



# Introduction to Computer Science

Polly Huang  
NTU EE

<http://homepage.ntu.edu.tw/~pollyhuang>  
[pollyhuang@ntu.edu.tw](mailto:pollyhuang@ntu.edu.tw)



# Chapter 11

## Artificial Intelligence

# Chapter 11: Artificial Intelligence

- ☀ 11.1 Intelligence and Machines
- ☀ 11.2 Understanding Images
- ☀ 11.3 Reasoning
- ☀ 11.5 Artificial Neural Networks
- ☀ 11.4 Other Areas of Research
- ☀ 11.6 Robotics
- ☀ 11.7 Considering the Consequences

## Computer vs. Human

- ☀ Machine
  - Performs precisely defined tasks with speed and accuracy
  - Not gifted with common sense
- ☀ Human
  - Capable of understanding and reasoning
  - More likely to understand the results and determine what to do next
  - Not gifted with complex computations

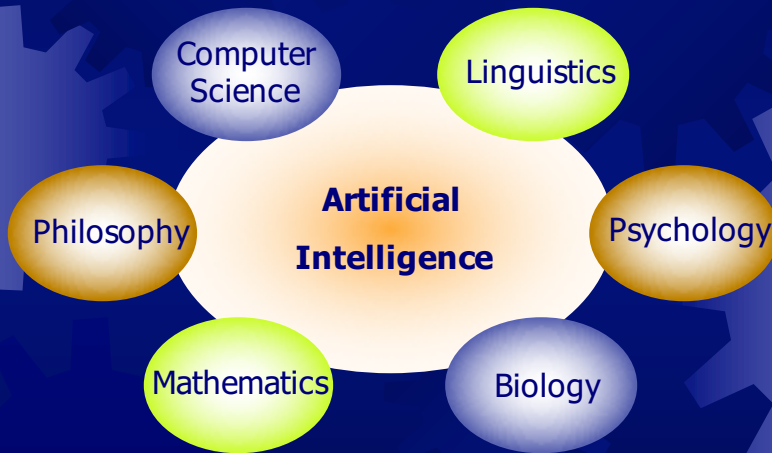
# Humanlike Computer

- ☀ The ideal hybrid
  - Continue without human intervention when faced with unforeseen situations
  - Possess or simulate the ability to reason
  - Psychologists and their models may be helpful

# Intelligent Agents

- ☀ **Agent**
  - **Device** that responds to stimuli from its environment
    - Sensors: to receive stimuli
    - Actuators: to react
- ☀ The goal of artificial intelligence
  - To build agents that behave **intelligently**

## Related Fields



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## AI Research Approaches

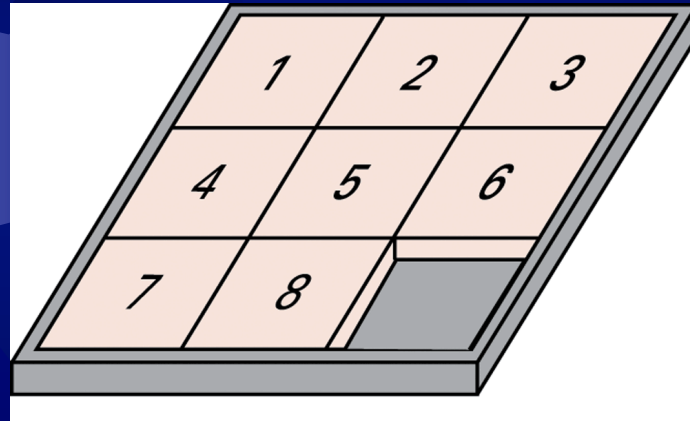
- ☀ Performance oriented
  - Researcher tries to maximize the performance of the agents
  - **Just do it**
    - Exhaustive search, probabilistic deduction
  - Computer scientists approach
- ☀ Simulation oriented
  - Researcher tries to understand how the agents produce responses.
  - **Wait, let me figure what's going on first**
    - Heuristic search, classification
  - Psychologists approach

