Artificial Intelligence & the Future of Healthcare

Alan Bernstein, O.C., PhD, FRSC

Presentation to the Senate Committee on Social Affairs, Science & Technology

Ottawa, March 29, 2017

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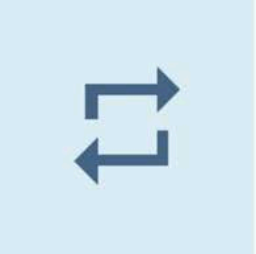
CANADIAN INSTITUTE FOR ADVANCED RESEARCH

Machine Learning - Basics

Learning Approaches

Supervised Learning: Learning with a labeled training set
Example: email spam detector with training set of already labeled emails

Unsupervised Learning: Discovering patterns in unlabeled data
Example: cluster similar documents based on the text content



Reinforcement Learning: learning based on feedback or reward
Example: learn to play chess by winning or losing

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Lukas Masuch. “Deep Learning - The Past, Present and Future of Artificial Intelligence.” (2015)

What is Deep Learning?

Part of the machine learning field of learning representations of data. Exceptional effective at learning patterns.

Utilizes learning algorithms that derive meaning out of data by using a hierarchy of multiple layers that mimic the neural networks of our brain.

If you provide the system tons of information, it begins to understand it and respond in useful ways.

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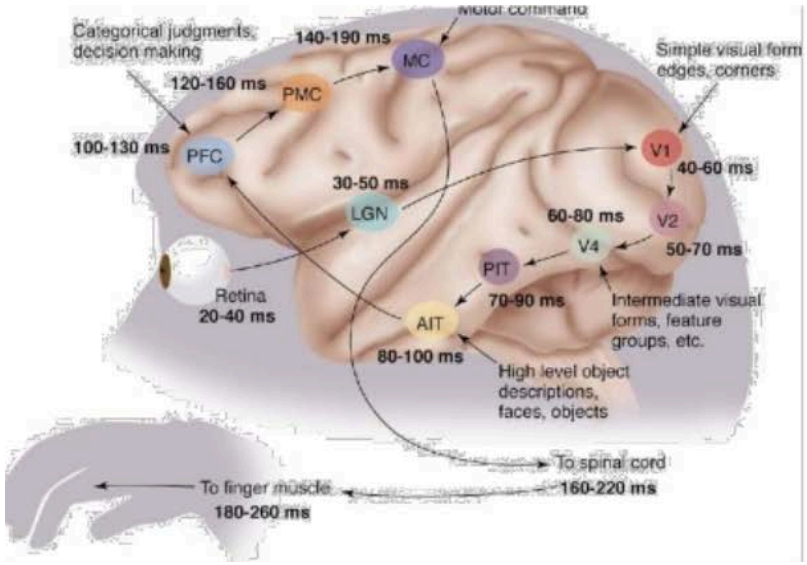
Inspired by the Brain



The first hierarchy of neurons that receives information in the visual cortex are sensitive to specific edges while brain regions further down the visual pipeline are sensitive to more complex structures such as faces.

Our brain has lots of neurons connected together and the strength of the connections between neurons represents long term knowledge.

