Artificial intelligence

COS 116: 4/26/2007

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Artificial Intelligence

- Definition of AI (Merriam-Webster):
  - The capability of a machine to imitate intelligent human behavior
  - Branch of computer science dealing with the simulation of intelligent behavior in computers
- Learning:
  - To gain knowledge or understanding of or skill in by study, instruction, or experience
  - Machine learning (last lecture) - branch of AI

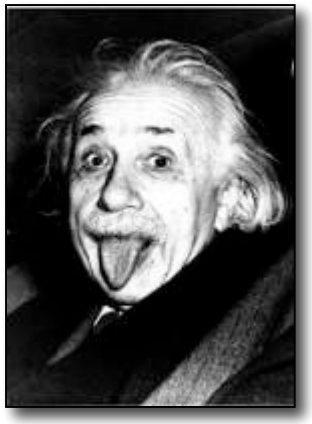
Intelligence in animal world

Is an ant intelligent?

- Build huge, well-structured colonies organized using chemical-based messaging (“Super-organism”)

What about dogs?

Deep mystery: How do higher animals (including humans) learn?

How does  become 

A crude first explanation: Behaviorism [Pavlov 1890's, Skinner 1930's]

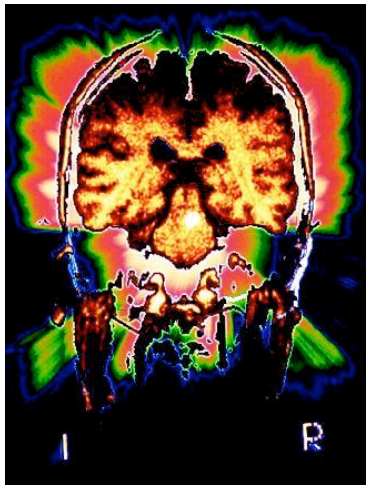
- Animals and humans can be understood in a "black box" way as a sum total of all direct conditioning events
- Bell → "Food is coming" →Salivate

- "This person likes me more if I call her "Mama" and that one likes me more if I call him "Papa".

Aside: What does behaviorism imply for societal organization?

More thoughts on behaviorism

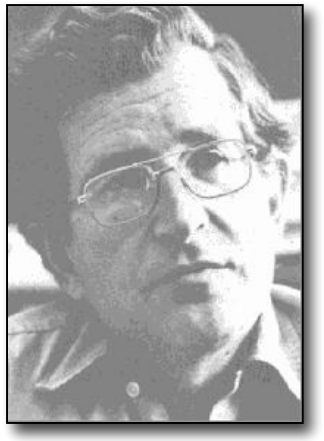
Original motivation: Cannot look inside the working brain anyway, so theory that assumes anything about its working is not scientific or testable.



Today

Little insight into how to design machines with intelligence. How did dogs, rats, humans sort through sensory experiences to understand reward/punishment?

Chomsky's influential critique of Behaviorism [1957]



- "Internal mental structures crucial for learning."

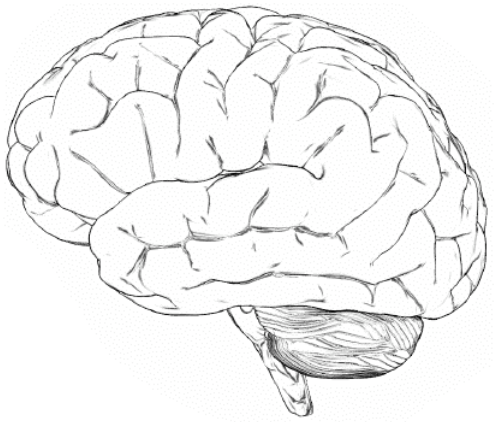
  Evidence: universal linguistic rules ("Chomsky grammars"); "self-correction" in language learning, ability to appreciate puns.

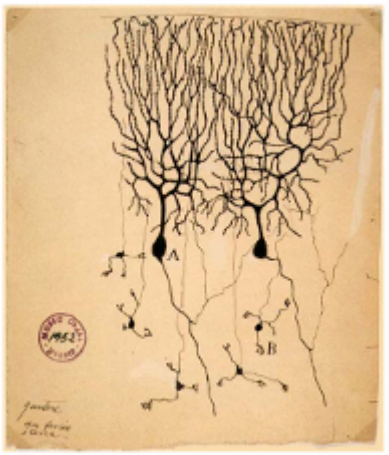
1. Brain is "prewired" for language.
2. Must understand mental structures to understand behavior

Presenting:

Your brain

The brain

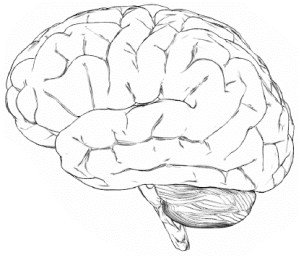




- Network of 100 billion neurons
- Evidence of timing mechanisms (“clock”)
- About 100 firings per second
  - Total of 10^{13} firings (“operations”) per second
  - Number of operations per sec in fast desktop PC: 10^{10}
  - Kurzweil predicts PC will match brain computationally by 2020

