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A Project Report

on

Diabetic Retinopathy Detection

carried out as part of the ***Minor Project IT3270*** *Submitted*

by

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CERTIFICATE

Date:

This is to certify that the minor project titled **Diabetic Retinopathy Detection** is a record of the bonafide work done by **ANKIT YADAV** (Reg No. 209302080) submitted in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Information Technology of Manipal University Jaipur, during the academic year 2022-23.

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ABSTRACT

Diabetic retinopathy is a complication of diabetes that attack the eye by destroying blood vessels in the retina. At first it is an asymptomatic problem or there is no visible change. As become severe it can affect the eyes and eventually cause partial or complete blindness.

Therefore, people with diabetes are always at risk of developing the disease.

Early detection can prevent the unexpected consequences of total and permanent blindness. Therefore, good analysis is required.

The current work includes deep learning, a dense connected **convolutional network** used for early detection of diabetic retinopathy. We classified fundus images as **no DR, mild, moderate, severe and hyperplastic DR** to severity.

Data evaluated is Diabetic Retinopathy Image Dataset. The plan is made in several steps: data collection, pre-processing, augmentation, and model. Our proposed model achieves 90% of accuracy. The main purpose of this project is to develop a dynamic system for automatic DR search.

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1. Introduction

Diabetes is one of the most common diseases and its prevalence is increasing worldwide. It is often associated with hyperglycaemia, which causes impaired insulin production and metabolism in the body and problem such as heart diseases, kidney failure, brain disease, and diabetic retinopathy. Diabetic retinopathy is a serious disease that causes vision loss that cannot be reversed or treated once it has occurred. People with a long history of diabetes, whether type 1 or type 2 diabetes, are most likely to develop the disease and the risk increases with age. According to the World Health Organization, DR is a serious eye disease that urgently needs to be addressed at the international level.

According to the report, there are 12000 ophthalmologists in India who treat 60 million diabetic eye patients. The main reason for the high number of the patients is that most people do not know that they have the disease. They also show insensitivity and imprudence to the disease. About 18% people with diabetes suffers from DR, and people with diabetes are 25 times more likely to develop DR than healthy people. It is difficult to diagnose this disease in the first stage because it has no or very few symptoms, makes the person forget and eventually causes blindness.

Therefore, early diagnosis of DR is important to avoid complications of disease. Diagnosing of disease require specialist and professionals with the right tools and techniques to facilitates progression using these disease tests.

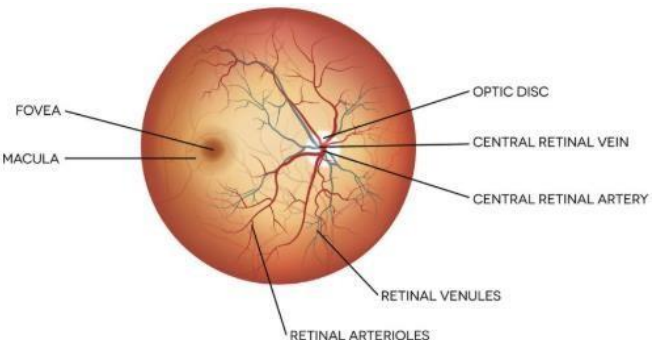

Figure 1. Normal Retina

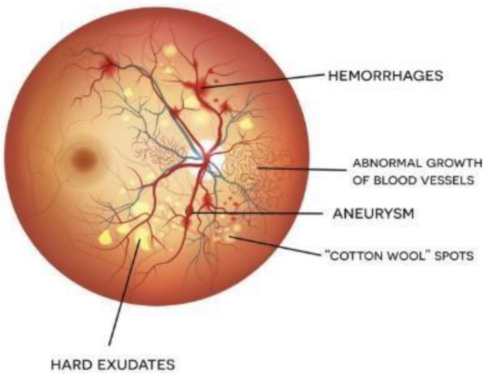

Figure 2. Diabetic Retinopathy

Images of the normal retina and diabetic retinopathy retina are shown in figure 1 and figure 2, respectively. Due to the need for an impartial investigative process to determine and assess the severity of DR. **Much of the research in DR is based on feature extraction using machine learning methods,** but with the advent of manual feature extraction problem arise that cause researchers to turn to deep learning, Further research in healthcare has expanded into many computer-assisted techniques.

