Cabrera DeBuc, D
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Nepal J Ophthalmol 2020; Vol 12 (23): 1-3

Guest Editorial

Artificial intelligence in the ophthalmic landscape

Delia Cabrera DeBuc, Ph.D.
Bascom Palmer Eye Institute, Department of Ophthalmology, University of Miami

Images from the eye have become enormous troves of data for algorithm development in search of biomarkers of ocular diseases as well as systemic and neurodegenerative conditions. Recent advances show that the eye is a critical player in the development and application of image analyses to foster the adoption of artificial intelligence (AI) for the prevention and management of ocular diseases in eye care systems. We are in a "second machine age and the age of AI", a period of extraordinary change that will revolutionize medicine and open new venues for ophthalmologists, allowing them to uplift the entire ophthalmic practice.

Various AI efforts have been proposed for ocular disease detection, such as diabetic retinopathy, age-related macular degeneration, diabetic macular edema, keratoconus, cataract, retinopathy of prematurity, reticular pseudodrusen, and glaucoma. (Ting DSW et al, 2019) Also, numerous studies have shown that the vessels and neural layers in the eye reflect what is going on in other organs, specifically the heart and brain. (Cabrera DeBuc, D et al, 2017) Therefore, AI algorithms could also be developed to detect conditions in different organs by taking advantage of ocular data.

A critical component of the adoption of AI applications is the interpretability, overfitting, and reproducibility of the algorithms. Particularly, AI models suffer from interpretability or black box limitations because they rely on complex nonlinear, multidimensional decision boundaries. These models also suffer from overfitting and can identify strong target correlated artifacts in medical images that are entirely irrelevant, leading to poor generalization. Consequently, the likely derivation of misleading predictions can be conversely very costly and time-consuming. Therefore, state-of-the-art techniques are mandatory to identify any of these issues in AI models. For example, activation maps, also known as heating maps show what the model is paying attention to when making its prediction using brightness. Thus, it can highlight the areas of interest for each prediction, which may help humans understand the processes the AI model uses to arrive at its outcomes.

Clinical prediction AI-based tools present unique challenges and obstacles to reproducibility. As with traditional statistical and reproducibility considerations, an AI model should be reproduced, and necessarily replicated, before it is deployed in a clinical setting. Unfortunately, there is a severe lack of public and open benchmarks for understanding how well various AI algorithms work, limiting confidence in the replicability of computations. Moreover, there are serious concerns regarding how well AI algorithms can be reproduced and validated across different ophthalmic institutions and study populations because data access is limited by data sharing options compromised by privacy barriers (e.g., ethical and legal).

Regarding clinical trial applications, AI is especially relevant for ophthalmic drug discovery and repurposing, recruitment and retention activities, prediction of differential effects of treatments, and biomarker identification. These clinical trials have limitations in sample size, time limitations, and realism that could be potentially solved by AI. There are already published studies of AI applications within clinical trials. For example, a fully automatic algorithm could replicate the result of the clinical trial for macular telangiectasia type 2 without any human involvement. (Loo J et al, 2020) Also, another AI-aided algorithm was used in Phase II clinical trial of the Detection of Apoptosing Retinal Cells (DARC) to accurately predict progressive glaucomatous damage 18 months before that detected with Optical Coherence Tomography. (Normando EM et al, 2020)

The idea that AI will replace people's jobs is a primary concern expressed by physicians and ophthalmologists. While the "second machine age" reinforces the idea of robots taking over human jobs on an unprecedented scale soon, economic history shows that, thus far, technological unemployment is a short-term adjustment. (Autor DH, 2015; Miller B and Atkinson RD, 2013) More recently, the World Development Report 2019 found that the assumption that robots will take away responsibilities from people seems to be unfounded. (World Bank, 2019) Ultimately, the future AI-ophthalmologist collaboration will require up-skilling and professional retooling to facilitate an efficient and high- quality eye care workforce.

On the other hand, traditional pathways used by countries to accelerate their economic development are progressively subject to disruptions in the technology fields. Mainly, AI applications are highly disruptive in that it can have the potential to address challenges faced by individuals at the bottom of the pyramid or income distribution. Prahalad, C. K., and Hart, S. L. (2002). It is well-known that these individuals lack the resources to purchase AI-based technologies or AI-enabled medical devices. However, they can potentially benefit from AI-as-a-service (AIaaS) offerings to take advantage of all the insight that can be gleaned from data through either their mobile devices or specific low-cost devices (e.g., low-cost, portable retinal camera). Thus, by harnessing AI-based applications, developing countries could unravel new approaches for improving eye care delivery and strengthening the supporting capabilities needed to reap the potential of AI in their eye care clinics.

AI and robotics are anticipated to be embedded in most human activities, optimizing, and augmenting people's lives and their workplace environment. (Autor DH, 2015; Miller B and Atkinson RD, 2013) In the coming 5-15 years, AI and robotics will likely transform the ophthalmic landscape. As AI-age technological developments continue, human-level AI will become commonplace. But what if we could generate machines with intelligence above the human level? There is no doubt that we will face massive changes in the next few decades. But how ophthalmologists will use their knowledge and purpose in their careers to adapt or advance with AI and robotics is the question.

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