Chapter 13

Artificial Intelligence

Chapter Goals

- Distinguish between the types of problems that humans do best and those that computers do best
- Explain the Turing test
- Define what is meant by knowledge representation and demonstrate how knowledge is represented in a semantic network

Chapter Goals

- Develop a search tree for simple scenarios
- Explain the processing of an expert system
- Explain the processing of biological and artificial neural networks
- List the various aspects of natural language processing
- Explain the types of ambiguities in natural language comprehension

Thinking Machines

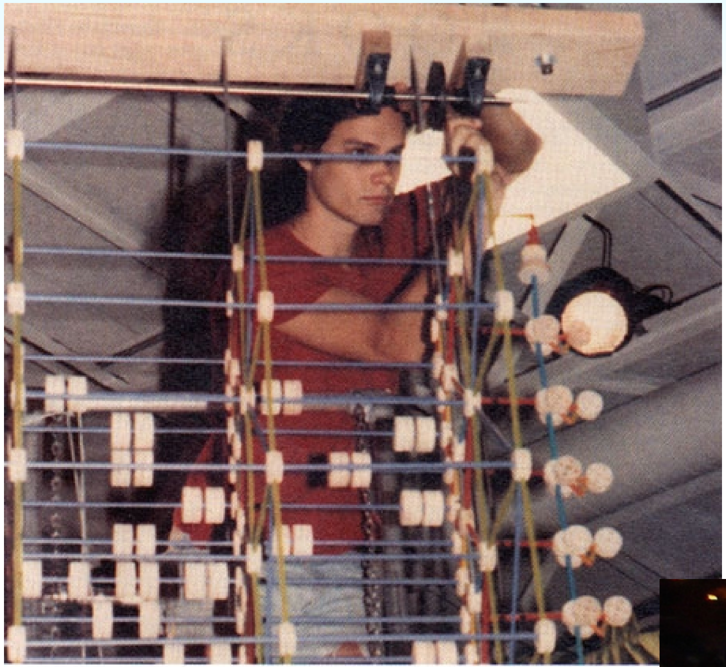
- A computer can do some things better --and certainly faster--than a human can
  - Adding a thousand four-digit numbers
  - Counting the distribution of letters in a book
  - Searching a list of 1,000,000 numbers for duplicates
  - Matching finger prints

Thinking Machines

Figure 13.1 **A computer might have trouble identifying the cat in this picture.**

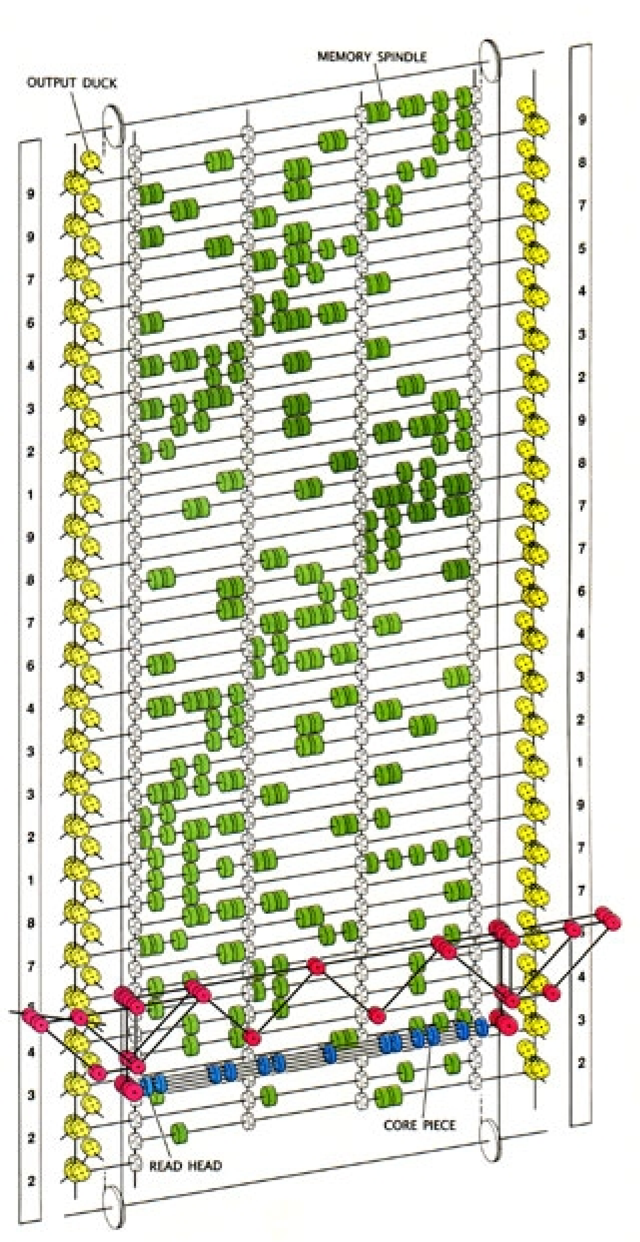
- BUT a computer would have difficulty pointing out the cat in this picture, which is easy for a human
- **Artificial intelligence** (AI) The *study* of computer systems that attempt to *model* and apply the *intelligence of the human mind*

