

Getting Ahead With AI Automation



Recent advances in this technology may help streamline screening and examinations and allow retina specialists to diagnose disease in patients remotely.

BY MEGAN A. KASETTY, BS; JAY C. WANG, MD; AND JOHN B. MILLER, MD

In learning to accurately diagnose and treat diseases, physicians review large volumes of clinical data, working to absorb the patterns and associations that are hallmarks of those diseases. In a remarkably similar way, but on a staggeringly shorter timeline, machines are being harnessed to do the same through *artificial intelligence* (AI). AI is the programming of machines to perform complex tasks typically completed by humans, such as predicting, learning, comprehending language, and identifying objects.¹ This can be accomplished through a variety of models over a spectrum of complexity.

BREAKING IT DOWN

On the simpler end, there is *machine learning*, a general subset of AI in which a set of algorithms can modify and refine itself when exposed to more data.¹ Ultimately, when faced with new data, the program learns to make accurate predictions or determinations. A more sophisticated way to accomplish this is through *deep learning*. Inspired by the networks of neurons that make up the brain, deep learning has become an increasingly popular form of AI due to its potential for superior accuracy, flexibility, and self-improvement.²

This high degree of accuracy is made possible by artificial neural networks composed of many layers that communicate via artificial neurons. In image processing, for example, these layers of neurons are tasked with interpreting features of images. Neurons in lower layers learn to recognize simple parts of an input image, such as pixels, and then pass outputs to subsequent layers that process more detailed aspects of the image.^{3,4}

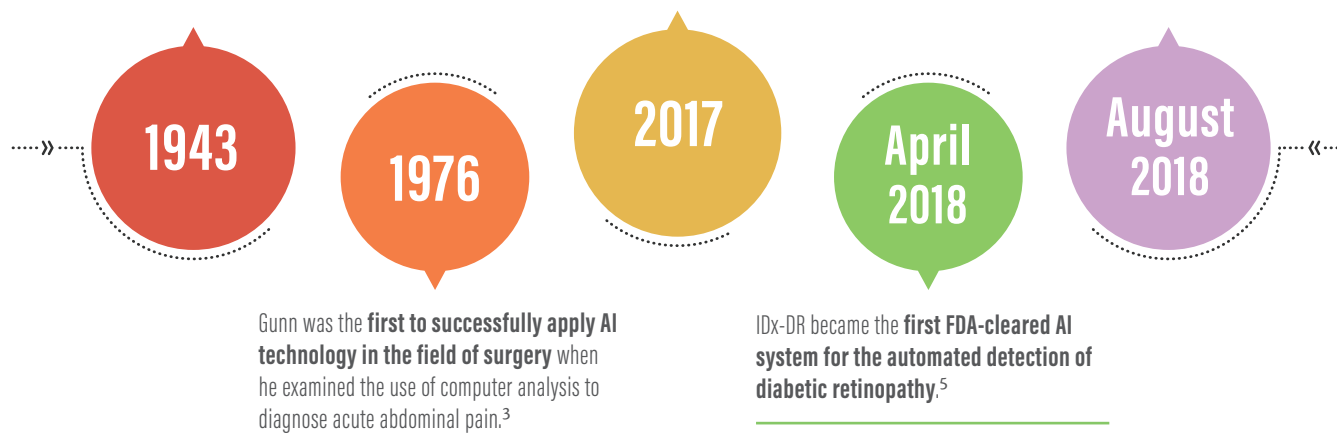
AT A GLANCE

- ▶ Artificial intelligence (AI) is the programming of machines to perform complex tasks typically completed by humans, such as predicting, learning, comprehending language, and identifying objects.
- ▶ Deep learning has become an increasingly popular form of AI because of its potential for superior accuracy, flexibility, and self-improvement.
- ▶ Automated screening for retinal diagnoses may reduce the number of healthy patients who would otherwise need eye screening in the clinic; it could help to ensure that subspecialists are examining and treating more patients with higher disease burden.
- ▶ Incorporating AI into the health care system can potentially help provide better access and make physicians more efficient.

McCulloch and Pitts invented the **first artificial neuron** using simple binary threshold functions.¹ Artificial neural networks have been applied in most fields of medicine and are used for clinical diagnosis, image analysis, data interpretation, waveform analysis, and for the diagnosis of cytologic and histologic specimens.²

The FDA granted clearance to the **first AI medical technology**: the Arterys Cardiac MR Suite.⁴

Results of DeepMind Technologies' first phase of a joint research partnership with Moorfields Eye Hospital showed that the **DeepMind for Google AI system can quickly interpret eye scans** from routine clinical practice and correctly recommend how patients should be referred for treatment for more than 50 sight-threatening eye diseases as accurately as world-leading expert physicians.⁶



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Deep learning has powered the first commercial AI medical technology to receive US FDA clearance and the European Union's CE Mark: the Arterys Cardiac MR Suite (Arterys), which was approved for retail use in 2017. This system was shown to match physician accuracy in measuring ventricular volume on cardiac MRI, taking only a fraction of the time needed by humans.⁵

Now, the field of AI has entered ophthalmology.