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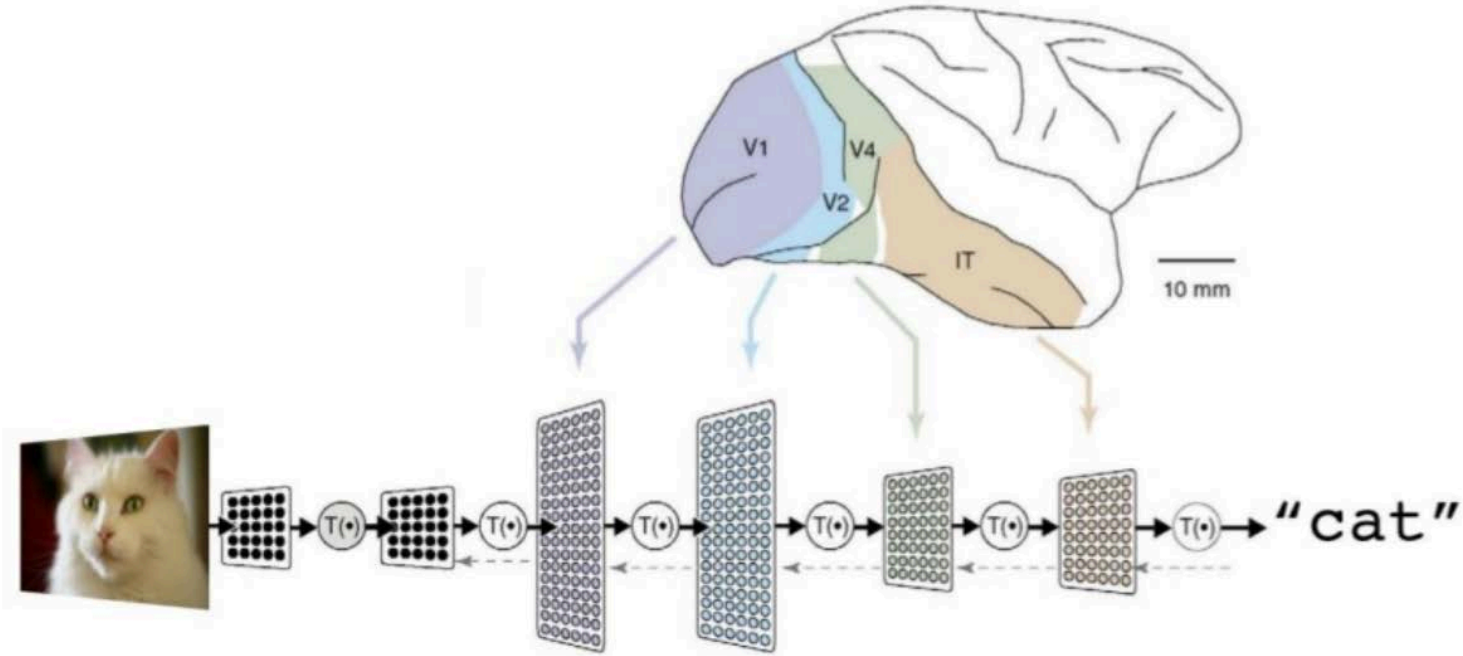
Deep Learning - Basics

Architecture



A deep neural network consists of a hierarchy of layers, whereby each layer transforms the input data into more abstract representations (e.g. edge -> nose -> face). The output layer combines those features to make predictions.

