Department of Electrical and Computer Engineering

North South University

Project Proposal

Eye Disease Classification using Deep Learning and Explainable AI

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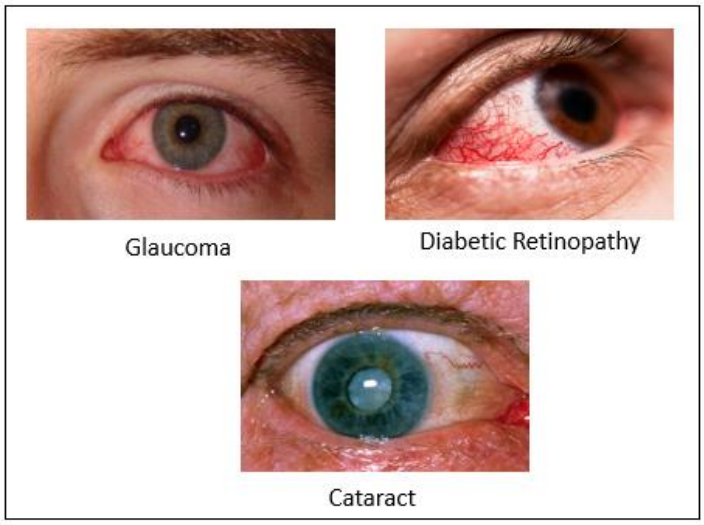
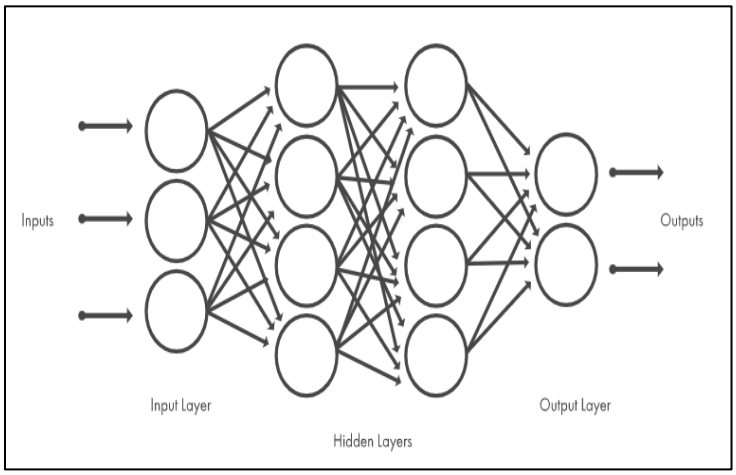
1. Background Study

Eye disease is the disease or disorder that affects the human eye. Eyestrain, red eyes, scratchy pain on eye surface, double vision, narrowed field of vision, eye spots are some of the symptoms of eye disease [1] . There are many different types of eye disease. Some of these are major and others are minor disease. Glaucoma, cataract, diabetic retinopathy are the most significant reasons for visual debilitation and preventable visual impairment. Glaucoma is the damage optic nerve. When an area of eye becomes cloudy it is recognized as cataract. Diabetic retinopathy is retinal damage of blood vessels due to diabetes. Inflammation of the eye, injuries to the eye and objects in the eye, genetically inherited diseases, migraine, diabetes, high blood pressure are some of the major reasons of eye disease. [2]



Deep learning is a subset of machine learning that teaches computers to do what comes naturally to humans: learn by example. In deep learning, a computer model learns to perform classification tasks directly from images, text, or sound. Deep learning neural networks attempts to mimic the human brain through a combination of data inputs, weights, and bias. These elements work together to accurately recognize, classify, and describe objects within the data. Deep neural networks consist of multiple layers of interconnected nodes, each building upon the previous layer to refine and optimize the prediction or categorization. This progression of computations through the network is called forward propagation. The input and output layers of a deep neural network are called visible layers. The input layer is where the deep learning model ingests the data for processing, and the output layer is where the final prediction or classification is made. Another process called backpropagation uses algorithms, like



gradient descent, to calculate errors in predictions and then adjusts the weights and biases of the function by moving backwards through the layers in an effort to train the model. Together, forward propagation and backpropagation allow a neural network to make predictions and correct for any errors accordingly. Over time, the algorithm becomes gradually more accurate. Nowadays, deep learning models can achieve state-of-the-art accuracy, sometimes exceeding human-level performance. [3] [4]

Explainable artificial intelligence (XAI) is a set of processes and methods that allows human to understand the decisions or predictions made by the AI. It is generated to break down the "black box" concept of AI which helps to characterize model accuracy, fairness, transparency and outcomes in AI-powered decision making [5] [6]. XAI can be used for both machine learning and deep learning-based analysis. Several frameworks are used for implementing explainable AI concept among which LIME and SHAPE are the most popular frameworks. The full form of LIME is Local Interpretable Model-agnostic Explanations in which model agnosticism refers to the property of LIME using which it can give explanations for any given supervised learning model by treating as a 'black-box' separately and local explanations implies that the explanations are locally faithful within the surroundings or vicinity of the sample being explained [7]. SHAPE explains output by assuming that each feature value of the instance is a player in a game where the prediction is the payout and this payout is fairly distributed among the features by using shapely values method. [8]

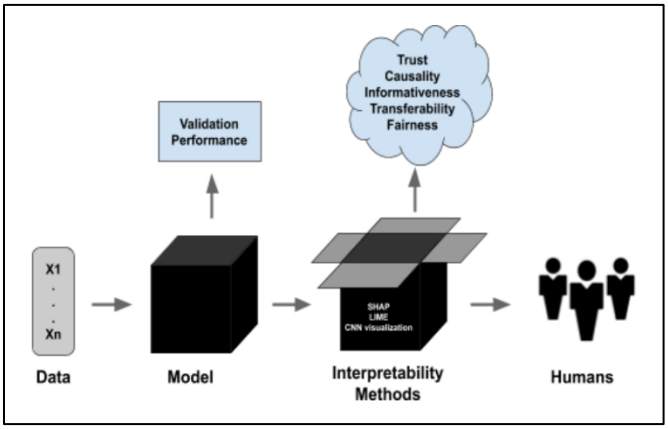


Figure : Concept of Explainable AI

The hike in the number of these eye diseases can be halted in the event that they are diagnosed at an early phase. These eye illnesses have many outwardly recognizable side effects. To precisely analyze eye illnesses, it is expected to examine an extensive variety of symptoms. Using digital image processing methods as well as deep learning techniques along with XAI can be used to detect high diseases at an early stage.