Thinking Machines



Edward Hardebeck helps to assemble the Tinkertoy computer

Danny Hillis



The Tinkertoy computer: ready for a game of tic-tac-toe

The Turing Test

- In 1950 English mathematician Alan Turing wrote a landmark paper that asked the question: *Can machines think?*
- How will we know when we've succeeded?
- The **Turing test** is used to empirically determine whether a computer has achieved intelligence

The Turing Test

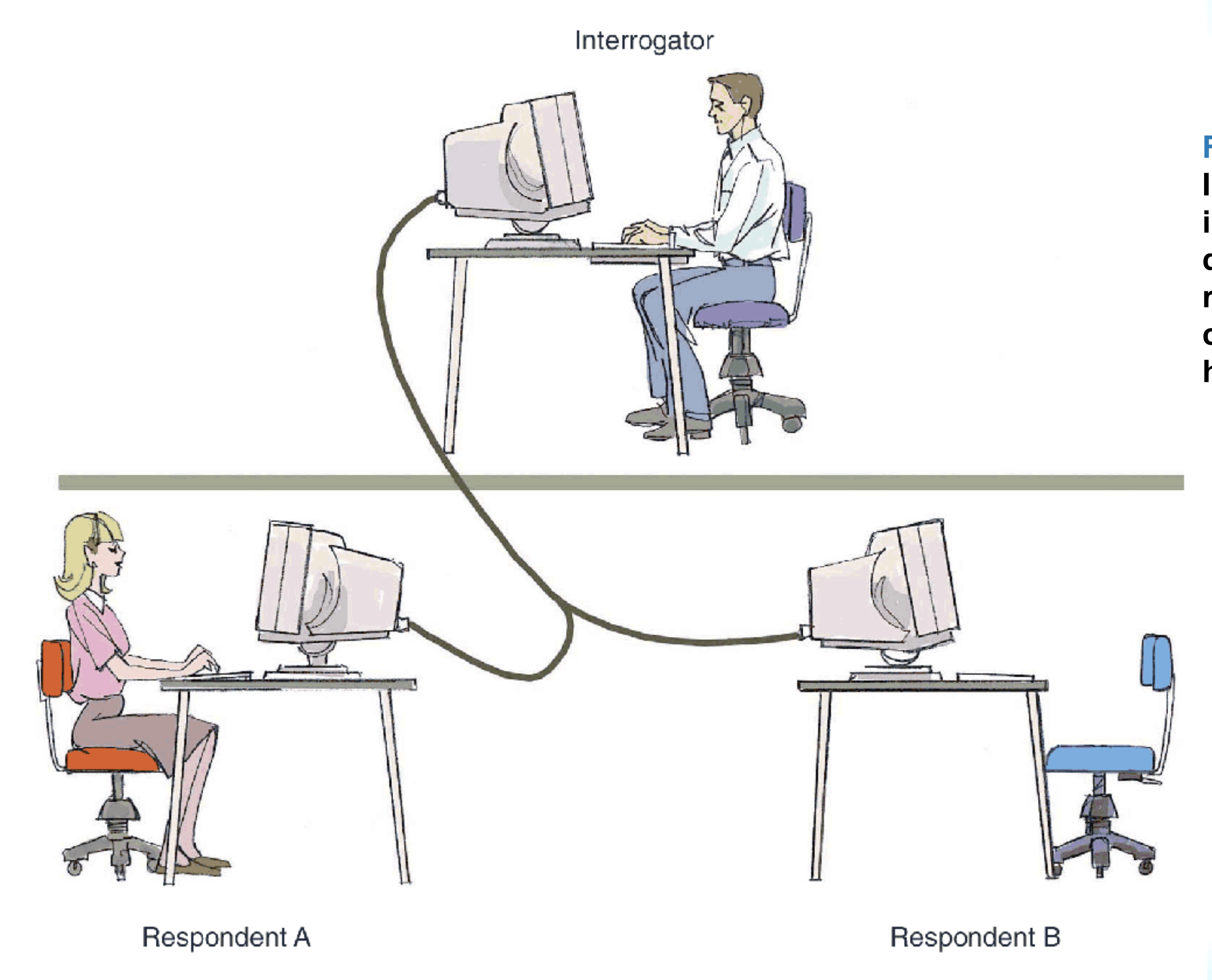
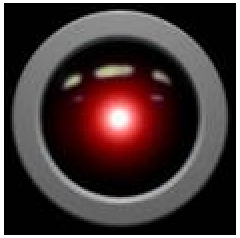


Figure 13.2
In a Turing test, the interrogator must determine which respondent is the computer and which is the human

The Turing Test

- **Weak equivalence** Two systems (human and computer) are equivalent in results (output), but they do not arrive at those results in the same way
- **Strong equivalence** Two systems (human and computer) use the same internal processes to produce results



HAL 9000

Knowledge

"To realize that our knowledge is ignorance,
This is a noble insight.
To regard our ignorance as knowledge,
This is mental sickness."

