Note: These articles are not reviewed.

Innovation in Focus: Do Two Famous Droids Signal the Future of Eye Care?

Chris Wroten, O.D., Dipl. ABO *is a graduate of Southern College of Optometry (SCO) and a partner and Chief Operating Officer for the Bond-Wroten Eye Clinics. Dr. Wroten has participated in clinical research, authored clinical case reports and eyecare articles, lectured as a continuing education speaker, and presented educational posters and workshops at regional and national optometric conferences. In addition to primary eye care, his special areas of interest lie in the treatment and management of ocular disease and contact lenses.*

The year was 1977, and everyone, from children to adults, was talking about it. Just shy of my seventh birthday, Dad was taking me to see the biggest movie blockbuster of the year while Mom stayed home with my younger sister. I vividly remember my excitement as we pulled up to the Broadmoor Theatre in Baton Rouge, Louisiana, to find the longest box office line I'd ever seen winding around the side of the building! Undeterred, I was willing to wait it out - as long as we could get tickets, which we barely did before it sold out.

As the lights dimmed and the projector started, a crawl appeared on the screen…"A long time ago, in a galaxy far, far away…" I was mesmerized for the next two hours by this groundbreaking film that four decades later would continue to set records and spawn new blockbuster movies, books, games, television series, comic books, merchandise sales, and even amusement park rides. *Star Wars* (now a.k.a. *A New Hope*) made a huge impression on me, and countless others, as I imagined myself as Luke Skywalker or Han Solo fighting Darth Vader and the evil Empire. I was also awestruck by the two droids who autonomously visualized and navigated their environment; understood spoken language, processed its meaning, reasoned a response, and then conversed with other characters; and who in many instances outsmarted their human adversaries. Robots weren't new to me, but R2-D2 and C-3PO displayed the most advanced forms of artificial intelligence I'd ever encountered.

Today, artificial intelligence has become so commonplace in society, that many things once considered revolutionary are no longer even considered AI. Taking a look back at some of AI's historical milestones and understanding a few basic terms will allow us to better understand several current AI health care projects and their potential impact on eye care.

A BRIEF TIMELINE OF AI

Ancient Times: early mathematicians/philosophers begin studying mechanical reasoning & propose robots, automatons, & smart machines

***1818:* Mary Shelley publishes *Frankenstein*, one of the earliest examples of AI in science fiction**

***1943:* Warren McCullouch & Walter Pitts publish formal design for "artificial neurons," the first recognized work of AI**

***1956:* AI formally coined & established at Dartmouth College Conference**

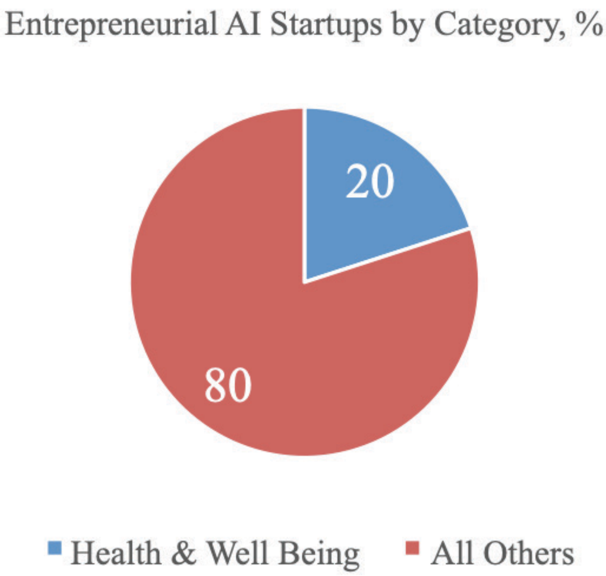
***1960s:* British & U.S. governments/other labs around world invest heavily in AI**

***1970s-80s:* Advances slow due to competing funding priorities, moral criticisms, & technological limitations**

***Late '90s-Early 21st Century:* AI used for logistics, data mining, medical diagnosis, & other areas due to advances in computational power & data storage[1]**

Today, health and well-being is a focal point for AI entrepreneurs, with 1 in 5 AI startups (more than in any other sector) devoted to this area (Fig. 1).[2]

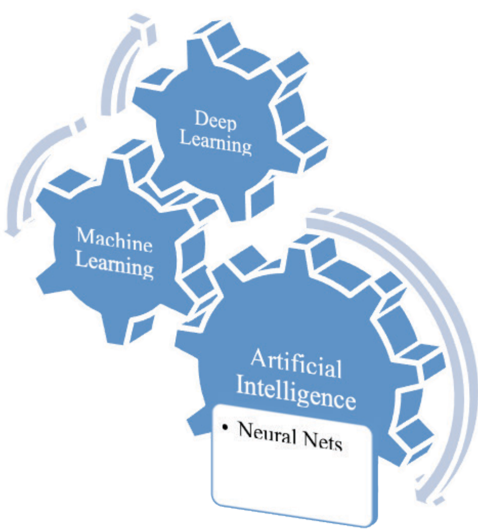
Figure 1: *There are more entrepreneurial AI startups devoted to health and well being (~20% of all startups) than in any other sector.*[2]



