A REPORT ON

DIABETIC RETINOPATHY DETECTION OF AN EYE

BY

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1. INTRODUCTION

1.1 OVERVIEW :

Diabetic retinopathy is an eye condition that can cause vision loss and blindness in people who have diabetes. It affects blood vessels in the retina (the light - sensitive layer of tissue in the back of your eye).Vision loss due to diabetic eye disease is on the rise and is expected to reach epidemic proportions globally in the next few decades.

Diabetic retinopathy (DR) often remains undetected until it progresses to an advanced vision threatening stage. The current state of DR screening in the real world, based on assessment of color fundus photographs (CFPs) by a retina specialist, leaves a large proportion of patients undiagnosed and therefore receiving medical help too late. Notwithstanding, early detectionand prevention of Dr progression are essential to mitigate the rising threat of DR.

1.2 PURPOSE :

Artificial intelligence (AI) may offer a solution to this conundrum. Deep learning (DL), and specifically, deep convolutional neural networks (DCNNs), can be used for an end-to-end assessment of raw medical images to produce a target outcome prediction. The diagnostic use of DCCN algorithms is already spreading in various healthcare areas, such as radiology, dermatology and pathology. In ophthalmology, groundbreaking work has recently been conducted on the automation of DR grading and prediction of cardiovascular risk factors by DCNN analysis of CFPs.

In this study, our aim is to identify retinopathy using different diabetic retinopathy . In addition to the earlier studies of referable diabetic retinopathy classifcation system we also present state-of-the-art results for the clinically used grade classification. Moreover, we present what preprocessing and regularization steps to the images needs to be done for the good functionality of the deep learning system and investigate systematically how the size with much smaller number of images used in training affects its performance.

2. LITERATURE SURVEY -

2.1 EXISTING PROBLEM :

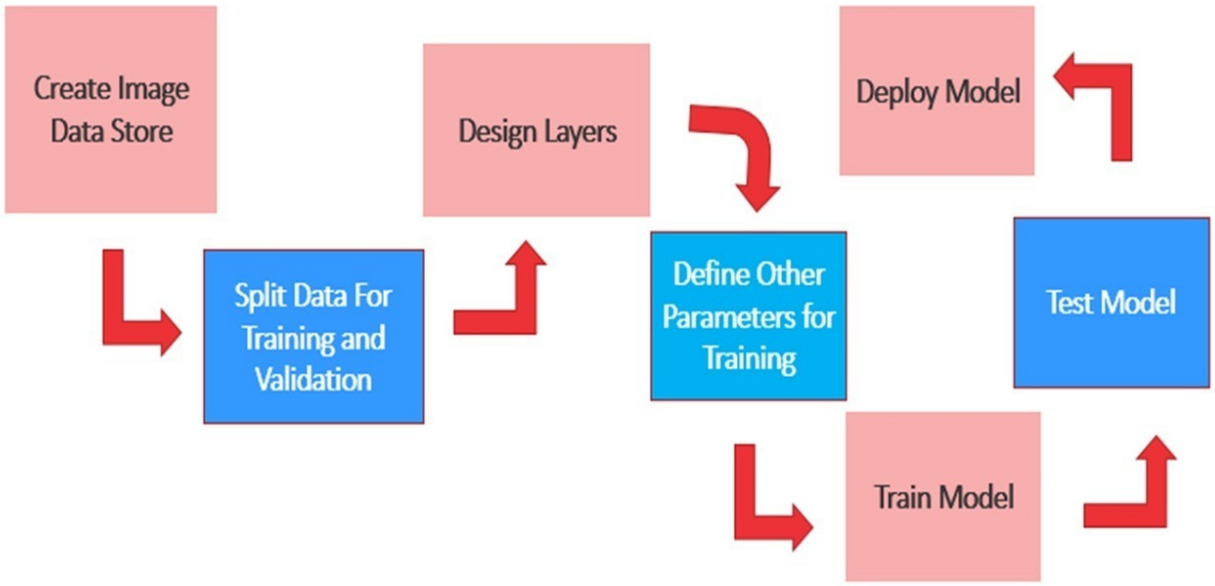
Diabetic retinopathy is an eye disease caused by diabetes that can lead to loss of vision or even complete blindness. Diabetic retinopathy accounts for 12% of all new cases of blindness in the United States, and is the leading cause of blindness for people aged 20 to 64 years. Diabetic retinopathy is a diabetes complication that affects eyes. It is caused by damage to the blood vessels of the light - sensitive tissue at the back of the eye (retina). Millions of people suffer from diabetic retinopathy, the leading cause of blindness among working aged adults.

