SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
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DIABETIC RETINOPATHY DETECTION USING FUNDUS PHOTOGRAPHY

ABSTRACT

- Diabetic retinopathy (DR) is a diabetes related eye disease which occurs when blood vessels in the retina become swelled and leaks fluid which ultimately leads to vision loss.
- It is estimated to have affected over 93 million worldwide and has become one of the leading causes for acquired blindness in the working population.
- Destruction of damaged retina by photocoagulation remains the primary treatment nearly 50 years after its introduction. The diabetes pandemic requires new approaches to understand the pathophysiology and improve the detection, prevention, and treatment of retinopathy

INTRODUCTION

- Diabetes has always been a very widespread disease. Approximately 40% of People suffering from prolonged diabetes are prone to a conditions called as Diabetic Retinopathy. Severe cases of Diabetic Retinopathy can even lead to permanent blindness.
- For the detection of Diabetic Retinopathy a patient needs to take the retinal images of the eye and show it to a specialised medical practitioner . There can be error in judgement by the expert and in many cases these specialised practitioners are not available everywhere. Hence we require a more advanced and easily available solution to detect Diabetic Retinopathy.
- It is here that Deep Neural Network comes into the picture. It provides an easy analysis of people’s fundus images and most importantly can be accessible everywhere.

LITERATURE SURVEY

Diabetic Retinopathy: Present and Past

- **DATABASE**: EyePACS-1 and Messidor-2
- **AUTHORS**: Ankita Guptaa, Rita Chhikarab
- **ALGORITHM USED**:

This paper reviews the various techniques used for detecting DR based on the features like blood vessels, microaneurysms, haemorrhages etc. In most of the experiments retinal fundus images were used in which images of retina were captured by fundus camera. This review bifurcates the detection of DR into two approaches; Blood vessels segmentation and Identification of lesions. This paper compares the experimental results of various machine learning techniques based on parameters like sensitivity, specificity, Area Under Curve (AUC), Accuracy. The results are also compared with the deep neural networks and analysis of best technique has been provided.

RECOGNITION OF DIABETIC RETINOPATHY BASED ON TRANSFER LEARNING

- **DATABASE:** EYEPAC'S DATASET
- **AUTHORS:** Yuchen Wu and Ze Hu
- **ALGORITHM USED**:

It uses the Migration Learning Approach which is one of the new machine learning approaches. There are four different approaches to implement this method They have used Feature based Transfer Learning. The pre-training model they used is based on ImageNet.

- **ACCURACY:**

The accuracy that was obtained using ResNet50 was 50%.

Deep Neural Network for Diabetic Retinopathy Detection

- **DATABASE:** EYEPACS DATABASE
- **AUTHORS:** Mamta Arora and Mrinal Pandey of Manav Rachna University
- **ALGORITHM USED**:

They basically followed a two step process which includes step 1 :data pre-processing and augmentation and step2: convolution layer. The convolutional layer was further divided into a 5 step process which involved convolutional layer, The basic building block of Convolutional neural extracting weights, Pooling Layer , connecting layer and logistic classifier

- **ACCURACY**: The accuracy that was obtained was 74%.

COMPUTER AIDED APPROACH FOR PROLIFERATIVE DIABETIC RETINOPATHY DETECTION IN COLOR RETINAL IMAGES

- **DATABASE**: MESSIDOR AND STARE
- **AUTHORS:** Anaswara Chandran, Prof. Nisha K K and Dr. Vineetha S
- **ALGORITHM USED**:

Random Forest classifier is used for the classification process because it has the ability to handle higher dimensional feature sets. Different patches of dataset are used to train various decision trees. The patches are extracted from the image sets. The patches undergo two distinct extraction processes namely Texture Feature Extraction and Vessel Feature Extraction. The decision trees after giving various decisions it's output is fed forward to random forest classifier which uses a rule based approach to classify the images to reach to a certain result.

- **ACCURACY**: The accuracy obtained was 89% for MESSIDOR dataset and 88% for dataset STARE

Diabetic Retinopathy Detection using feedforward Neural Network

- **DATABASE**: MESSIDOR dataset [8]
- **AUTHORS**: Jayant Yadav, Manish Sharma, Vikas Saxena
- **ALGORITHM USED**:

DR detection is being done by detecting two major parts of it, namely Exudates and Dot Hemorrhages. First, we will do the preprocessing (1. Extracting Optic Disk 2. Extracting Blood Vessels 3. Detection of Exudates 4. Detection of Dot hemorrhages) which is followed by training the dataset [8] using machine learning, which is by applying neural networks.