2. Problem Statement

Eye disease is one of the most prevalent clinical issues throughout the world. According to WHO, at least 2.2 billion people have a near or distance vision impairment [9]. It is estimated that nearly 750,000 people in Bangladesh are blind and more than six million people are living with visual impairment [10]. Eye diseases can lead to severe conditions like vision loss. An appropriate, interpretable and early detection system of eye disease can be a key solution for preserving vision. With the advancement of technology, a lot of approaches have been taken for clinical detection among which application of artificial intelligence is one of the most effective tools. The aim of this protection is therefore to build an eye disease detection system based on the techniques of deep learning and explainable AI which will not only classify several eye diseases using retinal fundus images but also gives an appropriate explanation on what basis it was classified.

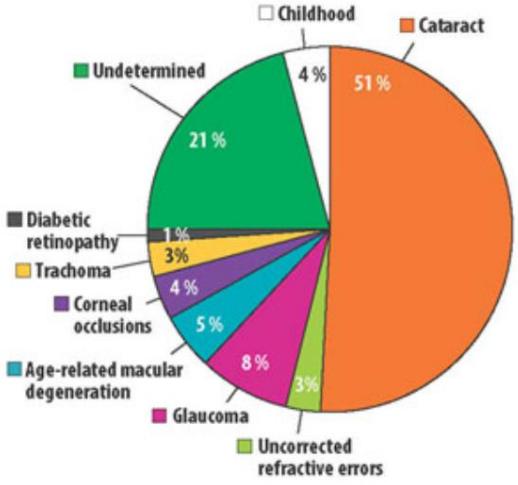


Figure: Pie chart of Global Eye disease [22]

3. Review of existing similar systems

The authors of "Deep Learning for Ocular Disease Recognition: An Inner-Class Balance" has proposed an approach for classifying different ocular disease using deep learning model. Their experiment is based on a publicly available Kaggle dataset titled as "Ocular Disease Recognition" containing the right and left eye fundus photographs of 5000 patients. There are 8 classes in this dataset. One class is for the image of people with normal eye and rest of the seven classes is for the image of people with seven types of eye diseases as Diabetes (D), Glaucoma (G), Cataract (C), Age related Macular Degeneration (A), Hypertension (H), Pathological Myopia (M), Other diseases/abnormalities (O). In this experiment, this multiclass classification problem was solved through binary classification problem where for each class, it was only compared with the normal class. All images were resized into 224 × 224. Dataset was splitted by following 70:30 train-test split ratio. VGG-19, which is a CNN-based model that uses 3 × 3 filters with a single stride and always employs the same padding and maxpooling layers of 2 × 2 filters with a stride of 2, has been used for classification. After the classification layer, a densely connected dropout layer, five convolutional layers were applied. This study provided accuracy of 98.13% for the normal (N) versus pathological myopia (M) class, 94.03% for normal (N) versus cataract (C), 90.94% for normal (N) versus glaucoma (G). [11]

The authors of "Detecting Deepfake Images Using Deep Learning Techniques and Explainable AI methods" has done research on detecting deepfake images using DL and then analyze the output with XAI for a proper explanation why the output is what it is and what part of the image caused the algorithm to come to that conclusion. For this experiment, the dataset was taken from Kaggle containing 70k real and 70k fake faces. Jupyter notebook, TensorFlow, NumPy, and Pandas were used as software tools. The images were resized to 256×256 and then split into the train, test, and validation sets. A total of 100,000 images were taken for the train set, another 20,000 each were for validation and test sets. The global average pooling layer and activation layer of Relu were used with a density of 512. To implement LIME, scikit-learn image segmentation function was carried out for the 3D boundary. Image segmentation helps understand the background from the image and makes the key features are isolated. Then through 3D masking, all the features were separated. The image temperature was adjusted and the red portions were the subjects face. The part that is only positive remains false in colored black. As deep learning technique, InceptionResnetV2, DenseNet201, InceptionV3, and ResNet152V2 are the applied CNN model. All these models' performances were good enough, such as InceptionV3 gained 99.68% accuracy, ResNet152V2 got an accuracy of 99.19%, and DenseNet201 performed with 99.81% accuracy. However, InceptionResNetV2 achieved the highest accuracy of 99.87%, which was verified later with the LIME algorithm for XAI, where the proposed method performed the best. [12]

The authors of "Explainable AI in Diagnosing and Anticipating Leukemia Using Transfer Learning Method" has proposed for Diagnosing and Anticipating Leukemia using several transfer learning algorithms and then applied explainable AI on the model with highest accuracy to interpret the reason behind specific classification. This experiment is based on Kaggle dataset containing microscopic blood cell images. All the images were resized to 299px×299px. Batch size were set as 32. All cells and normal cells were labeled 1 and 0 correspondingly. Then, ResNet101V2, VGG19, and InceptionResNetV2 were applied as transfer learning model and LIME framework has applied for implanting explainable AI. Among all transfer learning models, InceptionV3 has achieved the highest accuracy of 98.38%. LIME framework has used for implementing explainable AI. [13]

The authors of "EYE DISEASE IDENTIFICATION USING DEEP LEARNING" worked on four eye diseases namely, bulging eyes, cataracts, uveitis and conjunctivitis and their suggested deep neural network helps in early detection of eye disorders. The dataset of retinal images was taken from Kaggle. The process of identifying eye diseases using retinal images is broken down into several smaller processes, including feature extraction, classification, and picture pre-processing. The authors also used image enhancement techniques, data augmentation and prepared the data

according to the required matrix. For training, they used 80% of the dataset and remaining 20% was used for validation. There were basically two models one for predicting crossed eye and bulging eye and the other model predicts cataract/conjunctivitis/uveitis. Nine-layer CNN algorithm was applied; for the former dataset the accuracy was 96% and for the later model it was 92.31%. [14]

It is observed from the reviewed journals that transfer learning performs better for classification problems. As all of them have used LIME framework for implementing explainable AI and got a good output, it can be considered that LIME is a good framework for implementing explainable AI.

4. Objective

The ultimate target of our project is to save the vision of millions of individuals who lose their eyesight because of late diagnosis or not seeking legitimate treatment for an early diagnosis. Besides, we plan to make our framework an extremely accurate one as eye is one of the most delicate organs of human body so the outcomes ought to be close as perfect. Furthermore, most of the current systems gives no explanations or reasoning on the result so it turns out to be difficult to believe the findings of a machine. Therefore, we opt to utilize Explainable AI (XAI) so it very well may be perceived on what premise the outcomes were anticipated.

