CSC321 Lecture 1: Introduction

Roger Grosse and Nitish Srivastava

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Course information

- "Inverted classroom" format
  - Watch Geoff Hinton's lecture videos for homework
  - During class:
    - More in-depth discussion of the material
    - Question/answer session
    - Working through problems
- Two sections
  - Equivalent content, same assignments and exams
  - Both sections are full, so please attend your own.

Course information

- Required background
  - Programming experience (recommended)
  - Linear algebra: vector and matrix manipulations
  - Calculus: partial derivatives
  - Probability: Bayes' Rule, Gaussian distribution, mean, variance
- Formal prerequisites:
  - (MAT135H1, MAT136H1)/MAT135Y1/MAT137Y1/MAT157Y1
  - MAT223H1/MAT240H1
  - STA247H1/STA255H1/STA257H1
  - CGPA 3.0, or enrollment in a CSC subject POSt
- However, we will be generous about approving waivers
  - We give background pointers each week in case you want to review

Course information

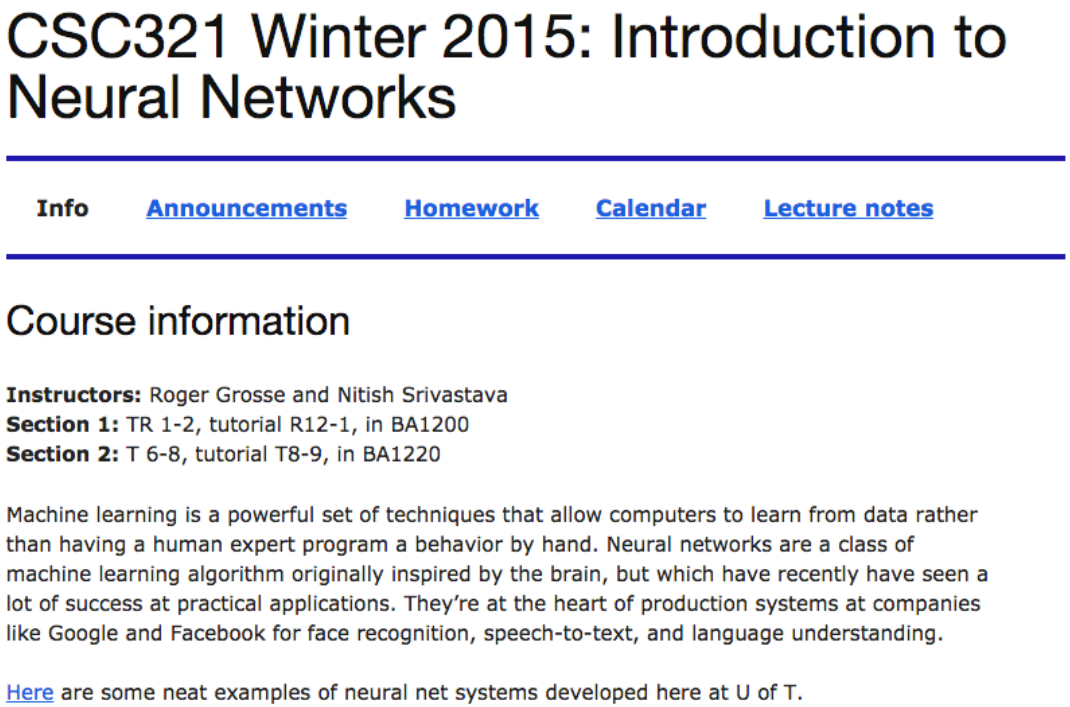
- Expectations and marking
  - Weekly lecture videos (about 1hr)
  - Quizzes on videos
    - due Monday night **before** classes which cover the content
    - collectively 10% of mark
    - open-book
    - best of 2 attempts
    - aim isn't to evaluate you, but to give you quick feedback and encourage you to think carefully about the material
  - 4 programming assignments (10% each)
    - Python
    - 10-15 lines of code
    - may also involve some mathematical derivations
    - give you a chance to experiment with the algorithms
  - Exams
    - midterm (15%)
    - final (35%)

Course information

- Textbooks
  - None, but we link to lots of free online resources.
- Tutorials
  - Roughly every other week
  - Programming background; introducing and discussing assignments

Course information

Course web page: `http://www.cs.toronto.edu/~rgrosse/csc321/`



CSC321 Winter 2015: Introduction to Neural Networks

Info | Announcements | Homework | Calendar | Lecture notes

Course information

Instructors: Roger Grosse and Nitish Srivastava
Section 1: TR 1-2, tutorial R12-1, in BA1200
Section 2: T 6-8, tutorial T8-9, in BA1220

Machine learning is a powerful set of techniques that allow computers to learn from data rather than having a human expert program a behavior by hand. Neural networks are a class of machine learning algorithm originally inspired by the brain, but which have recently have seen a lot of success at practical applications. They're at the heart of production systems at companies like Google and Facebook for face recognition, speech-to-text, and language understanding.

