AUTOMATION OF FUNDUS IMAGE ANALYSIS FOR GLAUCOMA DETECTION

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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DHAKA, BANGLADESH

JANUARY 2022

APPROVAL

This Project/internship titled "Automation of Fundus Image Analysis for Glaucoma Detection", submitted by Umme Rukaya Suny and Farjana Akter to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation held on January 3, 2022.

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DECLARATION

We hereby declare that this project has been done by us under the supervision of **Mr. Saiful Islam, Senior Lecturer, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ACKNOWLEDGEMENT

First, we express our heartiest thanks and gratefulness to almighty God for His divine blessing makes it possible to complete the final year project/internship successfully.

We are really grateful and wish our profound indebtedness to **Mr. Saiful Islam**, **Senior Lecturer**, Department of CSE Daffodil International University, Dhaka. Deep Knowledge & keen interest of our supervisor in the field of “Image Processing” to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior drafts and correcting them at all stages have made it possible to complete this project.

We would also like to express our heartiest gratitude to Prof. Dr. Touhid Bhuiyan, Head, Dept. of Computer Science & Engineering and other faculty members and the staffs of CSE department of Daffodil International University.

We would like to thank our entire course mate in Daffodil International University, who took part in this discussion while completing the course work.

Finally, we must acknowledge with due respect the constant support and patience of our parents.

ABSTRACT

To visualize the beauty of creation one needs perfect vision. The world is full of color and to enjoy this the Creator has provided us with two beautiful body organs. These organs are the most sensitive and precious body parts of a human being. In modern age, due to the regular different kinds of environmental pollution such as dust, radioactive rays etc. a human daily faces a lot of difficulties to maintain his or her precious vision. In Bangladesh, most people are unaware of eye related problems thus they are unable to detect eye related diseases in their initial state. When these diseases reach a critical state people start looking for proper treatments. But these treatments are very expensive and time consuming and often doctors are unable to heal them properly due to the late detection of the diseases. Out of these eye diseases one is highly hazardous as it attacks our brain fluid directly. With the help of machine learning and image processing this highly hazardous disease can be detected at its early stages. And early detection can help to minimize the effect on the human eye.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

We use our vision to see and feel the world around us since life would be so miserable without it. The most important part of our body is also one of the most delicate, and it must be treated with care to avoid any disorders or irregularities. The regular functioning of the brain requires healthy vision. The brain is the most essential organ in our bodies because it permits us to live complicated lives. Because the optic nerve connects the eye to the brain, a healthy dependency is important.

However, there are a variety of circumstances and disorders that can wreak havoc on our vision and cause us to lose it. Eye difficulties can also be caused by disorders affecting other organs. Any visual impairment can make us reliant on others. People of all ages, from children to the elderly, are susceptible to eye ailments or problems. A vision impairment is caused by an eye disease, which is defined as a condition or abnormal function of the eye. Unfortunately, at least Near or far vision impairment affects 2.2 billion individuals globally.

Vision impairment may have been avoided or cured in at least 1 billion of these cases, or nearly half of them. Those with moderate to severe distance vision loss due to Uncorrected refractive error (88.4 million), Diabetic retinopathy (3.9 million), Glaucoma (7.7 million), Corneal opacities (4.2 million), Cataract (94 million) and Trachoma (2 million), as well as individuals who suffer from uncorrected presbyopia (nearsightedness) (826 million)[1]. Among these issues, the American Academy of Ophthalmology predicts that twelve million people will be diagnosed with glaucoma in 2020, bringing the overall number of cases to 76 million.

Glaucoma is an age-related illness in which high intraocular pressure damages the visual nerve irreversibly, often resulting in blindness. As a result, glaucoma research and education are more critical than ever.

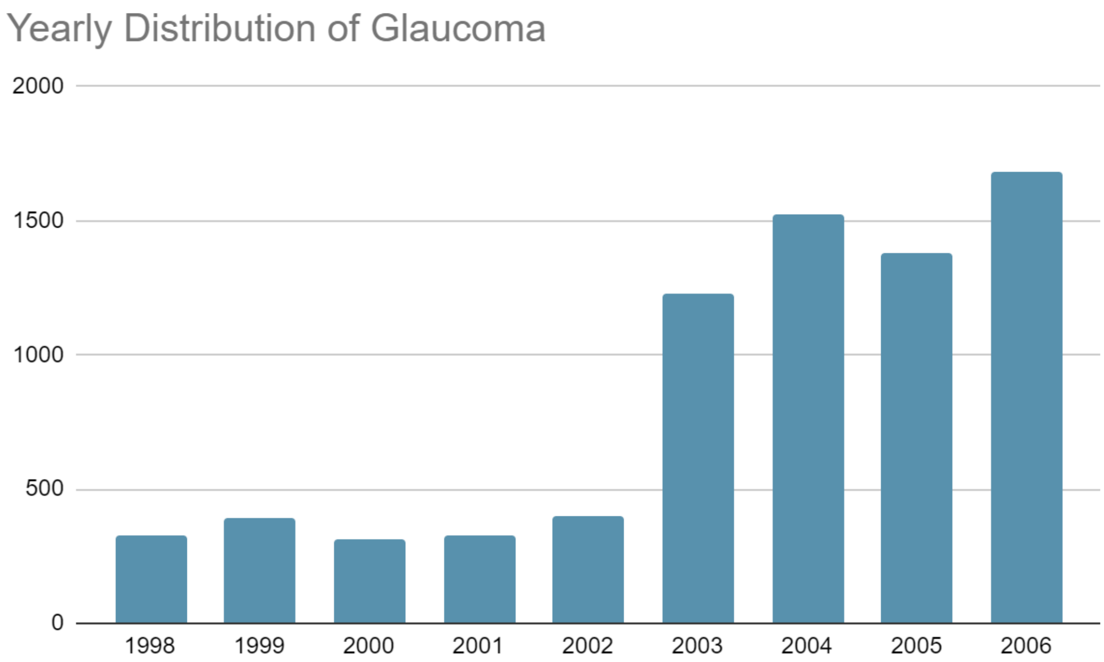

Fig 1.1.1: Yearly Distribution of Glaucoma from year 1998 – 2006 [2]

