Quantification of Retinal Tissue Damage

Semester Long Research Project

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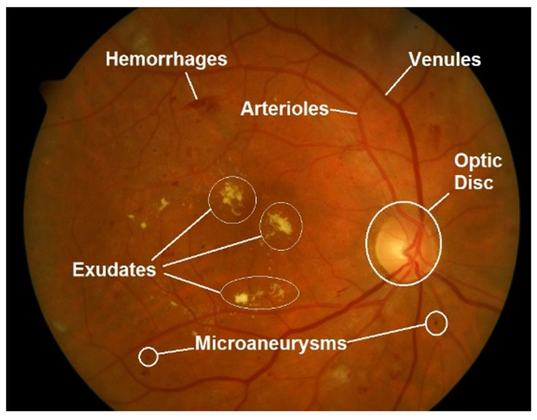
Abstract

In this project, we analyse fundus images to detect signs of retinal tissue damage. A system has been proposed for detection of abnormal eye images by extracting features such as blood vessels, exudates, microaneurysms, hemorrhages, fractal dimension, entropy and homogeneity through image processing techniques. Finally, the objective measurement of these features is computed and the resulting data is fed to several classifiers and analysed via machine learning techniques.

Introduction

The aim of this project is to quantify retinal tissue damage. We analyse images obtained through fundus photography which is a specialised non-invasive medical imaging technique. The abnormalities depicting the damage in the fundus images are:

1. Microaneurysm- microscopic blood-filled bulges in the artery walls.
2. Exudates- bright, small spots, consisting of lipids, which can have irregular shape.
3. Hemorrhages- chunks of blood vessels, appearing as red blobs, lying on the retina because of blood vessel rupture.
4. Blood vessels- formation of new blood vessels which are weak and disoriented which sometimes causes them to leak inside vitreous.

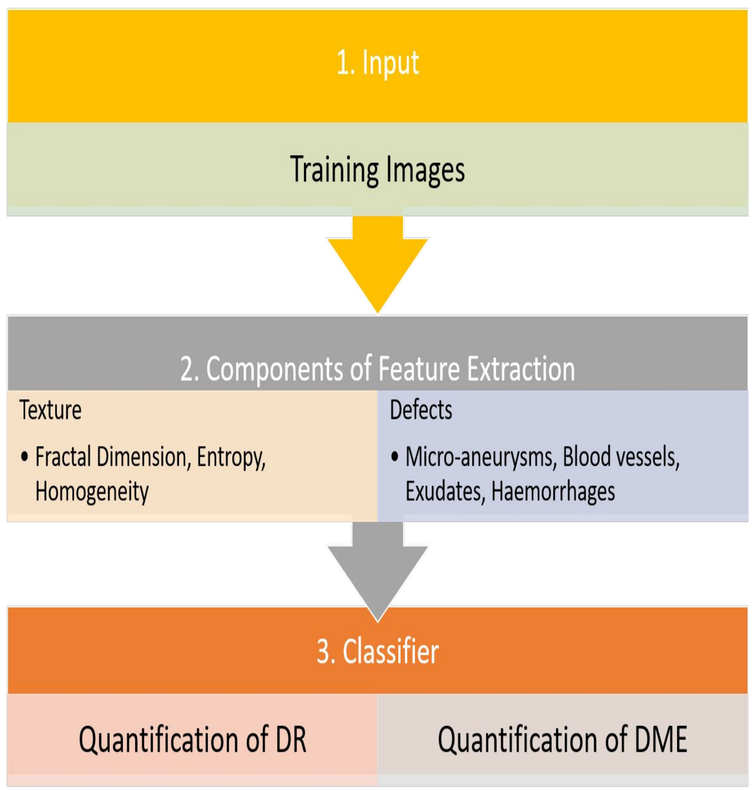


A labelled fundus image depicting abnormalities in fundus image.