OPHTHALMIC APPLICATIONS

In April, IDx-DR (IDx Technologies) became the first AI system cleared by the FDA for automated detection of diabetic retinopathy (DR).⁶ The system analyzes fundus photos captured with the Topcon NW400 (Topcon) robotic fundus camera to make its diagnoses. The diagnostic output is binary: either absence or presence of disease, characterized by more than mild DR.

Across most subspecialties of ophthalmology, numerous AI technologies are being developed and tested; potential tasks include automated cataract grading based on slit-lamp images⁷ and differentiating glaucomatous from nonglaucomatous visual fields.⁸ In retina, recent studies have described highly sensitive and specific AI screening

systems for age-related macular degeneration,^{9,10} retinopathy of prematurity,¹¹ and epiretinal membrane.¹² Other AI technologies in development aim to predict visual outcomes,¹³⁻¹⁵ disease progression,¹⁶⁻¹⁸ and anti-VEGF treatment requirements in diseases such as age-related macular degeneration and retinal vein occlusion.^{19,20}

Many of these AI systems boast sensitivity and specificity that rivals the ability of experienced retina specialists. How are they able to achieve such accuracy? Depending on the type of AI model used, there may be a considerable training period. One artificial neural network that was trained to diagnose referable DR with 90% sensitivity and 98% specificity used more than 128,000 fundus photos in its training dataset.²¹ Retina is an ideal subspecialty to meet this imaging demand and to capitalize on AI for screening, diagnosing, and making clinical recommendations. Fundus photos and OCT images are abundant, allowing training datasets to be built quickly and efficiently.

A LAND OF OPPORTUNITY

Over the past few decades, ophthalmologists have seen tremendous improvements in the quality and availability of retinal imaging. To maximize the benefits of this growth

of information, we need parallel advances in image processing. Deep learning AI systems are capable of unsupervised learning,³ carrying out unbiased searching of diseased and nondiseased retinal images for structural anomalies. Coupled with the interpretation of experienced retina specialists, this technology may lead to the discovery of novel imaging biomarkers of retinal diseases.²²

AI also has the potential to influence the rise of telemedicine in ophthalmology. Teleophthalmology is currently being used with success in a range of settings. Each year in the United States, there are nearly 2 million eye-related emergency department visits, and most emergency departments do not have ophthalmologists available at all times.²³

The University of Pittsburgh initiated a teleophthalmology program in which emergency medicine physicians can send fundus photos and basic history and examination findings to remote ophthalmologists for interpretation.²⁴ Additionally, there are teleophthalmology programs that facilitate retinopathy of prematurity screening in neonatal intensive care units and DR screening in at-risk populations such as American Indians and Alaskan Natives.²⁴

These programs rely on experienced ophthalmologists to read the images remotely, either on call or through a reading center, a task that requires a large amount of manpower. Small teleophthalmology programs are sustainable now, but demand for remote image interpretation is likely to rise with the growth of this field. Automated imaging screening could be used to meet this growing demand.

Not only is automated screening more time-efficient, but also some studies have shown automated DR screening to be more cost-effective when compared with manual screening.^{25,26} AI screening systems are cost-effective options even with

lower specificity when compared with manual screening, as automated screening is less costly than a clinic visit. Specificity is an area where AI systems continue to improve, helping to reduce the number of unnecessary additional screenings, whether automated or manual.²⁵ AI-based screening systems can also provide significant advantages for global outreach, especially in remote areas, where access to proper screening may not otherwise be possible or affordable.

Overall, the introduction of automated screening for retinal diagnosis may help to reduce the number of healthy patients who would otherwise need a healthy screening eye examination in the clinic. By improving sensitivity and specificity, it should also help to ensure that subspecialists are examining and treating more patients with higher disease burden. Incorporating AI into the health care system can potentially help provide better access and make physicians more efficient. ■

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MEGAN A. KASETTY, BS

- Clinical Research Fellow, Retina Service, Massachusetts Eye and Ear, Department of Ophthalmology, Harvard Medical School, Boston
- Megan_Kasetty@meei.harvard.edu
- Financial disclosure: None acknowledged

JOHN B. MILLER, MD

- Assistant Professor of Ophthalmology, Harvard Medical School, Boston, Massachusetts
- Director of Retinal Imaging, Massachusetts Eye and Ear, Harvard Medical School, Boston, Massachusetts
- John_Miller@meei.harvard.edu
- Financial disclosure: None acknowledged

JAY C. WANG, MD

- Vitreoretinal Fellow, Retina Service, Massachusetts Eye and Ear, Department of Ophthalmology, Harvard Medical School, Boston
- Jay_Wang@meei.harvard.edu
- Financial disclosure: None acknowledged