1.2 Motivation

In our country more and more people are having trouble with eye infections and diseases. As the number of patients is increasing rapidly the doctors are having trouble keeping up with the pace. Human eye is one of the most sensitive body organs. Hence most of the time doctors analyze the fundus images in the laboratory. This process is very lengthy and human dependent. So if we succeeded in doing the research properly, then -

For glaucoma as we are working on it, doctors may have to test several parts of the eyes, so this analysis process will be helpful to reduce the time of fundus images analysis which is used to detect glaucoma, thus detecting glaucoma can be faster than before. Patients' time will be saved as well, and they will not have to wait as long for any test results.

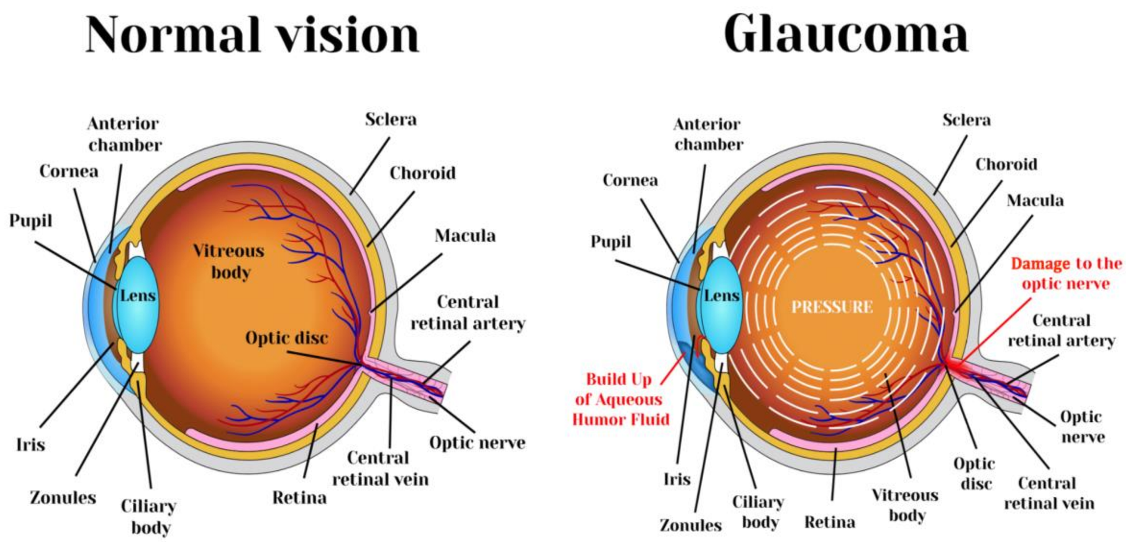

Fig 1.2.1: Normal vs Glaucoma vision

1.3 Rationale of the study

There are many works on ocular diseases prediction using fundus images. However, There are a lot of classification techniques but for this disease dataset is rare. Right now, we can see that there's been a lot of research on this glaucoma disease yet every one of those are not that unmistakable from one another while we are utilizing Convolutional Neural Network technique to discover the best accuracy result we can achieve which we will use for further application in future.

1.4 Research Question

- Can we collect authentic data from any hospital?
- Can we pre-process data and find the high accuracy?
- Can our dataset give us better accuracy than other related works?

1.5 Expected Output

Automation process by machine has always been effective and less time consuming than when the work is done by any human being. So we are hopeful that this research about the corneal nerve image analysis process will be helpful for both doctors and patients. And also this work may help to reduce the gap between medicine and computing fields. So our target is to resolve the lagging of less research on fundus image processing and being successful in this work.

Our applied algorithm will find the best feature which is responsible for Glaucoma and can be used on new data to predict this. The project's goal is to see how precise estimations react to our dataset.

1.6 Report Layout

Chapter 1: Gives a brief Introduction related to eye, Glaucoma, fundus image, important features, name of applied algorithm, objectives of the research. Also covered are our thesis motivation, the study's rationale, the research question, and the expected outcome.

Chapter 2: Gives a short introduction related to our paper, a brief description about previous study related to our work, a research summary, scope of the problems and challenges that we had to overcome.

Chapter 3: Gives a short introduction, Research Subject and Instrumentation, data collection procedure and implementation requirement. Also, a brief description about data collection, pre-processing, merging and cleaning data and finally feature selection.

Chapter 4: Gives a short introduction on model training, a brief experimental result on eleven machine learning models, descriptive analysis and summary of the results.

Chapter 5: Discusses summary of study, conclusion, recommendation and future work.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction:

We’ll talk about parallel types of works that are related to our work, a research synopsis, and the obstacles we confront in our research in our background study chapter. In the literature review part, we will look at more research papers and their methodologies, works, and correctness. We shall discuss the overall summary of research of our linked works in the research summary section. We will explore the obstacles we confront in doing this task at the end of this chapter, as well as how we might increase the accuracy of our model.

