Week 1

11.02.2019

Monday 09:00 – 11:00, BM A2
Tuesday 09:00 – 10:00, BM A2

Emre Ugur, BM 33
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http://www.cmpe.boun.edu.tr/~emre/courses/cmpe462
cmpe462@listeci.cmpe.boun.edu.tr

Quotes

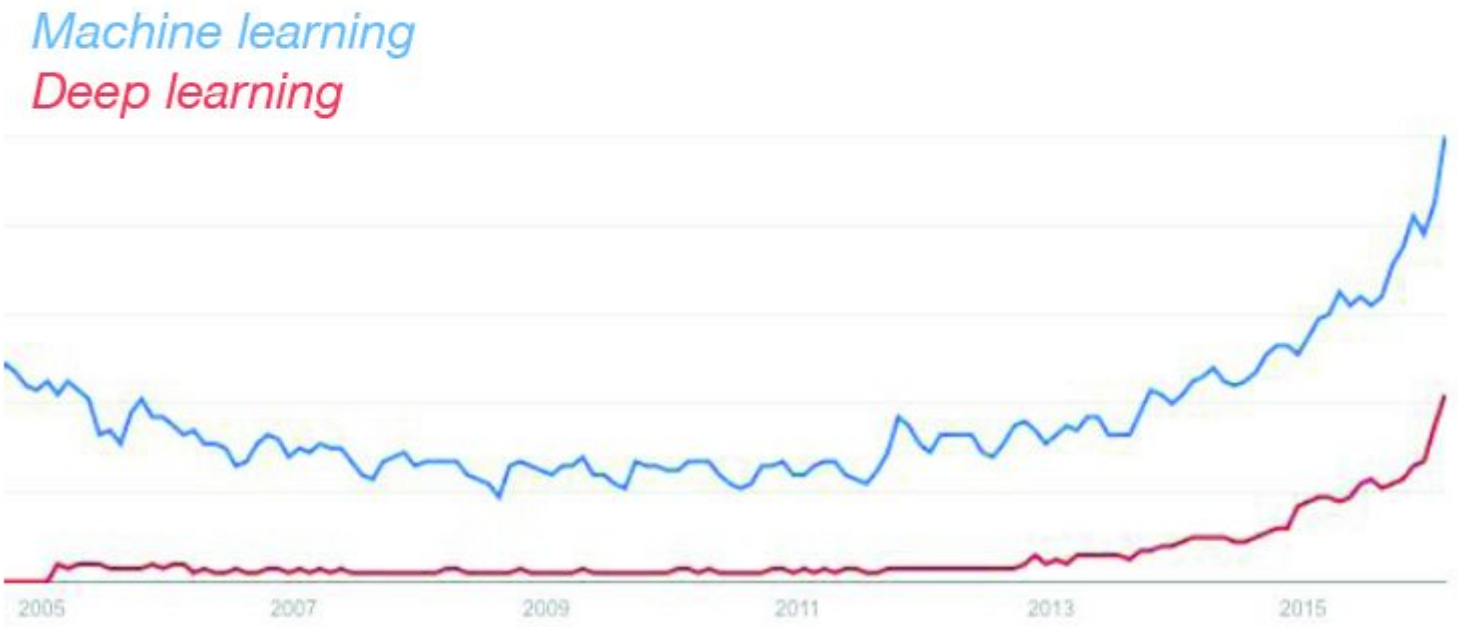
- "If you were a current computer science student what area would you start studying heavily?"
  - Answer: Machine Learning.
  - "The ultimate is computers that learn"
  - Bill Gates, Reddit AMA

- "Machine learning is the next Internet"
  - Tony Tether, Director, DARPA

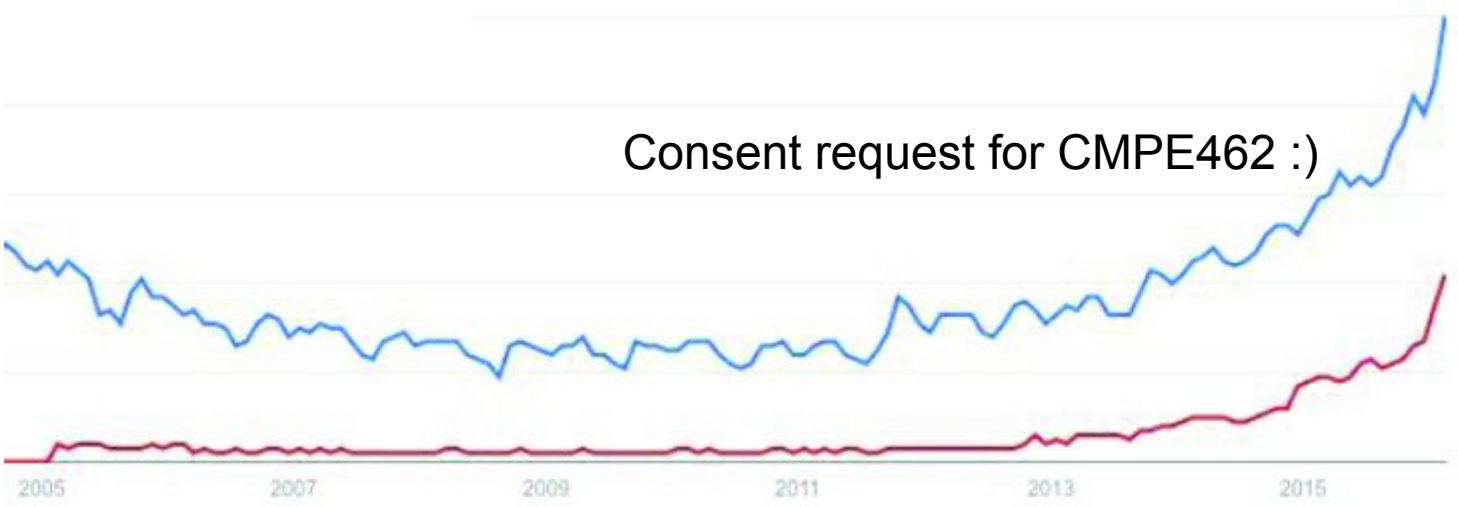
- "Machine learning is today's discontinuity"
  - Jerry Yang, CEO, Yahoo