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# The Eight Puzzle Problem

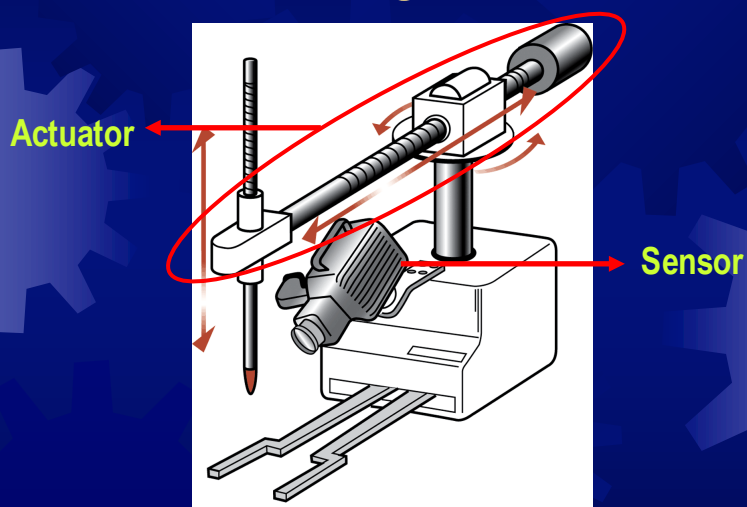


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# Puzzle-Solving Machine



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## Issues Involved

- ☀ Sensor – Camera
  - Understanding the images (11.2)
  - Finding a solution (11.3)
- ☀ Actuator
  - Based on the solution
  - Move arms to slide the tiles (Robotics 11.6)

## Levels of Intelligence: Not Really Intelligent

- ☀ Weak AI
  - 1. Reflex
    - Actions are fixed and predetermined
  - 2. Context aware
    - Actions affected by knowledge of the environment
    - Context information

## Levels of Intelligence: Trying to be Really Intelligent

### ☀ Strong AI

- 3. Goal seeking
  - Search for a solution
  - Key: efficient searching
- 4. Learning
  - Deduce from experience
  - Key: identifying majority

## Turing Test

- ☀ Proposed by Alan Turing in 1950
- ☀ Benchmark for progress in artificial intelligence
  - Human interrogator communicates with test subject by **typewriter**
  - Can the human interrogator distinguish whether the test subject is human or machine?

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# Understanding Images

## Computer Vision

- ☀ Template matching
  - Compare two bitmaps
  - Ex. recognizing well-formed characters
- ☀ Image processing
  - Consider characters by the common shape
  - Ex. recognizing hand-written characters
    - Edge enhancement
    - Region finding
    - Smoothing
- ☀ Image analysis
  - Guess what partial, obstructed objects are
  - Ex. recognizing what the image means



# Production Systems

- ☀ Capturing common characteristics of reasoning problems

## 1. Collection of **states**

- Start or initial state
- Goal state

## 2. Collection of **productions**

- Rules or moves
- Each production may have preconditions

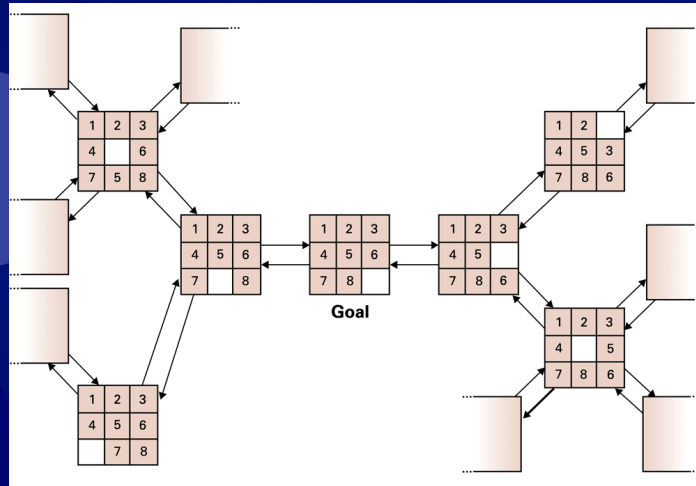
## 3. **Control** system

- Production to apply next

# Applications

- ☀ Playing games
  - 8 Puzzles, chess
- ☀ Drawing logical conclusions from given facts
  - Reasoning