- Lao Tzu, 4th Century BC

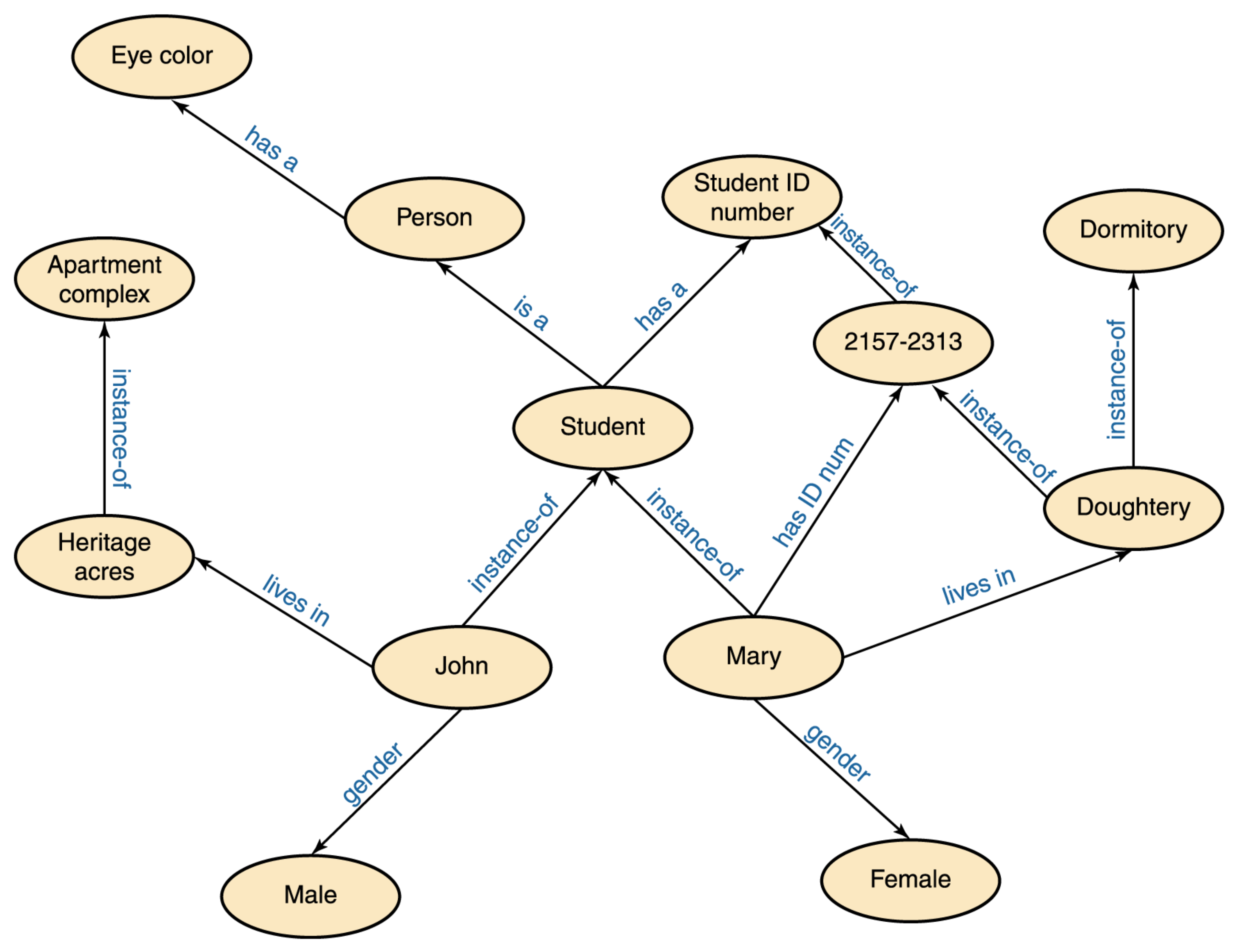
Knowledge Representation

- The knowledge needed to represent an object or event depends on the situation
- There are many ways to represent knowledge
  - Natural language
  - Though natural language is very descriptive, it doesn't lend itself to efficient processing

Semantic Networks

- **Semantic network** A knowledge representation technique that focuses on the relationships between objects
- A directed graph is used to represent a semantic network or net
- Vertices represent concepts; edges represent relations between concepts

Semantic Networks



Semantic Networks

- The relationships that we represent are completely our choice, based on the information we need to answer the kinds of questions that we will face
- The types of relationships represented determine which questions are easily answered, which are more difficult to answer, and which cannot be answered

Semantic Web

- A project to create a universal medium for information exchange by putting documents with computer-processable meaning (semantics) on the World Wide Web.

"I have a dream for the Web [in which computers] become capable of analyzing all the data on the Web – the content, links, and transactions between people and computers. A 'Semantic Web', which should make this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy and our daily lives will be handled by machines talking to machines. The 'intelligent agents' people have touted for ages will finally materialize."

