Seeing Eye to AI

Virtual & Real Reality of Trends Transforming Patient Care

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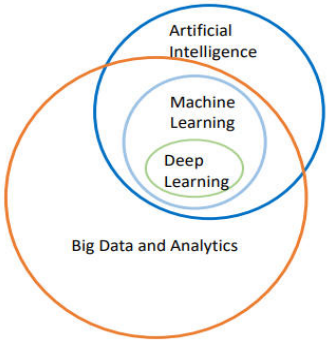
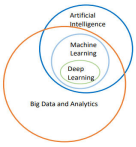


What is Artificial Intelligence (AI)

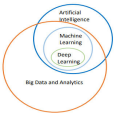
- capability of a machine to imitate intelligent human behavior
- identification of meaningful relationships in raw data



Artificial Intelligence

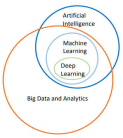
Uses:

- algorithms
- heuristics - shortcuts that ease the load of making a decision
- pattern matching
- rules
- deep learning
- cognitive computing
  encompasses AI, ML, and DL



Artificial Intelligence

- approximates conclusions – intuitive judgment
- without direct human input
- teaches itself to understand data



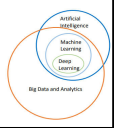
Machine Learning

Machine Learning is an application of AI that provides systems the ability to automatically learn and improve from experience without being explicitly programmed

Machine Learning programs are capable of some autonomy but human programmers need to modify code when errors occur

Machine Learning

- Programs utilize algorithms to modify themselves by responding to inputted data
- ML programs can be presented with labeled data and perform "supervised learning," or be taught to extract data from unlabeled data, which is to perform "unsupervised" learning
- Supervised learning can detect faces, identify objects in images, transcribe speech to text, and classify text as spam
- Unsupervised learning can compare documents for keywords, detect anomalies in images, predict changes in health status



Deep Learning

Deep Learning is a subset of machine learning where the algorithm used to make computers learn is a neural network --- OK more confused now!

A neural network is a collection of algorithms that recognize and learn patterns in data
(they are inspired by the human brain)

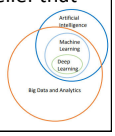
- Deep Learning systems can modify their algorithms independent of human programming

Deep Learning

- A Deep Learning system was recently able to distinguish between male and female fundus images based on the image alone
- none of the eye health professionals involved currently understand how this is possible or being achieved
- Deep Learning system also predicted refractive error from the fundus images

Big Data

- extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions
- IBM, creator of Watson, the AI system that communicates with users via human-like speech, has coined the term "cognitive computing" to encompass AI, ML, and DL. The term was adopted to give a human spin on the use of AI systems, representing IBM's belief that Watson and its offspring will complement human judgment and experience rather than replace them



AI Does Double Duty in Cataract Detection

Universal artificial intelligence platform for collaborative management of cataracts. Wu X, Huang Y, Li Z, et al. Br J Ophthalmol. September, 2, 2019 [Epub ahead of print]

Chinese researchers created a new artificial intelligence platform that not only has a high success rate in diagnosing cataracts but can also recommend which cases should be referred for further investigation

AI Does Double Duty in Cataract Detection

The AI system's training and validation datasets included 37,638 slit lamp photos. The study labeled the datasets using a three-step strategy:

First, it identified the **image capture mode** (mydriatic-diffuse, mydriatic-slit lamp, non-mydriatic-diffuse and non-mydriatic-slit lamp)

Next, the AI made a **clinical assessment** (normal, cataract or postoperative eye)

Finally, it **detected referable cataracts** based on etiology and severity

AI Does Double Duty in Cataract Detection

- Capture mode recognition: 99.28 - 99.71%.
- Cataract diagnosis: 99.82% for normal lenses
  99.96% for cataract
  99.93% for postoperative eye
  for mydriatic-slit lamp mode and more than 99% for other capture modes.
- Detection of referable cataracts: Over 91% in all tests

Evolution of AI in Medicine

Most healthcare data is unstructured

- AI can read and understand unstructured data
- AI can process natural language
- AI can read clinical text from any source
- AI can identify, categorize and code medical concepts

Evolution of AI in Medicine

Insights for patient data

- AI can identify problems in patients' historical records structured and unstructured text
- AI can summarize a history of the patient's care for each medical problem
- AI can provide a cognitive summary of a patient's record

Evolution of AI in Medicine

Patient similarity

- AI can identify clinical similarity between patients
  - leads to dynamic patient cohorts
  - enables an understanding of which care path works
  - better for a given group of patient

Evolution of AI in Medicine

Medical insights
- AI can find information in unstructured medical literature
- helps researchers to support hypotheses
- helps in the discovery of new insights
- Some think it should be called augmented intelligence

AI can identify documents that are semantically related to any combination of medical concepts

How artificial intelligence is changing the future of optometry

- ODs move further toward "data analysis" and away from "data collection"
- Being competent in the use of innovative technologies is a must that will include critical thinking and the ability to manage complex cases in real time
- OD's ability to properly use AI should be the focus – not the growing fear that ODs' jobs will be replaced because AI is accurate for what it does well, and poor for things it is not trained to understand
- There is real potential for earlier, more accurate, and more uniform diagnosis

How artificial intelligence is changing the future of optometry

- how AI can alter traditional models of the "professional-patient" relationship
- Patients are now using technology to better understand their own medical information and to ask more informed questions
- We will need human and language skills to provide patient education and patient care

