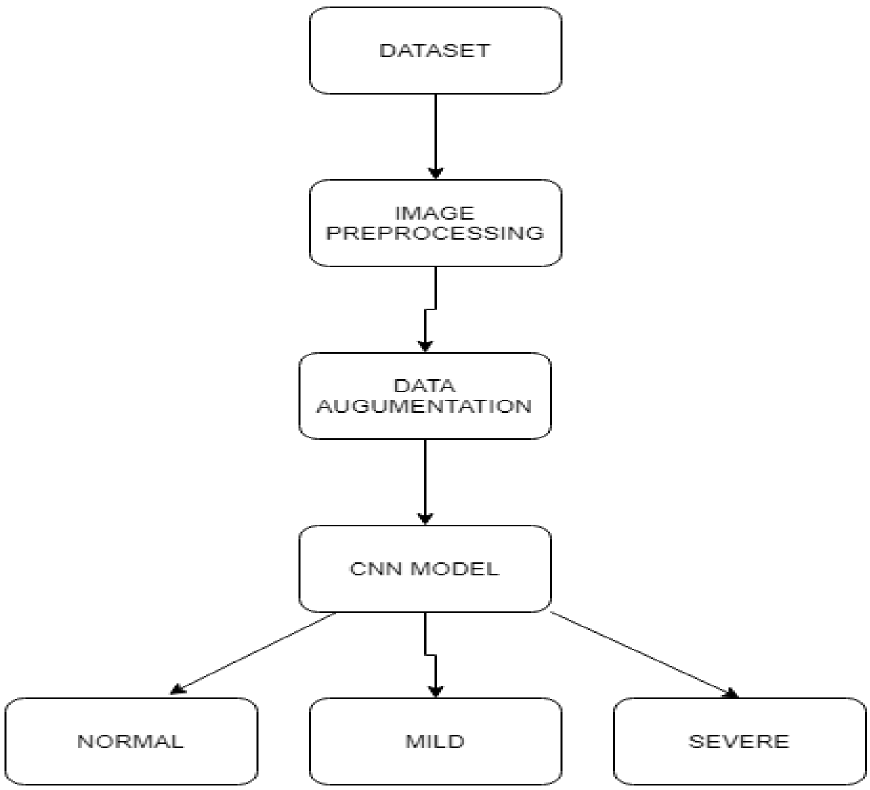

Fig 6. Data Flow multiclass classification

4.2 System Requirements

➢ **Dataset :** Labelled Eye Images converted into format suitable for Model Training.

➢ **Software Requirements**

Python 3.x (preferably, 3.5 or higher) installed and set-up

Required libraries: python-opencv,sklearn,numpy,pandas

➢ **Hardware Requirements.**

CPU with a minimum 4GB of RAM

GPU

Chapter 5

Design of System

5.1 Data Flow

For binary classification

a) Image Acquisition: The two sets of images that are cataract and normal eye image used as the dataset. These images are gathered from various free stock images websites and also images used in open source projects. Total size of dataset used in 97 images.

b) Image preprocessing: The images in the dataset are manually cropped to extract required regions of interest as the dataset used was not very uniform and then resized to a size of 128 pixels.

c) Texture feature Extraction: The two algorithms used to extract the texture features are GLCM & SIFT. The feature vectors are then concatenated to form the combined feature vector.

d) Splitting data for training and testing: The data is divided in the ratio of 75% for training and 25% for testing

e) Classifiers : SVM, Logistic Regression, KNN, Random Forest are used to segregate the result into normal or cataract diagnosed eyes.