## Ex. 8 Puzzle

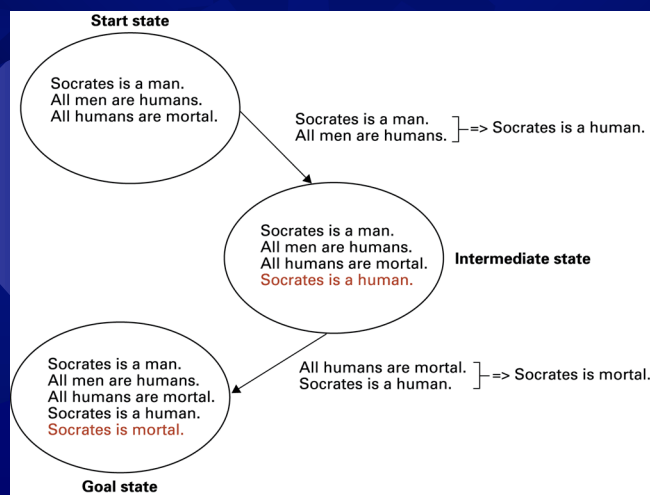


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## Ex. Deductive Reasoning



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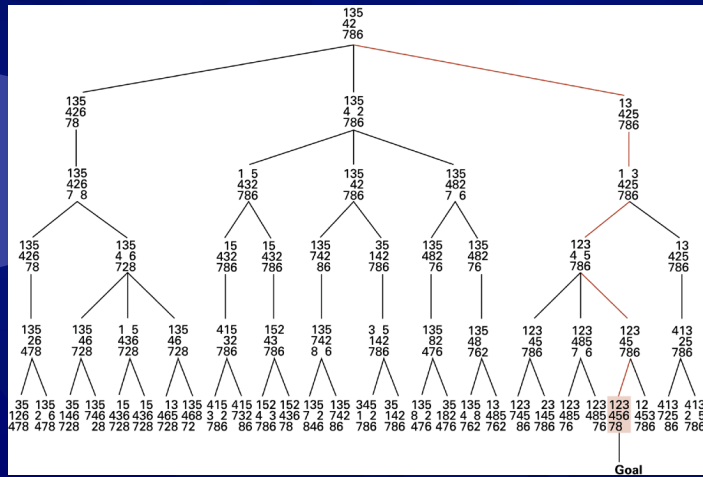
# Control System

- Search tree
  - Record of state transitions explored while searching for a goal state
- Searching for goal
  - Searches the state graph to find a path from the start node to the goal
- Strategies
  - Root: start state
  - Children: states reachable by applying one production
  - Walking up the tree from the goal

# An Unsolved Eight Puzzle

1	3	5
4	2	
7	8	6

# Breadth-First Search Tree



# Production Stack

- Top of stack —
- Move the 5 tile down.
  - Move the 3 tile right.
  - Move the 2 tile up.
  - Move the 5 tile left.
  - Move the 6 tile up.



## Quiz Time!



## Types of Searches

- ☀ Blind
  - Breadth-first search
  - Depth-first search
- ☀ Heuristics
  - Proximity to goal

## Heuristic Search

1	5	2
4	8	
7	6	3

These tiles are at least one move from their original positions.

These tiles are at least two moves from their original positions.

## Good Heuristics

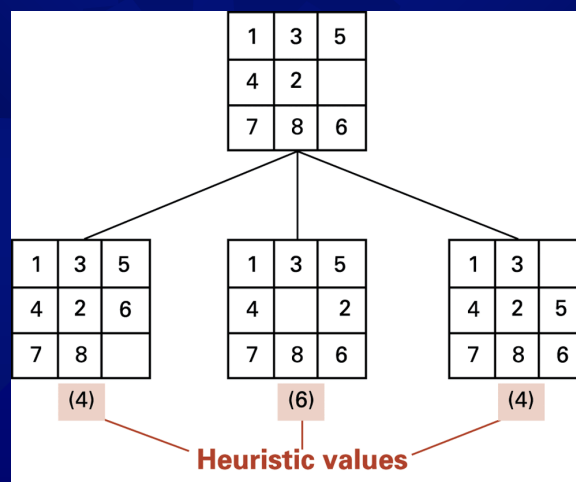
- ✦ Easier to compute than a complete solution
- ✦ Provide a reasonable estimate of proximity to a goal

