Introduction to Computer Science
Lecture 10: Artificial Intelligence

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What is AI?

Cognitive Science	LogicistIs that human?
Think like humans	Think rationally
Act like humans	Act rationally

Turing (1950) Test

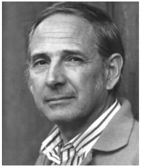
Eliza: chayden.net/eliza/Eliza.html
www.jabberwacky.com

Natural language processing
Knowledge representation
Automated reasoning
Machine learning

Rational Agent

Strong AI vs. Weak AI

- Weak AI
  - Machines can be programmed to exhibit intelligent behavior.
- Strong AI
  - Machines can be programmed to possess intelligence and consciousness.
- John Searle's Chinese room argument.



Levels of Intelligent Behaviors

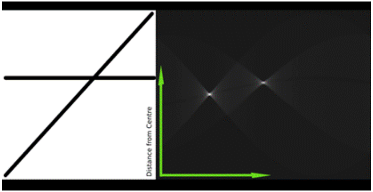
- Reflex: actions are predetermined responses to the input data
- More intelligent behavior requires knowledge of the environment and involves such activities as:
  - Goal seeking
  - Learning

Research Approaches in AI

- Performance oriented
  - Engineering track
  - To maximize the performance of the agents.
- Simulation oriented
  - Theoretical track
  - To understand how the agents produce responses.

Understanding Images

- Template matching
- Image processing
  - edge enhancement
  - region finding
  - smoothing
- Image analysis
  - Hough transformation (line, circles)



Natural Language Processing

- Syntactic analysis
  - Mary gave John a birthday card. Subject: Mary
  - John got a birthday card. Subject: John
- Semantic analysis, contextual analysis
  - John drove me home.
  - John drove me crazy.

  - The pigpen was built by the barn.
  - The pigpen was built by the farmer.

  - Do you know what time it is?

Natural Language Processing (contd.)

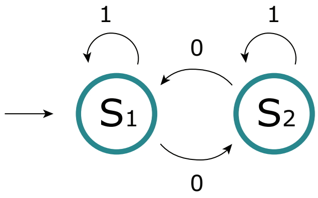
- Information retrieval / extraction
  - I've got a solution to your problem.
  - Shoot.
  - Right.

  - How was your date last night?
  - He/She has a good personality.

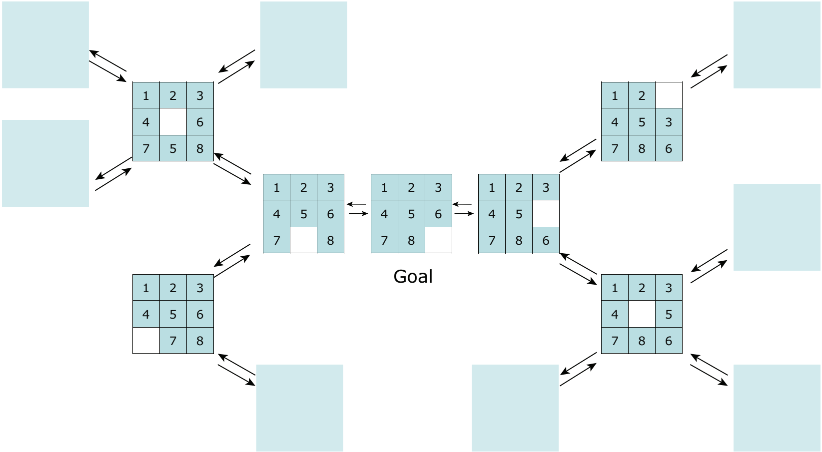
  - You can count on me.
  - Ya, right. That's comforting.