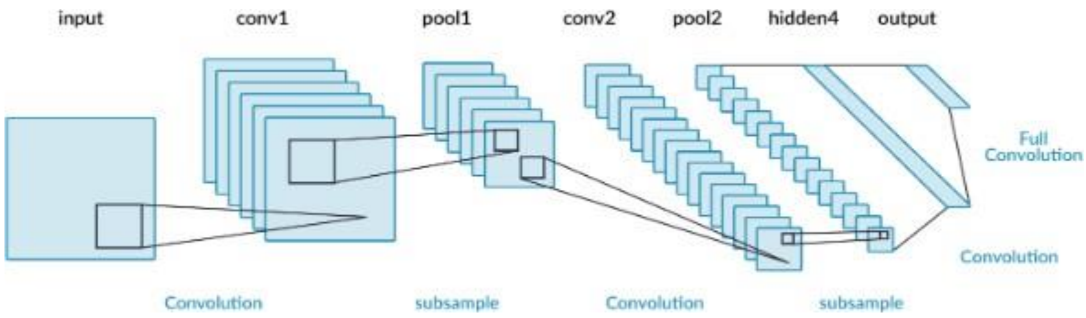

Figure 3. CNN Architecture

Figure 3. CNN Architecture CNN is a deep literacy trend to give formative results when it comes to job of image bracket. The armature of CNN with its different layers given in figure 3. The present exploration employs deep literacy methodology especially CNN using TensorFlow and Keras, which excerpts the features automatically, rather than manually for the bracket of eye images grounded on inflexibility position. The Dataset of INDIAN DIABETIC RETINOPATHY IMAGE DATAST was assembled for this study. The paper is organized into colorful sections as section 2 presents the recent work in this field. Section 3 gives the proposed result for detectingDR. Section 4 will bandy the results of the exploration. Section 5 will give a conclusion grounded on the exploration carried out in this study and eventually Section 6 will conclude the paper by stating the limitation and unborn work for farther study.

2. LITERATURE REVIEW

- Diabetic Retinopathy is one of the grave concerns that engrossed the whole world. Receiving the attention from various researchers to find the optimal solutions for the early detection of this disease, consequently leading to the prevention of premature fluctuations in vision. Many studies have been conducted and continues in this field with an aim to ease the lives of both doctors as well as patients. This section provides a review of much research works in the area of Diabetic retinopathy.
- **J. Calleja** in their work used a two staged method for Diabetic retinopathy detection: LBP (Local Binary Patterns) for feature extraction and Machine Learning specifically SVM and Random Forest for classification purpose. The results obtained by the random forest outperformed the SVM with an accuracy of 97.46%. However, the dataset used in this study was quite small with 71 images.
- Earlier works were based on manual feature extraction for detection of DR using various computer-based systems. **U. Acharya** used features like blood vessels, microaneurysms, exudates, and hemorrhages from 331 fundus images using SVM with an accuracy of more than 85%.
- **M. Gandhi** proposed a method for automatic DR detection with SVM classifier by detecting exudates from fundus images. Some works try to integrate manual feature extraction with deep learning feature extraction for DR. one of such work include **J. Orlando** where CNN with hand crafted feature is used for

feature extraction for detecting red lesion in the retina of an eye.

- **S. Preetha** In their literature predicted various diabetic related diseases using Data Mining and machine learning methods specifically for heart disease and skin cancer predictionwhile considering both advantages and disadvantages.

