Prognostication of Diabetic Retinopathy Using Machine Learning

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Abstract - *Prognostication of diseases is extremely important because the results of the prognostic studies can aid the doctors in better decision making regarding the treatment of the patient and serve well to reduce any anxiety in the patients regarding the course of their treatment. Diabetic retinopathy is basically a complication in diabetics that is brought about by the damage to the of the eye's blood vessels, that even though initially only causes mild problems, can eventually lead to irreversible loss of vision, and hence the early prognostication of Diabetic Retinopathy is exceedingly essential, as the early detection of this disease can reduce the risk or even avoid irreversible loss of vision. DR can be prognosticated by ophthalmologists with the help of color fundus images but that can cause the patient to lose a lot of valuable time. The method proposed by us in this paper is developed on CNN under deep learning that uses medical images in an unsupervised manner and aims at learning high- and low-level features which can aid in the detection, classification, feature extraction and eventually prognostication of Diabetic Retinopathy. The input images are initially pre-processed and prepared for the model by filtering, compressing and resizing the images. In this paper we successfully classify DR into Mild, Moderate, Severe Non-proliferative DR and Proliferative DR. The advantage of this method over others is the increased efficiency over other methods. It outperforms other methods if tested under the same condition, and it also trains faster and performs better. In the future we plan to use alternate neural network methods such as Probabilistic Neural Network and increase the estimations.*

Keywords **– TLBO, Diabetic Retinopathy, CNN, Machine Learning, SVM**

1. INTRODUCTION

The definition of prognostication of diseases refers to the forecast or prediction of the projectile of the disease following its inception. It basically refers to all the possible consequences of the disease and the frequency associated with each of these consequences as well as the chances of recovery of a person. Medical images are an extremely vital part of the prognostication process. The process of medical imaging has been used for quite some time for the routine and preventive screening of diseases such as cancer and other diseases. Prognosis of medical images is usually done by a doctor. It requires the doctor to be aware of the natural advancement of the certain disease along with taking into consideration many unique factors related to the specific patient and requires the doctor to have a very good knowledge of different treatment options. There are a lot of disadvantages of this method of prognostication, with one of the main ones being the loss of a patient's precious time that could have been used for the decision of a treatment option and initiating the patient's treatment. The only way to solve this problem is to decrease the time taken for the prognosis of the disease with the prognostication is to move towards the computer aided detection and prognostication of diseases. [26] [27]

Diabetic Retinopathy refers to a complication associated with diabetes that affects the eyes of a person. Initially it may not give rise to any kind of symptoms or maybe provide some mild problems in vision but it can eventually lead to the person becoming blind. Because Diabetes is a lifelong condition, it can sometimes take years to detect and treat Diabetic Retinopathy. If the disease is not prognosticated and nursed early on, this complication can lead to permanent loss of vision. One of the first challenges is the detection of diabetes itself all around the world. Another problem that hinders the early detection of Diabetic Retinopathy is the lack of visual symptoms in its early stages unlike some of the other diseases that exude visual symptoms from the very start. Hence the early prognosis of this disease is extremely vital and necessary. Diabetic Retinopathy has affected many people over the years and continues to affect many, but, at the same time many scientists, doctors, specialists and engineers have done a considerable amount of research to curb this issue. [26][28]

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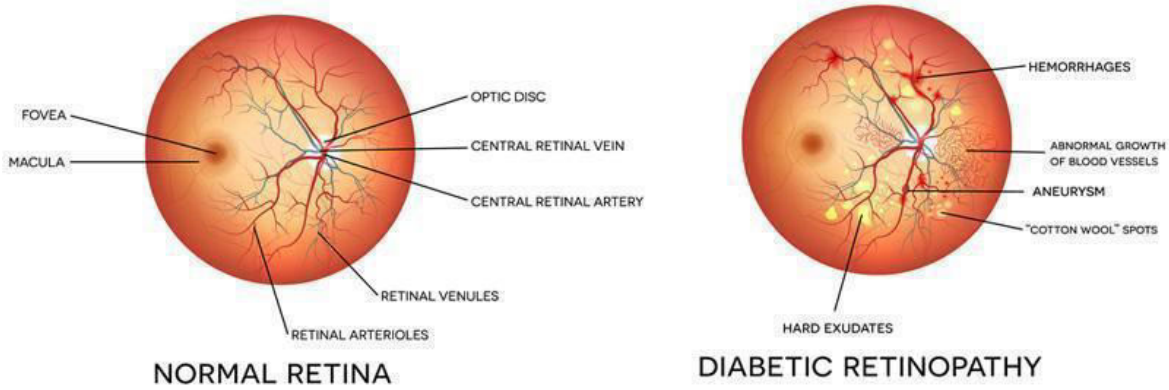

Figure 1. Normal Retina Vs Diabetic Retinopathy affected Retina

The method of prognostication proposed in this paper is ML . It is a computer algorithm field that provides the apparatus the ability to grasp the fundamentals, learn and improve automatically instead of manually. Deep learning can be called a sub field of Machine Learning that can draw , learn and improve from data that is both unstructured and unlabelled. It can most closely imitate the workings of a human brain through the use of neural networks. Initially, the diagnosis was done manually with little help from automated systems, but later, methodologies and algorithms were introduced in various stages of prognostication such as image pre-processing, enhancement, detection, classification, accuracy estimation that proved to be advantageous. Machine learning provides different methods, techniques and tools that can help aid in the prognostication of Diabetic Retinopathy where the input is the dataset of color fundus images and the output refers to the prediction or the diagnosis of the disease.[29][26]

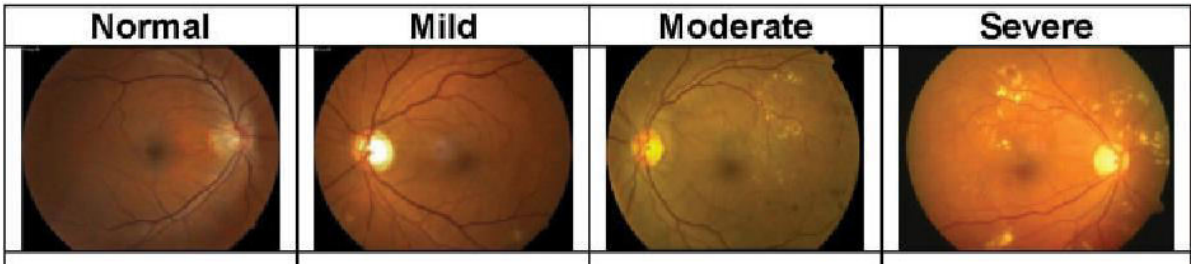

Figure 2. Stages of Diabetic Retinopathy depicted in Fundus Images

Given below is the comparison of different machine learning and neural network algorithms used to detect diabetic retinopathy and the respective advantages to each and every algorithm: -

ALGORITHM	**ADVANTAGES**
Deep neural networks combined with statistical analysis	It is a well-calibrated, intuitive and effective system.
Support Vector Machine	Higher specificity, sensitivity and accuracy
Convolutional Neural Networks	Increased specificity and sensitivity and increased accuracy when compared to GMM.

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Probabilistic Neural Network	Better precision and F-measure than SVM or LR
Resnet-50 with SVM	The use of a combination of algorithms provide better efficiency and accuracy

Table 1. Algorithms used and their respective advantages

The old approaches had a lot of advantages and accuracy but there were still some major disadvantages that the new proposed hybrid approach hopes to overcome such as fewer controllable parameters. When the artificial neural networks algorithm was used, their proposed system did not work as well for images with subtle findings in the medical images which affected their accuracy and heterogeneity was considerably high. Models also were incapable of classifying uncertainty. Some of the models used also were better at diagnosing and predicting one type of Diabetic Retinopathy better than the others. So a new hybrid approach must be good at predicting both NPDR and PDR. Improving interpretability while at the same time decreasing the sensitivity to noise is also an important factor to be considered while improving the old approaches and creating a new approach. There is also a need to improve the efficiency and accuracy of the approaches to make sure that the approach is actually effective. Using an approach that is novel and hybrid for the prognostication of the diabetic retinopathy disease can help improve on these factors.