Reasoning

- Production systems
  - Collection of states including initial state & goal state(s)
  - Collection of productions: rules or moves
  - Each production may have preconditions
  - Control system: decides which production to apply next
- Recall prolog
- Similar to finite state automata



Search a Production System

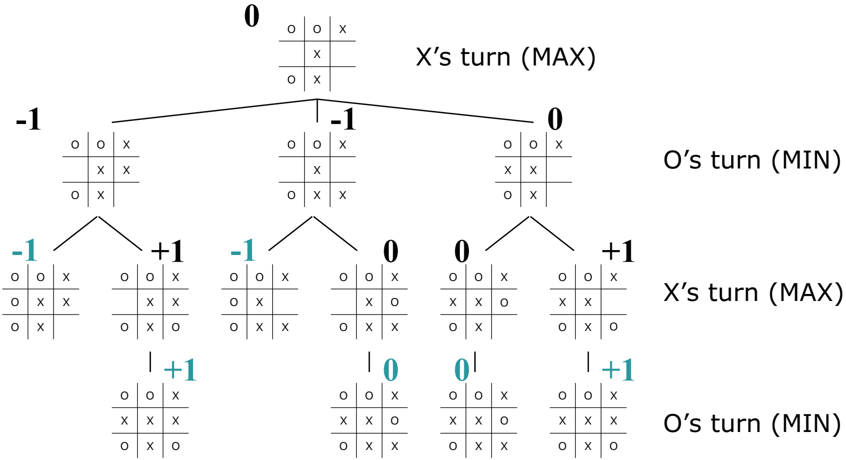


Computer Game Playing

- Let's meet an old friend
  - Tic-tac-toe

○	○	×
	×	
	×	

Game Tree & Minimax Search



Heuristic

- For most games, a complete search is practically impossible.
  - Chess $\sim 10^{47}$; Chinese chess $\sim 10^{48}$; Go $\sim 10^{171}$
- A quantitative estimate of the distance to a goal is needed.
- Requirements for good heuristics
  - Much easier to compute than a complete solution
  - Reasonable estimate of proximity to a goal

Let's Define a Heuristic

XX_	100
X__	10
___	0
OX*	0
O__	-10
OO_	-100

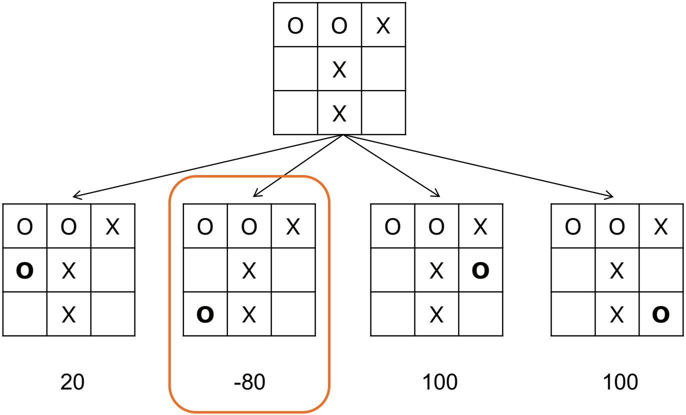
O	O	X
	X	
	X	

$\longrightarrow$

0+10+10-10+0+10+0+100 = 120

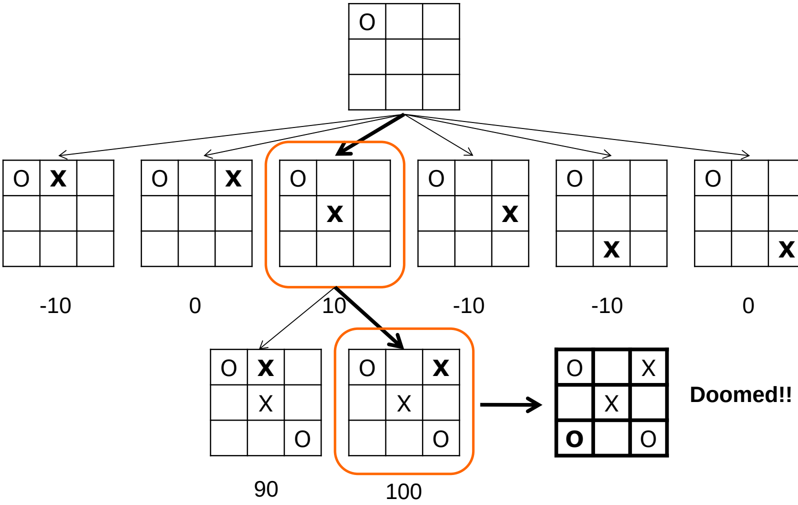
The board favors X

Does It Work?