Here are some neat examples of neural net systems developed here at U of T.

Includes detailed course information handout

Course information

Coursera page (for videos, quizzes, forum):
`https://utoronto.coursera.org/CSC321-003`

- Sign in with your UTorID
- **Not** the same as the version accessible through the main Coursera site
- **Not** the 2013 or 2014 versions — make sure it's 2015

What is machine learning?

- For many problems, it's difficult to program the correct behavior by hand
  - recommendation systems
  - face recognition
  - spam classification
- We want to program a system which will learn from data, or from experience

What is machine learning?

- Types of machine learning
  - **Supervised learning:** have labeled examples of the correct behavior
  - **Unsupervised learning:** no labeled examples – instead, looking for interesting patterns in the data
  - **Reinforcement learning:** learning system receives a reward signal, tries to learn to maximize the reward signal

Supervised learning examples

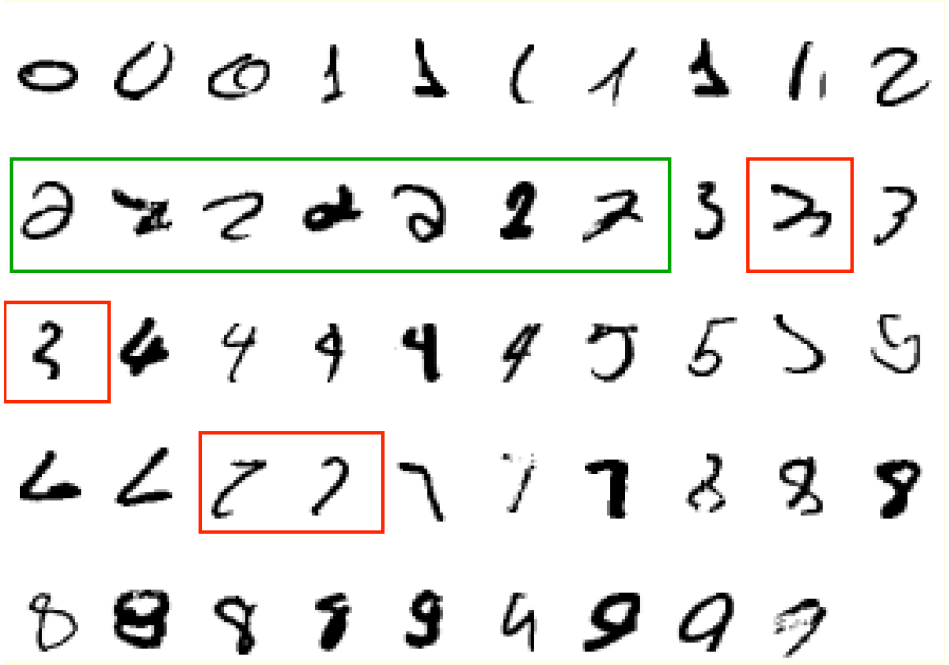
Supervised learning: have labeled examples of the correct behavior

e.g. Handwritten digit classification with the MNIST dataset

- task: given an image of a digit, predict the digit class
- 70,000 images of handwritten digits labeled by humans
- 60,000 used to train the classifier, 10,000 to test its performance
- This dataset is the "fruit fly" of neural net research
- Current best algorithm has only 0.23% error rate!

