EECS 349
Machine Learning

Instructor: Doug Downey

(some slides from Pedro Domingos, University of Washington)

Today

- Logistics
- ML Overview

Logistics

- **Instructor:** Doug Downey
  - Email: ddowney@eecs.northwestern.edu
  - Office hours: Mondays 4:00-5:00 (or by appt), Ford 3-345
- **TAs:** Dave Demeter, Zheng Yuan, Xutong Chen, 7 ugrad peer mentors
- **Web:** (linked from prof. homepage) http://www.cs.northwestern.edu/~downey/courses/349_Spring2018/
  - Also, Canvas, Piazza
- **Note**: No class this Friday (4/6)

Grading and Assignments (1 of 2)

Assignment	Points
Homework 1	15
Homework 2	5
Project Proposal	5+5 (peer mentoring)
Exam 1	10
Homework 3	10
Project Status Report	5+5 (peer mentoring)
Homework 4	10
Exam 2	10
Project Website	20
	100

A	A-	B+	B	B-	C+	C	C-	Etc…
93+	92-90	89-87	86-83	82-80	79-77	76-73	72-70	69…

Grading and Assignments (2 of 2)

- Four homeworks (40 pts)
  - Submitted via e-mail according to hmwk instructions
    - Late penalty 10% per day – must be within 1 week of original deadline
  - Significant programming, some exercises
    - Programming assignments in **groups of two (or one)**
- Exams (20 pts)
  - Monday of Week 4, Friday of Week 9
- Project (30 pts + 10 peer review)
  - Teams of ***k***
  - Define a task, create/acquire data for the task, train ML algorithm(s), evaluate & report

Expectations

- Grades
- Academic Integrity
  - You are expected to do your own work
    - More details in syllabus linked from course home page
  - Suspected violations of integrity policy will be referred to the administration
- Slides may not make sense if you don't come to class

Prerequisites

- Significant Programming Experience
  - EECS 214, 325 or the equivalent
  - Example: implement decision trees (covered starting Monday)
  - **Python** is the language we'll use
    - You'll have skeleton code to help you
    - (also, I barely know Python)
- Basics of probability
  - E.g. independence

Source Materials

- Papers & Web pages
- Reading for next week:
  - Required:
    - Decision trees (see the Decision Tree notes when they're posted)
  - Optional:
    - Gartner 2016 Hype Cycle
      (machine learning at peak hype as of 2016)

Participation

- Think/Pair/Share (next)
- Peer Review

Today

- Logistics
- ML Overview

Think/Pair/Share

Why study Machine Learning?

Think

Start

End

Think/Pair/Share

Why study Machine Learning?

Think

Start

End

Think/Pair/Share

Why study Machine Learning?

Pair

Start

End

Think/Pair/Share

Why study Machine Learning?

Share

For a lot of our problems today, we don't even know how we're able to do those things (such as face recognition, and we just know who it is, but what processes help you know?)

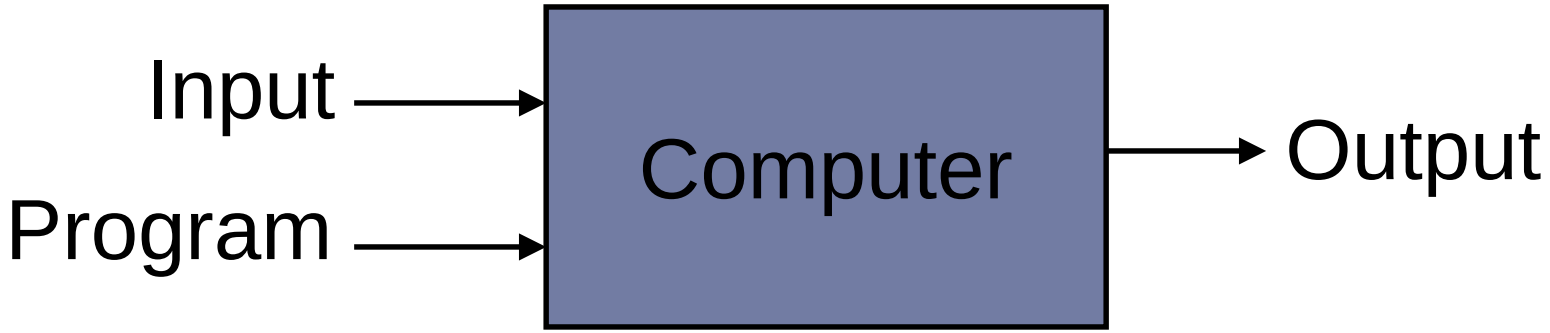
ML is applicable in these problem areas where it's sort of impossible to build an automated task because it's too complicated for us to understand

What is Machine Learning?

