Overview

- Brief Introduction to Artificial Intelligence
- FDA Approval for Screening Diabetic Retinopathy
- Intraocular Lens Calculations with Artificial Intelligence
- Future Use with Retinopathy of Prematurity
- Summary

What is Artificial Intelligence?

- Applying learning to non-sentient entities like machines

Why is Artificial Intelligence (AKA Machine Learning, Deep Learning) Useful?

- **Scalability** – Eye providers cannot necessarily screen millions at threat for specific diseases. For eyes, pictures are relatively easy to obtain. Interpreting them can be time consuming.
- **Quantitative** – Humans are subjective. Poor interobserver correlation. Algorithms give us quantitative, objective scores.
- **Efficiency** – Tracking disease progression much easier with quicker time to treatment.

Simple Neural Networks

- Sensory Inputs
- Memory Neurons
- Hebbian Learning: “Neurons that fire together, wire together”

Complex Neural Networks with Hebbian Learning

- Sensory Inputs
- Memory Neurons
- Hebbian Learning: “Neurons that fire together, wire together”

Example of Algorithm for Image Feature Extraction

Pattern Recognition

Ophthalmology is inherently a pattern recognition heuristic to diagnose disease.

NORMAL or ABNORMAL?

NORMAL

Pattern Recognition (cont’d)

HUMANS ARE EXCELLENT AT PATTERN RECOGNITION!
BUT WE ARE TERRIBLE AT COMMUNICATING SUBJECTIVE FINDINGS

NORMAL or ABNORMAL?

ABNORMAL

What features are abnormal?

Applying Algorithm to Fundus Photo of Severe Non-Proliferative Diabetic Retinopathy (nPDR)

The Early Treatment Diabetic Retinopathy Study defined Severe nPDR:

- 4 quadrants of 20 or more Microaneurysms, Dot Blot Hemorrhages, or Intraretinal Hemorrhages
OR
- 3 Quadrants of Venous Beading
OR
- 1 Quadrant of Intraretinal Microvascular Abnormality

IDx-DR – First FDA Approved Deep Learning Algorithm

Autonomous AI algorithm based on biomarkers

IDx-DR – Intended Screening Guidance

IDx-DR analyses images for signs of diabetic retinopathy, demonstrating less than A second.
**IDx-DR – Validation**

Receiver Operating Characteristic Curve

**IDx-DR**

Area Under Curve: 0.980

**IDP (3 Readers)**

Area Under Curve: 0.940

Reference Diabetic Retinopathy (moderate NPDR or worse)

Vision Threatening Diabetic Retinopathy (severe NPDR or worse)

**IDx-DR**

Area Under Curve: 0.994

**IDx-DR – Examples of False Negatives**

Right and left eye images of the 6/874 subjects diagnosed as having referable DR, per the adjudicated consensus of the retinal experts, that were false negatives for the referral DR output (i.e., were missed by the device). All six subjects had consensus grading of moderate DR without ME.

**Artificial Intelligence in Intraocular Lens Calculations**

ImageCourtesy: ASCRS/ASOA Symposium 2015

**Formula Optimization**

**STANDARD DOGMA**


**The Ladas Super Formula**


**The Hill-RBF Formula**

**Inter-Formula Validation**

**Formula Validation**

- Formula
  - Current Universal II
  - Fields' 1950
  - Early Treatment for Retinopathy of Prematurity (ETROP)
  - Differentiation
  - Fluorescein Dye

**Normal Retinal Development**

- Nasal Development by 36 weeks Gestational Age
- Temporal Development by 40 Weeks Gestational Age

**Premature Infants**

- Can have maldevelopment of retina known as Retinopathy of Prematurity

**Screening**

- Usually performed in infants with...
  - Birth weight < 1500 g
  - Gestational age ≤ 32 weeks

**Timing**

- Initial eye exam based on gestational age at birth

**International Classification of Retinopathy of Prematurity (ICROP)**

- Zone
- Stage
- Extent
- Presence of plus disease (vascular dilation and tortuosity)

**Better Treatment for Retinopathy of Prematurity Cooperative Group**

**WHEN TO TREAT:**


**Retinopathy of Prematurity – Disease Identifying Features**

- International Classification of Retinopathy of Prematurity (ICROP)
  - Zone
  - Stage
  - Extent
  - Presence of plus disease

**Retinopathy of Prematurity – Deep Learning**

- Automated categorization of data representations

**Continuous values between 1 & 9** designed to categorize a spectrum of disease

**Retinopathy of Prematurity – Validation**

- i-ROP score versus severity ranking

**Continuous values between 1 & 9**

- Normal
- Pre-Plus
- Plus

**Validation**

- i-ROP score versus severity ranking

- Data were analyzed by the Early Treatment for Retinopathy of Prematurity Cooperative Group. Arch Ophthalmol (2003).
Retinopathy of Prematurity – Tracking Patient Changes with and without Treatment

Summary

- Artificial intelligence assists in screening conditions with higher throughput than can be accommodated by eye providers.
- Diabetic Retinopathy, IOL Calculations, and Retinopathy of Prematurity all lend themselves to Machine Learning’s efficiency and reproducibility with quantitative scoring.
- Machine learning will likely expand to other Ophthalmic and Non-Ophthalmic domains including Corneal Ectactic Disorders, Ocular tumors, etc.
- The purpose of AI is to augment the health care provider…

Summary

…and not to replace the provider (or humankind) altogether.

OpenAI built a text generator so good, it’s considered too dangerous to release

References