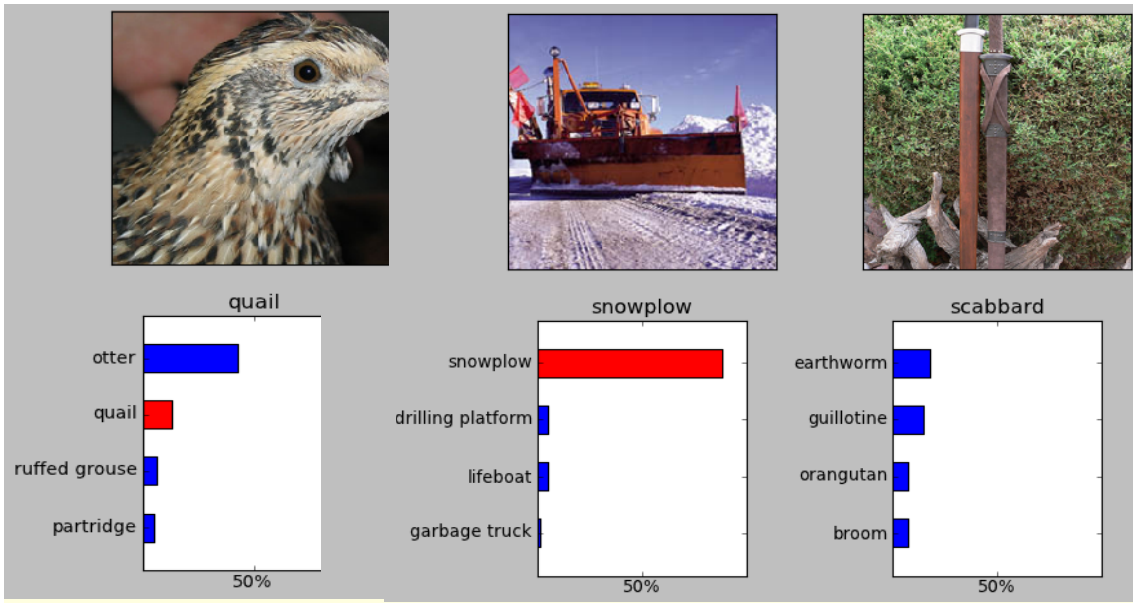
Supervised learning examples

What makes a "2"?



Supervised learning examples

Object recognition



(Krizhevsky and Hinton, 2012)

ImageNet dataset: thousands of categories, millions of labeled images

Lots of variability in viewpoint, lighting, etc.

Supervised learning examples

Caption generation

TAGS:

frisbees frisbee pushups golfers kickball

Nearest Neighbor Sentence:

- several people that are playing in a frisbee game .

Top-5 Generated:

- a group of girls are playing a game of frisbee .
- a group of girls are playing a soccer game .
- a group of girls playing on a soccer game .
- a group of people playing a game of frisbee .
- the young people are playing a game of frisbee .

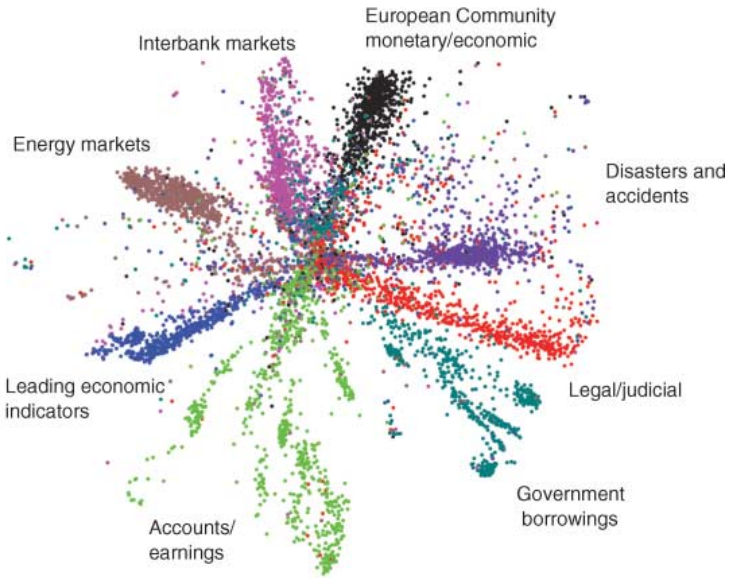
Given: dataset of Flickr images with captions

More examples at `http://deeplearning.cs.toronto.edu/i2t`

Unsupervised learning examples

Unsupervised learning: no labeled examples – instead, looking for interesting patterns in the data

E.g. visualization of documents; algorithm was given 800,000 newswire stories, and learned to represent these documents as points in two-dimensional space



Colors are based on human labels, but these weren't given to the algorithm

Unsupervised learning examples

Automatic mouse tracking

- When biologists do behavioral genetics researchers on mice, it's very time consuming for a person to sit and label everything a mouse does
- The Datta lab at Harvard is building a system for automatically tracking mouse behaviors
- Goal: show the researchers a summary of how much time different mice spend on various behaviors, so they can determine the effects of the genetic manipulations
- One of the major challenges is that we don't know the right "vocabulary" for describing the behaviors — clustering the observations into meaningful groups is an unsupervised learning task
- **(video)**