2. LITERATURE SURVEY

[1]presented a method that can evaluate the little changes of tissue structure which occurs in the early stages of Diabetic Retinopathy in animals. Contrasting features of the microscopic images were derived from the HE slices of animal retina. Some quantitative calculations were done on the nerve fiber in per unit length and on the layer of nerve fiber in terms of total area. In order to identify the section, the amount of unit area ganglion cells was additionally calculated. This method presented a calculative method of scanning as well as evaluating of DR and drug efficacy. This method has not only proved to be advanced, but its estimations is comparatively better to the results obtained from manual evaluations. The method proposed is greatly expansible and it can also be related to the examine the HE section images as well. [1]

[2]proposed to capture the predictive uncertainty of Deep Neural Networks by designing unlearned structure which is situated on data augmentation of test-time for diagnosing Diabetic Retinopathy. The effectiveness of TTAUG in capturing the uncertainty in clinicians' as well as DNNs' decisions. The proposed framework works by the assumption of the unpredictability of DNNs as a proxy for uncertainty which it then integrates into its learning. The motive is to ease the collaboration of human and machine into aided reading. This framework can be applicable only on the results of a network which is incapable of exploiting the calculated unpredictability in the hopes of improving the interpretability of DNNs in future. [2]

[3] presented the use of several frameworks such as AlexNet, GoggleNet and ResNet50 which rely on CNNs. These improvise the functioning of detection of Diabetic Retinopathy in conventional fundus camera pertainingto the retina and smartphone-based images. The frameworks were trained again and again on several datasets, eg., EyePACS, Messidor, IDRiD, etc. The results showed that ResNet50 had the highest accuracy, sensitivity and specificity compared to remaining frameworks. The results showed that ResNet50 had the highest accuracy, sensitivity and specificity compared to remaining frameworks. Following which, after simulating different FoVs, synthetic images smartphone-based images were produced from UoA-DR dataset from which ResNet50 was tested. Observation showed that the accuracy of detection rises with increasing size of FoV and retraining deep networks. [3]

[4] put forth a system for categorizing of Diabetic Retinopathy, DR|GRADUATE which is system based on deep learning that arrives to decisions by supplying an explanation that is medically interpretable as well as an estimate of the uncertainty of a prediction, which helps the ophthalmologist to measure the trustworthiness of a conclusion. The approach is based on Gaussian -sampling built upon a Multiple Instance Learning framework. The system was edified on Kaggle DR detection sets after which it was evaluated across numerous datasets. A quadratic-weighted Cohen's kappa value was measured. This value was soaring for images with decreased prediction variability. This system further allows outlier detection. The whole system was made so as to curb it's black box like functioning related to Deep Neural Networks. [4]

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[5]proposed a system that can analyze the presence of different microaneurysms in the color fundus images using a CNN algorithm that is embedded with deep learning as one of the main components.This process is further accelerated by the use of GPU which detects the medical images and segments it with low-latency and high-performance inference. The system trains the deep CNN for the semantic segmentation of medical images such as fundus images into infected or normal.This segmentation algorithm divides the pixels of the fundus image which helps in grading of the fundus images.In the system the development of a sparse PCA based unregulated approach was done coupled with LOG filter and MF filter.On contrasting the performance of the system with the already existing technologies, the performance indicates that the proposed system is enhanced in specificity and sensitivity and it exceeds current methods.[5]

[6]proposed a diagnostic method that was designed for the prediction and prognostication of Diabetic Retinopathy called VeriSee™.It is a software that assesses the image based on Deep Learning algorithms for instance, it uses CNN and revolutionary technologies that recognize and categorize the images.After the dataset was collected, it was graded by two board certified opthamologists, followed by image preprocessing using eye tracking and Gaussian blur.The Inception-V4 architecture was employed for the model to learn for any DR and referable DR but ResNet with the modified Feature Pyramid Network (FPN) architecture was utilized for the model to learn for PDR.On comparison of following accuracy of VeriSee™ with that of the opthamologists, it was found that VeriSee™ had high reliability with good specificity and sensitivity. For any DR, the specificity was found to be 90.1% and sensitivity to be 89.2%.[6]

[7]proposed a software-based algorithm on account of processes preceeding detection of Diabetic Retinopathy which promises to mitigate the complex nature of several algorithms like Support Vector Machine, CNNs, etc. The proposed tool is effective for non-intrusive and early detection . An image processing is carried out which is based on MATLAB to identify everything related to DR. The other requirement is a fundus camera, which makes it one of the simplest algorithms for early diagnosis of DR. The system counts the white pixels, based on which the eye images are classified either as DR or NDR images. The observation made after the analysis was that average of the counts of DR pixel is greater than that of counts of NDR pixels . [7]

[8]proposed a system that can overcome the issues faced while applying the traditional methodologies. After the acquisition of the image from the dataset, the image is pre-processed with image resizing and double conversion techniques followed by the segmentation of image where different operations such as morphological and operations based on threshold are performed on the image. For the purpose of extracting features with co-occurrence matrix, the GLCM feature is selected. Following the extraction procedure the classification is performed on the data using Probabilistic Neural Network that facilitates the identification of Diabetic Retinopathy and its severity level. This proposed system is then contrasted to other systems such as LR,SVM,DT etc and it is concluded that PNN has the highest accuracy and greater sensitivity and specificity among all the traditional techniques.[8]

[9]proposed a model that deals with the patches and the model can localize potential regions where the lesions can be detected.The model classifies the images on the basis of a probability map, that indicates the level of Diabetic Retinopathy of each and every pixel.The retinal images were enhances to make the lesions more visible during the image preprocessing using circular template matching. Each patch that is extracted from the given retinal image is classified and labelled as non-lesion or lesion.The model uses VGG16 model because of the architecture's high generalization capacity.The model's outputs for five rotation of the patches are averaged to improve the performance of CNN.The level of DR is then inferred from a map called lesion probability map.[9]

[10]presented a directed and guided machine learning techniques based on Artificial Neural Network which depended on extricating the 7 changeable characteristics in the retina. The methodology was processed in two steps, first, reconstruction of blood vessels, followed by amplification and re-continuity using written conventional algorithms. Second, An ANN was used which categorized the 4 types of DR. The framework also depended on plugins for MATLAB and an Image-J software based on Fiji. The system reached up to an accuracy of 97% and the misclassification error was 3.33%. The presented system achieved high performances . [10]

[11]presented a system of fractal analysis for Diabetic Retinopathy grade categorization. This analysis is based on Glaucoma – the part of DR. This analysis is used because of the ability of fractal dimension to categorize the retinal vasculature. The dataset used was MESSIDOR along with the Random Forest Classifier to distinguish the healthy and DR subjects. The system also aimed to classify the severity of DR patients at grade level, but it failed to do so, with

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which it is concluded that fractal analysis alone is not sufficient. Therefore, further research has been cited accordingly. [11]

[12]proposed an automated system that helps in detecting DR using SVM for extracting features and classification.The high level features that are present in the last layer which is fully connected that is based on the transfer learning from CNN algorithm are used as input features for the classification. This proposed process can reduce the computational time that is required for the classification process done by CNN along with the fine tuning.This system tests many CNN architectures with SVM, out of which it can be inferred that the amalgamation of resnet50 transfer learning algorithm and Support Vector Machine produced the maximum accuracy of 95.83% the base 12 and for the inception v3 algorithm and VGGNet type 19, it produced the maximum accuracy of 95.24% for the base 13. It can be surmised from this system that using a combination of features that are extracted from both CNN and SVM algorithms can be used to provide better results for the prediction and classification of DR disease.[12]

[13]proposed a strategy in which multiple types of weighted paths are applied into a CNN, termed WP-CNN that is inspired by ensemble learning.By stacking the WP-Blocks a deep network is built. The coefficients of multiple path are optimized using the process of back propagation.In each of the paths,convolutional layers with different size of kernels are used to capture the features of different fields.This output is then multiplied to the corresponding coefficients and the mean of the weighted outputs are calculated for the reduction in redundancy and fast convergenceThis mechanism is proven to be effective and accurate for the identification of referable DR.This algorithm achieves high accuracy with good sensitivity and specificity with larger area under the receiver operating curve.[13]

[14]proposed a strategy which utilizes Deep Learning over Machine Learning opening the gate to outline more vigorous and reliable methods for the detection and ultimately, diagnosing and the treatment of different DR complications. Also, Deep Learning algorithms have been utilized to extend numerous methods for segmentations including, categorizations of various DR lesions, retinal blood vessel segmentation, various other segmentations and detections, etc. Several datasets had been developed for study on treatment of DR. The various Deep Learning frameworks that had been applied for developing so that DR prognostication can be a success had been carefully overviewed and summarised citing the pros and cons as well as their overall performances. [14]

[15]presented a VG method with RT for image processing to classify four groups of Diabetic Retinopathy using fundus images. This methodology has been presented via 2 phases – feature extraction and categorization. In feature extraction, 2 VG algorithms, namely, NVG and HVG were applied along with 14 more features. The performance was evaluated using Error Correcting Output Codes classifier. Accordingly, the observed results showed that the NVG algorithm was more efficient than the HVG one, also, the NVG one gave an extremely high accuracy index of 97.92%, sensitivity of 95.83% and specificity of 98.61%. Another thing observed was that the results were competitive, from which a conclusion could be drawn that VG analysis of fundus is by far a sound overture to DR grading. It can also treat the initial phases of DR. [15]