For Multiclass classification

a. Image Preprocessing:
    i. First the Input Image is Resized into 224 *224.
    ii. The image is then converted into HSV(Hue-Saturation-Value) format.
    iii. To identify the Region of Interest(ROI) we have applied a mask to the image.
    iv. After that, we threshold the image.
    v. Apply Hough Circle in order to get the ROI.
    vi. Crop the image and store it in the respective directory.

b. Data Augmentation: The preprocessed images then divided into train and test directories in the ratio 3:1. The corresponding data generators are created.Variations in the augmented images include changes in the horizontal alignment and zoom.

c. Input to the CNN models: The three pre-trained models used by us were MobileNet, VGG-16 and SqueezeNet. The Models were trained for about 20-30 epochs with the aim to maximise the validation accuracy.

5.2 System Design

To make our results available to the end user, we have developed a web based graphical user interface using a popular python based framework which is *FLASK*.

The flow of our system is as follows:

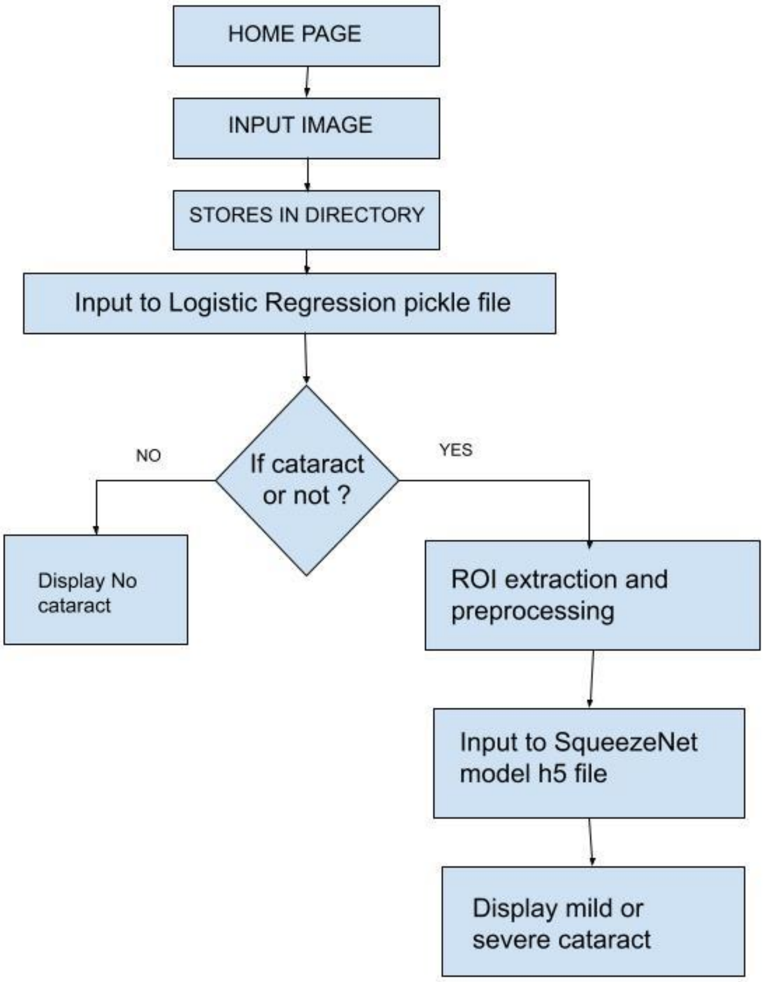

Fig 7. Flow of Flask GUI

At the home page once the user clicks on proceed the screen for inputting an image from them would be shown. This image is stored in our directory hence can be used to expand our dataset later. For convenience of the user the same image is flashed on the screen as well. This image is then given as an input to the pickle file that contains the Logistic Regression classifier trained on SIFT + GLCM features. This classifier then outputs the result as zero or one. The function in our flask web page then interprets the result as “cataract not detected” or “cataract detected” respectively.

If cataract has been detected then the system will move ahead to check the intensity of cataract. Before feeding the image to our deep learning model the region of interest is extracted and further sent for prediction. This is done by our transfer learning SqueezeNet model which is converted into .h5 format as the binary data file. The system then finally interprets and displays the result as mild or severe.