# Heuristic Search Algorithm

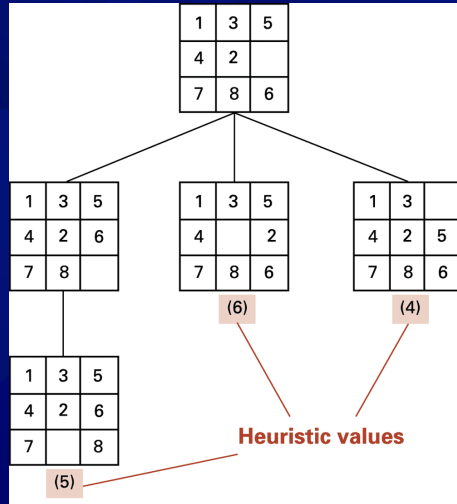
Establish the start node of the state graph as the root of the search tree and record its heuristic value.  
**while** (the goal node has not been reached) **do**  
 Select the leftmost leaf node with the smallest heuristic value of all leaf nodes.  
 To this selected node attach as children those nodes that can be reached by a single production.  
 Record the heuristic of each of these new nodes next to the node in the search tree  
**]**

Traverse the search tree from the goal node up to the root, pushing the production associated with each arc traversed onto a stack.  
 Solve the original problem by executing the productions as they are popped off the stack.

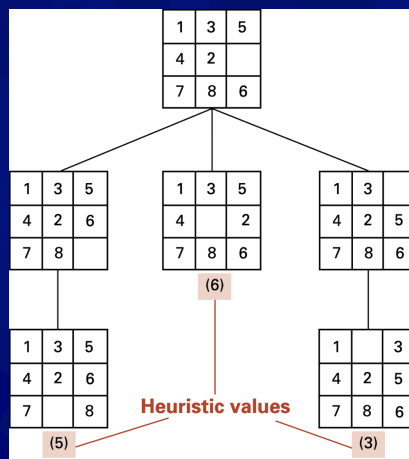
# Heuristic Search: Beginning



## Heuristic Search: 2 passes

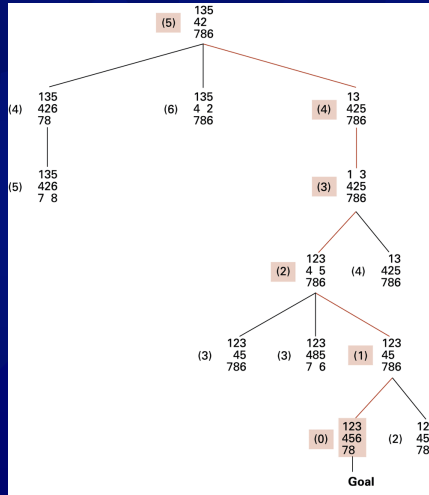


## Heuristic Search: 3 Passes





# Heuristic Search: Completion



## Quiz Time!

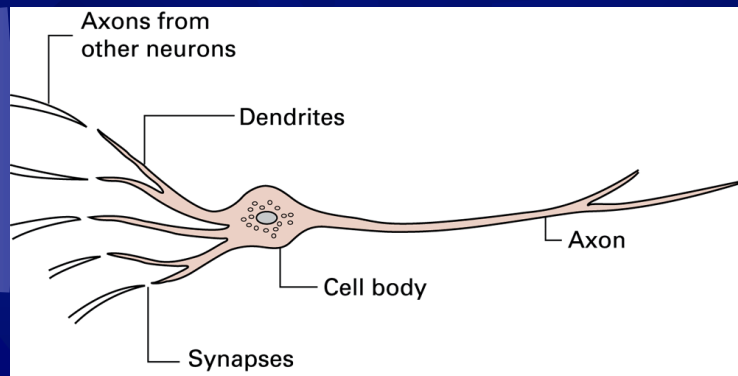
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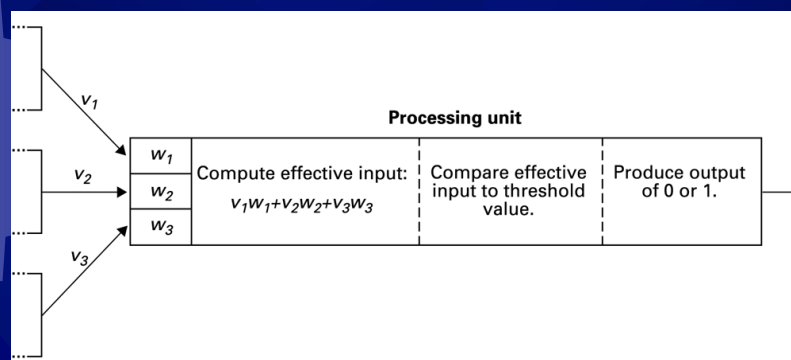
# Neural Networks

- ☀ Artificial Neuron
  - Input multiplied by a **weighting factor**
  - Output
    - 1 if sum of inputs exceeds a threshold value
    - 0 if otherwise.
- ☀ Network is programmed by adjusting weights/threshold using **feedback** from examples.