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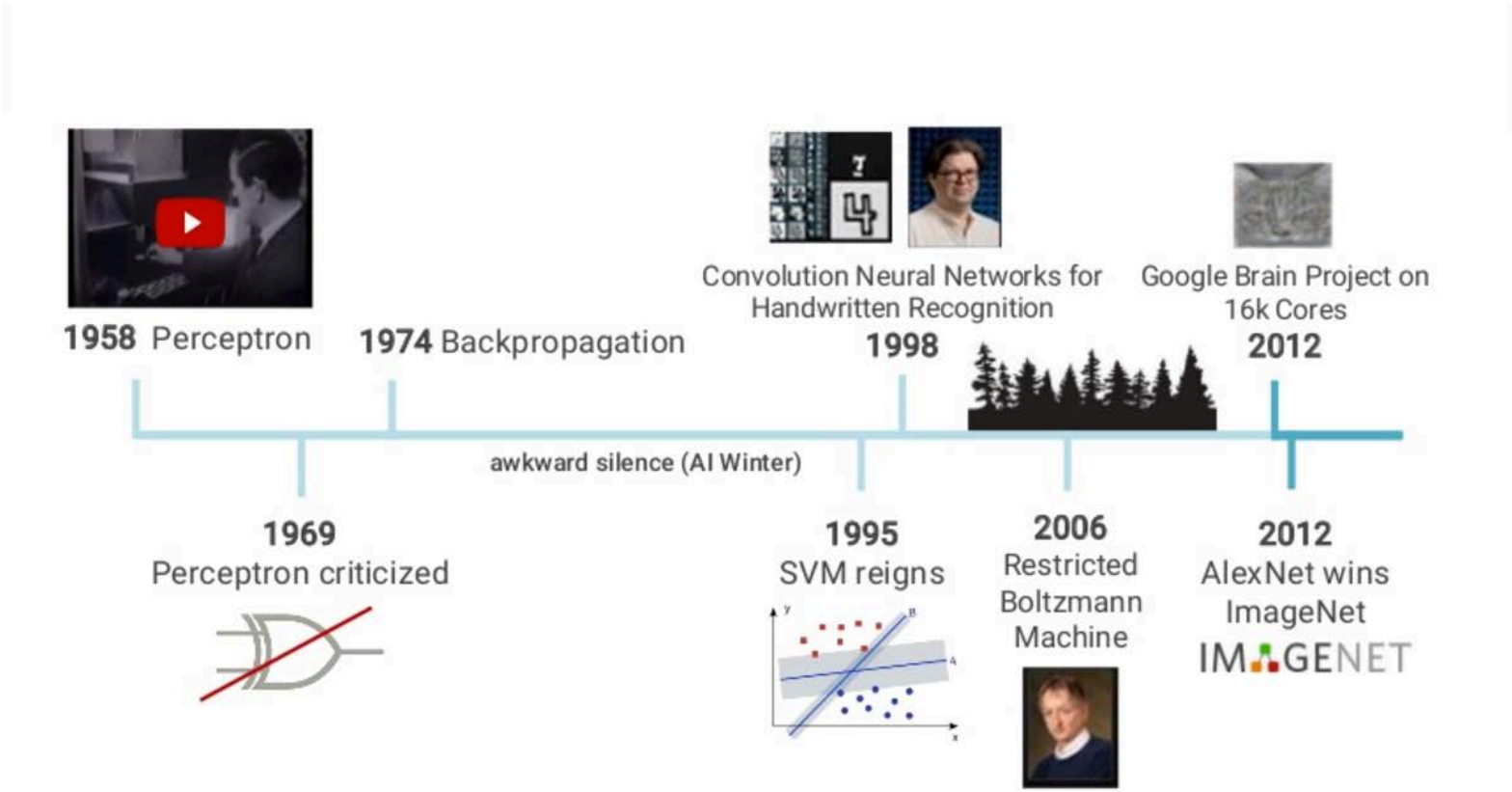
A brief history

A long time ago…



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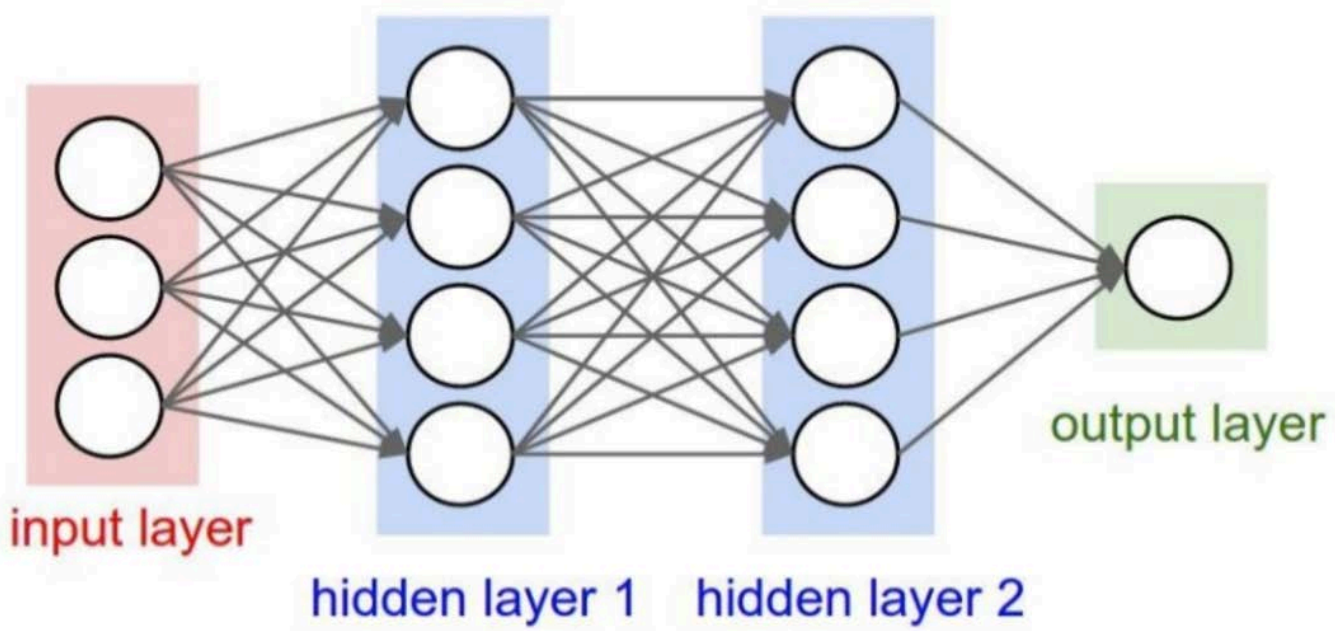
Deep Learning - Basics

