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Leveraging Machine Learning Techniques to Investigate the Relationship Between Structure and Function in Glaucoma

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Abstract

Purpose : The aim of this research is to investigate machine learning (ML) prediction models to understand the relationship between structural markers and visual function in glaucoma eyes.

Methods : Clinical data on 115 glaucoma eyes evaluated biannually for up to 7 years were used for this study. Structural measurements of retinal nerve fiber layer (RNFL) average thickness and cup-to-disk ratio (area, vertical and horizontal) and visual field mean deviation (MD) were available for the feature selection process. We classified mean deviation (MD) variable based on 5 stages as: Stage 0: greater than or equal to 0 (Class 0), Stage 1: -0.01 to -5.00 (Class 1), Stage 2: -5.01 to -12.00 (Class 2), Stage 3: -12.01 to -20.00 (Class 3) , Stage 4: less than or equal to -20.01 (Class 4). Our training data involved 780 samples and the testing data 195 instances (total of 975 samples) including multiple visits of patients. We implemented three classifiers: multilayer perceptron (MLP), support vector machine (SVM), K-nearest neighbor (KNN) to compare ML classifiers on a combination of structural markers.

Results : The impact of different structural markers (RNFL Average, Cup-to-Disk Ratio (Area, Vertical and Horizontal)) on the MD stage classification with 5 stages (classes) was studied. We observe that MLP and SVM are compatible and when using all four variables the

MLP model with 83.27% average test accuracy outperforms SVM and KNN with average test accuracy 82.94% and 81.73% respectively. (See Figure 1 and the table for more results and standard deviations. In Figure 1, A, B, C, and D are feature combinations with 1, 2, 3, and 4 features, respectively, and match the order and combinations in the table.) MLP and SVM outperform KNN in predicting the stages of visual field loss based on MD. The type and number of structural variables considered for the selection process do not markedly impact the results.

Conclusions : These findings provide useful insights on the ML methods that can be used to study the relationship between structure and function in glaucoma eyes.

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This figure displays the impact of various combinations of structural markers to predict visual function in glaucoma eyes using three different MLP, SVM, KNN classifiers.

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The table shows the average test accuracy of three different MLP, SVM, KNN classifiers on visual function in glaucoma eyes using a combination of structural markers.

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