- **ACCURACY**: 75% accuracy

Automated detection of diabetic retinopathy using SVM

- **DATABASE**: The Messidor database [10] consists of 1200 eye fundus color numerical images of the posterior pole.
- **AUTHORS:** Enrique V. Carrera, Andrés González, Ricardo Carrera
- **ALGORITHM USED**:

The proposed system (detection of blood vessels, micro aneurysms, the optic-disc, and hard exudates have been presented) was tested on 400 images of Messidor database and then SVM algorithm used on the processed data which showed great potential for future clinical trails for early detection of DR detection compared to other classification algorithms.

- **ACCURACY**: SVM can classify NPDR with an average accuracy of 85%.

Classification of Non-Proliferative Diabetic Retinopathy Based on Hard Exudates Using Soft Margin SVM

- **DATABASE**: Messidor database [14]
- **AUTHORS:** Handayani Tjandrasa, Ricky Eka Putra, Arya Yudhi Wijaya, Isye Arieshanti
- **ALGORITHM USED**:

This study proposes a classification system of NPDR based on exudate features. The main processes in this study are exudate segmentation, feature extraction and the classification of NPDR severity level. The exudate segmentation performs the exudate extraction and transforms the segmented exudates into a binary image. Finally, the extracted features are trained and tested using soft margin SVM as a classification model.

- **ACCURACY**: SVM model achieves high accuracy (90.54 %) when classify retinal fundus images as moderate NPDR or severe NPDR

EXUDATE DETECTION FOR DIABETIC RETINOPATHY WITH CONVOLUTIONAL NEURAL NETWORKS

- **DATABASE**: The database used is E-Ophtha EX
- **AUTHORS:** Shuang Yu, Di Xiao and Yogesan Kanagasingam
- **ALGORITHM USED**:

CNN model (Convolutional Neural Network) was used to detect the Diabetic Retinopathy. It is used to achieve pixel-wise exudate image patches. The Framework for exudate detection with deep learning includes three main procedures before the image is sent to the DR model that was established using CNN. The three major steps are Removal of Optic Disc Detection, Removal of Retinal Vessels,Ultimate Opening.

- **ACCURACY**: The accuracy obtained was of 91.2%

Guassian transformed glcm features for Classifying Diabetic Retinopathy

- **DATABASE**: DRIVE and MESSIDOR
- **AUTHORS**: Vaishali Suryawanshi, Shilpa Setpal
- **ALGORITHM USED**:

This paper proposes a new method by using MESSIDOR dataset for training and DRIVE dataset for testing, the proposed method uses exacting GLCM features and transforming the points using Gaussian function into higher dimension and feeding these points into two layer feed forward network for training.

- **ACCURACY**: The proposed method achieves 90% accuracy.

INFERENCE FROM THE SURVEY

- Regarding the pre-processing phase, we can conclude that Optic disc detection, Red Lesion detection, Blood Vessel and micro aneurisms play a major role in determining DR.
- DATA PREPROCESSING helps in increasing the quality of the photos. The quantity of the photos is also improved by using Keras ImageGenerator(). The fact that these previous systems use manual resources hence these resources are sometimes not available or exhausted.
- Owing to the fact that manual procedure of these tasks is a complex and time-consuming task, it would be more prudent to use the proposed system for Diabetic Retinopathy Detection.
- Automation tools and procedures like using CNN for detection of DR enables patients to get their retinas detected in a more accurate and efficient manner.
- The early detection of DR is also skipped out by ophthalmologists hence making this model one the more efficient methods.
- Thus enables CNN in saving time and improving efficiency, accuracy, and consistency while avoiding human errors and reducing human efforts

OBJECTIVE OF THE PROJECT

- Preliminary detection of Diabetic retinopathy is a challenging task as the doctors can't provide a diagnosis as there are no symptoms until vision loss occurs. Henceforth, patients with diabetes ought to have extensive retina screening annually.
- To detect this particular disease, a retinography based on Colour fundus photography is employed is conducted and analysed manually by ophthalmologists capturing the structures such as the blood vessels, exudates, haemorrhages, microaneurysms, and texture within the eye (retina) by either dilating the pupil or without dilation.
- However, the manual analysis and risk assessment is a time consuming, laborious and a fairly complex process which could be done more efficiently by a machine if automated to find the vital traits of the patients.
- Hence, the project entails the development of a Deep Learning model to diagnose diabetic retinopathy by extracting the key features while addressing performance-related issues, detection accuracy and real patient image dataset vs. standard database images within a low-cost background.

