Artificial Intelligence (AI) and Deep Learning (DL) Overview

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Outline

▪ Definition of AI and DL
▪ History/ Milestones
▪ Academia
  ◦ Course Enrollment
  ◦ Conferences
  ◦ Academic Production
▪ Open Source Tools
▪ Technical Performance
  ◦ Vision
  ◦ Natural Language Processing
  ◦ Theorem Proving
▪ Challenges and opportunities
AI and DL
Definition
AI and DL

- What’s AI?
  - Activity devoted to making machines intelligent

**Intelligence**
Quality that enables an entity to function appropriately and with foresight in its environment
What’s AI?

- Activity devoted to making machines intelligent

Including:
- Logistic regression
- Knowledge databases
- Naive Bayes
- Classification trees
- Random forest
- K-means
- ...
AI and DL - What’s DL?

Learning Algorithm

Input Space

Segway
Non-Segway

pixel 1

pixel 2

[Ref1]
AI and DL - Representation Learning - Deep Learning Model

[Diagram showing a deep learning model with layers for object recognition: visible layer (input pixels), 1st hidden layer (edges), 2nd hidden layer (corners and contours), 3rd hidden layer (object parts), and output (object identity).]

[Ref2]
AI and DL

- **What’s AI?**
  - Activity devoted to making machines intelligent

- **How does it relate to DL?**

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*Intelligence*
Quality that enables an entity to function appropriately and with foresight in its environment
AI Milestones
AI Milestones

- Othello: 1980
- Checkers: 1995
- Chess: 1997
- Jeopardy!: 2011
- Atari: 2015
- Imagenet: 2016
- Go: 2017
- Skin Cancer: 2017
- Switchboard: 2017
- Poker: 2017
- Pac-Man: 2017

[Ref3]
AI Milestones

- **Othello**: 1980
- **Checkers**: 1995
- **Chess**: 1997
- **Jeopardy!**: 2011
- **Atari**: 2015
- **Imagenet**: 2016
- **Go**: 2016
- **Poker**: 2017
- **Skin Cancer Switchboard**: 2017

**Poker: Libratus**
- CMU
- Powered by Bridges
- NIPS2017 Best paper award
- Science paper
AI in Academia
AI in Academia - Course Enrollment

ML Course Enrollment

[Ref3]
AI in Academia - Course Enrollment

- Bridges support of large ML courses
  - Spring 2017 - Deep Reinforcement Learning and Control: ~200 students
  - Spring 2018 - Deep Reinforcement Learning and Control: ~500 students

**Homework 1:** Implement Q-learning using deep learning function approximators in OpenAI Gym.

**Homework 2:** Implement Linear Quadratic Regulation (LQR) and Iterative Linear Quadratic Regulator (iLQR)

[Ref4] GPU Utilization for CMU 10-703, Deep Reinforcement Learning and Control, Spring 2017
AI in Academia - Main Conferences

Main conferences

- NIPS - Neural Information Processing Systems
  - NIPS2018 - Dec 2018, Montreal, Canada

- CVPR - Conference on Computer Vision and Pattern Recognition
  - CVPR2018 - Jun 2018, Salt Lake City, USA

- ICML - International Conference on Machine Learning
  - ICML2018 - Jul 2018, Stockholm, Sweden

- ICRA - International Conference on Robotics and Automation
  - ICRA2018 - May 2018, Brisbane, Australia

- IJCAI - International Joint Conference on Artificial Intelligence
  - IJCAI2018 - Jul 2018, Stockholm, Sweden

- ACL - Association for Computational Linguistics
  - ACL2018 - Jul 2018, Melbourne, Australia

- AAAI - Association for the Advancement of Artificial Intelligence (conference)
  - AAAI2018 - Feb 2018, New Orleans, USA
AI in Academia - Conference Attendance

Large Conference Attendance

- AAAI
- IJCAI
- NIPS
- CVPR
- ICML
- ICRA
- ACL

Attendees vs Year

[Ref3]
AI in Academia - AI Published Papers

![Graph showing the annual number of AI papers published from 2000 to 2015. The number of papers increases significantly over time.]

[Ref3]
AI in Academia - AI Published Papers

Growth of Annually Published Papers

Papers

Year

AI papers within CS
Papers in field of CS
Papers from all fields

(1996 Value) 1x
2x
4x
6x
8x
10x

2000
2005
2010
2015

[Ref3]
AI in Academia - AI/ML Published Papers - 2012 to 2017 by Organization

[Ref4]
AI Frameworks
AI Platforms - Open Source Software

[Ref3]
AI Platforms - Open Source Software

GitHub Stars of AI Software Libraries

[Ref3]
AI Technical Performance
AI Technical Performance - Vision

Object Detection

Large Scale Visual Recognition Challenge

Image Classification Task

Steel drum

Output: Scale T-shirt Steel drum Drumstick Mud turtle

Output: Scale T-shirt Giant panda Drumstick Mud turtle

1000 object classes 1’431,167 images

\[
\text{Error} = \frac{1}{100,000} \sum_{100,000 \text{ images}} 1 \quad [\text{incorrect on image } i]\]
AI Technical Performance - Vision

Object Detection

Large Scale Visual Recognition Challenge

Classification Results (CLS)

<table>
<thead>
<tr>
<th>Year</th>
<th>Classification Error</th>
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<tbody>
<tr>
<td>2010</td>
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<tr>
<td>2017</td>
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</tr>
</tbody>
</table>

16.7% ↓ 23.3% ↓

[Ref1]
AI Technical Performance - Vision

Object Detection

![Object Detection, LSVRC Competition](Ref3)
AI Technical Performance - Vision

Visual Question Answering

![Visual Question Answering, VQA 1.0](chart)

- Human Performance
- Best AI System

[Ref3]
AI Technical Performance - Natural Language Processing

Machine Translation

News Translation, WMT Competition

BLEU Score

[Ref3]
AI Technical Performance - Natural Language Processing

Question Answering

![Question Answering, SQuAD v1.1 graph](Ref3)

[Ref3]
Speech Recognition

Graph showing the progress of Speech Recognition, Switchboard HUB5'00 from 2010 to 2016. The graph compares human performance and the best AI system accuracy over time.

[Ref3]
Summary
Summary - AI Challenges and Opportunities

- **Computational complexity**
  - Larger and larger data. Big Data challenges.
  - Cycles to train:

- **Architectural decisions**
  - HW/SW
  - AI model
  - Data architecture

- **Adoption**
  - Bring new fields to explore AI techniques

- **Diversity**
  - Include everyone’s voice
Q&A
References

Some of the material and slides for this lecture were borrowed from:

[Ref1] - Ruslan Salakhutdinov class on Deep Learning at CMU (Fall 2017).

Ian Goodfellow and Yoshua Bengio and Aaron Courville

[Ref 3] - Artificial Intelligence Index Organization.
Material available at https://aiindex.org/

[Ref 4] - *ML and NL publications* by Marek Rei.
Recommended Resources

- Ian Goodfellow and Yoshua Bengio and Aaron Courville (2016) *Deep Learning Book*
- Trevor Hastie, Robert Tibshirani, Jerome Friedman (2009) *The Elements of Statistical Learning*