Reinforcement learning examples

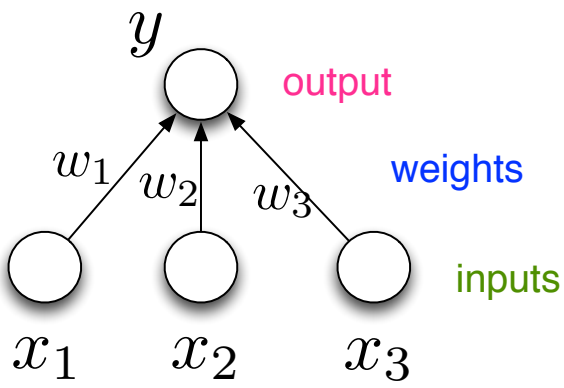
Reinforcement learning: learning system receives a reward signal, tries to learn to maximize the reward signal

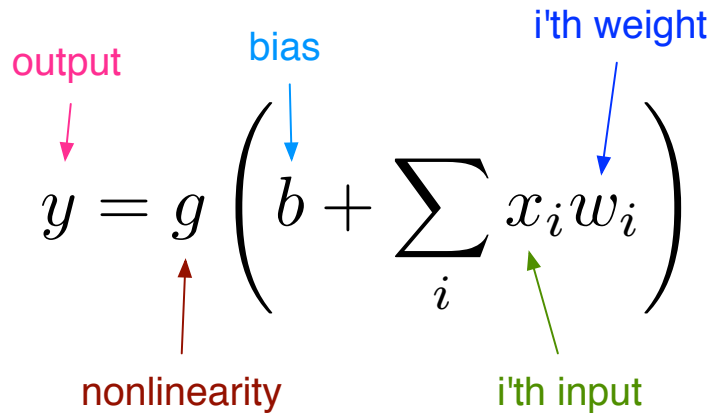
e.g. DeepMind's system which learned to play Atari games

- given raw screen as input, plus the score as the reward signal
- `https://www.youtube.com/watch?v=EfGD2qveGdQ`

What are neural networks?

- Most of the biological details aren't essential, so we use vastly simplified models of neurons.
- While neural nets originally drew inspiration from the brain, nowadays we mostly think about math, statistics, etc.





- Neural networks are collections of thousands (or millions) of these simple processing units that together perform useful computations.

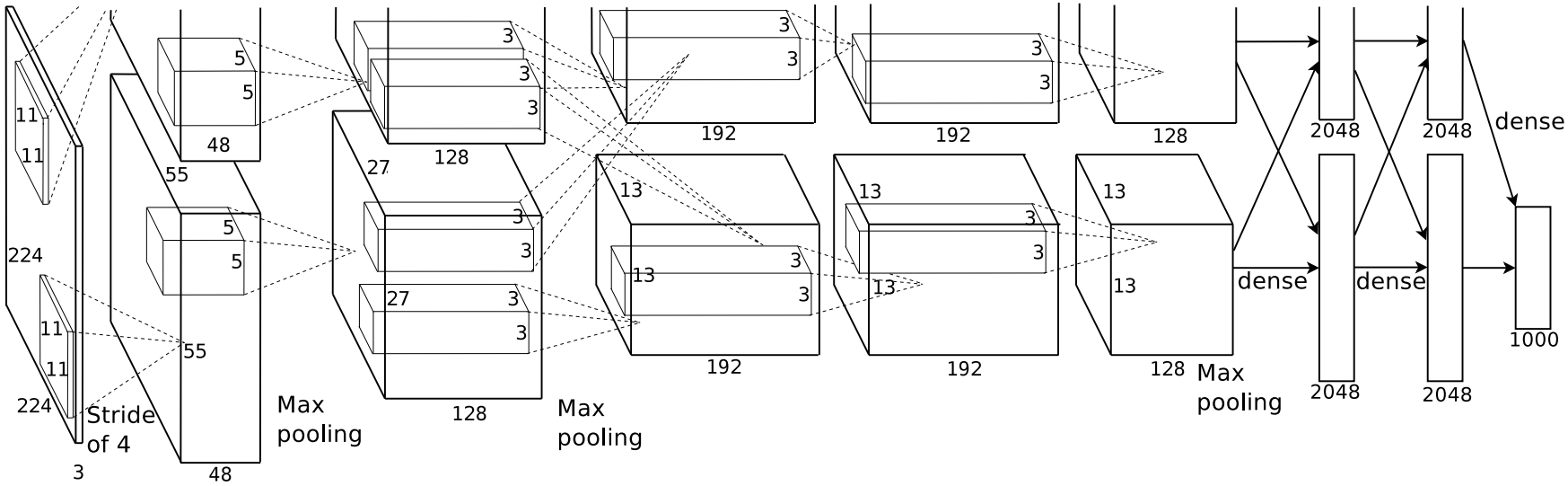
What are neural networks?