slide by David Sontag

Google Trends



Student Trends



MACHINE INTELLIGENCE 3.0

ENTERPRISE INTELLIGENCE

VISUAL
Orbital Insight, planet, clarifai, DEEPVISION, cortica, gamaya, SPACE_KNOW, Descrity, netra, deepomatic

AUDIO
Gridspace, TalkIQ, nexidia, twilio, CARIO, Expect Labs, Clover, Mobvoi, Qurious.AI, sayso active

SENSOR
PREDIX, GE IoT, MAANA, Sentenai, PLANET OS, UPTAKE, MUBIT, Preferred Networks, thingworx, KONUX, Alluvium

INTERNAL DATA
PRIMER, IBM WATSON, Cycorp, Palantir, ARIMO, Alation, sapho, Outlier, Digital Reasoning

MARKET
mattermark, Quid, DataFox, PREMISE, Bottlenose, MOTIVA, enigma, CBINSIGHTS, Tracxn, predata

ENTERPRISE FUNCTIONS

CUSTOMER SUPPORT
DigitalGenius, Kasisto, ELOQUENT, Wise.io, ACTIONIQ, zendesk, Preact, CLARABRIDGE

SALES
collective[i], 6sense, fusemachines, AVIDO, salesforce, INSIDE SALES.COM, clari, Zensight

MARKETING
MINTIGO, Lattice, RADIUS, LiftIgniter, PERSADO, brightfunnel, retention science, COGNICOR, AirPR, mogul

SECURITY
CYLANCE, DARKTRACE, ZIMPERIUM, deepinstinct, Sentinel, DEMISTO, graphistry, drawbridge, SignalSense, AppZen

RECRUITING
textio, entelo, Wade & Wendy, hi, unitive, SpringRole, GIGSTER, HireVue

AUTONOMOUS SYSTEMS

GROUND NAVIGATION
drive.ai, AdasWorks, ZOOX, Mobileye, UBER, Google, TESLA, nuTonomy, Auro Robotics

AERIAL
SKYDIO, SHIELD AI, Airware, dji, LILY, DroneDeploy, pilot.ai, SKYCATCH

INDUSTRIAL
JAYBRIDGE, OSARO, CLEARPATH, fetch, KINDRED, HARVEST AUTOMATION, rethink robotics

AGENTS

PERSONAL
amazon alexa, Cortana, Allo, facebook, Siri, Replika

PROFESSIONAL
butter.ai, pogo, SKIPFLAG, clara, x.ai, slack, talla, Zoom, sudo

INDUSTRIES

AGRICULTURE
BLUE RIVER, mavrx, tule, TRACE, Pivot Bio, Descartes Labs, udi

EDUCATION
KNEWTON, volley, gradescope, CTI, coursera, UDACITY, altschool

INVESTMENT
Bloomberg, sentient, SENTIUM, KENSHO, alphasense, Dataminr, CEREBELLUM CAPITAL, Quandl

LEGAL
blue J, BEAGLE, Everlaw, RAVEL, Seal, ROSS, LEGAL ROBOT

LOGISTICS
NAUTO, Acerta, PRETECKT, clearmetal, Routific, MARBLE, PITSTOP

INDUSTRIES CONT'D

MATERIALS
zymergen, Citrine, Eigen Innovations, SIGHT MACHINE, GINKGO BIOWORKS, nanotronics, CALCULARIO

RETAIL FINANCE
TALA, zestfinance, Lendo, earnest, Affirm, MIRADOR, wealthfront, Betterment

HEALTHCARE

PATIENT
PULSE, CareSkore, ZEPHYR HEALTH, IBM Watson Health, OncoraMD, SENTRIAN, Atomwise, Numerate

IMAGE
BUTTERFLY, 3SCAN, ARTERYS, enlitic, BAYLABS, imagia, Google DeepMind

BIOLOGICAL
iCarbonX, color, GRAIL, deep genomics, RECURSION, LUMINEX, Numerate, Atomwise, verily, WHOLE BIOME

TECHNOLOGY STACK

AGENT ENABLERS
OCTANE.AI, howdy, Maluuba, KITT AI, OpenAI Gym, Kasisto, AUTOMAT, semanticmachines

DATA SCIENCE
DOMINO, SPARKBEYOND, rapidminer, kaggle, DataRobot, yhat, AYASDI, dataiku, seldon, yseop, bigml

MACHINE LEARNING
CognitiveScale, GoogleML, context relevant, Cycorp, HyperScience, narrative logics, minds.ai, H2O.ai, SCALED INFERENCE, sparkcognition, Loop, GEOMETRIC INTELLIGENCE, deepsense.io, reactive, skymind, bonsai

