Deep Learning: Bringing Machine Intelligence to the Human World

Vincent Vanhoucke
Principal Scientist - Google Brain Robotics

presenting the work of many of my colleagues at Google.
WHAT ARE MACHINE LEARNING AND AI?

Artificial Intelligence
The science of making things smart

Machine Learning
Making machines that learn to be smart
Deep Learning is causing a machine learning revolution
IS THIS A CAT or DOG?

CAT  DOG

OUTPUT LAYER

ACTIVATED NEURONS

INPUT LAYER

DEEP NEURAL NETWORK
An Old Idea!
Kunihiko Fukushima: the Neocognitron, 1987
2008: U.S. National Academy of Engineering publishes

Grand Engineering Challenges for 21st Century

- Make solar energy affordable
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore & improve urban infrastructure
- Advance health informatics

- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools for scientific discovery

www.engineeringchallenges.org/challenges.aspx
Restore & improve urban infrastructure
Safer, more Efficient Transportation

7 million miles driven!
Enabled by Deep Learning
Live today in Phoenix, AZ
Advance health informatics
Healthy

Diseased

Hemorrhages

No DR  Mild DR  Moderate DR  Severe DR  Proliferative DR
Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

n = 9,963 images
AUC 99.1% [98.8, 99.3]

F-score

0.95
Algorithm

0.91
Ophthalmologist (median)

“The study by Gulshan and colleagues truly represents the brave new world in medicine.”
Dr. Andrew Beam, Dr. Isaac Kohane
Harvard Medical School

“Google just published this paper in JAMA (impact factor 37) [...] It actually lives up to the hype.”
Dr. Luke Oakden-Rayner
University of Adelaide
**Completely new Scientific Discoveries**

Predicting things that doctors can’t predict from imaging

Potential as a new biomarker

Preliminary 5-yr MACE AUC: 0.7

*Can we predict cardiovascular risk? If so, this is a very nice non-invasive way of doing so*

*Can we also predict treatment response?*

Predictive Tasks for Healthcare

Given a large corpus of training data of de-identified medical records, can we predict interesting aspects of the future for a patient not in the training set?

- will patient be readmitted to hospital in next N days?
- what is the likely length of hospital stay for patient checking in?
- what are the most likely diagnoses for the patient right now? and why?
- what medications should a doctor consider prescribing?
- what tests should be considered for this patient?
- which patients are at highest risk for X in next month?

Collaborating with several healthcare organizations, including UCSF, Stanford, and Univ. of Chicago.
Medical Records Prediction Results

Scalable and accurate deep learning for electronic health records

Alvin Rajkomar\textsuperscript{1,2}, Eyal Oren\textsuperscript{1}, Kai Chen\textsuperscript{1}, Andrew M. Dai\textsuperscript{1}, Nissan Hajaj\textsuperscript{1}, Peter J. Liu\textsuperscript{1}, Xiaobing Liu\textsuperscript{1}, Mimi Sun\textsuperscript{1}, Patrik Sundberg\textsuperscript{1}, Hector Yee\textsuperscript{1}, Kun Zhang\textsuperscript{1}, Yi Zhang\textsuperscript{1}, Gavin E. Duggan\textsuperscript{1}, Gerardo Flores\textsuperscript{1}, Michaela Hardt\textsuperscript{1}, Jamie Irvine\textsuperscript{1}, Quoc Le\textsuperscript{1}, Kurt Litsch\textsuperscript{1}, Jake Marcus\textsuperscript{1}, Alexander Mossin\textsuperscript{1}, Justin Tansuwan\textsuperscript{1}, De Wang\textsuperscript{1}, James Wexler\textsuperscript{1}, Jimbo Wilson\textsuperscript{1}, Dana Ludwig\textsuperscript{2}, Samuel L. Volchenboum\textsuperscript{4}, Katherine Chou\textsuperscript{1}, Michael Pearson\textsuperscript{1}, Srinivasan Madabushi\textsuperscript{1}, Nigam H. Shah\textsuperscript{3}, Atul J. Butte\textsuperscript{2}, Michael Howell\textsuperscript{1}, Claire Cui\textsuperscript{1}, Greg Corrado\textsuperscript{1}, and Jeff Dean\textsuperscript{1}

\textsuperscript{1}Google Inc, Mountain View, California
\textsuperscript{2}University of California, San Francisco, San Francisco, California
\textsuperscript{3}Stanford University, Stanford, California
\textsuperscript{4}University of Chicago Medicine, Chicago, Illinois

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https://arxiv.org/abs/1801.07860
Reverse-engineer the brain
Tracing Neurons using Machine Learning

Improving Connectomics by an Order of Magnitude
Engineer better medicines

and maybe...
Make solar energy affordable
Develop carbon sequestration methods
Manage the nitrogen cycle
Predicting Properties of Molecules

- State of the art results predicting output of expensive quantum chemistry calculations, but \(~300,000\) times faster

Engineer the Tools of Scientific Discovery
Open, standard software for general machine learning

Great for Deep Learning in particular

First released Nov 2015

http://tensorflow.org/

and

https://github.com/tensorflow/tensorflow
A vibrant Open-Source Community

Positive Reviews

95,000+
GitHub Stars

30,000+
GitHub repositories with ‘TensorFlow’ in the title

Rapid Development

1,400+
Contributors

30,000+
Commits in <30 months

Direct Engagement

10,000+
Stack Overflow questions answered

100+
Community-submitted GitHub issues responded to weekly
https://www.blog.google/topics/machine-learning/fight-against-illegal-deforestation-tensorflow/
Deep Learning for Image-Based Cassava Disease Detection

Amanda Ramcharan,¹ Kelsee Baranowski,¹ Peter McCloskey,² Babuali Ahmed,³ James Legg,³ and David P. Hughes¹,4,5,*

Penn State and International Institute of Tropical Agriculture

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5663696/
How a Japanese cucumber farmer is using deep learning and TensorFlow
Google Brain Robotics: Making Robots Useful in a Human-centered World
Learning Hand-Eye Coordination for Robotic Grasping with Deep Learning and Large-Scale Data Collection
Sergey Levine, Peter Pastor, Alex Krizhevsky, Deirdre Quillen
Visual Imitation
Deep Reinforcement Learning
Deep Learning Research in Tokyo!

Focus Areas

- Creative Applications of ML
- Generative Design tools using Neuroevolution and ML
- Human–ML interactive interfaces
Conference on Robot Learning

http://www.robot-learning.org

Hosted in 2019 in Japan

Contact:
Prof. Minoru Asada, Osaka University
Deep Learning

Provides novel answers to many Grand Challenges for the Future.

And a new bridge between computing, robots and the human world.