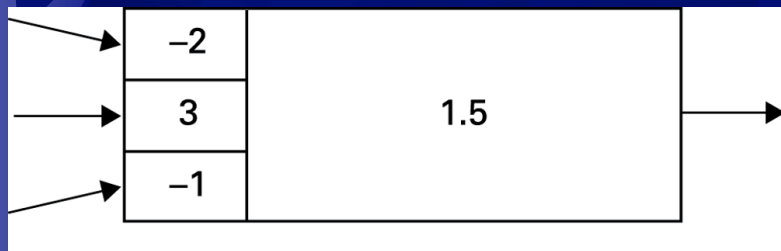
# A Biological Neuron



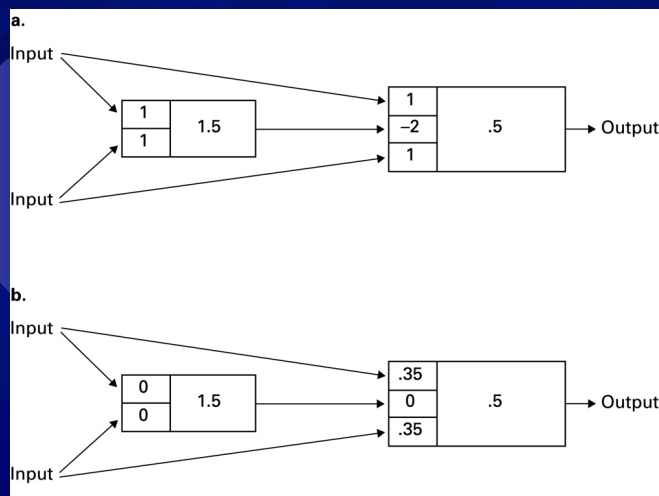
# Neuron as Processing Unit



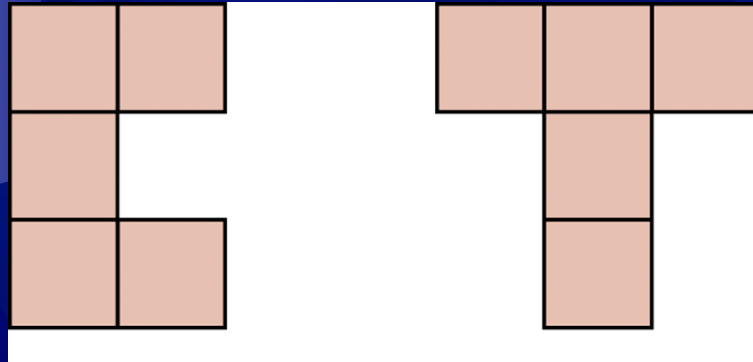
# An Example



# One Network, Two Programs



## Uppercase C and T

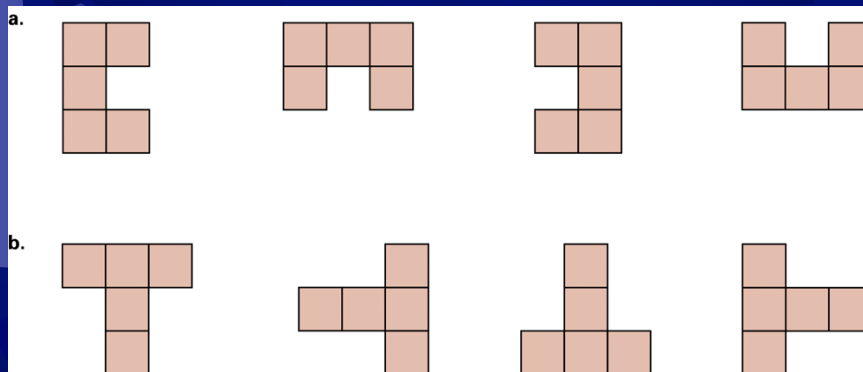


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## Various Orientations

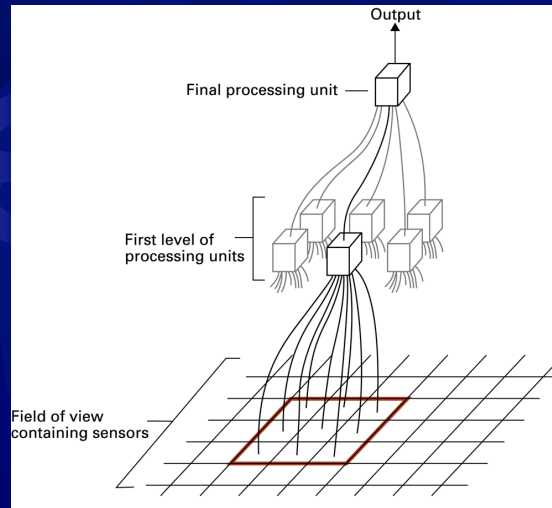


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# Character Recognition



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## 1st Level Processing Units

- One processing unit per 9 cells
  - Center cell weight = 2
  - Other cell weight = -1
- Input value per cell
  - 1, if highlighted
  - 0, otherwise
- Threshold 0.5
- Only when **center square** is highlighted and **one or less other cells** also highlighted, the output will be 1