Our directory structure at flask:

1. Templates folder: Directory for rendering contains all HTML files
2. Static folder: Stores the styling and images for the project
3. Static/input_images : Stores the images given as input from the user
4. App.py: Main file with all the functions for routes and prediction.
5. Mainmodel.pkl : A byte stream file with Logistic Regression (with GLCM + SIFT features) trained model.
6. squeezenet.h5: A binary data file with pre trained architecture and weights of SqueezeNet CNN

Main screen that the user would visit first:

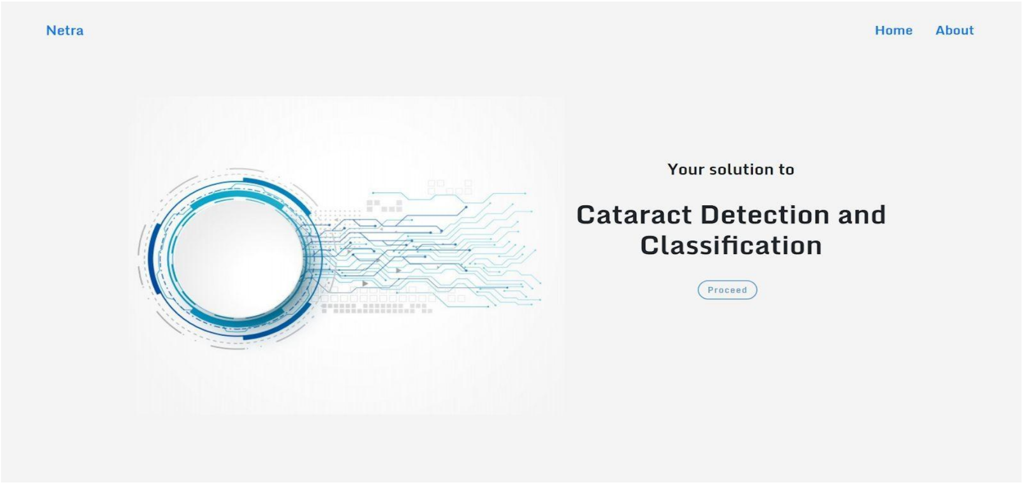

Fig 7. Main Page

Uploading the Image

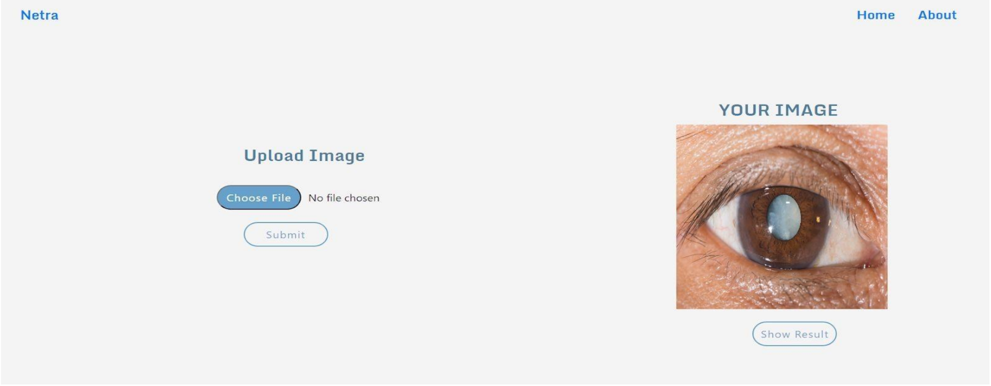

Fig 8. Add Image

Prediction by the model

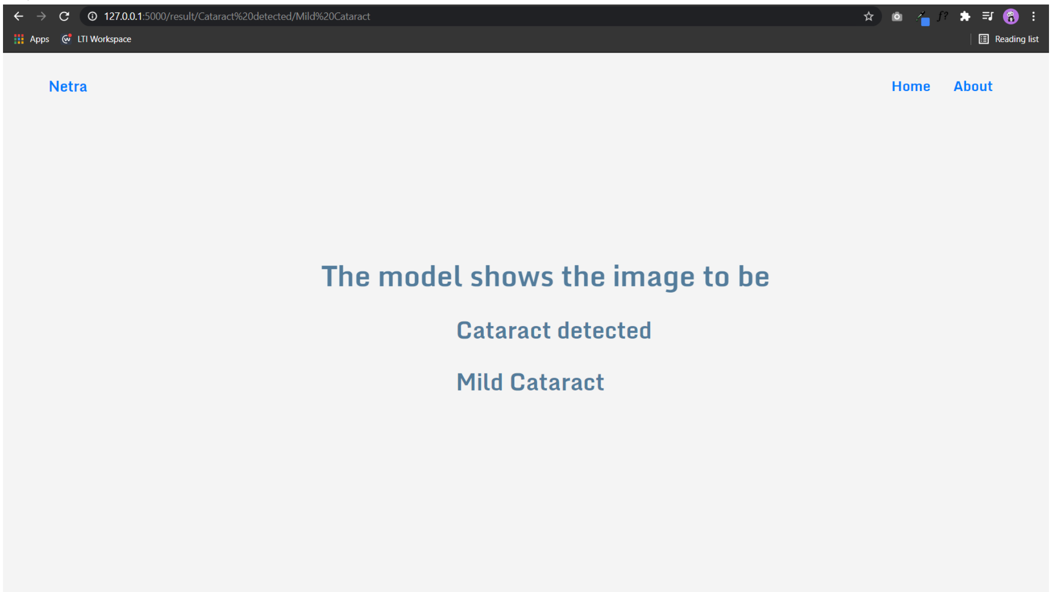

Fig 9. Results

Chapter 6
Experimental Results

Accuracy is one of the important metrics that help us to determine the performance of our classification or prediction model. It is possible to describe accuracy by the following formula.

Accuracy = No.of correct(true) predictions / Total no.of predictions

Precision = True Positive/(True Positive+False Positive)

Recall = True Positive/(True Positive+False Negative)

5.1 Binary classification for the presence of cataract

In this research paper we have made an attempt to evaluate the accuracy when different feature extraction algorithms are applied as classification parameters to the machine learning models trained with different algorithms such as SVM-Linear, SVM-Radial basis function, Random forest Logistic regression and KNN. The comparative study of the accuracies can be studied through the tables given below.