2.2 Related Works:

There are many researchers from all around the world working on Ocular parts’ Image Analysis. For detecting Adenoviral conjunctivitis Melih Gunay, İrem Kucukoglu et al. used corneal nerve images. They got accuracy 93% for GrabCut method and 96% for RGB thresholding and Vascularization [3]. For detecting Glaucoma Jagadish Nayak & Rajendra Acharya et al. used fundus images. They used DIP technique, Feature extractions and so on algorithms. They got an accuracy 100% and 80% on sensitivity and specificity respectively [4]. For detecting Keratoconus Alexandru Lavric,Valentin Popa et al. used CSVM, FGSVM algorithms and they got accuracy of 94% on Cubic Support Vector machine algorithm [5]. For detecting corneal epithelial cell damage Gemma Julio, Ma Dolores Merindano et al. used Binarization(Thresholding) and Particle analysis algorithms and they got an accuracy of 89.09% on SCM [6]. Linglin Zhanga, Jianqiang Lia et al. worked on Cataract and found accuracy 93.52% on Deep Convolutional Neural Network algorithm. Chalinee Burana-Anusorn, Waree Kongprawechnon et al. used Optic disc segmentation, Edge detection approach, Optic cup segmentation algorithms and got accuracy of 89% [7]. For detecting Dry eye Osama M.A. Ibrahim, Murat Dogru et al. used Corneal nerve images and used Optical Coherence tomography algorithms from which they got accuracy of 67% and 81% on sensitivity and specificity respectively [8]. For detecting Corneal Subbasal Nerve Plexus Cirous Dehghani, Nicola Pritchard et al. used CCMetrics, NeuronJ, ACCMetrics algorithms. Adnan Khan, Naveed Akhtar et al used CCMetrics, kolmogorov–smirnov test, ANOVA, nonparametric Kruskal–Wallis test, Pearson correlation algorithms for researching Corneal Nerve damage [9]. Zohreh Hosseinaee, Bingyao Tan et al. worked with Bayesian speckle reduction technique, anisotropic diffusion filtering algorithms for Corneal nerve analysis [10]. For detecting Dry eye Giuseppe Giannaccare, Marco Pellegrini et al. worked with ACCMetrics, Mann-Whitney U test, Heidelberg Retina

Tomograph algorithms and they got an accuracy of 97.4% and 90% of sensitivity and specificity respectively [11]. Bryan M. Williams, Davide Borroni worked with convolutional neural network, Heidelberg Retina Tomograph for detecting diabetic neuropathy [12]. For detecting Corneal Nerve Morphology Ioannis N. Petropoulos, Tauseef Manzoor et al. used Heidelberg Retinal Tomograph III, Bland–Altman plots algorithms. For Parkinson disease Sze Hway Lim, Maryam Ferdousi et al. used MDS-UPDRS III, Hoehn and Yahr scale algorithms [13].

2.3 Research Summary:

After discussing related work, we found out that the dataset used in our research paper is from kaggle, pre-processing dataset, dealing with missing values, feature selection and model training on that dataset provide us with better accuracy.

Table 2.3.1: Research Summary

SL. No	Author(s)	Eye Disease	Algorithms	Accuracy	Published years
1.	Melih G. et al.	Adenoviral Conjunctivitis Disease	AGM, SS, FE, GLCM, RT, CM	GrabCut methods provides -- 93% RGB thresholding and Vascularization -- 96%	2015
2.	Jagadish N. et al.	Glaucoma	DIP, FE, NNC	sensitivity = 100% and specificity = 80%	2008
3.	Alexandru L. et al.	Keratoconus	FT,MT,CT,LD, QD,LR,GNB,KNB,SVM, KNN	Cubic Support Vector Machine,94%	2017
4.	Gemma J. et al.	corneal epithelial cell damage	Binarization(Thresholding) and Particle analysis	89.09%(According to Surface covered by Microprojection(SCM))	2008

5.	Linglin Z. et al.	cataract	PP, CNN, GF	93.52% in cataract detection and 86.69% in grading task	2017
6.	Chalinee B. et al.	Glaucoma	ODS,EDA, OCS,EF	89% accuracy in determined CDR result	2013
7.	Osama M.A. et al.	Dry eye	OCT, TMHA	Sensitivity 67%, Specificity 81%	2010
8.	Cirous D.et al.	Corneal Subbasal Nerve Plexus	CCM,NJ, ACCM	CNFL quantified by using: CCMetrics = 17.4 6 4.3 mm/mm^2 NeuronJ = 16.0 ACCMetrics = 16.5 p< 0.05	2014
9.	Adnan K. et al.	Corneal Nerve Damage	CCM, ANOVA, KWT,PC	(p<0.001, p<0.001, p<0.001) tolerance of impaired Glucose (p=0.004, p<0.001, P=0.002) mellitus for type 2 diabetes (p<0.001, p<0.001, p<0.001)	2017
10.	Giuseppe G. et al.	dry eye disease	ACCM,HRT	Diagnosis based on either CNFW or CNBD, 1. sensitivity = 97.4% 2. specificity = 46.7%. on both CNFW and CNBD, 1. sensitivity = 66.7% 2. specificity = 90.0%.	2019
11.	Bryan M. W. et al.	diabetic neuropathy	CNN,HRTII	specificity = 87% and sensitivity = 68%	2019

12.	Ioannis N.et al.	Corneal Nerve Morphology	HRT III,BAP	intraobserver repeatability 0.66 to 0.74 and 0.17 to 0.64, for interobserver repeatability 0.54 to 0.93 and 0.15 to 0.85	2012
13.	Alberto R. et al.	Dry Eye Metrics and Corneal Nerve Morphology	ACCM	r FS-LASIK than SMILE ($p < 0.05$) FS LASIK ($p = 0.005$ and $p = 0.001$, respectively) FS-LASIK ($p = 0.001$).	2020
14.	Sze H. et al.	Parkinson disease	MDS-UPDRSIII,HYS, PDQ.	density of Corneal nerve fibre $p = 0.001$, density of Corneal branch $p = 0.003$, density of corneal total branch $p = 0.002$	2020

2.4 Scope of the Problem

Many people in Bangladesh suffer from glaucoma and go blind as a result of not taking correct medication. Also, they are not aware of this disease at an early stage. They don't know or don't take proper prevention to deal with the disease. Most people neglect this disease because they think it's not that serious. Also, there is not much work or study related to Fundus Image Analysis that is used by any organization. Some study was made but they used the dataset which might not be a valid one. In our research we have used an authentic dataset collected from Kaggle and predicted Glaucoma with a better performance. Many applications can be built with our proposed model and dataset.

