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5 burning questions about using artificial intelligence to prevent blindness

By Lauren Joseph @LaurenPJoseph

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One of the main frustrations of eye specialists is that many cases of blindness can be prevented, and that's driving them to find ways to detect eye diseases such as diabetic retinopathy and glaucoma as early as possible. For many experts, artificial intelligence is a promising way to enable screening for these conditions in primary care settings.

Dr. Robin Ross, an ophthalmologist and director of the Arizona-based Global Retina Institute, said, "85% of vision loss is preventable, but it's a matter of detecting it early. And that detection usually occurs before patients have symptoms."

Companies, from Google to a small firm in Iowa started by an eye doctor, are developing systems that use AI to analyze images of the eye. Many are designed to be assistive technologies that help doctors more easily and quickly detect a problem, but the Iowa firm, IDx, won Food and Drug Administration approval in April for an "autonomous AI" machine that can diagnose diabetic retinopathy without a physician's involvement. Only a technician is needed to operate the system.

Efforts to use AI in medicine date back to the middle of the 20th century, said Dr. Michael Abramoff, an ophthalmologist and CEO of IDx, but "never panned out because it was using imperfect noisy data. It's not that we have faster [computers] or algorithms, what's different is that we have low-cost, high-quality images and objective data."

Abramoff emphasized that the goal of AI is not to replace doctors. Instead, it's to find discrete, narrow tasks to replace with computers in order to reduce costs and inefficiency in the health care system.

But trying to use AI to replace tasks in the treatment of eye diseases involves numerous challenges, including: how to choose which diseases to target, how to obtain high-quality images, how to validate AI systems, who is liable when AI is implemented, and who can access this technology.

Which eye diseases are the most promising for AI?

Among the leading causes of progressive blindness[8] getting attention from AI researchers is diabetic retinopathy, a diabetes complication that affects blood vessels in the eye. It's one of the most common eye diseases in working-age individuals in high income countries, and researchers see a need for improved screening.

A study published in March[9] showed that only 15% of people with Medicare are getting the diabetic eye exams that they should. Many of these patients visit the doctor only after they have vision changes, which eye specialists say is too late to prevent vision loss.

Diabetic retinopathy is progressive, causing blindness in the most severe cases. In the U.S., the Centers for Disease Control and Prevention estimates that the number of people with diabetic retinopathy will nearly double by 2050, from 7.7 million to 14.6 million.

Researchers choose the diseases to target for various reasons, including how readily they can be treated with AI and their prevalence and severity.

With diabetic retinopathy, the back of the eye can be easily imaged. Furthermore, much is known about the progression of diabetes and eye disease.[11]

Dr. Pearse Keane, an ophthalmologist at Moorfields Eye Hospital in London who is collaborating with Google's DeepMind[12], said diabetic retinopathy is no longer the leading cause of blindness in the U.K. because of widespread screening efforts. But it is still a huge, and increasing, problem in low- and middle-income countries, where diabetes is increasing along with incomes.

Using DeepMind's algorithm, Keane led research showing it could detect and discern[13] between dozens of diseases at one time from eye scans, with accuracy as good as or better than eye specialists. But the team has faced challenges since the early findings[14] were published in August 2018, Keane said: "Each step along the way is a milestone."

What's the quality of the data, or the images?

"When you're creating this sort of prototype, the type of camera you use matters," said Dr. Nazlee Zebardast of Massachusetts Eye and Ear in Boston. "And then there's the issue of generalizability. The pictures that you took in a clinical trial are all good quality, but you're not going to get good quality images in the field, necessarily. There's variations that may not have been accounted for in the initial model."

The team at IDx decided to use photos of a part of the eye called the fundus, which can be captured using a more affordable and simpler imaging platform for implementing at the primary care level.

"In eye clinics, fundus imaging is like the chest X-ray, and optical coherence imaging is like the MRI," said Keane.

In addition, the availability of years of rigorous outcomes data from a long-running study of diabetic retinopathy aided the training of an algorithm to predict disease severity from the images.

