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Retinad: An Approach to Detect and Prevent Diabetic Retinopathy Contingent on Deep Learning

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ABSTRACT —

This paper aims to develop an application that can process captured photos and correctly identify and detect diabetic retinopathy levels in retinal images online or offline depends on the situation. It is very necessary in remote areas with few facilities, there should be such automatic system which can classify DR level from retinal images without any intervention from professional doctors. Screening for retinopathy is usually performed by an ophthalmologist with fundus examination or color retinal photography by a trained ophthalmologist or ophthalmic technician using a dilated or non-mydriatic fundus camera. Online web based retinal imaging has come up as an efficient way to save cost and method of scanning, providing results for diabetic retinopathy. As of now nonetheless the type of fundus camera is used in present, the retinal images that is captured is still evaluated by an ophthalmologist (retinal specialist) or trained evaluator to check the presence or severity of Diabetic Retinopathy. This is a serious complication of diabetes that can impair your vision. Diabetic retinopathy harms the tiny blood vessels that provide nourishment via blood to the retina. These vessels can rupture and leak fluids, leading to swelling of the retinal tissue and blurry eyesight that can gradually grow with time. Typically, in this condition both left and right are damaged also the risk increases as the person affected with diabetes is not treated soon. If neglected, diabetic retinopathy can result in permanent blindness, which can be a costly affair in remote or rural areas of India. Even though having limited datasets available our model achieved 96.7% accuracy and can be used to classify the severity of the damage caused.

I. INTRODUCTION

Diabetic retinopathy is a condition as a result of person or individuals having diabetes, that leads to gradual harm to specially the back part of the eyes called retina, which is the light-sensitive layer where the image that we see is sensed at the rear of the eye. This is a severe complication of diabetes that can endanger one's vision by damaging the tiny blood vessels can rupture and leak fluids, leading to swelling of the retinal tissue and blurry eyesight that can gradually grow with time. Typically, in this condition both left and right are damaged also the risk increases as the person affected with diabetes is not treated soon. If neglected, diabetic retinopathy can result in permanent blindness, which can be a costly affair in remote or rural areas of India.

High levels of sugar in the bloodstream can cause blockages in the small blood vessels that supply nourishment to the retina, leading to reduced blood flow.

Diabetic retinopathy is classified into two types.

a) Early Diabetic Retinopathy

b) Advanced Stage Diabetic Retinopathy

➢ Immature Diabetic Retinopathy: -

Non-proliferative diabetic retinopathy (NPDR), a more prevalent variant in which new blood vessels aren't developing (proliferating). The walls of the blood vessels in the retina deteriorate when you have NPDR. The smaller vessels occasionally develop tiny bulges that protrude from their vessel walls & leak fluid and blood into retina.

The retinal vessels can expand & have uneven diameters more quickly the larger they are. As more blood vessels are blocked, non-proliferative diabetic retinopathy (NPDR) can worsen from mild to severe. Macular edema, also known as retinal swelling, is a condition when retina's nerve fibers or the macular region start to swell. Treatment is required for this ailment. The retinal blood vessel changes when someone has NPDR. That’s why this should be taken care at an early stage to be on safer side.

