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Automatic Detection of Diabetic Retinopathy Using Convolutional Neural Network

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ABSTRACT: The diagnosis of Diabetic Retinopathy (DR) through color fundus images requires experienced clinicians to identify the presence of miniature features. To overcome this, a computer assisted tool to classify fundus images and to diagnose Diabetes Retinopathy (DR) is proposed. Convolution Neural Network (CNN) is used for extraction and classification of DR using color fundus images. In our approach, CNN uses Dense net architecture which helps for deeper network. In Dense net all the layers preceding to it are concatenated and given as input to current layer. It has an advantage of parameter efficiency, feature reuse and dense connectivity. Deep Learning based CNN is used to extract the features such as Hemorrhages, Micro-Aneurysms, Hard Exudates and Blood Vessels and to classify the fundus images in five categories 1) No DR 2) Mild DR 3) Moderate DR 4) Severe DR 5) Proliferative DR. The proposed method used MESSIDOR dataset and it achieved an accuracy of 84 %. The other parameters such as Specificity and Sensitivity respectively compared with the other state of art methods.

I. INTRODUCTION

Diabetic Retinopathy (DR) is a complication of diabetes that damages the blood vessels of retina causing blindness. If your blood glucose level is too high for long time, it blocks of the small vessels that keep your retina healthy. The eye will try to grow new blood vessels, but they won't develop well. The blood vessels start to weaken. They can leak blood and fluid into retina, this causes another condition called macular edema. DR normally has two different stages named as Proliferative DR (PDR) and Non- Proliferative DR (NPDR).

So, screening of done on retinal images due to its high sensitivity in detecting retinopathy. The analysis of the severity and degree of retinopathy is performed by the medical experts based on the fundus images of the patient's eye. As the numbers of diabetic patients are increasing rapidly, the numbers of retinal images produced by the screening programmers will also an increase, which requires large labor as well as cost to the healthcare services also gets increased. This could be extenuated with an automated system as a diagnosis tool. Many algorithms have been proposed to detect the person is affected with diabetes or not.

1.1 Types

Although diabetic retinopathy — caused by chronic high blood sugar — is the most common form of retinopathy, there are several other types.

All forms of the disease are associated with damage to the blood vessels in the retina. Other forms of retinopathy include:

1. Hypertensive retinopathy (damage caused by high blood pressure).
2. Arteriosclerotic retinopathy (caused by atherosclerosis, hardening or thickening of the arteries).

3. Retinopathy of prematurity (occurs in underweight, premature babies).

1.2 Stages

Diabetic retinopathy tends to go through these four stages:

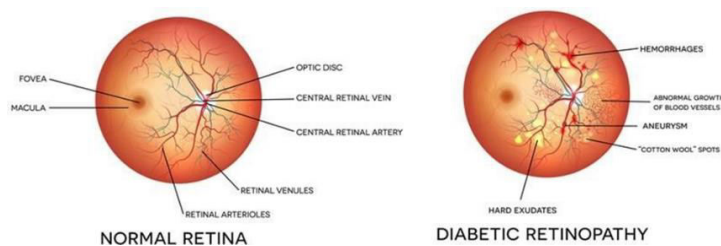
1. Mild non-proliferative retinopathy: In the disease's earliest stage, tiny blood vessels in your retina change. Small areas swell. These are called micro-aneurysms. Fluid can leak out of them and into your retina.
2. Moderate non-proliferative retinopathy: As your disease gets worse, blood vessels that should keep your retina healthy swell and change shape. They can't deliver blood to your retina. This can change the way your retina looks. These blood vessel changes can trigger diabetic macular edema (DME). That's swelling in the area of your retina called the macula.
3. Severe non-proliferative retinopathy: In the third stage, many blood vessels get blocked. They can't deliver blood to your retina to keep it healthy. Areas of your retina where this happens make special proteins called growth factors that tell your retina to grow new blood vessels.
4. Proliferative diabetic retinopathy (PDR): This is the most advanced stage. New blood vessels grow inside your retina and then into the jelly inside your eyeballs called vitreous humor. Fragile new blood vessels are more likely to leak fluid and bleed. Scar tissue starts to form. This can cause retinal detachment, when your retina pulls away from the tissue underneath. This can lead to permanent blindness.

