ADVANCES IN OPHTHALMOLOGY AND OPTOMETRY

Artificial Intelligence and Its Applications in Vision and Eye Care

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Keywords

- Artificial intelligence (AI) • Machine learning • Deep learning • Neural network
- Robotics • Algorithm • Vision • Eye care

Key points

- A complete description of artificial intelligence (AI) and neural networking with general examples of machine and deep learning and a specific neural network example of human vision.
- Explanations of current and evolving applications of AI and robotics in multiple categories of vision and eye care, including refractive care, cornea and ocular surface, anterior segment, retina, glaucoma, and more.
- Practical suggestions and planning for AI and robotics in clinical environments with general recommendations for preparing clinical practices (and thinking) for the integration and changes associated with AI.

PROLOGUE

> There is nothing more powerful than an idea whose time has come.
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> —Victor Hugo

Artificial intelligence (AI) is a concept and science whose time has come. The goal of this article is to provide an understanding of AI and neural networking producing the "deep learning" process through the application of "machine learning," "expert systems," and robotic interfacing. Beyond the basic understanding of these demonstrable tenets of this powerful

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computer science, this article discusses its applications related specifically to vision and eye care.

The article's discussion may be viewed as an intermediate or advanced level discourse of the subject. Given the exponential rate of progress in this disruptive science and technology, the reader in 5 years may very likely find this discussion elementary, if not outdated. In fact, because of the dynamic nature of the subject, some references in the article are not traditional for a scientific monograph, but rather news articles from current monthly, even weekly periodicals and Websites.

Finally, in spite of the objective nature of the computer-related science and technologies defining AI and robotics, the most challenging aspects of this rapidly evolving field may well be the subjective and ethical issues it generates. "Is AI creating an existential threat to the integrity, uniqueness, even the essence of humankind?" "Is it creating a 'humanoid' existence?" [1].

Some respected scientists and futurists such as Stephen Hawking [1], Tanya Lewis say [2], "…such powerful systems would threaten humanity." Other equally respected scientists such as Bill Gates ("AI is the holy grail") [3], Bernard Marr [4] claim "Artificial intelligence will reach human levels by around 2029." Meanwhile, scientific institutions such as MIT [5], Stanford University [6], Brookings Institute [7], etc. and expert business sources such as Harvard Business Review [8], Forbes [9], NY Times [10], etc. enthusiastically support and encourage AI's continued growth.

If this article meets its goals, you will have a general and objective understanding of AI. However, the authors do not address or opine on the associated subjective, ethical, and emotional questions regarding the science going forward. That will be for the readers to decide for themselves.

INTRODUCTION

The term "artificial intelligence" (AI) and its pursuit as a legitimate science was introduced by two cognitive scientists, Marvin Minsky and John McCarthy, at a Dartmouth College conference in 1956 [2]. Over the following 4 to 5 decades, general interest grew in AI, whereas its applied use of data, referred to as "machine learning," [2] slowly became more popular.

Finally, persistent, increasing international interest, combined with AI's machine learning applications in the financial market vagaries of the1990s and early 2000s began to produce mainstream and serendipitous press attention, particularly in 1997 (IBM's "Deep Blue" defeating chess grandmaster Gary Kasparov) and in 2011 (IBM's "Watson" defeating "Jeopardy" champions). Subsequent to these events and this time period, appreciation of AI grew from curiosity to excitement.

Health care began to use AI and robotic technologies earlier than many fields because of humanitarian needs and medical research's progress with AI in initial clinical trials and patient applications. Now, thanks to exponential growth over the past 10 years, AI promises to expand as an immediate and long-term opportunity (and challenge) in health care, including vision and eye care (Box 1).