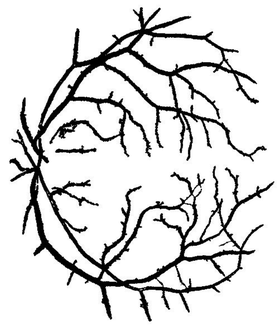
These abnormalities are associated with eye diseases- Diabetic Retinopathy (DR) and Diabetic Macular Edema (DME). DR is the leading cause of blindness in the working-age population of the developed world. It is estimated to affect over 93 million people worldwide. Approximately 7.7 million Americans have DR and of those, about 750,000 also have DME. Currently, detecting these diseases is a time-consuming and manual process that requires a trained clinician to examine and evaluate digital color fundus photographs of the retina. The expertise and equipment required are often lacking in areas where the rate of diabetes in local populations is high.

So, a solution is to build an automatic detection system for DR and DME.

Methodology



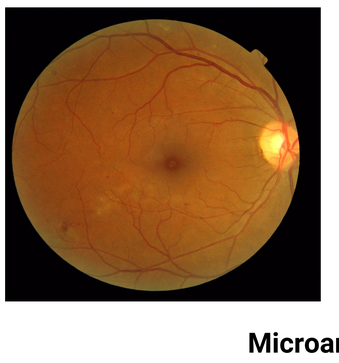
Feature Extraction Results

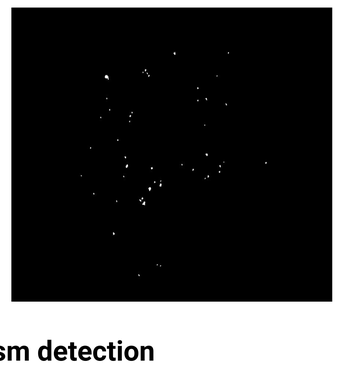


Blood Vessel Segmentation

Haemorrhages Detection

Exudates Detection

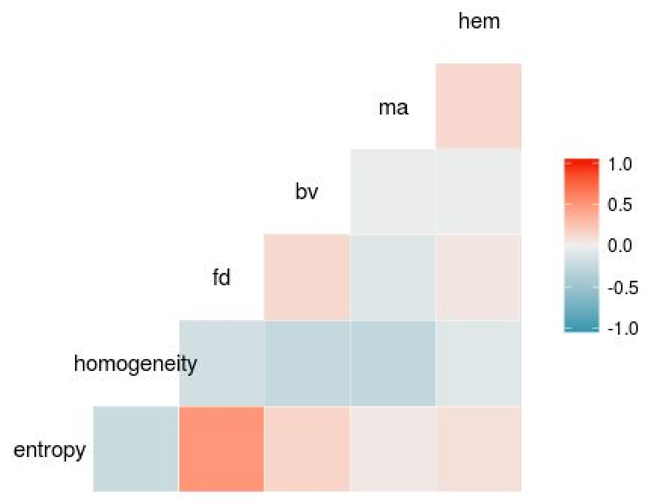




Microaneurysm detection

Data Analysis

Measurement of features extracted was done and data was recorded against the annotated **MESSIDOR** dataset. Machine learning analysis was done on this complete data.



Feature correlation matrix.

Machine Learning Model	Accuracy
Support Vector Machine	0.7291922
Random Forest	0.7302795
k-Nearest Neighbor	0.5659159
Adaboost	0.7071550
Artificial NN	0.7333688
Naive - Bayes	0.7087025
Linear Discriminant Analysis	0.7277994

Accuracy scores of DME classification.

Results & Conclusion

We obtain the following results from our analysis:

1. The image processing techniques used by us prove to be very consistent, giving exemplary results for blood vessel segmentation and exudates detection. Results of blood vessel segmentation are better than any previous work in the same field.
2. Entropy and fractal dimension are correlated and hence dropping one of these features does not affect the accuracy much.
3. Microaneurysm play a very crucial role in the classification of both DR and DME.
4. Highest accuracy achieved, **81%**, is for DME multi-class classification using Random Forests on all 1200 instances.
5. For DR binary classification, accuracy of 67% was achieved.

References

1. Tripathi, Shraddha, et al. "Automatic detection of exudates in retinal fundus images using differential morphological profile." International Journal of Engineering and Technology 5.3 (2013): 2024-2029.
2. Zhou, H. W., and H. Xie. "Direct estimation of the fractal dimensions of a fracture surface of rock." Surface Review and Letters 10.05 (2003): 751-762.