2.2 PROPOSED SOLUTION :

The main objective is to scale the efforts of lab technicians through technology to gain the ability to automatically screen images for disease and provide information on how severe the condition may be. This project is capable of classifying images based on disease pathology from four severity levels. A convolutional neural network (CNN) convolves an input image with a defined weight matrix to extract specific image features without losing spatial arrangement information. There will be a web application through which user can give their input image then they can check the predicted output and this application is integrated with trained CNN model.

3. THEORITICAL ANALYSIS -

3.1 BLOCK DIAGRAM:



3.2. SOFTWARE DESIGNING -

3.2.1 CNN Architectures

In order to assess the strengths and limitations of CNNs, several architectures were trained and tested with particular focus on a 22 layers deep model called GoogLeNet. This very efficient network achieves state-of-the-art accuracy using a mixture of low-dimensional embeddings andheterogeneous sized spatial filters21. Increased convolution layers and improved utilization of internal network computing resources allow the network to learn deeper features. For example, the first layer might learn edges while the deepest layer learns to interpret hard exudate, a DR classification feature. The network contains convolution blocks with activation on the top layer that defines complex functional mappings between inputs and response variable, followed by batch normalization after each convolution layer. As the number of feature maps increase, one batch normalization per block is introduced in succession.

The max pooling sample-based discretization process was performed with kernel size 3x3 and stride 21. The network was then flattened to one dimension after the final convolutional block. Dropout of network layers was performed until reaching the dense five node output layer, which uses a softmax activation function to compute the probability of classification labels. Leaky rectified linear unit activation was also applied with gradient value 0.01 to mitigate dead neuron bottlenecks during back-propagation2. The network uses convolutional layer L2 regularization to reduce model overfitting, cross-entropy computed error loss, and the Xavier method of initializing weights so that neuron activation functions start out in unsaturated regions.

3.2.2 Preprocessing :

All images were converted to a hierarchical data format for preprocessing, data augmentation ,and training. Preprocessing involved several steps: images were cropped using Otsu’s method to isolate the circular colored image of the retina. Images were normalized by subtracting the minimum pixel intensity from each channel and dividing by the mean pixel intensity to represent pixels in the range 0 to 1. Contrast adjustment was performed using the contrast limited adaptive histogram equalization (CLAHE) filtering algorithm.

3.2.3 Data Augmentation :

We augmented the number of images in real-time to improve network localization capability and reduce overfitting. During each epoch, a random augmentation of images that preserve collinearity and distance ratios was performed. We implemented random padding with zeros, zoom, rolling and rotation. These affine transformations are particularly effective when applied to disease class R1 which are the most difficult to grade and fewest in number.

3.2.4 Training and Testing Models :

A Deep Learning GPU Training System (DIGITS) with prebuilt convolutional neural networks for image classification facilitated data management, model prototyping and real-time performance monitoring. DIGITS is an interactive system and was first used to build a classification dataset by splitting the Messidor and MildDR fundus folder into training and validation subsets of 1077 and 269 images respectively. The images were cropped to area size 256x256 and used as input data by Imagenet models previously trained for generic classification tasks. The test subset folder contained 400 images from the Lariboisiere hospital Messidor partition and was disjoint from training data. This training system, which offered extensive hyperparameter selections, was then used to build model prototypes over 100 epochs requiring approximately 20 minutes each to complete. A Tesla K80 GPU hardware device powered the training and a form of early stopping determined the optimal test set model epoch. Advanced visualization monitoring and confusion matrix statistical analysis provided important insights.
The knowledge gained guided construction of more complex model architectures finely tuned for improved interpretation of our datasets see Appendix.

3.2.5 Transfer Learning :

Transfer learning based approaches were executed with pretrained AlexNet and GoogLeNet architectures from ImageNet. The last fully connected layer was removed, then a transfer learning scenario18 was followed by treating the remaining network components as a fixed feature extractor for the new dataset. The transfer learning retains initial pretrained model weights and extracts image features via a final network layer.

