Logistics

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  - Office hours: Mondays 2:00-3:00 (or by appt), Ford 3-345

- **TAs:** Mohammed Alam (Rony), Yanran Wang (Joyce), Zack Witten

- **Web:** (linked from prof. homepage)
# Grading and Assignments (1 of 2)

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Due Date</th>
<th>Points</th>
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<tbody>
<tr>
<td>Homework 1</td>
<td>14-Apr-15</td>
<td>10</td>
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<tr>
<td>Homework 2</td>
<td>TBD</td>
<td>15</td>
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<tr>
<td>Project Proposal</td>
<td>9-Apr-15</td>
<td>5+5</td>
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<td>Homework 3</td>
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<tr>
<td>Project Status Report</td>
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<td>Homework 4</td>
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<tr>
<td>Project Video</td>
<td>5-Jun-15</td>
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<tr>
<td>Project Website</td>
<td>5-Jun-15</td>
<td>20+5</td>
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<tr>
<td>Quizzes</td>
<td>Every Wednesday</td>
<td>8</td>
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**TOTAL POINTS** 103

<table>
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<tr>
<th>Grade</th>
<th>A-</th>
<th>A</th>
<th>B+</th>
<th>B</th>
<th>B-</th>
<th>C+</th>
<th>C</th>
<th>C-</th>
<th>Etc…</th>
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<tr>
<td>93+</td>
<td>92-90</td>
<td>89-87</td>
<td>86-83</td>
<td>82-80</td>
<td>79-77</td>
<td>76-73</td>
<td>72-70</td>
<td>69…</td>
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Grading and Assignments (2 of 2)

- Four homeworks (40 pts)
  - Submitted via e-mail according to hmwk instructions
    - Late penalty 5% per day – must be within 1 week of original deadline
  - Significant programming, some exercises
    - Any programming language
- Quizzes (8 pts) – Each Wednesday weeks 2-9
  - Bring a device to access Canvas. Practice quiz this week
- Project (40 pts + 15 peer review)
  - Teams of $k$
  - Define a task, create/acquire data for the task, train ML algorithm(s), evaluate & report
Prerequisites

- **Significant Programming Experience**
  - EECS 214, 325 or the equivalent
  - Example: implement decision trees (covered starting Wednesday)

- **Basics of probability**
  - E.g. independence

- **Basics of logic**
  - E.g. DeMorgan's laws
Advice

Look at Winter 2014 EECS 349 Homework #2 today
Source Materials

- (both “required”)
- Papers & Web pages
Think/Pair/Share

Why study Machine Learning?

Think
Start

End
Think/Pair/Share

Why study Machine Learning?
Think/Pair/Share

Why study Machine Learning?

Start

Pair

End
Think/Pair/Share

Why study Machine Learning?

Share
What is Machine Learning?

- “The study of computer programs that improve automatically with experience”
  T. Mitchell *Machine Learning*

- Automating automation
- Getting computers to program themselves
- Writing software is the bottleneck
- Let the data do the work instead!
Traditional Programming

Input → Computer → Output

Program → Computer

Machine Learning

Input → Computer → Program

Output
No, more like gardening

- **Seeds** = Algorithms
- **Nutrients** = Data
- **Gardener** = You
- **Plants** = Programs
Case Study: Farecast

Search Flights
Find cheap flights and free airfare predictions

- Round Trip
- One Way
- Multi-City

Please enter a To city

From:
Chicago, IL (CHI) - All airports

Include Nearby Airports

To:
Seattle, WA (SEA) - Seattle/Tacoma

Include Nearby

7-Day Low Fare Prediction
Tip: Buy
Fares Rising $42
Confidence: 66%
Details
Applies to ORD->SEA only

Daily Low Fare History

<table>
<thead>
<tr>
<th>Date</th>
<th>Fare</th>
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<tbody>
<tr>
<td>69 Days Ago</td>
<td>$390</td>
</tr>
<tr>
<td>Now</td>
<td>$305</td>
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<tr>
<td>$220</td>
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<td>$135</td>
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Sample Applications

- Web search
- Computational biology
- Finance
- E-commerce
- Space exploration

- Robotics
- Information extraction
- Social networks
- Finance
- Debugging
- [Your favorite area]
Relationship of Machine Learning to...