5. Feasibility Study indicating possible solution

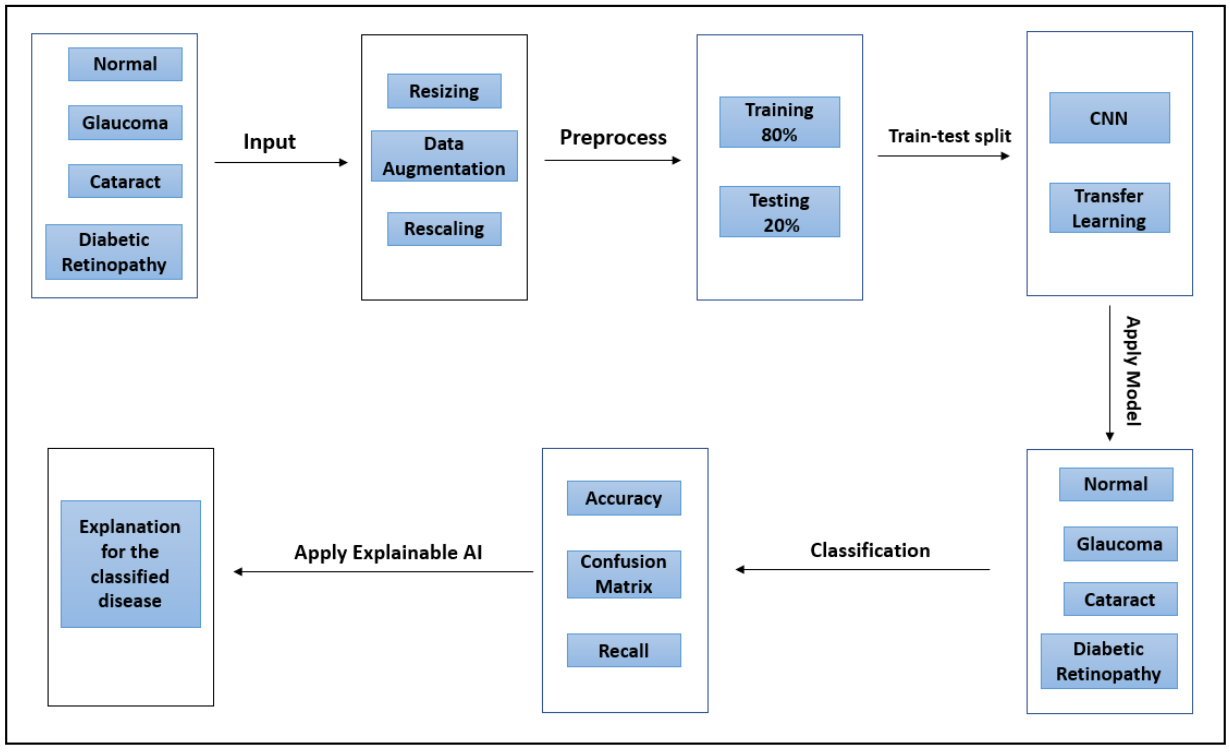
Eye is one of the most sensitive organs of our human body. Eye diseases have been on rise and a lot of projects proposed different methods to diagnose different kinds of eye diseases. The methods opted for diagnosis is image classification techniques which take fundus images of eyes with different diseases and classifies them. This requires training of different models and then using the most accurate one for prediction. For implementing this technique and ensuring high accuracy, a huge dataset is required. Hence it takes a lot time for building model. This problem can be overcome if a model can be used which is already trained and it will efficiently work on new dataset with just few modifications. As a result, it will reduce the time complexity of a system. Most of the system focuses on diagnosis of the disease only. They do not give any explanation on what basis it has diagnosed as this disease. Only clinical accuracy might not be enough trustworthy

since it deals with patients live. Using a technique which can give proper explanation of prediction can be a solution for this problem.

6. Expected results of the project

Our project “Eye disease classification using Deep Learning Techniques and Explainable AI” is based on eye diseases like Glaucoma, Cataract and Diabetic Retinopathy. We expect to train our model to give an accurate prediction over 95%. The model takes retinal fundus images as input and classifies the eye disease and then explains on what basis it was classified. For the explanation it will highlight those parts on the retinal fundus image which made it predict the eye disease.

7. Diagrams for the complete system



8. Explanation of the functioning of the complete system

A Detailed explanation of all the steps of point 7 is given in this section.

- **Input**

The input for this system will be a dataset of retinal fundus images taken from dataset provider kaggle.com [7] . This dataset contains retinal images of left and right eye with four different classes. One class indicates normal eye and rest of the three classes indicates three types of eye disease named Diabetic Retinopathy, Cataract and Glaucoma.

- **Pre-process**

Preprocessing is required to improve image quality so that models can analyze it more efficiently. It is used to shorten model training time and speed up model inference as well. In our system, image pre-processing will be performed through resizing, orienting and controlling the colors of images. We will start adjusting by downscaling images from the smallest image available since deep learning algorithms run faster on smaller images. Image orientation will be made by angle detection of the images and then adjusting them into a particular angle. Color of images will be controlled based on the number of channels.

- **Train-test split**

Train-test split is required for understanding how a model will perform on new data. The training portion of the dataset will be used for model training and the testing portion will be used for evaluating the performance of trained models. We will use 80% of our dataset for training and 20% for testing purposes.

- **Build Model**

In our system, we will use convolutional neural network (CNN) which is the most analyzed deep learning algorithm. Convolution is the basis of this algorithm. Different layers such as convolutional layers, activation layers, pooling layers, and flattening layers will be used for building CNN model. For the improvement of CNN's performance, transfer learning algorithms will be applied. VGGNet, ResNet, Inception model will be used as pre-trained model for implementing transfer learning algorithms.

- **Classification**

Based on the trained model, the system will provide output indicating the class of retinal image. Model accuracy will be evaluated by measuring how much accurately the model has classified images.