NATURAL LANGUAGE
agolo, AYLIEN, LEXALYTICS, Narrative Science, spaCy, LUMINOSO, cortical.io, MonkeyLearn

DEVELOPMENT
SIGOPT, HyperOpt, fuzzyio, pkite, rainforest, lobe, Anodot, Signifai, LAYER 6, bonsai

DATA CAPTURE
CrowdFlower, diffbot, CrowdAI, import.io, Paxata, DATASIFT, amazon mechanical turk, enigma, WorkFusion, DATALOGUE, TRIFACTA, parsehub

OPEN SOURCE LIBRARIES
Keras, Chainer, CNTK, TensorFlow, Caffe, H2O, DEEPLEARNING4J, theano, torch, DSSTNE, Scikit-learn, AzureML, neon, MXNet, DMTK, Spark, PaddlePaddle, WEKA

HARDWARE
KNUPATH, TENSTORRENT, Cirrascale, NVIDIA, nervana, Movidius, tensilica, GoogleTPU, 10^28 Labs, Qualcomm, Cerebras, Isosemi

RESEARCH
OpenAI, maluuba, ELEMENT AI, vicarious, KNOGGIN, Numenta, Kimera Systems, Cogitai

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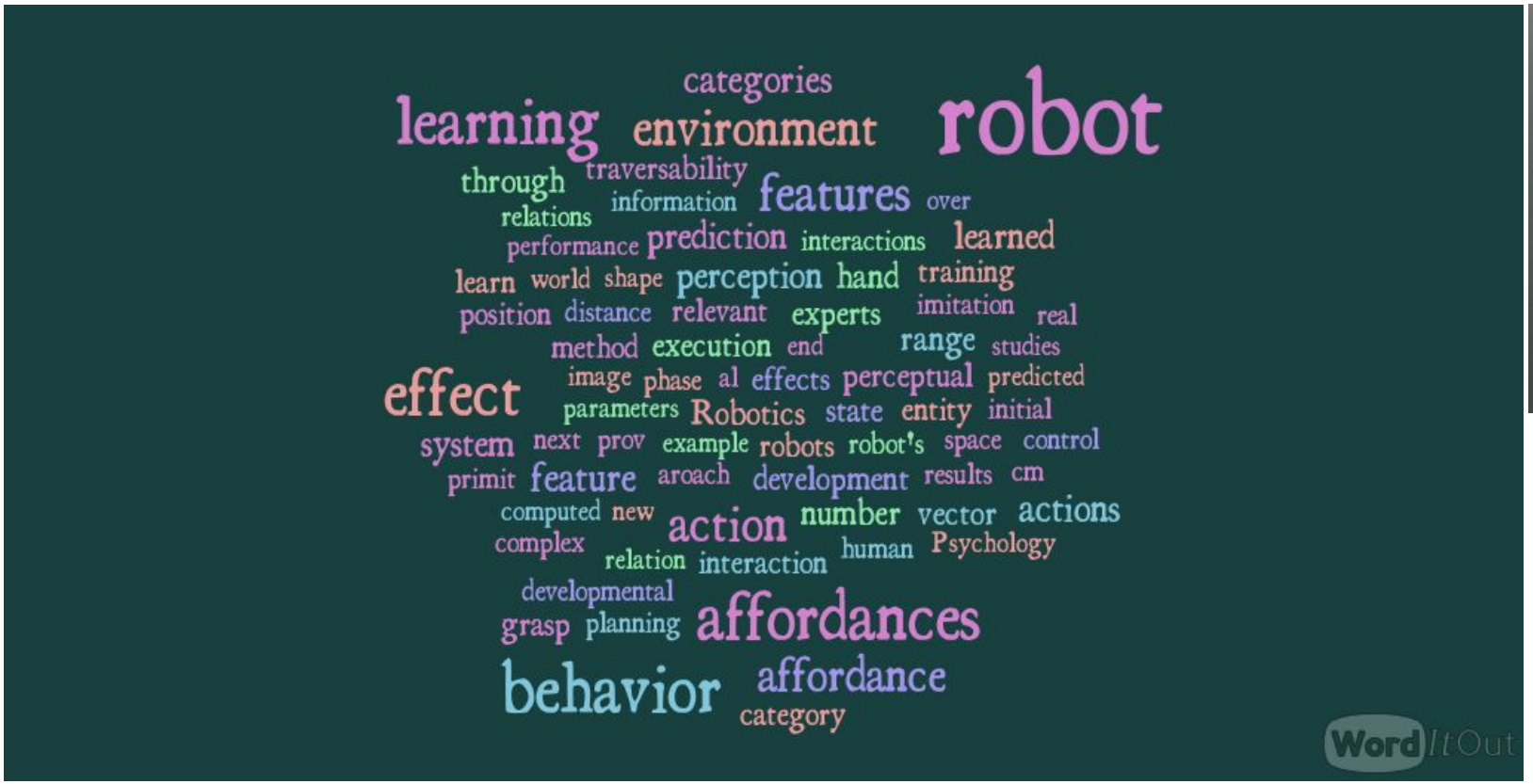
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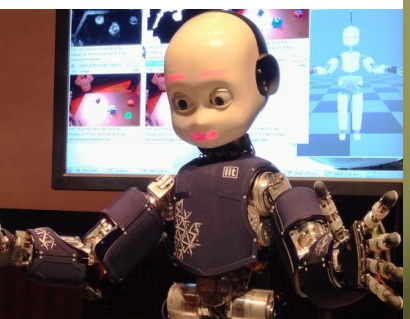
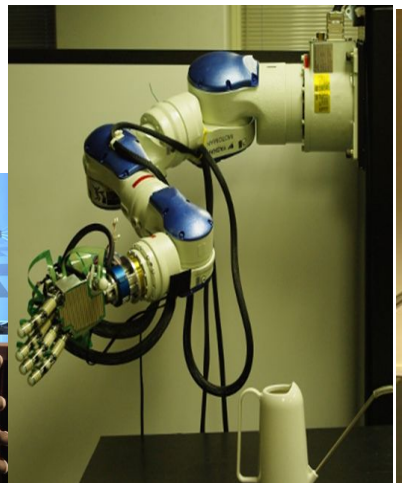
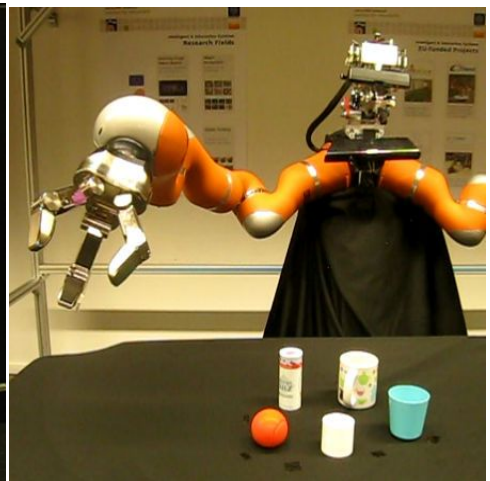
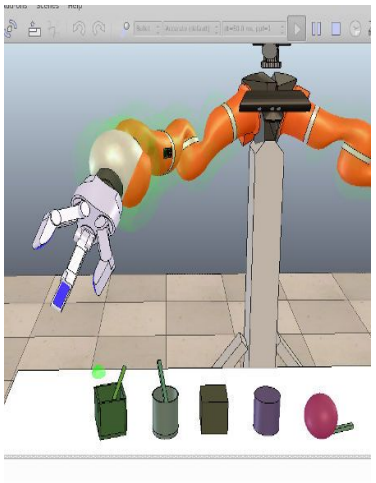
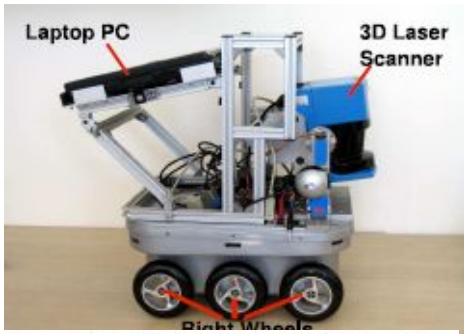
WordItOut