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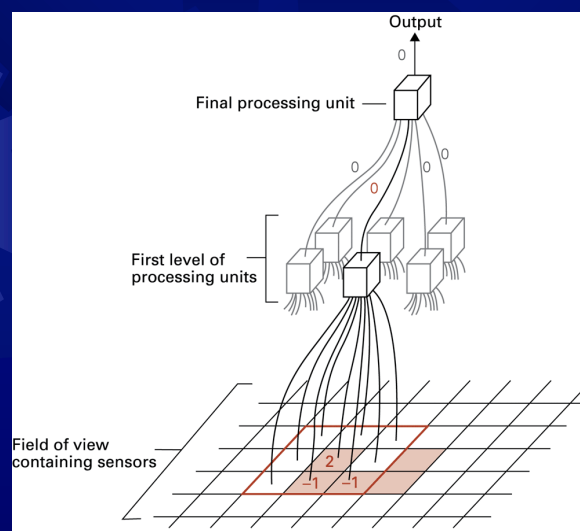
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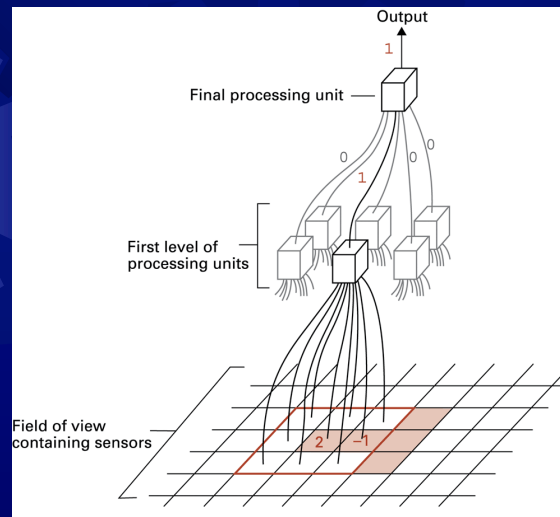
## 2nd Level Processing Units

- All outputs from the 1<sup>st</sup> level
- Weight 1
- Threshold 0.5
- The final output will be 1 (character T) when **at least one output from the 1<sup>st</sup> level processing unit is 1**
- The final output will be 0 (character C) when **no output from the 1<sup>st</sup> level processing unit is 1**

## The Letter C



## The Letter T



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## Associative Memory

- ☀ Associative memory
  - The retrieval of information relevant to the information at hand
- ☀ Application of neural network
  - Given a partial pattern
  - Transition themselves to a completed pattern.