- **Select most optimum Algorithm**

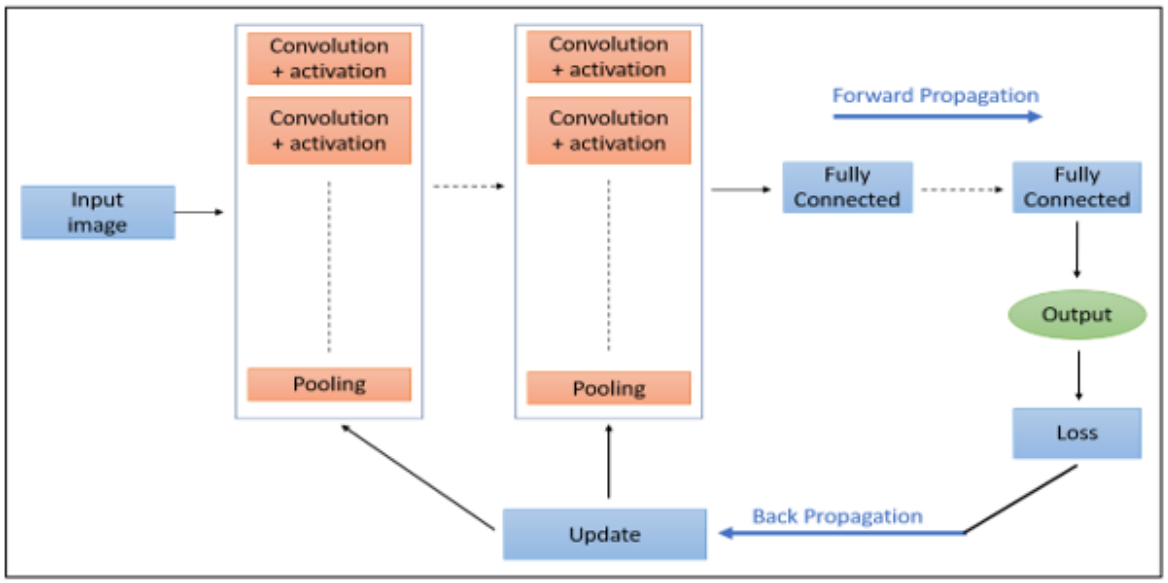
From all the algorithms applied on the dataset, we will select the algorithm with most robust performance. For evaluating performance, the algorithm providing more accuracy will be considered as more efficient.

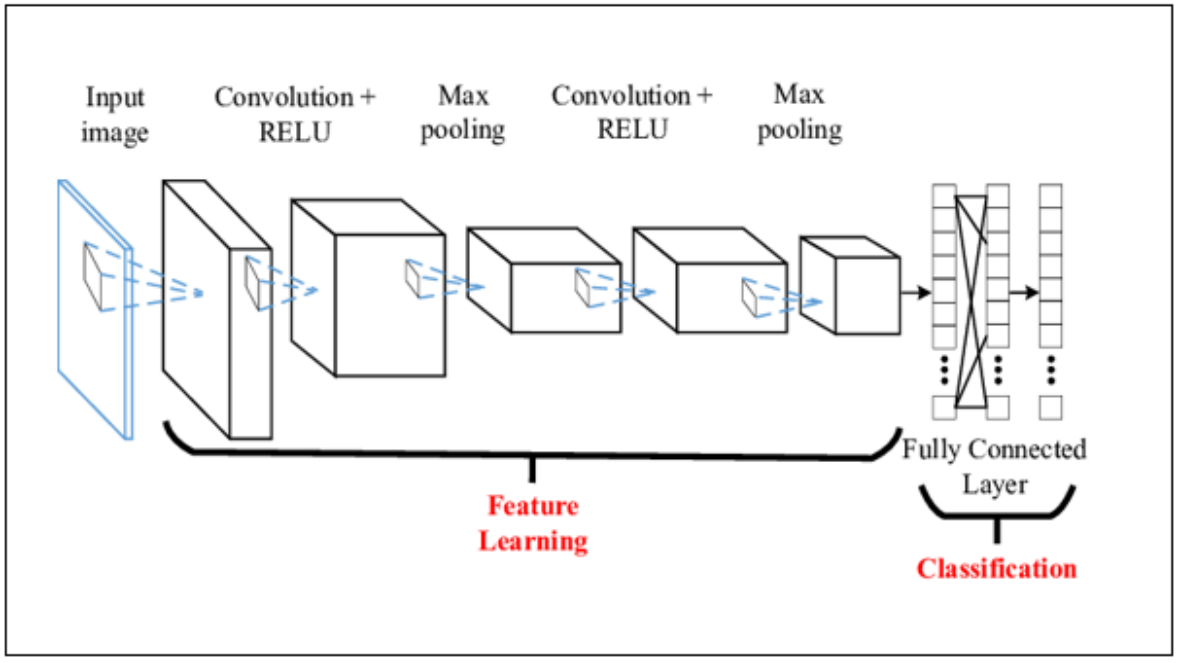
- **Apply explainable AI**

Explainable AI technique will be applied on the most optimum algorithm so that the system can interpret on what basis it has classified the retinal images as a particular class. We will use LIME (local interpretable model-agnostic explanations) framework for implementing explainable AI.

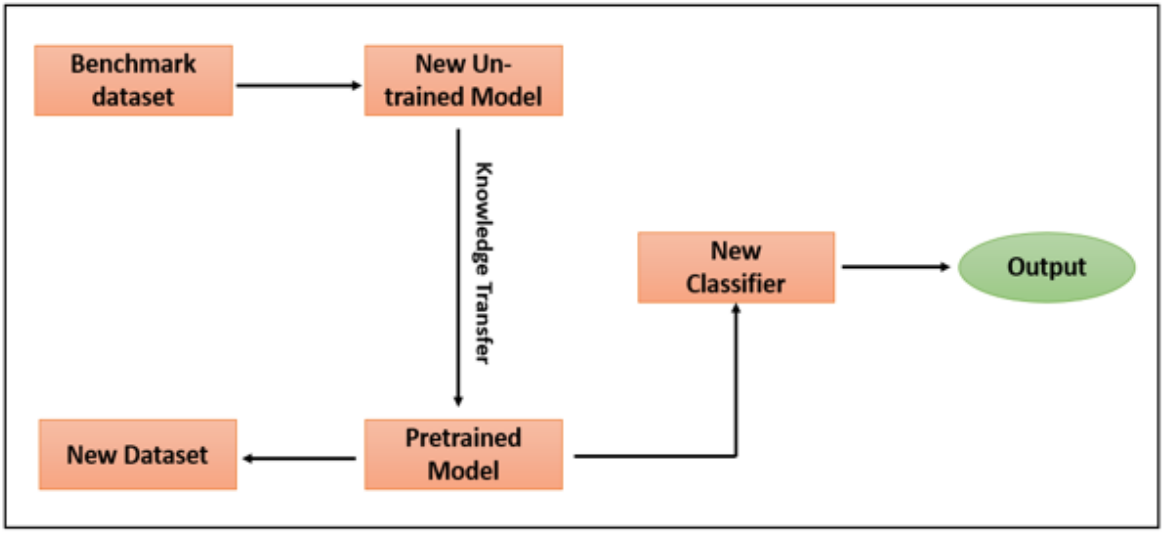
9. Diagrams drawn using software showing the layout of the systems

