

Data-Driven Diagnostic Use



With AI and deep learning, the future is bright, but collaboration among investigators will be required.

BY FELIPE A. MEDEIROS, MD, PhD

Glaucoma is the leading cause of irreversible vision loss worldwide,¹ affecting approximately 80 million people.² The disease can affect patients' quality of life and impair their ability to perform many activities of daily living, such as driving, reading, or walking.³ However, glaucoma may remain asymptomatic until relatively late stages. In developed countries, up to 50% of patients with glaucoma do not know they have the disease; in developing countries, this number may reach 90%.¹

LACK OF CLEAR DIAGNOSTIC CRITERIA

How is glaucoma diagnosed? Despite the importance of this question, one is likely to obtain a host of different and perhaps contradictory answers from ophthalmologists and even glaucoma specialists. The lack of clear diagnostic criteria has greatly hindered research toward development of better methods for early diagnosis of glaucoma as well as progress on understanding the mechanisms of disease. Presented with photographs of optic nerves or print-outs of visual fields, glaucoma specialists frequently disagree about whether or not the images show evidence of glaucomatous damage, notably in cases of early disease.⁴

AI AND BIG DATA

We may be about to experience the end of this era of uncertainty with the help of artificial intelligence (AI) and big

data. Advances in computational power, speed, and networking capabilities have allowed unprecedented development of AI algorithms that can objectively and accurately classify medical data. A deep learning algorithm was recently shown to have sensitivity and specificity comparable to that of experts in grading fundus photographs for diabetic retinopathy.⁵

Deep learning networks are a form of neural network. Although they have garnered much attention in recent years from the lay media, the concepts of neural networks and deep learning are not new. What has changed is that today computer scientists finally have access to both the vast computational

power and the enormous amounts of data, in the form of images, text, and video, that are needed to make neural networks work well. For example, in the aforementioned study, more than 10,000 images were included; studies with even larger amounts of data are likely to emerge soon.

APPLICATIONS IN GLAUCOMA

The opportunities for use of AI in the field of glaucoma are enormous. As in the diabetic retinopathy study, deep learning algorithms could be trained to recognize signs of glaucomatous damage in disc photographs. As portable and inexpensive methods for acquisition

AT A GLANCE

- ▶ A lack of clear diagnostic criteria has hindered research toward development of better methods for early diagnosis of glaucoma and progress on understanding the mechanisms of disease.
- ▶ Advances in computational power, speed, and networking capabilities have allowed unprecedented development of AI algorithms that can objectively and accurately classify medical data.
- ▶ Deep learning algorithms could potentially be trained to recognize signs of glaucomatous damage in disc photographs.
- ▶ The most accurate training of AI algorithms still relies on initially providing the computer with clear examples of abnormal versus normal features.

50% 60% 70% 80% 90%

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of fundus photographs become widely available, this could bring the opportunity to screen widely for glaucomatous optic nerve damage, potentially decreasing the enormous number of patients that currently obtain late diagnoses. Objective AI-based diagnosis might also be derived from imaging of the optic nerve, retinal nerve fiber layer, or macula with optical coherence tomography.

It is important to note that the most accurate training of AI algorithms still relies on initially providing the computer with clear examples of abnormal versus normal features, a training process called *supervised learning*. After being trained with known cases, the algorithm can then classify new cases. In this situation, one still has to rely on correct classifications by clinicians to create a reference standard set. This task could be approached by requiring consensus of a large number of graders. After the AI algorithm is trained, it can continuously improve over time by a process of *reinforcement learning*. In addition, methods such as unsupervised or semi-supervised learning can be used to effectively train AI algorithms.

The benefits of AI algorithms could extend not only to early diagnosis but potentially also to detection of change over time. In a recent study, we showed that when standard automated perimetry testing is performed once a year, it takes approximately 7 to 8 years to detect progression in a glaucoma patient whose disease is progressing at a global rate of change of -0.5 dB/year, which corresponds approximately to the average rate of disease progression.⁶ Only 41%

of patients showing progression at this rate would be detected in 5 years. This is clearly inefficient and may result in irreversible loss of function and potential decrease in quality of life in a sizeable proportion of patients with the disease.⁷

Although machine learning algorithms to improve detection of visual field loss have been developed, they have generally failed to demonstrate major improvements over current standard methods for detecting change over time. However, it is likely that the recent advances in AI methods may result in significant improvements in performance for detecting change in the near future. It should be noted that, although deep learning has sometimes been seen as a panacea for all AI-targeted problems, there are other types of algorithms that may prove superior even to deep learning in the face of highly structured data, such as visual field test results.

Finally, efforts to integrate results from risk factors such as age, IOP, corneal thickness, corneal hysteresis, and others are likely to improve the ability of these models to detect change. In a 2012 study, we showed that integrating risk factors through a Bayesian approach improved the estimation of rates of visual field loss in glaucoma.⁸ It is likely that more sophisticated AI algorithms could do even better.

CONCLUSION

In order to fully benefit from advances in AI algorithms, it is important that we collect and share valid data so that we can make that data not only big, but

useful. We need to understand the limitations of available methods and always keep in mind the well-known maxim from the world of computing: *Garbage in, garbage out*.

This is likely to require efforts from many different investigators. The availability of electronic medical records is certainly accelerating this process. In addition, initiatives such as the Intelligent Research in Sight (IRIS) registry of the American Academy of Ophthalmology are likely to bring enormous contributions once the collaboration reaches its maturity. The future is certainly bright for data-driven diagnosis in glaucoma. ■

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