ARCHITECTURE DIAGRAM

FUNDUS CAMERA

Images

DATASET

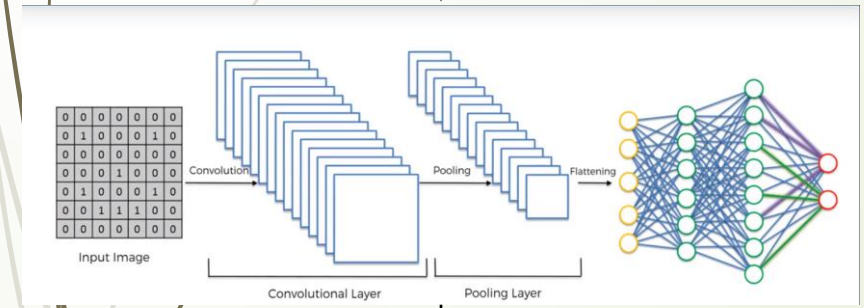
Supervised learning

LABELLING BY OPHTHALMOLOGIST

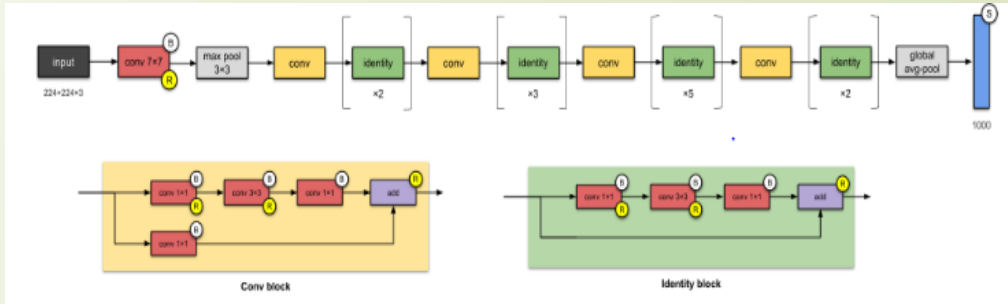
DATA PRE-PROCESSING

IMAGE DATA GENERATOR

CNN



ResNet50



MODEL.H5

FLASK

MODEL.H5

WEBSITE USER INTERFACE

USER

Images

OUTPUT

MODULES DESCRIPTION

MODULE 1:FUNDUS CAMERA

- A fundus camera is a specialized low power microscope that has an attached camera. An angle of 30deg is considered the normal angle of view, creates the film image two times(approx) larger than life. Wide-angle cameras capture images that are between 40 deg to 140deg and provide proportionately less retinal magnification.
- Fundus photography documents the retina, the neurosensory tissue in our eyes which translates the optical images we see into the electrical impulses our brain understands. The fundus image of the retina can be photographed directly.
- We define fundus imaging as the process whereby reflected light is used to obtain a two-dimensional (2D) representation of the 3D, semitransparent, retinal tissues projected on to the imaging plane

MODULE 2: DATASET

- The dataset consists of the fundus image of the eye. These datasets were obtained through various medical healthcare facilities.
- For the development of algorithm, macula- centered fundus images were obtained from EYEPACS in the U.S and three other hospitals in India.
- Since including all the images consisting of various unrequired features would lead to over fit of the model hence will lead to bad modelling of the CNN. Therefore, to achieve efficient modelling, we progressed to a more smaller but ideal dataset that would help in learning different features.
- The dataset consisted of fundus image from varied patients who had extremely varied levels of lightening and hence are being able to be labelled in a consistent manner

MODULE 3:DATA PREPROCESSING

- Data pre-processing is an integral step in Machine Learning as the quality of data and the useful information that can be derived from it directly affects the ability of our model to learn, thus it is one of the most major steps to pre-process the data before feeding it to the model.
- Image processing is the first and the most important part of data processing as the performance of the Machine learning model depends solely on the data it is trained with. Techniques such as segmentation, Fourier Transforms, Wavelet Transforms, and Image Augmentation are employed to build more robust and accurate models when training data is limited.
- the Keras ImageDataGenerator class actually works by: • Accepting a batch of images used for training. • Taking this batch and applying a series of random transformations to each image in the batch (including random rotation, resizing, shearing, etc.). • Replacing the original batch with the new randomly transformed batch. • Training the CNN on this randomly transformed batch (i.e., the original data itself is not used for training).

