Applications 9B

Artificial Intelligence

Artificial Intelligence (AI)

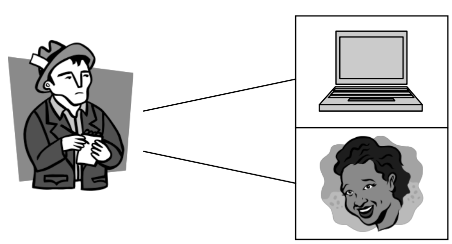
- Branch of computer science that studies the use of computers to perform computational processes normally associated with human intellect.
- Some areas of AI:
  - Expert systems
  - Knowledge representation
  - Machine learning

A little history

- Karel Capek's 1923 play R.U.R. (Rossum's Universal Robots) is the first to use the word robot in English
  - http://jerz.setonhill.edu/resources/RUR/
- Vannevar Bush (designer of the Differential Analyzer) publishes As We May Think in 1945.
  - http://ccat.sas.upenn.edu/~jod/texts/vannevar.bush.html
- Weiner introduces the term cybernetics in 1948.
  - The theoretical study of communication and control processes in biological, mechanical, and electronic systems, especially the comparison of these processes in biological and artificial systems. - Answers.com

The Turing Test

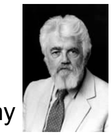
- Turing publishes Computing Machinery and Intelligence in 1950.
- Describes the Turing Test to determine whether a computer can be called intelligent.



A machine is considered intelligent if an interrogator cannot tell if a human or a computer is answering a set of questions using typewritten responses.

The beginning of AI

McCarthy



- John McCarthy (inventor of the programming language Lisp) coins the term "artificial intelligence" in 1956 at a Dartmouth conference.
- Allen Newell and Herbert Simon contributed to one of the first AI programs, the General Problem Solver (GPS) in 1957.
  - For more info: http://tip.psychology.org/simon.html
  - Faculty members at Carnegie Mellon University.
  - Awarded the Turing Award in 1975 for "basic contributions to artificial intelligence, the psychology of human cognition, and list processing."

Newell

Simon

Types of AI

- Weak AI
  - The computer is an intelligent, problem-solving device.
- Strong AI
  - Not only can a computer solve problems in an intelligent manner, but the computer is self-aware (or has a sense of consciousness).

Arguments against Strong AI

- Chinese Room Argument - John Searle 1981
  - A person who understands no Chinese is put in a room.
  - This person is given an algorithm to translate incoming Chinese characters to outgoing Chinese characters.
  - An interviewer asks questions in Chinese to the person in the room (on paper), and the person uses the algorithm to write a response which is returned to the interviewer.
  - This person passes the Turing test (indistinguishable from a native Chinese writer).
  - Does the person inside the room <u>understand</u> Chinese?

Arguments against Strong AI

- Blockhead - Ned Block 1980
  - A theoretical system for simulating a conversation.
  - Most conversations can only start with a small subset of sentences from a language.
  - Given these sentences, only another subset of sentences would be appropriate responses, etc.
  - A system could be developed (theoretically) that would be programmed with all the valid combinations only.
  - This system would obviously pass the Turing test.
  - Does this system actually understand anything that it is responding to?

Heuristics

- Since it is believed that human thought is not entirely algorithmic, many problems in AI are solved by using heuristics.
- A <u>heuristic</u> is an algorithm that typically finds a reasonably good solution to a problem (rather than the optimal, best solution) in order to reduce the running time to a reasonable amount.

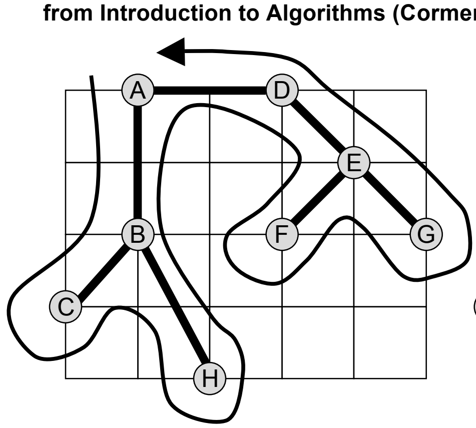
Heuristics Example:
Traveling Salesperson

- Generate a minimal spanning tree starting from some node A (using Prim's algorithm).
- Trace around the nodes (as we did with the binary search tree sort) and list the nodes of the MST as we first encounter them.
- Build a Hamiltonian path from node A to the last node in the list and then connect the last node back to node A to form the route.