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

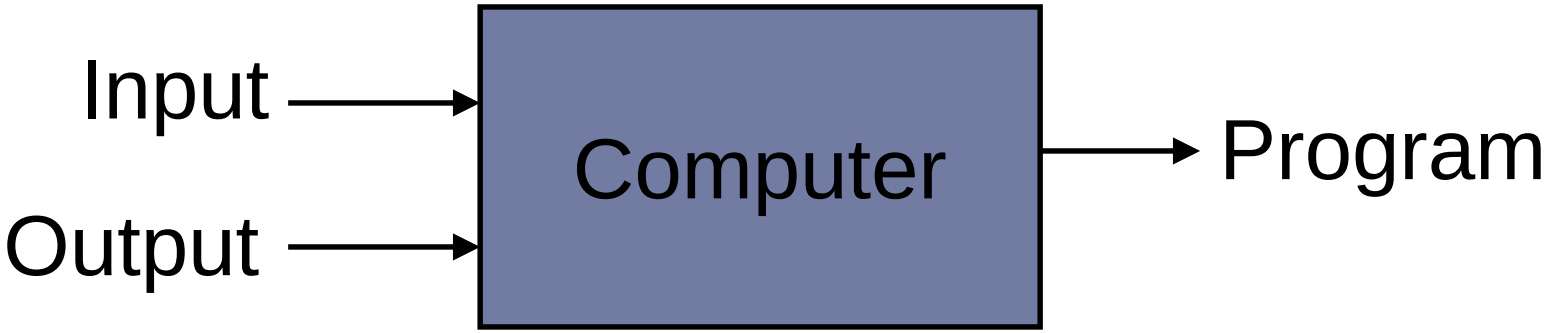
- Automating automation
- Getting computers to program themselves
- Writing software is the bottleneck
- Let the data do the work instead!

Traditional Programming



Machine Learning

We can tune search engine algorithms using this approach



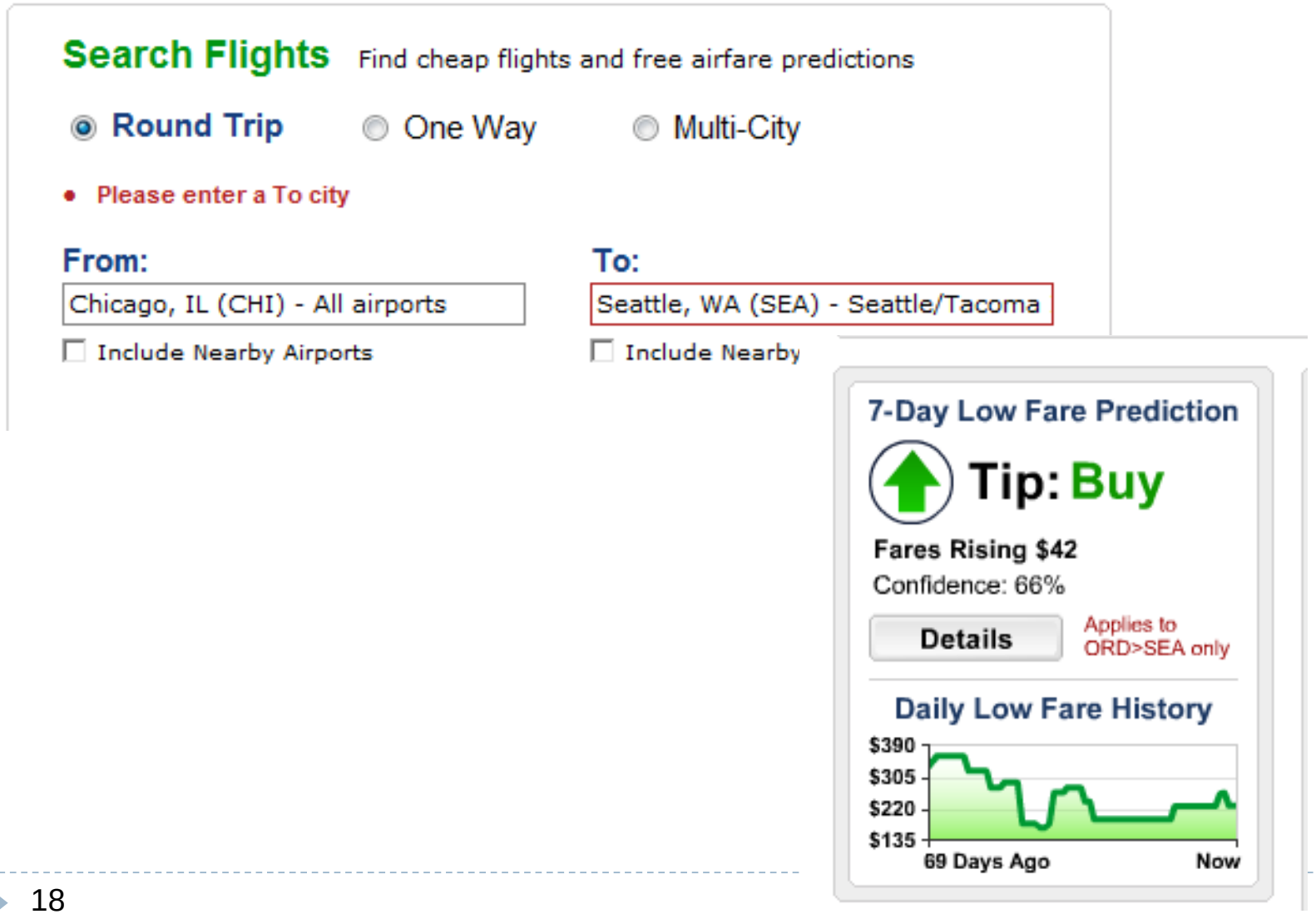
Why didn't we do this all along? (Ans: We didn't have as much data)