-Tim Berners-Lee, 1999

Search Trees

- **Search tree** A structure that represents all possible moves in a game, for both you and your opponent
- The paths down a search tree represent a series of decisions made by the players

Search Trees

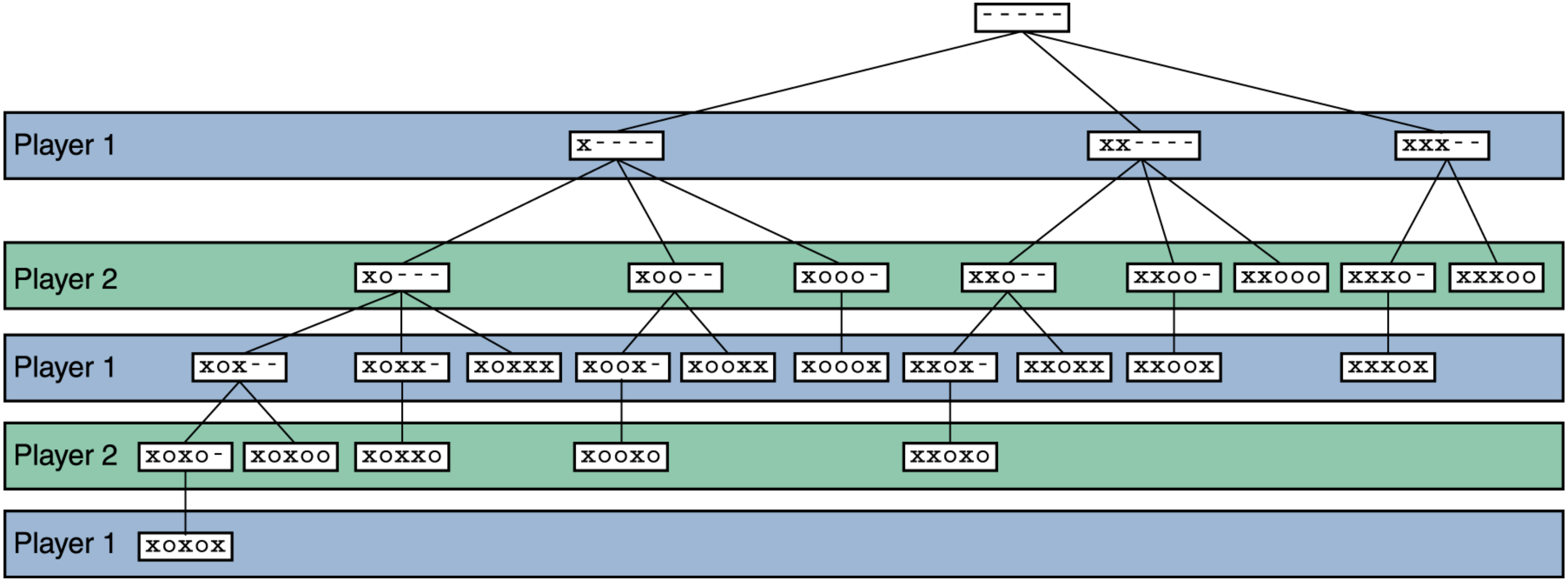


Figure 13.4 **A search tree for a simplified version of Nim**

Search Trees

- Search tree analysis can be applied nicely to other, more complicated games such as chess
- Because these trees are so large, only a fraction of the tree can be analyzed in a reasonable time limit, even with modern computing power

Search Trees

Techniques for searching trees

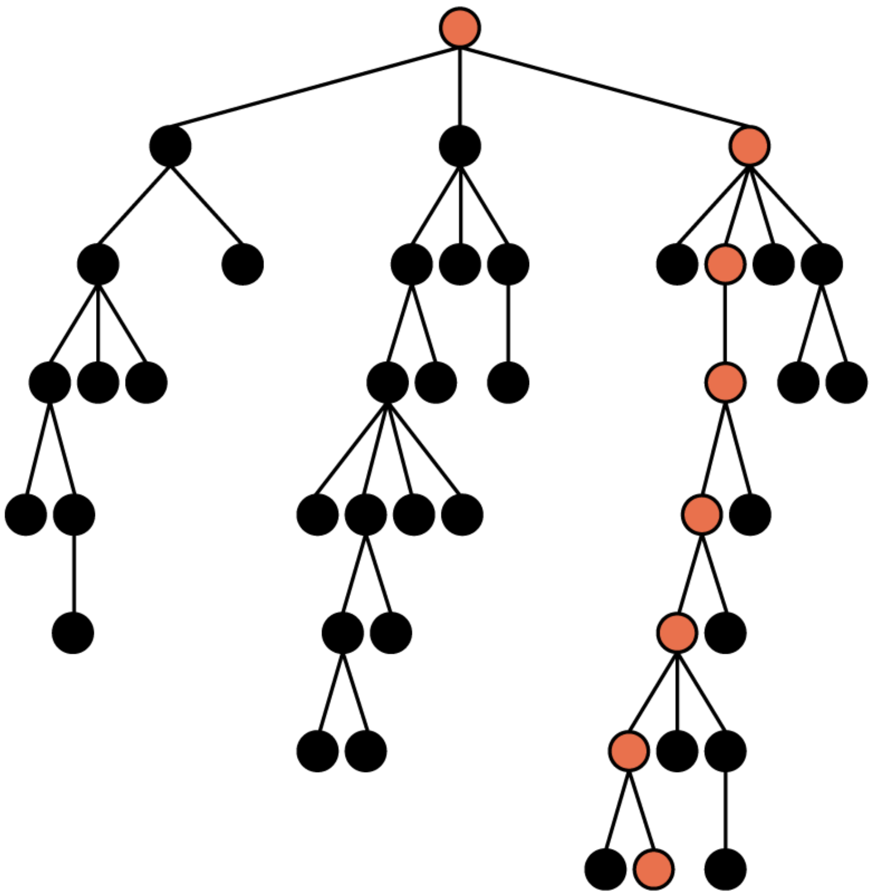
- **Depth-first** A technique that involves the analysis of selected paths all the way down the tree
- **Breadth-first** A technique that involves the analysis of all possible paths but only for a short distance down the tree