MODULE 4:Architecture

- A Convolutional Neural Network (ConvNet/CNN) could be a Deep Learning algorithm that has the ability or the potential to take in an input image, assign importance (learnable weights and biases) to varied aspects/objects within the image and be able to differentiate one from the other.
- The pre-processing required in a ConvNet is much lower as compared to other classification algorithms.
- Transfer Learning was also used using ResNet50 architecture for classification. This method uses the previously obtained knowledge into further classifying the images

MODULE 5: WEBSITE

- **HTML and CSS:** HTML is a standard markup language for web pages. HTML helps in creating the basic structure of the web application, it is also useful in creating forms on web applications. CSS is one of the essential components that helps in making the website look appealable to the user. CSS stands for cascading style sheets. It mainly helps in determining how the text looks on the web application.
- **Flask:** Flask is a web framework, therefore, flask provides with tools and libraries that help us build web applications. Flask is a micro-framework, meaning they have no or very little dependencies. Flask is able to incorporate deep learning and machine learning models onto a web application. Flask being a light weight framework provide little or no dependencies debug.

NOVELTY IN METHODOLOGY

- **Gaussian Blur–** Gaussian Blur is a mathematical function used to reduce noise and to remove nonessential features present in the image. Gaussian Blur helps in blurring the edges and reducing the contrast.
- **Auto Cropping –** Auto cropping is a data pre-processing approach that was applied to the dataset to remove the background noise and realize all the essential feature parameters present in the fundus dataset.
- **Tranfer Learning–**Transfer learning is one of the machine learning techniques which helps the model by incorporating model weights file in the neural architecture

ALGORITHMS USED

DATA PRE-PROCESSING

- PADDING (removal)
- GAUSSIAN BLUR
- AUTO CROPPING

REMOVAL OF PADDING

- The input data consists of fundus images in various dimensions. The image is encapsulated with noise in the form of padding of blackened pixels. The removal of the padding layer reduces the noise present in the input image while focusing on the essential components of the data. The input data is resized to a specific size(256x256) which provides uniformity to the dataset which provides stability in applying pre-processing operations and feeding data to neural networks.

GAUSSIAN BLUR

- Gaussian Blur is a mathematical function used to reduce noise and to remove nonessential features present in the image. Gaussian Blur helps in blurring the edges and reducing the contrast. Gaussian Blur have been used for feature extraction and it further helps enhance the essential features of the input data. This helps the algorithm to differentiate between essential and nonessential features present in the image.

AUTO CROPPING (CIRCULAR CROP)

- The pre-processed(Gaussian blur filters) image still consists of nonessential components in the form of noise around the corners of the image due to the spherical shape of the eyeball. Auto cropping is a data pre-processing approach that was applied to the dataset to remove the background noise and realize all the essential feature parameters present in the fundus dataset. Auto Cropping perceives the major portion of the eye required by identifying the circular component of the image where the eye is located. The remaining portion which consisted of nonessential features was blackened out to remove any intrusion to the neural network by the noise. Auto Cropping helps in eradicating the noise as well as extracting all the features of the eye present in the image.

DATA AUGMENTATION

- KERAS IMAGE DATA GENERATOR

It is a data augmentation function that is used to increase the dataset size and helps generate a more normalised input for the network. The training data is fed as batch of images to the network. The ImageDataGeneraor takes the training data as input which undergoes certain transformations. The new set of images along with the previous dataset realize to be the new dataset for the system. This helps us improve the normalisability of the model.

NEURAL NETWORK ARCHITECTURE

- CONVOLUTIONAL NEURAL NETWORK
- TRANSFER LEARNING IN RESNET

CONVOLUTIONAL NEURAL NETWORK

- CNN consists of three distinct layers such as a convolutional layer, pooling layer and the fully-connected layer. All the features are extracted with the use of various convolutional and max-pooling layer. The high dimensional features which were extracted from the last pooling layer are fed onto the fully connected layer for final optimization.
- Hyper parameters decide the neural structure and determine how the network behaves during training and testing. These parameters are set to optimize the stability and accuracy of the model.
- **Dropout function –** It is used to avoid overfitting of the model.
- **Activation function-** helps to institute linearity in the models.
- **Epochs-** Number of times training happens on training set.
- **Optimization-** it is an algorithm that is used for changing values of parameters such as weights and learning rate to reduce losses.

TRANSFER LEARNING IN RESNET

- Transfer learning is one of the machine learning techniques which helps the model by incorporating model weights file in the neural architecture. It is a popular deep learning technique which helps in optimization and improvement of the learning process in a neural network. In a classification model such as ResNet50 reducing computational overhead is very cost effective transfer learning becomes a major benefit.
- RESNET50 is a pre trained neural network model which has been trained over the ImageNet database. The training of the neural networks is eased out on application of ResNet50 as it provides residual learning framework.

