ARVO EDUCATION COURSE

Saturday, April 27, 2019
8am-4:30pm
Vancouver Convention Centre
Vancouver, British Columbia, Canada

Artificial intelligence – from benchtop to bedside

Course organizers

Lead organizer: Michael David Abramoff, MD, PhD, FARVO, Ophthalmology & Visual Sciences, University of Iowa Hospitals & Clinics, IDx

Rajat N Agrawal, MD, MS, CEO Retinal Global

Michael F Chiang, MD, Ophthalmology and Medical Informatics, Oregon Health & Science University

Susan C Orr, OD, Chief Medical Officer & VP Medical Affairs, Notal Vision

Arthur H Shedden, Jr., MBA, MD, Senior Safety Officer, Johnson & Johnson Vision Care, Inc.

Daniel SW Ting, MD, PhD, Singapore National Eye Centre

Tien Y Wong, FRCS, PhD, FARVO, Singapore National Eye Centre

Presentations - preliminary

Presenters and presentations may change.

8-8:05am

Welcome and Introduction

Michael David Abramoff, MD, PhD, FARVO, Ophthalmology & Visual Sciences, University of Iowa Hospitals & Clinics, IDx

General welcome to the day.

8:05-8:20am

Artificial Intelligence (AI) Introduction and Perspective

Randall Pugh, PhD, Johnson & Johnson Vision

The attendee will gain a base level understanding of AI and its current state and have the basis to consider its societal and philosophical implications. A brief history will be presented with key milestones of AI development. The current state of AI and its potential to transform society and humankind will be discussed. The evolutionary possibilities when combined with other emerging technologies such as robotics will be considered.

8:20-8:35am

General Introduction on AI in healthcare. Importance of differentiating types of AI, including autonomous and assistive, as well as the implications for patient safety, efficacy, and clinical implementation

Michael David Abramoff, MD PhD, FARVO

General Introduction on AI in healthcare. We will briefly sketch the history of AI in healthcare, review the different types of medical AI, including research focused versus clinically focused AI, autonomous vs assistive AI,

explainable vs non-explainable AI. We will the introduce the consequences these have on AI algorithm, efficacy, and patient safety where applicable.

8:35-8:50am

Overview of deep learning algorithms (DLSs) in medical imaging for Ophthalmology

Daniel SW Ting, MD, PhD, Singapore National Eye Centre

In medicine, the most robust deep learning algorithms have been from image-centric specialties, including radiology, dermatology, pathology and ophthalmology. In ophthalmology, DLSs were able to effectively detect diabetic retinopathy, glaucoma, age-related macular degeneration (AMD), retinopathy of prematurity (ROP), refractive error, and cardiovascular risk factors based on colour fundus photographs. Additionally, several retinal conditions (e.g. drusens, neovascular AMD, diabetic macular edema) can be detected accurately using optical coherence tomography (OCT). This presentation will provide a brief overview of the current state-of-art deep learning systems in Ophthalmology.

8:50-9:05am

Global Eye Health: Disease Burden and Clinical Unmet Need

Tien Y Wong, FRCS, PhD, FARVO, Singapore National Eye Centre

Visual impairment (VI) is a major public health problem, associated with reduced quality of life, and increased frailty risk. Globally, 400 million suffer from VI. The five major causes of VI are under-corrected refractive error, cataract, glaucoma, age-related macular degeneration and diabetic retinopathy. These conditions will increase as the global population ages. About 80% of VI and these conditions are preventable if detected early. Hence, screening programs for VI and major eye diseases are critical to prevent blindness. Artificial intelligence (AI) has the potential to significantly enhance and impact on screening programs for VI and eye diseases, and thus to impact on global blindness.

9:05-9:20am

How does AI fit in with the current eye practices in Unites States?

James C. Folk, MD, University of Iowa Hospitals & Clinics

A-I could fit as a “doctor extender” in current eye practices. Cameras with algorithms could be placed in multiple locations such as a primary care office, a community health center or even a pharmacy. Automation would send the results to the electronic medical records of the primary care doctor and the eye doctor. Depending on the population and the A-I results, about 10% of patients would need to see an eye doctor whereas 90% could be safely screened again in one year. The same model could also be used for other eye diseases.

9:20-9:30am: Questions and Answers

Pugh, Abramoff, Ting, Wong

9:30-10am: Break

10-10:15am

Algorithm Design: Technical network (CNNs), softwares, CPU/GPU/TPU

Ranya Habash, MD, Chief Medical Officer, Everbridge, Assistant Professor of Ophthalmology, Bascom Palmer Eye Institute

This is a technical overview of algorithm design, which resembles the biological structure of neural networks in cognitive function. We will explore the mathematics behind Hebb's rule, mapping inputs to outputs, and backpropagation to calculate weights used in powering multilayer neural networks. We will compare the makeup of these networks to the brain's own methods for learning and memory.