Magic?

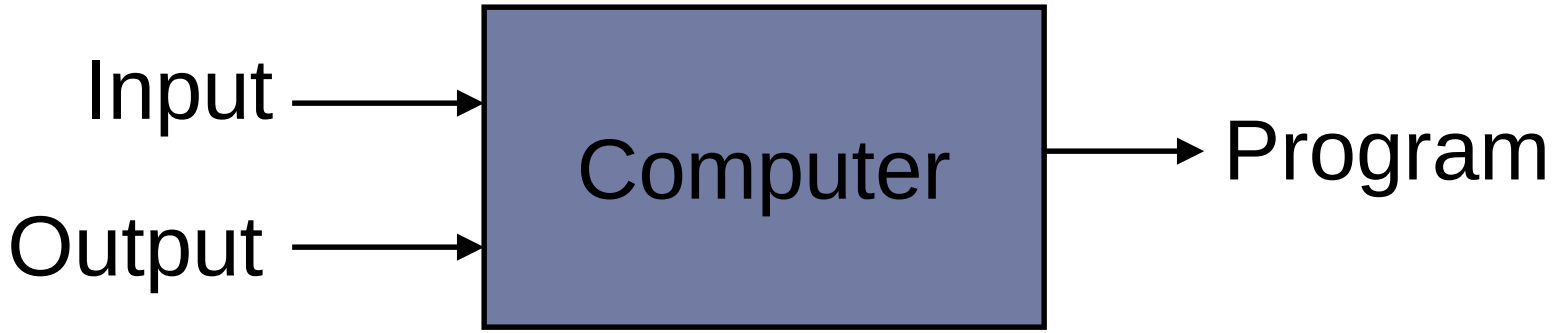
No, more like gardening

- **Seeds** = Algorithms
- **Nutrients** = Data
- **Gardener** = You
- **Plants** = Programs

Example: Farecast



Sample Applications



Relationship of Machine Learning to…

- **Statistics**
- **Analytics / Data Science**
- **Artificial Intelligence**

ML is a subfield of AI

AI is interested in HUMAN intelligence (not really the subject of ML)

