2021 2nd Global Conference for Advancement in Technology (GCAT)
Bangalore, India. Oct 1-3, 2021

Eye Disease Detection Using Machine Learning

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2021 2nd Global Conference for Advancement in Technology (GCAT) | 978-1-6654-1836-2/21/$31.00 ©2021 IEEE | DOI: 10.1109/GCAT52182.2021.9587740

Abstract*-The dominant causes of visual impairment worldwide are Cataract, Glaucoma, and retinal diseases among patients. The alarming cases of these diseases call for an urgent intervention by early diagnosis. The proposed system is designed and developed to easily facilitate the detection of cataract, glaucoma and retinal diseases among patients. The Logistic Regression, Random Forest, Gradient Boosting and Support Vector Machine algorithms are used for detection. The proposed system will help people to get the proper treatment of the aforementioned diseases at an early stage thus reducing the percentage of blindness being caused. The proposed system evaluates the effectiveness and safety of cataract surgery in eyes with age-related degeneration along with glaucoma and retinal diseases detection. This paper shows the accuracy of algorithms and SVM classifiers based upon the glaucoma, retina, cataract and normal eye's fundus images. The idea of classifying the images based on its fundus and extracting features is widely known now-a-days and also it plays a vital role in the final outcome. This paper talks about the multiclass built models of these classifiers and on the basis of the ROC curves plotted it predicts the output of the images. As far as the algorithms are concerned, the efficiency of algorithms helps it stand best out of many and in our case Gradient boosting proves to give best results for the eye with cataract with 90% accuracy. Then the supervised algorithms logistic regression and random forest gives the accuracy of 89% and 86% respectively.

Keywords: ***Cataract, Glaucoma, retinal disease, machine learning, models***

I. INTRODUCTION

Cataracts are most commonly caused due to aging but may also occur due to trauma or radiation exposure, may be present from birth, or may occur following eye surgery performed due to other problems.Additionally, they are more common in women. To solve all these problems the cataract detection model was originated, which can detect the cataract at an early stage and people can start with the treatment at an early stage thus reducing the percentage of blindness due to cataract. The existing system uses Deep Convolutional Neural Network (DCNN) algorithm for cataract detection. The proposed system is designed and developed to easily facilitate the detection of cataract, glaucoma and retinal diseases among patients. It will help people to get the proper treatment of these diseases at an early stage thus reducing the percentage of blindness being caused. Detection of these diseases at an early stage not only helps the patients to get rid of it, but at the same time it also helps the doctors to cure the diseases easily as the more severe the disease is, the harder it is to cure.