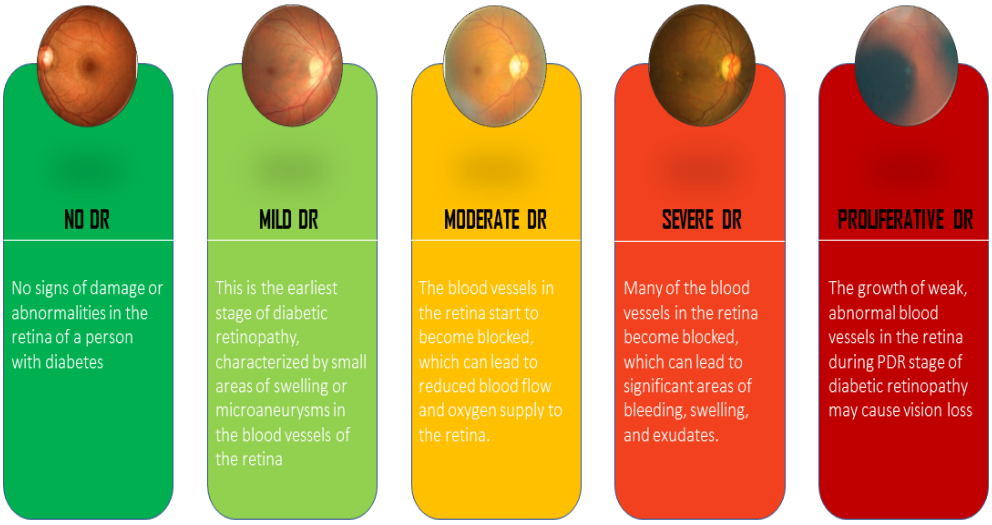

Fig 1. Details about the Different Severity of DR

➢ Advanced Stage of Diabetic Retinopathy: -

Diabetic retinopathy is a predicament of diabetes that can beget damage to the blood vessels of the retina. It can progress to a more complicated type, known as proliferative diabetic retinopathy, in which the blood vessels in the retina near out, causing the growth of new, unusual blood vessels. These new blood vessels can blunder into the jelly- suchlike clear substance that fills at the center of your eye. Ultimately, the growth of new blood vessels may beget scar towel to form, which can beget the retina to detach from the reverse of your eye. However, pressure can make up in the eyeball If the new blood vessels intrude with the normal inflow of fluid out of the eye. This can damage the whim-whams that carries images from the eye to the brain (optical whim-whams), performing in glaucoma.

In order to identify diabetic retinopathy (DR) early on and receive prompt treatment, especially for sight-threatening diabetic retinopathy, it is critical for all people with diabetes, regardless of type, to have frequent annual retinal examinations (STDR). Optometrists or skilled eye technicians may utilize them, although ophthalmologists normally perform retinal screening using fundus examination or retinal color photography using traditional mydriatic or non-mydriatic fundus cameras. To assess the presence and severity of DR, ophthalmologists or other qualified graders must grade the retinal images regardless of the type of fundus camera employed.

An automated method that uses computer-based analysis of fundus photos will lessen the strain on healthcare systems during the Diabetic Retinopathy screening due to the increased prevalence of diabetes and the lack of skilled retinal experts and graders for retinal photographs. As a result, there has been an increase in interest in recent years in the creation of automated analytic software using deep learning, AI, and machine learning approaches for assessing retinal pictures in people with diabetes. Software that mimics human intellect is referred to as AI.

II. EXISTING METHODOLOGY

Early detection and treatment are key to preventing vision loss, and there are several ways to diagnose and monitor DR.

- A mydriatic eye exam is one of these techniques, which entails using eye drops to enlarge the pupil that is done by doctors or the examiner and look for evidence of DR in the retina.
- The retina can also be imaged in great detail using optical coherence tomography (OCT), this is another technique used as existing methodology. The thickness of the various retinal layers can be determined using OCT, which can also identify swelling or fluid accumulation in the retina.
- Fundus photography is another diagnostic tool for DR. This involves taking pictures of the retina with a specialized camera, which can help detect signs of DR, such as blood vessel abnormalities, swelling, and bleeding.
- A more advanced approach uses artificial intelligence (AI) to analyze retinal images and detect signs of DR. Artificial intelligence algorithms can analyze thousands of images and quickly identify signs of DR, enabling early detection and treatment.

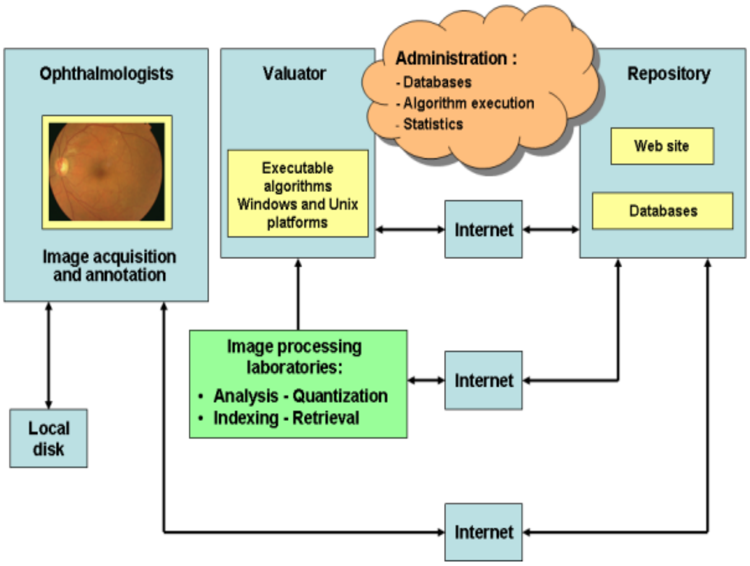

Fig 2. Workflow Architecture

In summary, there are several approaches to diagnosing and monitoring diabetic retinopathy, including mydriatic examination, optical coherence tomography, fundus photography, and AI analysis of retinal images.