Artificial Neural Networks



Consists of one input, one output and multiple fully-connected hidden layers in-between. Each layer is represented as a series of neurons and progressively extracts higher and higher-level features of the input until the final layer essentially makes a decision about what the input shows.

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nature
THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE
LESIONS LEARNT
Artificial intelligence powers detection of skin cancer from images
STAR TREK
SAFETY CATCH
MATERIAL GAINS

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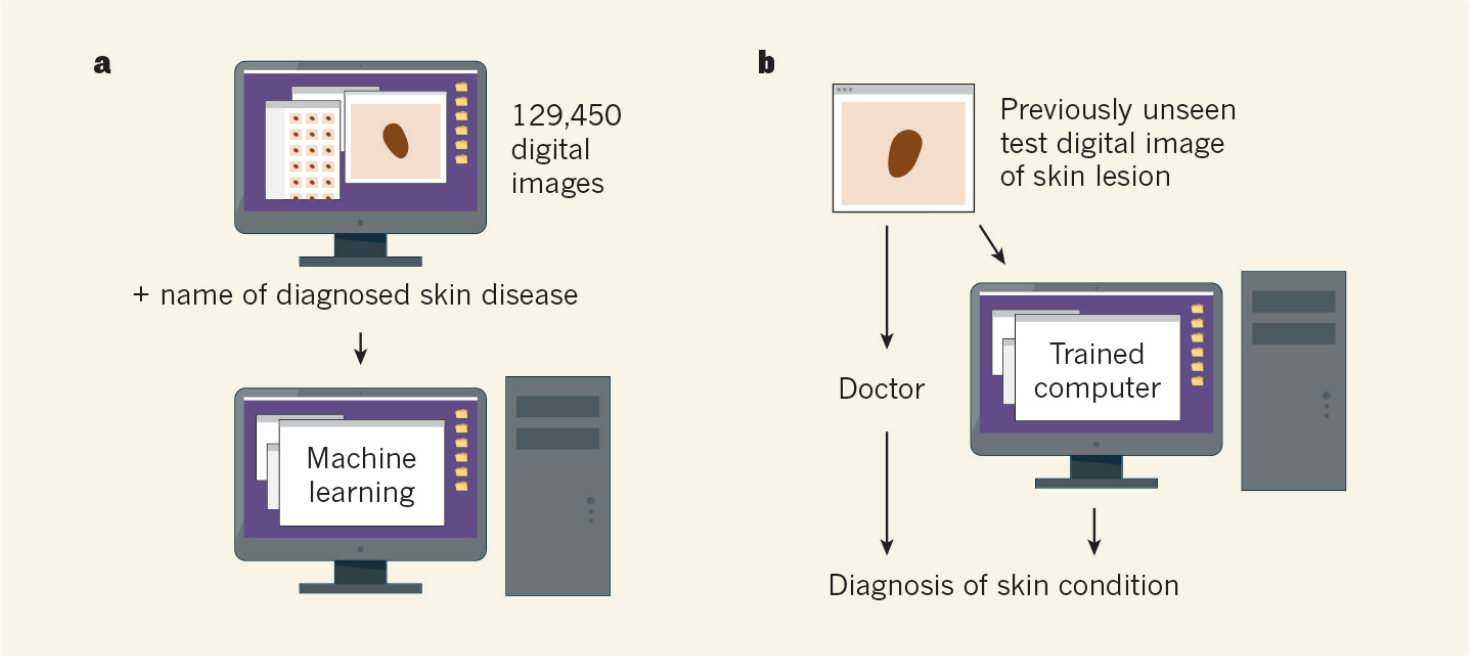
Dermatologist-level classification of skin cancer with deep neural networks