[16]proposed a system that uses multi channel convolutional neural network to detect DR from fundus images.This paper proposed 3 different CNN models containing different layers and parameters i.e different number of epochs sizes and batch sizes.During the pre processing stage the input is firstly separated into different channels :R,B,G and grey-scale .The first model consists of ReLU activation and 2 convolution layers of 32 filters with the kernel size of 3 x 3.The second model consists of 1 convolutional layer with 32 filters and kernel size of 5 x 5 with ReLU activation.The third model consists of 4 convolutional layers.Overall the best accuracy is achieved by the second model with extremely high accuracy for all the channels and grey scale images followed by model 1 which is then followed by model 3.The second model outperformed recent algorithms.[16]

[17]proposed a system of detection of DR by the extraction of the area and number of microaneurysms . Histogram equalization,Green channel extraction and some morphological processes were used for the image pre processing. Followed by the pre processing,techniques such as PCA, CLAHE , average filtering and morphological processes were used for the detection of microaneurysms in the fundus image.Further, the classification of the images to predict DR was done using linear support vector machine(SVM).The value of sensitivity and specificity achieved by this indicates that this model works better for NPDR.[17]

[18]proposed a method of detecting DR by detecting hard exudates with respect to red lesions.For the first

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step,CLAHE was used to increment the image contrast during the pre-processing phase. Using the background subtraction methodology the possible candidate exudate lesions were detected initially followed by candidate extraction method and anatomy detection method, following which false exudate lesions detected were removed using the method based on decorrelation stretch. The results of this method proved that it was a more efficient method of detecting lesions and Diabetic Retinopathy than was previously available.[18]

[19]proposed an automated system which classifies fundus images aiming to improve the diagnostic efficiency of Diabetic Retinopathy. The method was achieved by using CNN for DR detection and transfer learning methods were presented to categorize DR fundus images. Feature learning was also introduced to reduce the process of extracting features from fundus images as well as hyper parameter tuning. These processes allowed to overcome the challenges faced: categorization, segmentation, and detection. AlexNet, VggNet, GoogleNet, ResNet were adopted to analyse how the presented models fair with the categorization of DR images.Kaggle platform, which is an open platform was used to train the models. The best estimations on categorization which were achieved was 95.68% focussing on yielding better estimation on DR image categorization. [19]

[20]proposed a simple yet effective and efficient system for the automated detection of DR.The detection process consists of 8 steps starting with converting the image to gray scale image followed by the extraction of field of pupil of the image and the mea brightness is moved to 0.5This step is followed by the application of Max Filter and the threshold specification in the images.After thresholding, the connected components are acquired and the optical disc is removed.Which is followed by the removal of the objects in the image that are not exudates and the image is thresholded again.For the final step two statistical measures are calculated , the percentage of total exudates in the image and the percentage of the biggest exudate.This method can be used to detect exudates and assist ophthalmologists in the prediction of DR.[20]

[21]presented a new innovative approach to introduce two hybrid Artificial Neural Network models paired with Particle Swarm Optimization algorithm to diagnose Diabetic Retinopathy based on Video-Oculography signals. Four different statistical features were extracted from wavelet coefficients by Discrete Wavelet Transform and IMFs by Hilbert-Huang Transform for the training of models. One ANN model with VOG signals gave classification accuracy of 95.83%, another with DWT gave 93.75% and yet another one paired with C4.5 algorithm coefficients gave 96.87% accuracy. Additionally, whilst using Multilayer Perceptron Neural Network. The obtained results indicate that HHT-ANNPSO model with IMF1-4 provides better performance than the previous models. [21]

[22]proposed an automatic system which detects DR in digital fundus images using a discriminative Dictionary Learning based methodology. There is no need for any feature selection and segmentation in the before mentioned methodology. This method applies learned dictionaries done by K-SVD algorithm which gives a best atomic representation of fundus images. The classifier rule is based on the sparsity of atomic representation by selected atoms of each class and, hence, the best discriminative atoms are obtained. The rule of categorization is based on the best sparse representation, which means, the test image belongs to the class with minimum count of best specific atoms. The accuracies obtained were 70% for normal images and 90% for diabetic images. [22]

[23]put forth a method to differentiate between DR and AMD and normal images.In the image pre processing, the retinal image is converted to gray scale image and the image noise is reduced.In the feature extraction step, the LLBP process is used which is the combination of standard LBP and magnitude process.Following this step, the feature selection using Kernel PCA is done.A cross-validation of ten- fold is used as an evaluation model and totally three types of classifiers are used to classify four types of problems.The classifiers that were used are KNN(K nearest neighbors), SVM and Naive Bayes.These classifiers are used to classify in binary classification for DR and AMD, DR and Normal, AMD and Normal and a multi-class classification for AMD,DR, and Normal.When the accuracy of the method proposed was contrasted to LBP standard, the result found was that the proposed method had higher accuracy,sensitivity and specificity.[23]

[24]proposed a system that utilizes vector machine classifiers to detect DR.The green channel is extracted from the input image.Contrast limited adaptive histogram equalization or CLAHE of openCV1and gaussian filter is applied to the image for image enhancement and removal of unwanted parts of image.In the vessel detection phase, thresholding and erosion is done to remove the false vessel part.The final step to vessel detection is removal of small segment where small segmented vessels are then removed.Then the detection of early stage of DR is done using vector machines such

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as FVM and SVM.This process can help in the early detection of DR and help in the person getting treated early to avoid total vision loss.[24]

[25]put forth an algorithm that incorporates Diabetic Retinopathy detection, aiming to increase the accuracy and estimations of the prevailing manual screening methods. The features of DR that were detected were exudates, haemorrhages and blood vessels and the stages that detected these were pre-processing of images, detection of vessel and haemorrhages, optic disk obliteration and detection of exudates. The algorithm and processes were edified and evaluated using 49 and 89 fundus images. They acquired some of these datasets from DIARETDB1 database. DR stages were recognised respectively from the images that consequently procured. The testing results determined the detection percentage for vessels of blood and haemorrhages is 98% and for the exudates is 100%. Such high accuracy meant that the system is reliable. [25]

3. PROPOSED SYSTEM AND ARCHITECTURE

This corresponds to the architecture diagram of the proposed system. The architecture follows the diagram and flow depicted above. It can be broken down into the following modules:

- Input: The input taken in the proposed system is a dataset of images. The images are color fundus retinal images. The dataset used was collected from a variety of sources. The dataset contains images which are taken from various websites such as MESSIDOR are implemented as input. This dataset contains images that depict the condition of retina in the various stages of Diabetic Retinopathy and some images that portray a healthy retina so as to have a well-rounded set. The input color fundus images depict a human eye retina with optical disk, blood vessels of both types - ruptured and healthy, microaneurysms along with hard and soft exudates that facilitate in the detection of Diabetic Retinopathy in the human eye.

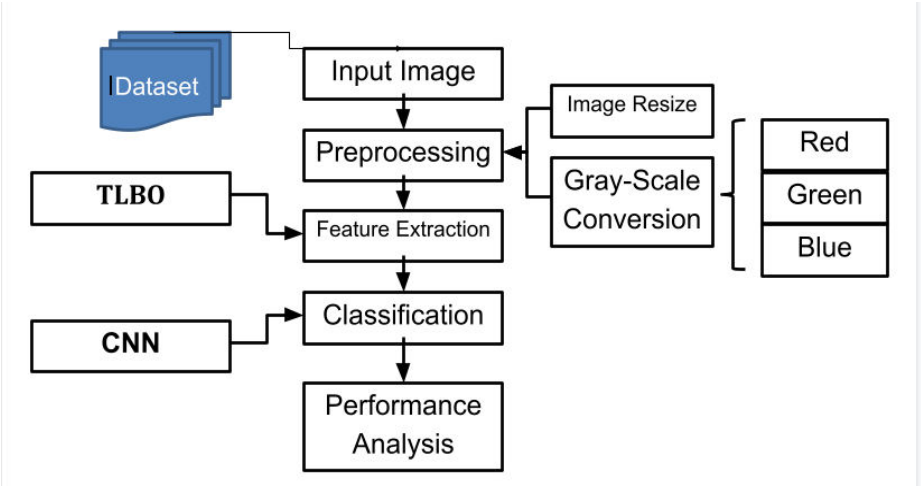

Figure 3. Architectural Diagram of the approach

- Preprocessing: The collected input images are now subjected to preprocessing. This step is done to make the images clear and reduce noise in the image. Hence, this module will help the model to learn the features more effectively and decrease the time taken. It is important to carry out the pre-processing of the images as a noisy dataset with too high dimensions will end up consuming a lot of space and make the model harder to train. This module in the proposed system consists of the following parts:

1) Resizing- In this step of the module, we resize the given image to the (300,300) dimensions. Since, neural networks always need to receive the input images of the same size, and the machine learning models always train better on smaller images, hence all the images need to be resized to make them uniform before inputting them to the model. It also helps in reducing the number of pixels in an image. OpenCv is a library in python that provides us several interpolation methods that can be used for resizing an image.[30]

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2) Dividing input images into colour channel: There are three channels(Blue, red and green) in an RGB image. It can be said that RGB channels are to heed the human eye color receptors roughly & they are used in all kinds of image scanners as well as displays.Let us consider that the RGB image is composed of twenty four bits, then it can be said that the image consists of three images, each of one channel of eight bits ,wherever every image stores distinct pixels of standard brightness from the range of 255 and 0.The image has been passed through blue channel. So, that the microaneurysms are differentiable and identifiable.[31]

3) Gray scale conversion: An image can be called a rectangular array consisting of pixels where every pixel represents a property. This property may depict several measures, but usually the calculated quantities are the mean brightness or the brightnesses of the image filtered on its way through filters. The transformation of a color image to a gray-scale image is largely the conversion of 24 bit values to 8 bit values.The grounds for such conversion is that less amount of data or knowledge has to be provided for every pixel & they eliminate the need to use harder to process color images. The matplotlib module of python is used for this purpose [26].

- Feature Extraction / Optimization: In this step, the proposed system uses the TLBO algorithm. TLBO is a kind of teaching-learning inspired optimizing algorithm, which focuses on the idea of a teacher passing knowledge onto a student in the classroom and then the information is passed onto the whole classroom through mutual exchange. This algorithm is a population-based algorithm and consists of 2 phases- the teacher phase and the learner phase. This is used to optimize the image data and then extract features from image. We extract the features of the retinal images in the dataset that help us in identifying the images that are affected by Diabetic Retinopathy.

The novel idea of our system is TLBO which is used during feature extraction. Rastrigin, SphereNew and Ackley functions have been used respectively.

```
function F = Rastrigin(a)
    F = sum((a.^2 - 10.*cos(a.*pi.*a) + 10))

    function d = SphereNew(z)
    d = sum(z.^2)
```

Teacher phase – The teacher tries to drastically increase the mean outcome of the class in the subject that is taught by them depending on their capacity. The best result on the whole considering all the subjects in the entirety of the class of students can be determined as the outcome of the best student. The deviation between their corresponding result of each subject and existing mean result decides the end outcome.

$$Diff\_Mean_{s,k,l} = r_i \left(Y_{s,kbest,l} - T_{Fac} M_{s,l} \right) \quad (1)$$

$Y_{s,kbest,l}$ outcome of the leading student.
T_{Fac} teaching factor which determines the amount of average to be altered.
R_l is a number that is randomly selected within the span [0, 1].

$$T_{Fac} = round\ [1 + rand\ (0,1)\{2-1\}] \quad (2)$$

$$Y'_{s,k,l} = Y_{s,k,i} + Diff\_Mean_{s,k,l} \quad (3)$$

$Y'_{s,k,l}$ is agreed on if it gives a better function value. Each and every finalized values at the end of the teacher phase is preserved are the input to the learner phase. Hence it can be said that the learner phase is dependent upon the teacher phase.

Learner Phase – This part of the algorithm is the 2nd part where the students increase their knowledge through mutual interaction. The learner masters new ideas if the other student has more information than them. Here, after depending on a sample size of 'n', the learning phase is concluded down below. [32]

Randomly choose 2 learners 'A' & 'B' such That $Y'_{sum\text{-}A,l} \neq Y'_{sum\text{-}B,l}$ (where, $Y'_{sum\text{-}A,l}$ and $Y'_{sum\text{-}B,l}$ are the updated values of the function of $Y_{sum\text{-}A,l}$ and $Y_{sum\text{-}B,l}$ of A and B, respectively at the end of teacher phase)

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$$Y''_{t,A,l} = Y'_{t,A,l} + r_l \ (Y'_{t,A,l} - Y'_{t,B,l}) \text{ , If, } Y'_{sum\text{-}A,l} < Y'_{sum\text{-}B,l} \quad (4)$$

$$Y''_{t,A,l} = Y'_{t,A,l} + r_l \ (Y'_{t,B,l} - Y'_{t,A,l}) \text{ , If, } Y'_{sum\text{-}B,l} < Y'_{sum\text{-}A,l} \quad (5)$$

$Y''_{t,A,l}$ is acquired only if it gives a better function value.

The Equations (4) and (5) are for minimization problems. If there are maximization problems, the Equations (6) and (7) will be utilized.

$$Y''_{t,A,l} = Y'_{t,A,l} + r_l \ (Y'_{t,A,l} - Y'_{t,B,l}) \text{ , If } Y'_{sum\text{-}B,l} < Y'_{sum\text{-}A,l} \quad (6)$$

$$Y''_{t,A,l} = Y'_{t,A,l} + r_l \ (Y'_{t,B,l} - Y'_{t,A,l}) \text{ , If } Y'_{sum\text{-}A,l} < Y'_{sum\text{-}B,l} \quad (7)$$

- Classification: In this step, CNN is used along with SVM to train the dataset and then create a model that is then used against the dataset to classify the images into normal, or diseased. The images are then classified to represent the stage or the grade of the Diabetic Retinopathy present in the image. The images can be graded as Mild, Moderate or Severe according to the presence of aneurysms and hard or soft exudates. Roughly equal class representations are created to train the images in the most uniform way possible. Through fractional max pooling of the features, the final output image is generated and consequently the stage of Diabetic Retinopathy in a person is predicted. This model then predicts the different stages of Non-proliferative Diabetic Retinopathy the image depicts.[26]

  The process used for the training of the data is CNN. CNN or convolutional neural networks is an algorithm associated with deep learning which uses an input image and then assigns biases or weights to the different objects present in the image and differentiate them from one another.Pre-processing of the input image required in a CNN algorithm is greatly lower as compared to other training and classification algorithms. With enough amount of training, CNN has the capability to learn the filters/characteristics.Inspired by the organization of the Visual Cortex, the model of a ConvNet is similar to that of the inter-connectivity pattern and communication with one neurons to another in the brain.The Receptive Field is a restricted region in the visual field and individual neurons appear to respond to stimuli only in that area. A cluster of similar fields overlap and become part of the entire visual area. [33]

  CNN – This is short for Convolutional Neural Networks and belongs to the category of a feed-forward type of neural network that is usually used to examine images which are put in a grid like topology which are processed. It's also known as a ConvNet. A convolutional neural network is used to predict and organize objects in an image. In CNN, each and every image is illustrated in the form of an array which shows pixel values. A convolution neural network has different hidden layers that assist in extricating information from any image. The four distinguished layers in CNN are Convolution, fully connected, ReLU and Pooling.

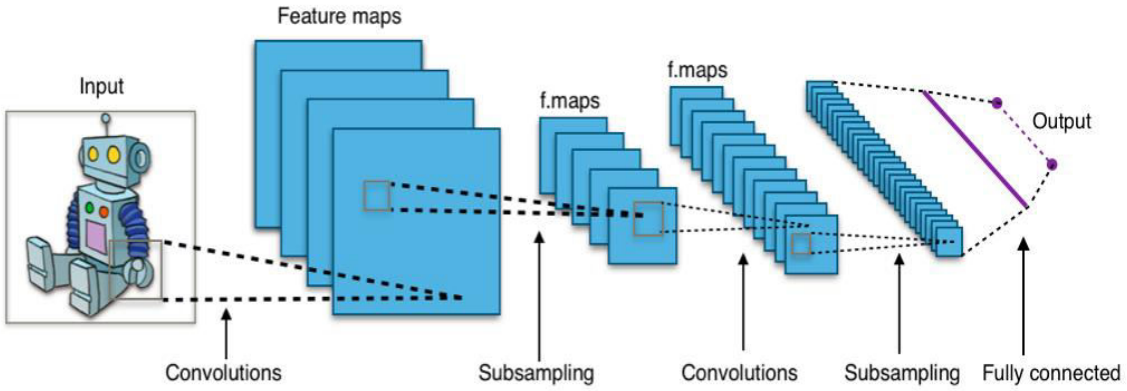

Figure 7. Convolutional layers in the Neural Network

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The process used in classification of the images into grades is SVM. SVM is a process that analyses training data to find an optimal way to classify the images. SVM can be used for categorization or regression. The process is carried out by extending the plotting to a n-dimensional space and then differentiating between two classes using a hyper plane.The aim of SVM is to increase the margin that is the distance between the plane and vectors. [34]