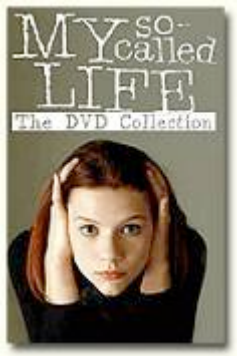
A comparison

Your brain



10^{11} neurons

Your life on a DVD



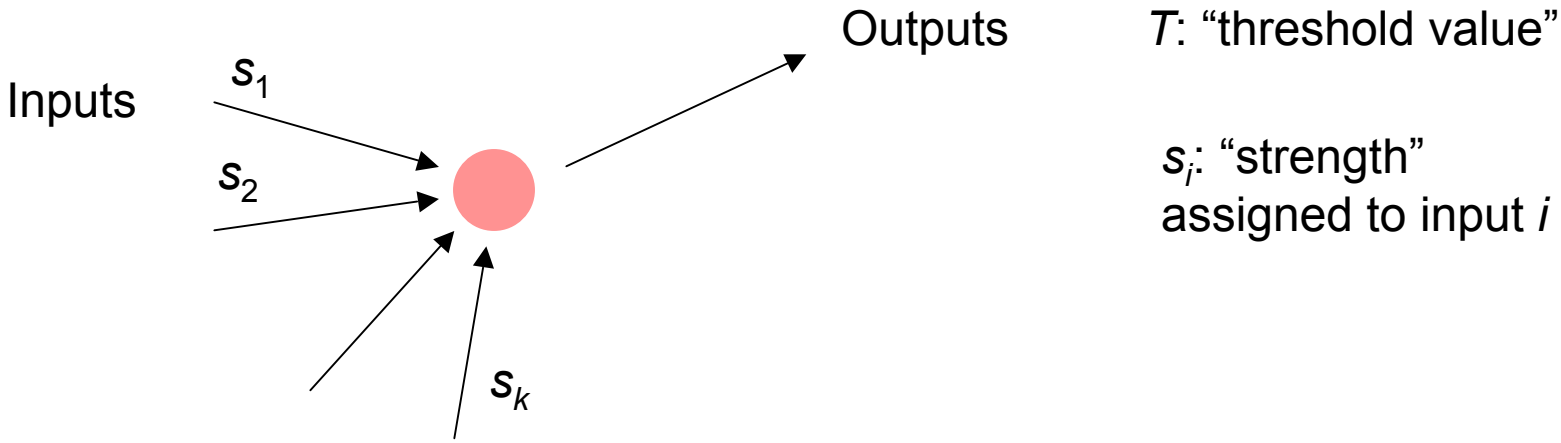
4.3 Gb for 3 hours

> 10^{17} bytes for entire life

Conclusion: Brain must contain structures that compress information and store it in an interconnected way for quick associations and retrieval

A simplistic model of neurons—Neural Net [McCulloch – Pitts 1943]

- Neuron computes "thresholds"



- Take the sum of strengths of all neighbors that are firing
- If sum > *T*, fire

Does a neural network model remind you of something??

Why AI is feasible in principle: the simulation argument

- Write a simulation program that simulates all 10^{11} neurons in the brain and their firings.
- For good measure, also simulates underlying chemistry, blood flow, etc.
- Practical difficulty: How to figure out properties (threshold value, s_i) of each of 10^{10} neurons, the intricate chemistry

Hope

Maybe the brain is organized around simpler principles.

A machine's "experience" of world

- *n* sensors, each produces a numeric "experience" = an array of *n* numbers
- Example: video camera: 480 x 640 pixels
  $n = 480 \times 640 = 307200$
- In practice, reduce *n* via compression or preprocessing

