Early Detection of Diabetic Retinopathy from Eye Images

Comp 479-001

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Diabetic retinopathy is a leading cause of vision impairment and blindness among individuals with diabetes. It is critical for early detection in order to prevent the progression of this condition because the disease rarely shows signs or symptoms until the condition has reached advanced stages. The advancements in the technological field with tools such as medical imaging and artificial intelligence, have made it possible to detect early signs of diabetic retinopathy by analyzing images of the retina. These methods of early detection can identify micro aneurysms, hemorrhages, and abnormal blood vessels giving a timely diagnosis. This project explores how machine models are able to use methods to detect the disease early on which improve patient outcomes and reduce diabetic complications or additional risks such as vision impairment.

This dataset contains extracted information from the Messidor image set. In French, MESSIDOR stands for Methods to Evaluate Segmentation and Indexing Techniques in the field of Retinal Ophthalmology. The subjects in the image set are medical patients with a certain class of severity of diabetic retinopathy. The target variable of this data is called pre_screening, and it is a binary (0,1) variable that indicates whether an image showed severe retinal abnormality. There are 19 other predictor variables, all binary or numeric, which are assessment quality, ma1-ma6 (feature values for microaneurysm detection), exudate1-exudate8 (feature values for exudates found by dividing the number of lesions with the diameter of the region of interest), macula optic disc distance, optic disc diameter, AM or FM classification, and class for signs of diabetic retinopathy.

In order to create our logistic regression model, we first split our dataset into train (70%), development (15%), and test (15%) datasets. We trained a logistic regression classifier with default parameters using the training dataset, which resulted in an accuracy of 0.75. In order to improve accuracy, we performed grid search on our development set in order to find the best C value. After finding the best C value for the model, 1000, we tested our final model on our test set, resulting in an accuracy of 0.80.

To analyze our diabetic retinopathy dataset we utilized both logistic regression and a fully connected neural network (FCNN) in order to predict the presence of diabetic retinopathy. The methods were employed to complement one another and provide insights of the datasets structure and overall performance. Logistic regression is a model that performs well on datasets that are linearly separable. We established this baseline model for the predictive aspect of the model, as well as interpreting how the features correlate with the target variable. FCNN captures non-linear relationships and interaction between features, this is something logistic regression cannot do. There are hidden layers and activation functions that are applicable in order for the model to learn the different patterns in the dataset. In our dataset this is useful because our features may not be strictly linear. We used the metrics of accuracy and F1 score for binary classification. Accuracy is utilized in order to measure the percentage of correct predation over the total number of instances. This measures the overall model's performance. The F1 score is a combination of precision and recall into a single metric, and is more informative for our dataset. This calculates the portion of true positives among predicted positives and recall measures the proportion of true positive amount actual positives. This creates a clear picture of the model's ability to identify positive cases, patients with diabetic retinopathy. Our dataset involves medical classifications where false negatives can have more consequences. Precision and recall metrics are very important here. The measurement of the model's performance in identifying retinopathy cases ensures that the model minimizes the error of both false positives and false negatives.

For the logistic regression model, we used accuracy as our performance metric. After evaluating the model on the test dataset, we found the test accuracy to be 0.80, meaning about 80% of the predictions due to the weights of the predictor variables were correct. The weighted average, which accounts for the average performance of the weights, was the same, also being 0.80. This means that the model performs the same between both classes. Finally, the logistic regression model has an F1 score of 0.79, meaning that the model has relatively strong precision and recall, even though there is room for improvement.

We decided to evaluate our FCNN model with accuracy and F1 score. After evaluating the model on the test dataset, we found the test accuracy to be 0.9091, meaning about 91% of the predictions due to the weights of the predictor variables were correct. The weighted accuracy, which accounts for the average performance of the weights, was similar. This value was calculated to be about 0.87. The macro average was found to be about 0.48, which is the average without considering the weights, showing the importance of the coefficients for each variable. In this case, the impact of the variables on the predictions varied heavily. Overall, the FCNN proved to be a very capable model for predicting whether an image depicted severe retinal abnormality.

In this project we looked at the ability of learning algorithms to use diabetic retinopathy data from the messidor image set to predict diabetic retinopathy. To test our algorithm, we tested out two learning algorithms: a logistic regression and fully connected neural network. The results of our logistic regression being an accuracy score of 0.80 , this signifying a strong performance, indicating that the logistic regression model is capable of accurately predicting diabetic retinopathy in 80% of cases.

The FCNN, our results showed a 0.9091 accuracy. This being over the 0.7 threshold and holding significance as it shows that our model is reliable and holds potential for further use. The results of our project imply that we have successfully trained an algorithm to use the retinopathy data to predict diabetic retinopathy in future patients. The limitation of this project is that we are heavily reliant on the data of the images and not the images itself. To further this study/project we would need a program that takes the images and is able to break it down and give us the results in a similar way to the data that was provided by the messidor project.

The project demonstrates how machine learning models, specifically neural networks, can accurately predict diabetic retinopathy from image data. The FCNN model showed strong performance and was able to achieve an accuracy of 0.9091. This implies that this model can be a tool used for early detection and potentially preventing vision loss but relies on processed image data. To improve the model, the machine would need to work directly with the images themselves and use techniques such as deep learning for more accurate predictions.