

Artificial Intelligence II (CS4442 & CS9542)

2024 Winter

Department of Computer Science
University of Western Ontario

Outline

- ▶ Administrative Issues
- ▶ Artificial Intelligence
- ▶ Machine Learning
- ▶ Deep Learning

Administrative Issues

Administrative Issues

- ▶ Lectures: Mondays (9:30-11:30am) and Wednesdays (9:30-10:30am).
- ▶ Instructors: Yalda Mohsenzadeh & Boyu Wang
 - Emails: ymohsenz@uwo.ca & bwang@csd.uwo.ca
 - Boyu Wang Office Hours: 10:30am-11:30am on Wednesdays @ MC-366 or by appointment
 - Yalda Mohsenzadeh Office Hours: 10:30pm-11:30pm on Wednesdays at MC-385 or by appointment
- ▶ Teaching Assistant: Gezheng Xu, Ruizhi Pu, Ruiyi Fang
 - Email: gxu86@uwo.ca, rpu2@uwo.ca, rfang32@uwo.ca
 - Office Hours: 10am-11am, Tuesday (Gezheng Xu); 2pm-3pm, Wednesday (Ruizhi Pu); 10am-11am, Thursday (Ruiyi Fang)
 - Zoom link: <https://westernuniversity.zoom.us/j/99212891950> (no passcode)

Course Website: OWL

- ▶ Most announcements about the course, lecture materials, or the assignments should be addressed via OWL.
- ▶ Long, detailed questions are probably best answered during office hours.
- ▶ Use your judgement.

Class Materials

- ▶ No required textbook, but several textbooks available describing parts of the material that we will cover.
 - Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
 - Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
 - Goodfellow, Bengio, Courville, *Deep Learning*, MIT Press, 2016.
 - Forsyth and Ponce, *Computer Vision: A Modern Approach*, Prentice Hall, 2002.
 - Individual papers or web resources may be assigned to supplement lecture material.
- ▶ Class slides: posted on OWL.

Prerequisites

- ▶ Knowledge of a programming language (e.g., Python, Matlab)
- ▶ Solid knowledge of probability/statistics, calculus and linear algebra; basic knowledge of optimization; general facility with math
- ▶ Some AI background is recommended *but not required*

Evaluation – Undergraduate Students

- ▶ Four homework assignments (60%)
 - Each assignment will involve components that are conceptual or algorithmic, as well as some practical implementation.
 - Each assignment must be submitted in PDF format. It is recommended that assignments be completed in \LaTeX compiled to PDF.
 - You should also submit your code (e.g., .py, .ipynb, .m files)
 - Homework assignments should be done **individually**.
 - 10% of each assignment will be taken off each day for late submissions; after 5 days being late, no points are given anymore.
 - You should **must obtain at least 50% score of the assignments** to pass the course.
- ▶ Group project (40%)

Evaluation – Graduate Students

- ▶ Four homework assignments (40%)
 - Each assignment will involve components that are conceptual or algorithmic, as well as some practical implementation.
 - Each assignment must be submitted in PDF format. It is recommended that assignments be completed in \LaTeX compiled to PDF.
 - You should also submit your code (e.g., .py, .ipynb, .m files)
 - Homework assignments should be done **individually**.
 - 10% of each assignment will be taken off each day for late submissions; after 5 days being late, no points are given anymore.
 - You should **must obtain at least 50% score of the assignments** to pass the course.
- ▶ Group project (60%) – project presentation (10%) + project report (50%)

