Using Fused Data from Perimetry and Optical Coherence Tomography to Improve the Detection of Visual Field Progression in Glaucoma

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Introduction: Visual field (VF) testing and optical coherence tomography (OCT) are both used to monitor glaucoma progression. However, combining these modalities can be challenging due to differences in data types. This study aims to develop a machine learning-based data fusion model to combine data from VF testing and OCT for improved detection of VF progression detection.

Methods: "We developed an autoencoder (AE) model to fuse differential light sensitivity from VF testing and retinal nerve fiber layer thickness profiles from OCT. The AE model was designed to discover a compact encoding of the input VF and RNFLT profile data, with the encoding serving as the AE-fused data. During model training, a novel encoding loss was introduced to ensure the similarity of AE-fused data to VF tests while capturing key features from OCT measurements. Therefore, the resulting AE-fused data can be interpreted in the same way that a VF test is interpreted.

For model evaluation, we labeled eyes as progressing if the linear regression slope of mean deviation was worse than −0.5 dB/year, calculated from all measured VF data for each eye. Then, we used data from only the first two years to detect VF progression. The detection sensitivity and specificity obtained from the AE-fused data were compared to those from the measured VF data and a state-of-the-art Bayesian linear regression (BLR) model that integrates structural and functional changes. "

Results: A total of 2504 VF-OCT test pairs from 253 eyes of 140 glaucoma patients were included for model training and evaluation. In the initial 2-year follow-up, the specificity of detecting VF progression using AE-fused data was 0.70 (95% CI: 0.68 to 0.71), representing a 94% improvement (P<0.001) over the detection specificity with the measured VF data (0.36, 95% CI: 0.35 to 0.38) and a 27% improvement (P<0.001) over the detection specificity when using data from the BLR model (0.55, 95% CI: 0.54 to 0.57). In the same period (i.e., the initial 2 years), the sensitivity of detecting VF progression with the AE-fused data was 0.53 (95% CI: 0.47 to 0.58), outperform-ing that of the BLR model (0.35, 95% CI: 0.31 to 0.38, P<0.001) and insignificantly lower than that of using measured VF data (0.54, 95% CI: 0.51 to 0.58, P=0.291).

Conclusions: The capacity of the autoencoder data fusion model to generate clinician-interpretable AE-fused data can improve VF progression detection, making it a promising data integration approach in glaucoma management.