1.3 Causes

If your blood glucose level (blood sugar) is too high for too long, it blocks off the small blood vessels that keep your retina healthy. Your eye will try to grow new blood vessels, but they won't develop well. The blood vessels start to weaken. They can leak blood and fluid into your retina. This can cause another condition called macular edema. It can make your vision blurry.

As your condition gets worse, more blood vessels become blocked. Scar tissue builds up because of the new blood vessels your eye has grown. This extra pressure can cause your retina to tear or detach.

This can also lead to eye conditions like glaucoma or cataracts (the clouding of your eye's lens) that may result in blindness.



II. LITERATURE SURVEY

Firstly, they detected DR by using image processing technique [1] implemented on the input fundus image. The model initially applies the Gaussian blurring, which removes the noise in the image. Later, the image is filtered bilaterally and performs the contour operation. After this color space conversion takes place it creates grayscale image. This picks the grayscale power of each pixel present as a structure. Based on the changes in aliment features, exudates, micro-aneurysms and Hemorrhages are extracted. After classification, it predicts that the person has diabetes are not. This method is a time- consuming process.

The method [2] describes a scheme to detect exudates on the basis of mathematical morphology on non-dilated retinal image. Initially the retinal image was first transformed from RGB to HSI colorspace. The median filtering and adaptive

histogram equalization was used to reduce noise and for contrast enhancement. Finally, Fuzzy Clustering was applied to achieve an accuracy of 99.11%.

The author in [3] proposed detection of DR based on the presence of bright lesions on retina. As the brightness of optic disc and bright lesions are similar, the optic disc is removed initially. Exudates are extracted and its various features are obtained. Later feature based hierarchical classification is performed for detection of different stages. Two methodologies Random Forest Algorithm and Artificial Neural Network are explored and accuracy, sensitivity and specificity are evaluated at each stage. The accuracy of the system is 8%.

The paper [4] used a computer assisted diagnosis based on digital processing of retinal images. It automatically classifies the non-proliferative DR Grade of any retinal images. Initially, preprocessing stage isolates blood vessels, Micro aneurysms, hemorrhages and hard exudates in order to extract feature using Support Vector Machine (SVM). A decision tree classifier is also implemented to contrast the results obtained with our SVM classifier. This method has been tested on 400 images labeled according to 4 scale of NPDR. As a result, the sensitivity and accuracy are 94.6% and 85%. But the limitation here is it is applicable to smaller dataset in order to perform on large dataset the processing time will be more and detection of micro-aneurysms is very poor.

III. TECHNIQUES OF DIABETIC RETINOPATHY

3.1 MACHINE LEARNING

Machine learning (ML) is a category of an algorithm that allows software applications to become more accurate in predicting outcomes without being explicitly programmed. The basic premise of machine learning is to build algorithms that can receive input data and use statistical analysis to predict an output while updating outputs as new data becomes available.

3.1.1 Types of Machine Learning

Machine Learning Algorithms can be classified into 3 types as follows –

Supervised Learning:

In Supervised Learning, the dataset on which we train our model is labeled. There is a clear and distinct mapping of input and output. Based on the example inputs, the model is able to get trained in the instances. An example of supervised learning is spam filtering. Based on the labeled data, the model is able to determine if the data is spam or ham. This is an easier form of training. Spam filtering is an example of this type of machine learning algorithm.

Unsupervised Learning:

In Unsupervised Learning, there is no labeled data. The algorithm identifies the patterns within the dataset and learns them. The algorithm groups the data into various clusters based on their density. Using it, one can perform visualization on high dimensional data. One example of this type of Machine learning algorithm is the Principle Component Analysis. Furthermore, K-Means Clustering is another type of Unsupervised Learning where the data is clustered in groups of a similar order.

Reinforcement Learning:

Reinforcement Learning is an emerging and most popular type of Machine Learning Algorithm. It is used in various autonomous systems like cars and industrial robotics. The aim of this algorithm is to reach a goal in a dynamic environment. It can reach this goal based on several rewards that are provided to it by the system.

3.2 Artificial Intelligence

“Artificial Intelligence is the science of machines doing things that would require intelligence if done by man.” That means, AI is not specifically related to computer science. This is a field of study that encompasses human behaviour, biology,

psychology, and even language and linguistics. There's still not a common consensus among academicians about its definition.