2.5 Challenges

Several challenges were overcome including collecting data from Kaggle is the tough one as there is no dataset available regarding this disease. After collecting dataset of glaucoma we merge all of them in one file. Preprocessing these images is the toughest one job. Despite these challenges it was possible to extract visual information contained in the high-risk data for patients within the study utilizing machine learning.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter we mainly discuss about our data collection, feature selection, data preprocessing, data cleaning, data resizing. The brief description has been given here. How we have collected our data, then merge it with another dataset and after this we have cleaned the dataset and performed some algorithms to find out the strongly correlated features for further processing.

3.2 Research Subject and Instrumentation

The exploration zone that is being studied and investigated for clear knowledge is what we mean by research subject. For clear organization, but also for providing accurate information on various examination borders, research subjects are responsible. Instrumentation, on the other hand, refers to the necessary equipment or devices used by analysts.

3.3 Data Collection Procedure

The most important thing in research is data because without data we can’t train and test our machine learning and deep learning model. Data is, genuinely, thought of as the focal point of the machine learning process. Furthermore, for our research, we must choose between limited options of data. Thus, It has become the most difficult assignment for us to do in our research. As there is a few research work done in fundus Image analysis so dataset is not that much available in kaggle or other dataset sites. We have collected one dataset from Kaggle about detecting glaucoma using fundus images.

3.4 Implementation Requirement

We did our most of training and testing phase on Jupyter Notebook. It is a platform whose goal is giving services for dozens of programming languages. This environment is the same as Google Colab's environment. Based on the complexity of our problem the following things are essential:

Hardware and Software Requirements

- Any Operating System
- Any Internet Browser
- CPU with a decent speed
- RAM (minimum 16 GB)
- Hard Disk (minimum 1 TB)

Development Requirements

- Stable Internet Connection
- Python Environment
- Anaconda Individual Edition
- Jupyter Notebook

3.5 Workflow

We follow few stages to do this research such as dataset collection, data cleaning, Data pre-processing, applied algorithms and build our own model. The following steps are:

- **Data Collection**: We have collected our dataset from kaggle which is the hardest task in our research. As there are few available dataset for fundus image analysis so we selected one dataset and used it for our research. In that dataset there are 1566 images of the fundus image of the eye. We divide this dataset into two parts which are train dataset and test dataset. In the train dataset we use 1306 images and for the test dataset we use 260 images.

- **Data Preprocessing:** After collecting data we preprocess the dataset. Firstly we download anaconda software. Using that software we resize our dataset images into 100X100 pixels. Then for enriching our dataset we apply rotation, mirroring process. Then we removed the impurity by deleting the repetitive images. Then we applied gray scaling.

- **Model Building:** We build our model for deep learning and machine learning algorithms and . Finally, we train and test our dataset to achieve a good accuracy and compare our models with each other and show the difference between our models and which model gives the high accuracy.

- **Performance evaluation:** In this portion, we discuss about our model performance. We used different graphical images like confusion matrix without normalization and confusion matrix with normalization. During the training and testing process we got accuracy and loss which has been illustrated using accuracy graph and loss graph respectively.

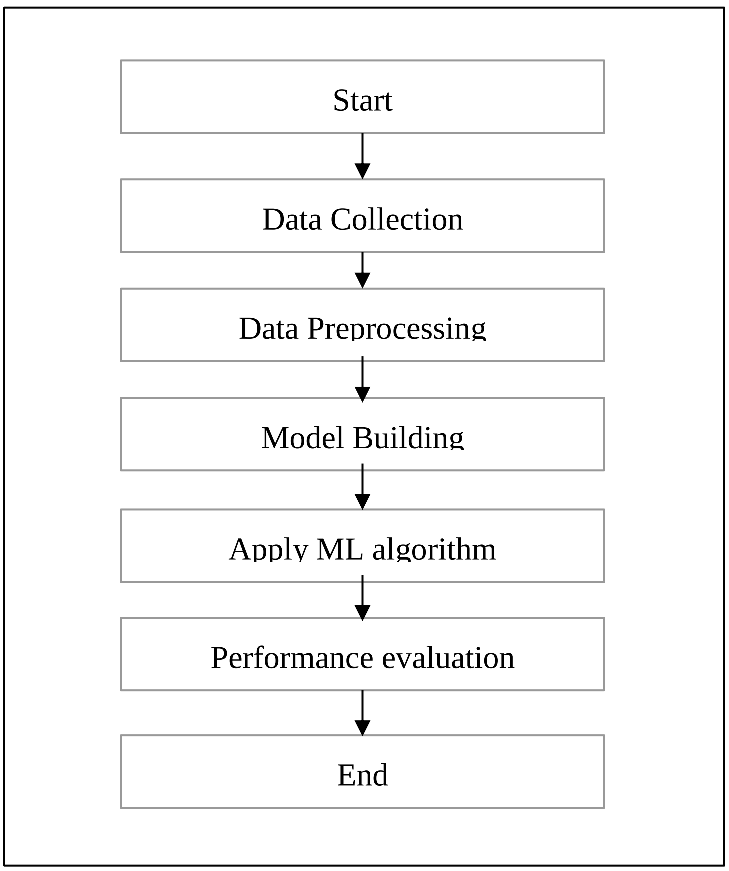

Fig 3.5.1: Research Methodology

3.6 Understanding Algorithm: We applied Convolutional Neural Network in our model. The process is given below:

3.6.1 Convolutional Neural Network:

A deep learning neural network that is a type of deep learning neural network is a convolutional neural network. The convolutional neural network is a notable development in the field of image recognition. CNN has become one of the most widely utilized machine learning algorithms in recent years.

