How Machine Learning Will Transform Medicine
The World Has Changed

- Exponential growth of unstructured data
- Democratization of hardware
- Breakthroughs in machine learning

Transforming multiple industries... especially medicine
Trend 1: Exponential Growth Of Unstructured Data

Industry

- 80% of world’s data is unstructured
- Medical knowledge & data*
  - 1950: 50 years to double knowledge
  - 1980: 7 years to double knowledge
  - 2015: <3 years to double knowledge
  - 1 Million GB of health data generated per person

* From IBM Computing, Cognition, & the Future of Knowing by Dr. John E Kelly III

Consequences

- Need for automatically analyzing & interpreting data

How do we analyze & interpret all that data?
Trend 2: Democratization Of Hardware

Industry

- Cloud computing
- Moore’s Law

Consequences

- Vast amounts of compute are readily available to at very low cost

Enables everyone to have access to massive amounts of computing power
Trend 3: Start Of Cognitive Computing

Industry

- 1997: DeepBlue defeats Gary Kasparov at Chess
- 2011: Watson wins at Jeopardy!
- 2015: Microsoft wins ImageNet Computer Vision Challenge
- 2016: DeepMind’s AlphaGo wins Go (4-1)

Why and how are computers suddenly beating experts in strategy, natural language, & “seeing”
Terminology

- **Machine Learning**: Class of algorithms where performance improves over time as more data is processed
  - Training: Model development to teach
  - Scoring: Using the model to evaluate a situation

- **Deep Learning**: A subset of Machine Learning where there are multiple layers between the input and the output layers of a model

- **Cognitive Computing**: Ability to understand, reason, remember, learn, & act w/human-like intelligence using structured & unstructured data
  - Natural Language Processing (Siri, Amazon Echo)

“Goal of cognitive computing is to illuminate aspects of our world that were previously invisible—patterns & insight in unstructured data”

From IBM Computing, Cognition, & the Future of Knowing by Dr. John E Kelly III
Cognitive Computing & Medicine

Transformative opportunity to make sense of unstructured data

- Paradigm Shifts:
  From algorithmic to statistical, probabilistic, & evidence-based
- Dataset increases $\rightarrow$ Accuracy improves
- Compute increases $\rightarrow$ Better/powerful ML $\rightarrow$ Accuracy improves
- Enables deeper human engagement, elevating expertise, & enhancing exploration and discovery
- Examples
  - IBM Watson—50+ cognitive areas, 35+ APIs
  - Alphabet DeepMind Health w/UK’s National Health Services
  - Merck: Accelerate drug discovery
  - Startups: Enlitic (Radiographs, CT, MRI), Atomwise (drug), Freenome (DNA)

Intelligence = data + training/algorithms + compute
Implications

Where will we see machine learning in medicine?

• Clinical Decision Support / Business Intelligence
• Wellness/Prevention: “Supervisory Monitoring”
• (Deeper) Data Analysis & Image Recognition
• Predictive Diagnosis

Holy Grail

• Cognitive: “What is the optimal treatment?”

Solutions will be a hybrid of machine learning, traditional AI techniques, & human support
References & Further Reading

  - **Overview of ML in CDS** (Tanveer Syeda-Mahmood): [www.youtube.com/watch?v=A4Uk88-DOBA](http://www.youtube.com/watch?v=A4Uk88-DOBA)

- IBM Computing, Cognition, & the Future of Knowing by Dr. John E Kelly III

- **DeepMind Health**: [https://deepmind.com/applied/deepmind-health/](https://deepmind.com/applied/deepmind-health/)

- **Machine Learning Course**: [https://work.caltech.edu/lectures.html#lectures](https://work.caltech.edu/lectures.html#lectures)

- **Ray Kurzweil**: Future of intelligence on youtube