Breadth-first tends to yield the best results

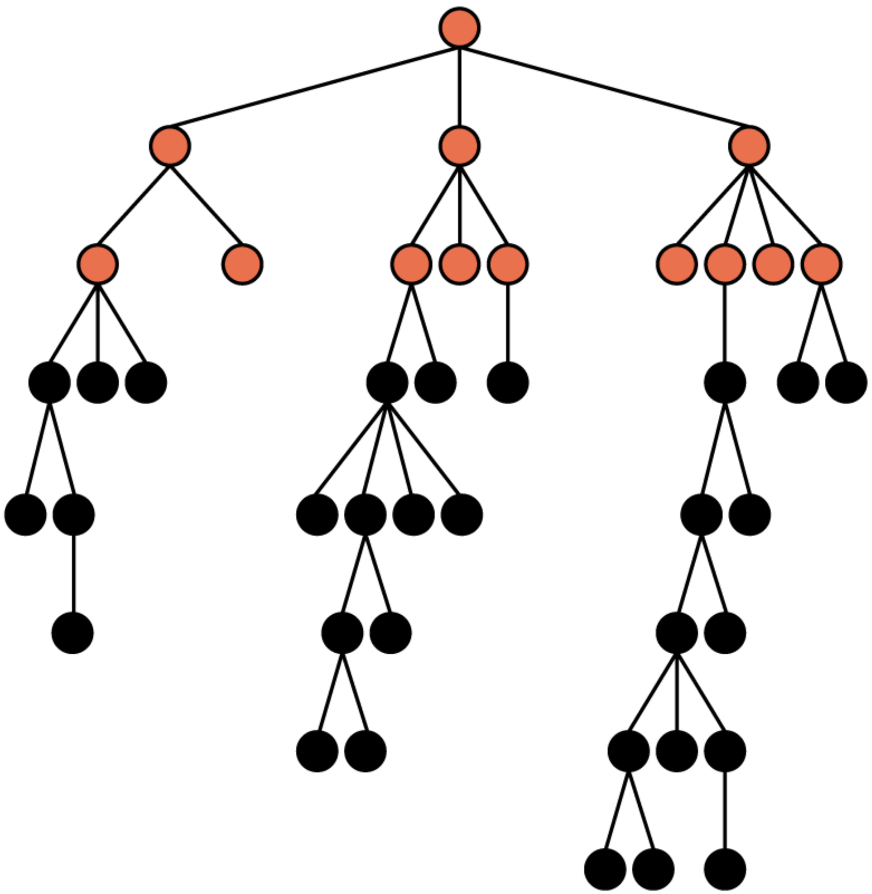
(navel-gazing kills!)

Search Trees

Depth-First Search



Breadth-first Search



Expert Systems

- **Knowledge-based system** A software system that embodies and uses a specific set of information from which it extracts and processes particular pieces
- **Expert system** A software system based on the knowledge of human experts in a specialized field
  - An expert system uses a set of rules to guide its processing
  - The inference engine is the part of the software that determines how the rules are followed

Expert Systems

- Example: What type of treatment should I put on my lawn?
  - NONE—apply no treatment at this time
  - TURF—apply a turf-building treatment
  - WEED—apply a weed-killing treatment
  - BUG—apply a bug-killing treatment
  - FEED—apply a basic fertilizer treatment
  - WEEDFEED—apply a weed-killing and fertilizer combination treatment

Expert Systems

- Boolean variables
  - BARE—the lawn has large, bare areas
  - SPARSE—the lawn is generally thin
  - WEEDS—the lawn contains many weeds
  - BUGS—the lawn shows evidence of bugs

Expert Systems

- Some rules
  - if (CURRENT – LAST < 30) then NONE
  - if (SEASON = winter) then not BUGS
  - if (BARE) then TURF
  - if (SPARSE and not WEEDS) then FEED
  - if (BUGS and not SPARSE) then BUG
  - if (WEEDS and not SPARSE) then WEED
  - if (WEEDS and SPARSE) then WEEDFEED

Expert Systems

- An execution of our inference engine
  - System: Does the lawn have large, bare areas?
  - User: No
  - System: Does the lawn show evidence of bugs?
  - User: No
  - System: Is the lawn generally thin?
  - User: Yes
  - System: Does the lawn contain significant weeds?
  - User: Yes
  - System: You should apply a weed-killing and fertilizer combination treatment.