Andre Esteva[1]*, Brett Kuprel[1]*, Roberto A. Novoa[2,3], Justin Ko[2], Susan M. Swetter[2,4], Helen M. Blau[5] & Sebastian Thrun[6]

The ~~doctor~~ algorithm will see you now



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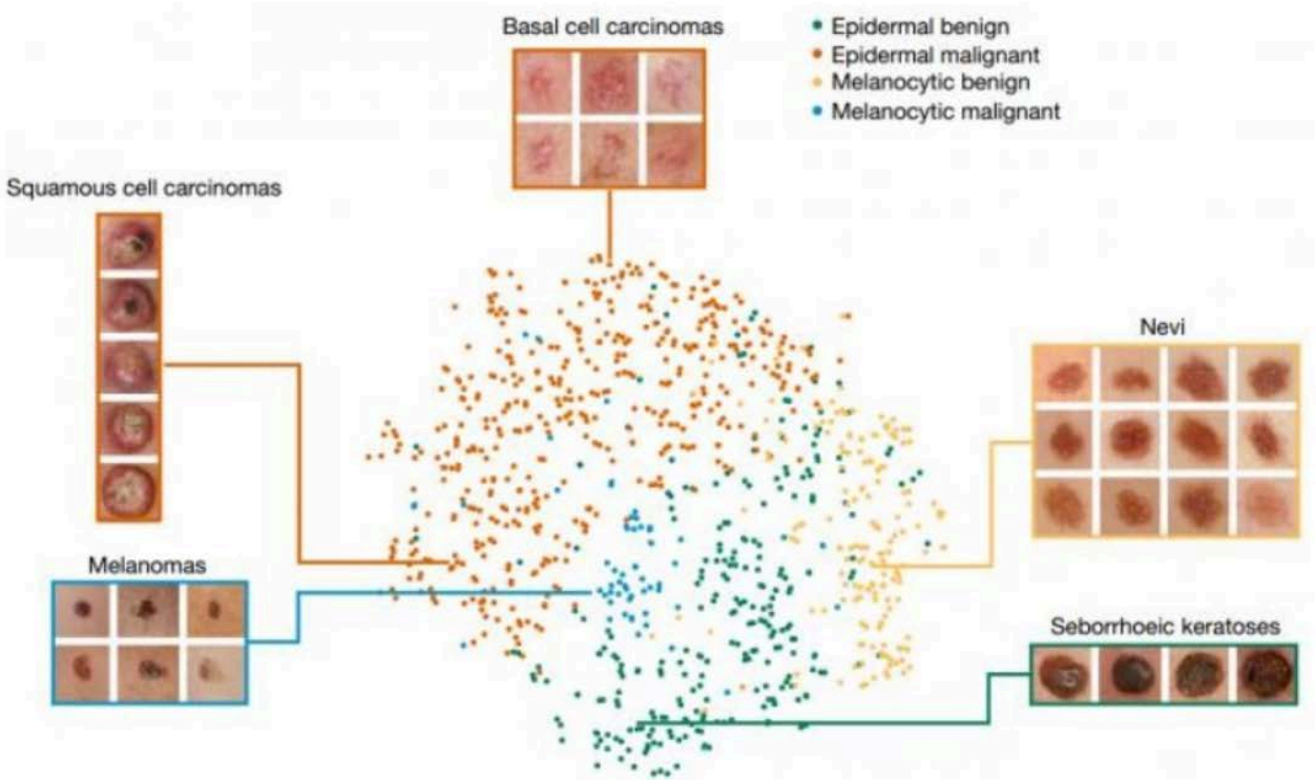
Nature, Vol. 542, 37 (2017)

Deep Learning in Medicine

Skin Cancer Diagnoses



The CNN performed just as well as almost two dozen veteran dermatologists in deciding whether a lesion needed further medical attention.