- While many research or works are there about using machine learning approaches or data mining approaches, a quite different approach also came into the way of detection of diabetic retinopathy. **S. Sadda** make use of quantitative approach to identify new parameters for detecting proliferative diabetic retinopathy. It is based on the hypothesis that location, number and area of lesions can improve the forecasting process of Retinopathy. The methods used for this study were Subjects and Imaging Data, Ultrawide Field Image Lesion Segmentation, Quantitative Lesion Parameters and Statistical Analysis. Comparison of lesions were made based on Lesion number, Lesion surface area, Lesion distance from the ONH center and Regression analysis.
- The work presented by **J. Amin** provides a review of various methodologies for diabetic retinopathy by detecting hemorrhages, microaneurysms, exudates and also blood vessels, and analyzes the various results obtained from theses methodologies experimentally in order to give indepth insight of ongoing research.
- The study carried out by **Y. Kumaran** and **C. Patil** focuses on the different types of preprocessing and segmentation techniques mostly and gives an in detail procedure for detection of diabetic retinopathy in human eye consisting of number of systems and classifiers.
- **M. Chetoui** Proposes a diagnostic method for DR using machine learning specifically SVM and Texture features. Texture features used were LTP (Local Ternary Pattern) and LESH (Local Energy-based ShapeHistogram) that provided better results when compared to Local Binary Pattern (LBP). The accuracy of 88.4% was obtained by LESH with SVM.

3. PROPOSED METHODOLOGY

The main ideal of this work is to make a stable and noise compatible system for discovery of diabetic retinopathy. This work employs the deep literacy methodology for detecting the diabetic retinopathy grounded on inflexibility position(No DR, Mild, Moderate, Severe and Proliferative DR). numerous processes were carried out before feeding the images to the network. We trained two models in this work our proposed model and the retrogression model and also a comparison was made between the rigor attained by the two models. Though our proposed model performed more than the retrogression model. The figure 4 shows the proposed methodology.

Figure 4 Proposed Methodology

3.1 source: Data used for this study has been taken from Diabetic Retinopathy Image Dataset. **Data** The datasets contains thousands of retinal images under different conditions. For every subject, two images of both the eyes are given as left and right. As the images come from different sources like different cameras, different models, etc. It has an abundance of noise associated with it, which apparently needs to be removed, thus, requiring a number of pre-processing steps. The diabetic retinopathy associated with each image has been rated on the scale of 0-4 as:

0 - No DR

1 - Mild

2 – Moderate

3 - Severe

4 - Proliferative DR

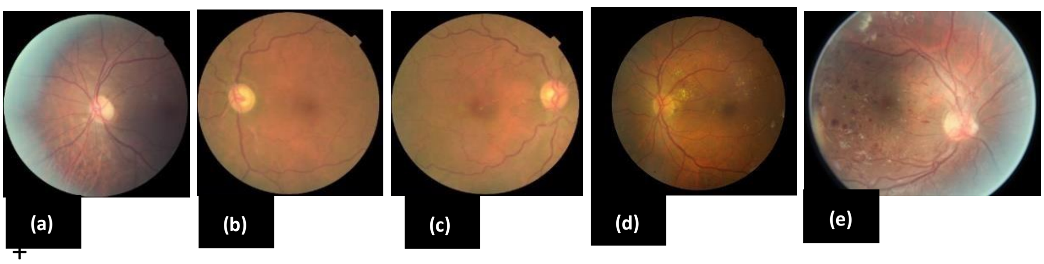

Figure 5 Image samples based on severity from dataset: (a) is level ‘0’, (b) is level ‘1’, (c) islevel ‘2’, (d) is level ‘3’, (e) is level ‘4’.

3.2 Data Per-processing: As the images in the dataset contains a lot of noise, like some images may be out of focus, some may have a lot of exposure, some may have extra lighting, presence of the black background, etc. so we need to do pre-processing to get them in the standard format. Following things are carried out in pre-processing step:

- *Cutting the black border:* The black background of the fundus image does not add any information to the image and is therefore useless so, the black background around the images are omitted.

- *Remove the black corner:* After removing the black border there still exist some black corners as the fundus image is round in shape. In this step black corners are removed from the image.

- *Resizing image:* The images are resized to 256*256 (width*height).

- *Applying the Gaussian Blur:* Gaussian blur is applied to the images by specifying the kernel size to 256/6. This method helps in removing the Gaussian noise.