Artificial Neural Network

- Attempts to mimic the actions of the neural networks of the human body
- Let's first look at how a biological neural network works
  - A neuron is a single cell that conducts a chemically-based electronic signal
  - At any point in time a neuron is in either an excited or inhibited state

Artificial Neural Network

- A series of connected neurons forms a pathway
- A series of excited neurons creates a strong pathway
- A biological neuron has multiple input tentacles called dendrites and one primary output tentacle called an axon
- The gap between an axon and a dendrite is called a synapse

Artificial Neural Network

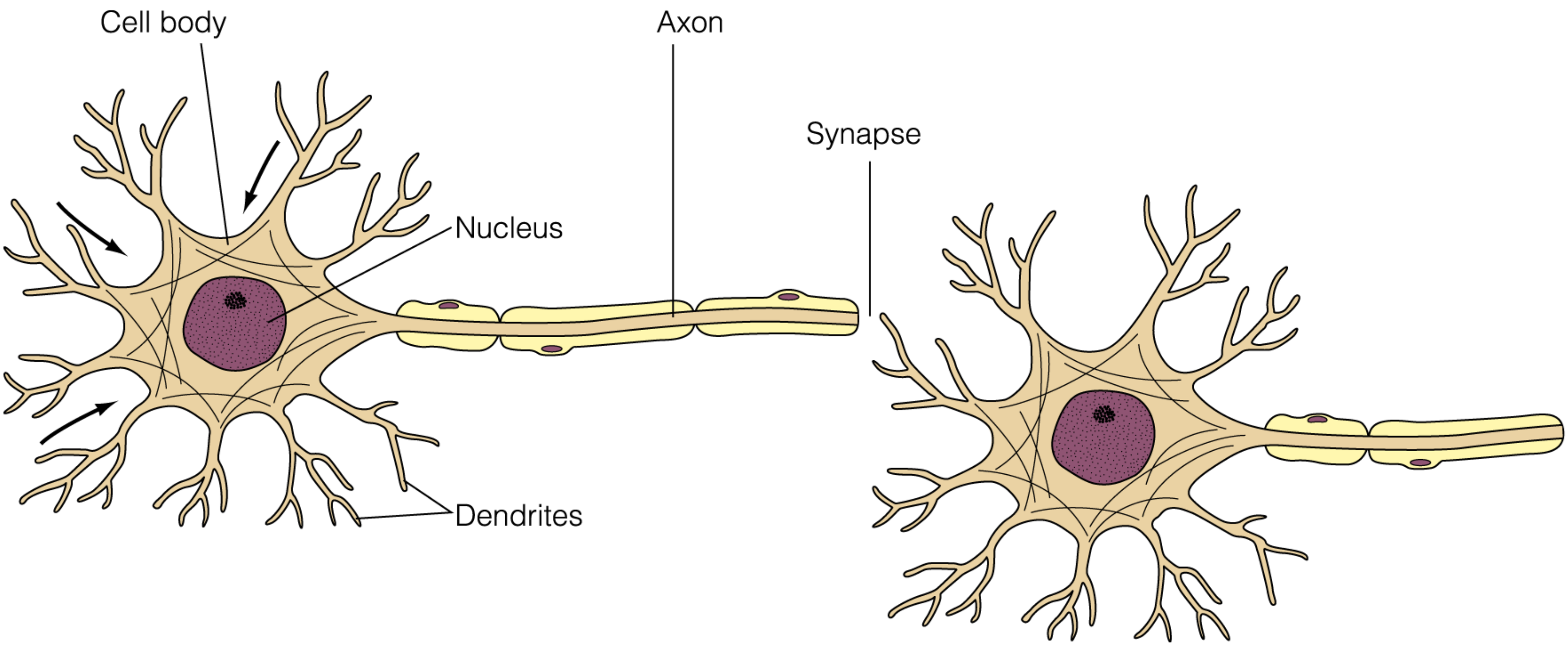


Figure 13.6 A biological neuron

Artificial Neural Network

- A neuron accepts multiple input signals and then controls the contribution of each signal based on the "importance" the corresponding synapse gives to it
- The pathways along the neural nets are in a constant state of flux
- As we learn new things, new strong neural pathways in our brain are formed

Artificial Neural Networks

- Each processing element in an artificial neural net is analogous to a biological neuron
  - An element accepts a certain number of input values and produces a single output value of either 0 or 1
  - Associated with each input value is a numeric weight