Final Project

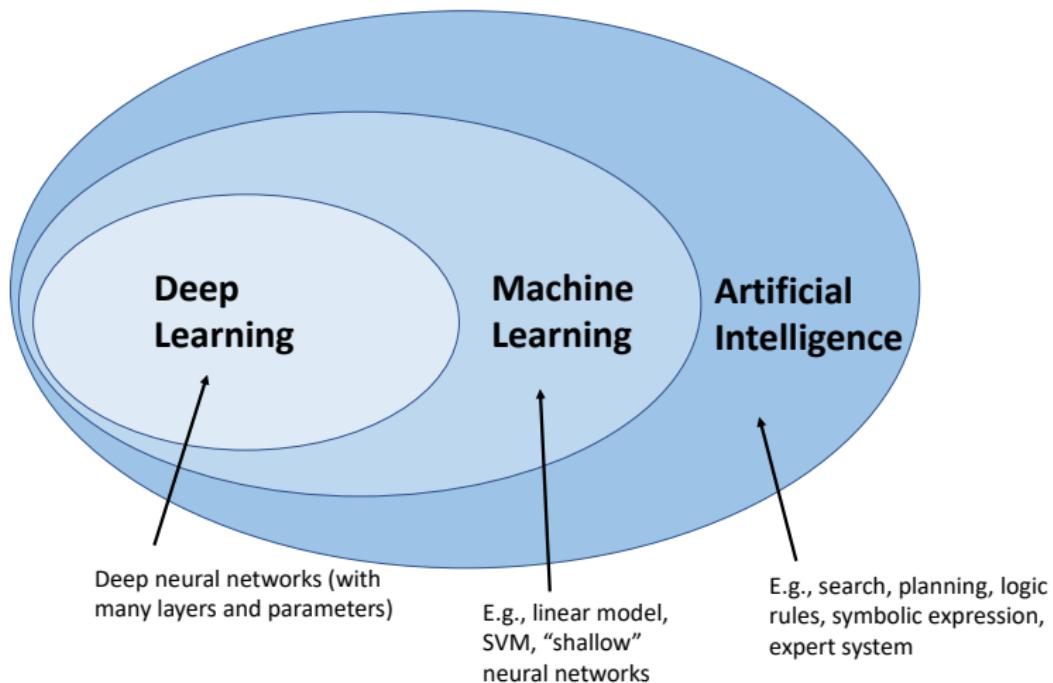
- ▶ Students are encouraged to formulate a project related to their own interest or research
- ▶ Students who do not have such problems should contact Yalda and/or Boyu to discuss possible projects
- ▶ Completed in groups of 2-4 members (undergraduate students) or 2-3 members (graduate students)
- ▶ Both undergraduate and graduate students are required to write a project report
- ▶ Graduate students are also required to do a final project presentation (10 minutes per team). The presentations will be scheduled in the last week of class, during of the class time.

Artificial Intelligence

What is Artificial Intelligence (AI)?

- ▶ Originally, AI is a subfield of computer science, aiming to build a machine solving tasks that humans are good at (e.g., natural language, speech, image recognition, ...)
- ▶ Interdisciplinary science with multiple approaches (computer science, philosophy, psychology, neuroscience...)
- ▶ Most recent achievements are in *machine learning*, especially *deep learning*.

AI & Machine Learning & Deep Learning



- ▶ This course: introduction to artificial intelligence

- ▶ This course: introduction to artificial intelligence

- ▶ This course: introduction to machine learning

- ▶ This course: introduction to
 - Cover (some of) the most commonly used machine learning concepts and algorithms.
 - Focus on the mechanisms of the algorithms: explain the problem settings, the mathematical formulations, why they work; but **NOT** how to implement them.
 - Deep learning and its applications on computer vision
(Yalda Mohsenzadeh)

Machine Learning

What is Machine Learning?

- ▶ *Machine learning is the field of study that gives computers the ability to learn without being explicitly programmed*
– Arthur Samuel
- ▶ *Learning is any process by which a system improves performance from experience*
– Herbert Simon

Machine learning aims to construct a computer system that acts like humans do by **learning from data**.

Machine Learning is Changing the World

- ▶ *A breakthrough in machine learning would be worth ten Microsofts*
 - Bill Gates, Microsoft
- ▶ *Web rankings today are mostly a matter of machine learning*
 - Prabhakar Raghavan, Google
- ▶ *Machine learning is the hot new thing*
 - John Hennessy, Stanford

Why (Study) Machine Learning?