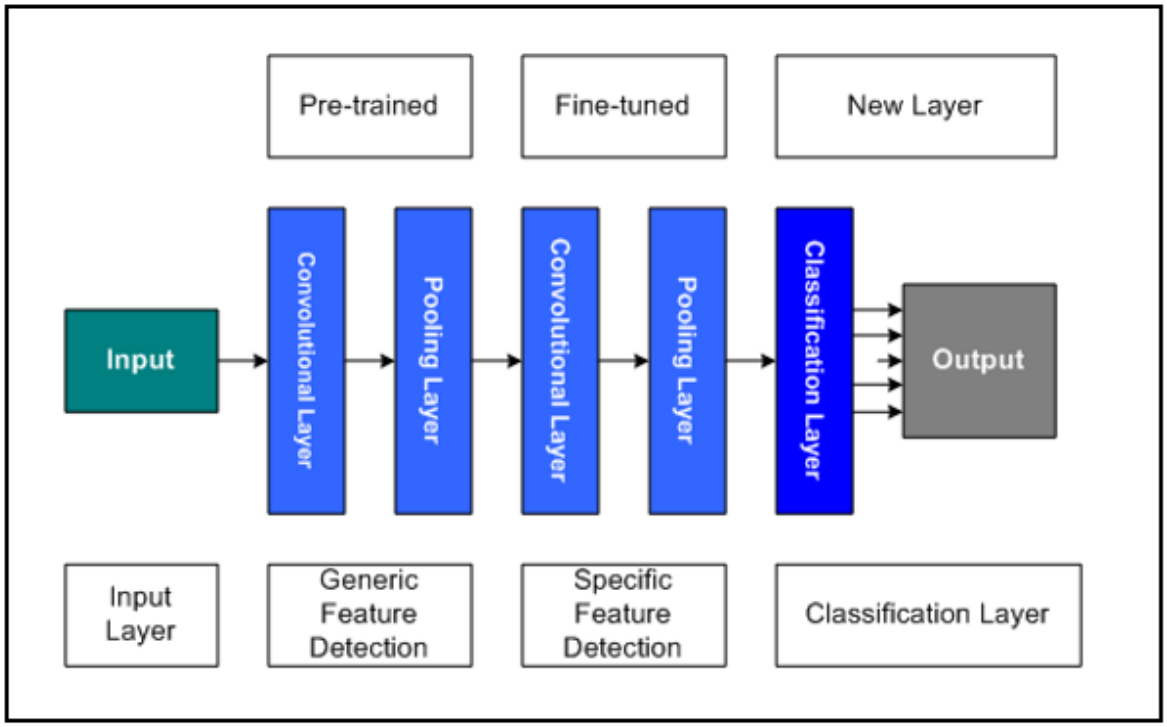
CNN Architecture



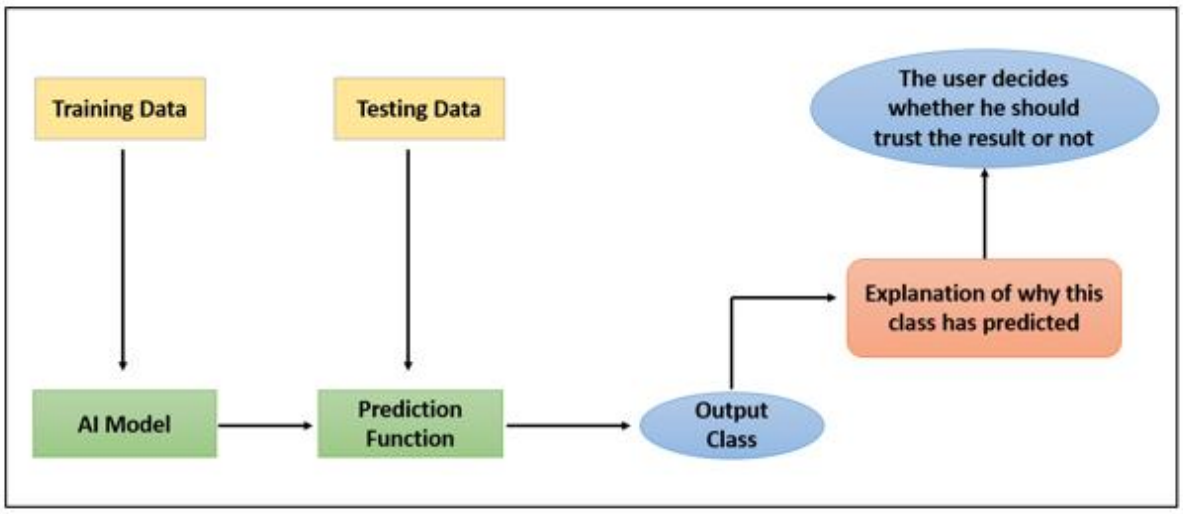


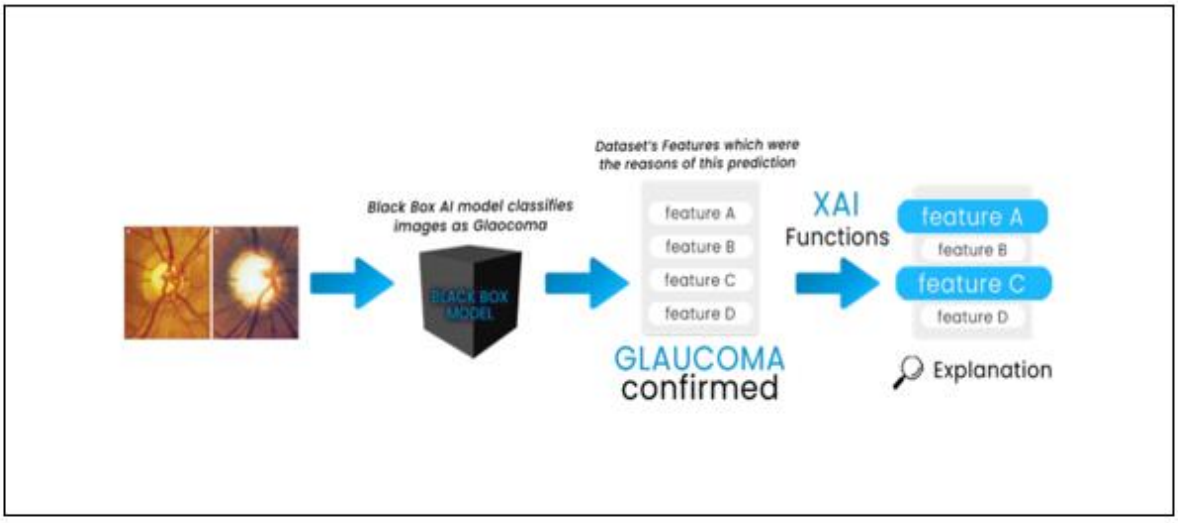
Transfer Learning Architecture





Explainable AI Architecture





10. Diagrams drawn using MS Word or MS Visio showing flow chart for processing

It has covered in point 7.