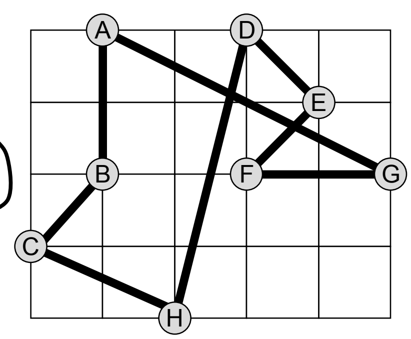
Heuristics Example:
Traveling Salesperson

- This heuristic can be used if all nodes are on the 2D plane and the cost between each pair of nodes is its Euclidean distance.
- This route will be at most twice the optimal.
  - Often it is much closer to the optimal.

Heuristics Example:
from Introduction to Algorithms (Cormen/Leiserson/Rivest/Stein)



A B C H D E F G

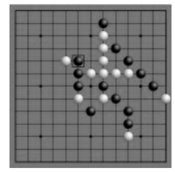


Approx. Cost = 19.074

Optimal Cost = 14.715

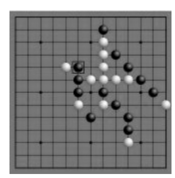
(A B C H F G E D)

AI Opponents

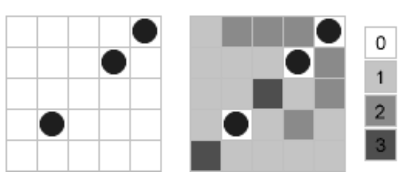


- Consider the game of Pente.
  - Players alternate, placing their stones on the game board at the intersection of lines, one at a time.
  - The object of the game is to be the first player to either get five stones in a straight line or capture 5 pairs of stones of the other player.
  - If we were write a computer program to play Pente against a human player, how does the computer calculate its moves when there are a huge amount of possibilities to consider?

AI Opponents



- We can use heuristics to make the problem easier to deal with.
  - Check for x-pieces in a row.
  - Check for capture possibilities.
  - Check for x-pieces in a row for opponent.
  - Check for opponents potential to make a capture.



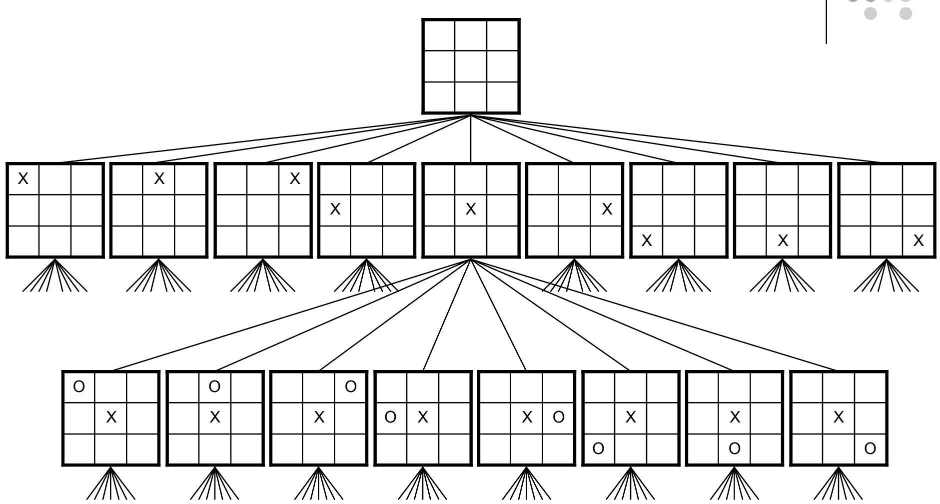
Example:
Code each cell based on number of opponent pieces in same row, column and diagonal.

http://www.generation5.org/content/2000/boardai.asp

Game Trees

- For most games, the number of possible moves and potential outcomes is super-polynomial.
- An AI technique used to manage this computation is the use of a game tree.
  - A tree is built with a root node representing the current state of the game.
  - Children nodes are generated representing the state of the game for each possible move.
  - The tree is propagated down, building more children nodes for moves allowed by the next move, etc.
  - Leaves are terminal states of the game.