II. LITERATURE SURVEY

Principal Component Analysis Based Cataract Grading and Classification of Random forests proposed by Weiming Fan et. al [1] ensembles the method of regression and boosting. There is slight decrease in the classification accuracy ratio because of new feature set. [1]. Automatic Feature Learning to Grade Nuclear-Cataracts Based on Deep Learning proposed by Xinting Gao et. al. [2] applies method for nuclear cataract. According to this research, cataract grading is more efficient as the process of feature extraction and classification are combined together. The system achieves a 70.7% accuracy which represents significant improvements [2]. Automatic Cataract detection proposed by Niya et. al [3] helps to identify whether cataract disease is present in an optical eye image or not. The efficiency of an automatic Cataract detection and classification system depends on each and every stage like pre-processing, feature extraction and selection of classifier. Most of the existing systems uses slit lamp images for Cataract detection which is expensive and less accurate [3]. Automatic Cataract Detection and Grading Using D-CNN proposed by Linglin Zhanga et. al. [4] also ensures that the cataract grading is more efficient, as the process of feature extraction and classification are combined to one step.[4] Classification of Cataract Fundus Image Based on Deep Learning network proposed by Yanyan Dong et. al. [5] separates the characteristics of the various nonlinear combinations in the fundus image by a multi-layer nonlinear mapping. [5]. Ran et. al [6] proposed the deep convolutional neural network for detection and classification of the type of cataract eye and normal eye. There are 3 steps being used in this model: 1) Pre-processing: In order to prevent uneven illumination, the original fundus image is converted from RGB colour space to green channel which can hold most effective features of original colour image. 2) Architecture: A residual learning framework can ease the training of networks which can be done in a way that the input of the bottom layer is not only output to the middle layer but is also added into the upper layer with the result of the middle layer 3) Training: A total of 8030 retinal fundus images are collected as the database where people with no cataract are 4761, mild cataract-2283, moderate-675 and severe is 401 by professional graders and are used to train the model. [6]. In [7] the framework starts with dividing the applied images into training and testing dataset after which pre-processing is done to reduce the interference of different illumination for further steps. Next, DCNN feature extractor adopts the method of shallow module, residual mode and pooling module. Where, shallow and residual module extract the features with their algorithm and methods. And pooling module transfers such final feature vectors for RF grader. RF is used to reduce the DCNN fluctuations on dataset. As, RF is a combination of tree predictor, RF achieves better and detailed six-level cataract grading other than the four-level grading. Comparatively to M-SVM and DCNN, DCNN-RF has gained higher accuracy, sensitivity, specificity respectively [7]. Jindal et. al. [8] proposed Cataract Detection using Digital Image Processing which classifies different types of cataract as Radiation Cataract, Secondary Cataract, Conginetal Cataract and Traumatic Cataract. The effectiveness of any of these cataract types can be used to classify whether the particular person is suffering from mild, moderate or severe cataract. The cataract detection using image processing provides a very cost effective and efficient way to detect it. Image processing is process that uses algorithms to manipulate and analyse images and obtain relevant information. The main image processing techniques are; Image pre-processing, Image Enhancement, Image Segmentation, Feature Extraction and Image Classification. In the proposed work [8], two approaches are used for cataract detection. In the first approach the above-mentioned image processing techniques are used to detect the eye of a person and to decide whether the person is suffering from the cataract or not. And in the second approach, the same technique of image processing is used that determines the degree of cataract on the human eye. Both the algorithms are implemented by the Python programming [8]. Musa Yusuf et. al [9] presents a web-based Computer Aided Diagnostic for cataract detection system using Convolutional Neural Network that can be implemented even by any layman person outside the clinic environment.[9]. Yue Zhou et. al. [10] proposed cataract classification methods using discrete deep neural network and compared among different cataract detection and grading methods. [10].

This paper develops a definition of novelty relative to a prior model which used D-CNN classifiers for categorizing the cataracts based on its presence or absence. This paper focuses on the four different algorithms that work on the set of data and classifies it over various algorithms and models to get the accuracy of the prediction. As discussed above the classifiers implemented showcase the prediction of the data based on its various image parameters and processing method. The previous discoveries mostly focused on classifying the cataracts based on where and how they develop in your eye. Also, the classification of cataract and its early detection was very crucial task which has been overcome by implementation of the various models that predict and helps the early detection of cataract.

III. METHODOLOGY

The standard flow of the proposed model is described in Fig 1. Each step is necessary for the flow of the system. It involves loading an image, image processing, creation of model, applying PCA (principal component analysis) on features, ROC (receiver operating curves) for models, training and testing of dataset and finally accuracy of each model.

Read the data files: First, the required libraries are imported and then the dataset is loaded by proving the path. The libraries used are NumPy for linear algebra operations and pandas for importing the data and processing. Sklearn is used to ensemble the models as well as for selection of model and for importing various classifiers. The data is loaded and then shuffled to perform further operations.

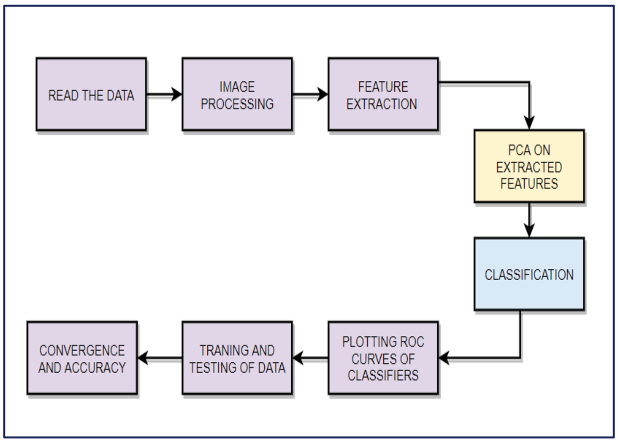

Fig. 1. Block Diagram of cataract detection process

Image processing**:** It is performed on the images which are imported to extract various features from images. The histogram of images is plotted to extract features like mean, energy standard deviations, entropy, log-kurtosis. Thresholding feature is created to get the idea of adaptive thresholding, where the adaptive thresholding leaves some artefacts from where we can extract several features. Then the dataset is divided into training and testing sets.