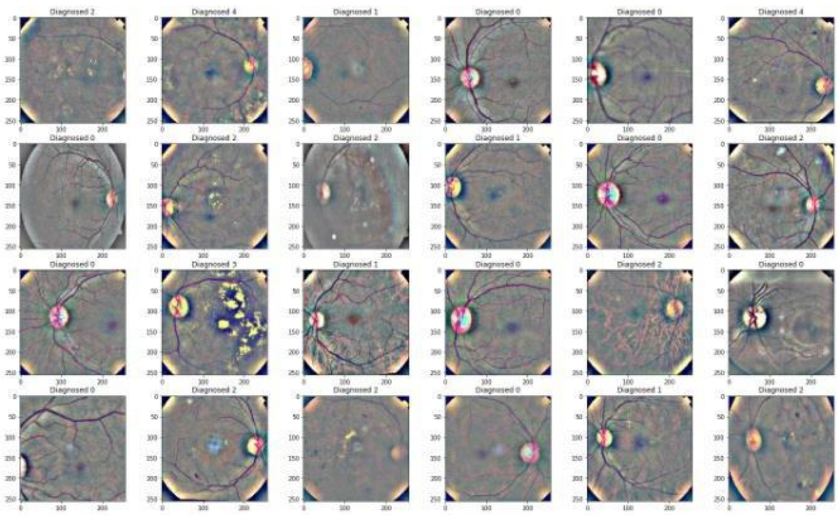

Figure 6 Images obtained after pre-processing.

3.3 Data Augmentation*:* After analyzing the data, we notice that the data is highly unbalanced among the diabetic retinopathy severity image classes as shown in figure 7, which gave rise tothe propensity of data augmentation.

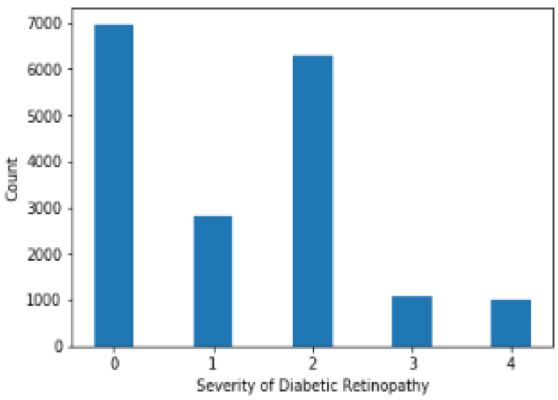

Figure 7 highly unbalanced data before data augmentation

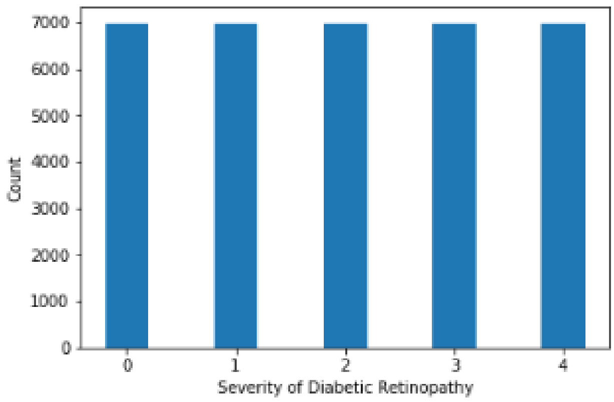

Figure 8 Balanced data after data augmentation

Data augmentation is framed by aligning one class to the class with most samples, in order to balance the data among the diabetic retinopathy severity classes, as shown in figure 8. Images were mirrored and rotated to augment the dataset, 7000 images were obtained in each class after augmentation shown in figure 9.