11. Graphs drawn using MS Excel

It is not required for our project.

12. Figures and graphs showing inputs and outputs

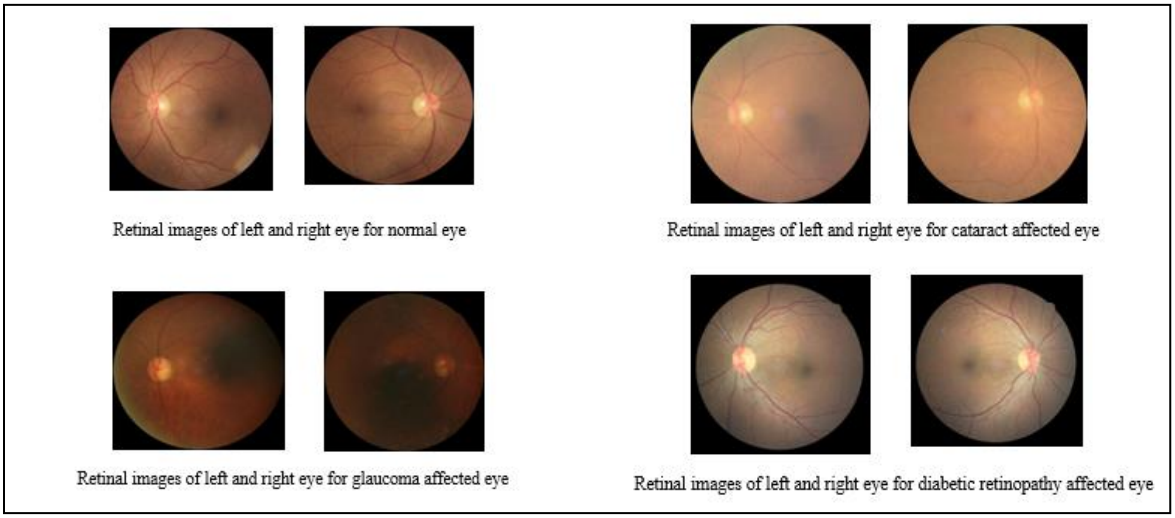


Figure – 12.1

Figure-12.1 shows the images from our dataset [16]. Representation of output will be possible after implementing our project.

13. Tables showing input and output data

Not possible for our project.

14. Working steps (Work plan)

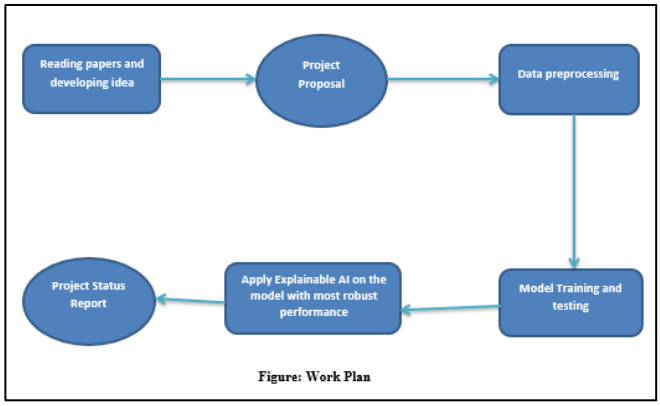


Figure: Work Plan

The first and foremost work was to read enough papers and gather knowledge about the topic. The second step is to develop a project idea and prepare the Project Proposal. The third step is Data Preprocessing which included preprocessing of the images in the dataset. Upon completion of data preprocessing, data splitting and model training and testing will be done. Then we will apply explainable AI on the model which will provide the maximum accuracy. The last step in the work plan is to make a final Project Status Report which will show the current status of the project.

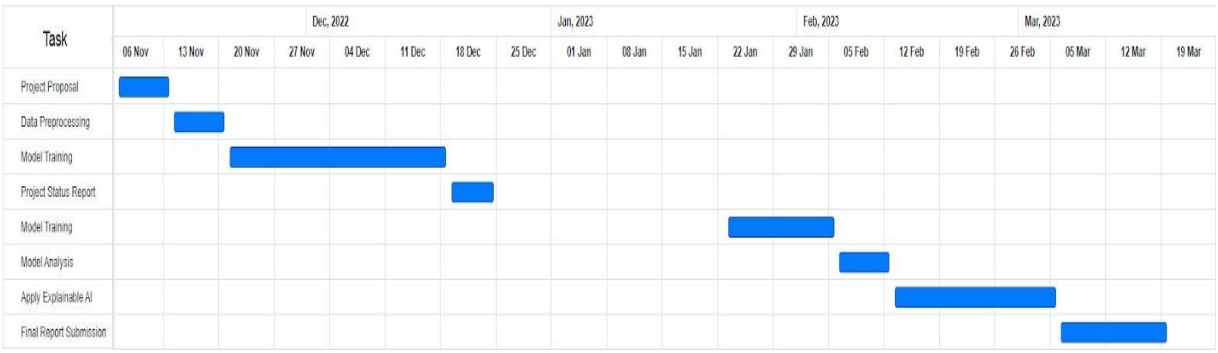
15. Major Milestones

The major milestones in the project are developing of the project idea based on reviewing problem statement related articles, acquiring a good dataset, data preprocessing, model training and testing using deep learning algorithms, model training and testing using transfer learning algorithms, applying explainable AI and final report submission.

16. Required tools and components. Bill of materials required to build the circuit or software system, and the approximate cost

Our project is a software-based project. We will use Goole Colab for implementing our project. It is free of charge to use. Detail of this will be discussed in point 18.