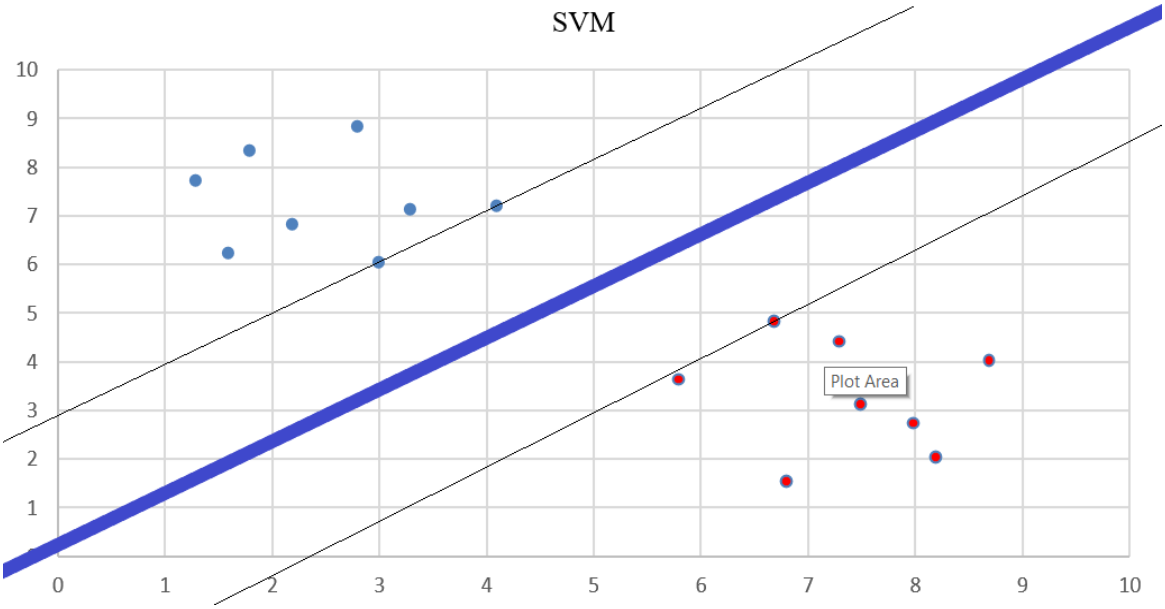

Figure 8. A graph showing how SVM works

The way of classification and grading the image is that the test features of the image are compared to the train features of each and every image in the training dataset. The difference between the test features and the train features is found out and the image with the train features that provide the maximum number of zeroes in the difference between the test and the train features is selected and the grade of Non- proliferative Diabetic Retinopathy in that image is considered to be the grade of Diabetic Retinopathy in the test image as well. The number 0 in the result corresponds to no disease or no sign of Diabetic Retinopathy. The number 1 in the result corresponds to mild disease or mild signs of Diabetic Retinopathy. The number 2 in the result corresponds to moderate disease or moderate signs of Diabetic Retinopathy. The number 3 in the result corresponds to severe disease or severe signs of Diabetic Retinopathy. [35]

Performance Estimation: In this module, the performance metrics like Accuracy will be estimated.

- Accuracy is one of the most important metrics for the evaluation of different models. Informally, accuracy is the proportion of forecasts the model got right. Actually, accuracy has the subsequent formula:

Accuracy = Number of the forecasts that were correct/ Number of forecasts that were totally made

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN} \quad (8)$$

- The feature extraction process extracts three extremely important features from the pixels of the data, the mean, the standard deviation and the variance.

The mean of those pixels of data in the image can be found by:

$$m = \frac{sum\ of\ the\ terms}{number\ of\ terms} \quad (9)$$

Where, m= mean

The standard deviation of the pixels of the data in the image can be calculated by:

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$$\sigma = \sqrt{\frac{\sum(a_i - \mu)^2}{S}} \quad (10)$$

Where, σ = standard deviation of the population
S = the sample size
a_i = One of the values of the distribution
μ = the mean of the sample size

The variance of the pixels of data in the image can be calculated by:

$$V^2 = \frac{\sum(a_i - \underline{a})^2}{s - 1} \quad (11)$$

Where, V^2 = Variance
a_i = One of the values of the distribution
a^{bar} = Mean of the distribution
s = the number of values in the distribution

4. EXPERIMENTAL RESULTS AND ANALYSIS

In this paper, a unique hybrid approach is suggested that uses convolutional neural networks along with TLBO method for optimization during feature extraction for prognosticating the grade of diabetic retinopathy in a human retina using the input of color fundus images.The proposed system is executed in python. Libraries such as pandas, numpy, matplotlib, open cv were used in the system along with pickle, keras, sklearn and tensorflow to predict the grade of Diabetic Retinopathy in the input image.

Numpy stands for Numerical Python and is basically a library in python that is used to work with arrays. It was created by Travis Oliphant in 2005. It provides a type of array object that is about 50 times faster than the traditional lists used in python for arrays. Pandas on the other hand is an extremely powerful data manipulation tool that was written specifically for the python language. It is really flexible and fast for the use of Data analysis as well. It was developed in 2008 by AQR Capital Management.Matplotlib is an amazing library created to generate interactive and complex visualizations in Python.It is especially used for difficult static and animated visualizations. The use of keras provides an interface for neural networks on Python.It basically acts as an interface for the tensorflow library. Tensorflow is an all-inclusive , flexible and far reaching ecosystem of libraries and tools that help a developer in creating cutting edge technology and projects.

Also, a teaching-learning based optimization algorithm was used at the time feature extraction to boost the performance of the system.Spyder was used along with Google colab and Jupyter notebook to implement the proposed method. Spyder is an open source scientific environment written in the language of python for the use of the developers of python.Jupyter is an document based on JSON and Google colab is an extremely useful product by the Google Research for python that is an amazing tool for data analysis and machine learning.

Four types of color fundus images belonging to different grades are considered for analysis. The sample images of all the grades are shown below:

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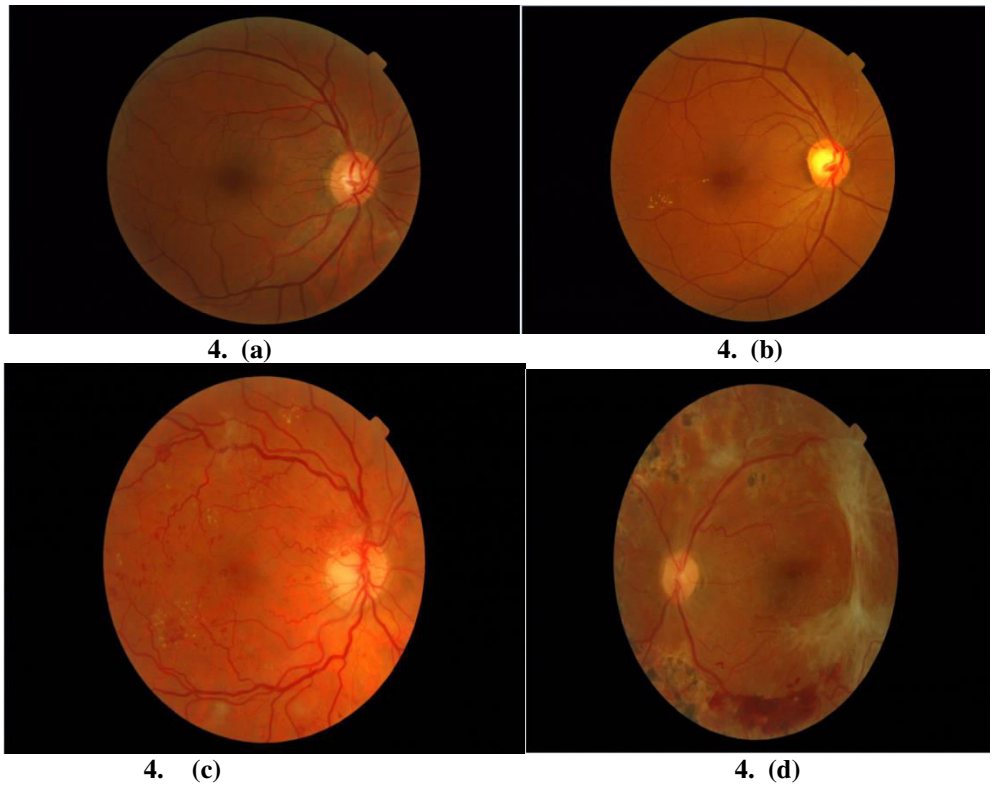
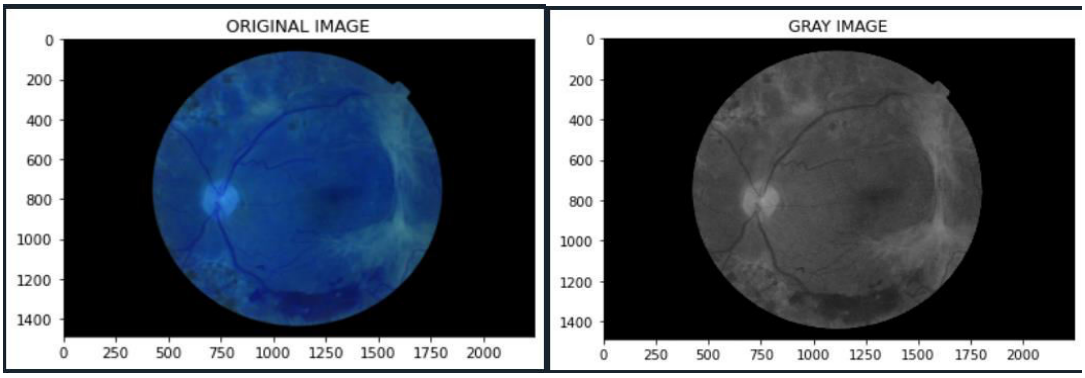