In order to obtain the most precise results, many disciplines of research have focused on CNN. The following are the four layers of a CNN model:

Layers of convolutional neural networks:

1. Convolutional layers
2. Relu function
3. Polling layers
4. Flattening layers

Convolutional operates on two 2D images in this case. One is an input image, while the other is a filter for the input image that produces an output image. Another phase in the convolutional layer implementation is the rectified linear unit. This layer uses the "relu" activation function on feature maps to boost the network's non-linearity. Polling,on the contrary, gradually reduces the size of the input representation. It enables the detection of objects in an image. It aids in reducing the number of parameters as well as the quantity of computation needed. Polling also aids with the prevention of overfitting. Polling comes in a variety of forms. However, in our study, we employed maximum polling.

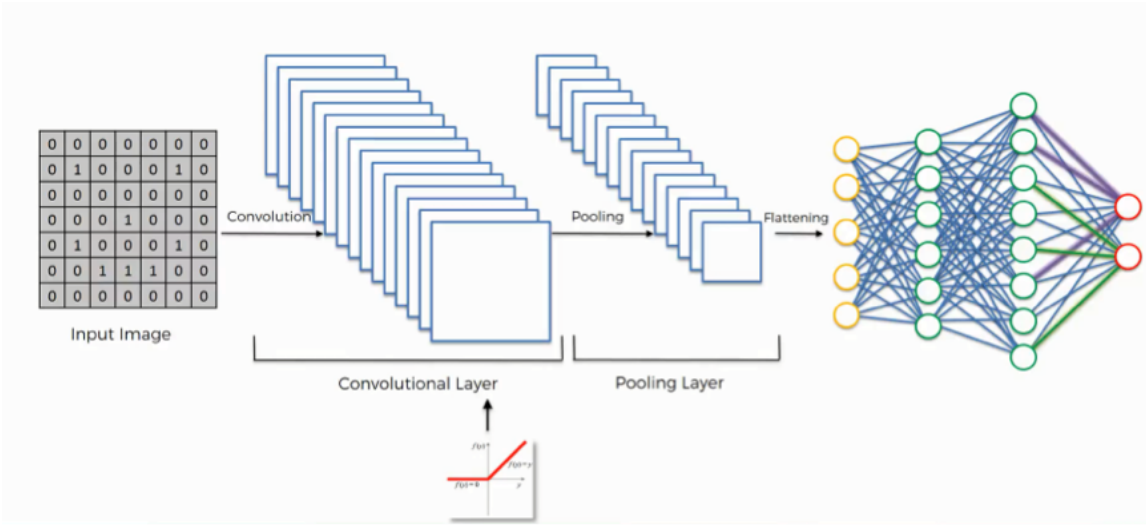

Fig 3.6.1: Diagram for Convolutional Neural Network

3.6.2 Convolution Neural Networks (CNN) Model

We have used 11 layers in our CNN model to train. They are mainly,

1. **Conv2D layers:** In this layer we were using 128 hidden layers, filters = 3, activation function = 'linear'.
2. **MaxPooling2D:** After the 2D convolution layer we used Maxpooling2D for dimensionality reduction.
3. **Dense Layer:** we used 256 hidden fully connected layers with activation function = 'linear'.
4. **Dropout Layer:** Dropout is a regularization method. We were using this layer for reducing overfitting and improving model performance. In our model we were using dropout = 0.4.

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 100, 100, 32)	320
max_pooling2d (MaxPooling2D)	(None, 50, 50, 32)	0
conv2d_1 (Conv2D)	(None, 50, 50, 64)	18496
max_pooling2d_1 (MaxPooling 2D)	(None, 25, 25, 64)	0
conv2d_2 (Conv2D)	(None, 25, 25, 128)	73856
max_pooling2d_2 (MaxPooling 2D)	(None, 13, 13, 128)	0
dropout (Dropout)	(None, 13, 13, 128)	0
flatten (Flatten)	(None, 21632)	0
dense (Dense)	(None, 256)	5538048
dropout_1 (Dropout)	(None, 256)	0
dense_1 (Dense)	(None, 2)	514

Fig 3.6.2: Model structure of CNN

Here we have built our model where we used 11 layers among them there are 3 Conv2D layers, 3 Maxpooling 2D layers, 2 dropout layers, 2 dense layers and 1 flatten layer. We defined our kernel size 3x3 and for activation function we have used linear activation function. And this is the model summary. For layer type conv2d the output shape is (None, 100, 100, 32) and parameter is 320, for layer type max_pooling2d the output shape is (None, 50, 50, 32) and parameter is 0, for layer type conv2d_1 the output shape is (None, 50, 50, 64) and parameter is 18496, for layer type max_pooling2d_1 the output shape is (None, 25, 25, 64) and parameter is 0, for layer type con2d_2 the output shape is (None, 25, 25, 128) and parameter is 73856, for the layer of max_pooling2d_2 output shape is (None, 13, 13, 28) and parameter is 0, for the layer of dropout the output shape is (None, 13, 13, 28) and parameter is 0, for the layer of flatten the output shape is (None, 21632) and parameter is 0, for the layer of dense the output shape is (None, 256) and parameter is 5538048, for layer of dropout_1 the output shape is (None, 256) and parameter is 0 and for the layer of dense_1 the output shape is (None, 2) and parameter is 514.

CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Introduction

A feature selection method was implemented, as well as a machine learning model, to improve accuracy in this chapter. For this we divided our data into two parts. Train data and test data. After dividing the dataset, the model training algorithm will be implemented.

