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Retina *Review Article*

Artificial intelligence use in diabetes

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ABSTRACT

Diabetic retinopathy (DR) affects the small vessels of the eye and is the leading cause of blindness in people on reproductive age; however, less than half of patients are aware of their condition; therefore, early detection and treatment is essential to combat it. There are currently multiple technologies for DR detection, some of which are already commercially available. To understand how these technologies work, we must know first some basic concepts about artificial intelligence (AI) such as machine learning (ML) and deep learning (DL). ML is the basic process by which AI incorporates new data using different algorithms and thus creates new knowledge on its base, learns from it, and makes determinations and predictions on some subject based on all that information. AI can be presented at various levels. DL is a specific type of ML, which trains a computer to perform tasks as humans do, such as speech recognition, image identification, or making predictions. DL has shown promising diagnostic performance in image recognition, being widely adopted in many domains, including medicine. For general image analysis, it has achieved strong results in various medical specialties such as radiology dermatology and in particular for ophthalmology. We will review how this technology is constantly evolving which are the available systems and their task in real world as well as the several challenges, such as medicolegal implications, ethics, and clinical deployment model needed to accelerate the translation of these new algorithms technologies into the global health-care environment.

Keywords: Artificial intelligence, Deep learning, Ophthalmology, Diabetes, Retinal images

INTRODUCTION

According to the World Health Organization global report on diabetes from the year 2016,[1] the number of people affected by diabetes worldwide has vary from 108 million in 1980 to an estimated 425 million in 2017 and will be about 629 million in 2045.

Diabetic retinopathy (DR) is a vasculopathy that affects the small vessels of the eye. It is the leading cause of blindness in people on reproductive age and the third cause of preventable blindness worldwide. Between 40% and 45% of diabetic patients will present, some stage of DR at some point in their lives. However, less than half of patients are aware of their condition; therefore, early detection and treatment of DR is essential to combat it.[1,2]

There are currently multiple technologies for DR detection, some of which are already commercially available. The most recognized and renowned are: IDx-DR, RetmarkerDR, EyeArt, Google, Singapore SERI-NUS, Bosch DR Algorithm, and RetinaLyze.

To understand how these technologies work, we must know first some basic concepts about artificial intelligence (AI) such as machine learning (ML) and deep learning (DL), which we will explain below:

The beginnings of modern AI go back to classical philosophers who tried to describe human thought as a symbolic system; but the field of AI was not formally founded until 1956 at a conference at Dartmouth College in Hanover, New Hampshire, where the term AI was first used.[3]

AI is the compendium of sciences and techniques that try to emulate the behavior of human intelligence in machines. Stuart Russell and Peter Norvig differentiated four types, in 2009: Systems that think like humans, such as artificial neural networks; systems that act like humans, such as autonomous robots; systems that use rational logic, such as expert systems; and systems that act rationally, such as intelligent agents.[4-8]

All these forms of intelligence require to be "trained" in some way. Many of them learn from experience or from data collected as part of their core functions. Others are trained for extremely specific purposes.[4-8]

DISCUSSION

ML is the basic process by which AI incorporates new data using different algorithms and thus creates new knowledge on its base, learns from it, and makes determinations and predictions on some subject based on all that information. AI can be presented at various levels. The very high-level ones (those that can "think" considering the most abstract criteria) use a form of learning called "DL."

DL is a specific type of ML, which trains a computer to perform tasks as humans do, such as speech recognition, image identification, or making predictions. Instead of organizing data to run through predefined rules (like expert systems), DL modifies its own rules so that the computer learns on its own by recognizing pattern. DL uses multiple layers of computer algorithms that form a neural network. This network uses sets of algorithms modeled after the human brain, which was designed to recognize patterns. A subtype of DL is the convolutional neural network, which can recognize images and stage or classify them, for which it has become a crucial component in medicine.[4-8]

DL has shown promising diagnostic performance in image recognition, being widely adopted in many domains, including medicine. For general image analysis, it has achieved strong results in various medical specialties such as radiology,[9] dermatology,[10] and in particular for ophthalmology.[11-14]

Today, modern AIs not only learn and deepen knowledge but also adjust their own learning parameters. The victory in 1997 of the expert system created by IBM called Deep Blue, over the world chess champion Gary Kasparov, was a paradigm shift. From that moment, the history of AI changed forever, as no human could outperform chess expert systems.

Unlike other programs, Alpha Zero, the AI created by Deep Mind and owned by Google since 2014, is not based on human knowledge. Its understanding of chess, beyond the basic rules, comes solely from its ability to self-learn (DL). After playing nearly 5 million games over 4 h against himself, Alpha Zero attained the same knowledge as humans in nearly 1400 years. Starting from a blank sheet of paper, it was able to train the underlying neural network to learn to unimagined limits without any human input. By discarding moves and deducing new strategies, it has acquired knowledge capable of humiliating any other system. Alpha Zero's intelligence is not only referred to chess, as it can learn to perform any task, including writing music or creating images.[15]

At present, we can find examples of AI very frequently: Cell phones, cameras, and even smart TVs implement different AI applications: Face detection, voice identification, text reading, route analysis, and many others. It is enough to say, "Ok Google" or "Hey Siri" to the smartphone to have contact with a very advanced AI.[16-20]

The first medical AI work dates to the early 1970s. As electronic medical records become mainstream, image acquisition and data storage expand, AI enables detailed analysis as well as pattern recognition of this clinical data.