TERMINOLOGY

Artificial Intelligence (AI) = a broad field attempting to "automate human/cognitive processes" (Fig. 2)

Figure 2: *Deep Learning (DL) is a subset of Machine Learning (ML), both powered by Neural Network algorithms to continuously improve program performance. All of these are types of Artificial Intelligence (AI).*



Neural Networks (aka neural nets) = basis for earliest AI research; modeled after cortical neuron networks in the human brain - a single artificial neuron ("N") accepts input from multiple others, each of which when activated cast a weighted vote "for" or "against" whether "N" itself should activate; learning requires an algorithm to adjust these weighted votes based on training data, which can then identify hidden relationships & patterns in raw data, organize & classify it, & continuously learn & improve over time.[3]

Machine Learning (ML) = a subfield of AI that drove research from 1980's-2010's; aims to develop programs (aka models) via exposure to training data alone, then spontaneously & continuously improve themselves; e.g. self-driving cars, fraud detection algorithms, & personalized suggestions online merchandisers provide based on past history.[3]

Deep Learning (DL) = one of many subfields of ML; any artificial neural network which can learn a long chain of causal links; the models then form stacks of layers which train the computer to learn on its own[4,5]; all of today's leading AI research involves DL neural nets.

CURRENT HEALTH CARE AI PROJECTS

Hanover

Microsoft developed this AI platform to advance the state of the art of machine reading to accelerate "curation as a service" in precision medicine. Basically, the goal is to automate and exponentially enhance the process of reading a cancer patient's genomics data; analyzing all diagnosis-specific, evidence-based medicine available; reviewing relevant clinical trials and treatment protocols; and enrolling patients in the trial protocol which offers the greatest chances for a cure. This is all done in conjunction with a doctor's oversight.[6]

Deep Mind

The Deep Mind Artificial Intelligence Computer Program was founded in 2010 in London, before being bought by Google in 2014. It taught itself to play 49 different video games with only raw pixel input, and researchers at Moorfield's Eye Hospital (London) have now input over 1 million anonymized retinal photographs that had already been flagged for signs of disease, allowing the AI algorithm to teach itself how to recognize the signs of ocular disease. This AI system can interpret scans from clinical practice with unprecedented speed and accuracy, correctly recommending how patients should be referred for treatment for over 50 sight-threatening conditions as accurately as leading experts.[7]

Watson

IBM researchers in Australia have trained their artificial intelligence platform, Watson, to detect abnormalities in retinal photographs to identify posterior segment diseases like age-related macular degeneration (AMD), diabetic retinopathy (DR), and glaucoma earlier than can existing strategies. Investigators at the University of Melbourne input 88,000 retinal images to Watson, and through DL techniques it was able to measure cup-to-disc ratio and determine signs of glaucoma with up to 95%.[8] Another study by researchers in New York in conjunction with Watson was recently published showing a diagnostic accuracy rate of 94% for glaucoma by analyzing optical coherence tomography scans.[9] Watson has also been used to increase graduation rates for guide dogs for the visually impaired by 20% by identifying those dogs most likely to succeed in those rigorous training programs based on genetic maps, breeders, trainers, and veterinary medical records.[10]

IDx-DR

IDx is developing feature-recognition-based AI algorithms to automate the diagnosis of glaucoma, AMD, and DR. This algorithm is programmed to look for signs of retinal disease (versus the ML-based AI utilized by the other algorithms presented here). The company's IDx-DR platform received U.S. Food & Drug Administration approval in 2018, becoming the first standalone, AI-driven retinal image analyzer. The algorithm is specifically paired with Topcon's NW400 Retinal Camera, which then scans and analyzes images for DR without human intervention post-image acquisition. In short order, the software provides doctors with an assessment of whether "more than mild" diabetic retinopathy is present. If so, the patient is referred to an eye care professional, and if the screening is negative, it's recommended the patient return in 12 months for repeat analysis. Initial studies demonstrate 87.2% sensitivity and 90.7% specificity.[11,12]

Ambient Clinical Intelligence (ACI)

