

6.034  
**Learning:  
 Nearest Neighbors**

Randall Davis





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Outline


- Models of problem solving
- 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*


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Major ideas


- ★ Representation choice matters
- ★ The power of the similarity heuristic
- ★ Credit assignment
- ★ The remarkable power of sleep


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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?

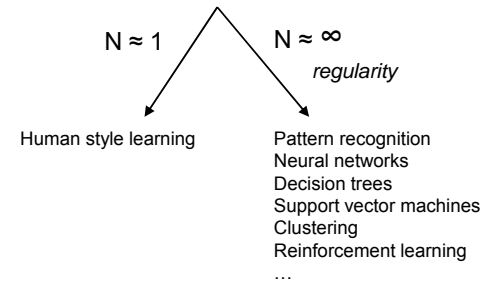
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## Machine Learning Techniques

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

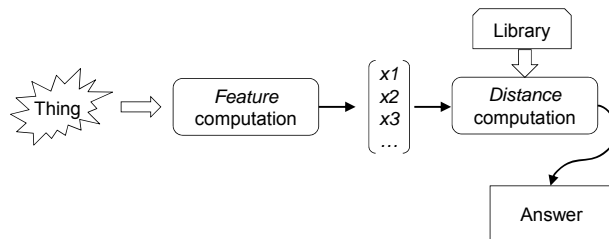
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## Machine Learning Techniques



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## Fundamental Operation



Fundamental Questions:

- 1) What *features*?
- 2) What *distance*?
- 3) (*Why*) *did it work*?

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## Aside

- Credit Assignment

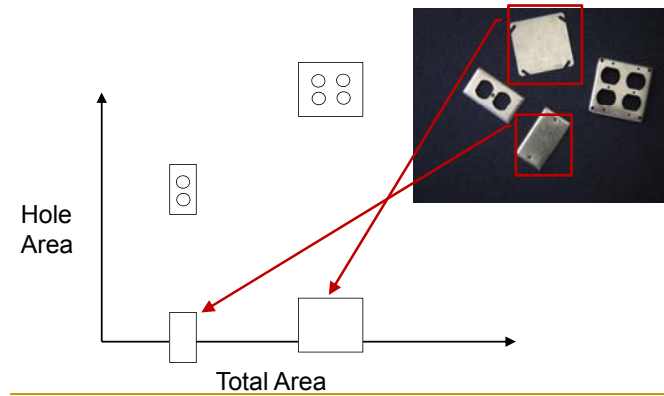
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## NN Motivating Example



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## Representation Choice

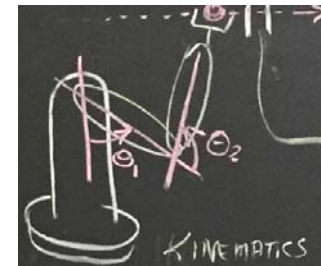


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## The Similarity Heuristic

- 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

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Two motors, sources of torque,  $t_1, t_2$

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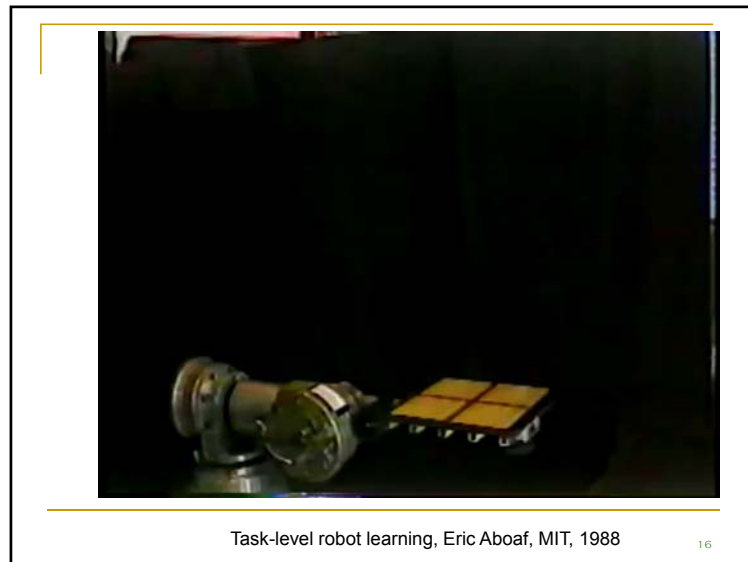
$$\begin{aligned} \tau_1 = & \ddot{\theta}_1 (I_1 + I_2 + m_2 l_1 l_2 \cos \theta_2 + \frac{m_1 l_1^2 + m_2 l_2^2}{4} + m_2 l_1^2) \\ & + \ddot{\theta}_2 (I_2 + \frac{m_2 l_2^2}{4} + \frac{m_2 l_1 l_2}{2} \cos \theta_2) \\ & - \dot{\theta}_2^2 \frac{m_2 l_1 l_2}{2} \sin \theta_2 \\ & - \dot{\theta}_1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