SCREENSHOT OF THE PROJECT

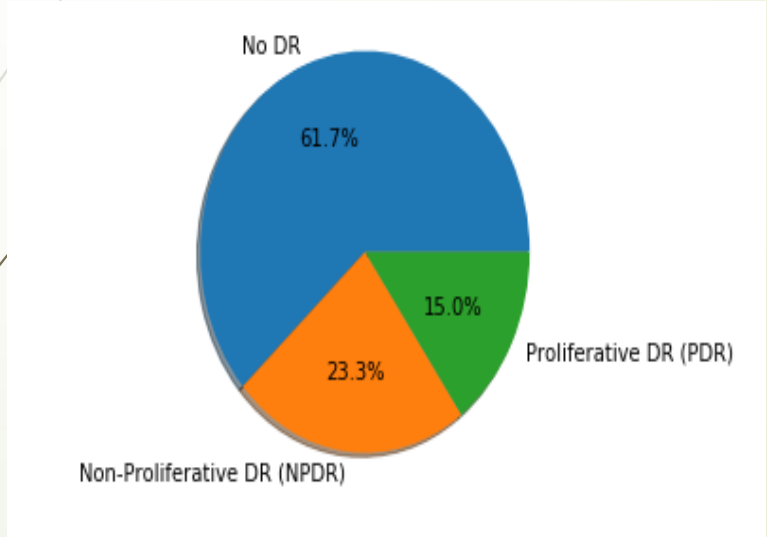


Figure 1 SAMPLE DATASET

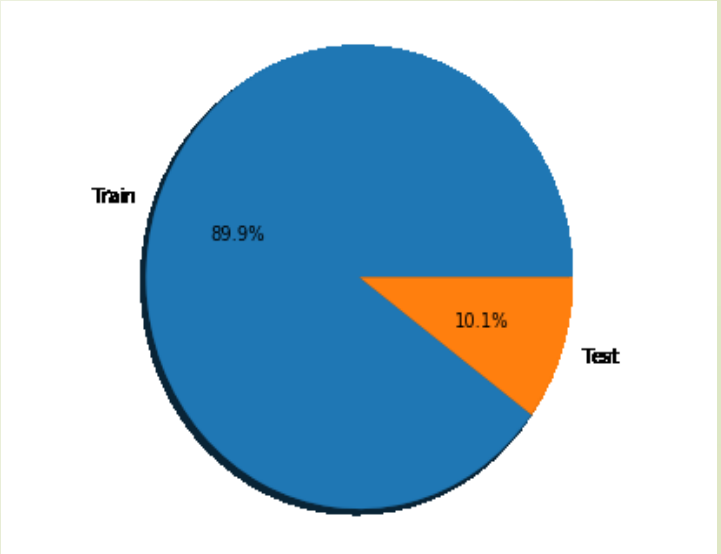


Figure 2 SPLITTING OF TRAINING AND TESTING

CNN

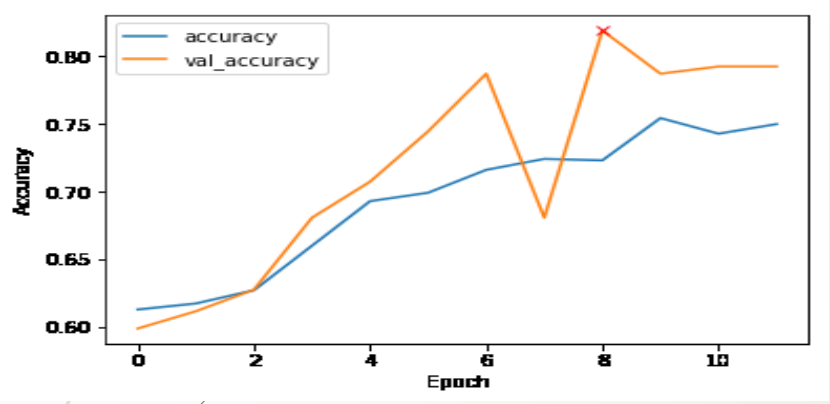


Figure 1 ACCURACY without GAUSSIAN BLUR

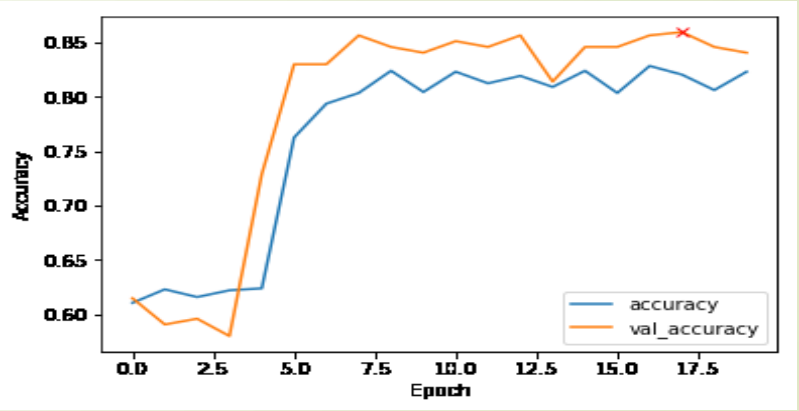


Figure 2 ACCURACY with GAUSSIAN BLUR