In this blog post, we try to give a broader picture of AI. How it is organized and its various areas and fields of study. First we will discuss the terminologies associated with AI and then we will discuss the techniques used in implementing AI.

3.1.2 Techniques Used in AI

Myriads of AI techniques have emerged in the past decade for implementing and building AI systems.

1. Natural Language Processing

In a one-liner, natural language processing is the study of how a computer interacts with a human language. Broadly, in application sense, it refers to speech recognition and speech synthesis in human language.

This field of study is already in application phase and companies are using it in their voice assistants. Apple's Siri, Google Assistant, Microsoft's Crotona, and Amazon's Alex relies a lot on natural language processing.

Natural language processing further uses different techniques for implementation like parsing techniques, text recognition, and part-of-speech tagging.

2. (Artificial) Neural Networks

Neural networks are available in living beings. Humans and animals use a complex network of billions of neurons (which makes neural systems) to take decisions in day life and learn new things to do. Building artificial neural networks is an attempt to create neural networks modelled on our own brains!

These networks can identify patterns in inputs as it processes a lot of data and learn from it. It uses different learning methods: supervised learning, unsupervised learning, and reinforced learning. Neural networks have wide applications in pattern recognition, machine learning, and deep learning.

3. Vector machines

Vector machines are really capable in solving classification problems. For instance, an email system like Gmail for classifying an email as 'Social' or 'Promotion' or 'Personal' in nature and categorizing them in their respective categories.

The fundamental of vector (or sometimes called support vector) machines is to create parameters that draw the line between two distinct objects dividing them into two classes. This technique of AI has wide applications in image recognition, face recognition, and text recognition systems.

3.1 Neural Networks

You've probably already been using neural networks on a daily basis. When you ask your mobile assistant to perform a search for you—say, Google or Siri or Amazon Web—or use a self-

driving car, these are all neural network-driven. Computer games also use neural networks on the back end, as part of the game system and how it adjusts to the players, and so do map applications, in processing map images and helping you find the quickest way to get to your destination.

3.3.1 Working of Neural Network

A neural network is usually described as having different layers. The first layer is the input layer, it picks up the input signals and passes them to the next layer. The next layer does all kinds of calculations and feature extractions—it's called the hidden layer. Often, there will be more than one hidden layer. And finally, there's an output layer, which delivers the final result.

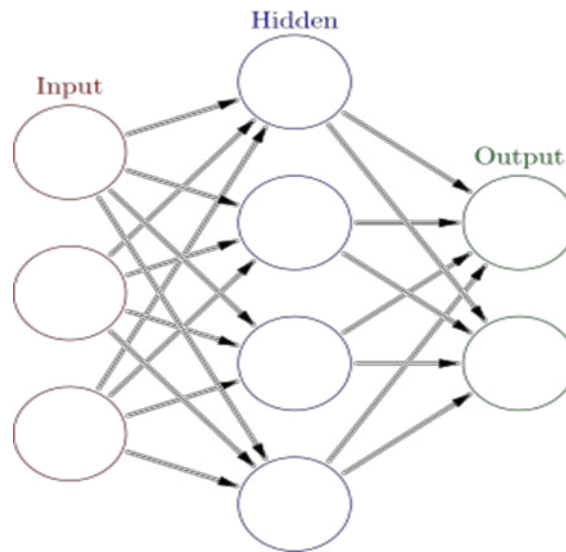


Fig 3.1 Simple Neural Networks

IV. EXISTING METHOD AND PROPOSED METHOD

4.1 EXISTING METHOD:

4.1.1 ARTIFICIAL NEURAL NETWORK:

Single perceptron (or neuron) can be imagined as a Logistic Regression. Artificial Neural Network, or ANN, is a group of multiple perceptron/ neurons at each layer. ANN is also known as a Feed- Forward Neural network because inputs are processed only in the forward direction:

As you can see here, ANN consists of 3 layers – Input, Hidden and Output. The input layer accepts the inputs, the hidden layer processes the inputs, and the output layer produces the result. Essentially, each layer tries to learn certain weights.