10:15-10:30am

AI algorithm design: key considerations for real-world performance

Samuel G Finlayson, MS, Harvard Medical School and MIT

Recent advances in AI make it historically easy to train machine learning models that achieve high accuracy on a range of tasks. But are they actually learning what we think they are? In this session, we'll review the machine learning pipeline with a focus on commonly neglected failure mechanisms and the steps we can take to mitigate them. We'll discuss (and contrast) concepts such as label leakage, dataset shift, overfitting, interpretability, model inspection, and adversarial robustness. In doing so, we'll try to develop a cohesive framework for ensuring our models will behave as in intended when deployed in real, prospective clinical scenarios.

10:30-10:45am

Machine Learning - Diabetic Retinopathy and Beyond

Naama Hammel, MD, Clinical research scientist, Google LLC

This talk will cover:

- Principles and best practices of machine learning research
- Deep learning systems for detection of diabetic retinopathy and other eye diseases
- What's next? Machine learning applications and future research directions in ophthalmology

10:45-11am

DLSs for Glaucoma and Tele-Ophthalmology

Louis R Pasquale, MD, FARVO, Icahn School of Medicine, Mount Sinai Health System

This presentation will discuss 3 gaps in glaucoma addressed by artificial intelligence (AI).

Gap 1: Glaucoma is an optic nerve disease categorised by excavation and erosion of the neuroretinal rim that clinically manifests itself by increased optic nerve head (ONH) cupping. Yet, because the ONH area varies by fivefold, there is virtually no cup to disc ratio (CDR) that defines pathological cupping, hampering disease detection. AI is capable of detecting discs above a specified cup-disc ratio although it not yet able to identify the disc associated with manifest visual field loss

Gap 2: The outputs from visual field tests typically provide reliability parameters, age-matched normative comparisons and summary global indices, but more detailed analysis of this functional data is lacking. An AI algorithm called archetype analysis is capable of decomposing the total deviation plot of a visual field into components and provide weighting coefficients regarding any regional deficits.

Gap 3: Several computer programs to detect VF progression exist, ranging from assessment of global indices over time to point-wise analyses, to sectoral VF analysis; however, these approaches are often not aligned with clinical ground truth nor with one another. AI algorithms can detect VF progression earlier than these conventional computer strategies and produces results that are more in line with clinical ground truth.

11-11:15am

Comparison of DLSs for age-related macular degeneration (AMD)

Neil M. Bressler, MD, Johns Hopkins Medicine

Description to come

11:15-11:30am

DLS for retinopathy of prematurity (ROP) detection

Michael F Chiang, MD, Ophthalmology and Medical Informatics, Oregon Health & Science University

This presentation will discuss motivations, challenges, and solutions regarding applications for machine learning and deep learning for retinopathy of prematurity (ROP) diagnosis.

11:30 -11:45am

Panel Discussion: DLS applications in the real-world practice

Finlayson, Hammel, Pasquale, Chiang, Tan, Habash, Bressler

11:45-12:45pm: Lunch

12:45-1pm

Deep Learning Systems for Retinal Disease using Optical Coherence Tomography

Pearse Andrew Keane, MD, FRCOphth, Moorfields Eye Hospital NHS Foundation Trust

Deep learning systems use artificial neural networks – so-called because of their superficial resemblance to biological neural networks – as computational models to discover intricate structure in large, high dimensional datasets. Since 2012, deep learning has brought seismic changes to the technology industry, with major breakthroughs in areas as diverse as image captioning, speech recognition, natural language translation, robotics, and even self-driving cars. In 2015, Scientific American listed deep learning as one of their "world changing" ideas for the year.

In July 2016, Moorfields Eye Hospital in London announced a formal collaboration with DeepMind, arguably the world's leading organisation for AI research. This collaboration has involved the application of deep learning to >1 million anonymised OCT scans with the aim of automating the diagnosis of macular diseases such as age-related macular degeneration (AMD) and diabetic retinopathy (DR). Preliminary results suggest that this algorithm is on a par with experienced retinal specialists in the triaging of these conditions. In addition to performing classification tasks (e.g., screening, triage, diagnosis), the Moorfields-DeepMind algorithm is capable of performing automated segmentation for a wide range (>10) of retinal morphologic parameters on OCT (segmentation is a term used in computer vision research which describes the delineation of specific features on an image). I will give an overview of this system and its application to retinal OCT scans.

1-1:15pm

Deep learning to prognosticate neovascular AMD

Ursula Schmidt-Erfurth, MD, FARVO, Department of Ophthalmology, Medical University of Vienna

High-resolution three-dimensional imaging ideally provides ultrastructural data for artificial intelligence (AI)-based analyses. Using deep learning (DL) methods, OCT imaging is able to identify markers of disease progression in intermediate age-related macular degeneration (AMD). Qualitative as well as quantitative

parameters are ranked in respect to their importance for disease conversion. Drusen volume as well as hyperreflective foci (HRF) and changes in neurosensory layer thickness are relevant prognostic markers in neovascular AMD.

