Introduction to Deep Learning

Princeton University COS 495
Instructor: Yingyu Liang
What is deep learning?

• Recent buzz word
Industry

• Google

OUR MISSION: **SOLVE INTELLIGENCE**

We joined forces with Google in order to turbo-charge our mission. The algorithms we build are capable of learning for themselves directly from raw experience or data, and are general in that they can perform well across a wide variety of tasks straight out of the box. Our world-class team consists of many renowned experts in their respective fields, including but not limited to deep neural networks, reinforcement learning and systems neuroscience-inspired models.

Founded by Demis Hassabis, Shane Legg and Mustafa Suleyman in London, 2010. DeepMind was supported by some of the most iconic tech entrepreneurs and investors of the past decade, prior to being acquired by Google in early 2014 in their largest European acquisition to date.
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Industry

- Facebook
Industry

• Microsoft

Microsoft Researchers’ Algorithm Sets ImageNet Challenge Milestone
Industry

- Elon Musk

Elon Musk and Peter Thiel launch OpenAI, a non-profit artificial intelligence research company.
Toyota Invests $1 Billion in Artificial Intelligence

By JOHN MARKOFF  NOV. 6, 2015

Gill Pratt, a roboticist who will oversee Toyota’s new research laboratory in the United States, at a news conference Friday in Tokyo. Yuya Shino/Reuters
Academy

• NIPS 2015: ~4000 attendees, double the number of NIPS 2014
Academy

- Science special issue
- Nature invited review

REVIEW

Deep learning

Yann LeCun\textsuperscript{1,2}, Yoshua Bengio\textsuperscript{3} & Geoffrey Hinton\textsuperscript{4,5}
What is deep learning?

• A machine learning framework that shows impressive performance on many Artificial Intelligence tasks
Image

- Image classification
  - 1000 classes

ImageNet experiments

Human performance: ~5%

Slides from Kaimin He, MSRA
Image

- Object location

Our results on COCO – too many objects, let’s check carefully!

Slides from Kaimin He, MSRA
Image captioning

Figure from the paper “DenseCap: Fully Convolutional Localization Networks for Dense Captioning”, by Justin Johnson, Andrej Karpathy, Li Fei-Fei
• Question & Answer

I: Jane went to the hallway.
I: Mary walked to the bathroom.
I: Sandra went to the garden.
I: Daniel went back to the garden.
I: Sandra took the milk there.
Q: Where is the milk?
A: garden

I: The answer is far from obvious.
Q: In French?
A: La réponse est loin d’être évidente.

Figures from the paper “Ask Me Anything: Dynamic Memory Networks for Natural Language Processing”, by Ankit Kumar, Ozan Irsoy, Peter Ondruska, Mohit Iyyer, James Bradbury, Ishaan Gulrajani, Richard Socher
Game

Google DeepMind's Deep Q-learning playing Atari Breakout
From the paper “Playing Atari with Deep Reinforcement Learning”,
by Volodymyr Mnih, Koray Kavukcuoglu, David Silver, Alex Graves, Ioannis Antonoglou, Daan Wierstra, Martin Riedmiller
At last — a computer program that can beat a champion Go player  PAGE 404

ALL SYSTEMS GO
The impact

• Revival of Artificial Intelligence
• Next technology revolution?

• A big thing ongoing, should-not-miss
Questions behind the scene

• Return of artificial neural network
  • What’s different
  • Why get great performance

• Future development
  • The road to general-purpose AI?
Goal of the course

• Introduction
• Key concepts
• Ticket to the party
Syllabus

• Part I: machine learning basics
  • Linear model, Perceptron, SVM
  • Multi-class
  • Training by gradient descent
  • overfitting

• Part II: supervised deep learning (feedforward network)

• Part III: unsupervised learning

• Part IV: deep learning in the wild
Syllabus

• Part I: machine learning basics
• Part II: supervised deep learning (feedforward network)
  • Multiple-layer and Backpropogation
  • Regularization
  • Convolution
• Part III: unsupervised deep learning
• Part IV: deep learning in the wild
Syllabus

• Part I: machine learning basics
• Part II: supervised deep learning (feedforward network)
• Part III: unsupervised deep learning
  • PCA
  • Boltzmann machine, Deep Boltzmann machine
  • autoencoder
• Part IV: deep learning in the wild
Syllabus

• Part I: machine learning basics
• Part II: supervised deep learning (feedforward network)
• Part III: unsupervised deep learning
• Part IV: deep learning in the wild
  • Read papers on advanced topics
  • Play with the code
  • Presentation
Textbook and materials

• Deep Learning:
  http://www.deeplearningbook.org/

• Software framework: Tensorflow
  • in Python
  • Easy to install/use
  • Can try it on your laptop
Grading

• Problem Sets (5 sets): 70%
• Design Projects: 25%
• Oral Presentation: 5%