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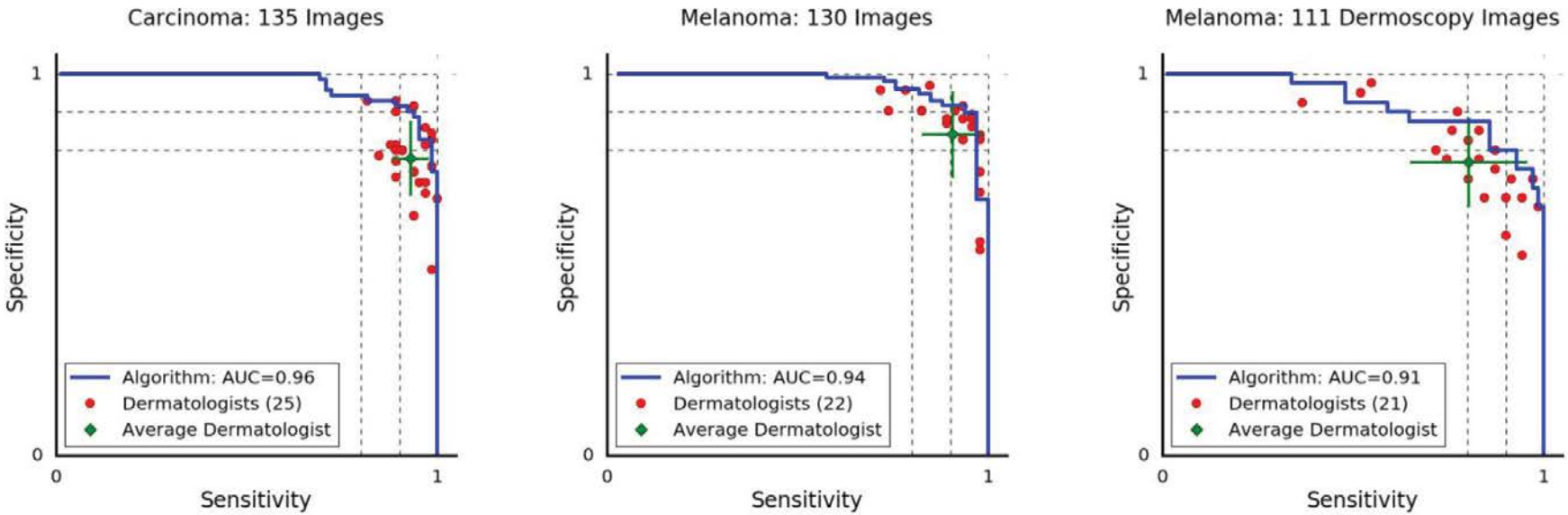
Deep learning outperforms the average dermatologist at skin cancer classification



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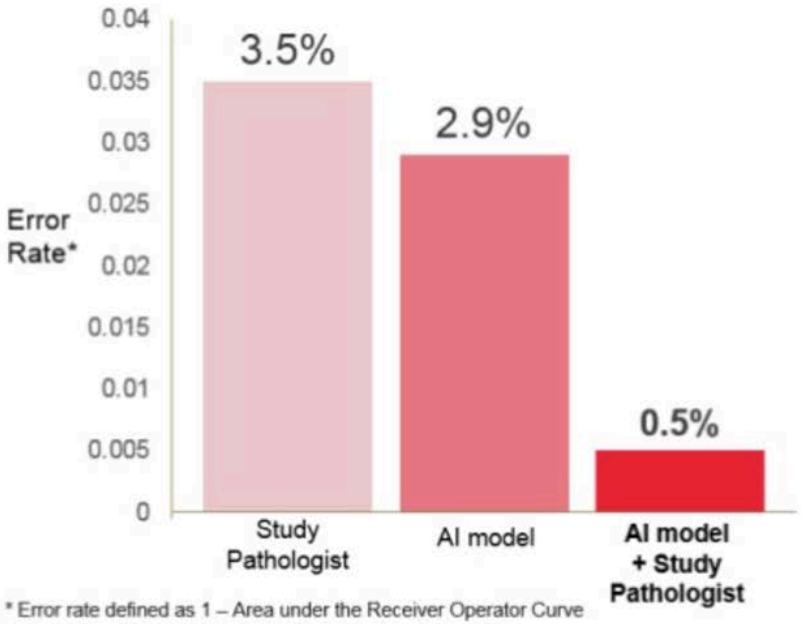
Nature, Vol. 542, 115 (2017)

Deep Learning in Medicine

Breast Cancer Diagnoses

(AI + Pathologist) > Pathologist



* Error rate defined as 1 – Area under the Receiver Operator Curve
** A study pathologist, blinded to the ground truth diagnoses, independently scored all evaluation slides.