Early detection and treatment are key to preventing vision loss, and people with diabetes should maintain their eye health by getting frequent eye exams and getting proper reports.

III. PROPOSED METHODOLOGY

The purpose of this paper is to develop an application capable of processing the photographs taken and correctly identifying and detecting the levels of diabetes from completely offline retinal images. In remote areas or when there are no highly skilled doctors diagnosing the disease, it is very necessary to have such an automatic system which can classify the level of diabetes based on the retinal images without any intervention of specialized doctors. The Kaggle dataset is used to form images and determine DR values. Diabetic retinopathy is the field of diagnosing the degree of diabetes based on retinal images. In total, it can be divided into five types of diabetes: Severity 0-> No DR, Severity 1-> Mild, Severity 2-> Moderate, Severity 3->Severe, Severity 4-> Proliferative DR In most countries, especially in poor development, there remains an unmet need for regular retinal screening for all diabetic patients.

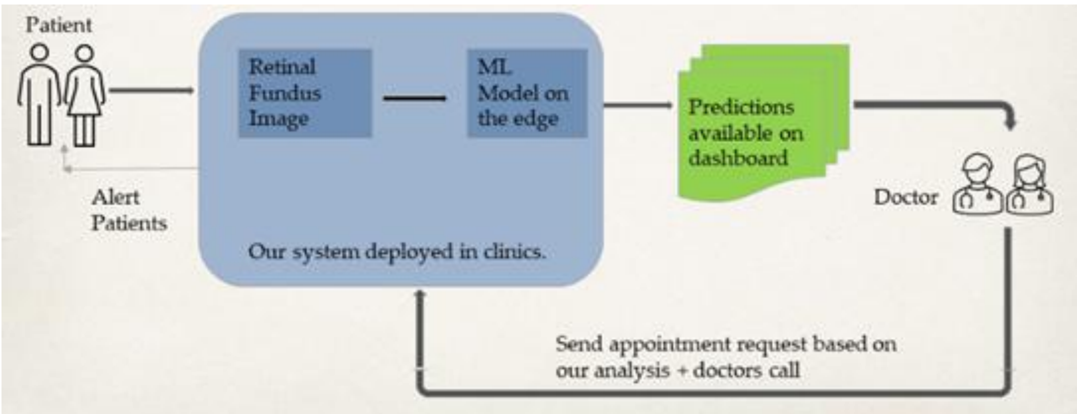

Fig 3. Proposed Architecture

Widely accepted for DR screening is retinal photography that has been evaluated and interpreted by an ophthalmologist or retinal specialist along with a qualified evaluator. However, in many nations, including India, the lack of qualified retina doctors and assessors continues to be a major barrier. Even when they are available, reviewers' busy schedules could cause DR assessments and recommendations to be submitted later than expected.

A. Software Requirement

➢ Backend - PyTorch (Deep learning framework)

- Programming Languages - Python, SQL
- API - Twilio cloud API (For sending SMS)

B. Model Training

- Convolution layer - In this layer, the convolution technique is done to an image using a predetermined stride and padding.
- Pooling layer - By specifying a mask and an operation, which is subsequently applied by moving the mask across the entire image depending on the supplied stride, the pooling layer is used to reduce the dimensionality of feature maps.
- Fully Connected layer - Due to its high parameter utilization, which is a traditional neural layer put at the end of the neural network, is rarely used today.

