6.034
Learning: Nearest Neighbors

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AI Methods

- Problem solving
  - G+T, *search, optimal search, games, constraint satisfaction*
- Inference
  - *rule-based systems, Bayesian inference*
- Machine learning
  - k-nearest neighbors, id trees, neural nets, deep neural nets, support vector machines, genetic algorithms, near miss/one-shot
- Communication, perception, action
  - natural language processing, vision, robotics

Outline

- Models of learning
  - A rough view of the landscape
  - Nearest neighbors
    - Part identification
    - Arm control
    - Similarity: text, movies, etc.
- Sleep
  - *To sleep! perchance to dream;*

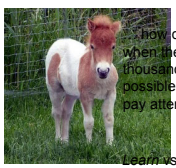
Hamlet, Act iii, scene 1

Major ideas

- Essence and accident
- Representation choice matters
- The power of the similarity heuristic

What's *essential* about being a dog and what's *incidental?*

… how do *we* figure that out?



… how do *we* do it when there are thousands of possible "things" to pay attention to?

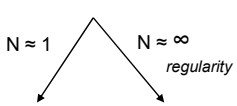
Learn vs memorize

Learn vs. memorize
↓ generalize ↓ just particular examples

Machine Learning Techniques

- Pattern recognition
- Neural networks
- Decision trees
- Support vector machines
- Clustering
- Reinforcement learning
- Genetic algorithms
- …

Machine Learning Techniques

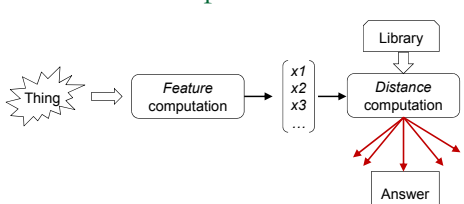


Human style learning

(humans require only a small amount of examples)

Pattern recognition
Neural networks
Decision trees
Support vector machines
Clustering
Reinforcement learning
…

Fundamental Operation

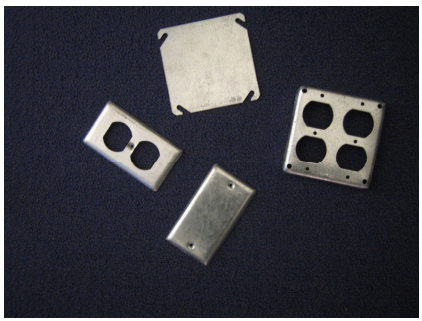


Fundamental Questions:
1) What *features*?
2) What *distance*?
3) (Why) did it work?

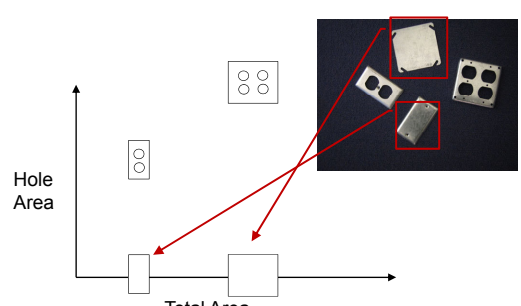
Features, Distance

- Features
  - Typically task specific (what I want to pay attention to)
- Distance
  - Euclidean : b/w vectors
  - …

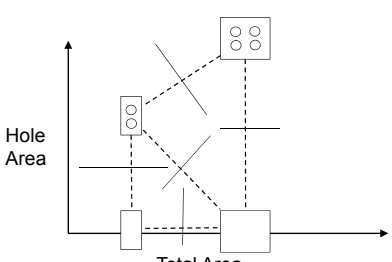
Motivating Example



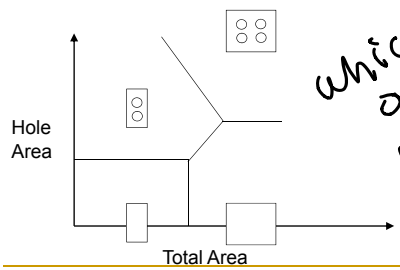
Representation Choice



Representation Choice



Representation Choice



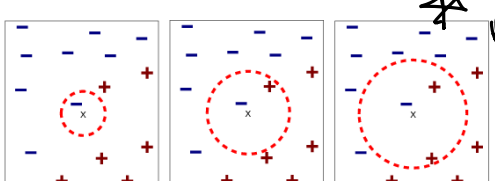
which one is it easiest to for category

- generalizing instead of memorizing

The Similarity Heuristic

- Things alike in some ways are likely to be alike in other ways as well.
  - Medical diagnosis
  - Legal reasoning
  - …

K-Nearest Neighbor

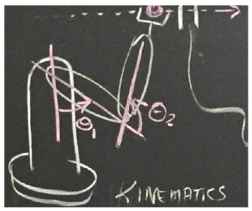


odd neighbors

* what if it is noisy?
* look @ 2 nearest neighbors
* but want odd # of neighbors to break ties