Built multiclass classification model: Here, our model is trained on 4 different types of classifiers namely logistic regression, random forest, gradient boosting, SVM (support vector machine).

Logistic regression: It is a supervised Machine learning algorithm used as the Classifier. Logistic regression analysis is used to examine the association of independent variable with one dependent variable. The type of logistic regression used is multinomial.

Fig. 2. Shows the flow chart of the proposed system. Random Forest: It is a classification algorithm consisting of many decisions' trees. It uses bagging and feature randomness when building each individual tree to try to create an uncorrelated forest of trees whose prediction by committee is more accurate than that of any individual tree.

Gradient Boosting: It is a type of machine learning boosting. It relies on the intuition that the best possible next model, when combined with previous models, minimizes the overall prediction error.

Support vector machine (SVM): It is a supervised machine learning algorithm, which can used for both regression and classification. Here, we are specifically using it to classify the data. SVM divides the input data into sets, depending on the number of categories provided.

Plot ROC curves: ROC is a useful tool for predicting the probability of a binary outcome.

Training of binary classifiers: Finally, accuracy of the classifiers is calculated for glaucoma, retina disease, cataract and normal eye and depending upon this we conclude the best classifying algorithm and its accuracy.

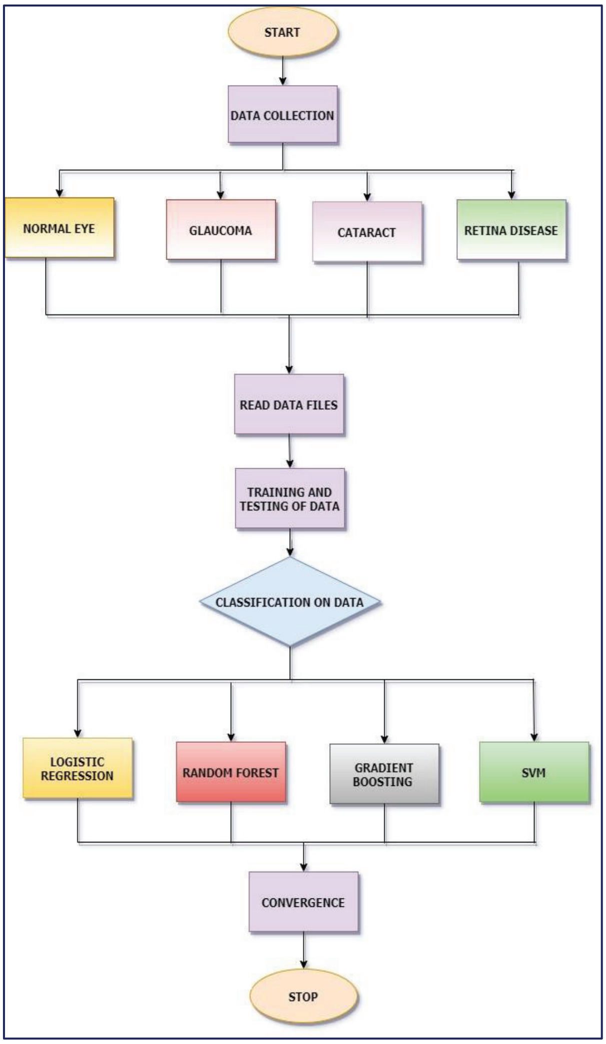

Fig. 2. Flow Chart of eye disease detection

IV. OBSERVATIONS IN PROPOSED WORK

In order to implement the proposed work and to achieve high performance efficiency, we observed and analysed the various existing work and studied them thoroughly. We also studied the language python3 that helped us in building our Algorithm. We also varied the number of images in dataset, in order to train our model very effectively. Also observed the output with the shuffling of images in dataset. We also noticed one thing that the images which we provided can't be directly applied to train the model. We