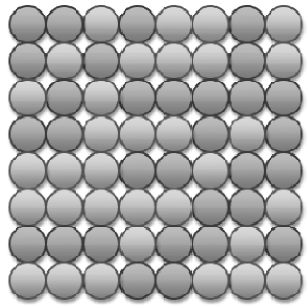
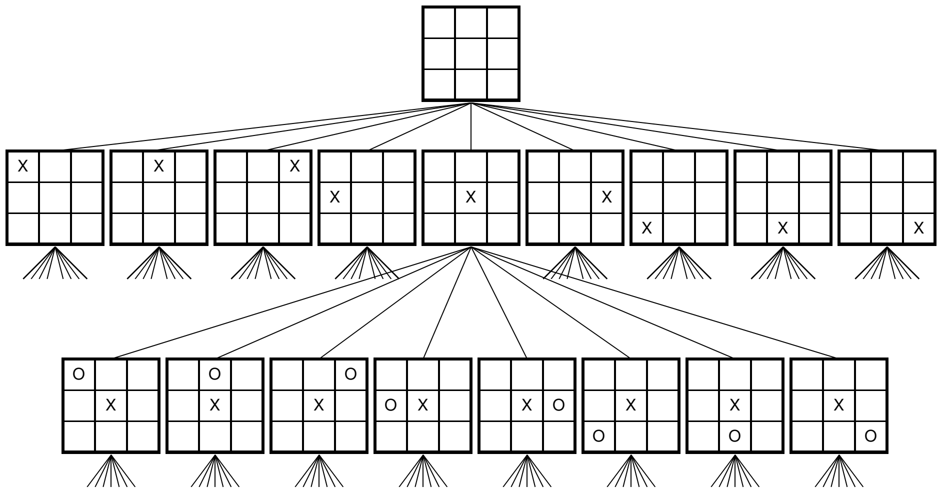


UNIT 13B
AI: Games & Search Strategies

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



Game Trees are BIG!

- 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?

Dealing with the Huge Search Space

- 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 use heuristics to narrow the search space in the tree that must be examined. (More on this soon.)

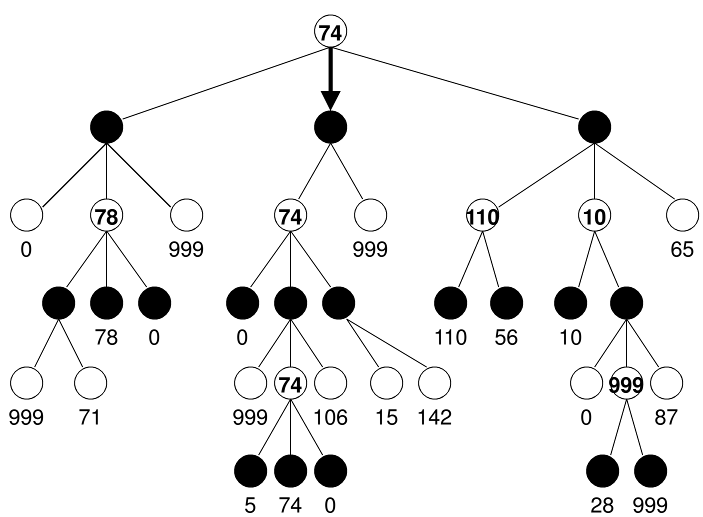
Minimax Algorithm

- An approach used in game theory to minimize the loss in a 2-player game.
- Can be used by “AI” players to guide its search through the search tree to find the “best move”.
- Based on the minimax theorem attributed to John von Neumann.
  - For every two-person, zero-sum game, there always exists a mixed strategy for each player such that the expected payoff for one player is the same as the expected cost for the other.

Minimax Algorithm

- 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.

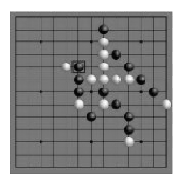
Example



Heuristics

- Since it is believed that human thought is not entirely algorithmic, many problems in AI are solved by using heuristics.
- A heuristic 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.

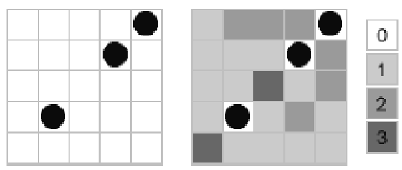
AI Opponents



- 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?

Heuristics

- 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

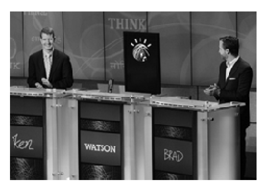
“Deep Blue”

- 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?

"Chinook"

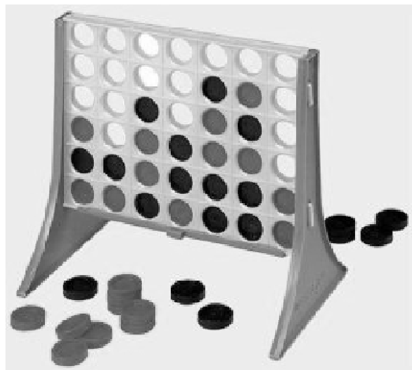
- Created by computer scientists from the University of Alberta to play checkers (draughts) in 1989.
- In 2007, the team led by Jonathan Schaeffer announced that Chinook could never lose a game.
- Chinook's algorithms featured:
  - a library of opening moves from games played by grandmasters
  - a deep search algorithm
  - a good move evaluation function (based on piece count, kings count, trapped kings, player's turn, "runaway checkers", etc.)
  - an end-game database for all positions with eight pieces or fewer. and other minor factors.
- Is Chinook intelligent?

"Watson"



- IBM's "Watson" computer beats champions Ken Jennings and Brad Rutter in a 2-game match on Jeopardy! in 2011.
- Watson parsed clues into different keywords and fragments.
- Watson had 4TB of data content but was not connected to the Internet during the game.
- Watson executed 1000s of proven language analysis algorithms concurrently. The more algorithms that pointed to the same answer, the more confident Watson was and the more likely it would buzz in.
- Is Watson intelligent?

Connect Four

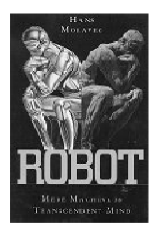


The future of AI?

- **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.

- **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.

Flesh and Machines



Robot: Mere Machine to Transcendent Mind