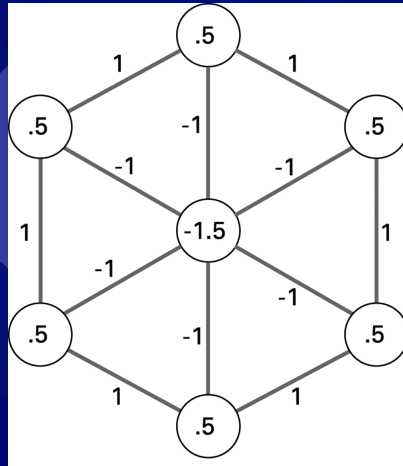
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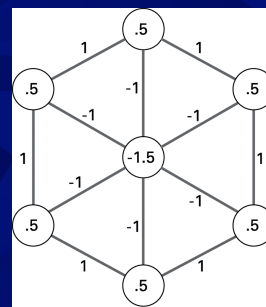
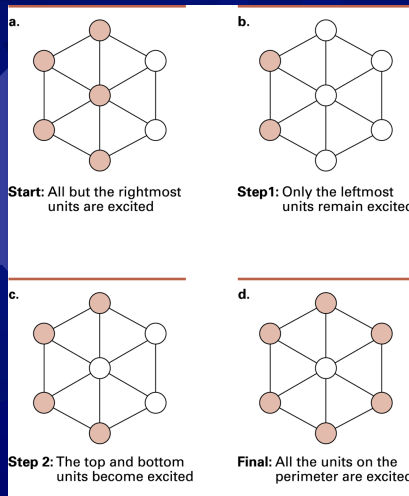


# Example Neural Network



1. Circle – Processing unit
2. Number in circle – Threshold
3. Line – Output to be the input of the connected processing unit
4. Number on line – Weight of input

# Stablization



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# Genetic Algorithms

- ☀ Simulate genetic processes to evolve algorithms
  - Start with an initial population of “partial solutions.”
  - Graft together parts of the best performers to form a new population.
  - Periodically make slight modifications to some members of the current population.
  - Repeat until a satisfactory solution is obtained.

## Crossing Two Strategies

a. Two strategies are cut in the same place

cut  
SRSR ... SR|SR ... SR  
SR'SR' ... SR'|SR' ... SR'

b. The tail of each strategy is attached to the head of the other, producing two new strategies

SRSR ... SR --- SR ... SR  
SR'SR' ... SR' --- SR' ... SR'

## Neural Networks

### ☀ Artificial Neuron

- Input multiplied by a weighting factor
- Output
  - 1 if sum of inputs exceeds a threshold value
  - 0 if otherwise.

☀ Network is programmed by adjusting weights/threshold using **feedback** from examples.

# Application Configuring Neural Networks

a. The configuration of an artificial neural network

b. A table indicating how the units in the network are connected

	1	2	3	4	5
1	0	0	1	1	0
2	0	0	1	1	0
3	0	0	0	0	1
4	0	0	0	0	1
5	0	0	0	0	0

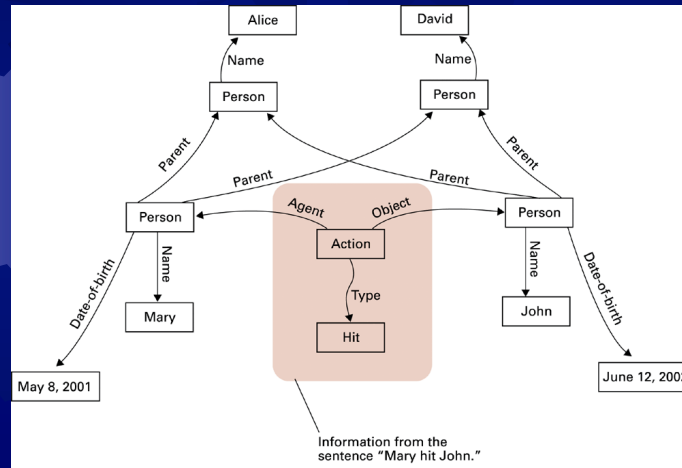
c. Encoded version of artificial neural network

0011000110000010000100000

# Language Processing

- ☀ Syntactic analysis
- ☀ Semantic analysis
- ☀ Contextual analysis
  
- ☀ Information retrieval
- ☀ Information extraction (knowledge representation)
  - Semantic net

# A Semantic Net



# Robotics

## ☀ Before

- A field within mechanical and electrical engineering

## ☀ Now

- A much wider range of activities
- Robocup competition
- Evolutionary robotics

## Expert systems

- ☀ Software package to assist humans in situations where expert knowledge is required
- ☀ Example: medical diagnosis
- ☀ Often similar to a production system
- ☀ Blackboard model
  - Whatever the expert says
  - Several problem-solving systems share a common data area

## Debates

- ☀ When should a computer's decision be trusted over a human's?
- ☀ If a computer can do a job better than a human, when should a human do the job anyway?
- ☀ What would be the social impact if computer "intelligence" surpasses that of many humans?



Questions?

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