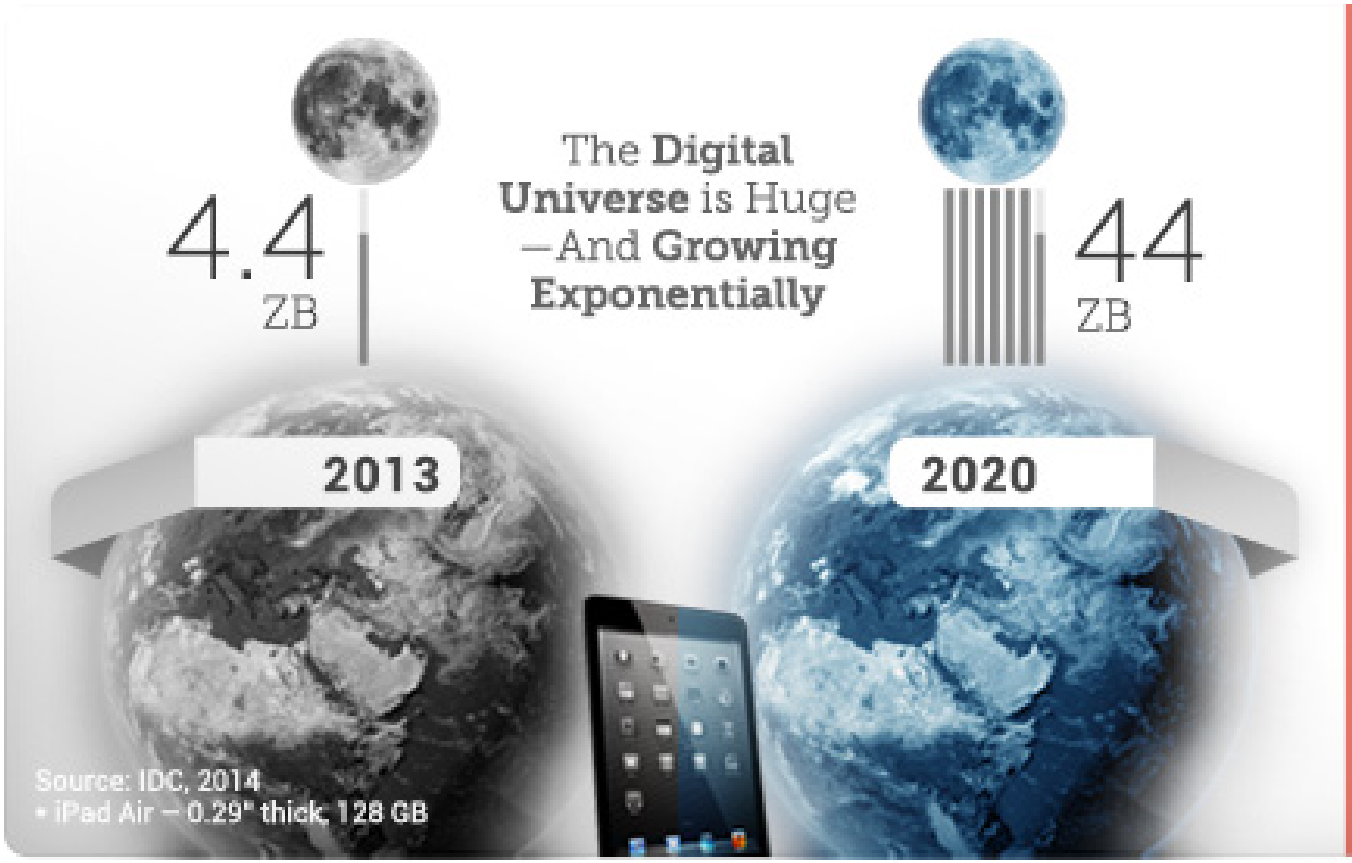
Why study Machine Learning? (1 of 4)

- "A breakthrough in machine learning would be worth ten Microsofts" (Bill Gates)
- "Machine learning is the next Internet" (Tony Tether, former Director, DARPA)

These quotes are ~10 years old
(e.g. Gates is from the NYT, 2004)

More recent:
"Artificial intelligence is one of the great opportunities for improving the world today," (Reid Hoffman, co-founder of $1B deep learning research center)

Why study Machine Learning? (2 of 4)