Feature dataset 1: SIFT with various classifier algorithms The table below describes the accuracy of various classification algorithms with the use of SIFT features with SVM algorithm having the highest classification accuracy of 92% along with Logistic Regression. Random forest algorithm achieved an accuracy of 84%. Among all the algorithms used, KNN achieved the lowest accuracy i.e. 68% for cataract classification.

Table No.1 Accuracy rates of various classifiers with SIFT features

Classifier	Accuracy
1. SVM-LINEAR	92%
2. SVM-RBF	92%
3. Random Forest	82%
4. Logistic Regression	92%
5. KNN	68%

Feature dataset 2: GLCM with various classifier algorithms The table below describes the accuracy of various classification algorithms with the use of various GLCM features. Logistic Regression algorithm has achieved the highest classification accuracy of 80%.

The SVM-Linear kernel algorithm achieved accuracy of 76% while SVM-RBF achieved the lowest accuracy i.e. 56%. Random forest algorithm achieved an accuracy of 64%. The KNN algorithm has achieved an accuracy of 60% for cataract classification.

Table No.2 Accuracy rates of various classifiers with GLCM features

Classifier	Accuracy
6. SVM-LINEAR	76%
7. SVM-RBF	56%
8. Random Forest	64%
9. Logistic Regression	80%
10. KNN	60%

Feature dataset 3: Combination of GLCM and SIFT feature vectors and applied on various classifier algorithms From the above two feature sets used for classification, it can be observed that the algorithms have achieved better accuracies when used with the SIFT features. Also, the GLCM features have also provided considerable accuracy, which incepts the idea of using a new feature set by concatenating the SIFT and GLCM features. Further in the attempt to improve the accuracies we trained our final model by combining the features from SIFT and G LCM which were 2303 and 5 respectively giving a total of 2308 features in our final vector set.

