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

- 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*.

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

Danny Hillis

Edward Hardebeck helps to assemble the Tinkertoy computer

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

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

Figure 13.2
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

- 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:
  \[ v_1w_1 + v_2w_2 + v_3w_3 \]

- 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 Networks

Inputs → Outputs

Figure 1: Single Node and Transfer Function \( f(w'p + b) = y \)
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

#### Figure 13.7 Phonemes for American English

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<td><strong>Examples</strong></td>
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<td>out, cow</td>
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<tr>
<td>ɔj</td>
<td>boy, boil</td>
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</table>
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
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

  \[ I \text{ saw the Grand Canyon flying to New York. } \]

- **Referential ambiguity** can occur with the use of pronouns

  \[ The \text{ brick fell on the computer but it is not broken. } \]
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](http://www.rfc-editor.org/rfcsearch.html)
  Search RFCs
- [http://www.cert.org](http://www.cert.org)
  Center for Internet security
- [http://www.counterpane.com/alerts.html](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"