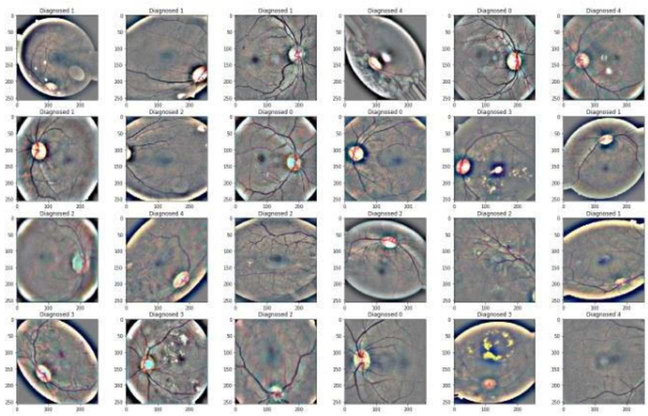

Figure 9 Images Obtained after Data Augmentation

3.4Modelling: We used a DenseNet-169 (Densely connected convolutional neural network) and Regression model for training purpose. In DenseNet-169 weights are loaded into the network without the top or last layer. When modelling the network, initially there is no last layer. We design this layer by using Global Average Pooling 2D, a Dropout layer set at 0.5 and an output comprising of five nodes for each class. Global Average Pooling 2D is same as that of 2D average Pooling in operation, but it considers the entire input block size as pool size. A Dropout layer address the issue of over-fitting. Adam optimization algorithm is used for optimizing the weights on training this model. A sequential modelling approach is used for adding layers and customizing the layers like convolutional, dropout, dense, optimizers, etc.

- *Convolution layer*: It employs several kernels or filters to run across the fundus images and calculate a dot product. Every kernel or filter in this layer draws various image characteristics.

- *Pooling layer*: It provides an abstract representation of convolved features by reducing the spatial dimension. It is somewhat similar to convolution layer but it takes the max or min region depends on the type of pooling from kernel-overlapped input.
- *Dropout layer*: The dropout approach has been used to control neural networks in order to reduce over-fitting.
- *Flatten layer*: Flattening transforms the data to the next layer in a 1-dimensional series

The figure 10 shows the deep DenseNet-169 model with three Dense blocks and three transition layers consisting of pooling and convolution layer