Table No.3 Accuracy rates of various classifiers with SIFT and GLCM features.

Classifier	Accuracy
11. SVM-LINEAR	96%
12. SVM-RBF	96%
13. Random Forest	96%
14. Logistic Regression	96%
15. KNN	56%

The above table shows accuracies obtained by various classification algorithms by using the combined feature set of GLCM and SIFT features. The highest accuracy achieved is 96% by SVM, Random Forest and Logistic Regression and KNN algorithm having lowest accuracy of 56%.

5.2 Multi class classification for the detection of cataract type

In this research paper we have made an attempt to evaluate the accuracy when different feature extraction algorithms are applied as classification parameters to the deep learning models trained with different algorithms such as VGG 16, MobileNet and SqueezeNet. The sample images from the dataset has been listed below

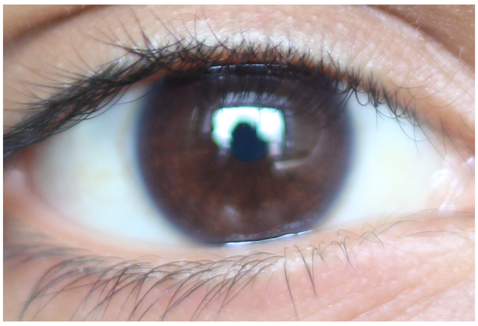

Fig 10. Healthy Eye Image from dataset

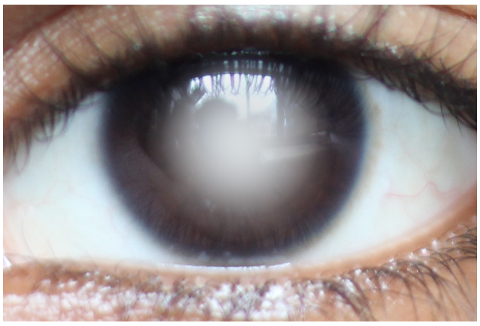

Fig 11. Mild Cataract Eye Image from dataset

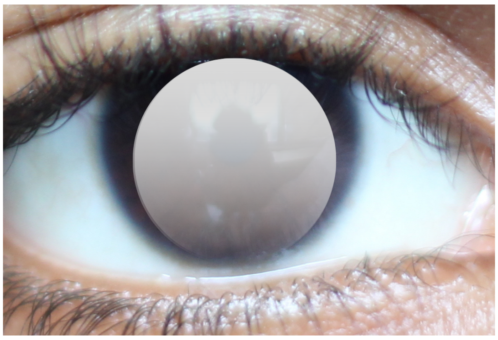

Fig 12. Severe Cataract Eye Image from dataset

The comparative study of the accuracies can be studied through the tables given below.

Table No.1 Accuracy rates of various classifiers with preprocessed images of size 224

Sr.No	Model	Validation Accuracy
1	VGG 16	96.88
2	MobileNet	90.62
3	SqueezeNet	97.66

The table shown above shows the accuracies obtained by applying various Deep Learning Models namely VGG16, MobileNet and SqueezeNet. The highest accuracy obtained is 97.66% by SqueezeNet. The MobileNet model resulted in the lowest accuracy i.e. 90.62% and VGG16 achieved accuracy of 96.88%.