4. EXPERIMENTAL INVESTIGATIONS -

4.1 SYMPTOMS :

The early stages of diabetic retinopathy usually don’t have any symptoms. Some people notice changes in their vision, like trouble reading or seeing faraway objects. These changes may come and go.In later stages of the disease, blood vessels in the retina start to bleed into the vitreous (gel-like fluid in the center of the eye). If this happens, you may see dark, floating spots or streaks that look like cobwebs. Sometimes, the spots clear up on their own — but it’s important to get treatment right away. Without treatment, the bleeding can happen again, get worse, or cause scarring.

4.2 OTHER TYPES OF DIABETIC EYE DISEASE :

Diabetic retinopathy is the most common cause of vision loss for people with diabetes. But diabetes can also make you more likely to develop several other eye conditions:

* Cataracts. Having diabetes makes you 2 to 5 times more likely to develop cataracts. It also makes you more likely to get them at a younger age.

* Open-angle glaucoma. Having diabetes nearly doubles your risk of developing a type of glaucoma called open-angle glaucoma.

4.3 AM I AT RISK FOR DIABETIC RETINOPATHY?

Anyone with any kind of diabetes can get diabetic retinopathy — including people with type 1, type 2, and gestational diabetes (diabetes that can develop during pregnancy). Your risk increases the longer you have diabetes. More than 2 in 5 Americans with diabetes have some stage of diabetic retinopathy. The good news is that you can lower your risk of developing diabetic retinopathy by controlling your diabetes.
Women with diabetes who become pregnant — or women who develop gestational diabetes — are at high risk for getting diabetic retinopathy. If you have diabetes and are pregnant, have a comprehensive dilated eye exam as soon as possible. Ask your doctor if you’ll need additional eye exams during your pregnancy.

4.4 WHAT CAUSES DIABETIC RETINOPATHY?

Diabetic retinopathy is caused by high blood sugar due to diabetes. Over time, having too much sugar in your blood can damage your retina — the part of your eye that detects light and sends signals to your brain through a nerve in the back of your eye (optic nerve).

Diabetes damages blood vessels all over the body. The damage to your eyes starts when sugar blocks the tiny blood vessels that go to your retina, causing them to leak fluid or bleed. To make up for these blocked blood vessels, your eyes then grow new blood vessels that don't work well. These new blood vessels can leak or bleed easily.

4.5 HOW WILL MY EYE DOCTOR CHECK FOR DIABETIC RETINOPATHY?

Eye doctors can check for diabetic retinopathy as part of a dilated eye exam. The exam is simple and painless — your doctor will give you some eye drops to dilate (widen) your pupil and then check your eyes for diabetic retinopathy and other eye problems. If you have diabetes, it's very important to get regular eye exams. If you do develop diabetic retinopathy, early treatment can stop the damage and prevent blindness.

If your eye doctor thinks you may have severe diabetic retinopathy or DME, they may do a test called a fluorescein angiogram. This test lets the doctor see pictures of the blood vessels in your retina.

4.6 PREVENTIVE MEASURES :

Managing your diabetes is the best way to lower your risk of diabetic retinopathy. That means keeping your blood sugar levels as close to normal as possible. You can do this by getting regular physical activity, eating healthy, and carefully following your doctor's instructions for your insulin or other diabetes medicines.

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To help control your blood sugar, you'll need a special test called an A1c test. This test shows your average blood sugar level over a 3-month period. Talk with your doctor about lowering your A1c level to help prevent or manage diabetic retinopathy.
Having high blood pressure or high cholesterol along with diabetes increases your risk for diabetic retinopathy. So controlling your blood pressure and cholesterol can also help lower your risk for vision loss.

4.7 TREATMENT FOR DIABETIC RETINOPATHY AND DME:

In the early stages of diabetic retinopathy, your eye doctor will probably just keep track of how your eyes are doing. Some people with diabetic retinopathy may need a comprehensive dilated eye exam as often as every 2 to 4 months.