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### Nearest Neighbors to the Rescue

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

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

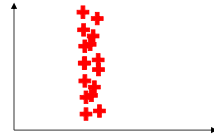
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- ### Could this work in people?
- Back of the envelope/sanity check
    - bytes per entry in table?
      - 100
    - Number of joints?                      Need 10<sup>11</sup> bytes
      - 100
    - Number of segments                      Is your brain up to it?
      - 100
    - Number of pitches                              10<sup>10</sup> neurons
      - 100
    - Number of days                                      10<sup>11</sup> in cerebellum
      - 100
    - Number of years                                      Synapses: ~10<sup>5</sup>
      - 10

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## Difficulties

- Narrow spread of values
  - Normalize
- What if your features are wrong?



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## What Goes Around Dep't: 2013



Playing Atari with Deep Reinforcement Learning, 2013.

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## Caveats

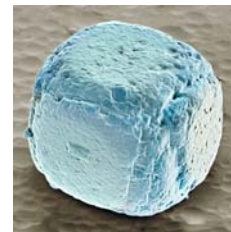
**The most important thing to know is that all the agent is given is sensory input (what you see on the screen) and it was ordered to maximize the score on the screen.**

**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

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### One-Shot learning

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

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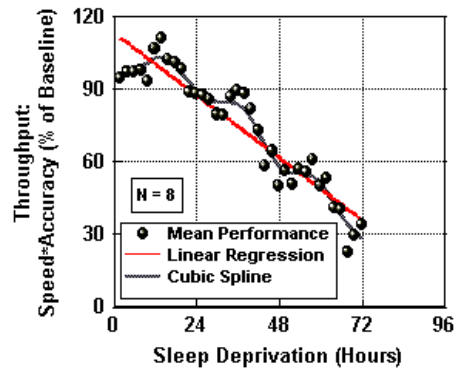
I'd now for something completely different...

A little health advice, seriously



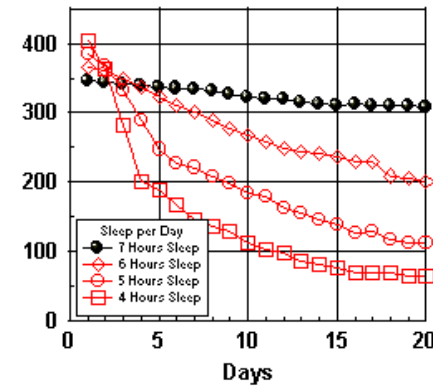
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### Loss of Sleep Degrades Cognition



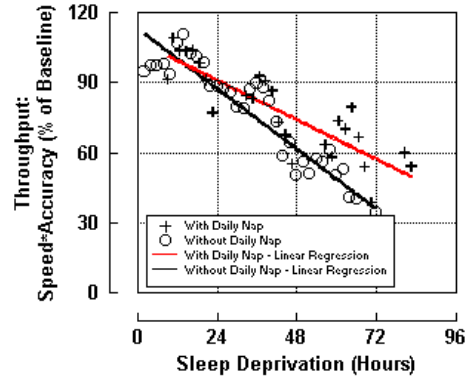
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### Sleep Loss Accumulates



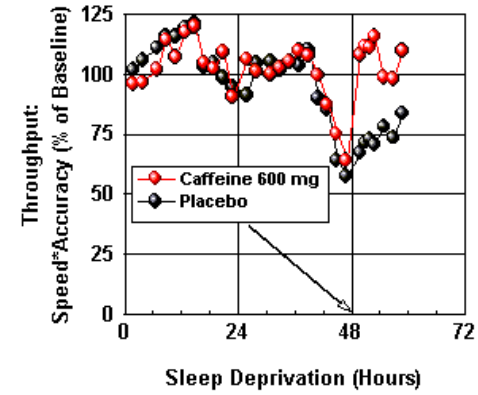
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## Naps Help



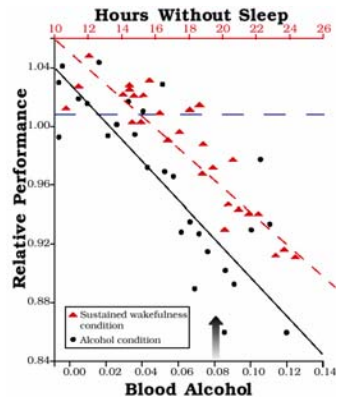
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## Caffeine Helps



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## You might as well go in *drunk*



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