17. Gantt Charts of the expected timeline of progress



18. Required tools and components

Google Colab is a free Jupiter notebook environment that runs entirely in the cloud. It provides free Cloud service with free GPU. Therefore, it cut down the need to buy a laptop for a better GPU. Most importantly, it does not require a setup and the notebooks created can be simultaneously edited by team members - just the way we edit documents in Google Docs. All the machine learning, deep learning libraries such as PyTorch, TensorFlow, Keras, OpenCV can be easily imported on Google Colab. [17]

19. Target Population

We are focusing on each person of the country from lower working class to high society. The application is a demonstrative application utilized for early diagnosis of eye diseases and each and every individual in the nation can reap the rewards of this application. But the fundamental targeted people would be individuals dwelling in distant regions and the ones who can't manage the cost of the repeated visit expenses of ophthalmologist. Most individuals in our nation lives with a pitiful pay and getting contaminated by an illness on top of that would purge their pockets. Eye checkups require visit charges of ophthalmologist including the vehicle fares in addition to the various types of manual examinations should be conducted for knowing the specific eye disease. All this would require a huge amount of cash which many can't afford. At the end, they wind up losing their vision without knowing what infection they got. Besides, people who lives in far off regions don't

approach ophthalmologist as a large portion of them has their chambers in cities. So, visiting ophthalmologists for routine exams would be hard for them. Therefore, this segment of individuals could be profited from this application as it will chop down the need to do those additional manual examinations, wait for results for long time. Besides, every other can use it as it doesn't expect cash to run a test.

20. What makes the solution an ‘innovation’?

The solution we have concocted can be named as an 'Innovation' in light of the fact that the current frameworks that diagnose eye diseases gives no explanation on what premise was it classified. So, it turns out to be somewhat difficult to trust the predictions of a machine and go for a therapy that too for a delicate organ like eye. Our project offers "Explainability" for the disease it predicts. It marks the parts of the picture that made it reach such a conclusion.

21. How the project will be sustainable?

The project is sustainable as it fulfills the needs of current population and won’t compromise the needs of future generations while ensuring a balance in the health sector. Apart from the current features, numerous extra elements and more sort of eye illnesses can be consolidated for classification. More models can be trained and compared for best accuracy. As it’s a software-based system, its sustainability depends on the updating of the current features or adding new features and making it more valuable and economical for the future.

22. How people will be benefit from the project?

The project will be beneficial for each class of people. It will save the vision of many by making an early conclusion of eye sicknesses like Cataract, Glaucoma and Diabetic Retinopathy. An early finding will assist many individuals with doing the right therapy without burning through any time and save their vision. The application requires no cash to run nor it's should be bought. A retinal fundus pictures are sufficient to foresee an eye disease. Moreover, people who live hand to mouth could involve it for diagnosis and set aside a ton of cash which in any case would have been squandered on numerous manual examinations that right now is the only option to diagnose an eye disease. As there are no distinction on who can utilize it or who can't so it's available to the whole population who can use it for their own benefit.

23. What are the risks? How the risks will be managed?

The main risk that is related with the project is Misdiagnosis. Even assuming the designated accuracy of the model is supposed to be more than 97% there's generally an opportunity the machine can malfunction and predict a wrong eye disease. To deal with the risk, we will train our model with a huge dataset so it can differentiate as accurately as possible between the eye disease and a normal eye. Besides we are focusing on attaining an accuracy of close to 99% as we will be utilizing Transfer Learning strategies.

24. Unprivileged women and people will benefit?

The system will definitely come in handy for the unprivileged. The application is an illustrative application used for early diagnosis of eye diseases. Yet, the crucial role it will play is in providing services to the people abiding in far off districts and the ones who can't deal with the expense of the visit costs of ophthalmologist. Eye tests require visit charges of ophthalmologist incorporating the transport fees notwithstanding the different kinds of manual tests that ought to be done for knowing the particular eye illness. This would cost a lot of money which many can't manage. Toward the end, most end up losing their vision. Besides, people who leaves in distant locales doesn’t get much opportunity to visit an ophthalmologist as most of the doctor’s chambers are in urban communities. So, visiting ophthalmologists for routine tests would be hard for them. Therefore, this portion of people could be benefitted by this this system as it will slash down the need to do those extra manual assessments and diagnose the disease without conducting any test. Hence, they can go directly for the treatment without wasting money on examinations.

25. Disabled will benefit?

As our project is for the people who are experiencing eye diseases so people who fall in that criteria will be benefited. As for the disabled people, if they have any eye disease, they can also use this system. It’s open for the entire population.

26. What is the impact on environment, social, economic, political, legal, technology, health and safety?

As our project is a software-based project and we will not be using any kind of hardware's it will not have any impact on the environment.

Concerning its impact on the social front, it'll be helpful for people with eye diseases like Cataract, Glaucoma and Diabetic Retinopathy. Not only it'll cut down the cost of manual examinations but it'll help in an early diagnosis of eye diseases which will save the vision of many people of the society. As said, it'll cut down cost of many examinations conducted to diagnose an eye disease so it'll be beneficial economically for many people with a meager income source. Our project isn't bounded by any political or legal aspects.

Our project will play a significant role for the betterment of technology in health sector. Lastly, our project doesn't use any chemicals, electromagnetic rays or any kind of harmful substances so it'll not be causing any harm to the health and safety of the users.

27. Strength, weakness, opportunities and threat

The significant strength of our project is that it provides explanation to the eye disease it'll be predicting. Due to its explainability, it standouts from the rest of the existing projects that predicts eye diseases.

The weakness that this project might experience is that it involves a machine for prediction. No matter what said or done, there is a slight opportunity of the machine misdiagnosing even with a higher accuracy.

There are numerous opportunities connected with our project. It can be improved by involving more muddled calculations for better expectation accuracy. More sorts of eye illnesses could likewise be incorporated to make it predict various kinds of infections.

Concerning threat, there's no danger related with our venture.

28. Individual responsibilities for this project

Since it is a group project, all the participants will contribute for all the tasks of this project. The project is specifically divided among the members of group, so that each part of project works perfectly. In particular, Ishrat Jahan (ID:1921909042) will work on data preprocessing and building deep learning models, Faisal Hasan Tanjil (ID: 2013162042) will work on building

transfer learning model and Trina Pandit (ID: 1912517642) will work for the application of explainable AI.

29. Professional responsibilities

All the journals, dataset provider, websites, tools that will use for the project are publicly available. Proper citations will be given for all these things.

30. Limitations of the work

If the retinal images are not properly taken due to problem of ophthalmoscope or inefficiency of technician, the model will not be able to provide accurate output. This model can only be used by ophthalmologist and clinicians. General people may not understand the functionality of our project.