Where researchers aren't satisfied with current imaging techniques, they're creating new ones. Sheng-Kwei "Victor" Song, of the University of Washington School of Medicine in St. Louis, invented DBSI, a kind of MRI imaging currently used in clinical research to study axons in glaucoma. Similarly, Jennifer Hunter, of the University of Rochester's Flaum Eye Institute, serves as a leader in the Advanced Retinal Imaging Alliance, which is repurposing a specialized imaging technique called "adaptive optics" in research to view eye disease on a cell-by-cell level.

How is the accuracy of the AI system validated?

"The biggest challenge for many of these AIs is what is the truth," Abramoff said. "It's not how you build your machine learning algorithm. [These are] almost a commodity nowadays. How do you prove it?"

AI systems and their creators must recognize bias in the machine's learning, and correct for it.

After designing the algorithm for an AI system, the next challenge is validating it. One common approach is to compare an algorithm's performance on a task — diagnosing a condition, for example — with that of a group of physicians. But Abramoff and Keane stressed the importance of using patient outcomes data for validating a system's accuracy.

"Even an average of multiple doctors is not right," said Abramoff. "The fact that all the clinicians in the world agree to something doesn't mean that that is the same as that it agrees with patient outcome."

Eventually a prospective study must assess the diagnostic accuracy, safety, and equity of an AI system, they said. IDx took on this task, enrolling 900 patients at 10 centers across the U.S. before receiving FDA approval for commercial use.

Should AI always keep doctors in the loop?

There are many approaches to building an algorithm through machine learning, a type of AI, and one called end-to-end learning, creates what's called the "black box" problem.

For example, a machine might be fed 15,000 labeled pictures of dogs and 15,000 labeled pictures of wolves to train it to identify the differences between these animals. However, even if the

decision of the computer is right, how it reached the decision is unknown.

"Then you try it in the real world, and it flops, it just doesn't work at all," said Keane. While trying to figure out the easiest way to tell the difference between the two, it could be that the machine noticed something else in the background of the photos, such as snow, that it learned to call "wolf."

In medicine, he said, that can leave a doctor having to choose whether to trust an algorithm when it says, "This patient is going to go blind and needs an urgent injection into their eyes." With AI and machine learning, said Keane, we need to mix enthusiasm with skepticism. "There's a concern that some of the algorithms may get the right answer for the wrong reasons or, even worse, give you the wrong answer," he said.

The IDx system avoids the "black box" problem, Abramoff said. He and the IDx team created an algorithm, not from scratch, but built on top of clinical knowledge. This more expensive approach involved hiring clinicians to provide input into how they assess images and guide the algorithm to make certain associations. Thus, the IDx team has insight into how clinical decisions are made.

Unlike other AI in medicine, the IDx system is the first autonomous model approved for use in clinical settings. "Autonomous AI is something very specific. It assumes medical liability. It makes a clinical decision without a physician," Abramoff said. As a result, the company assumes liability for the diagnoses.

Will the technology be affordable where it is most needed?

Creating and validating AI systems takes years and is enormously expensive, putting them beyond reach for places where diabetic retinopathy and other eye diseases are a burgeoning problem.

The price of a fundus camera used by IDx is around $15,000, according to Ross, of the Global Retina Institute, who looked into buying these cameras for local clinics in the Phoenix area. The business model IDx uses varies by country. In the U.S., the company uses a pay-per-click model, billing $34 per exam, during which four images are taken. That may be affordable for many in the U.S., but what about people without insurance? Or populations outside of the U.S.?

Ross, who consults around the world, said diabetes "is the next epidemic for low income countries" because of nutritionally deficient diets and obesity.

"It is going to be the next explosion of global blindness," said Ross. Even with reduced prices in certain areas, she said, "in low-income countries, people live on $1 a day. It's not like the health care system is robust and can afford a $25 per click rate."

Correction: An earlier version of this story misstated the pricing of IDx's service.

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