Predicting Diabetic Retinopathy Severity via Generative Adversarial Nets, Convolutional Neural Network & Support Vector Machines

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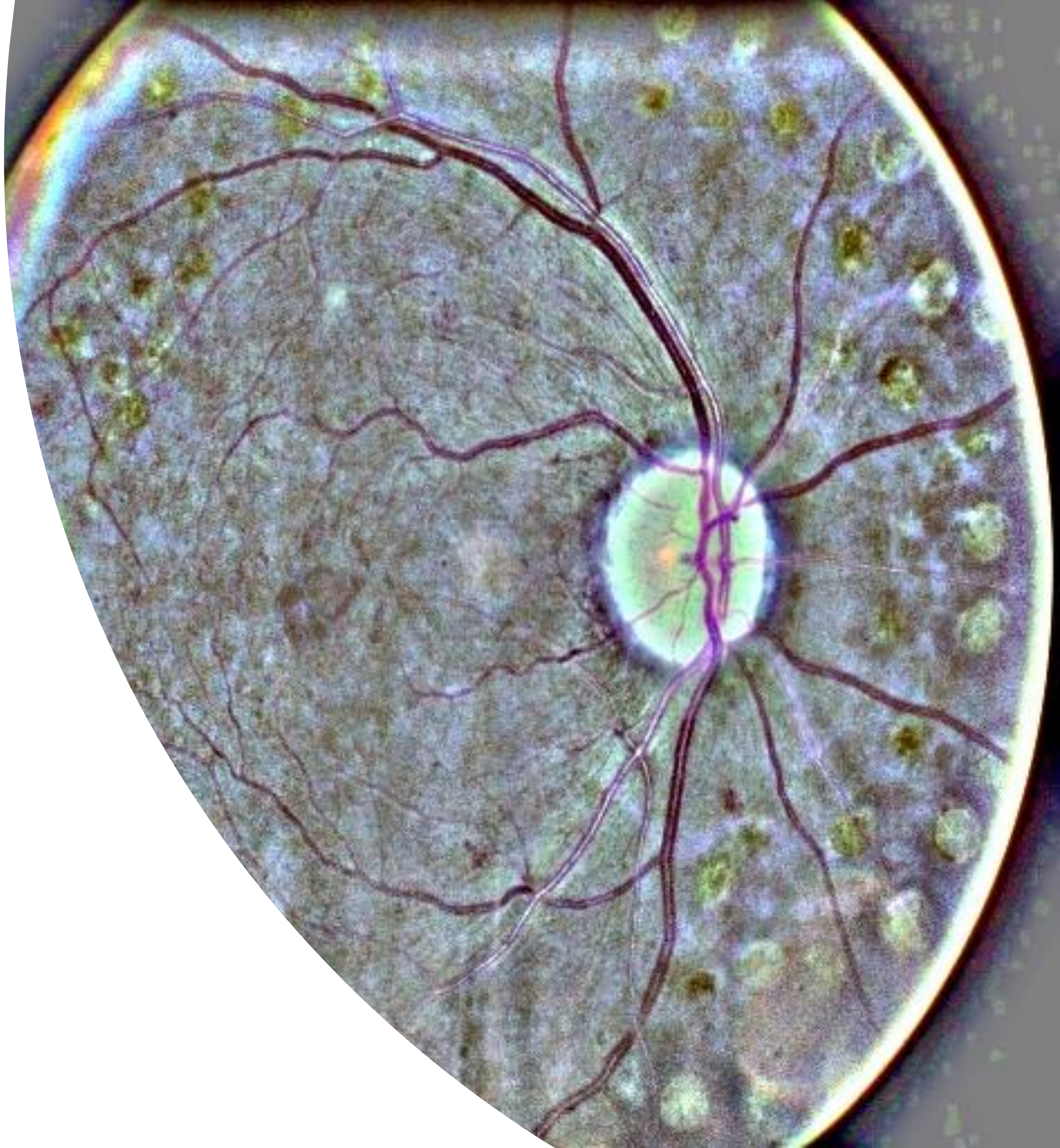
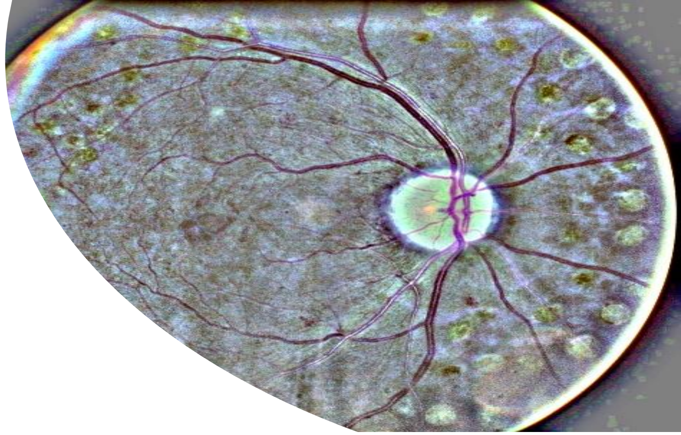
Motivation and Background

- Diabetic retinopathy (DR) is most common diabetic eye disease leading to fatal blindness
- Worldwide 33% of patients with diabetic mellitus shows sign of DR
- Symptomlessness is the major cause of non detection at earlier stages resulting in blood vessels leakage and abnormality in retina in later stages
- Many studies on Glaucoma and diabetic retinopathy prediction using CNN, deep neural network, fractal analysis and support vector machine have been done in past but with varied accurate models or with less images as data set
- Less images in a deep learning model may not be able to generalize the model for independent data set
- A comparative study among the methods may help in building more stable and generalized model for earlier DR prediction