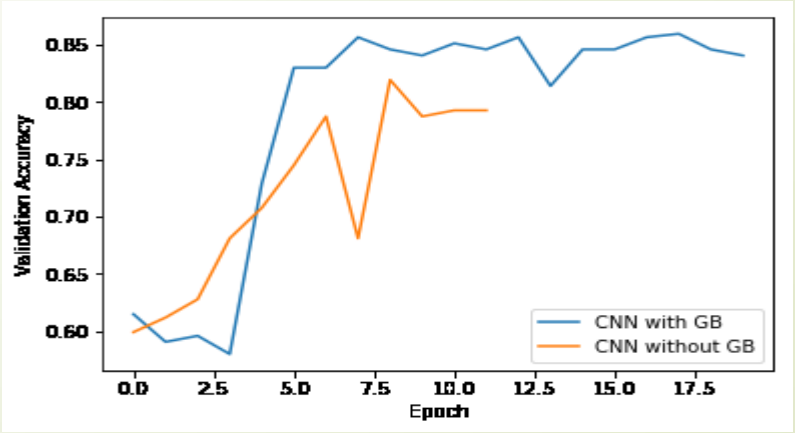


Figure 3 COMPARISON

ResNet50

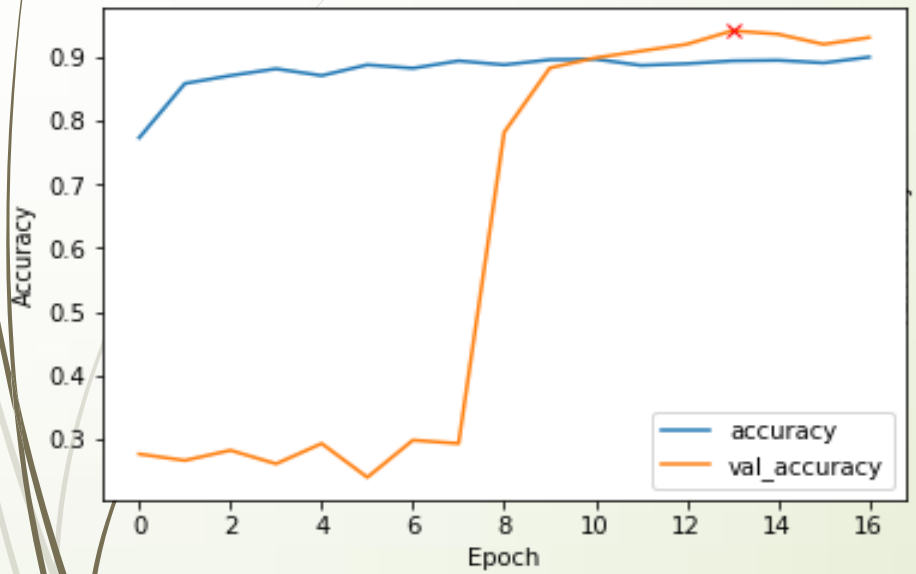


Figure 1 ResNet50 ACCURACY

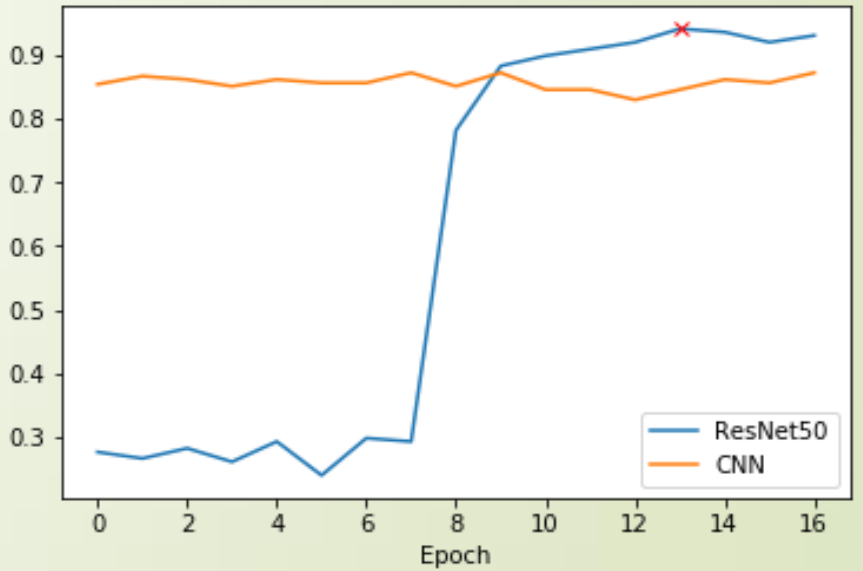
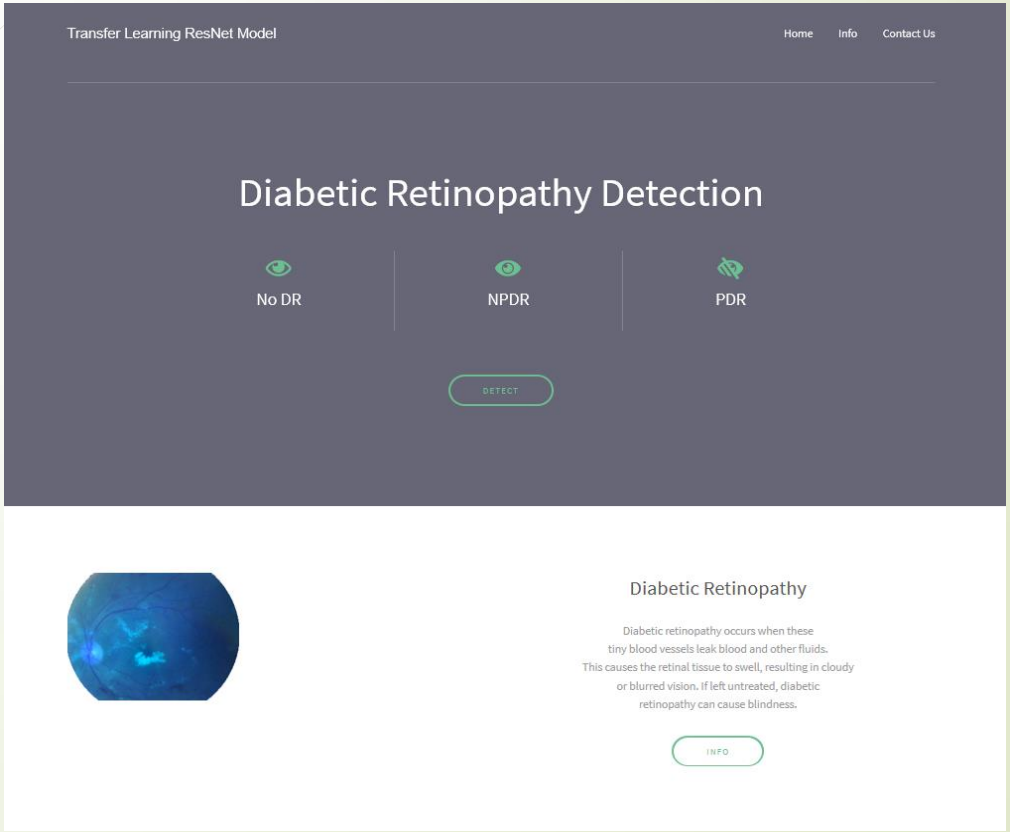


Figure 2 COMPARISON

WEBSITE


Transfer Learning ResNet Model
Home
Info
Contact Us
Diabetic Retinopathy Detection
No DR
NPDR
PDR
DETECT
Diabetic Retinopathy
Diabetic retinopathy occurs when these tiny blood vessels leak blood and other fluids. This causes the retinal tissue to swell, resulting in cloudy or blurred vision. If left untreated, diabetic retinopathy can cause blindness.
INFO

Transfer Learning ResNet Model

Home Info Contact Us

Patient DR Diagnosis

Upload Fundus Image

Upload data

Predict !!