SIFT + GLCM with various classifier algorithms:

The table below describes the accuracy of various classification algorithms with the use of SIFT and GLCM features. We have evaluated the metrics such as confusion matrix,accuracy, precision,recall,f1-score and support of various machine learning models such as SVM-linear, XGBoost, Random Forest and Adaboost Classifier. The results are shown below :

Random Forest :

Confusion Matrix :

```
[[49  3  0]
 [ 5 26  2]
 [ 1  3 21]]
```

	precision	recall	f1-score	support
mild	0.89	0.94	0.92	52
normal	0.81	0.79	0.80	33
severe	0.91	0.84	0.87	25
accuracy			0.87	110
macro avg	0.87	0.86	0.86	110
weighted avg	0.87	0.87	0.87	110

AdaBoost Classifier :

Confusion Matrix:

```
[[49  2  1]
 [ 4 27  2]
 [ 2  1 22]]
```

	precision	recall	f1-score	support
mild	0.89	0.94	0.92	52
normal	0.90	0.82	0.86	33
severe	0.88	0.88	0.88	25
accuracy			0.89	110
macro avg	0.89	0.88	0.88	110
weighted avg	0.89	0.89	0.89	110

XGBoost Classifier:

Confusion Matrix:

```
[[51  1  0]
 [ 0 32  1]
 [ 1  1 23]]
```

	precision	recall	f1-score	support
mild	0.98	0.98	0.98	52
normal	0.94	0.97	0.96	33
severe	0.96	0.92	0.94	25
accuracy			0.96	110
macro avg	0.96	0.96	0.96	110
weighted avg	0.96	0.96	0.96	110

SVM-Linear:

Confusion Matrix:

```
[[43  5  4]
 [ 5 21  7]
 [ 2  0 23]]
```

	precision	recall	f1-score	support
mild	0.86	0.83	0.84	52
normal	0.81	0.64	0.71	33
severe	0.68	0.92	0.78	25
accuracy			0.79	110
macro avg	0.78	0.79	0.78	110
weighted avg	0.80	0.79	0.79	110

Table No.2 Accuracy rates of various classifiers with SIFT+ GLCM features

Classifier	Accuracy
1. Random Forest	87%
2. AdaBoost Classifier	89%
3. XGB Classifier	96%
4. SVM-Linear	79%

In the above table, we can see that the SIFT+GLCM Features with the Machine learning algorithms have produced a lower accuracy when compared to the Deep Learning Models.

The highest accuracy is 96% achieved by the XGBClassifier and the lowest accuracy is 79% by the SVM-Linear algorithm. The Random Forest and AdaBoost Classifier have obtained considerably good accuracies of 87% and 89% respectively.

Table No.3 Comparison of proposed system with existing system[16]

Number	Filename	Actual	Predicted	Rightly Classified
1	eye10c.jpg	healthy eyes	healthy eyes	True
2	eye12c.jpg	healthy eyes	healthy eyes	True
3	eye13c.jpg	healthy eyes	healthy eyes	True
4	eye1c.jpg	healthy eyes	healthy eyes	True
5	eye9c.jpg	healthy eyes	healthy eyes	True
6	eye16c.jpg	mild cataract	mild cataract	True
7	eye17c.jpg	mild cataract	healthy eyes	False
8	eye20c.jpg	mild cataract	healthy eyes	False
9	eye21c.png	mild cataract	healthy eyes	False
10	eye3c.png	mild cataract	healthy eyes	False
11	eye22c.jpg	severe cataract	severe cataract	True
12	eye2c.jpg	severe cataract	mild cataract	False
13	eye4c.png	severe cataract	mild cataract	False
14	eye5c.png	severe cataract	mild cataract	False
15	eye7c.jpg	severe cataract	healthy eyes	False

.

The above table shows the output generated by the SqueezeNet model for 15 testing images from the dataset used in [16]. The model has been able to classify the healthy eyes accurately. Overall the model has been able to classify a fair amount of images in the testing data accurately and the accuracy for these 15 images is 55%.

Sample Images from the dataset

Fig 13. Healthy Eye Image from comparison dataset[16].

Fig 14. Mild Cataract Eye Image from comparison dataset[16].

Fig 15. Severe Cataract Eye Image from comparison dataset[16].

Chapter 7

Conclusion and Future scope

a. Conclusion

In this project, various machine learning and deep learning algorithms have been proposed for the Cataract detection and Classification.