Laptop PC
3D Laser Scanner

Course in general

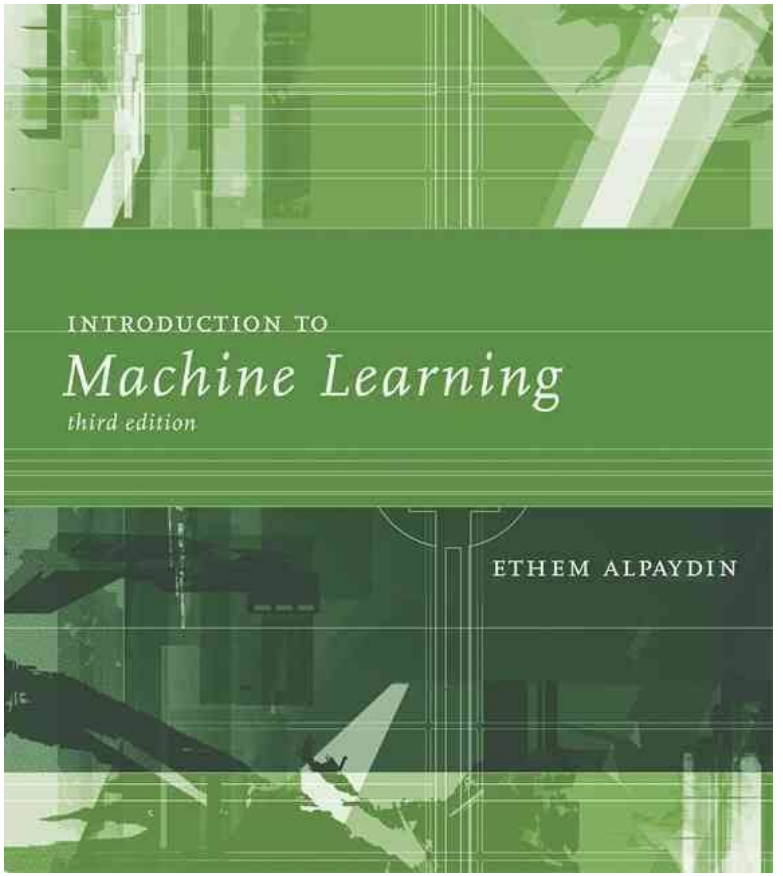
- Available to only senior undergrads and a couple of grads
- Will follow the structure of the previous CMPE462

