Lecture 1:
- Course outline and logistics
- What is Machine Learning
Today’s Schedule

• Course outline and logistics

• An overview of Machine Learning
Course outline and logistics
Logistics

• Instructor:

Aykut ERDEM (aykut@cs.hacettepe.edu.tr)

• Teaching Assistant:

Aysun Kocak (aysunkocak@cs.hacettepe.edu.tr)
Burcak Asal (basal@cs.hacettepe.edu.tr)

• Lectures: Tue 10:00 - 10:50_D10
  Thu 09:00 - 10:50_D9

• Tutorials: Fri 09:00 - 10:50_D8
About this course

• This is a undergraduate-level introductory course in machine learning (ML)
  - A broad overview of many concepts and algorithms in ML.

• Requirements
  - Basic algorithms, data structures.
  - Basic probability and statistics.
  - Basic linear algebra and calculus.
  - Good programming skills.

• BBM 409 Introduction to Machine Learning Practicum (New)
  - Students will gain skills to apply the concepts to real world problems.

  common distributions, Bayes rule, mean/median/model
  vector/matrix manipulations, partial derivatives
Communication

• The course webpage will be updated regularly throughout the semester with lecture notes, programming and reading assignments and important deadlines.  

• We will be using Piazza for course related discussions and announcements. Please enroll the class on Piazza by following the link 
  http://piazza.com/class#spring2016/bbm406
Reference Books

- Bayesian Reasoning and Machine Learning, Barber, Cambridge University Press, 2012. (online version available)
- Pattern Recognition and Machine Learning, Bishop, Springer, 2006
Grading Policy

• Grading for BBM 406 will be based on
  – a course project (done in pairs) (25%),
  – a midterm exam (30%),
  – a final exam (40%), and
  – class participation (5%)

• In BBM 409, the grading will be based on
  – a set of quizzes (20%), and
  – 3 assignments (done individually)
Assignments

• 3 assignments, first one worth 20%, last two worth 30% each

• **Theoretical**: Pencil-and-paper derivations
  • **Programming**: Implementing Python code to solve a given real-world problem

• A quick Python tutorial in this week’s tutorial session.
KEEP
CALM
AND
DO YOUR
HOMEWORKS
Course Project

• Done individually, or in teams of two students.

• Choose your own topic and explore ways to solve the problem

• Proposal: 1 page (Mar 8) (10%)
Progress Report: 4-5 pages (Apr 19) (25%)
Poster Presentation: (last week of classes) (20%)
Final Report: (due at the beginning of poster session) (45%)
Collaboration Policy

• All work on assignments have to be done **individually**. The course project, however, can be done **in pairs**.

• You are encouraged to discuss with your classmates about the given assignments, but these discussions should be carried out in an abstract way.

• In short, turning in someone else’s work, in whole or in part, as your own will be considered as a violation of academic integrity.

• Please note that the former condition also holds for the material found on the web as everything on the web has been written by someone else.

Course Outline

- Week 1  Overview of Machine Learning, Nearest Neighbor Classifier
- Week 2  Linear Regression, Least Squares  
  Assg1 out
- Week 3  Machine Learning Methodology
- Week 4  Statistical Estimation: MLE, MAP, Naïve Bayes Classifier  
  Assg1 due, Assg2 out
- Week 5  Linear Classification Models: Logistic Regression, Linear Discriminant Functions, Perceptron 
  Course project proposal due
- Week 6  Neural Networks  
  Assg2 due
- Week 7  Midterm Exam  
  Assg3 out
Course Outline (cont’d.)

- Week 8  Deep Learning
- Week 9  Support Vector Machines (SVMs)
  Assg3 due
- Week 10  Multi-class SVM
- Week 11  Decision Tree Learning
  Project progress report due
- Week 12  Ensemble Methods: Bagging, Random Forests, Boosting
- Week 13  Clustering
- Week 14  Principle Component Analysis, Autoencoders
Machine Learning: An Overview
• “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
Google Trends

Machine learning
Deep learning
Learning

"What I cannot create, I do not understand."

"Know how to solve every problem that has been solved."

Richard Feynman
Two definitions of learning

(1) Learning is the acquisition of knowledge about the world.

*Kupfermann* (1985)

(2) Learning is an adaptive change in behavior caused by experience.

*Shepherd* (1988)
Empirical Inference

• Drawing conclusions from empirical data (observations, measurements)

• Example 1: Scientific inference

\[ y = \sum a_i k(x, x_i) + b \]

\[ y = a \times x \]

Leibniz, Weyl, Chaitin
Empirical Inference

• Example 2: Perception
Empirical Inference

• Example 2: Perception

"The brain is nothing but a statistical decision organ"

H. Barlow
What is machine learning?
Example: Netflix Challenge

- Goal: Predict how a viewer will rate a movie
- 10% improvement = 1 million dollars
Example: Netflix Challenge

- Goal: Predict how a viewer will rate a movie
- 10% improvement = 1 million dollars
- Essence of Machine Learning:
  - A pattern exists
  - We cannot pin it down mathematically
  - We have data on it
Watch out AlphaGo vs. Lee Sedol in March!