4. (a) **4. (b)**

4. (c) **4. (d)**

Fig – 4. (a) Fundus image with No Diabetic Retinopathy 4. (b) Fundus image with Mild Diabetic Retinopathy 4. (c) Fundus image with Moderate Diabetic Retinopathy 4. (d) Fundus image with Severe Diabetic Retinopathy

The images that were used in the dataset were taken using a color video 3CCD camera that has a field of view that was tilted at 45 degrees. All the images are in .tif format due to the image containing high quality graphics. For each of these grades of images, one image was selected to portray the analysis. Images underwent the pre-processing stage to get resized and then generated a blue channel image and gray scale converted image. The results of the pre- processing stage are shown below:



5. (a) **5. (b)**

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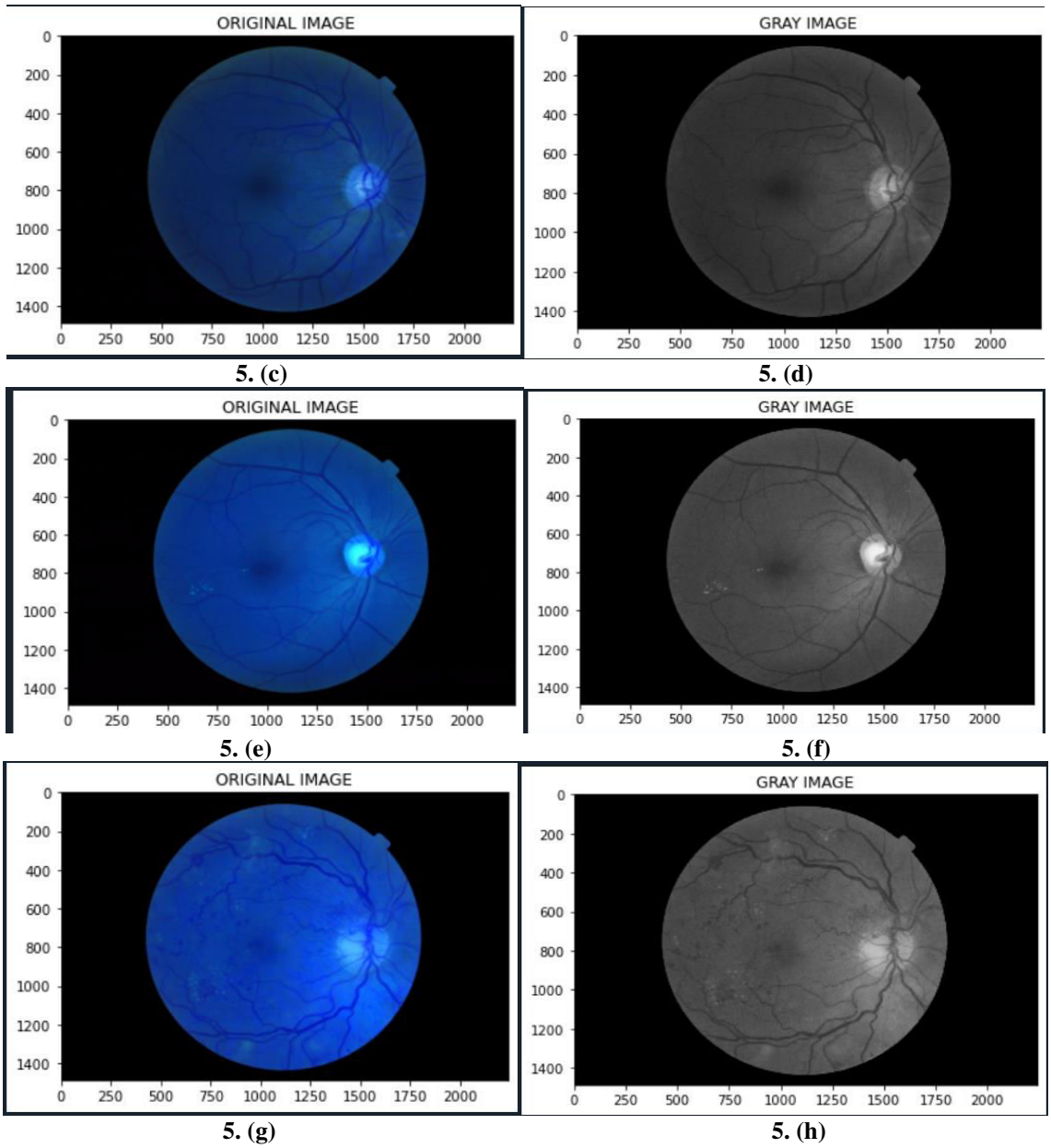

Fig- 5. (a) Blue channel 5. (b) Gray-scale conversion of the severe Diabetic Retinopathy fundus image
(c) Blue channel 5. (d) Gray-scale conversion of No disease fundus image
(e) Blue channel 5. (f) Gray-scale conversion of the mild Diabetic Retinopathy fundus image
(g) Blue channel 5. (h) Gray-scale conversion of the moderate Diabetic Retinopathy fundus image

The first step in pre-processing of these images is the resizing of the images. The images initially had a resolution of (2240,1488) pixels and those images were resized to (300,300). The main reason behind resizing the images was that the machine learning and deep learning models train better and faster on smaller images with less resolution. For an image double the size of the standard image , the model needs to train on four times as many pixels and while using a whole dataset of images, that time adds up to be become a great discrepancy.Also it is required to train the model on images of the same size and to make sure that all the input images are of the same size ,resizing is done on the raw dataset.OpenCv is a library in python that provides us several interpolation methods that can be used for resizing an image.

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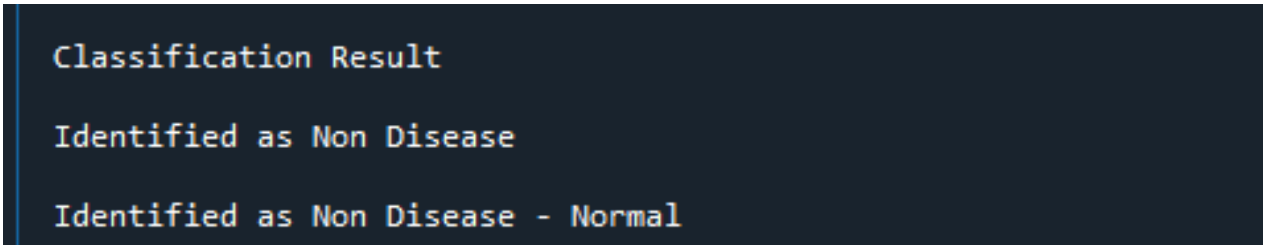
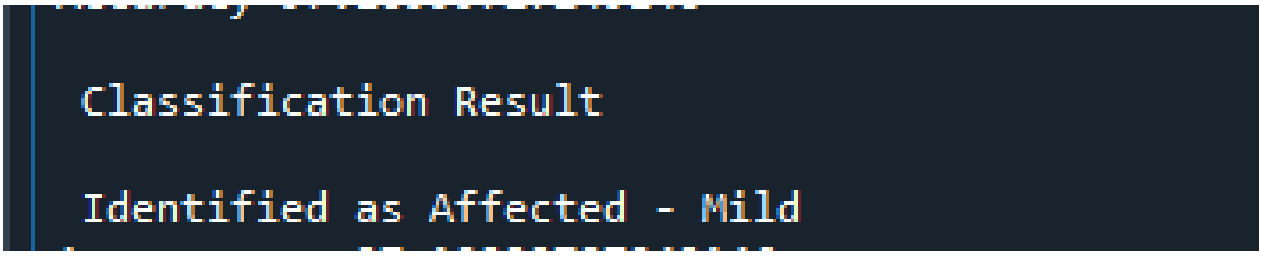
The next step in the pre-processing of the images is the Blue channel extraction and gray- scale conversion of the images. The use of gray- scaling is to convert the continuous tone images to the images that can be manipulated by the computer easily.The conversion is fundamentally the conversion of 24 bit values to 8 bit values. The grounds for such conversion is that less data or information needs to be provided for each pixel and they eliminate the need to use harder to process color images. The matplotlib module of python is used for this purpose.