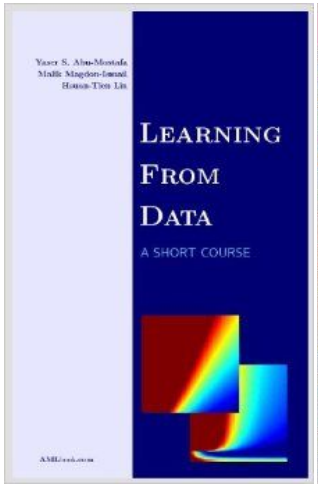
About this course

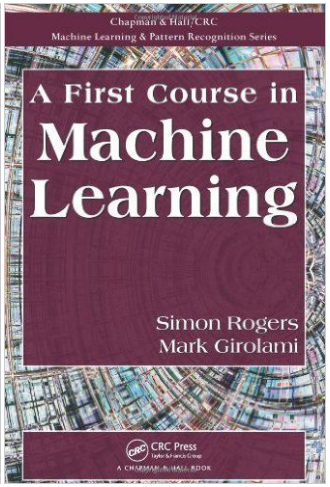
- Undergraduate-level introductory course
- A broad overview of many concepts and algorithms in ML
- Equipped with broad set of tools

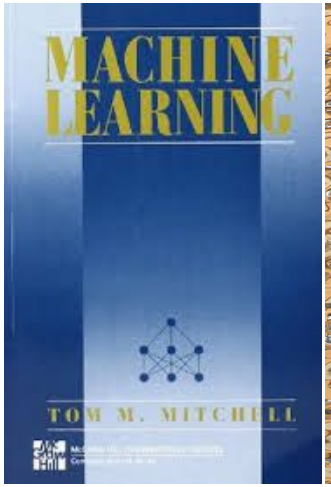
- Requirements
  - Algorithms, data structures.
  - Probability and statistics.
  - Linear algebra and calculus

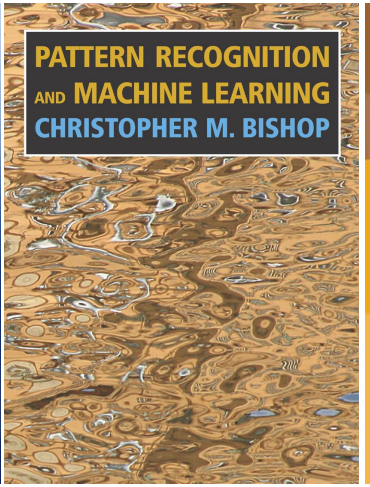
Textbook and resources

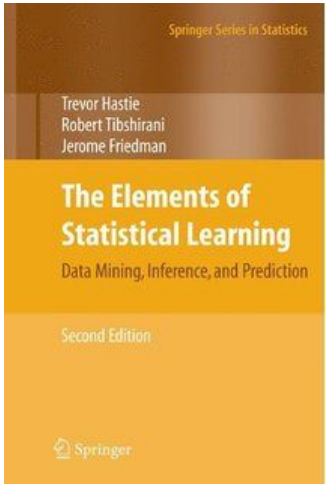


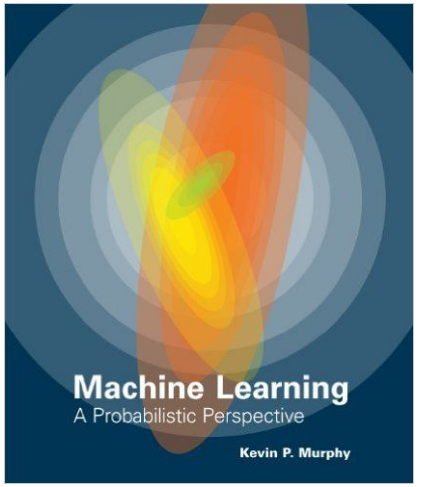












Responsibilities - grades

- Midterm: 20%
- Project: 30%
- Final: 30%
- **Homeworks: 20%**

- Implementation of the learning algorithms
- Matlab/Octave/R/Python
- 3 or 4 homeworks
- Announced at least 1 week before due date
- Late submission policy:
  - Maximum a total of 4 days
  - Very strict
-
- Discussion is welcome, but implementation should be independent.
- Please do not cheat, otherwise fail in the course.

Responsibilities - grades

- Midterm: 20%
- **Project: 30%**
- Final: 30%
- Homeworks: 20%

- 2-3 people groups
- Machine Learning algorithm in an application
- At the end, a presentation