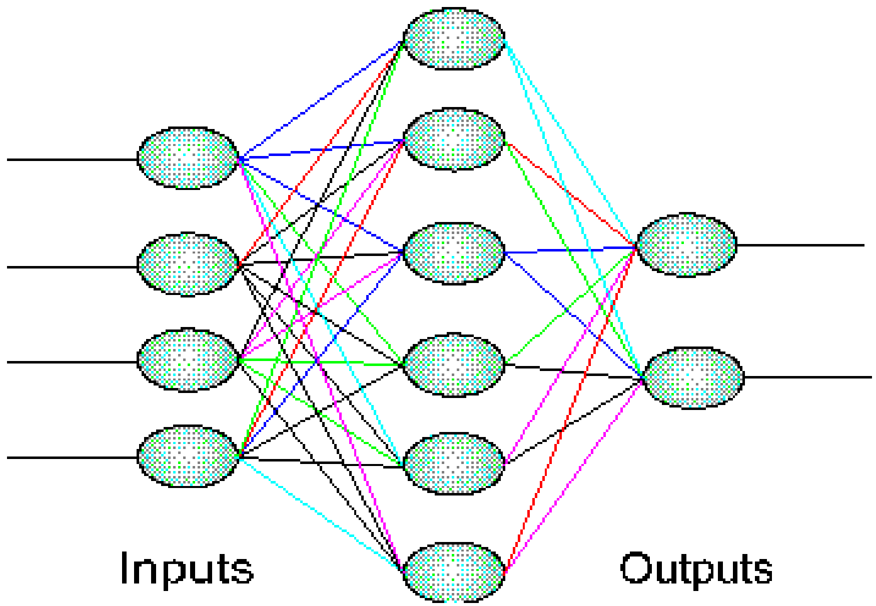
Artificial Neural Networks

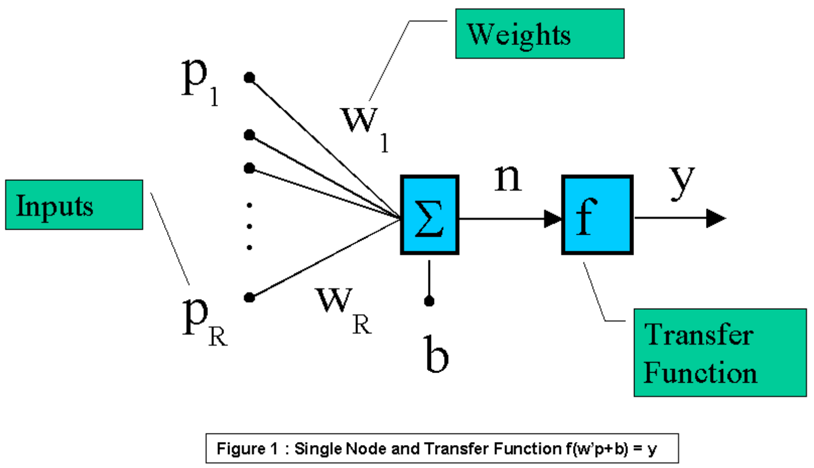
- The **effective weight** of the element is defined to be the sum of the weights multiplied by their respective input values

  v1*w1 + v2*w2 + v3*w3

- Each element has a numeric threshold value
- If the effective weight exceeds the threshold, the unit produces an output value of 1
- If it does not exceed the threshold, it produces an output value of 0

Artificial Neural Netoworks





Artificial Neural Networks

- The process of adjusting the weights and threshold values in a neural net is called **training**
- A neural net can be trained to produce whatever results are required

Natural Language Processing

- There are three basic types of processing going on during human/computer voice interaction
  - Voice recognition—recognizing human words
  - Natural language comprehension—interpreting human communication
  - Voice synthesis—recreating human speech
- Common to all of these problems is the fact that we are using a natural language, which can be any language that humans use to communicate

Voice Synthesis

- There are two basic approaches to the solution
  - Dynamic voice generation
  - Recorded speech
- **Dynamic voice generation** A computer examines the letters that make up a word and produces the sequence of sounds that correspond to those letters in an attempt to vocalize the word
- **Phonemes** The sound units into which human speech has been categorized

Voice Synthesis

Consonants			
Symbols	Examples	Symbols	Examples
p	pipe	k	kick, cat
b	babe	g	get
m	maim	ŋ	sing
f	fee, phone, rough	š	shoe, ash, sugar
v	vie, love	ž	measure
θ	thin, bath	č	chat, batch
ð	the, bathe	ǰ	jaw, judge, gin
t	tea, beat	d	day, bad
n	nine	ʔ	uh uh
l	law, ball	s	see, less, city
r	run, bar	z	zoo, booze

Vowels	
Symbols	Examples
i	eel, sea, see
I	ill, bill
e	ale, aim, day
ɛ	elk, bet, bear
æ	at, mat
u	due, new, zoo
ʊ	book, sugar
o	own, no, know
ɔ	aw, crawl, law, dog
a	hot, bar, dart
ə	sir, nerd, bird
ʌ	cut, bun

Semi Vowels	
w	we
h	he
j	you, beyond

Dipthongs	
aj	bite, fight
aw	out, cow
ɔj	boy, boil

Figure 13.7 **Phonemes for American English**

Voice Synthesis

- **Recorded speech** A large collection of words is recorded digitally and individual words are selected to make up a message

  Telephone voice mail systems often use this approach: “Press 1 to leave a message for Nell Dale; press 2 to leave a message for John Lewis.”

Voice Synthesis

- Each word or phrase needed must be recorded separately
- Furthermore, since words are pronounced differently in different contexts, some words may have to be recorded multiple times
  - For example, a word at the end of a question rises in pitch compared to its use in the middle of a sentence

Voice Recognition

- The sounds that each person makes when speaking are unique
- We each have a unique shape to our mouth, tongue, throat, and nasal cavities that affect the pitch and resonance of our spoken voice
- Speech impediments, mumbling, volume, regional accents, and the health of the speaker further complicate this problem

Voice Recognition

- Furthermore, humans speak in a continuous, flowing manner
  - Words are strung together into sentences
  - Sometimes it's difficult to distinguish between phrases like "ice cream" and "I scream"
  - Also, homonyms such as "I" and "eye" or "see" and "sea"
- Humans can often clarify these situations by the context of the sentence, but that processing requires another level of comprehension
- Modern voice-recognition systems still do not do well with continuous, conversational speech

Natural Language Comprehension

- Even if a computer recognizes the words that are spoken, it is another task entirely to understand the *meaning* of those words
  - Natural language is inherently ambiguous, meaning that the same syntactic structure could have multiple valid interpretations
  - A single word can have multiple definitions and can even represent multiple parts of speech
  - This is referred to as a lexical ambiguity

Time flies like an arrow.