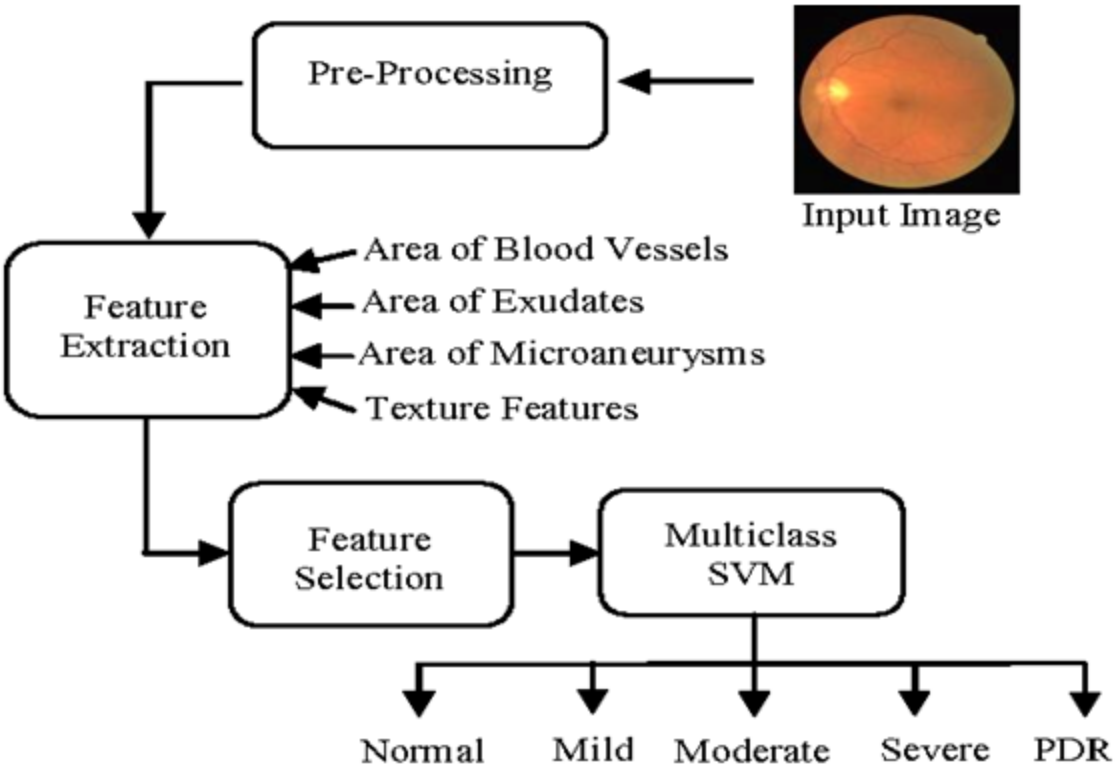
In later stages, it's important to start treatment right away — especially if you experience changes in your vision. While it won't undo any damage to your vision, treatment can stop your vision from getting worse. It's also important to take steps to control your diabetes, blood pressure, and cholesterol.

- Injections : Medicines called anti-VEGF drugs can slow down or reverse diabetic retinopathy. Other medicines, called corticosteroids, can also help.

- Laser treatment : To reduce swelling in your retina, eye doctors can use lasers to makethe blood vessels shrink and stop leaking.

- Eye surgery : If your retina is bleeding a lot or you have a lot of scars in your eye, your eye doctor may recommend a type of surgery called a vitrectomy.

5. FLOWCHART :



6. RESULT :

6.1 DIABETIC RETINOPATHY - IT'S IMPACT :

- Diabetic retinopathy (DR) is blood vessel damage in the retina that happens as a result of diabetes
- It is the leading cause of blindness in the United States (U.S.).

- Symptoms include blurred vision, difficulty seeing colors, floaters, and even total loss of vision.

- People with diabetes should have their vision checked at least once annually to rule out DR.

- There are retinal surgeries that can relieve symptoms, but controlling diabetes and managing early symptoms are the most effective ways to prevent DR.

- Patients With Diabetes Need Annual Eye Exams : Without exception and at a minimum, both the AAO and AOA recommend that every patient with diabetes receive an annual eye exam. The pupils must be dilated to allow proper examination of the retina.It doesn't matter if you take insulin or not. The disease has no bias.

- Diabetes Mellitus Affects the Retina :The retina is the light sensitive tissue that lines the inside of the eye. It is the principle tissue in the eye targeted by diabetes Without a healthy retina, you can not see. It is perhaps the most important structure of the eye.

- Diabetic Retinopathy May be Asymptomatic : Diabetic retinopathy is a slowlyprogressive disease. The key to saving vision is early diagnosis and before there are any symptoms of blurred or decreased vision. Don't let good vision fool you into thinking there is nothing wrong with your eyes!

- Good Sugar Control Does NOT Prevent the Disease :There is nothing to prevent the development of diabetic retinopathy. While sugar control may slow the development of the disease, there is no proof that it will actually prevent the disease. Most doctors and patients are unaware of this one fact.