Responsibilities - grades

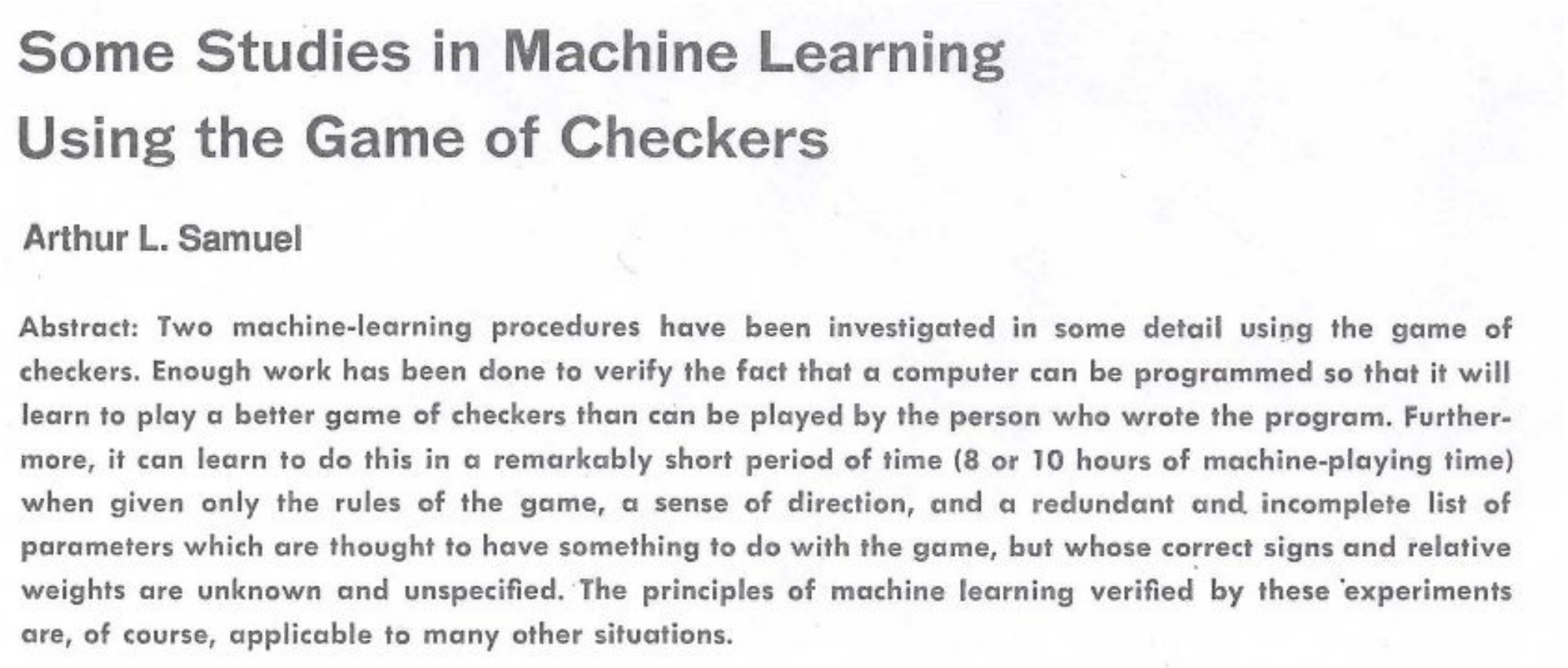
- Midterm: 20%
- Project: 30%
- **Final: 30%**
- Homeworks: 20%

- All topics included.

1. Introduction
2. Supervised Learning
3. Bayesian Decision Theory
4. Parametric Methods
5. Dimensionality reduction, clustering
6. Non-parametric methods - Nearest Neighbor
7. Decision Trees
8. Neural Networks
9. Support Vector Machines
10. Combining multiple learners
11. Reinforcement Learning
12. Model Assessment and Comparison

What is Machine Learning

- Arthur Samuel (1959). Field of study that gives computers the ability to learn without being explicitly programmed.



Some Studies in Machine Learning Using the Game of Checkers

Arthur L. Samuel

Abstract: Two machine-learning procedures have been investigated in some detail using the game of checkers. Enough work has been done to verify the fact that a computer can be programmed so that it will learn to play a better game of checkers than can be played by the person who wrote the program. Furthermore, it can learn to do this in a remarkably short period of time (8 or 10 hours of machine-playing time) when given only the rules of the game, a sense of direction, and a redundant and incomplete list of parameters which are thought to have something to do with the game, but whose correct signs and relative weights are unknown and unspecified. The principles of machine learning verified by these experiments are, of course, applicable to many other situations.

1959. Some Studies in Machine Learning Using the Game of Checkers. IBM Journal of Research and Development (Volume:44, Issue:1.2)

What is Machine Learning

- Arthur Samuel (1959). Field of study that gives computers the ability to learn without being explicitly programmed.
- Tom Mitchell (1998). A computer program is said to *learn* from experience E with respect to some task T and some performance measure P, if its performance on T, measured by P, improves with experience E

Why “Learn” ?

- Machine learning is programming computers to optimize a performance criterion using example data or past experience.
- There is no need to “learn” to calculate payroll
- Learning is used when:
    - Human expertise does not exist (navigating on Mars),
    - Humans are unable to explain their expertise (speech recognition)
    - Solution changes in time (routing on a computer network)
    - Solution needs to be adapted to particular cases (user biometrics)

What We Talk About When We Talk About "Learning"

- Learning general models from a data of particular examples
- Data is cheap and abundant (data warehouses, data marts); knowledge is expensive and scarce.
- Example in retail: Customer transactions to consumer behavior:

  People who bought "Da Vinci Code" also bought "The Five People You Meet in Heaven" (www.amazon.com)
- Build a model that is *a good and useful approximation* to the data.

Data Mining

- Retail: Market basket analysis, Customer relationship management (CRM)
- Finance: Credit scoring, fraud detection
- Manufacturing: Optimization, troubleshooting
- Medicine: Medical diagnosis
- Telecommunications: Quality of service optimization
- Bioinformatics: Motifs, alignment
- Web mining: Search engines
- ...

What is Machine Learning?