Natural Language Comprehension

- A natural language sentence can also have a syntactic ambiguity because phrases can be put together in various ways

  I saw the Grand Canyon flying to New York.

- Referential ambiguity can occur with the use of pronouns

  The brick fell on the computer but it is not broken.

Assignment #3

- **Research** these two RFCs: **RFC1129** and **RFC968**. Given a **brief** - paragraph, not a single sentence – **description** based on the abstract, introduction, or basic content
- Pick **google.com** and one other site. Using **whois** and **ARIN**, get as much information as possible about the IP addressing, the DNS and the site (location, owner, etc.)
- **Due next Wednesday, December 6** – or you can email it earlier

Useful Websites

- http://www.rfc-editor.org/rfcsearch.html
  Search RFCs
- http://www.cert.org
  Center for Internet security
- http://www.counterpane.com/alerts.html
  Some recent alerts

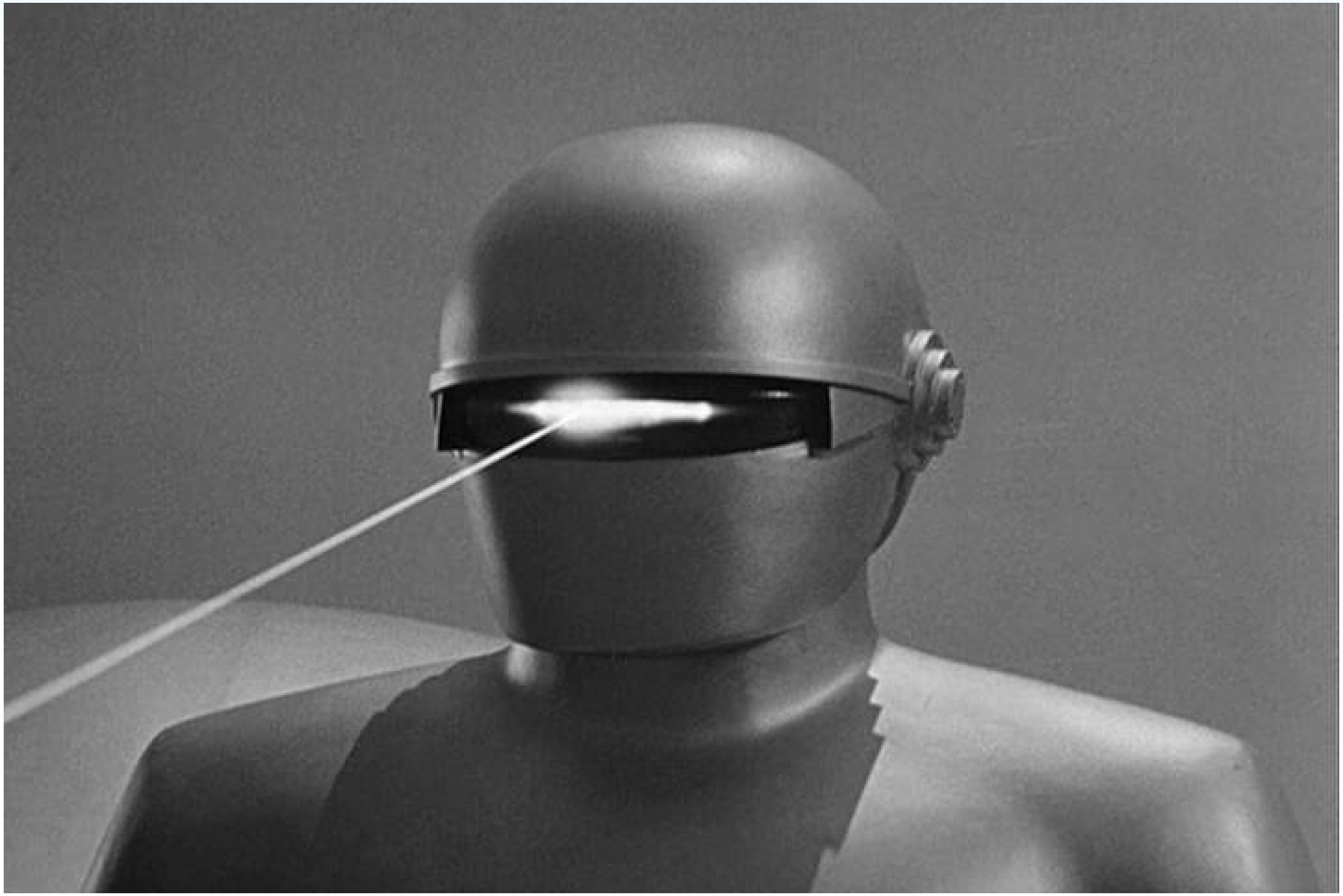
Homework

- **Read Chapter Thirteen – and review slides**

- …Next Class We'll Hand Out the **Final Exam**…

- …and cover **LAMP** and **WAMP** Technology

...Have A Nice Night



"Klaatu barad nikto"