- ▶ Easier to build a learning system than to hand-code a working program (play games)
- ▶ Human expertise does not exist (navigating on Mars)
- ▶ Humans can't explain their expertise (speech recognition)
- ▶ Models are based on huge amounts of data (DNA analysis)
- ▶ Models must be customized (news filtering)
- ▶ Discover knowledge and patterns in highly dimensional, complex data (social network analysis)
- ▶ Understanding animal and human learning (language, recognition)
- ▶ Create real AI!

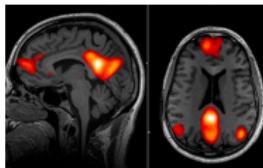
Sample Applications



Natural language processing



Computer vision



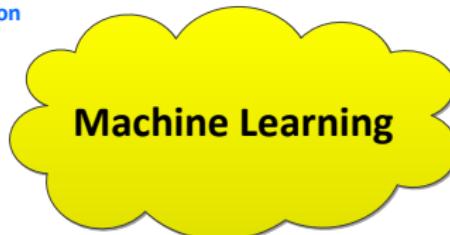
Medicine



Finance and economics



Software engineering



Smart grids and smart cities

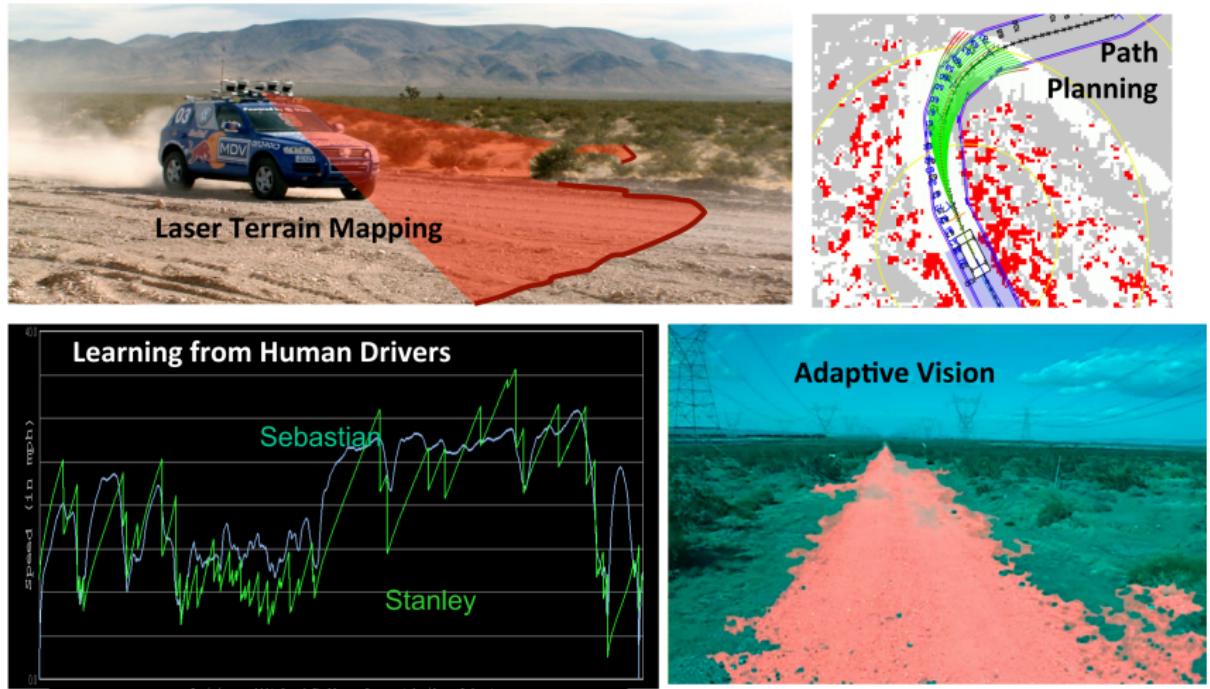


Web applications



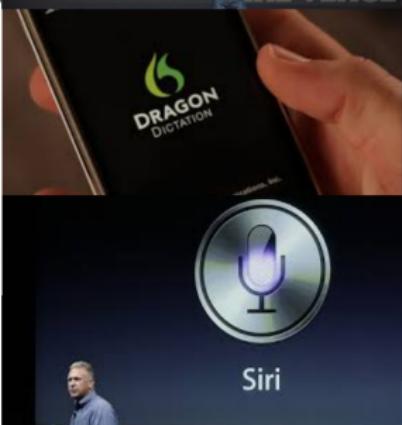
Neuroscience and neural engineering

Autonomous Car Technology



Images taken from Sebastian Thrun's multimedia website.