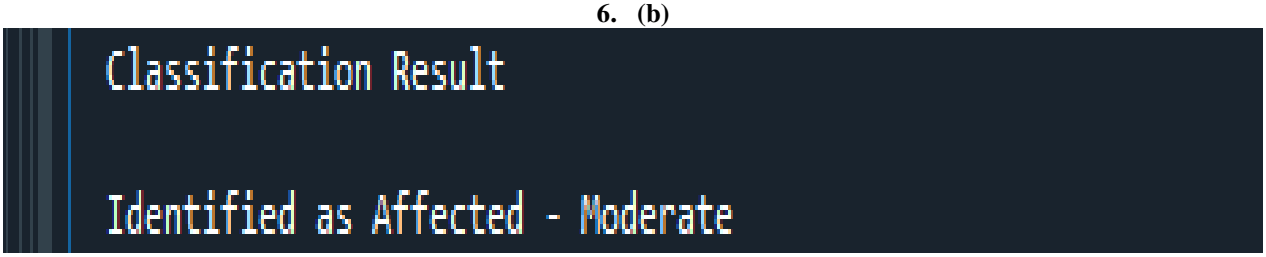
The output of the input images , that is, the grade of the Non-proliferative Diabetic Retinopathy in the input images respectively are shown below:



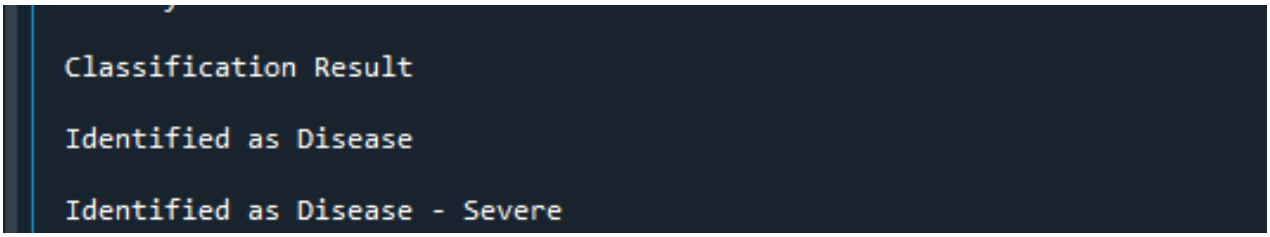
6. (a)



6. (b)



6. (c)



6. (d)

Fig- 6. (a) The grade prediction output of the 1st image corresponding to No disease in the human retina image 6. (b)The grade prediction output of the 2nd image corresponding to Mild disease in the human retina image. 6. (c) The grade prediction output of the 3rd image corresponding to Moderate disease in the human retina image. 6. (d) The grade prediction output of the 4th image corresponding to Severe disease in the human retina image.

The pictures above show the respective outputs for the input color fundus images. The pre-processed color fundus images undergo the process of feature extraction using TLBO. It helps in detecting the cases of Diabetic retinopathy which are not immediately obvious to the naked eye. the proposed system uses the TLBO algorithm.

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The analysis of the system indicates that the 1st category under which the image is classified shows the presence of microaneurysms. Retinal microaneurysms appear as small red dots which are often in clusters but may occur in isolation. These microaneurysms do not affect the vision. The 2nd category of images show the occurrence of retinal hemorrhages in which a clear substance bleeds from the blood vessels.. The 3rd category implies that there is a definite venous beading in two or more quadrants, 20 intraretinal haemorrhages such as cotton wool spots, venous beading, and severe intraretinal microvascular abnormalities.

Name of the paper	**Accuracy of the system**
Classification of Diabetic Retinopathy and Normal Retinal Images using CNN and SVM [12]	95.83%
Referable diabetic retinopathy identification from eye fundus images with weighted path for convolutional neural network [13]	94.23%
Application of deep learning image assessment software VeriSee for diabetic retinopathy screening [6]	90.7%
Deep convolutional neural networks for diabetic retinopathy detection by image classification [19]	95.68%
Prognostication of Diabetic Retinopathy using Machine Learning	97.04%

The images that were input in the system were processed and were categorized into 4 grades; mild (presence of retinal microaneurysms, which do not affect the vision), moderate (presence of retinal haemorrhages, leaking substance), severe (formation of new vessels with exudate), non-diseased. The accuracy obtained by the system is 97.04%. The images were graded into the above categories with the use of SVM classifier along with CNN. The accuracy with which the images were graded was found out and compared to other algorithms that incorporate CNN and it was found out that the use of TLBO for optimization was useful in increasing the performance of the system to assist the ophthalmologist in the diagnosis of Diabetic Retinopathy.

5. CONCLUSION

This proposed system concludes that the efficiency of the system can be enhanced if the dataset is increased, and the system is monitored under better hardware. There is an opportunity for improvement of other estimation elements other than accuracy of the system and juxtapose them against other hybrid approaches including combinations of different neural networks and enhancing algorithms as well as classifiers. Currently, there are several kinds of neural networks that have not yet been properly implemented in the medical field, in the future, there is a scope of these neural networks being executed such as Probabilistic Neural Networks to increase the estimations and the overall performance.

6. REFERENCES

6.1 Journal Article-

[1] Qiwei Xie, Yanfei Liu, Hui Huan, Bei Hong, Jinxin Wang , Hua Han and Yue Liu, “An innovative method for screening and evaluating the degree of diabetic retinopathyand drug treatment based on artificial intelligence algorithms”, Manufacturing Development, Pharmaceutical Research and Medical Science, ScienceDirect, Pharmacological Research, Volume 159, Article 104986, https://doi.org/10.1016/j.phrs.2020.104986, September 2020.
[2]Murat Seçkin Ayhan, Laura Kühlewein, Gulnar Aliyeva, Werner Inhoffen, Focke Ziemssen and Philipp Berens, “Expert-validated estimation of diagnostic uncertainty for deep neural networks in diabetic retinopathy detection”,