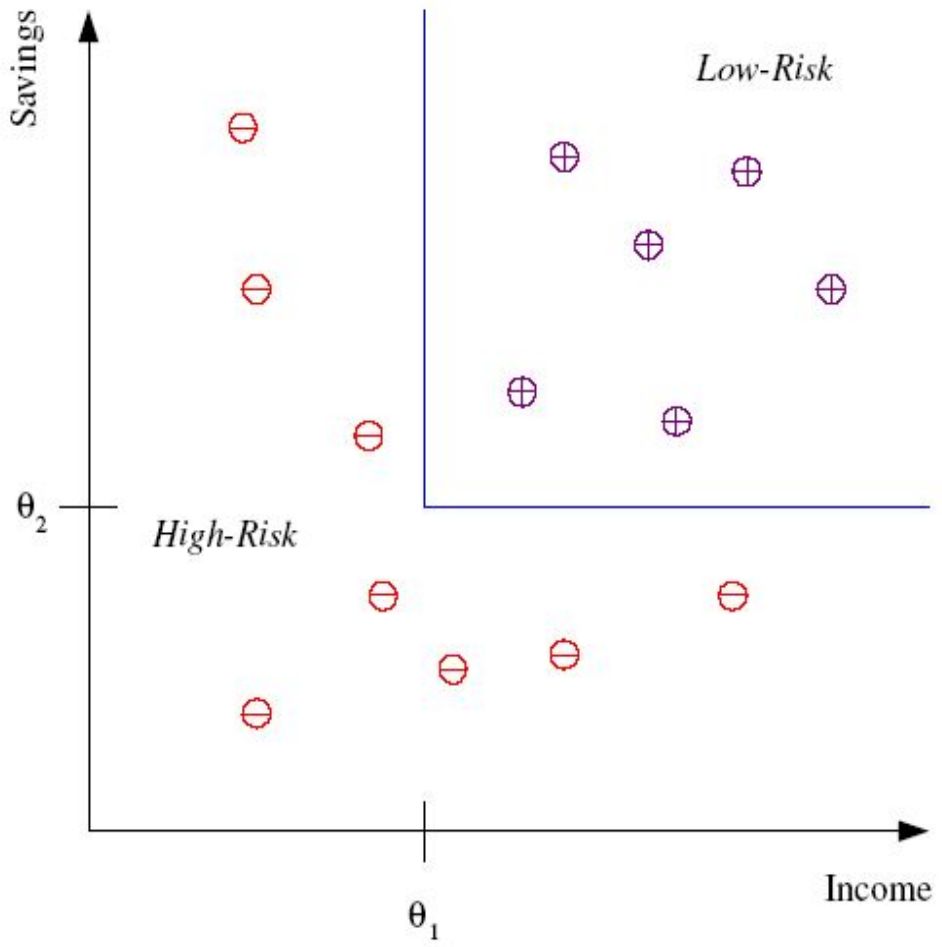
- Optimize a performance criterion using example data or past experience.
- Role of Statistics: Inference from a sample
- Role of Computer science:
  - Efficient algorithms to solve the optimization problem
  - Representing and evaluating the model for inference

Applications

- Supervised Learning
    - Classification
    - Regression
- Unsupervised Learning
- Reinforcement Learning

Classification

- Example: Credit scoring
- Differentiating between low-risk and high-risk customers from their *income* and *savings*



Discriminant: IF *income* > θ_1 AND *savings* > θ_2
THEN low-risk ELSE high-risk

Classification: Applications

- Aka Pattern recognition
- Face recognition: Pose, lighting, occlusion (glasses, beard), make-up, hair style
- Character recognition: Different handwriting styles.
- Speech recognition: Temporal dependency.
    - Use of a dictionary or the syntax of the language.
    - Sensor fusion: Combine multiple modalities; eg, visual (lip image) and acoustic for speech
- Medical diagnosis: From symptoms to illnesses

Face Recognition

Training examples of a person

Test images

AT&T Laboratories, Cambridge UK
http://www.uk.research.att.com/facedatabase.html

Regression

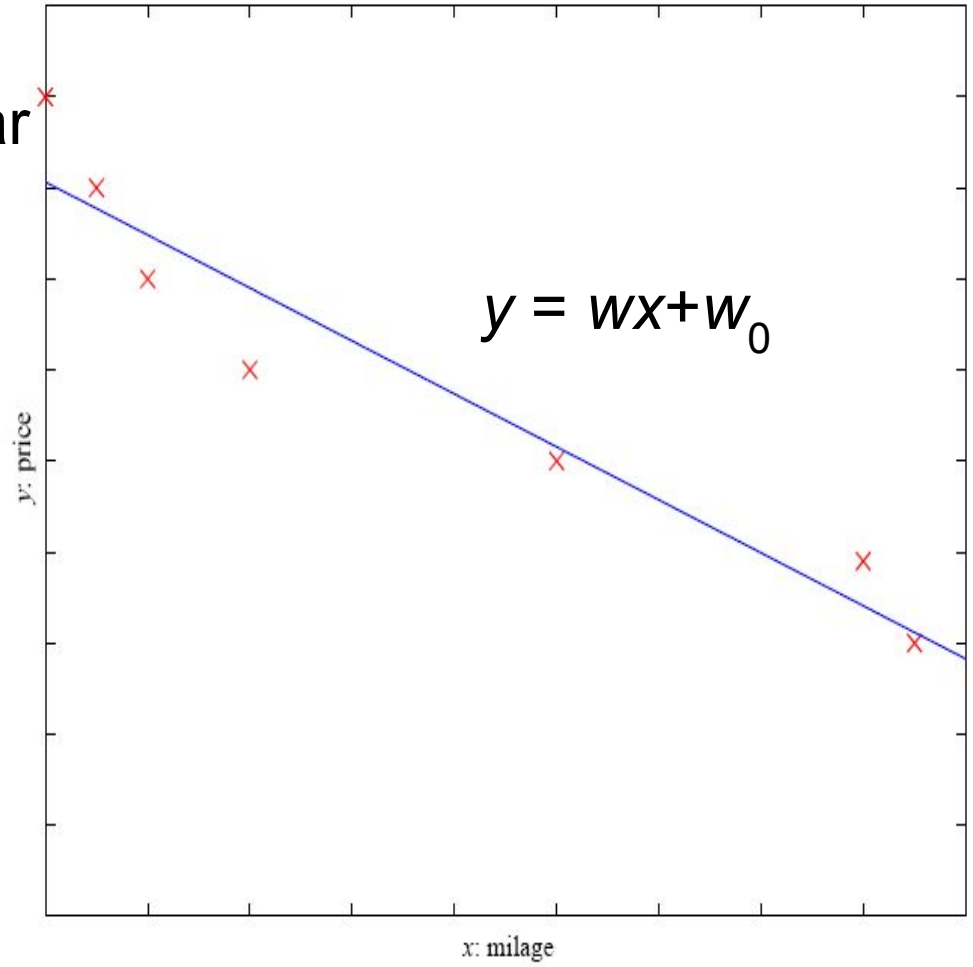
- Example: Price of a used car
- x : car attributes