4.2 Experimental Results

In our dataset, there were 1566 data. We are predicting “class” attributes which value are: Positive and Negative. Total number of Negatives was 867 and the total number of Positives was 699. We will keep 1306 data into train dataset where the number of negatives is 771, and number of positive is 536, which is 83% of our main dataset. Remaining 260 data will be kept in the test dataset where the number of negatives is 96, and number of positive is 192, which is 17% of our main dataset. We applied a model on our train dataset, and predicted with test dataset. Then a machine learning model was implemented and various performances like confusion matrix, accuracy, F1-score and Support were found.

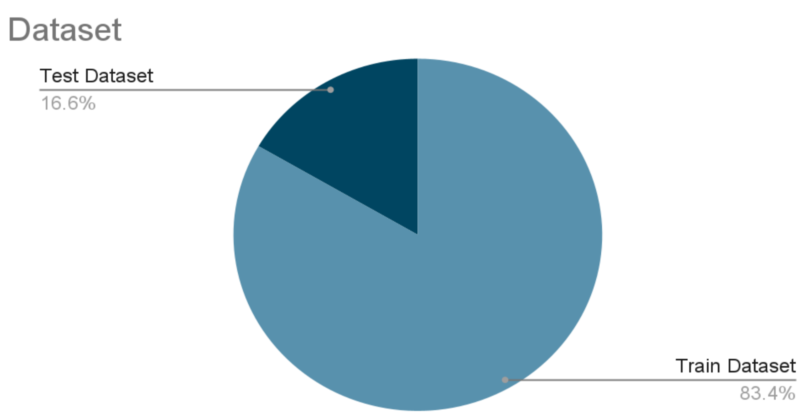

Figure 4.2.1: Dataset Pie Chart

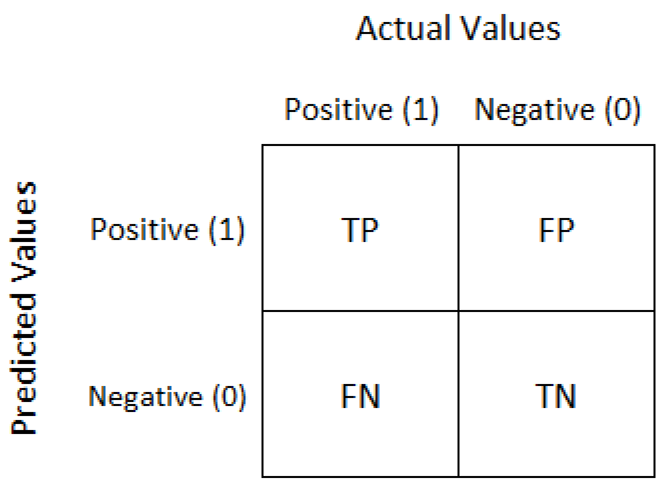

Fig 4.2.2: Confusion Matrix

Here we have discussed the support, recall, F1-score, precision, accuracy and confusion matrix of our classification technique.

	precision	recall	f1-score	support
Class 0	0.74	1.00	0.85	96
Class 1	0.00	0.00	0.00	34
accuracy			0.74	130
macro avg	0.37	0.50	0.42	130
weighted avg	0.55	0.74	0.63	130