- Statistics
- Analytics
- Data Mining
- Artificial Intelligence
“A breakthrough in machine learning would be worth ten Microsofts” (Bill Gates, Chairman, Microsoft)

“Machine learning is the next Internet” (Tony Tether, former Director, DARPA)

“Machine learning is the hot new thing” (John Hennessy, President, Stanford)

“Web rankings today are mostly a matter of machine learning” (Prabhakar Raghavan, Dir. Research, Yahoo)

“Machine learning is going to result in a real revolution” (Greg Papadopoulos, CTO, Sun)

“Machine learning is today’s discontinuity” (Jerry Yang, CEO, Yahoo)
Why study Machine Learning? (2 of 3)

The Digital Universe is Huge — And Growing Exponentially

If the Digital Universe were represented by the memory in a stack of tablets, in 2013 it would have stretched two-thirds the way to the Moon.*

By 2020, there would be 6.6 stacks from the Earth to the Moon.*

Source: IDC, 2014
iPad Air — 0.29" thick, 128 GB

One example, proportion of physicians using EMRs

- 2001: 18%
- 2011: 57%
- 2013: 78%

...what will be able to learn from these?
ML in Practice

- Understanding domain, prior knowledge, and goals
- Data integration, selection, cleaning, pre-processing, etc.
- Learning models
- Interpreting results
- Consolidating and deploying discovered knowledge
- Loop
What You’ll Learn in this Class

- How do ML algorithms work?
  - Learn by implementing, using

- For a real problem, how do I:
  - Express my problem as an ML task
  - Choose the right ML algorithm
  - Evaluate the results
ML in a Nutshell

- Tens of thousands of machine learning algorithms
- Hundreds new every year
- Every machine learning algorithm has three components:
  - Representation
  - Evaluation
  - Optimization
How do we represent the function from input to output?

- Decision trees
- Sets of rules / Logic programs
- Instances
- Graphical models (Bayes/Markov nets)
- Neural networks
- Support vector machines
- Model ensembles
- Etc.
Evaluation

- *Given some data, how can we tell if a function is “good”?*
  - Accuracy
  - Precision and recall
  - Squared error
  - Likelihood
  - Posterior probability
  - Cost / Utility
  - Margin
  - Entropy
  - K-L divergence
  - Etc.
Given some data, how do we find the “best” function?

- Combinatorial optimization
  - E.g.: Greedy search
- Convex optimization
  - E.g.: Gradient descent
- Constrained optimization
  - E.g.: Linear programming
Types of Learning

- **Supervised (inductive) learning**
  - Training data includes desired outputs

- **Unsupervised learning**
  - Training data does not include desired outputs

- **Semi-supervised learning**
  - Training data includes a few desired outputs

- **Reinforcement learning**
  - Rewards from sequence of actions
Inductive Learning

- **Given** examples of a function \((x, f(x))\)
- **Predict** function \(f(x)\) for new instances \(x\)
  - Discrete \(f(x)\): Classification
  - Continuous \(f(x)\): Regression
  - \(f(x) = \text{Probability}(x)\): Probability estimation

- Example:
  - \(x = \langle \text{Flight}=\text{United 102}, \text{FlightDate}=\text{May 26}, \text{Today}=\text{May 7} \rangle\)
  - \(f(x) = +1\) if flight price will increase in the next week, or \(-1\) otherwise
What We’ll Cover

- **Inductive learning**
  - Decision tree induction
  - Instance-based learning
  - Linear Regression and Classification
  - Neural networks
  - Genetic Algorithms
  - Support vector machines
  - Bayesian Learning
  - Learning theory
  - Reinforcement Learning

- **Unsupervised learning**
  - Clustering
  - Dimensionality reduction
Bring a device to access Canvas for quiz on Wednesday
Take a look at Homework #2 from EECS 349 Winter 2014 (see my Web page)

Reading:
- Skim: Forbes article
  (linked on course Web page)

Recommended:
- Mitchell, Chapters 1 & 2
- Alpaydin, Ch 1 & 2