

## Artificial intelligence and its applications in ophthalmology

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The term artificial intelligence (AI) was proposed in 1956 by Dartmouth scholar John McCarthy, which refers to hardware or software that exhibits behavior which appears intelligent.<sup>1</sup> During recent times, AI gained immense popularity as new algorithms, specialized hardware, huge data and cloud-based services were developed. Machine learning (ML), a subset of AI, originated in 1980 and is defined as a set of methods that automatically detect patterns in data and then incorporate this information to predict future data under uncertain conditions. Another escalating technology of ML called Deep learning (DL), launched in 2000s, is an escalating technology of ML and has revolutionized the world of AI. These technologies are powerful tools utilized by modern society for objects' recognition in images, real-time languages' translation, device manipulation via speech (such as Apple's Siri®, Amazon's Alexa®, Microsoft's Cortana®, etc.). The steps for AI model include preprocessing image data, train, validate and test the model, and evaluate the trained model's performance. To increase AI prediction efficiency, raw data need to be preprocessed. Data collected from different sources needs to be integrated and the most relevant features selected and extracted to improve the learning process performance. Data set is randomly partitioned into two independent subsets, one is for modeling and the other is for testing. The test set is used to evaluate the final performance of the trained model. The area under receiver operating characteristic curves (AUC) is most used evaluation metrics for quantitative assessment of a model in AI diagnosis. The AUCs effective models range from 0.5 to 1; higher the value of AUC, better the performance of the model.<sup>2</sup> In the medical field, AI gained popularity by visualization of input images of highly potential abnormal sites which can be reviewed and analyzed in future.

AI and DL algorithms or systems are also widely used in field of ophthalmology. More intensively studied fields are diabetic retinopathy, age related macular degeneration, and cataract and glaucoma. Various ophthalmic imaging modalities used for AI diagnosis include fundus image, optical coherence tomography (OCT), ocular ultrasound, slit-lamp image

and visual field. Diabetic retinopathy (DR), a diabetic complication, is a vasculopathy that affects one-third of diabetic patients leading to irreversible blindness. AI has been in use to predict DR risk and its progression. Gulshan and colleague were the first to report the application of DL for DR identification.<sup>3</sup> They used large fundus image data sets in supervised manner for DR detection. Other studies applied DL to identify and stage DR. DL-based computer-aided system was introduced to detect DR through OCT images, achieving a specificity of 0.98.<sup>4</sup> A computer-aided diagnostic (CAD) system based on CML algorithms using optical coherence tomography angiography images to automatically diagnose non-proliferative DR (NPDR) also achieved high accuracy and AUC.<sup>5</sup> Age-related macular degeneration (AMD) is the leading cause of irreversible blindness among old people in the developed world. ML algorithms are being used to identify AMD lesions and prompt early treatment with accuracy usually over 80%.<sup>6</sup> Using ML to predict treatment of retinal neovascularity in AMD and DR by anti-vascular endothelial growth factor (Anti VEGF) injection requirements can manage patients' economic burden and resource management. ML algorithms have been applied to diagnose and grade cataract using fundus images, ultrasounds images, and visible wavelength eye images.<sup>7</sup> Glaucoma is the third largest sight-threatening eye disease around the world. Glaucoma patients suffered from high intraocular pressure, damage of the optic nerve head, retina nerve fiber layer defect, and gradual vision loss. Studies using DL methods to diagnose glaucoma are few. So far, fundus images and wide-field OCT scans have all been used to construct DL-based glaucomatous diagnostic models. Mostly, the DL-based methods show excellent results.<sup>8</sup>

In this era of “evidence-based medicine,” clinicians and patients find it difficult to trust a mysterious machine to diagnose yet cannot provide explanations of why the patient has certain disease. In future, advanced AI interpreters will be launched which will contribute significantly to revolutionize current disease diagnostic pattern.

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