Outline

1. What is ML / ML research?
2. What’s hot?
3. What are particular institutions known for?
4. What is UCSD known for?
What is machine learning (ML)?

“What scientific discipline that is concerned with the design and development of algorithms that allow computers to change behavior based on data.” – Wikipedia.

- **Data**
  - Handwritten digits from USPS.
  - User interaction logs from Google.
  - Sensor readings from a robot.

- **Behavior**
  - Optical character recognition.
  - Targeted advertising.
  - Be like a human.
How can machines learn?

- Data = examples of (situation, behavior, outcome) triples.
- Infer a policy for what to do in different situations in order to effect the desired outcomes.
- Hopefully, policy generalizes to situations not previously encountered.
What is machine learning research?

• “Core” ML: develop algorithms for common learning tasks (e.g., classification, ranking, regression, reinforcement learning).
  
  – Often focus on different issues encountered in applications (e.g., prior knowledge, multiple tasks, sparse structure).

• Applied ML: develop algorithms for real applications (e.g., bio, information retrieval, NLP, robotics, speech, vision).
  
  – Sometimes also leads to advances in core ML.

• Theoretical ML: mathematical study of learning (e.g., generalization ability of learning algorithms, computational and representational complexity, game-theoretic analysis).
  
  – Goal is to inform development of core ML and applied ML.
What’s hot?

Some ML-related symposia and workshops from 23rd Annual Conference on Neural Information Processing Systems (NIPS):

- Analyzing networks and learning with graphs
- Applications for topic models: text and beyond
- Causality and time series
- Large-scale machine learning: parallelism and massive datasets
- Partially observable reinforcement learning
- Transfer learning for structured data
**Topic #1: Exploiting low-dimensional structure**

- Data increasingly high-dimensional.
  - Dimension = # features/variables describing each data point.
    - e.g., NLP: features = words; Bio: features = SNPs.
  - Curse of dimensionality: statistical and computational.

- But features often exhibit statistical dependencies or other structure that can be exploited.
  - Sparsity: only a few relevant features among many irrelevant ones.
  - Latent structure: the high-dimensional observed variables are the noisy / redundant manifestation of a few latent unobserved variables.

- What are the algorithms for discovering such structure? What statistical efficiency gains can be achieved?
Topic #2: Large-scale machine learning

- Lots of data being generated and collected.
  - Old days: \( \sim 10^4 \) examples, \( 10^2 \)-\( 10^3 \) features (say).
  - Now: e.g., Wikipedia, \( 3M \) articles, \( 25M \) links, \( 2M \) word vocab.
  - Cannot even compute a correlation matrix (\( \Omega(n^2) \) time/space). Many basic optimization routines (e.g. Newton's method) similar or worse.

- Which algorithms dominate in the data-laden regime?
  - e.g. First-order gradient descent vs second-order Newton method?

- How do we parallelize learning algorithms?
  - Split up examples across cores \( \rightarrow \) statistical efficiency suffers.
  - Split up variables across cores \( \rightarrow \) computational efficiency suffers.
What are particular institutions known for?

Top four schools in AI according to US News & World Report 2008:

1. MIT: the “AI” in “CSAIL” is “artificial intelligence” (see http://www.csail.mit.edu/node/3#AI).

2. CMU: machine learning department (see http://www.ml.cmu.edu/). Also departments for compbio, NLP, and robotics; Google on campus.


4. Berkeley: Bayesian methods, NLP, optimization, theory, vision, . . .

The gist: top schools have research in both core ML and applications.

Rest of top ten: UT Austin, UW, GIT, UIUC, UMD, UMass Amherst
Also industry (Facebook, Google, IBM, Microsoft, NEC, Yahoo!, . . .) and abroad (MPI, NICTA, Toronto, UCL, . . .)
What is UCSD known for?

ML spans several departments (CSE, ECE, CogSci, Neuroscience, . . . )

• Core ML, theory (Charles, Gert (ECE), Lawrence, Sanjoy, Yoav)
• Cognitive science and neuroscience (Gary, Nuno (ECE), . . . )
• Data mining (Charles)
• Speech and audio (Gert, Lawrence)
• Vision (David, Nuno, Serge)
• Other applications (Charles, Gert, Lawrence, Yoav, . . . )
• . . .

See http://ai.ucsd.edu/ for more.
What is UCSD known for?

Some BFDs:

• Charles: judge for the $1M Netflix competition.
• David: founded “Photometria” (virtual cosmetics company).
• Gary: pioneering work in neural networks and cognitive modeling.
• Sanjoy: co-author of popular algorithms textbook.
• Serge: founded “Digital Persona” (fingerprint tech company).
• Yoav: co-winner of Gödel and Kanellakis prizes for “AdaBoost”.
Questions?