Nuance is marketing this platform as a way to help mitigate health care provider burnout from excessive time navigating patient charts and completing documentation details. ACI "listens" to clinicianpatient conversations and interfaces with the EHR to facilitate workflows and enhance automation of tasks and clinical knowledge. It automatically documents patient care interactions without distracting the physician's attention from their patient. By utilizing wall-affixed hardware containing 16 microphones and voice biometrics for security purposes (e.g. authentication, speaker identification, patient consent & physician document signing), the doctor can also complete medication orders and sign the note using an embedded virtual assistant. The hardware/software combination captures what patients and providers say, with relevant patient responses automatically added to the chart, thus eliminating the need for the doctor to manually enter it later. Successful pilot trials are in place now, with a widespread launch planned for 2020.[13,14,15]

Others

Numerous electronic health record companies and practice management software firms are working to incorporate AI into their products, as well, to maximize scheduling, patient flow, payor management, optical administration, and a host of other areas. Thanks to AI, small-to-medium sized practices may soon have access to cutting edge technologies and management strategies that were perhaps out of reach beforehand due to resource limitations and the high costs previously associated with them.

POTENTIAL IMPACTS ON EYE CARE

All of these AI products offer the ability to analyze enormous volumes of data with the potential to streamline and enhance quality of care and patient outcomes. As one colleague in Texas aptly noted, who owns the data, where it's housed, and how it's accessed will be critical, especially as some companies fold in the future. So what does all this mean for optometry? Will massive changes occur to the way we practice, threatening to replace the care we provide with AI driven devices, instead of human doctors, or will the status quo largely prevail? Will refractive eye care become the purview of automated AI systems and apps without appropriate doctor oversight?

Personally, despite all the advances in AI to-date, I don't think we're in danger of being replaced by Drs. R2-D2 and C-3PO any time soon. Recent studies have shown early AI algorithms may not perform as well in real-world clinic settings as in controlled study environments,[16] but that will certainly improve over time. Additionally, research is showing that AI, in combination with doctor interpretation, is more accurate than either option alone.[17]

As long as we continue to provide our patients with excellent care, listen to their needs, stay abreast of the latest innovations in eye care, and remain open to the appropriate adoption of new technologies, there will always be a place for us. However, should we bury our head in carbonite we run the risk of experiencing the same fate as the Death Star. AI can exponentially elevate the care we provide when implemented the right way, and it's incumbent upon us to be involved early and advocate for our patients as new developments emerge.

With Microsoft, Google, and IBM involved in health care AI, there's sure to be something that comes of it. I certainly don't claim to know exactly how or when, but one thing is abundantly clear - change is coming, and those who aptly embrace it will best be poised for future success. May the Force be with you!

REFERENCES

1. https://en.wikipedia.org/wiki/History_of_artificial_intelligence
2. https://avc.com/2019/06/ai-and-health-care/
3. https://www.sas.com/en_us/insights/analytics/machine-learning.html
4. https://blogs.sas.com/content/sgf/2018/01/05/looking-beyond-hype-deep-learning-ai/#par_styledcontainer_89b1
5. https://www.sas.com/en_us/insights/analytics/deep-learning.html#deepworld
6. https://hanover.azurewebsites.net/#overview
7. DeFauw, J., et. al. "Clinically applicable deep learning for diagnosis and referral in retinal disease." *Nature Medicine*, vol. 24, pgs1342–1350 (2018)
8. "IBM is training Watson to detect glaucoma." Feb 22, 2017; American Academy of Ophthalmology; https://www.aao.org/headline/ibm-is-training-watson-to-detect-glaucoma
9. Maetschke S., et al. "A feature agnostic approach for glaucoma detection in OCT volumes." PLoS One, 2019 Jul 1;14(7):e0219126. doi: 10.1371/journal.pone.0219126. eCollection 2019.
10. https://www.ibm.com/watson/stories/guiding-eyes/
11. https://www.mobihealthnews.com/content/study-results-support-fda-approval-diagnostic-algorithm-experts-remain-wary
12. Kent, C. "AI & Ophthalmology: Two Approaches to Diagnosis." *Review of Ophthalmology*; 11 JUL 2018
13. https://reviewob.com/ai-system-that-frees-doctors-to-focus-on-patients-in-exam-room/
14. https://medcitynews.com/2019/06/nuance-ai-exam-room/
15. Dietsche, E. "Nuance's AI makeover to clinical documentation takes exam room to the future." *MedCity News*, June 13, 2019.
16. Kanagasingam Y, et al. "Evaluation of Artificial Intelligence–Based Grading of Diabetic Retinopathy in Primary Care." *JAMA Netw Open*. Published online September 28, 20181(5):e182665. doi:10.1001/jamanetworkopen.2018.2665
17. Sayres, R., et al. "Using a Deep Learning Algorithm and Integrated Gradients Explanation to Assist Grading for Diabetic Retinopathy." *Ophthalmology*, Vol. 126, Issue 4, 552 – 564.