must crop it further or must adapt its important information to train our model, so with the help of many papers and Algorithm we got to know that Histogram Equalization that helped us more in our work. As we wanted to train our model very effectively and smoothly with all the four types of Eye diseases and expected that our model must give us the accuracy of different eye diseases for different machine learning algorithms. Hence, implementing linear regression, gradient boosting, random forest and SVM we got to know range of accuracies for different eye diseases with respect to following methods. In short, the observations we made can be explained as we train our model using supervised and unsupervised methods for detecting the four different eye disease and predict them correctly, and may give us the accuracy of its prediction. Hence, by making use of these techniques we have come up with the better accuracy, specificity in the predicted output.

V. RESULT ANALYSIS

The imported fundus dataset images were not directly used in the proposed work. Rather, further following operations Viz; Normalize histogram, histogram statistics and adaptive thresholding were performed on images in order to extract the features like its mean, entropy, Auto cropping the image, etc. PCA was then applied on these extracted images. Then some of the multiclass classification models are build.

Lr = LogisticRegression (multi_class = 'multinomial', solver = 'lbfgs', C=1, penalty='l2', fit_intercept = True, max_iter = 5000, random_state=42)

lr.fit (X_train, Y_train1)

Forest = RFC (n_estimatorsxy = 100, max_depth1 = 3, random_state1 = 42)

forest.fit (X_train, Y_train1)

gb = GBC (learning_rate = 0.01, n_estimators = 100, subsample = 1, max_depth =2, random_state=42)

gb.fit (X_train, Y_train1)

svm1 = svm.SVC (gamma='scale', probability = True)

svm1.fit (X_train, Y_train1)

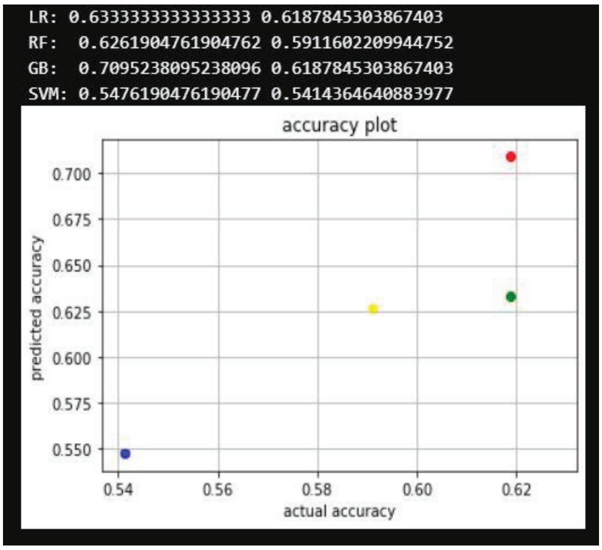

Fig. 3. Accuracy plot of 4 multiclass classifiers

VI. PLOT ROC CURVES FOR THE RESPECTIVE METHODS

ROC is a probability curve and AUC represent the degree or measure of separability. The ROC curve is plotted with true positive rate (TPR) (x-axis) against false positive rate (FPR) (y-axis).