- Diabetic Retinopathy Can Cause Blindness : While diabetic retinopathy can cause a spectrum of vision loss, true blindness is quite rare. In fact, fewer than 1% of patients with diabetes will sustain "significant" vision loss in their lifetime.In other words, blindness may be prevented most of the time, but early detection and treatment is essential.

- Ophthalmologist or Optometrist Doesn't Matter : In my opinion, not shared by many of my colleagues, I don't think it matters if you are examined by an ophthalmologist (M.D.) or optometrist (O.D.). In my experience, most eye doctors are able to identify/recognize diabetic retinopathy. You should then be referred to a retinal specialist.Diabetic retinopathy has a characteristic appearance that can be recognized easily.

- Retinal Specialists Treat Retinal Disease :Okay, no kidding, but my point is that there are many ways to treat diabetic retinopathy. While you may not be examined regularly by a retina specialist, you should evaluated by a retina specialist once the disease is diagnosed. There are so many treatments available to you at this time to improve or stabilize the condition.

- Every Patient With Diabetes Will Develop the Disease : I have seen very few patients with diabetes over 30 years that are lucky enough not to have developed the disease. I think it is safe to say that most will develop the disease and I tell all my patients to expect the diabetic retinopathy to develop.

- Why? If you expect the disease to develop, you are most likely going to have regular exams. If you expect the disease to develop, then you get rid of the "denial" and seekproper medical treatment. Also, by expecting to develop the disease, you won't feel disappointed in yourself for failing to take better care of your health.

- Macular Edema and Proliferative Diabetic Retinopathy : There are only two "stages" that require treatment. Swelling in the macular area is called macular edema. Macular edema causes blurry vision. Most diabetic patients get this form.Proliferative diabetic retinopathy (PDR) affects fewer patients, but can lead to blindness if not treated.Both macular edema and PDR may occur simultaneously.

- Anti-VEGF, Laser, Steroids and Vitrectomy for Diabetic Retinopathy : We now have an array of treatments depending on the stage and severity. Regardless of the treatment, early detection gives you the best prognosis for maintaining your vision!

6.2 STAGES OF DIABETIC RETINOPATHY :

There are four stages of diabetic retinopathy :

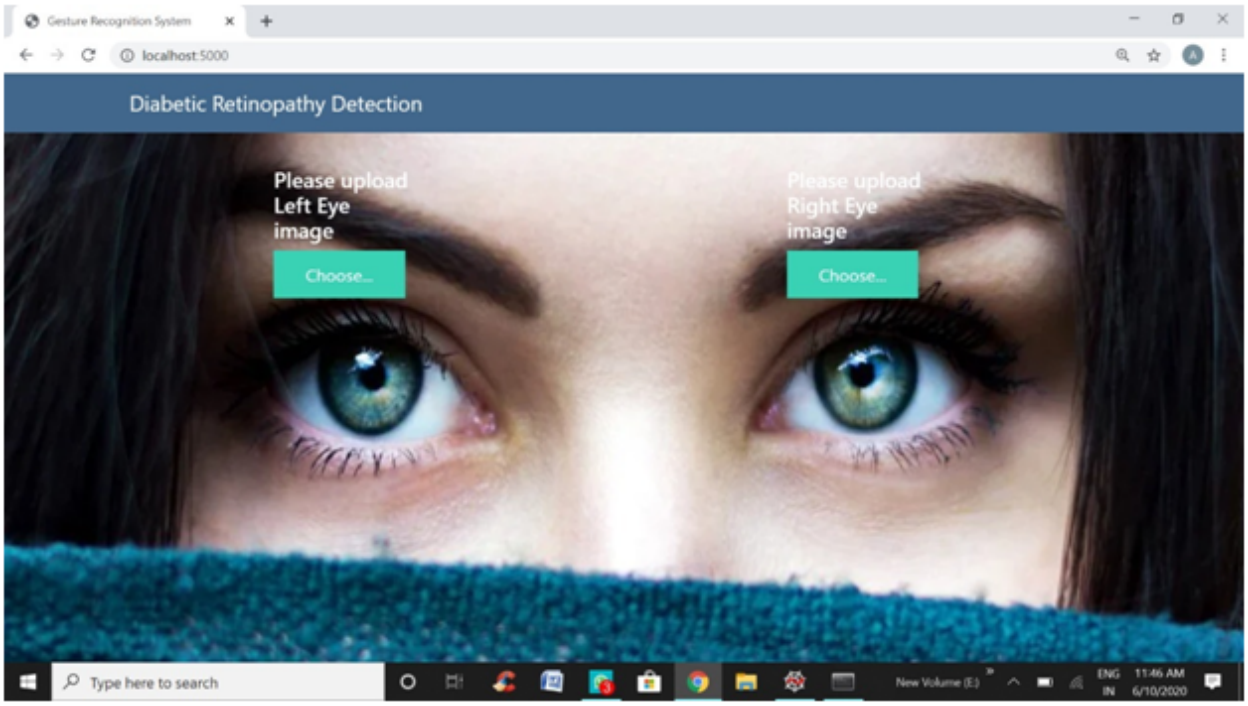
- Mild Nonproliferative Retinopathy – This is the earliest stage of diabetic retinopathy, and it's characterized by balloon-like swelling in the retina's blood vessels. These are called microaneurysms, and these vessels can leak into the eye.