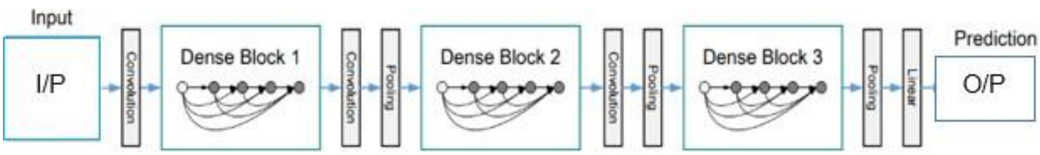

Figure 10 DenseNet-169 model with three dense blocks

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
densenet169 (Model)          (None, 8, 8, 1664)        12642880
_________________________________________________________________
global_average_pooling2d_1 ( (None, 1664)              0
_________________________________________________________________
dropout_1 (Dropout)          (None, 1664)              0
_________________________________________________________________
dense_1 (Dense)              (None, 5)                 8325
=================================================================
Total params: 12,651,205
Trainable params: 12,492,805
Non-trainable params: 158,400
_________________________________________________________________
None
```

Figure 11 summary of the model.

3.4 Implementation: The implementation was executed using python language, where a wide variety of libraries were employed for processing of images and to get acquainted with the system for creating convolutional neural network like DenseNet-169. The type of library utilized for image management (like rotation and resizing) and pre-processing was OpenCV. However, the mathematical functions required for the implementation was performed by NumPy. TensorFlow, keras and Scikit-learn were also used for efficient management of deep learning models and for defining the model. The implementation of model makes use of GPU enable device for easier and faster processing.

4. RESULT AND DISCUSSION

We trained our proposed model using DenseNet-169 on a combination of dataset. Therewas a lot of noise associated with the images provided by the dataset therefore, preprocessing was needed. For preprocessing, we first removed the black border of the images in order to focus more on the fundus image only, black corners of images was also removed, then the images were resized to a standard format of 256*256 of width and height. At last a Gaussian blur was applied to the images in order to remove the Gaussian noise. After preprocessing we analyze that the data is highly unbalanced among the severity classes, majority of data belonged to the class '0'i.e. No DR. in order to address this issue, we used data augmentation, which gives us 7000 images from each severity class and made the data balanced. After preprocessing and augmentation of images, data was finally fed to the DenseNet-169 for training the model. After evaluating our model the training accuracy of 0.953 was obtained, while as validation accuracy of 0.9034 was achieved. We also calculated the Cohen Kappa score which comes out to be 0.804. We also applied a regression model to our dataset and compute its validation accuracy which is 0.789. Our proposed model outperforms the regression model. The results of our model are summarized in table 1.

Table 1 Result of the Proposed Model

Training Accuracy	Validation Accuracy	Cohen kappa score
95%	90%	80%

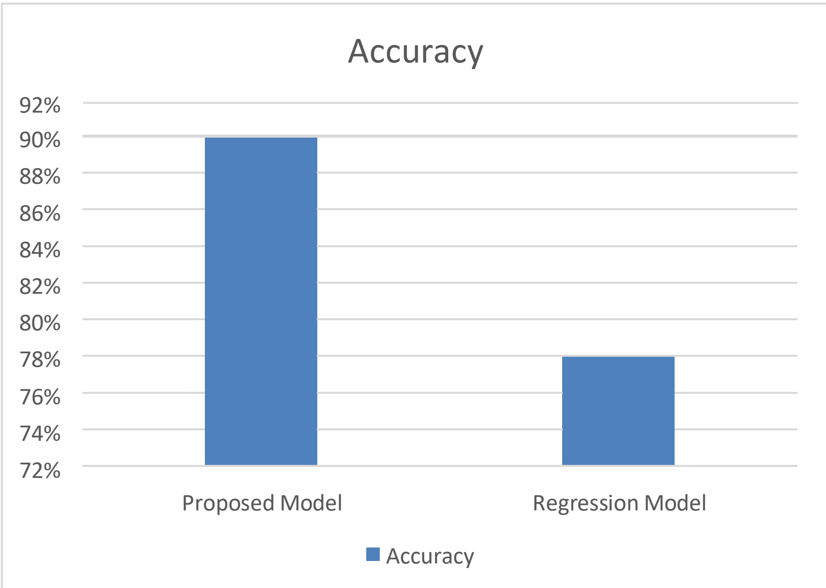

Figure 12 Accuracy Obtained By Proposed Model and Regression Model

Besides Regression model, the proposed model was compared to a number of machine learning classifiers like Support Vector Machine (SVM), K-Nearest Neighbor (KNN) and Decision Tree (DT). The results are summarized in the table 2, where accuracies of the different classifiers are given.

Table 2 Results Obtained By Various Classifiers

CLASSIFIER	**DATASET**	**ACCURACY**	**DR CLASSES**
SVM[29]	Messidor, Diabeticret DB1.	85.6%	Normal, Non PDR, PDR.