This is the best choice for O based on our heuristic.

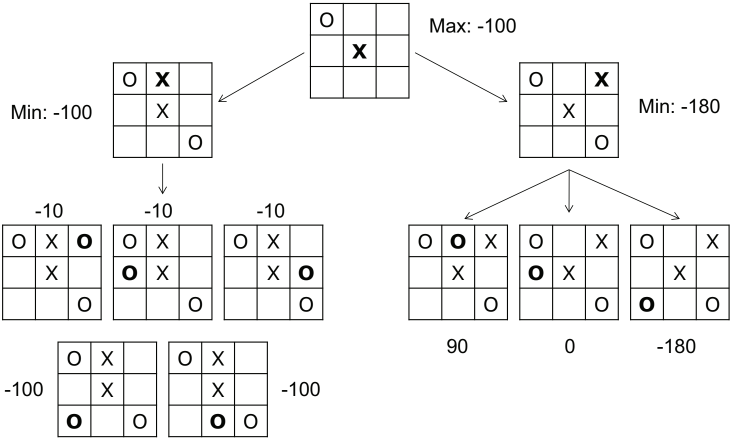
How About This?



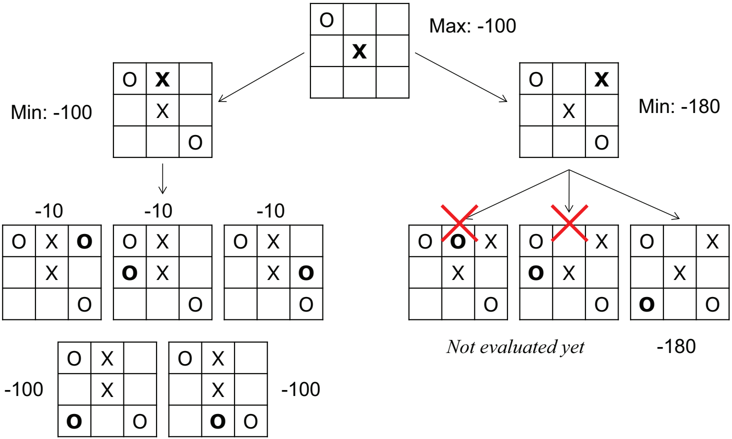
What's Wrong?

- Heuristics are not perfect
  - Otherwise, we'd call them solutions
- Heuristics are usually more accurate toward the end of the game.
- Need some search procedure for more accurate estimation.

Heuristic + Minimax Search



Alpha-Beta Pruning

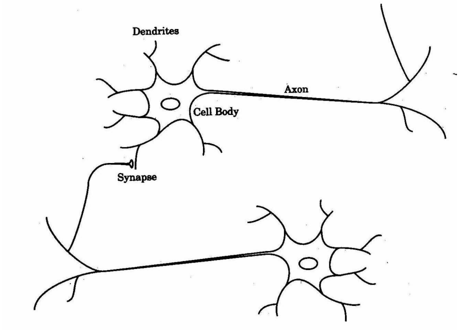


Learning

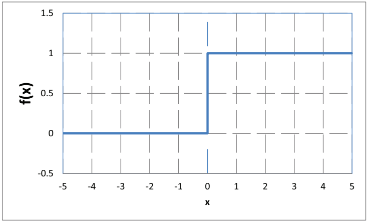
- Supervised vs. unsupervised
- Supervised
  - Learning by provided examples
  - Imitation
  - Parameter tuning
- Unsupervised
  - Learning by experiences
  - Reinforcement
  - Evolutionary (semi-supervised)