- Moderate Nonproliferative Retinopathy – During this stage, the blood vessels nourishing the retina swell and may even become blocked. This can contribute to diabetic macular edema (DME) which is a build-up of fluid in the macula region of the retina.Because the macula is critical for sharp, clear vision, DME can cause vision changes. In fact, DME is the most common reason people with diabetic retinopathy experience vision loss. Although DME can occur at any stage of diabetic retinopathy, itbecomes increasingly likely as diabetic retinopathy worsens.

- Severe Nonproliferative Retinopathy – At this stage, an increasing number of blood vessels nourishing the eye have become blocked. As a result, the retina is signaled to grow new blood vessels.

- Proliferative Diabetic Retinopathy (PDR) – This is the final stage of diabetic retinopathy. New blood vessels proliferate, growing inside the retina and into the vitreous gel, which is the fluid that fills the eye. Because these blood vessels are delicate, they may begin to leak and bleed. As a result, scar tissue may form, causing retinal detachment, the pulling away of the retina from underlying tissue. Retinal detachment may cause spotty vision, flashes of lights, or severe vision loss.

6.3 OUTPUT :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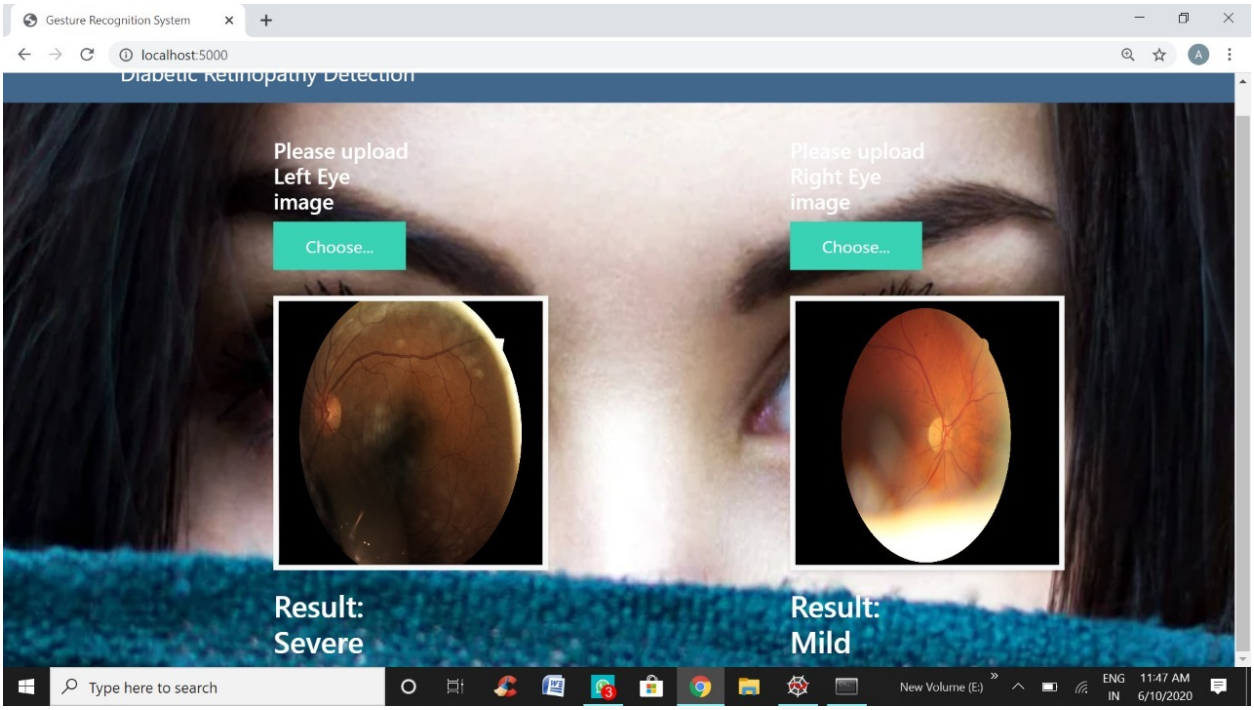
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7. ADVANTAGES :