DOI: 10.9756/INT-JECSE/V14I4.112

Ophthalmic Research, Computational Neuroscience, Bioinformatics and Medical Informatics, ScienceDirect, Medical ImageAnalysis, Volume 64, Article 101724, https://doi.org/10.1016/j.media.2020.101724, August 2020.
[3] Recep E. Hacisoftaoglu, Mahmut Karakaya and Ahmed B. Sallam, "Deep learning frameworks for diabetic retinopathy detection with smartphone-based retinal imaging systems", Computer Science and Eye Institute, ScienceDirect, Pattern Recognition Letters, Volume 135, Pages 409-417, https://doi.org/10.1016/j.patrec.2020.04.009 , July 2020.
[4] Teresa Araújo, Guilherme Aresta, Luís Mendonça, Susana Penas, Carolina Maia, Ângela Carneiro, Ana Maria Mendonça and Aurélio Campilho, "DR|GRADUATE: Uncertainty-aware deep learning-base d diab etic retinopathy grading in eye fundus images", Systems and Computer Engineering, ophthalmology, Surgery and Physiology, ScienceDirect, Medical I mage Analysis,Volume 63, Article 101715, https://doi.org/10.1016/j.media.2020.101715, July 2020
[5] Lifeng Qiao, Ying Zhu and Hui Zhou, "Diabetic Retinopathy Detection Using Prognosis of Microaneurysm and Early Diagnosis System for Non-Proliferative Diabetic Retinopathy Based on Deep Learning Algorithms", in IEEE Access, vol. 8, pp. 104292-104302, doi: 10.1109/ACCESS.2020.2993937, May 2020.
[6] Yi-Ting Hsieh, Lee-Ming Chuang, Yi-Der Jiang, Tien-Jyun Chang, Chung-May Yang, Chang-Hao Yang, Li-Wei Chan, Tzu-Yun Kao, Ta-Ching Chen, Hsuan-Chieh Lin, Chin-Han Tsai and Mingke Chen, "Application of deep learning image assessment software VeriSee™ for diabetic retinopathy screening", Opthalmology and Internal Medicine, ScienceDirect, Journal of the Formosan Medical Association In press, https://doi.org/10.1016/j.jfma.2020.03.024 , April 2020
[7] Aishwarya Singh Gautam, Saikat Kumar Jana and Manash Pratim Dutta, "Automated Diagnosis of Diabetic Retinopathy using image processing for non-invasive biomedical application," 2019 International Conference on Intelligent Computing and Control Systems (ICCS), Madurai, India, 2019, pp. 809-812, doi: 10.1109/ICCS45141.2019.9065446, April 2020.
[8] Vishnuvarthanan Govindaraj, Mirthula Balaji, Thamimul ansari Mohideen and Syed ali Fathima Jamal mohideen, "Eminent identification and classification of Diabetic Retinopathy in clinical fundus images using Probabilistic Neural Network," 2019 IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS), Tamilnadu, India, 2019, pp. 1-6, doi: 10.1109/INCOS45849.2019.8951349, January 2020.
[9] Gabriel Tozatto Zago, Rodrigo Varej~ao Andre~ao, Bernadette Dorizzi and Evandro Ottoni Teatini Salles, "Diabetic retinopathy detection using red lesion localization and convolutional neural networks", Electrical Engineering, Control and Automation Engineering,ScienceDirect, Computers in Biology and Medicine, Volume 116, Article 103537, https://doi.org/10.1016/j.compbiomed.2019.103537, January 2020
[10] Mohamed M. Abdelsalam, "Effective blood vessels reconstruction methodology for early detection and classification of diabetic retinopathy using OCTA images by artificial neural network", Computers and System, ScienceDirect, Informatics in Medicine, Unlocked, Volume 20, Article 100390, https://doi.org/10.1016/j.imu.2020.100390, 2020
[11] Farrikh Alzami, Abdussalam, Rama Arya Megantara, Ahmad Zainul Fanani and Purwanto, "Diabetic Retinopathy Grade Classification based on Fractal Analysis and Random Forest," 2019 International Seminar on Application for Technology of Information and Communication (iSemantic), Semarang, Indonesia, 2019, pp. 272-276, doi: 10.1109/ISEMANTIC.2019.8884217, October 2019.
[12] Dinial Utami Nurul Qomariah, Handayani Tjandrasa and Chastine Fatichah, "Classification of Diabetic Retinopathy and Normal Retinal Images using CNN and SVM," 2019 12th International Conference on Information & Communication Technology and System (ICTS)", Surabaya, Indonesia, 2019, pp. 152-157, doi: 10.1109/ICTS.2019.8850940, September 2019.
[13] Yi-Peng Liu, Zhanqing Li, Cong Xu, Jing Li and Ronghua Liang, "Referable diabetic retinopathy identification from eye fundus images with weighted path for convolutional neural network", CS and Information Engineering, ScienceDirect, Artificial Intelligence in Medicine, Volume 99, Article 101694, https://doi.org/10.1016/j.artmed.2019.07.002, August 2019
[14] Norah Asiri, Muhammad Hussain, Fadwa Al Adel and Nazih Alzaidi, "Deep learning based computer-aided diagnosis systems for diabetic retinopathy: A survey", Computer, Information Science and Ophthalmology, ScienceDirect, Artificial Intelligence in Medicine, Volume 99, Article 101701, https://doi.org/10.1016/j.artmed.2019.07.009, August 2019
[15] Zeynab Mohammadpoory, Mahda Nasrolahzadeh, Naghmeh Mahmoodian and Javad Haddadnia, "Automatic identification of diabetic retinopathy stages by using fundus images and visibility graph method", Biomedical Engineering, Science Direct, Measurement, Volume 140, Pages 133-141, https://doi.org/10.1016/j.measurement.2019.02.089, July 2019

DOI: 10.9756/INT-JECSE/V14I4.112

[16] M. Mohsin Butt, Ghazanfar Latif, D.N.F. Awang Iskandar, Jaafar Alghazo and Adil H. Khan, "Multi-channel Convolutions Neural Network Based Diabetic Retinopathy Detection from Fundus Images", CS and IT, ScienceDirect, Procedia Computer Science, Volume 163, Pages 283-291, https://doi.org/10.1016/j.procs.2019.12.110, 2019
[17] Shailesh Kumar and Basant Kumar, "Diabetic Retinopathy Detection by Extracting Area and Number of Microaneurysm from Colour Fundus Image," 2018 5th International Conference on Signal Processing and Integrated Networks (SPIN), Noida, 2018, pp. 359-364, doi: 10.1109/SPIN.2018.8474264, September 2018.
[18] Krathi Kumar Palavalasa and Bhavani Sambaturu, "Automatic Diabetic Retinopathy Detection Using Digital Image Processing," 2018 International Conference on Communication and Signal Processing (ICCSP), Chennai, 2018, pp. 0072-0076, doi: 10.1109/ICCSP.2018.8524234, November 2018.
[19] Shaohua Wan, Yan Liang and Yin Zhang, "Deep convolutional neural networks for diabetic retinopathy detection by image classification",Information and Safety Engineering, Medical Information Analysis & Tumor Diagnosis, ScienceDirect, Computers & Electrical Engineering, Volume 72, Pages 274-282, https://doi.org/10.1016/j.compeleceng.2018.07.042 , November 2018
[20] Aydin Incedere and Sami Arica, "Detection of Exudates from Digital Fundus Images of Diabetic Retinopathy Patients," 2017 21st National Biomedical Engineering Meeting (BIYOMUT), Istanbul, 2017, pp. i-iv, doi: 10.1109/BIYOMUT.2017.8479059, October 2018.
[21] Ceren Kaya, Okan Erkaymaz, Orhan Ayar and Mahmut Özer, "Impact of hybrid neural network on the early diagnosis of diabetic retinopathy disease from video-oculography signals", Biomedical Engineering, Computer Engineering, Ophthalmology, Electrical and Electronics Engineering, ScienceDirect, Chaos, Solitons & Fractals, Volume 114, Pages 164-174, https://doi.org/10.1016/j.chaos.2018.06.034 , September 2018
[22] Narjes Karami and Hossein Rabbani, "A dictionary learning based method for detection of diabetic retinopathy in color fundus images," 2017 10th Iranian Conference on Machine Vision and Image Processing (MVIP), Isfahan, 2017, pp. 119-122, doi: 10.1109/IranianMVIP.2017.8342333, April 2018**.**
[23] Devvi Sarwinda, Alhadi Bustamam and Aniati M. Arymurthy, "Fundus image texture features analysis in diabetic retinopathy diagnosis," 2017 Eleventh International Conference on Sensing Technology (ICST), Sydney, NSW, 2017, pp. 1-5, doi: 10.1109/ICSensT.2017.8304447, March 2018.
[24] S. S. Chorage and S. S. Khot, "Detection of diabetic retinopathy and cataract by vessel extraction from fundus images," 2017 International conference of Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, 2017, pp. 638-641, doi: 10.1109/ICECA.2017.8203617, December 2017.
[25] Z. A. Omar, M. Hanafi, S. Mashohor, N. F. M. Mahfudz and M. Muna'im, "Automatic diabetic retinopathy detection and classification system," 2017 7th IEEE International Conference on System Engineering and Technology (ICSET), Shah Alam, 2017, pp. 162-166, doi: 10.1109/ICSEngT.2017.8123439, December 2017.
[26] K.C.Prabu Shankar, Chitransh Nigam, Tirthik Karmakar 2020. The Traffic Congestion Using Image Processing. International Journal of Advanced Science and Technology. 29, 05 (May 2020), 4670 - 4675.
[27] Ramkumar J, M. Baskar, M Viswak, M D Ashish, "Smart Shopping with Integrated Secure System based on IoT ", International Journal of Advanced Science and Technology, Vol. 29, No. 5, pp: 301-312, ISSN: 2005-4238, April 2020.
[28] Ramkumar J, M. Baskar, K. Ravishankar, Venkateswara Reddy Yakkanti," Health monitoring through pills dispenser for Alzhiemer disease based on IoT", International Journal of Advanced Science and Technology , Vol. 29, No. 4,pp: 1810-1818, ISSN: 2005-4238, April 2020.

6.2 Web Articles-

[29]https://www.healthknowledge.org.uk/public-health-textbook/research-methods/1a-epidemiology/sudies-disease-prognosis
[30] https://link.springer.com/article/10.1007/s11864-020-00810-3
[31]https://www.mayoclinic.org/diseases-conditions/diabetic-retinopathy/symptoms-causes/syc- 20371611
[32] https://www.expert.ai/blog/machine-learning-definition/
[33] https://sisu.ut.ee/imageprocessing/book/3
[34] https://en.wikipedia.org/wiki/Channel_(digital_image)
[35]https://sites.google.com/site/tlborao/
[36] https://machinelearningmastery.com/convolutional-layers-for-deep-learning-neural-networks/
[37] https://towardsdatascience.com/https-medium-com-pupalerushikesh-svm-f4b42800e989
[38] https://monkeylearn.com/blog/introduction-to-support-vector-machines-svm/

DOI: 10.9756/INT-JECSE/V14I4.112