- Some near-synonyms for neural networks
  - "Deep learning"
    - Emphasizes that the algorithms often involve hierarchies with many stages of processing

"Deep learning"

Deep learning: many layers (stages) of processing

E.g. this network which recognizes objects in images:

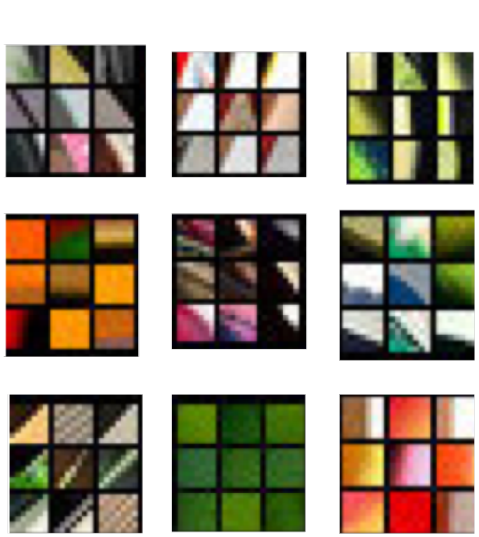


(Krizhevsky et al., 2012)

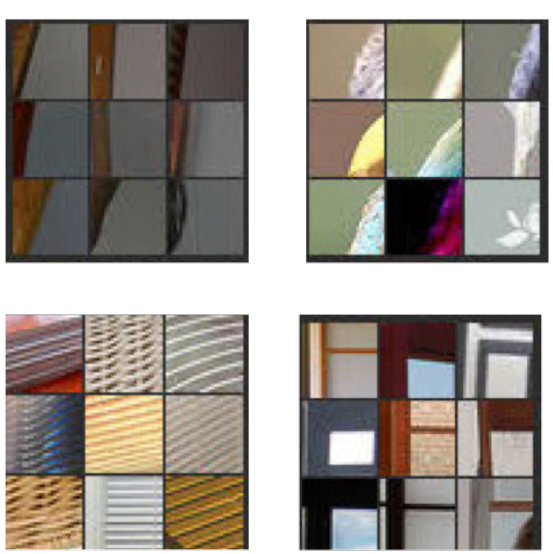
Each of the boxes consists of many neurons similar to the one on the previous slide!

"Deep learning"

Here are the image regions that most strongly activate various neurons at different layers of the network. (Zeiler and Fergus, 2014)



Layer 1



Layer 2

Layer 5

Higher layers capture more abstract semantic information.

What are neural networks?

- Some near-synonyms for neural networks
  - "Deep learning"
    - Emphasizes that the algorithms often involve hierarchies with many stages of processing
  - "Representation learning"
    - The algorithms typically map the raw data into some other space which makes the relationships between different things more explicit

What is a representation?

- In your past computer science courses, you may have learned about various data structures for representing words, documents, etc.
  - arrays of characters
  - dictionaries of word counts
  - tries (i.e. trees of prefixes)