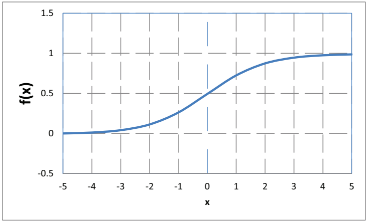
Artificial Neural Networks

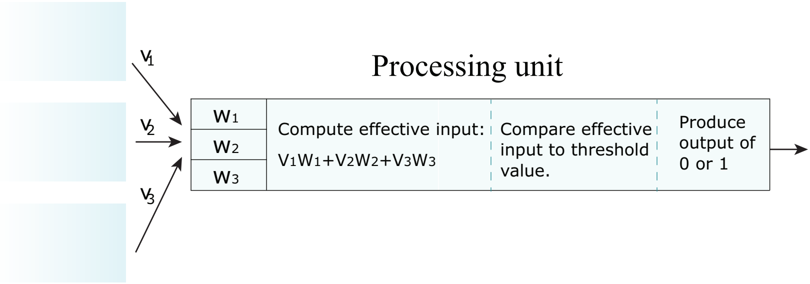
- Human brain
  - 10^{11} neurons
  - 10^{14} synapses



Perceptron



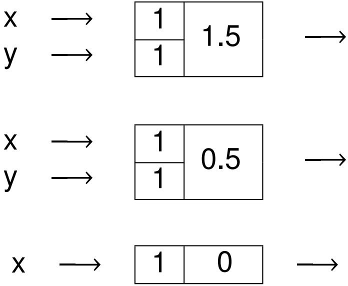


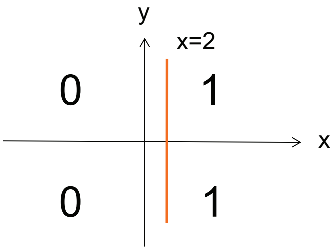


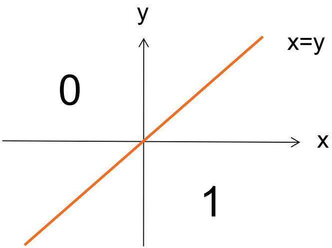
1 *iff* greater than or equal to the threshold

Some Building Blocks

- AND
- OR
- SIGN



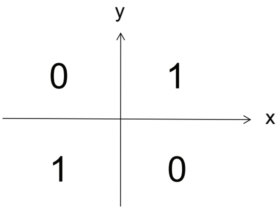


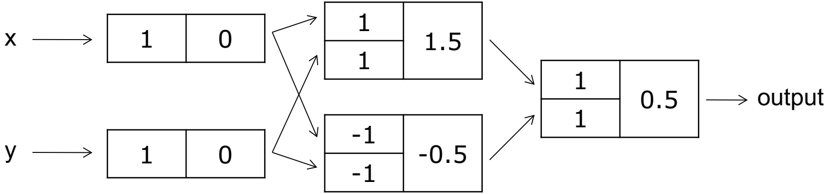


x $\longrightarrow$ $\boxed{1 \mid 2}$ $\longrightarrow$ output

x $\longrightarrow$, y $\longrightarrow$ $\boxed{\begin{array}{c|c} 1 & \\ \hline -1 & 0 \end{array}}$ $\longrightarrow$ output

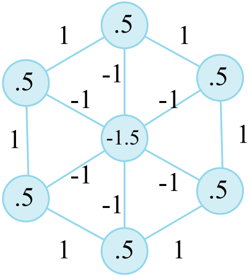
The XOR Problem





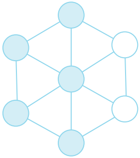
Associative Memory

- Content addressable



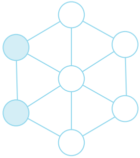
How Does It Work

a.



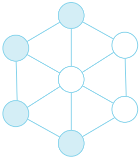
Start: All but the right-most units are excited

b.



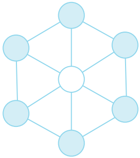
Step 1: Only the leftmost units remain excited

c.



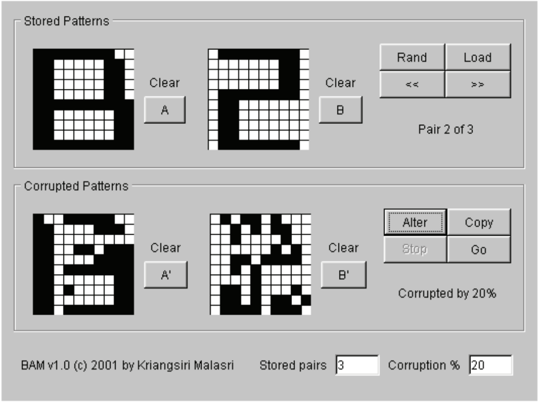
Step 2: The top and bottom units become excited

d.