Deep Learning drops error rate for breast cancer Diagnoses by 85%. Researchers trained their models with millions of labeled images to find the probability that a patch contains cancer, eventually creating tumor probability heatmaps.

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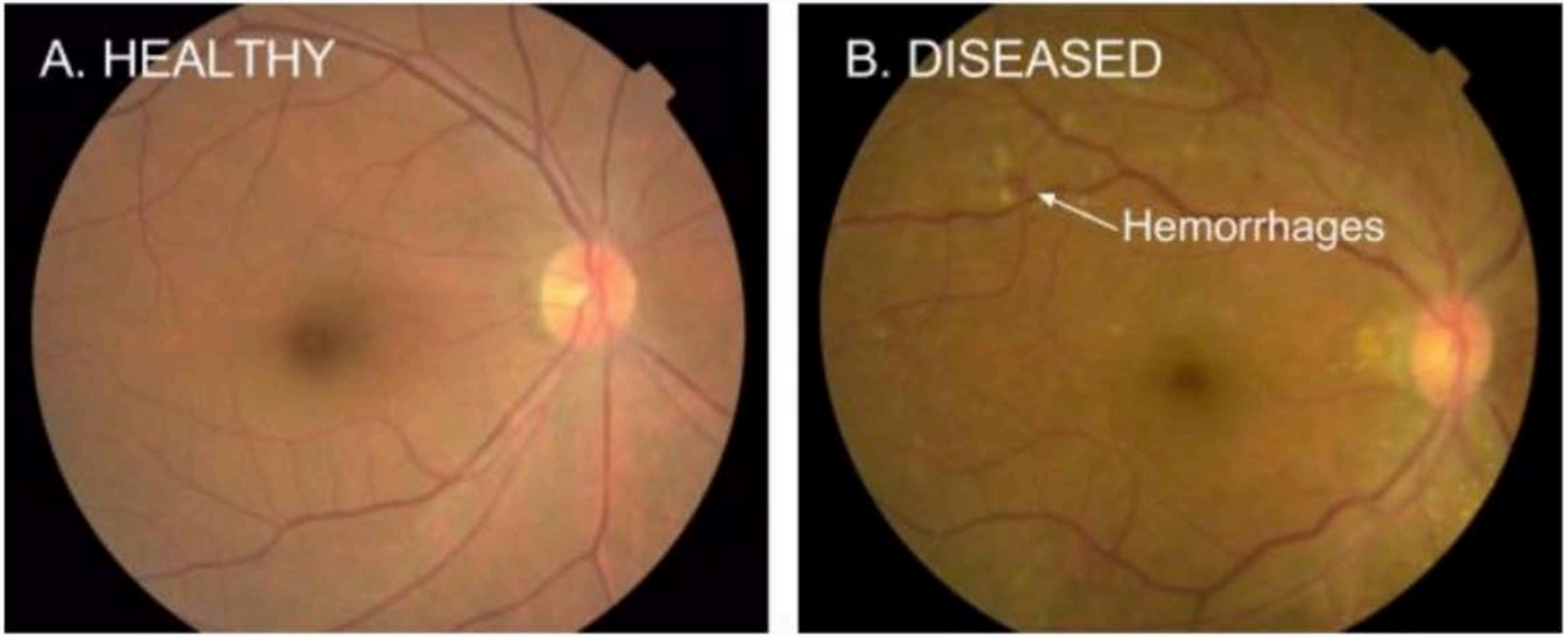
Deep Learning in Medicine

Detection of diabetic eye disease



Their deep learning algorithm performed better than the median board-certified ophthalmologist in assessing signs of diabetic retinopathy

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Lukas Masuch. “Deep Learning - The Past, Present and Future of Artificial Intelligence.” (2015)

Artificial intelligence (AI) will transform medicine and health care

- “If US healthcare were to use big data creatively and effectively [...], the sector could create more than $300 billion in value every year.” McKinsey Big Data report, May 2011
- AI is the best technology we have for integrating, interpreting and acting on big data

AI will learn from everyone’s data, but provide personalized care

- Genetic diagnosis and treatment tailored to the individual’s genome
- Recommendations based on daily sampling of personal device data, such as heart rate, diet, and metabolites
- Putting patients in touch with other patients with similar symptoms and genetics