For Cataract Detection , we have used texture features. We have used a new set of features by concatenating two sets of features: SIFT (Scale Invariant Feature Transform) and GLCM (Gray Level Cooccurrence Matrix). Thus, the new set of features have been obtained and used for Cataract prediction. The various machine learning algorithms proposed in our project are SVM(Linear), SVM(RBF), KNN, Logistic Regression, Random Forest. Out of which the highest accuracy achieved is 96%. Therefore, the combined set of features have obtained better results than the individual features.

For Cataract Classification, we have extracted the region of interest i.e. pupil and trained our Deep Learning models for classifying the eye image as mild cataract, severe cataract or normal eye image. The various Deep Learning models used are VGG 16, MobileNet and SqueezeNet. Out of these SqueezeNet has been able to achieve the highest accuracy of 97.66%. We have also evaluated the accuracies for various Machine learning Algorithms such as SVM-linear, XGBoost, Random Forest and Adaboost Classifier on the texture features obtained from the SIFT and GLCM algorithms. However the accuracies obtained are less when compared to the Deep Learning Models. In conclusion, Deep Learning models have achieved better accuracies when compared to the machine learning models.

b. Future Scope

The accuracy of the system can be increased by working on a large dataset with a different variety of pupil color space. Developing mobile applications along with existing websites will help the patients enabling easy access . A communication channel can be established between patients and ophthalmology clinics. Live video conference between patient and doctor to save time.

Literature Cited

[1] "Blindness and vision impairment" 12 October 2017: World Sight Day https://www.who.int/blindness/world_sight_day/2017/en/

[2] M. R. Supriyanti, M. H. Habe, and M. M. Kidode, Normal Eye vs Cataract Eye. 2012 [Online]. Available:https://www.intechopen.com/books/oculardiseases/utilization-of-portable-digital-camera-fordetecting-cataract

[3] "Cataracts," Mayo Clinic, 23-Jun-2018. [Online]. Available: https://www.mayoclinic.org/diseasesconditions/cataracts/symptoms-causes/syc20353790.

[4] Chart used for acuity test[Online] Available: https://www.zazzle.com/health+mousepads?rf=238177452029091674&tc=2280303

[5] Slit-lamp examination[Online] Available: http://www.webdicine.com/drooping-eyelid-part-2.html

[6] Fundus image obtained after retinal exam[Online] Available: https://www.reviewofophthalmology.com/article/cataract-complications-the-retinal-perspective

[7] "Recent Approaches for Automatic Cataract Detection Analysis Using Image Processing" Journal of Network Communications and Emerging Technologies (JNCET), October (2017)

[8] "Remote Automated Cataract Detection System Based on Fundus Images" International Journal of Innovative Research in Science, Engineering, and Technology (June 2016)

[9]" Automatic Retinal Disease Classification Using Machine Learning and AI"

[10] " Cataract Detection using Smartphone" Journal of Network Communications and Emerging Technologies (JNCET), December (2017)

[11] Jagadale, A., Sonavane, S., & Jadav, D.V. (2019). Computer-Aided System For Early Detection Of Nuclear Cataract Using Circle Hough Transform. 2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI), 1009-1012.

[12] Agarwal, V., Gupta, V., Vashisht, V.M., Sharma, K., Sharma, N. (2019). Mobile Application Based Cataract Detection System. 2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI), 780-787.

[13] Tawfik, H.R., Birry, R.A., & Saad, A.A. (2018). Early Recognition and Grading of Cataract Using a Combined Log Gabor/Discrete Wavelet Transform with ANN and SVM.

[14] Patwari, Professor & Arif, Muammer & Chowdhury, Md Nurul & Arefin, A. & Imam, Md. Ikhwanul. (2011). Detection, Categorization, and Assessment of Eye Cataracts Using Digital Image Processing.