AI for Optometry

- *autonomous IDx-DR device* which facilitates detection of retinopathy in diabetic patients aged 22 years and older, without an ocular examination
- *telemedicine photo systems* that enable detection of retinopathy of prematurity (ROP)
  A recent study demonstrated that Deep Learning algorithms could be used to accurately screen for ROP via telemedicine

AI for Optometry

- *Neural network differentiation of optic neuritis and anterior ischaemic optic neuropathy*, L A Levin, J F Rizzo, S Lessell, British Journal of Ophthalmology Sep 1996, 80 (9) 835-839
- *Progressive assessment of age related macular degeneration using an artificial neural network approach*, J Morgan-Davies, N K Taylor, A M Armbrecht, p Aspinall, B dhillon, British Journal of Ophthalmology Feb 2001, 85 (2) 238

AI for Optometry

Glaucoma management in the era of artificial intelligence, Sripad Krishna Devalla, Zhang Liang, Tan Hung Pham, Craig Boote, Nicholas G Strouthidis, Alexandre H Thiery, Michael J A Girard, British Journal of Ophthalmology Oct 2019

AI for Optometry

- *Improved automated detection of diabetic retinopathy on a publicly available dataset through the integration of deep learning*, Abramoff MD, Lou Y, Erginay A, et al. IOVS. 2016;57(10):5200-6

The system evaluated 128,175 retinal images for the presence of DR and diabetic macular edema, as well as image quality. The DR severity (none, mild, moderate, severe or proliferative) was graded according to the International Clinical Diabetic Retinopathy scale. An AI algorithm was designed to identify 'referable' cases—defined as moderate or worse DR—as a way to demonstrate its viability as a screening tool. Its performance in several tests yielded sensitivities for referable DR that ranged from 87% to 97.5%, and specificity of 94%.

Integration of AI

- Increased integration of AI into everyday medical applications
- opportunity to improve efficiency of treatment
- may lead to lower costs

Potential directions for AI for medicine in the near future

- Brain-computer interfaces (BCIs) backed by AI could restore or augment motor functions in some patients
- AI could spot disease before patient experiences symptoms
- AI could identify nuances that may escape the human eye scanning down to the pixel level
- Aid in targeting more individualized therapies

Potential directions for AI for medicine in the near future

- Leverage wearables and smartphones for data and diagnostics
- extracting data contained in hand-held devices
- smartphone images analyzed by AI algorithms

Potential Liability for Physicians Using Artificial Intelligence

- Because current law shields physicians from liability as long as they follow the standard of care, the "safest" way to use medical AI from a liability perspective is as a confirmatory tool to support existing decision-making processes, rather than as a source of ways to improve care

Behavioral Optometry and Trends Transforming Patient Care

Virtual Reality – use of Vivid Vision, Optics Trainer

- dichoptic stimulus presentation, interocular contrast balance, and manipulation of monocular and stereoscopic cues to rehabilitate stereoscopic vision
- Augmented Reality – Oculenz

  Oculenz™ mediated reality glasses corrects the original image through pixel manipulation to correct for eye deficits such as macular degeneration and myopic degeneration
  - Also working on using the system to treat amblyopia

Behavioral Optometry and Trends Transforming Patient Care

Binovi

ability to track results repeatability of procedures college and pro teams adapting new technology leads to more awareness and acceptance from patients

Senaptec

Assess, analyze and improve visual and neuromotor skills

Behavioral Optometry and Trends Transforming Patient Care

- Right Eye

  eye tracking to uncover paths to better vision health, brain health ,reading and sports performance

On the Cutting Edge

- *Nano-Drops* could correct nearsightedness, farsightedness and astigmatism
- The three-step system will involve measuring refraction using a smartphone app, stamping an individualized optical pattern onto the top layer of the cornea with a proprietary laser device based on that measurement, and then applying synthetic biocompatible protein nanoparticle drops to activate the stamped optical pattern, changing the trajectory of light passing through the cornea
- Nano-Drops achieved a correction of 3 diopters for farsightedness and 2.5 diopters for nearsightedness in preclinical animal tests. Two more years of development are expected before clinical trials begin

- *Orasis Pharmaceuticals* recently initiated a Phase 2b clinical study in the United States to evaluate its CSF-1 pharmaceutical-grade daily eye drops to replace reading glasses in those with with presbyopia
- *DeepOptics* is developing dynamic electronic multifocal eyeglasses with high-tech lenses that detect viewing distance and adjust automatically for the user

  In addition to vision correction, the company also is collaborating with leaders in the augmented reality (AR) space to integrate *DeepOptics tunable lenses* in next-gen AR headsets

- *AEye Health* invented an at-home retinal diagnostic screening system based on artificial intelligence, computer vision and a database of 100,000 images of the retina and its inner structures
- AEye Health aims by 2020 to be the first FDA-approved retinal screening solution for home use

- *Medisim* is working toward FDA approval of BinoVision video goggles to treat children with amblyopia
- BinoVision goggles turn any digital content – movies, cartoons, games, music videos, TV shows — into a fun mode of therapy by presenting separate, independent views of the same image to each eye. The image presented to the amblyopic eye is enhanced as a way of stimulating the brain to improve its visual function

- *NovaSight* aims to prevent pediatric vision loss by combining AI and eye tracking in products geared to children's attention spans.
- The company has two products:

  EyeSwift vision-assessment system

  CureSight amblyopia treatment system

  CureSight treats amblyopia by tracking children's eye movements and providing corrective feedback while they watch a short animation