Using Machine Learning Classifiers to Identify Glaucomatous Change Earlier in Standard Visual Fields

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PURPOSE. To compare the ability of several machine learning classifiers to predict development of abnormal fields at follow-up in ocular hypertensive (OHT) eyes that had normal visual fields in baseline examination.

METHODS. The visual fields of 114 eyes of 114 patients with OHT with four or more visual field tests with standard automated perimetry over three or more years and for whom stereophotographs were available were assessed. The mean (_SD) number of visual field tests was 7.89 _ 3.04. The mean number of years covered (_SD) was 5.92 _ 2.34 (range, 2.81–11.77). Fields were classified as normal or abnormal based on Statpac-like methods (Humphrey Instruments, Dublin, CA) and by several machine learning classifiers. The machine learning classifiers were two types of support vector machine (SVM), a mixture of Gaussian (MoG) classifier, a constrained MoG, and a mixture of generalized Gaussian (MGG). Specificity was set to 96% for all classifiers, using data from 94 normal eyes evaluated longitudinally. Specificity cutoffs required confirmation of abnormality.

RESULTS. Thirty-two percent (36/114) of the eyes converted to abnormal fields during follow-up based on the Statpac-like methods. All 36 were identified by at least one machine classifier. In nearly all cases, the machine learning classifiers predicted the confirmed abnormality, on average, 3.92 _ 0.55 years earlier than traditional Statpac-like methods.

CONCLUSIONS. Machine learning classifiers can learn complex patterns and trends in data and adapt to create a decision surface without the constraints imposed by statistical classifiers. This adaptation allowed the machine learning classifiers to identify abnormality in visual field converts much earlier than the traditional methods. (*Invest Ophthalmol Vis Sci*. 2002;43: 2660–2665)

In this study, we investigated whether machine learning classifiers, including neural networks, are useful for identifying which individuals with initially normal visual fields will have development of abnormal visual fields later, due to glaucoma.

Neural networks are a subset of machine learning classifiers. The terminology has been changed in the artificial intelligence community to the latter term to include classifiers that “learn”, but do not necessarily mimic, a simple neural pathway of the brain, as neural networks do. Machine learning classifiers usually use a form of supervised learning. Supervised learning refers to systems that are trained, instead of programmed, by a set of examples that are input– output pairs.1

The input is the data and the output is the classification made by the machine learning method. During training, the classifier is told whether it is correct or incorrect based on a gold standard, and, after each run-through, it adjusts its internal parameters to arrive at more correct responses. This process is repeated until the classification performance does not improve. After training, the goal is that the machine classifier has learned and can correctly classify new input data that were not part of the original training sets. An attractive aspect of these classifiers is their ability to learn complex patterns and trends in data and to create decision rules adaptively, without the constraints imposed by statistical classifiers.2,3

In a previous study, we compared the ability of several classifiers to detect early field loss.4 The inputs to the classifiers in that study were threshold values from standard visual fields plus the age from either healthy eyes or from eyes with glaucomatous optic neuropathy (GON). Because there is no absolute agreed-on gold standard for the presence of early glaucoma, the surrogate gold standard in this previous study, used to train the classifiers, was the absence or presence of GON. Visual field results were not used to select subjects or as a gold standard to train the output. The output from each classifier was a designation of either “normal field” or “glaucomatous field”. The classifiers’ results were also compared with those of two glaucoma experts and the Statpac 2 indices5,6 (Humphrey Instruments, Dublin, CA) that are typically used to identify field abnormalities. We found that several machine learning classifiers representing different methods of learning and reasoning performed well in comparison with both Statpac 2 and the glaucoma experts when classifying the visual fields.

The purpose of the present study was to apply the best candidate machine learning classifiers from our previous study, along with more Statpac-like traditional classifiers, to a new set of longitudinal standard automated perimetry (SAP) data from 114 ocular hypertensive eyes. If the classifiers could identify visual field converts from this group, they might have great utility in situations in which experts in glaucoma are not available and for standardization of methods in clinical trials.