DT[30]	Messidor	85.1%	Normal, Mild, Moderate, Severe.
KNN[29]	Messidor, Diabeticret DB1	55.1%	Normal, Non PDR, PDR.
Regression	Diabetic Retinopathy Detection 2015 &APTOS 2019 from kaggle.	78%	No DR, Mild, Moderate, Severe and Proliferative DR.
Proposed Model	Diabetic Retinopathy Detection 2015 &APTOS 2019 from kaggle.	90%	No DR, Mild, Moderate, Severe and Proliferative DR.

The proposed model achieves the highest accuracy of 90%, followed by SVM with an accuracy of 85.6%, Decision Tree with 85.1%, Regression with 78%, and KNN with the least accuracy of 55.17%.

Figure 13 shows comparison between the classifiers in which the proposed model shows the highest accuracy among other classifiers.

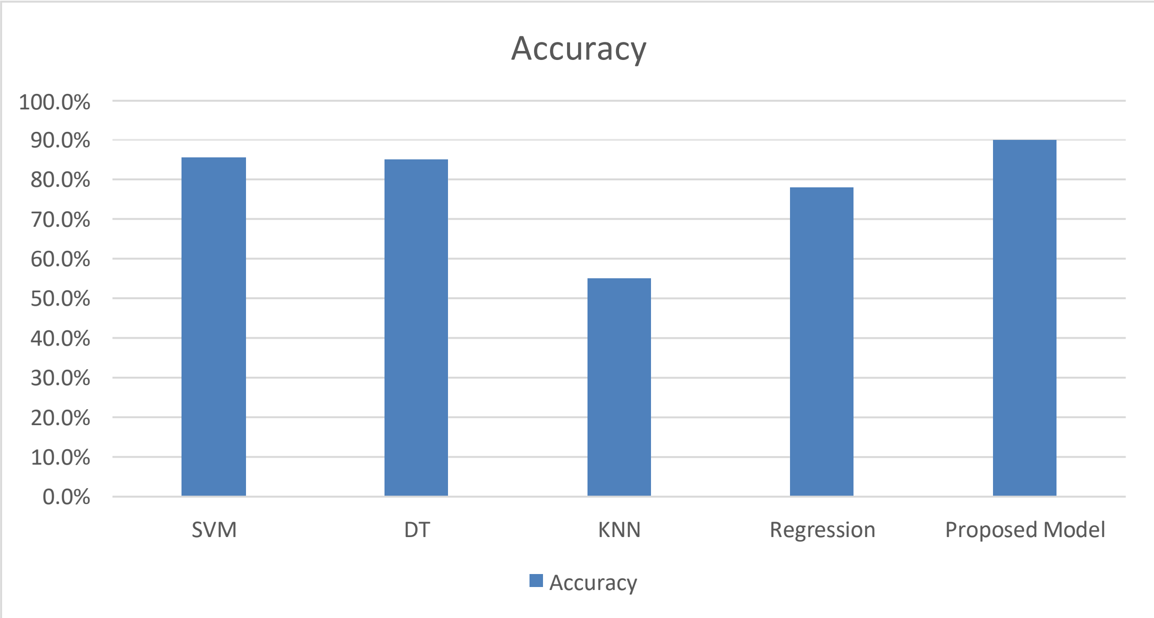

Figure 13 Accuracy Obtained By Various Classifiers.

5.CONCLUSION

Traditional method for detection of DR is prolonged, challenging and costly, thus many researches were brought up to automate the detection process by using machine learning and deep learning approaches. In this work, we presented a comprehensive study of various methodologies for detecting diabetic retinopathy automatically and attempted to propose our own deep learning approach for the early diagnosis of retinopathy by using a DenseNet-169(which is a new CNN architecture, having many deep layers). A lot of preprocessing and augmentation was done to standardize the data in a desired format and to remove the unwanted noise. Beside DenseNet-169 classifier, wealso used a regression model to draw the comparison between the results. Moreover, machine learning classifiers like SVM, DT and KNN were compared with the proposed system. Where the best accuracy among all was obtained by the proposed model and it also classifies the images into more no of classes. Our proposed model performed better than the regression model by achieving the accuracy of 90% however, 78% accuracy was yielded by the regression model.

6.LIMITATION

As there are a number of images taken under different conditions, needs to undergo a lot of preprocessing and augmentation, some features of image might be missed out, so such techniques should be used that not only preserve all the tiny important features but at the same time is able to do a successful pre-processing. Moreover multiple images should be provided for every patient which would in turn increase the possibility of classifying the images correctly as more information can be gathered rather than only two images per person.

7.FUTURE SCOPE

The possibility of tweaking hyper-parameters is constantly growing with the emergence of new neural networks through better pooling methods. Such methods can be considered for future work to uncover the possibilities of increasing performance in this area. Furthermore, using different networks for training the model by the process of ensemble can also lead towards the better results. As different model have their own advantages in terms of performance, if tied together, can help in improving overall productivity of a system rather than an individual model. We have used two datasets in our study, using more no of datasets or a combination of various datasets may improve the generalizability. The deployment of such systems can be done by using the MobileNet, which is a convolutional neural network for developing mobile applications. The web applications can be developed that can work for windows, Linux and Android operating systems as a diabetic retinopathy diagnostic tool.

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