Speech Technology



Slide credit: Li Deng, MS Research

Deep Learning in the Headlines

BUSINESS NEWS

MIT
Technology
Review

Is Google Cornering the Market on Deep Learning?

A cutting-edge corner of science is being wooed by Silicon Valley, to the dismay of some academics.

By Antonio Regalado on January 20, 2014



How much are a dozen deep-learning researchers worth? Apparently, more than \$400 million.



This week, Google reportedly paid that much to acquire DeepMind Technologies, a startup based in

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Deep Learning's Role in the Age of Robots

BY JULIAN GREEN, JETPAC 05.02.14 2:56 PM



Slide credit: Eric Eaton, UPenn

Bloomberg Businessweek Technology

Acquisitions

The Race to Buy the Human Brains Behind Deep Learning Machines

By Ashlee Vance [▼](#) | January 27, 2014

intelligence projects. "DeepMind is bona fide in terms of its research capabilities and depth," says Peter Lee, who heads Microsoft Research.

According to Lee, Microsoft, Facebook ([FB](#)), and Google find themselves in a battle for deep learning talent. Microsoft has gone from four full-time deep learning experts to 70 in the past three years. "We would have more if the talent was there to

DEEP LEARNING

- » Computers learning and growing on their own
- » Able to understand complex, massive amounts of data

DATA ECONOMY
DEEP LEARNING

BROUGHT TO YOU BY:

Other Success Stories



[Silver et al. Nature, 2016, 2017]



[Krizhevsky et al. NIPS, 2012]



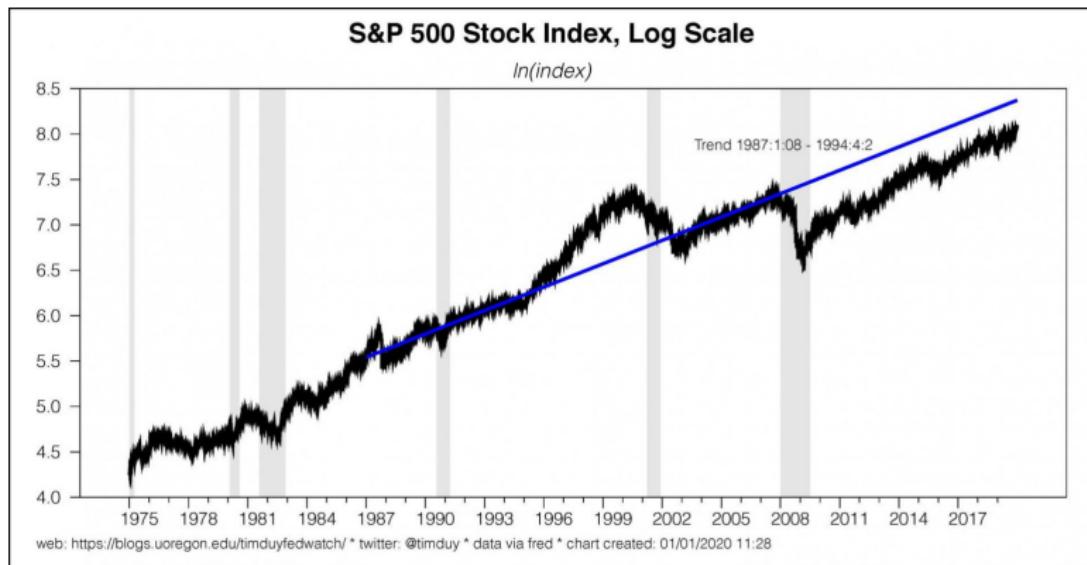
<https://openai.com/blog/openai-five/>

Types of Learning

- ▶ Supervised learning
 - Given: data + desired outputs (labels)
- ▶ Unsupervised learning
 - Given: data (without desired outputs)
- ▶ Semi-supervised learning
 - Given: data + a few desired outputs
- ▶ Reinforcement learning
 - Given: Rewards from sequence of actions (an interactive process)