Human medical experts will be assisted by AI

- AI-assisted pathology
- AI-assisted surgery
- AI-assisted development of therapies

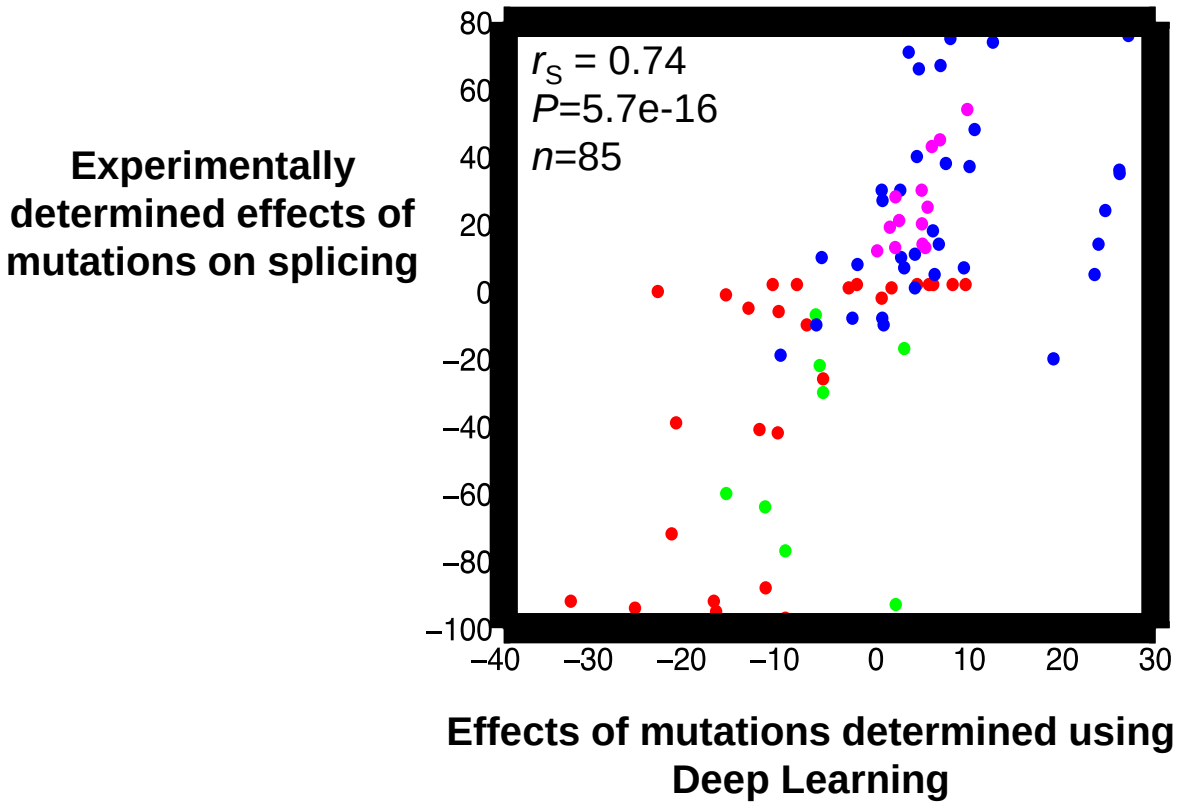
Spinal Muscular Atrophy: First Therapy

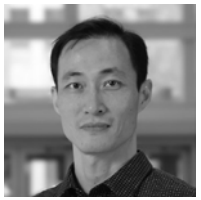
Science, December 6, 2016

- Leading genetic cause of infant mortality: 1/10,000
- Nov 7, 2016: FDA approves therapy
- Time to develop: 13 years
- Cost: $750,000/baby/year
- *Can **Deep Learning** get us there **faster** and at **lower cost?***

Deep Learning accurately predicts spinal muscular atrophy mutations

Xiong et al, Science 2015





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deep genomics

Brendan J Frey, PhD, FRSC

SCIENTIFIC REPORTS

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Genetic algorithm for the optimization of features and neural networks in ECG signals classification

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Hongqiang Li[1], Danyang Yuan[1], Xiangdong Ma[1], Dianyin Cui[1] & Lu Cao[2]