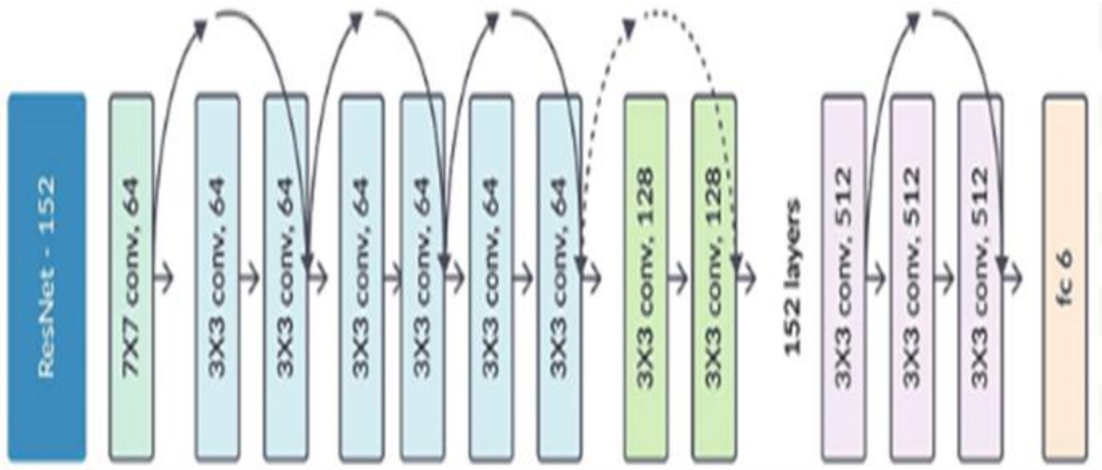

Fig 4. Resnet152 model

This is the model details used in our final training.

The ResNet-152 architecture consists of 152 layers, making it one of the deepest convolutional neural networks to date. It uses a series of convolutional, pooling, and fully connected layers to learn the characteristics of the input image. The network architecture includes jump connections or residual connections, which allow the network to learn a residual mapping between the input and output of a layer. This helps overcome the problem of leaky gradients and allows the network to learn more complex features.

We used two models:

CNN: Accuracy achieved: 0.8723404407501221, Loss: 1.0099958181381226

Resnet152: Accuracy achieved: 0.967, Loss: 0.107

Inside the function, the model is trained with the train loader and validated with the validation loader. The optimizer makes it possible to adjust the parameters of the model according to the calculated loss. This feature also uses the learning rate scheduler to adjust the optimizer learning rate. Calculate and store training and validation losses and validation accuracy for each epoch. Save the model if validation loss decreases.

IV. DATASET AND PREPROCESSING

In this study, the blinded APTOS 2019 test was used. The Diabetic Retinopathy (DR) dataset from the APTOS contains 13k photos of the retinal fundus. This dataset was generated as part of a Kaggle competition to categorize the severity of diabetic retinopathy in the provided photos. The dataset, which contains pictures of both the right and left eyes, is broken down into five classes that correspond to the severity of diabetic retinopathy Severity 0-> No DR, Severity 1-> Mild, Severity 2-> Moderate, Severity 3->Severe, Severity 4-> Proliferative DR.

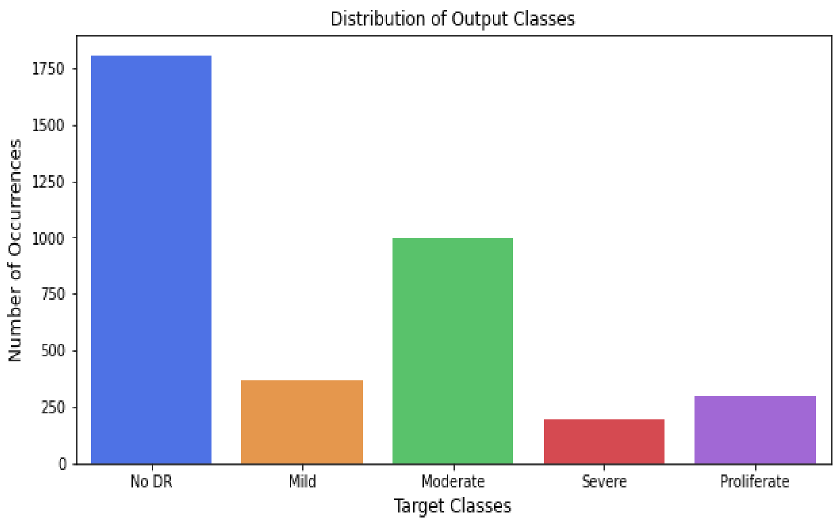

Fig 5. APTOS Dataset Distribution of Output Classes

Photographing the fundus, commonly referred to as the back of the eye, is a method called fundus photography. For this, a specialized fundus camera that consists of an advanced microscope attached to a camera with a flash is used. The center and periphery of the retina, the macula, and the optic disc can all be seen on a fundus image. Using colored filters or unique dyes like fluorescein and indocyanine green, fundus photography is possible. The high definition, color images in the APTOS collection have a size of 2136x3216 pixels. These photos were gathered from various locations throughout the world, primarily in the Asia-Pacific region. To cut down on the computational cost, the dataset was preprocessed to trim the images around the macula region and resize them to 512x512 pixels.