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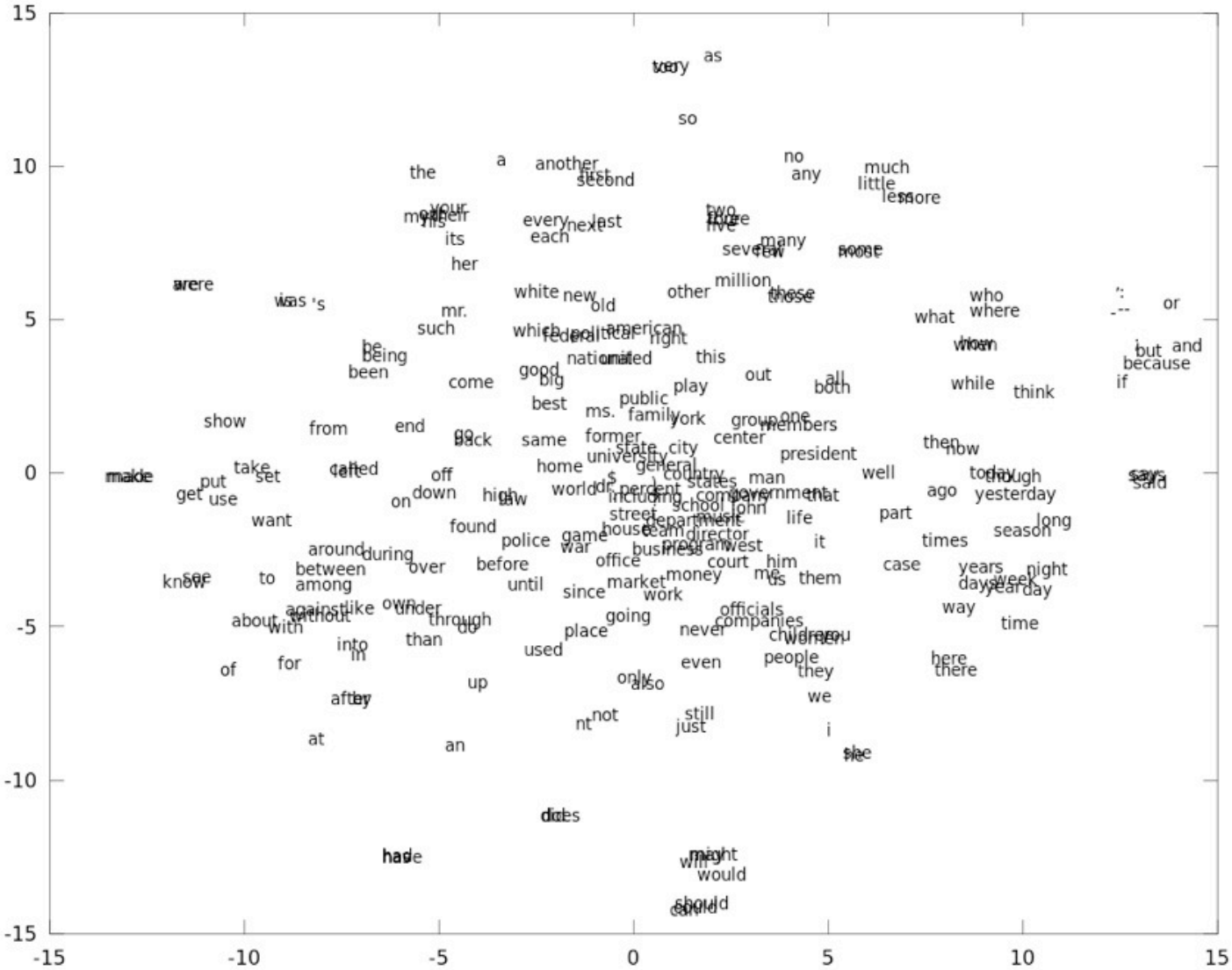
- How you represent your data determines what questions are easy to answer.
  - E.g. a dict of word counts is good for questions like "What is the most common word in *Hamlet*?"
- Simple data structures aren't enough to do higher-level semantic reasoning, e.g.
  - Did this reviewer like the book?
  - Alice liked *Harry Potter*. Will she like *The Hunger Games*?
  - Translate this book into French.

What is a representation?

We will discuss some algorithms for representing words as vectors.



What is a representation?

- In a good representation, mathematical relationships between the vectors should encode semantic relationships between the things we care about. For instance,
  - Measure similarity between words using the dot product of their vectors (or dissimilarity using Euclidean distance)
  - Represent a web page with the average of its word vectors
  - Complete analogies like "Paris is to France as London is to _____" by doing arithmetic on word vectors
- It's very hard to construct representations like these by hand, so we need to learn them from data
  - This is a big part of what neural nets do, whether it's supervised, unsupervised, or reinforcement learning!

Outline of course

- Weeks 1-8: supervised learning
- Weeks 9-11: unsupervised learning
- Week 12: reinforcement learning (maybe)
- Throughout the semester: learning representations of images and text

Reminders

- No tutorial this week
- Next lecture: linear regression, a simple learning algorithm
- Check out the web site for a detailed schedule
- Reminder: first two quizzes due 11:59pm next Monday