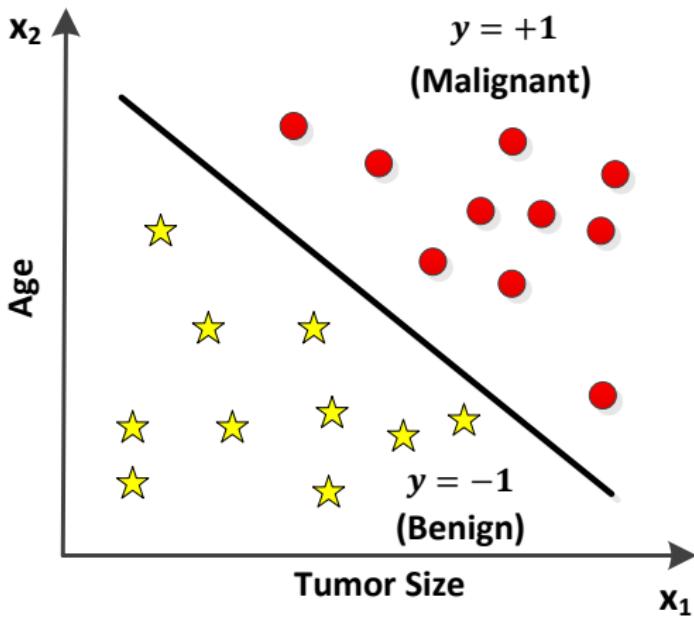
Supervised Learning: Regression

Given $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$, learn a function $f(x)$ to predict y given x . If y is real-valued \Rightarrow regression.



Supervised Learning: Classification

Given $(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$, learn a function $f(x)$ to predict y given x . If y is categorical \Rightarrow classification.



Unsupervised Learning

Given x_1, x_2, \dots, x_n (without labels), Output hidden structure behind the x 's (e.g., clustering)

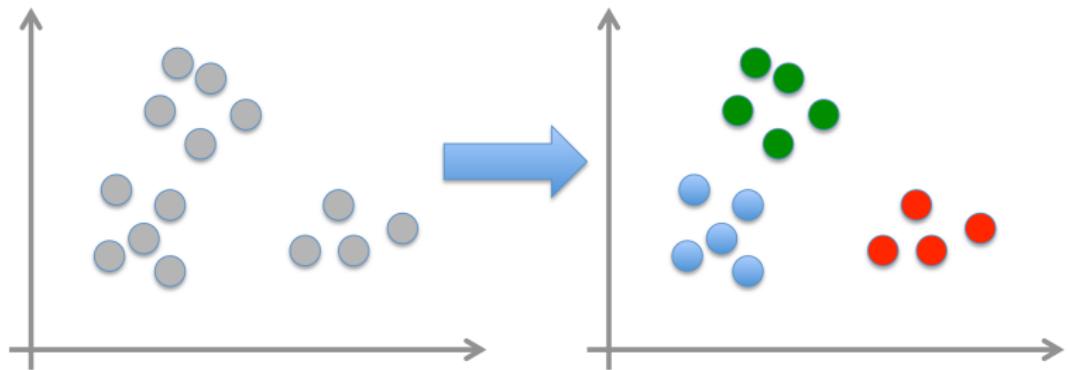


Image credit: Eric Eaton, UPenn

Anticipated Lecture Topics

- ▶ Supervised learning
 - A brief review of mathematical tools
 - Linear regression
 - Logistic regression
 - Regularization
 - Support vector machines
 - Kernel methods
 - Ensemble methods
 - Bayesian learning
- ▶ Unsupervised learning
 - Clustering
 - Dimensionality reduction
- ▶ Deep learning and computer vision (Yalda Mohsenzadeh)