The terms we used in AUC and ROC is Recall, Specificity, FPR, TPR, Precision -

```
True Positive Rate = TP / (TP + FN)
Specificity = TN / (TN + FP)
False Positive Rate = FP / (FP + TN)
Precision = TP / (TP + FP)
Recall == Sensitivity == True Positive Rate
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making use of these parameters, ROC-AUC curves of four different classifiers are plotted with respect to four different types of diseases, including micro and macro average curves in it.

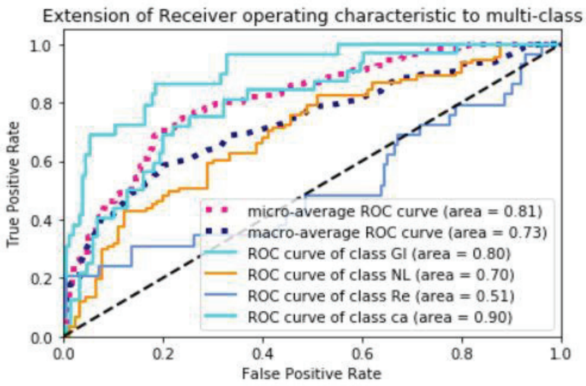

Fig. 3.a Test accuracy of logistic regression

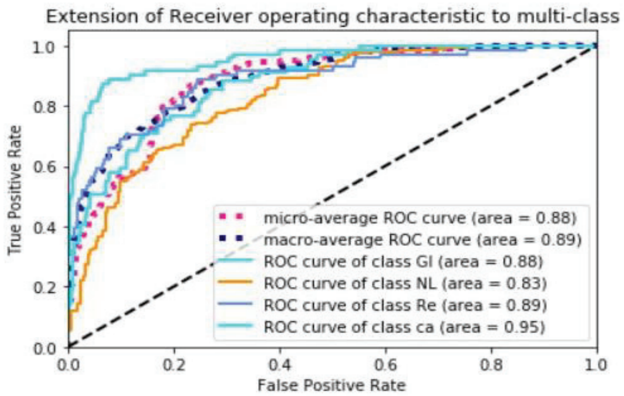

Fig.3.b Train accuracy of logistic regression

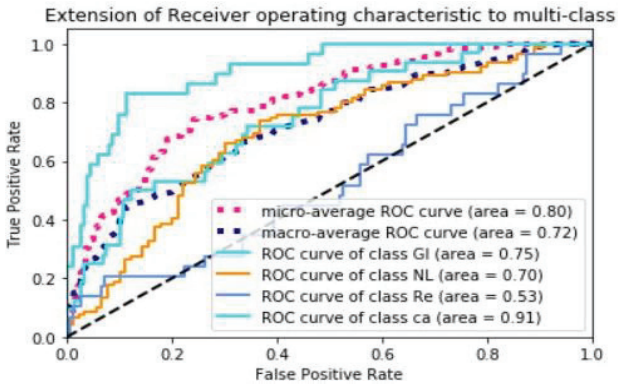

Fig.3.c Test accuracy of Random forest

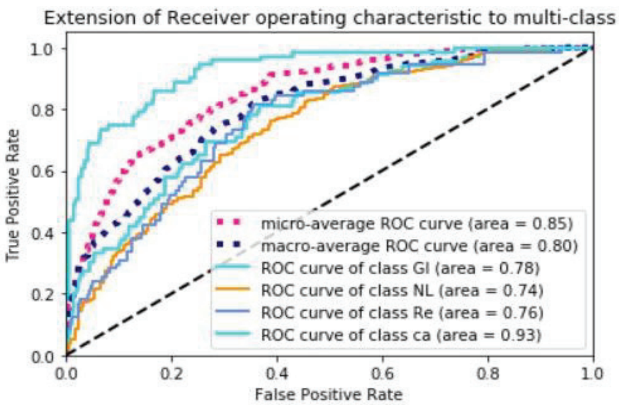

Fig.3.d Train accuracy of Random forest

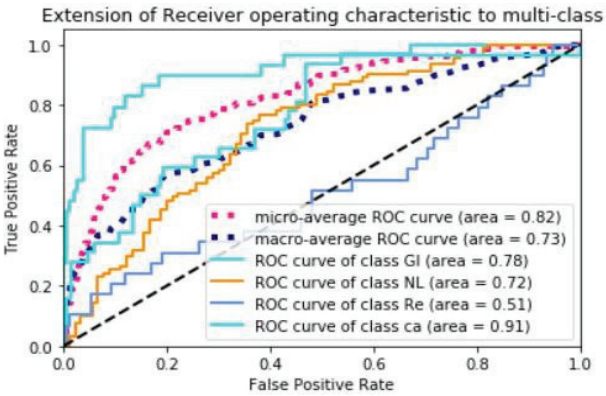

Fig.3.e Test accuracy of Gradient Boosting

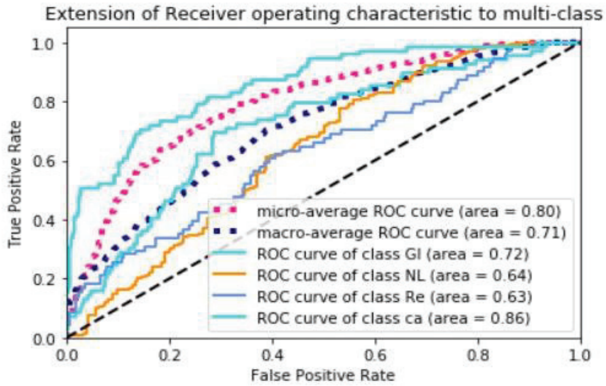

Fig.3.f Train accuracy of Gradient Boosting

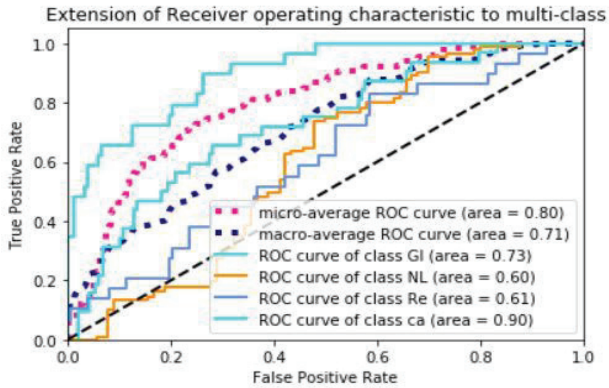

Fig.3.g Test accuracy of SVM

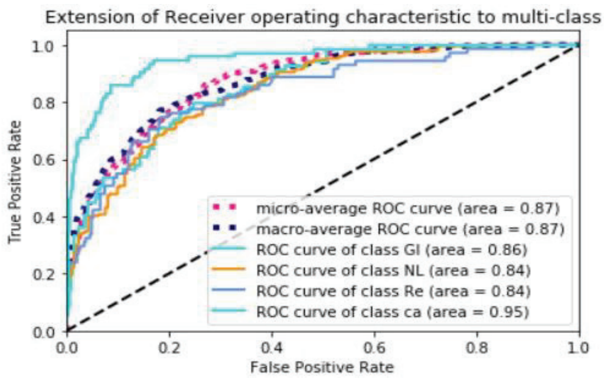

Fig.3.h Train accuracy of SVM

The curves in Fig. 3 explains that as FPR is increased TPR increases. The height of the respective plotted curves claims that which classifiers proves to be good method for appropriate disease. Further, these classifiers are performed on actual dataset. Using supervised algorithm, we came up with the accuracy up to 85%, after using unsupervised algorithm (PCA) on respective images we end up with achieving accuracy upto 90% for some of the diseases, as shown in Fig. 4.

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LR Gl :  0.861878453038674