At last – a computer program that can beat a champion Go player

ALL SYSTEMS GO

Match days: 9, 10, 12, 13, 15 March - will be livestreamed on YouTube. More details soon. We are very excited to be coming to South Korea!

Demis Hassabis @demishassabis · Feb 4
It is a real privilege and honour to be playing the greatest Go player of the past decade, and a legend of the game #LeeSedol #AlphaGo

Thrilled to officially announce the 5-game challenge match between #AlphaGo and Lee Sedol in Seoul from March 9th-15th for a $1M prize!

Demis Hassabis @demishassabis · Feb 4
Comparison

- **Traditional Programming**
  - Data → Computer → Output
  - Program → Computer → Output

- **Machine Learning**
  - Data → Computer → Program
  - Output → Computer → Program
What is Machine Learning?

- [Arthur Samuel, 1959]
  - Field of study that gives computers
  - the ability to learn without being explicitly programmed

- [Kevin Murphy] algorithms that
  - automatically detect patterns in data
  - use the uncovered patterns to predict future data or other outcomes of interest

- [Tom Mitchell] algorithms that
  - improve their performance (P)
  - at some task (T)
  - with experience (E)
What is Machine Learning?

• If you are a Scientist

• If you are an Engineer / Entrepreneur
  • Get lots of data
  • Machine Learning
  • ???
  • Profit!

Data → Machine Learning → Understanding
Why Study Machine Learning?
Engineering Better Computing Systems

• Develop systems
  • too difficult/expensive to construct manually
  • because they require specific detailed skills/knowledge
    • knowledge engineering bottleneck

• Develop systems
  • that adapt and customize themselves to individual users.
  • Personalized news or mail filter
  • Personalized tutoring

• Discover new knowledge from large databases
  • Medical text mining (e.g. migraines to calcium channel blockers to magnesium)
    • data mining
Why Study Machine Learning?

Cognitive Science

• Computational studies of learning may help us understand learning in humans
  • and other biological organisms.

• Hebbian neural learning
  • “Neurons that fire together, wire together.”
Why Study Machine Learning?

The Time is Ripe

• Algorithms
  • Many basic effective and efficient algorithms available.

• Data
  • Large amounts of on-line data available.

• Computing
  • Large amounts of computational resources available.
Where does ML fit in?

Psychology
- biology of learning
- inspiring paradigms
- Ex: neural networks

Computer Science
- algorithm design
- data structure
- complexity analysis
- Ex: kd tree

Applied Maths
- optimization
- linear algebra
- Ex: convex optim

Applications
- new challenges
- Ex: ad placement

Statistics
- estimation techniques
- theoretical framework
- optimality, efficiency
- Ex: learning theory

Machine Learning
A Brief History of AI

A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence.

(John McCarthy)
A Proposal for the
DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

June 17 - Aug 16

We propose that a 2 month, 10 man study of artificial intelligence be
carried out during the summer of 1956 at Dartmouth College in Hanover, New
Hampshire. The study is to proceed on the basis of the conjecture that every
aspect of learning or any other feature of intelligence can in principle be so pre-
cisely described that a machine can be made to simulate it. An attempt will be
made to find how to make machines use language, form abstractions and concepts,
solve kinds of problems now reserved for humans, and improve themselves. We
think that a significant advance can be made in one or more of these problems if
a carefully selected group of scientists work on it together for a summer.

The following are some aspects of the artificial intelligence problem:

1) Automatic Computers

If a machine can do a job, then an automatic calculator can
be programmed to simulate the machine. The speeds and
memory capacities of present computers may be insufficient
to simulate many of the higher functions of the human brain,
but the major obstacle is not lack of machine capacity, but
our inability to write programs taking full advantage of what
we have.

2) How Can a Computer be Programmed to Use a Language

It may be speculated that a large part of human thought con-
sists of manipulating words according to rules of reasoning
AI Predictions: Experts

Image Credit: http://intelligence.org/files/PredictingAI.pdf
AI Predictions: Non-Experts

Image Credit: http://intelligence.org/files/PredictingAI.pdf
AI Predictions: Failed

![Graph showing AI predictions for different years](http://intelligence.org/files/PredictingAI.pdf)
Why is AI hard?
What humans see

slide by Larry Zitnick
What computers see
“I saw her duck”
“I saw her duck”
“I saw her duck”
We’ve come a long way… IBM Watson

- What is Jeopardy?

- Challenge:
  - http://youtu.be/_429UlzN1JM

- Watson Demo:
  - http://youtu.be/WFR3lOm_xhE?t=22s

- Explanation
  - http://youtu.be/d_yXV22O6n4?t=4s

- Future: Automated operator, doctor assistant, finance
  - IBM Watson wins on Jeopardy (February 2011)
  - Watson provides cancer treatment options to doctors in seconds (February 2013)
Why are things working today?

• More compute power
• More data
• Better algorithms/models

Figure Credit: Banko & Brill, 2011