Final: All the units on the perimeter are excited

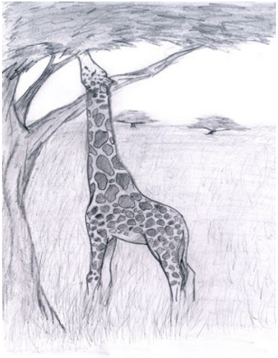
Example



BAM applet: http://www.cbu.edu/~pong/ai/bam/bamapplet.html

Darwin's Theory of Evolution

- Evolution
  - The change in populations of organisms over generations.
- Darwin's idea: Natural selection
  - Struggle to survive
  - Survival of the fittest
  - Genetic variation: inherited traits



Black-Box Optimization

$$x \longrightarrow \boxed{f} \longrightarrow y$$

- Finding the x that yields the highest y with an unknown f
- Evolving the giraffe that is the fittest in an unknown environment.
- Instead of finding a solution, let's evolve a solution.

(1+1) Evolutionary Strategy

- Simplest evolutionary strategy

- One parent: n-dimension real vector, $P = (p_1, ..., p_n)$
- Generate one child by mutation: $C = (c_1, ..., c_n)$
  - $c_i = p_i + N(0, \sigma^2)$
- Replace P by C if C is better.
- Modify σ according to the replacement rate r.
  - One fifth rule

1/5 Rule Intuition

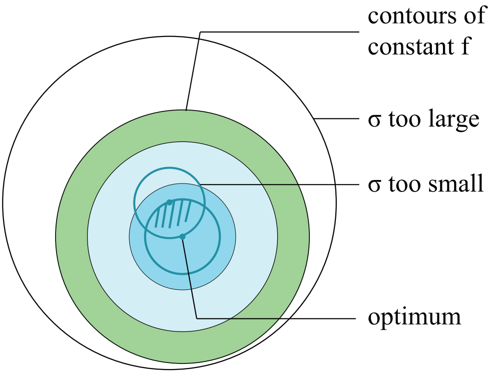
- $\sigma \leftarrow \sigma / C^{1/n}$, *if* $r > \Theta$
- $\sigma \leftarrow \sigma \cdot C^{1/n}$, *if* $r < \Theta$

- If replacement rate high, not exploring enough → increase step size.

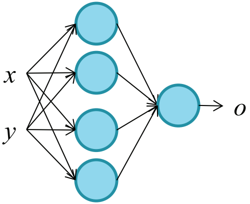
- If replacement rate low, too daring → reduce step size.

- $\Theta = 1/5$ (Guessed by Rechenberg) and $C = 0.817$ (Progress analysis by Schwefel)

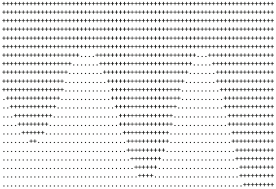
Visualization of 1/5 Rule

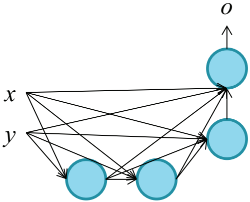


Training NN with (1+1)ES

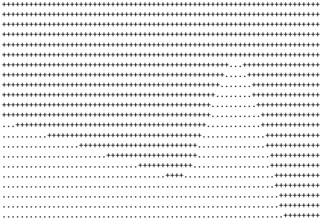


Target:

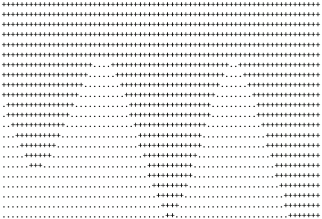




5 neurons, 17 parameters



4 neurons, 18 parameters



Total Differences: 172(123.084600)/1540