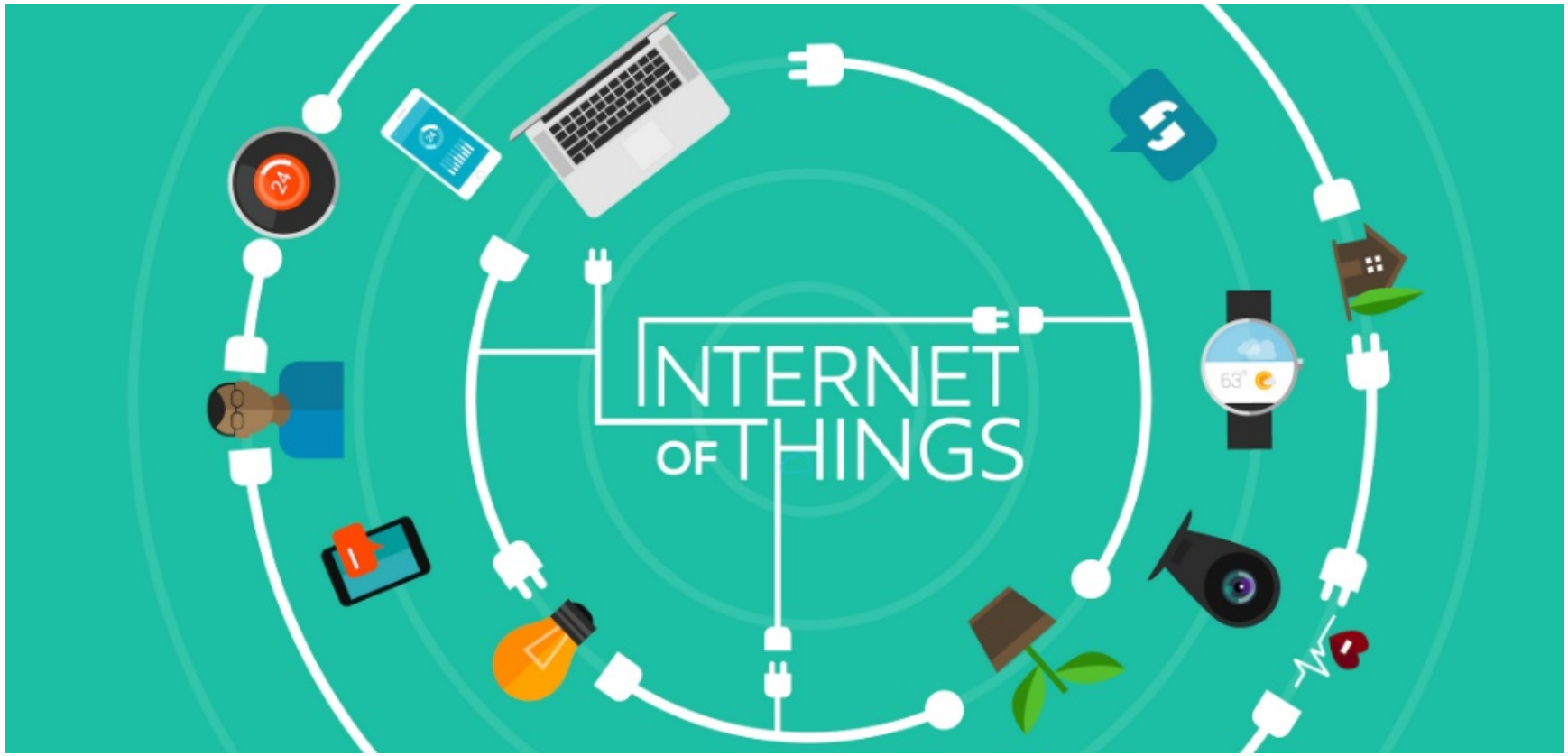


If the Digital Universe were represented by the memory in a stack of tablets, in **2013** it would have stretched two-thirds the way to the Moon*

