Machine Learning overview
Chapter 19
What we will cover

• Some popular ML problems and algorithms
  – Take Machine Learning, Data Science, NLP, Computer Vision for more
  – Use online resources & experiment on your own

• We will focus on when/how to use techniques and only touch on how/why they work

• Basic ML methodology and evaluation

• Use various platform for examples & demos (e.g., scikit-learn, Weka, TensorFlow, PyTorch)
  – Great for exploration and learning
What is learning?

• Learning denotes changes in a system that ... enable a system to do the same task more efficiently the next time – Herbert Simon

• Learning is constructing or modifying representations of what is being experienced – Ryszard Michalski

• Learning is making useful changes in our minds – Marvin Minsky
Why study learning?

- **Discover** new things or structure previously unknown
  - Examples: data mining, scientific discovery
- **Fill in skeletal or incomplete specifications** in a domain
  - Large, complex systems can’t be completely built by hand & require dynamic updating to incorporate new info.
  - Learning new characteristics expands the domain or expertise and lessens the “brittleness” of the system
- **Acquire models directly from data** rather than by manual programming
- **Build agents** that can adapt to users, other agents, and their environment
- **Understand and improve efficiency of human learning**
AI and Learning Today

• 50s&60s: neural network learning popular
  Marvin Minsky did neural networks for his dissertation
• Mid 60s: replaced by paradigm of manually encoding & using symbolic knowledge
  Cf. Perceptrons, Minsky & Papert book showed limitations of perceptron model of neural networks
• 90s: more data & processing power drove interest in statistical machine learning techniques & data mining
• Now: machine learning techniques & big data play biggest driver in almost all successful AI systems
  … and neural networks are the current favorite approach

seeAlso: Timeline of machine learning
A man adjusting the random wiring network between the light sensors and association unit of scientist Frank Rosenblatt's Perceptron, or MARK 1 computer, at the Cornell Aeronautical Laboratory, Buffalo, New York, circa 1960. The machine is designed to use a type of artificial neural network, known as a perceptron.
Al Learning in the 1970s

Winston’s ARCH learning experiments ...

Marvin Minsky

First we need to understand how to program machines to be intelligent in some way, then we can take on the task of getting the to learn how to do it.
AI timelines show Machine Learning beginning to dominate in the early 2000s

1950: Alan Turing thinks up the Turing Test
1951: The term ‘artificial intelligence’ is coined
1956: The SNARC is built. It is the first neural net machine
1957: Chatbot ELIZA is demonstrated
1963: LISP program reads and solves word-based algebra problems
1964: ‘The Winter of AI’
1965: Machine learning theory is expounded
1967: MYCIN diagnoses infectious blood diseases
1970s: Neural network theory gains in popularity
1972: DART logistics planning application used by US military
1982: AI-based algorithms begin to be used in many vertical markets
1991: IBM’s DeepBlue beats world champion at chess
1997: IBM’s Watson wins US gameshow Jeopardy!
2000s: Google Brain describes a scene in a picture
2005: Google Brain recognises a picture of a cat
2011: Babel Fish machine translation tool released
2012: TensorFlow open source ML software library is released
2014: AI generalises learnt information across different environments
2015: AlphaGO Zero teaches itself to play Go
2016: Use of ML in medical diagnosis
2017: Pix2pix outputs images from drawings
2018: AI discovers a new planet – Kepler 90i
Google’s AIY Vision Kit ($89.99 at Target) is an intelligent camera that can recognize objects, detect faces and emotions. Download and use a variety of image recognition neural networks to customize the Vision Kit for your own creation. Included in the box: Raspberry Pi Zero WH, Pi Camera V2, Micro SD Card, Micro USB Cable, Push Button.

Currently $59.00 on Amazon
Machine Learning Successes

- Games: chess, go, poker
- Text sentiment analysis
- Email spam detection
- Recommender systems (e.g., Netflix, Amazon)
- Machine translation
- Speech understanding
- Siri, Alexa, Google Assistant, ...
- Autonomous vehicles
- Individual face recognition
- Understanding digital images
- Credit card fraud detection
- Showing annoying ads
Major Machine learning paradigms (1)

- **Rote**: 1-1 mapping from inputs to stored representation, learning by memorization, association-based storage & retrieval
- **Induction**: Use specific examples to reach general conclusions
- **Clustering**: Unsupervised discovery of natural groups in data
Major Machine learning paradigms (2)

• **Analogy:** Find correspondence between different representations
• **Discovery:** Unsupervised, specific goal not given
• **Genetic algorithms:** *Evolutionary* search techniques, based on *survival of the fittest*
• **Reinforcement:** Feedback (positive or negative reward) given at the end of a sequence of steps
• **Deep learning:** *Artificial neural networks* with *representation learning* for ML tasks
Types of learning problems

• **Supervised**: learn from training examples
  – Regression:
  – Classification: Decision Trees, SVM

• **Unsupervised**: learn w/o training examples
  – Clustering
  – Dimensionality reduction
  – Word embeddings

• **Reinforcement learning**: improve performance using feedback from actions taken

• Lots more we won’t cover
  – Hidden Markov models, Learning to rank, Semi-supervised learning, Active learning, ...
<table>
<thead>
<tr>
<th>Supervised Learning</th>
<th>Unsupervised Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrete</td>
<td></td>
</tr>
<tr>
<td>classification or categorization</td>
<td>clustering</td>
</tr>
<tr>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>regression</td>
<td>dimensionality reduction</td>
</tr>
</tbody>
</table>
Supervised learning

• Given training examples of inputs & corresponding outputs, produce “correct” outputs for new inputs

• Two important scenarios:

  – **Classification**: outputs typically labels (goodRisk, badRisk); learn decision boundary to separate classes

  – **Regression**: aka curve fitting or function approximation; Learn a continuous input-output mapping from examples, e.g., for a zip code, predict house sale price given its square footage
Unsupervised Learning

Given only *unlabeled* data as input, learn some sort of structure, e.g.:

- **Clustering**: group Facebook friends based on similarity of post texts and friends
- **Embeddings**: Find sets of words whose meanings are related (e.g., doctor, hospital)
- **Topic modeling**: Induce N topics and words most common in documents about each
Machine Learning

• ML’s significance in AI has gone up and down over the last 75 years
  – Today it’s very important for AI and data science

• Driving ML are three trends:
  – Cheaper and more powerful computing systems
  – Open-source ML tools (e.g., scikit-learn, TensorFlow)
  – Availability of large amounts of data

• Understanding ML concepts and tools allow many to use them with success