Get in touch

Name

Name

Email

Email

Message

Message

Transfer Learning ResNet Model

Home Info Contact Us

Patient DR Diagnosis

Upload Fundus Image

Upload data

No DR

Get in touch

Name

Name

Email

Email

Message

Message

RESULTS AND DISCUSSIONS

- In this paper, the proposed methodology contains a series of simple yet effective preprocessing techniques like removal of padding, auto cropping and Gaussian blur which has shown great effect in the DR detection model.
- From the comparison of CNN layers with and without Gaussian Blur where the former came out to be triumphed by a significant improvement in the overall stability and precision of the model. Auto cropping and Gaussian Blur removes the irrelevant portions captured in a fundus image and keeps the vital part of the eye to be used for the detection and classification of the Diabetic retinopathy.
- As seen with the accuracy curve of the CNN model, Gaussian Blur helps to improve the accuracy of Diabetic Retinopathy detection . CNN was only able to achieve about 81% but with Gaussian blur added as a preprocessing technique, the model was able to achieve an accuracy of about 86%. This shows how valuable Gaussian blur is as a preprocessing technique for Fundus Images.
- ResNet was the most successful architecture with an accuracy of about 94%. ResNet was able to achieve this with the help of transfer learning which greatly reduces computation time and other preprocessing techniques which resulted in an optimal score of 94%. This shows that it is capable of detecting Diabetic Retinopathy in real time.

COMPARISON OF MODELS USED

NAME	PERFORMANCE		
	VALIDATION ACC	TEST ACC	LOSS FUNC
CNN without Gaussian Blur	81.91%	69.19%	0.189
CNN with Gaussian Blur	86.16%	78.67%	0.1425
RESNET50 withGaussian Blur	93.9%	92.99%	0.0002

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PUBLISHING DETAILS

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CERTIFICATE

This certifies that the research paper entitled **'Diabetic Retinopathy Detection using Fundus Photography'** authored by **'Hritik Rao, Pranjay Bajaj, Kanmani Sivagar'** was reviewed by experts in this research area and accepted by the board of 'Blue Eyes Intelligence Engineering and Sciences Publication' which has published in **'International Journal of Innovative Technology and Exploring Engineering (IJITEE)'**, ISSN: 2278–3075 (Online), Volume-9 Issue-6, April 2020, Page No. 1194-1198.

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Jitendra Kumar Sen
(Manager)

Dr. Shiv Kumar
(CEO)

SOFTWARE USED

- **Python 3.x:** Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development.
- **Tensor Flow 1.1x**: TensorFlow is an open source software library released in 2015 by Google to make it easier for developers to design, build, and train deep learning models.
- **Numpy** : NumPy is a general-purpose array-processing package. It provides a high-performance multidimensional array object, and tools for working with these arrays.
- **Open CV:** *OpenCV* (Open Source Computer Vision) is a library of programming functions mainly aimed at real-time computer vision. In simple language it is library used for Image Processing. It is mainly used to do all the operation related to Images.
- **Pandas:** Pandas is one of those packages and makes importing and analyzing data much easier.

VARIOUS STAGES OF COMPLETION

- **Review 0:** We researched and gathered information on this topic using various published research paper especially the ones published in IEEE.
- **Review 1:** 50% of the code developed . The feeding of data, data pre-processing and data augmentation was completed.
- **Review 2:** The CNN architecture as well as the Transfer Learning model using ResNet was build. Hence 80% of the code was build.
- **Review 3:** The model was deployed using Flask on a website that was build using HTML and CSS.

Therefore, all the project work was completed before starting the project report. This feat was accomplished because of the review process held by SRM.

INNOVATIVE IDEA/ORIGINALITY.

- **Transfer Learning-ResNet50-**
- Transfer learning is a novel approach for building neural networks for deep learning models.
- We mimic the heuristic ability of using previously learned knowledge to learn a new concept.
- Use state-of-the-art architectures trained on larger datasets as feature extractors for our dataset.
- We fine tune the top layers of the selected architecture and select their weights to train our model.
- We have Used RESNET50 as the Feature Extractor by first freezing all the layers and later keeping the final convolutional layer as trainable and fine tuning the model

CHALLENGES FACED

- The datasets available were not very reliable. We had too research the best possible dataset that was available.
- In a deep learning model there are numerous data pre-processing techniques available. The research paper as well as online suggestions helped us in narrowing down our pre-processing techniques.
- The CNN model was not able to achieve a very good result. Hence we found some online sources suggesting about the capabilities of transfer Learning using ResNet50.
- Choosing the appropriate hyper parameters, learning rate was a big task. We were able to accomplish it by some hit and trial method.

FACILITIES USED

- **INTERNAL FACILITIES USED:** There were no internal facilities used as all the work was done on our laptop and there were no hardware components that was required.

- **EXTERNAL FACILITIES USED:** The dataset was obtained through available open sources. Kaggle was used as the Jupiter notebook to help develop the model.

END