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

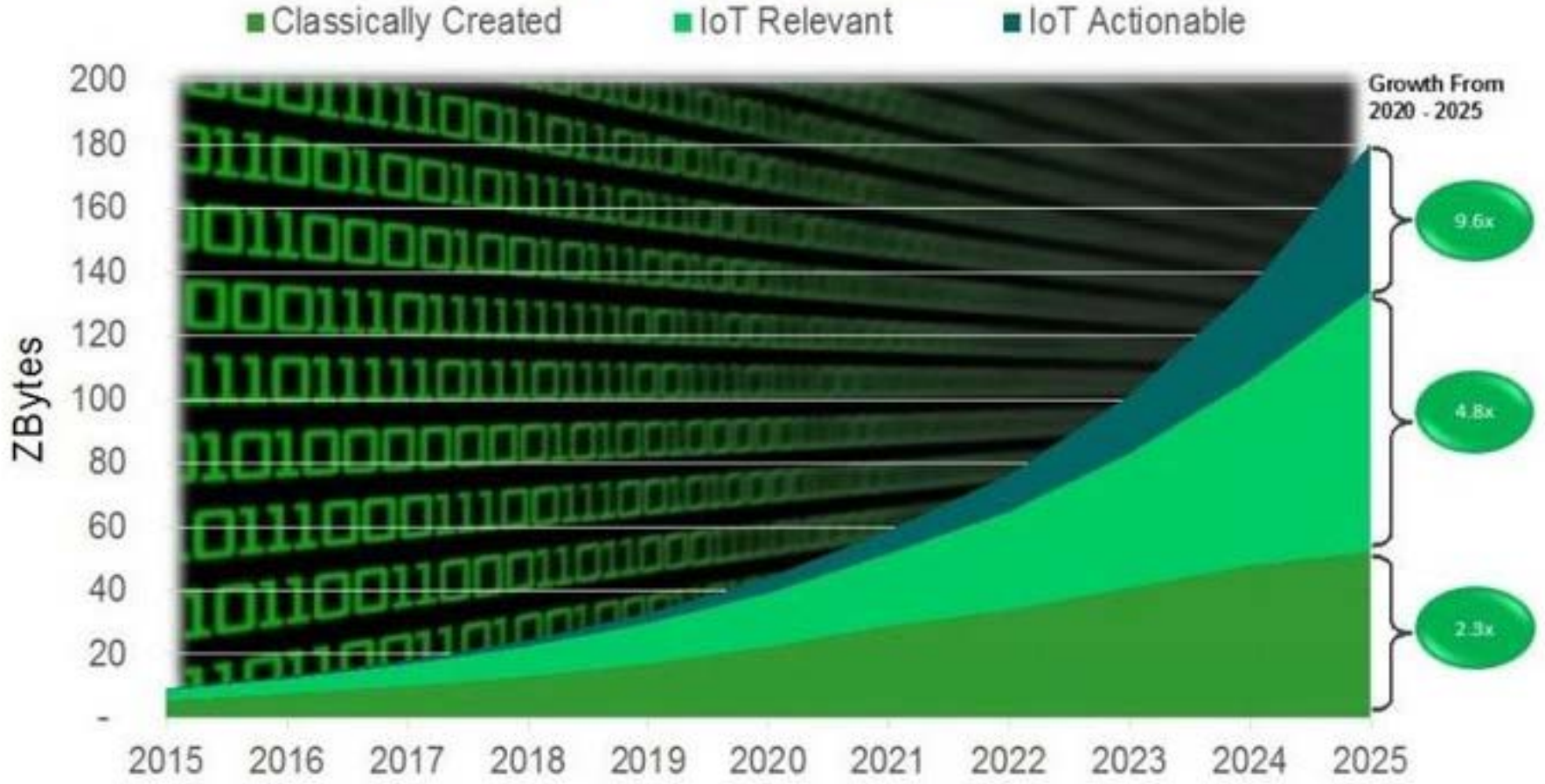
http://www.emc.com/leadership/digital-universe/2014iview/executive-summary.htm

Why study Machine Learning? (3 of 4)