RF Gl :  0.861878453038674
GB Gl :  0.856353591160221
SVM Gl :  0.861878453038674
.................
LR Re :  0.8232044198895028
RF Re :  0.8287292817679558
GB Re :  0.8176795580110497
SVM Re :  0.8176795580110497
.................
LR ca :  0.8950276243093923
RF ca :  0.8839779005524862
GB ca :  0.9060773480662984
SVM ca :  0.8176795580110497
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Fig. 4. Final output (Accuracy)

VII. CONCLUSION

In narrow and well-defined areas, ML has shown better methods and results in expanding health systems, capacity of eye screening in multiple clinical applications. We have come across many of the challenges that affects the treatment of various disease including cataract, so the technique we have proposed proves to be better in those situations. It is totally software based which reduces the cost. May be in future work it may include the way of creating the mobile application kind of sources. Which is a real time operation application i.e., we can capture the images, at the same time and instant we may detect the cataract. Adding to this we introduced new technique of machine learning i.e., ROC (Receiver operating curve) which gives us the idea prior applying our model and algorithms to original data. Finally, we would conclude that in spite of single classifier, each type of classifier proves to predict better accuracy for all categories of dataset.

ACKNOWLEDGEMENT

We thank Dr. Shubhangi Kharche, Associate Professor, Electronics & Telecommunication Engineering, SIES Graduate School of Technology for valuable suggestions and Guidance throughout the course of the research.

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