  y : price

  $y = g(x \mid \theta)$

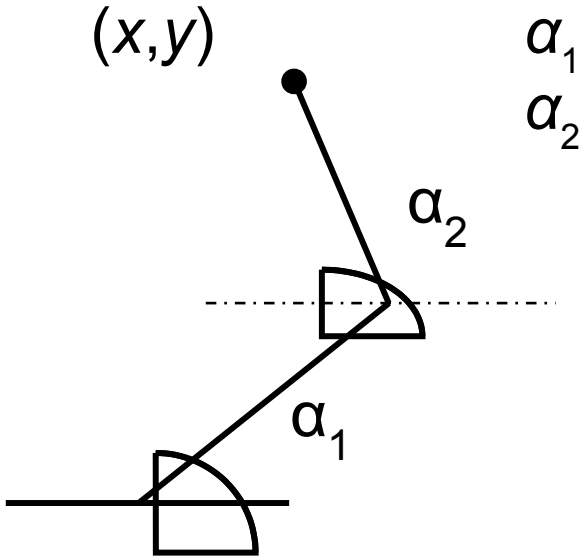
  $g(\ )$ model,

θ parameters

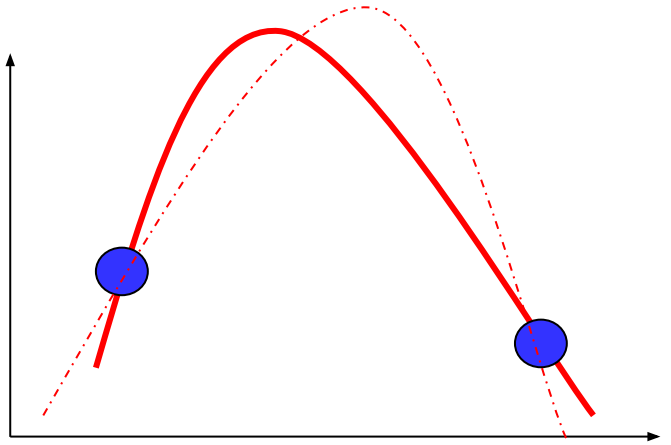


Regression Applications

- Navigating a car: Angle of the steering wheel
- Kinematics of a robot arm



$\alpha_1 = g_1(x,y)$
$\alpha_2 = g_2(x,y)$



Supervised Learning: Uses

- Prediction of future cases: Use the rule to predict the output for future inputs
- Knowledge extraction: The rule is easy to understand
- Compression: The rule is simpler than the data it explains
- Outlier detection: Exceptions that are not covered by the rule, e.g., fraud

Unsupervised Learning

- Learning “what normally happens”
- No output
- Clustering: Grouping similar instances
- Example applications
    - Customer segmentation in CRM
    - Image compression: Color quantization
    - Document clustering: bag-of-words
    - Bioinformatics: Learning motifs

Reinforcement Learning

- Learning a policy: A sequence of outputs
- No supervised output but delayed reward
- Game playing
- Robot in a maze
- Multiple agents, partial observability, ...

Resources: Datasets

- UCI Repository: http://www.ics.uci.edu/~mlearn/MLRepository.html
- UCI KDD Archive: http://kdd.ics.uci.edu/summary.data.application.html
- Statlib: http://lib.stat.cmu.edu/
- Delve: http://www.cs.utoronto.ca/~delve/

Resources: Journals

- Journal of Machine Learning Research www.jmlr.org
- Machine Learning
- Neural Computation
- Neural Networks
- IEEE Transactions on Neural Networks
- IEEE Transactions on Pattern Analysis and Machine Intelligence
- Annals of Statistics
- Journal of the American Statistical Association
- ...

Resources: Conferences

- International Conference on Machine Learning (ICML)
- European Conference on Machine Learning (ECML)
- Neural Information Processing Systems (NeurIPS)
- Uncertainty in Artificial Intelligence (UAI)
- Computational Learning Theory (COLT)
- International Joint Conference on Artificial Intelligence (IJCAI)
- International Conference on Neural Networks (ICANN)
- ...

Next lecture

- Review of basics: Probability and Linear Algebra
- Any volunteers for presentation?