[15] Pathak, S., & Kumar, B. (2016). A Robust Automated Cataract Detection Algorithm Using Diagnostic Opinion Based Parameter Thresholding for Telemedicine Application. Electronics, 5, 57.

[16] Jindal, I., Gupta, P., & Goyal, A. (2019). Cataract Detection using Digital Image Processing. 2019 Global Conference for Advancement in Technology (GCAT), 1-4.

[17] "Texture Analysis Using the Gray-Level Co-Occurrence Matrix (GLCM) - MATLAB & Simulink.MathWorksIndia.[Online].Available:https://in.mathworks.com/help/images/textureanalysis-using-the-gray-level-co-occurrence-matrixglcm.html.

[18] "SIFT Image Features" [Online].
Available:http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/A
V0405/MURRAY/SIFT.html

[19] "Texture Analysis Using the Gray-Level Co-Occurrence Matrix (GLCM) - MATLAB & Simulink - MathWorks India. [Online].
Available:https://in.mathworks.com/help/images/textureanalysis-using-the-gray-level-co-occurrence-matrixglcm.html.

[20] "SIFT Image Features" [Online]. Available:
http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIE S/A V0405/MURRAY/SIFT.html

[21] "ML - Support Vector Machine(SVM)" [Online] Available:
https://www.tutorialspoint.com/machine_learning_with_pytho n/
machine_learning_with_python_classification_algorithms_sup p
ort_vector_machine.htm

[22] "Machine Learning – Logistic Regression"[Online]
Available:https://www.tutorialspoint.com/machine_learning_w
ith_python/machine_learning_with_python_classification_algo rithms_logist
ic_regression.htm

[23] " Classification Algorithms – Random Forest"[Online]
Available:https://www.tutorialspoint.com/machine_learning_w
ith_python/machine_learning_with_python_classification_algo rithms_rando m_forest.htm

[24] "KNN Algorithm - Finding Nearest Neighbors"[Online]
Available:https://www.tutorialspoint.com/machine_learning_w
ith_python/machine_learning_with_python_knn_algorithm_fin
ding_nearest_neighbors.htm

[25] "Boosting in Machine Learning | Boosting and AdaBoost" [Online] Available:
https://www.geeksforgeeks.org/boosting-in-machine-learning-boosting-and-adaboost/

[26] "A Gentle Introduction to XGBoost for Applied Machine Learning" [Online]
Available: A Gentle Introduction to XGBoost for Applied Machine Learning

[27] "MobileNetV1 — Depthwise Separable Convolution (Light Weight Model)"[Online] Available:
https://towardsdatascience.com/review-mobilenetv1-depthwise-separable-convolutio
n-light-weight-model-a382df364b69

[28] “VGG16 – Convolutional Network for Classification and Detection ”[Online] Available: https://neurohive.io/en/popular-networks/vgg16/

[29] “Computer Vision and Pattern Recognition”[Online] Available:https://arxiv.org/abs/1602.07360

Publications

The phase 1 implementation of the project which works on binary classification of cataract has been compiled into a conference paper and accepted in the " International Conference on Artificial Intelligence: Advances and Applications (ICAIAA 2021)."

Acknowledgement

This acknowledgment is a token of gratitude, I feel towards the people who have helped me to make this report a rich experience. I am delighted to offer our sincere thanks to my Institute and my respected Principal Dr. Mukesh D. Patil for enabling me to add a formal project. Report on my BE project work, which has made me acquire tremendous knowledge. I would like to express profound gratitude to my project guide Mr. Swapnil Shinde, and project coordinator Mrs.Reshma Gulwani of B.E. Program for their invaluable support, encouragement, supervision and useful suggestions throughout this project work. Their moral support and continuous guidance enabled us to complete my work successfully. I am very grateful for the valuable cooperation and constant en- couragement from Mr. Swapnil Shinde and Head of Department Dr. Ashish Jadhav.Their regular suggestions made my work easy and proficient. Last but not the least, I am thankful and indebted all those who helped me directly or indirectly in completion of this project report.