31. List of research publication on the problem statement

There are some research publications on the problem statement. A list of research publication, which we have gone through for our background study, is given below:

- M. S. Khan, N. Tafshir, K. N. Alam, A. . R. Dhruba, M. . M. Khan, A. A. Albraikan and F. A. Almalki, "Deep Learning for Ocular Disease Recognition: An Inner-Class Balance," *Hindawi,* vol. 2022, p. 12, 2022. [11]
- F. R. Khanam, F. R. Khanam, K. N. Alam, M. Hadjouni, H. Elmannai, S. Bourouis, R. Dey and M. M. Khan, "Detecting Deepfake Images Using Deep Learning Techniques and Explainable AI Methods," *Intelligent Automation & Soft Computing,,* vol. 35, no. 2, p. 2151–2169, 2023. [12]
- W. H. Abir, M. F. Uddin, F. R. Khanam, T. Tazin, M. M. Khan, M. Masud and S. Aljahdali, "Explainable AI in Diagnosing and Anticipating Leukemia Using Transfer Learning Method," *Hindawi,* vol. 2022, p. 14, 2022. [13]
- S. K. Sattigeri, N. Harshith, N. G. Dhanush, K. A. Ullas and M. S. Aditya, "EYE DISEASE IDENTIFICATION USING DEEP LEARNING," *IRJET,* vol. 09, no. 07, 2022. [14]

32. Conclusion

As the number of population is increasing dramatically, the number of patients experiencing eye diseases is supposed to increment emphatically. In such a situation, early acknowledgment and right administration of eye sicknesses are the principal targets to save vision and. The use of Deep Leaning (DL) and Transfer Learning in ophthalmology might be useful at this point, having the ability to speed up the diagnosis process. This growing examination enlivened various investigations of artificial intelligence application additionally to ophthalmology, prompting the development of many advanced algorithms. Further combination of deep learning and explainable AI into ophthalmology clinical practice is supposed to enhance and work on the momentum infection and the board interaction, including a prior identification.

33. Bibliography

[1] D. C. Kraff, "KRAFF EYE INSTITUTE," 19 05 2022. [Online]. Available: https://kraffeye.com/blog/8-warning-signs-and-symptoms-of-possible-eye-problems. [Accessed 2022 11 27].

[2] "news24," 20 05 2015. [Online]. Available: https://www.news24.com/life/wellness/body/condition-centres/eye/overview/causes-of-eye-disease-20150519. [Accessed 27 11 2022].

[3] "MathWorks," [Online]. Available: https://www.mathworks.com/discovery/deep-learning.html#:~:text=Deep%20learning%20is%20a%20machine,a%20pedestrian%20from%20a%20lamppost.. [Accessed 27 11 2022].

[4] "IBM," 01 05 2020. [Online]. Available: https://www.ibm.com/cloud/learn/deep-learning#:~:text=Deep%20learning%20is%20a%20subset,from%20large%20amounts%20of%20data.. [Accessed 27 11 2022].

[5] "IBM," [Online]. Available: https://www.ibm.com/watson/explainable-ai. [Accessed 27 11 2022].

[6] "The Fred Hollows Foundation," [Online]. Available: https://www.hollows.org/us/where-we-work/south-asia/bangladesh-2#:~:text=Nearly%20750%2C000%20people%20in%20Bangladesh,aged%2050%20years%20and%20. [Accessed 27 11 2022].

[7] "GeeksforGeeks," [Online]. Available: https://www.geeksforgeeks.org/introduction-to-explainable-aixai-using-lime/. [Accessed 27 11 2022].

[8] P. BANERJEE, "kaggle," 2019. [Online]. Available: https://www.kaggle.com/code/prashant111/explain-your-model-predictions-with-shapley-values/notebook. [Accessed 27 11 2022].

[9] "World Health Organization," 12 10 2022. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment#:~:text=Globally%2C%20at%20least%202.2%20billion,has%20yet%20to%20be%20addr. [Accessed 27 11 2022].

[10] "The Fred Hollows Foundation," [Online]. Available: https://www.hollows.org/us/where-we-work/south-asia/bangladesh-2#:~:text=Nearly%20750%2C000%20people%20in%20Bangladesh,aged%2050%20years%20and%20. [Accessed 27 11 2022].

[11] M. S. Khan, N. Tafshir, K. N. Alam, A. . R. Dhruba, M. . M. Khan, A. A. Albraikan and F. A. Almalki, "Deep Learning for Ocular Disease Recognition: An Inner-Class Balance," *Hindawi,* vol. 2022, p. 12, 2022.

[12] F. R. Khanam, F. R. Khanam, K. N. Alam, M. Hadjouni, H. Elmannai, S. Bourouis, R. Dey and M. M. Khan, "Detecting Deepfake Images Using Deep Learning Techniques and Explainable AI Methods," *Intelligent Automation & Soft Computing,,* vol. 35, no. 2, p. 2151–2169, 2023.

[13] W. H. Abir, M. F. Uddin, F. R. Khanam, T. Tazin, M. M. Khan, M. Masud and S. Aljahdali, "Explainable AI in Diagnosing and Anticipating Leukemia Using Transfer Learning Method," *Hindawi,* vol. 2022, p. 14, 2022.

[14] S. K. Sattigeri, N. Harshith, N. G. Dhanush, K. A. Ullas and M. S. Aditya, "EYE DISEASE IDENTIFICATION USING DEEP LEARNING," *IRJET,* vol. 09, no. 07, 2022.

[15] "Kaggle," [Online]. Available: https://www.kaggle.com/datasets/gunavenkatdoddi/eye-diseases-classification?fbclid=IwAR0h26xGztITcj5ahHvTz-F4Qfs8Smb2MfFHSWUANzoiD7YYYcC8HThDQW0.

[16] "kaggle," 2022. [Online]. Available: https://www.kaggle.com/datasets/gunavenkatdoddi/eye-diseases-classification?fbclid=IwAR0h26xGztITcj5ahHvTz-F4Qfs8Smb2MfFHSWUANzoiD7YYYcC8HThDQW0. [Accessed 11 2022].

[17] "tutorialspoint," [Online]. Available: https://www.tutorialspoint.com/google_colab/what_is_google_colab.htm. [Accessed 11 2022].

[18] "Hindawi," [Online]. Available: https://www.hindawi.com/journals/cin/2022/5007111/.

[19] "TechScience," [Online]. Available: https://file.techscience.com/ueditor/files/iasc/TSP_IASC-35-2/TSP_IASC_29653/TSP_IASC_29653.pdf.

[20] "Hindawi," [Online]. Available: https://www.hindawi.com/journals/cin/2022/5140148/.

[21] [Online]. Available: https://www.irjet.net/archives/V9/i7/IRJET-V9I7185.pdf.

[22] "Fogarty International Center," [Online]. Available: https://www.fic.nih.gov/News/GlobalHealthMatters/november-december-2012/Pages/eye-institute.aspx. [Accessed 2022].