4.2 PROPOSED METHOD:

4.2.1 CONVOLUTION NEURAL NETWORK:

The convolutional neural network, or CNN or ConvNet for short, is a specialized type of neural network model designed for working with two- dimensional image data, although they can be used with one-dimensional and three-dimensional data.

It's a deep, feed-forward artificial neural network. Feed-forward neural networks are also called multi-layer perceptron (MLPs). The models are called "feed-forward" because information flows right through the model. There are no feedback connections in which outputs of the model are fed back into itself. CNN use many filters to extract features the first layers learn basic feature detection filters: edges, corners, etc after that the middle layers learn filters that detect parts of objects finally the last layers have higher representations: they learn to recognize full objects, in different shapes and positions. There are two types of pooling techniques Max pooling and Average pooling.

4.2.2 CNN ARCHITECTURE:

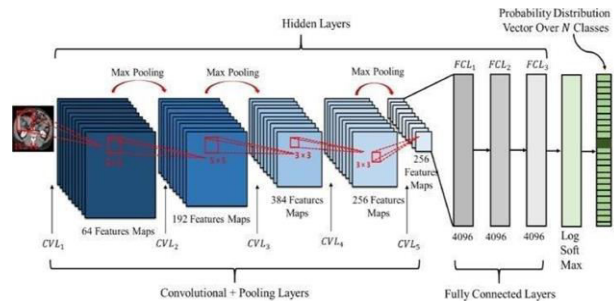


Fig 4.3 :CNN Architecture

There are five types of layers in a convolutional neural network:

1. Convolution layer.
2. Rectified linear unit layer (ReLU).
3. Sub sampling layer/Pooling layer.
4. Fully connected layer.
5. SoftMax layer.

V. SOFTWARE REQUIREMENTS

5.1 ANACONDA

It is a free and open-source distribution of the Python and R programming languages for scientific computing (data science, machine learning applications, large-scale data processing, predictive analytics, etc.), that aims to simplify package management and deployment.

Anaconda distribution comes with more than 1,500 packages as well as the Conda package and virtual environment manager. It also includes a GUI, Anaconda Navigator, as a graphical alternative to the Command Line Interface (CLI).

Anaconda Navigator is a desktop Graphical User Interface (GUI) included in Anaconda distribution that allows users to launch applications and manage conda packages, environments and channels without using command-line commands. Navigator can search for packages on Anaconda Cloud or in a local Anaconda Repository, install them in an environment, run the packages and update them. It is available for Windows, macOS and Linux.

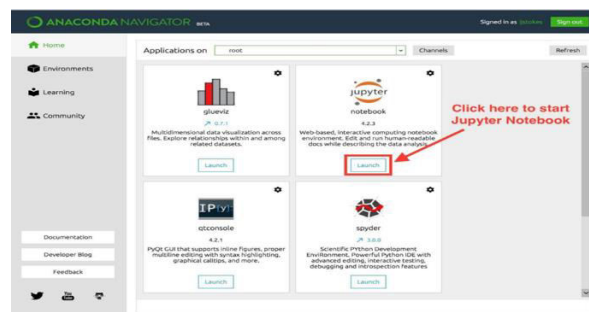


Fig5.1 : Anaconda Navigator



5.2 PYTHON

Python is a powerful multi-purpose programming language created by Guido van Rossum.

It has simple easy-to-use syntax, making it the perfect language for someone trying to learn computer programming for the first time.

You can create scalable Web Apps using frameworks and CMS (Content

Management System) that are built on Python. Some of the popular platforms for creating

Web Apps are: Django, Flask, Pyramid, Plone, Django CMS.

Sites like Mozilla, Reddit, Instagram and PBS are written in Python.

5.3 Tensorflow

Currently, the most famous deep learning library in the world is Google's TensorFlow. Google product uses machine learning in all of its products to improve the search engine, translation, image captioning or recommendations. To give a concrete example, Google users can experience a faster and more refined the search with AI. If the user types a keyword a the search bar, Google provides a recommendation about what could be the next word.

5.4 Keras

Keras runs on top of open source machine libraries like TensorFlow, Theano or Cognitive Toolkit (CNTK). Theano is a python library used for fast numerical computation tasks. TensorFlow is the most famous symbolic math library used for creating neuralnetworks and deep learning models. TensorFlow is very flexible and the primary benefit is distributed computing. CNTK is deep learning framework developed by Microsoft. It uses libraries such as Python, C#, C++ or standalone machine learning toolkits. Theano and TensorFlow are very powerful libraries but difficult to understand for creating neural networks.