Fig 4.2.3: Result of Support, Recall, F1-Score, Precision

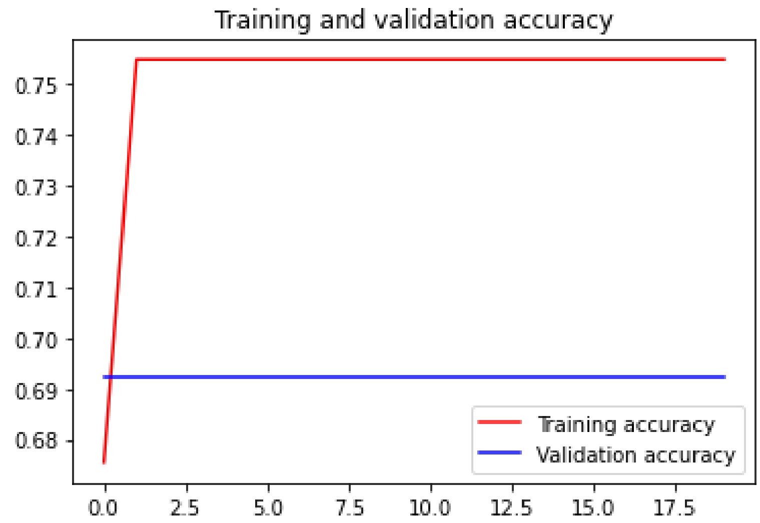

Fig 4.2.4: Train and Test accuracy of CNN model

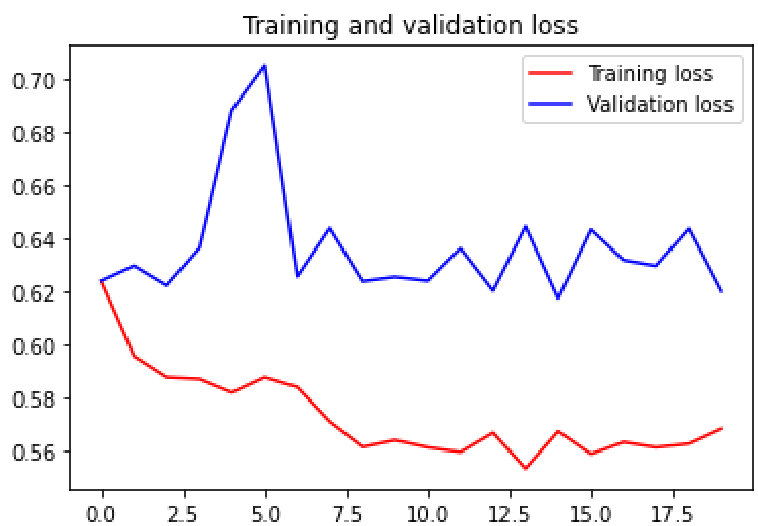

Fig 4.2.5: Train and Test loss of CNN model

1. **Confusion matrix, without normalization:**

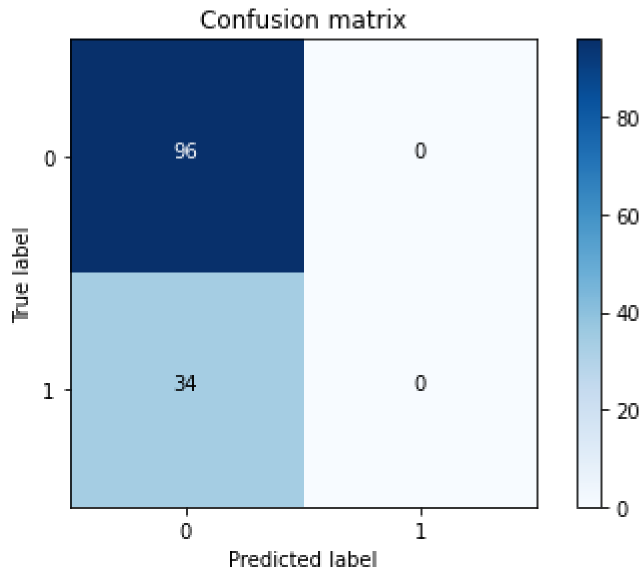

Figure 4.2.6: Confusion Matrix (without normalization)

2. **Confusion matrix with Normalization:**

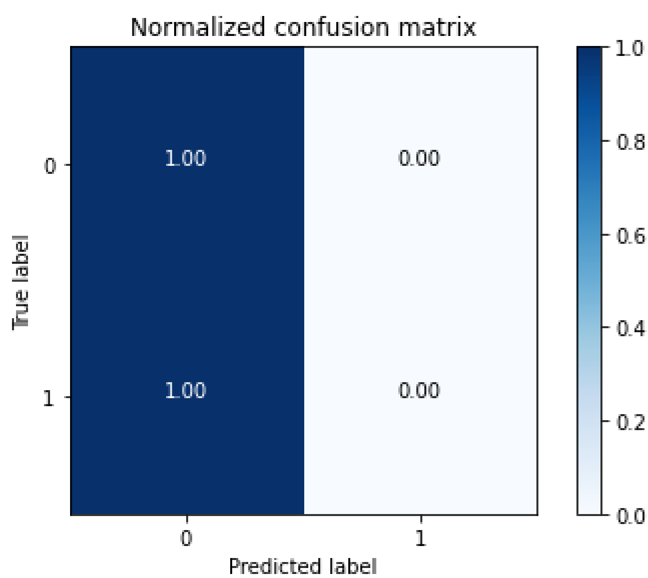

Figure 4.2.7: Confusion Matrix (with normalization)

4.3 Descriptive Analysis

We have applied Convolutional Neural Network for which we have collected our dataset from kaggle. In the dataset there were 650 rgb images. Firstly, we built up a model and applied CNN on these raw dataset. But we couldn't use all these images because of memory shortage as images' pixels were high (3072 x 2048). So we used 350 images and we got accuracy of 50 percent. Then we resized the images into 500 x 500 pixels and used 650 images for which we got accuracy of 63 percent. Furthermore, for getting better accuracy we again resized our images into 100 x 100 pixels and overfitted our dataset for which we got 1566 images. Then we worked on this new dataset and got an accuracy of 73 percent by applying CNN.

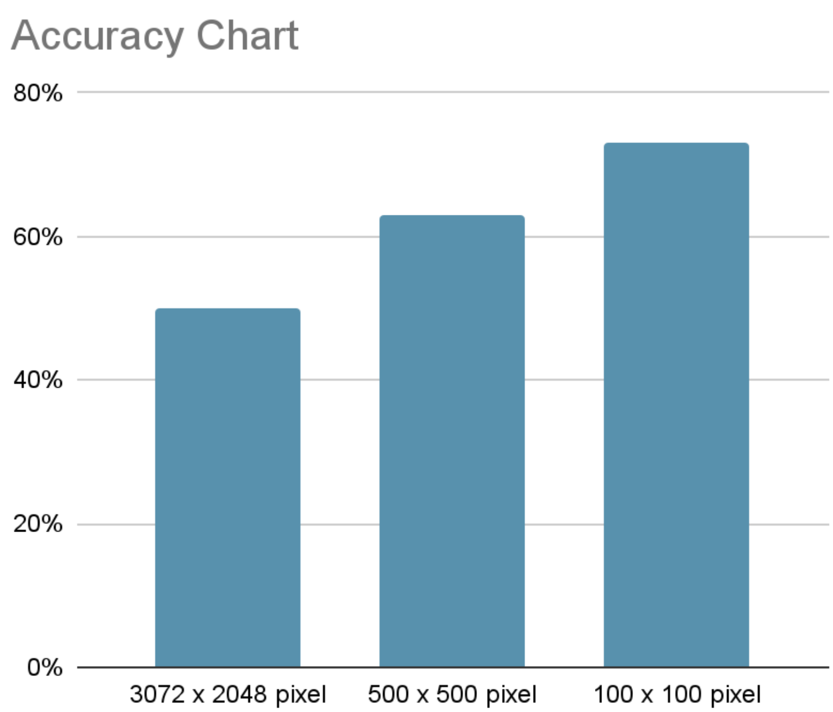

Fig 4.3.1: Accuracy Bar chart with image pixel

For training our model we set epoch value 20 and batch size 64.