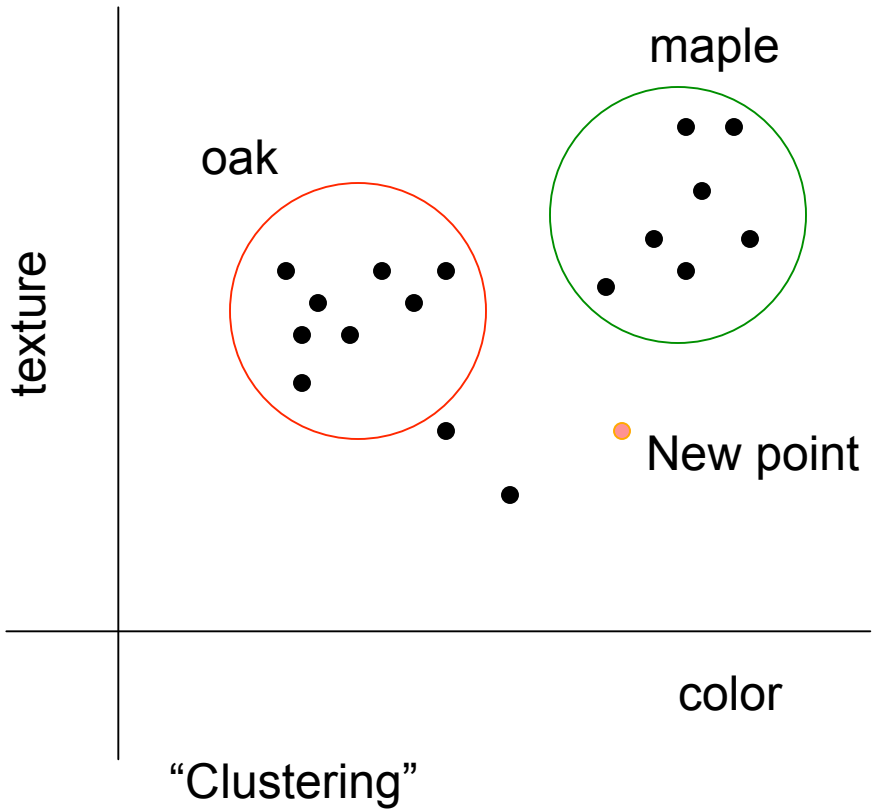
Example: Representing wood samples

Brownness scale	1	…	10
	light		dark
Texture scale	1	…	10
	smooth		rough

(3, 7) = wood that is fairly light brown but kind of on the rough side

A learning task and its mathematical formulation

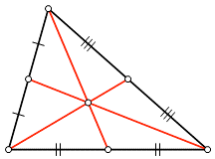
- Given: 100 samples of oak, maple
- Figure out labeling ("clustering")
- Given a new sample, classify it as oak, maple, or mahogany



An algorithm to produce 2 clusters

- Start with some notions:
  - Mean of k points $(x_1, y_1), (x_2, y_2), \ldots, (x_k, y_k)$ is

$$\left(\frac{x_1 + x_2 + \ldots + x_k}{k}, \frac{y_1 + y_2 + \ldots + y_k}{k} \right)$$



("center of mass")

  - Distance between points $(x_1, y_1), (x_2, y_2)$ is $\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$

2-means Algorithm (cont.)

1. Start by randomly breaking points into 2 clusters
2. Repeat many times:

{

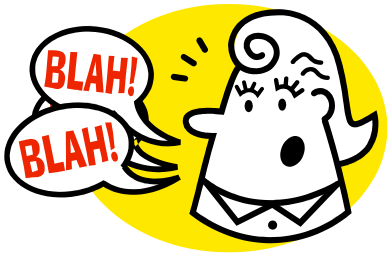
- Compute means of the current two clusters
- Reassign each point to the cluster whose mean is closest to it; this changes the clustering

}

This is *heuristic* -- the clustering is not guaranteed to be optimal but generally works well.

What about learning something more dynamic?

- Speech?



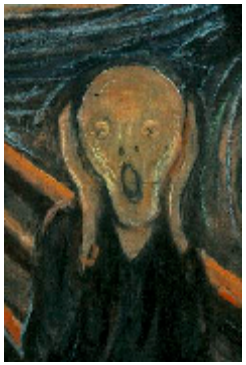
- Motion?

Similar data representation

- Handwriting?

One major idea: modeling uncertainty using probabilities

- Example: Did I just hear
  "Ice cream" or "I scream"?



- Assign probability ½ to each

- Listen for subsequent phoneme
  - If "is", use knowledge of usage patterns to increase probability of "Ice cream" to 0.9

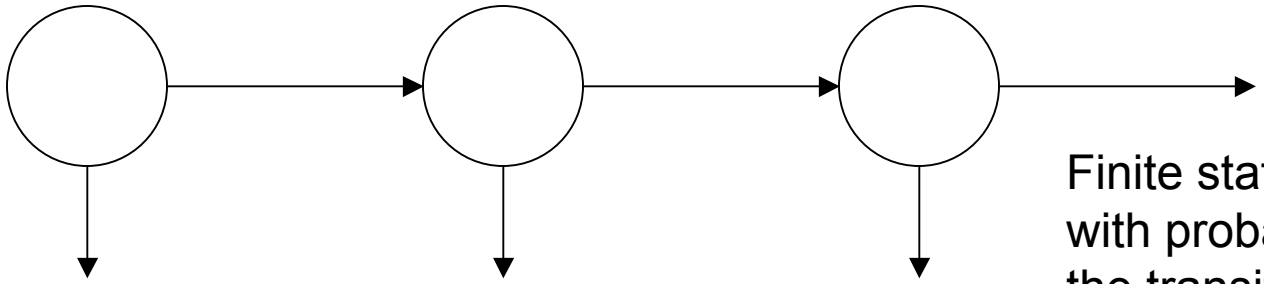
Probabilities + states: Markov models

- Markov decision process
- Hidden Markov models

Are “learnt” by machine after extensive training.
(Condensed representation of data corpus)

Rough overview of speech recognition

- Markovian model of language (machine's idea of how language is produced)



- Estimate model parameters using data corpus + user training

Homework: Turing test

- Turinghub.com
- Randomly assigns you to chat with a machine or a human
- Note: Machine cannot possibly store answers to all possible 5-minute conversations!