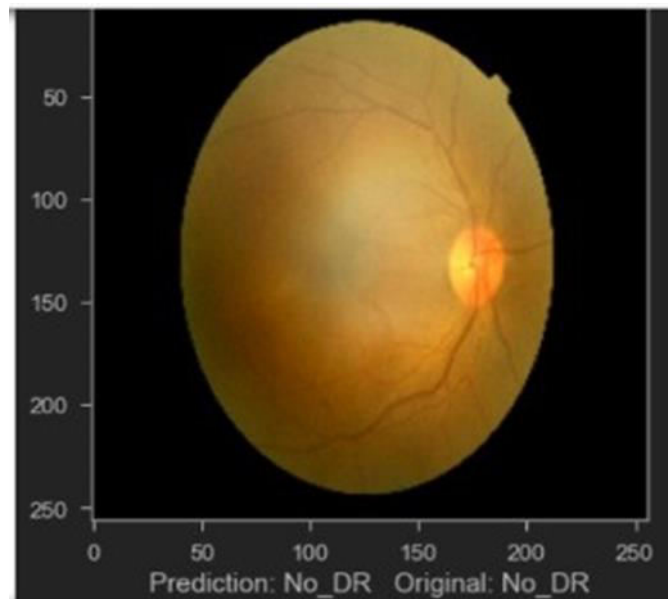
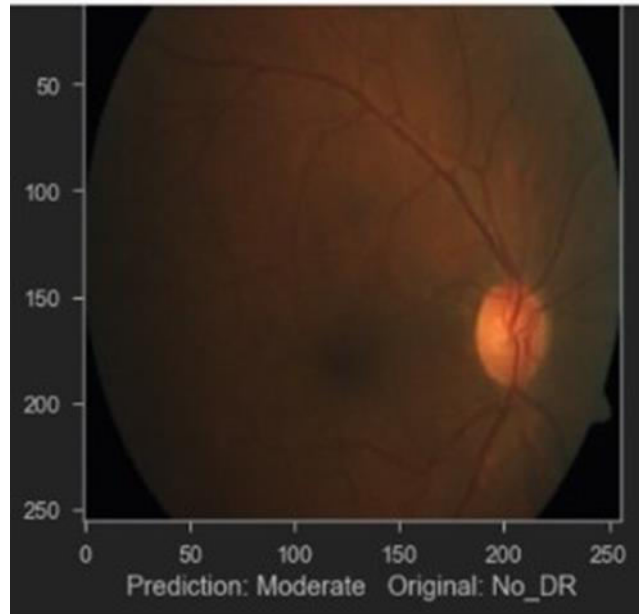
5.5 Pytorch

Pytorch is defined as an open source machine learning library for Python. It is used for applications such as natural language processing. It is initially developed by Face book artificial-intelligence research group, and Uber's Pryor software for probabilistic programming which is built on it.

Originally, Pytorch was developed by Hugh Perkins as a Python wrapper for the LusJIT based on Torch framework. There are two Pytorch variants.

Pytorch redesigns and implements Torch in Python while sharing the same core C libraries for the backend code. Pytorch developers tuned this back-end code to run Python efficiently. They also kept the GPU based hardware acceleration as well as the extensibility features that made Luau- based Torch.

VI. RESULT



VII. CONCLUSION AND FUTURE SCOPE

Conclusion

Detection of Diabetic Retinopathy helps in prevention of blindness. This can be used to detect the stages of Diabetic Retinopathy by visualizing various features like micro aneurysm, hemorrhages and exudates. These features are detected from retinal images that are collected from few datasets. Convolutional Neural Network method is used to detect the features and classify them. By using this method accuracy of 84% is obtained.



Future Scope

In future, Deep learning method is used to detect the diabetic retinopathy for high accuracy and to decrease the time consumption. It uses large set of labeled images for high value of sensitivity and specificity.

Also, an API may be implemented in android mobile to detect the Diabetic Retinopathy using Deep learning, Artificial Intelligence and other techniques.

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