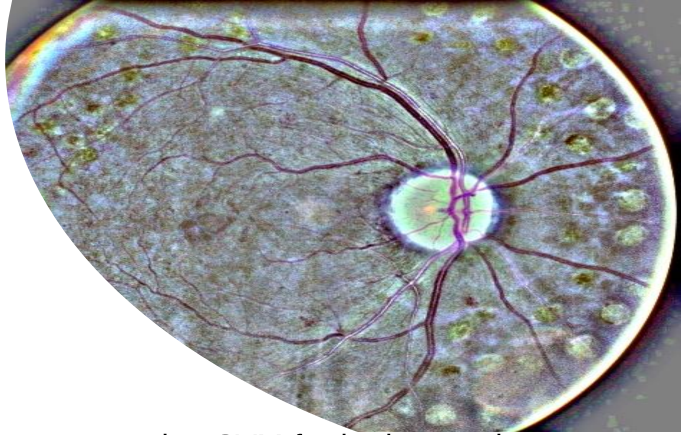
Research Question

- Which back propagation model amongst Convolutional Neural Network, Support Vector Machines and Generative Adversarial Network comparatively better in prediction of Diabetic Retinopathy?
- Which model can be stabilized and generalized on an independent data set for accuracy in Prediction?



Methodology

- Data set
  - Data set was available on Kaggle which has 65K of images labelled as No diabetic retinopathy, mild, moderate, severe and proliferative diabetic retinopathy
  - Categorical classification from 0 to 4 stating different stages of DR
  - Images of 512*512*3(RGB) was available as part of the data set
  - A total of 5251 images for train and 500 images for test and 250 independent images were taken randomly from the total data set of 65K images for training the model and testing the model
- Data Transformation
  - Data was transformed to image size of 28*28*3 for capitalizing on computational time and speed
  - For CNN model data was reshaped in array format
  - Denoising of the images was done using Image median filter
  - For SVM model data set was converted from array format to data frame format
  - PCA Analysis was done on SVM dataset for reducing variables with multicollinearity
- Data Transformation -- Continued
  - PCA Analysis did not reduce the independent variables
  - Applied SVM kernel on Independent data frame by abandoning PCA
  - Used same array data for GAN training also
- Iterations
  - Did iterations for CNN with varied optimizers like adadelta, RmsProp and Adam after hyper tuning parameters for kernel size, filters, epoch, batch size, flattening layers and dense layers
  - Adam optimizer yielded good results for train and test data on CNN
  - SVM hyper tuning of parameters was done for C and sigma values
  - SVM also yielded good results on train and test data
  - GAN model results were also stable with adversarial and discriminator loss
  - SVM and CNN model were tested on independent data set for stability and generalization of the model



Results

Parameters	Train Data		Test Data		Generative Adversarial Network
	Convolutional Neural Networks	Support Vector Machines	Convolutional Neural Networks	Support Vector Machines	
Loss Function	0.0792		0.0819		
Accuracy	0.9893	0.9343	0.9880	0.9020	
Kappa		0.9174		0.8775	
P-Value		2.20E-16		2.20E-16	
Adversarial Loss					1.3393
Discriminator Loss					0.5742

- CNN's had better accuracy than compared to SVM for both on train and test data with 98.9% and 98.8% respectively
- SVM also returned a good accuracy of 93.43% and 90.20% on train and test data respectively
- Sensitivity was ranging from 88.95% to 97.85% across label of DR and Specificity was ranging from 95.90% to 99.36% across varied class category of DR for Train data in SVM. For 95% CI datasets accuracy was between 92.73 to 94.09% for train data in SVM
- Sensitivity was ranging from 82% to 97% across label of DR and Specificity was ranging from 96% to 99% across varied class category of DR for test data in SVM. For 95% CI datasets accuracy was between 87.25 to 92.66% for test data in SVM
- Final adversarial loss was 1.33927 and discriminator loss was 0.57423 for GAN which was around the optimal range

Conclusions and Discussions

- CNN seems to have higher accuracy than SVM in terms of DR prediction both on train and test data
- SVM model performs better and is stable on independent images than compared to CNN model. We saw on independent data set of 250 images SVM returned an accuracy of 49.2% as against 38.8% by CNN model
- GAN also performed very well in terms of returning within benchmark band of parameters for adversarial loss and discriminator loss with 1.3393 and 0.5742, respectively.
- CNN requires more images for learning than SVM to have stable model for prediction on independent data set
- Though with high accuracy on train and test data the CNN and SVM models returned lower accuracy as stated in point 2 on independent data set. Models could not be generalized both for CNN and SVM

Contributions

- Study found that SVM requires less data for training and will result in better stable model than CNN.
- CNN requires more images for training to result in a stable and generalized model for application on independent data set
- A code in R which gives Prediction probabilities for severity of diabetic retinopathy
- Application of GAN for first time in Diabetic retinopathy prediction.

Limitations of research work

- Did not have access to Graphical Processing units and had to use local system memory with 32 GB RAM for image processing
- With GPU’s more image samples could have been taken for training and testing the models
- More images for training could have resulted in more generalized and stable model
- Due to lack of GPU and higher computational power input image of 512*512*3 was reduced to 28*28*3 thereby compromising on more features and dimensions of image. Higher resolution could have resulted in higher accuracy of models on independent data set

Future Research work and opportunities

- Creating an Ensemble model for prediction by combining one or more back propagation algorithms
- Using Informational GAN for prediction of class labels or categories of diabetic retinopathy severity amongst the ocular images
- Developing an application-based utility where images can be scanned from a mobile or image processing hardware and returning the prediction of retina in terms of Diabetic retinopathy severity.
- Develop a model each one for Left and right eye, so that model accuracy and stability further improves