Table 4.3.1: Epoch Result

Epoch	Loss	Accuracy	Loss of Validation	Accuracy of Validation
1	0.5653	0.7548	0.6539	0.6923
2	0.5526	0.7548	0.6222	0.6923
3	0.5616	0.7548	0.6661	0.6923
4	0.5675	0.7548	0.6213	0.6923
5	0.5687	0.7548	0.6171	0.6923
6	0.5620	0.7548	0.6323	0.6923
7	0.5637	0.7548	0.6242	0.6923
8	0.5612	0.7548	0.6173	0.6923
9	0.5764	0.7548	0.6254	0.6923
10	0.5719	0.7548	0.6370	0.6923
11	0.5670	0.7548	0.6305	0.6923
12	0.5675	0.7548	0.6169	0.6923
13	0.5664	0.7548	0.6172	0.6923
14	0.5711	0.7548	0.6193	0.6923
15	0.5599	0.7548	0.7922	0.6923
16	0.5854	0.7548	0.6307	0.6923
17	0.5698	0.7548	0.6405	0.6923
18	0.5876	0.7548	0.6248	0.6923
19	0.5586	0.7548	0.6173	0.6923
20	0.5557	0.7548	0.6760	0.6923

4.4 Summary

We got better accuracy using large dataset (1566 images) of 100 x 100 pixels on Convolutional Neural Network. We got test loss 60 percent and test accuracy 73 percent. Data cleaning is the only way to increase precision at that point.. The more data that has been preprocessed, the more precise assumptions that this classifier will reveal.

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT AND SUSTAINABILITY

5.1 Impact on Society

This program will have a significant social impact. People can use the system developed as a result of this study to see if they have any eye disorders and this study is a blessing for ordinary people who find it difficult to get advice from an eye specialist, due to a lack of funds and the number of eye specialists available. Furthermore, people can examine the eye problem in a matter of seconds, whereas it generally takes a good amount of time to check thoroughly. As the automation process is much faster and accurate than checking the reports manually, this research on fundus image analysis will save time and energy for both doctors and patients.

5.2 Impact on Environment

Every work has a significant environmental impact. This project has a favorable impact on the environment. There is no way to deliver any dangerous compounds or anything that would harm the environment. Instead, it will reduce the number of papers and other equipment required for manual report preparation. In addition, this research will assist people in predicting their illnesses while causing no harm to the environment.

5.3 Ethical Aspects

Using a machine learning system for clinical applications raises some ethical problems. The authority to use the dataset was initially questioned. Using an internet-based dataset raises obvious ethical concerns. Our datasets have been collected from Kaggle and researchers can access Kaggle's datasets for free. Another problem exists which is a specialist can explain why and how illness occurs, as well as the potential consequences of that illness. However, the users are completely unaware of how a machine distinguishes that illness. As a result, it could raise concerns about the end's precision. Transmission of the program under open-source licenses is a likely solution to the problem.

5.4 Sustainability Plan

The goal of this study is to ease the suffering of both ordinary people and doctors. Greater progress will be made in the research to ensure its long-term survivability. This research will not be limited to web applications at this time; instead, an android version as well as an iOS cover version will be developed. The existing website page will be updated in strategy to garner more visitors, and clients will be given instructions on how to use it. Later on, more analyses will be made in an attempt to improve the model's performance.

CHAPTER 6

SUMMARY, CONCLUSION, RECOMMENDATION AND IMPLICATION FOR FUTURE RESEARCH

6.1 Summary

Our main objective was to resolve the lack of research on fundus image processing, develop a model which will be able to detect glaucoma disease more accurately than currently possible using fundus image analysis, reducing time consumption and the doctor's industriousness in checking patients' reports. We gathered a dataset from Kaggle for this purpose. We have cleaned data, removed missing values, and distinguished the characteristics that are most associated with eye diseases. We used CNN machine learning algorithm, with this algorithm obtained 73 percent accuracy

6.2 Conclusion

Eye infections and diseases are becoming increasingly common in our country. The percentage of patients is increasing significantly, and doctors are having difficulty keeping up. Fundus imaging, in addition to Corneal and Retinal imaging, could provide a detailed view of the human eye's nerve and vascular structure, making it beneficial for recognizing and diagnosing glaucoma. However, manually inspecting these images is time-consuming and inefficient, therefore these procedures must be automated. However, there is a huge amount of research on automated ocular parts' image analysis, research on fundus image analysis has lagged for a variety of reasons that have yet to be discovered. That's why we tried to work on fundus image analysis.

6.3 Future Work

We're currently working on a small dataset. We will work on a huge dataset as much as possible in the future to improve accuracy. We'll create a web application and Android app as well as an iOS cover in our later work. Patients will be able to consult with eye professionals through our application, which we will design. As a result, all procedures, such as checking up, generation of reports, consulting specialists, and so on, would be easier and more efficient for people.

APPENDIX

LIST OF ABBREVIATION

CNNs	- convolutional neural networks
SVM	- Support Vector Machine
GNB	- Gaussian Naive Bayes
KNB	- Kernel Naive Bayes
LR	- Linear Regression
LogR	- Logistic Regression
KNN	- k-Nearest Neighbors
DCNN	- Deep Convolutional Neural Network
AUC	- Area Under the Curve
ROC	- Receiver Characteristic Operator
GLCM	- Gray-Level Co-occurrence Matrix
IVCM	- in vivo confocal microscopy
OCT	- optical coherence tomography
CDR	- Cup-to-disc ratio
SNP	- corneal subbasal nerve plexus
CNFL	- corneal nerve fiber length
NGT	- normal glucose tolerance
IGT	- impaired glucose tolerance
T2DM	- type 2 diabetes mellitus
CNFD	- corneal nerve fiber density
CNBD	- corneal nerve branch density

CTBD	- corneal nerve total branch density
CNFA	- corneal nerve fiber area
CNFW	- corneal nerve fiber width
CNFrD	- corneal nerve fractal dimension
DED	- Dry Eye Disease
NF	- Nerve fiber
RGB	- Red Green Blue
NIKBUT	- noninvasive keratograph breakup time
PD	- Parkinson’s Disease
SCM	- surface covered by microprojection
AMD	- Age-related Macular Degeneration

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