Tic-Tac-Toe



Tic-Tac-Toe

- Assuming that all nine positions must be filled before the game ends, how big does this tree get?
- Of course, in real Tic-Tac-Toe, a player can win without filling the whole board.
  - What is the first level of the tree where this can occur?
  - How big is this tree up to this level?

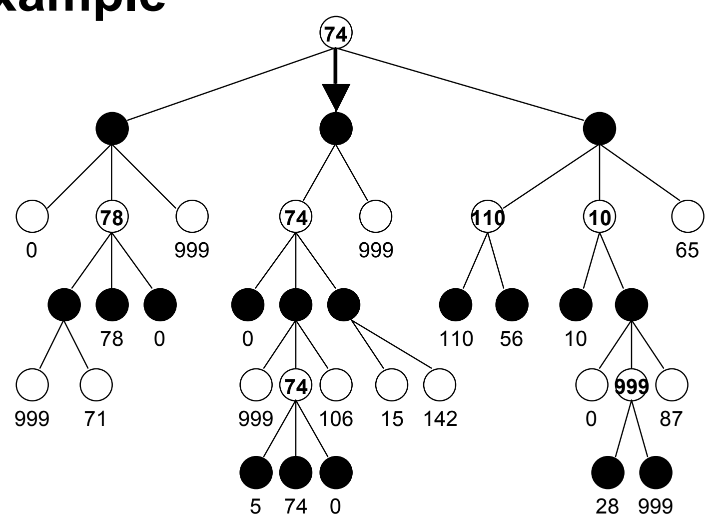
It's Intractable

- How does a computer program that plays tic-tac-toe, or chess, deal with the huge size of the game trees that can be generated?
  - In chess, the average number of possible next moves is around 35, and the average number of moves in a chess game is around 100, so the number of possibilities a computer must check is about 35^{100}, which is beyond hope, even for our fastest computers!
- These programs also use heuristics to narrow the search space in the tree that must be examined.

Minimax Method

- Assume a two-player game.
- Each leaf is given a score indicating the relative merit of this outcome for the player who goes next.
  - These score are usually determined by heuristics (formulas) on the game board, depth, etc.
- Starting from the leaves:
  - For each parent node that represents the player that goes next, propagate up the maximum of the children.
  - For each parent node that represents the opposing player, propagate up the minimum of the children.
- The player to go next will move in the direction of maximum benefit.

Example



Deep Blue

- IBM's "Deep Blue" computer beats Gary Kasparov in a chess match in 1997.
- Heuristics values:
  - The value of each piece. (1 for pawn up to 9 for queen)
  - The amount of control each side has over the board.
  - The safety of the king.
  - The quickness that pieces move into fighting position.
- For more info:
  - http://www.research.ibm.com/deepblue/home/html/b.html
- Is Deep Blue intelligent?

Loebner Prize

- Starting in 1990, Hugh Loebner has offered to give $100,000 and a solid gold medal to the first person to create a program that passes the Turing Test.
- Every year a prize of $2,000 and a bronze medal is awarded to the most human-like computer.
  - Won by Robert Medeksza in 2007 for Ultra Hal Assistant, a digital secretary and companion (available from Zabaware, an Erie PA-based AI company).

The future of AI?

- **Rodney A. Brooks** (MIT) argues that humans and machines will eventually "merge" as robotics becomes more sophisticated and biotechnology begins to implant machines in humans.

Flesh and Machines

- **Hans Moravec** (CMU) argues that machines will be programmed with much more sophisticated algorithms to exhibit human intelligence. These machines will eventually evolve beyond humans and form a new race that will become the dominant race of the universe.

Robot: Mere Machine to Transcendent Mind