It’s detectable in its early stages, and there are effective treatments that can prevent vision loss". “Screening for diabetic retinopathy is effective and cost-effective in identifying people who are at risk of vision loss. This has been shown many times.”

7.1 DISADVANTAGES :

The ultimate and most severe complication of diabetic retinopathy is neovascular glaucoma.The newly formed vessels grow from the pupil into the chamber angle, obstructing the outflow of the aqueous humor. Untreated neovascularization glaucoma can lead to painful blindness and shrinking of the eye.

8. APPLICATIONS :

Rising prevalence of diabetes worldwide has necessitated the implementation of populationbased diabetic retinopathy (DR) screening programs that can perform retinal imaging and interpretation for extremely large patient cohorts in a rapid and sensitive manner while minimizing inappropriate referrals to retina specialists. While most current screening programs employ mydriatic or nonmydriatic color fundus photography and trained image graders to identify referable DR, new imaging modalities offer significant improvements in diagnostic accuracy, throughput, and affordability. Smartphone-based fundus photography, macular optical coherence tomography, ultrawide-field imaging, and artificial intelligence-based image reading address limitations of current approaches and will likely become necessary as DR becomes more prevalent. Here we review current trends in imaging for DR screening and emerging technologies that show potential for improving upon current screening approaches.

9. CONCLUSION :

Automated detection and screening offers a unique opportunity to prevent a significant proportion of vision loss in our population. In recent years, researchers have added CNNs into the set of algorithms used to screen for diabetic disease. CNNs promise to leverage the large amounts of images that have been amassed for physician interpreted screening and learn from raw pixels. The high variance and low bias of these models could allow CNNs to diagnose a wider range of nondiabetic diseases as well.

However, while we achieve state-of-the-art performance with CNNs using binary classifiers, the model performance degrades with increasing number of classes. Though it is tempting to surmise that more data may be better, previous work in the field has corroborated that CNN ability to tolerate scale variations is restricted and others have suggested that in the case of retinal images, more data cannot supplement for this inherent limitation. Gulshan et al. reported a 93-96% recall for binary classification of disease but reports that recall is not improved when training with 60,000 samples vs 120,000 samples of a private dataset.

Visualizations of the features learned by CNNs reveal that the signals used for classification reside in a portion of the image clearly visible by the observer. Moderate and severe diabetic retinal images contain macroscopic features at a scale that current CNN architectures, such as those available from the ImageNet visual database, are optimized to classify. Conversely, the features that distinguish mild vs normal disease reside in less than 1% of the total pixel volume, a level of subtleness that is often difficult for human interpreters to detect.

Medical images are fraught with subtle features that can be crucial for diagnosis. Fortunately, the most often deployed architectures have been optimized to recognize macroscopic features such as those present in the ImageNet dataset. We may therefore require a new paradigm for diagnosing diseases via CNN models. This could be a two stage lesion detection pipeline that involves feature localization followed by classification and further preprocessing steps to segment out pathologies difficult to discern by manual inspection, and finally rebalancing network weights to account for class imbalances seen in medical datasets. Overall, our future goals involve improving detection of mild disease and transitioning to more challenging and beneficial multi-grade disease detection.

10. FUTURE SCOPE:

The accuracies of the models can be improved by using higher resolution images of the retina, to train such a model - a highly compute-intensive CPU and GPU would be required. With the constant improvements in Image processing algorithms and techniques, it would soon be possible to have better extraction of images. Experimentation can be done with a number of CNN models and changing the parameters of other learning models to get even better and even more dependable results.