http://www.gartner.com/newsroom/id/3598917

The Content Created World 2015 – 2025 *

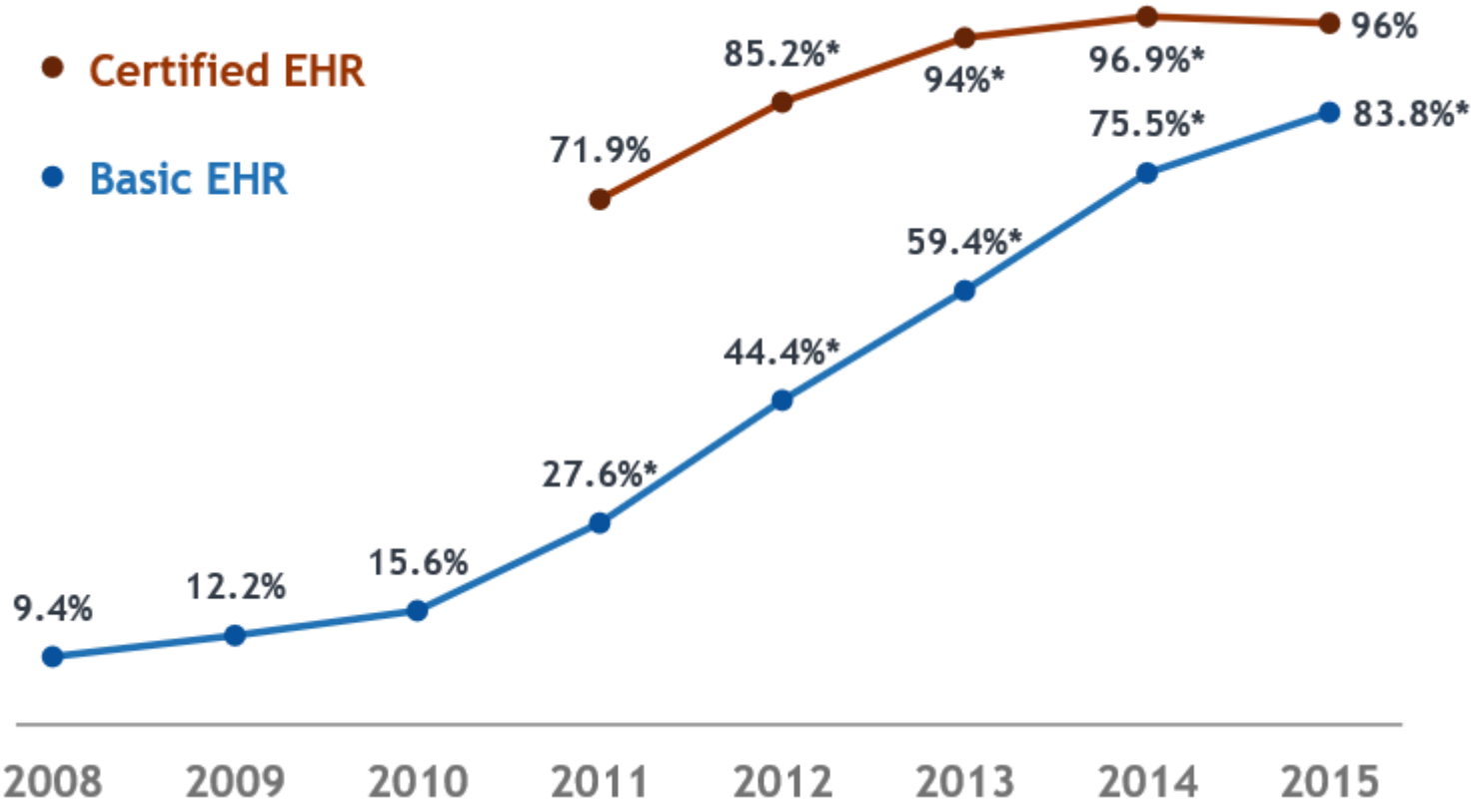


Source: The Internet of Things: Getting Ready to Embrace Its Impact on the Digital Economy (IDC #DR2016_GS4_VT)

@Vernonxt
@CMacIDC

Why study Machine Learning? (4 of 4)

Hospitals possessing (Certified EHR) or adopting (Basic EHR) electronic medical records. What will we be able to learn from these?



https://dashboard.healthit.gov/evaluations/data-briefs/non-federal-acute-care-hospital-ehr-adoption-2008-2015.php

What You'll Learn in this Class

- How do ML algorithms work?
  - Learn by **implementing**, using
- When **should** I use ML?
- 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**

Representation

- *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.

Optimization

- *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

Inductive Learning

- **Given** examples of a function (**x**, *f*(**x**))
- **Predict** function *f*(**x**) for new instances **x**
  - Discrete *f*(**x**): Classification — outputs to distinct categories (ex. spam or not spam)
  - Continuous *f*(**x**): Regression — ex. predicting airline ticket a week in advance
  - *f*(**x**) = Probability(**x**): Probability estimation — between 0 and 1 (semantic information)

- Example:
  - **x** = <Flight=United 102, FlightDate=May 26, Today=May 7>
  - *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
  - Neural networks
  - Bayesian Learning
  - Logistic Regression
  - Support vector machines
  - Learning theory
  - Reinforcement Learning
- **Unsupervised learning**
  - Clustering
  - Dimensionality reduction

we just want to make sense of the data

Today

- Logistics
  - 4 homeworks, 2 exams, course project. No final.
  - Take a look at the course Web page for more.
- ML Overview
  - Like gardening
  - data = rich source of fuel for ML
  - More soon…