The Similarity Heuristic

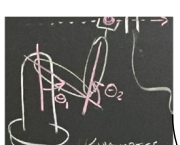
- Things alike in some ways are likely to be alike in other ways as well.
  - Medical diagnosis
  - Legal reasoning
  - …
  - Getting a robot to throw a baseball, play tennis



Two motors, sources of torque, t1, t2

$$\begin{aligned}\tau_1 =& \ddot{\theta}_1(I_1 + I_2 + m_2 l_1 l_2 \cos\theta_2 + \frac{m_1 l_1^2 + m_2 l_2^2}{4} + m_2 l_1^2) \\ &+ \ddot{\theta}_2(I_2 + \frac{m_2 l_2^2}{4} + \frac{m_2 l_1 l_2}{2}\cos\theta_2) \\ &- \dot{\theta}_2^2 \frac{m_2 l_1 l_2}{2}\sin\theta_2 \\ &- \dot{\theta}_1\dot{\theta}_2 m_2 l_1 l_2 \sin\theta_2, \\ \tau_2 =& \ddot{\theta}_1(I_2 + \frac{m_2 l_1 l_2}{2}\cos\theta_2 + \frac{m_2 l_2^2}{4}) \\ &+ \ddot{\theta}_2(I_2 + \frac{m_2 l_2^2}{4}) \\ &+ \dot{\theta}_1^2 \frac{m_2 l_1 l_2}{2}\sin\theta_2.\end{aligned}$$

Nearest Neighbors to the Rescue



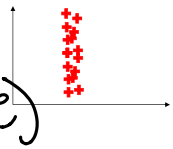
Ex.	Th1	Th2	Th1'	Th2'	Th1''	Th2''	T1	T2
1								
2								
3								
…								

Task-level robot learning, Eric Aboaf, MIT, 1988

Ipadtabsall game getting better over time)

Difficulties

- Narrow spread of values
  - Normalize
  - $Z = \frac{x_i - \mu}{\sigma}$ (z score)



- What if your features are wrong?

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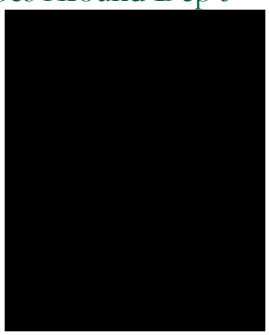
What Goes Around Dep't



Playing Atari with Deep Reinforcement Learning, 2013.

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Caveats

The most important thing to know is that all the agent is given is sensory input (what you see on the screen) and it was ordered to maximize the score on the screen.

No domain knowledge is involved! This means that the algorithm doesn't know the concept of a ball or what the controls exactly do.

- *"magic"?!*
- "realizes", "tunnel", "wall" ??

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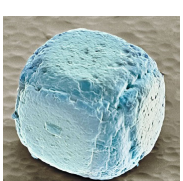
Dealing with exaggeration



"Take it with a grain of salt"
(Means: Be skeptical)

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Looking Ahead

One-Shot learning

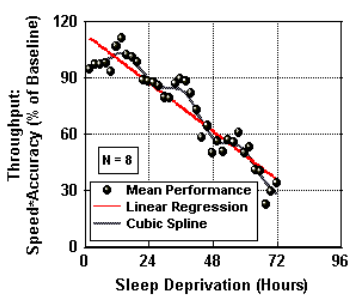
Human-level concept learning through probabilistic program induction
Lake, Salakhutdinov, Tenenbaum
Science, Dec 2015

learn alot from very few examples

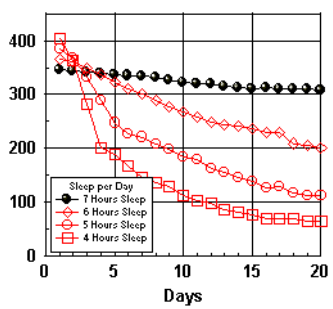
And now for something completely different…

A little health advice, seriously

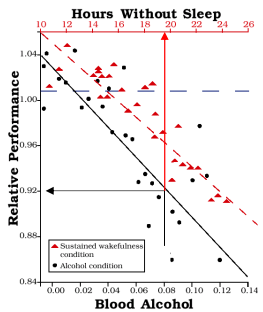
Loss of Sleep Degrades Cognition



Sleep Loss Accumulates



You might as well go in *drunk*



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What can you do??

- Take a nap.

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The Army Rolls Out a New Weapon: Strategic Napping

Because fatigue can corrode mission performance, a new physical training manual tells soldiers to grab 40 winks when they can, part of a new holistic approach to health in the ranks.

By Dave Philipps, *New York Times*
Oct. 1, 2020, 5:00 a.m. ET

Changing schedules, long duty shifts and overnight missions led to chronic fatigue that fueled a voracious dependency on energy drinks

The new guidance comes as the military has become increasingly aware that chronic sleep deprivation during missions can cripple decision-making and lead to disaster. The Navy recently overhauled sleep schedules at sea after determining that fatigue was a factor in two fatal warship collisions.

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