1:15-1:30pm

Transfer learning - how will this technology help to diagnose ophthalmic diseases and beyond

Kang Zhang, MD, PhD, Ophthalmology, University of California, San Diego

We establish an AI diagnostic tool based on a deep-learning framework for the screening of patients with common treatable blinding retinal diseases. Our framework utilizes transfer learning, which trains a neural network with a fraction of the data of conventional approaches. Applying this approach to a dataset of optical coherence tomography images, we demonstrate performance comparable to that of human experts in classifying age-related macular degeneration and diabetic macular edema. Our AI platform can aid in expediting the diagnosis and referral of these treatable conditions, thereby facilitating earlier treatment resulting in improved clinical outcomes.

1:30-1:45pm

Potential challenges of AI in OCT imaging

Bhavna Josephine Antony, M.Sc., PhD, Research Scientist, IBM Research Australia

AI for medical image analysis and computer vision vary as there are distinct problems faced in each domain. OCT image analysis in particular is confounded by the varying image resolution, acquisition protocols and other image characteristics. Here, I will briefly illustrate some of the main challenges that AI for OCT imaging is facing currently, and will have to overcome in the near future.

1:45-2pm

Panel Discussion: DLS in OCT applications in the real-world practice

Keane, Schmidt-Erfurth, Zhang, Antony, Abramoff, Orr

2-2:30pm: Break

2:30-2:45pm

Artificial Intelligence Eye Screening using Smartphones: The Good, the Bad, and the Ugly

Kaushal Solanki, Phd, CEO Eyenuk, Inc.

Artificial intelligence (AI) systems are gaining attention for population eye screening. Smartphone-based retinal fundus cameras are attractive for artificial intelligence eye screening, especially for autonomous diabetic retinopathy screening, which is also supported by promising clinical evidence. Smartphone-based fundus cameras are portable and inexpensive, and the smartphone also provides a natural software and communication platform using apps that are easy to use. To set up real-world screening programs that utilize smartphone fundus photography and cloud-based AI analysis, there are a few considerations that must be addressed, which include (a) whether dilation of all or subset of patients is possible, (b) training of photographers for the cameras that operate differently, (c) availability of network (3G/LTE or Wifi), and (d) use of camera mounts. Therefore, institutions, non-profits, or Governments interested in setting up screening programs using the smartphone-based photography must (i) use AI systems that have been extensively tested in real world, (ii) incorporate extensive photographer training program and continuously test the photographer skills, (iii) carefully validate

the end-to-end system in their setup via initial pilot implementation, (iv) use portable camera mounts, and (v) consider dilating all or specific population groups (eg, older age groups or with smaller pupil). In other scenarios a tabletop fundus camera with AI is still the best option. The future does hold great promise for portable and/or smartphone-based fundus imaging to be truly clinic-ready for population eye screening using artificial intelligence.

2:45-3pm

Autonomous AI and Quality Management Systems

David Vidal, VP of Quality & Regulatory Affairs, IDx

This presentation covers the combination of Regulations, Standards, Frameworks, and Guidance documents used for an autonomous AI Quality Management System (QMS), including QMS recommendations for future guidelines related to autonomous AI.

3-3:15pm

AI technology implementation: productizing autonomous diagnostic AI

Meindert Niemeijer, PhD, IDx

This presentation will cover some of the pitfalls and practical considerations associated with the productization of an autonomous diagnostic AI algorithm. Including such topics as algorithm training, verification and validation. The importance of algorithm explainability and the need for an independent reference standard to establish truth.

3:15-3:30pm

The submission and examination process of an AI eye product by US FDA

Speaker request pending with FDA for Malvina B Eydelman, MD, Director, Division of Ophthalmic and Ear, Nose & Throat Devices, FDA (tentative)

Description to come

3:30-3:45pm

AI outside the developed world: applications and regulatory aspects

Rajat N Agrawal, MD, MS, CEO Retinal Global

The presentation will highlight the pathways and likely challenges that AI developers focused on ophthalmology systems will face when working to implement systems in underdeveloped areas of the world. The presentation will highlight the current systems in place in some of these underdeveloped countries, and provide suggestions for access. Regulations exist in few of these underdeveloped countries, which may be a boon for AI platforms in implanting their systems, if they already have an approval from leading regulatory agencies such as FDA. On the other hand, if regulatory systems exist, these are slow to react and approve, which delays the pathway to final approval and implementation of systems in such areas. The presentation will highlight the process, with an example to highlight the steps and likely challenges.

3:45-4pm

The development, mechanics and ethical implications of AI

Susan C Orr, OD, Chief Medical Officer & VP Medical Affairs, Notal Vision

Description to come

4-4:20pm

Panel Discussion: Commercialization and regulatory requirement

Solanski, Vidal, Niemeijer, Eydelman, Orr, Raj, Wong and Leopold Schmetterer, PhD, FARVO

4:20-4:30

Wrap up

Michael David Abramoff, MD PhD, FARVO

Summary and take-home messages