IDX-DR

It is the first and only autonomous AI system for automated early detection and diagnosis of DR cleared by the FDA. It is indicated for the detection of mild non-proliferative DR in adults over 22 years who have not previously been diagnosed with DR.

It uses Topcon's NW400 non-mydriatic cameras[16] and works by capturing retinal images that the operator sends to the software, which, through diagnostic algorithms, based on DL combines the results with multiple partially dependent biomarkers, some using also convolutional neural networks to analyze images for signs of DR. One minute after submitting the examination, IDx-DR provides a disease result with follow-up instructions for your treatment. The system uses standard 45° color images, two images per eye (one centered disk and one centered macula).

The results are easy to read: Test with insufficient quality, negative in mild RDNP with a new follow-up in 12 months, detection of mild RDNP, and consult an ophthalmologist.[10-14]

IDX-DR has also recently been verified in a real-life setting within a Dutch diabetes care system. Of 1410 patients, 80.4% were judged to be of sufficient quality by three independent human raters, compared to 66.3% accepted by the IDX-DR system.[20]

RETINALYZE

It is the first fully automated software to use an imaging test to detect dark retinal lesions. With a sensitivity of 93.1% and a possible accuracy of 98.3%, it is almost as reliable as the examination performed by a human grader.

The first reports were made with images taken on 35 mm film with the use of detection methods based on lesions. Good sensitivities of 93.1%, 71.4%, and 89.9% and specificities of 71.6%, 96.7%, and 85.7% were reported.

Since the prior results were published, RetinaLyze went through a "black" period without being available until it was reintroduced in 2013 in its actual form, with DL enhancements, there are no recent studies on its effectiveness in this form.

RetinaLyze is a cloud-based fundus image analysis software that offers automated screening for DR, AMD, and glaucoma. It is CE marked as a Class I device. Images are delivered through a website-based system, which offers end-to-end encryption.

The system is a vector-based algorithm and is a proprietary method for determining the presence or absence of retinal lesions in an image. A photo of the retina is taken with a non-mydriatic fundus camera (any retinal camera that takes quality images) and is automatically stored in the cloud, ready for analysis. RetinaLyze, in just 30 s, analyzes the photo and detects possible lesions. The result appears automatically noting the location of the lesions.[15-18]

SINGAPORE SERIES NUS

It is a high-impact study carried out by researchers from Singapore, who describe the development of a DL system algorithm that analyzes fundus images with DR. More than half a million retinographies were used for training it. The system demonstrated a sensitivity of 90.5% for DR detection.[19]

RETMARKERDR

RetmarkerDR is a CE marked Class IIa medical device developed in Portugal and has been used in local detection of DR some years from now. It is a mathematical algorithm that automatically analyzes fundus photographs and identifies people who are at risk of progression. Retmarker's automatic algorithms analyze all photographs and automatically identify all diabetics who do not have any DR lesions. When there are photographs from the previous visits, Retmarker uses its own biomarker (red dots: Microaneurysms and hemorrhages) to analyze and identify if there is disease activity.[13,20-26]

EYEART

EyeArt was the first software to analyze images based on fundus photographs taken on phone apps, combined with an automatic AI detection system. Retinal images of 296 patients taken with a cellular device were analyzed. Although the EyeArt algorithms have not been trained using phone-based fundus photography, they achieved a sensitivity of 95.8% for any RD.

EyeArt can take a variable number of retinal images in a single patient visit, automatically excluding low-quality images. You can analyze images from previous visits to estimate disease progression. Like other automatic DR detection devices, it has been listed as a Class IIa medical device in the European Union and is also commercially available in Canada.

EyeArt has been retrospectively verified on a database of 78,685 patients encountering a refer/non-refer outcome and had a detection sensitivity of 91.7% (95% CI: 91.3–92.1%) and specificity of 91.5% (95% CI: 91.2–91.7%).[27-33]

GOOGLE

In 2016, a study sponsored by Google Inc. validating a new DR detection algorithm based on convolutional neural networks was published. This algorithm was validated in a nationwide DR screening program in Thailand. A total of 25,326 images from 7517 patients with diabetes at different stages of severity were analyzed. The algorithm has improved over time, from the detection of referable and non-referable binary parameters to detection of all five DR severity levels. In addition, this study compares the algorithm performance with retinal specialists from Thailand, India, and the United States. Compared to human raters, the algorithm had significantly higher sensitivity across all DR severity levels ($P < 0.001$). These results can be translated into a 23% reduction in false negatives at the cost of slightly increasing false negatives and positive in 2%.[33]

BOSCH DR

Bosch's program its AI software based on a convolutional neural network to which allows: two alternatives poor quality or disease/no disease. In a recent study of 1128 eyes studied, 44 (3.9%) were judged inconclusive by the algorithm, with only four of 568 as images of insufficient quality. The study compares the AI response, based on a single-field, non-mydriatic color image, with a classification assessment based on seven-field mydriatic stereoscopic ETDRS images performed on the same eye. This algorithm achieved results with sensitivity, specificity, PPV, and NPV rates of 91%, 96%, 94%, and 95%, respectively.

However, little is known about the raters or scoring criteria employed in this study, no further reports on the effectiveness of this algorithm are available at this time.[34]

CONCLUSION

DR detection using AI will play a key role in preventing DR blindness. In recent years, an increasing number of DR detection and screening systems have been created. Many groups have published strong performance of AI algorithms for detection and diagnosis; however, for the implementation in real-world environments, more research is required, also to address several challenges, such as medicolegal implications, ethics, and clinical deployment model to accelerate the translation of these new technologies into the global health-care environment.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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