Dataset	Time	Images	Format	Task
APTOS(Kaggle)	2019	13k	Jpeg	DR grading
Diabetic Retinopathy 224x224 Gaussian filtered	2020	3.6k	png	DR grading/Lesion segmentation

Table 1. Datasets

Gaussian filtered retina scan images are used in the photographs to identify diabetic retinopathy. APTOS 2019 Blindness Detection has the original dataset available. These photos have been downsized to 224x224 pixels so that many pre-trained deep learning models may easily utilize them.

Data Processing: This code processes data for a PyTorch model. It defines a custom dataset class called CreateDataset that takes a pandas dataframe, directory path, and transformation, and has two methods: len and getitem. It also creates transformation pipelines for training and testing data, instances of CreateDataset for training and testing, and data loaders using torch.utils.data.DataLoader.

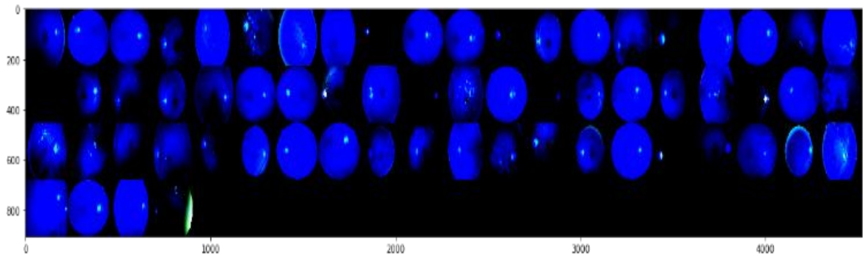

Fig 6. Processed Output Images

V. RESULTS

The trained model was close enough in learning and differentiating different severity of the diabetic retinopathy within accuracy of 96.7% in the final model trained under limited input data set, with the collected data the model was able to predict five basic classes of DR i.e. Severity 0-> No DR, Severity 1-> Mild, Severity 2-> Moderate, Severity 3->Severe, Severity 4-> Proliferative DR.

Image processing was very useful to train the model about extracting the data from poorly positioned retinal image acquired from the fundus camera. This model is still not industry-ready but a step towards building a sustainable environment to detect the severity of the Diabetic Retinopathy.

This also provides an alternative to hardware. Deep learning algorithms can help reduce the dependency on hardware, which can help reduce the cost of production.

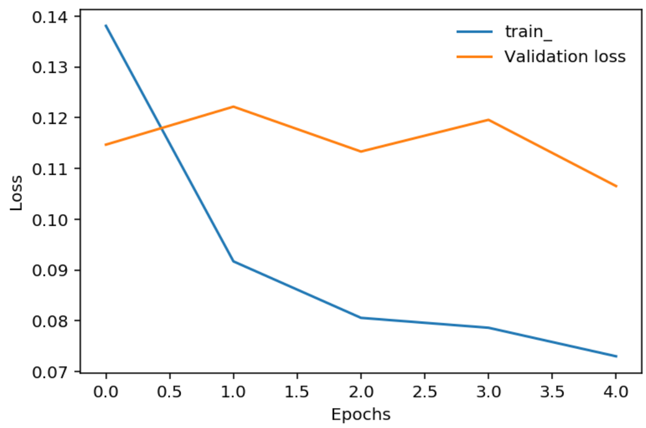

Fig 7. Loss Validation Function

A total of main neural network implementation goals was achieved and implemented, and several existing algorithms were assessed thereby reducing the dependency on in-built libraries.

VI. FUTURE SCOPE

This application can be modified in future to make it more user friendly and add on more advanced and innovative features in it to increase the through put and also the user experience while using this application. There can be a camera which can be modified and attached as a mounting to capture the images and reduce the cost burden for buying the costly devices for testing and reduce the time taken for computation purpose.

Also, can monitor and send personalized messages to doctors with the patient's eye history report.

VII. CONCLUSION

The expressive capabilities of a deep CNN and machine learning techniques are used in this study to provide a unique method for the automatic detection of DR in retinal pictures. Preprocessing, feature extraction, and classification steps make up the model, which aims to achieve high accuracy while reducing model complexity and training time. In order to accomplish this, features from images are extracted using a pre-trained network without retraining the network's weights. The paper proposes a unique model that automatically detects DR in retinal pictures by combining potent representational capabilities of a deep CNN. Preprocessing, feature extraction, and classification make up the model's three keyphases. This method's main goal is to lower the model's complexity and training time while maintaining high accuracy. Without changing the weights, pre-trained networks are used to extract visual features. The testing show that the suggested model outperforms other models trained on the same dataset in terms of results. Given the scarcity of labeled DR image datasets, the model's short data requirement for training makes it more advantageous. Optometrists could also diagnose and categorize DR using our methodology.

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