Lecture 33:
How can computation...
Win games against you?

Chess: Mechanical Turk

Automaton Chess Player
- Chess-playing machine 1770-1854
- Play strong game of chess against human opponent
- Arms move chess pieces
- Gears shown off inside

The Turk won most games
- Europe and the Americas
- Defeated many challengers including statesmen Napoleon Bonaparte and Benjamin Franklin

The Turk: a mechanical illusion
- Human chess master hiding inside to operate the machine
- Revealed in 1820s
Chess: Deep Blue

Feb 1996: first machine to win chess game vs. reigning world champion
  • Garry Kasparov under regular time controls
  • Lose match
May 1997: Upgrade wins match
  • Search 6-8 moves ahead (up to 20 moves)
  • Kasparov said saw "deep intelligence and creativity" in machine’s moves
    - Claimed person was directing Deep Blue
    - Change between games to fix weaknesses

What types of Strategy Games?

Examples:
  Tic-Tac-Toe, Connect 4, Othello, Checkers, Chess
No chance involved (no dice or card games)
Both players have complete information
  • No hidden information (no Stratego or Magic)
Two players alternate moves
  • No simultaneous moves
Win, Tie, or Lose:
  • Game ends in a pattern, capture, by the absence of moves
Exercise: Variation of Nim (Subtraction Game)

Rules:
• 2 players, 7 objects
• Take turns
• Remove 1, 2, or 3 objects
• Winner: Takes last object

Play several times, alternate who goes first

Can you devise winning strategy?

If solve for 7 objects, try with different numbers of starting pieces

Record states:
• Fill in 7 slots
• Use X (player 1)
• Use 0 (player 2)

Example:
X
X000
X000XXX → X wins

Strategies?

Random
• Just pick 1, 2, or 3 at random!

Exhaustive search
• Record every possible move for X and O
• Which ones lead to winning? Do those next game...

Insight
• Remove 1, 2, or 3 such that remaining N mod 4 = 0
Exhaustively Analyze all Possibilities

7 Empty slots
Possibility 1: Initial move of 3 X's

Conclusion: X can always win if it places 3 (given 7 initially)
Leaving 4 squares is good...

Exhaustively Analyze all Possibilities

Possibility 2: Initial move of 2 X's

No matter what X does, O can win

X may not win if it takes 2 (given 7 initially)
Leaving 5 is bad...
Nim Game Trees:
Empty Board – 2 moves

Nodes: Game positions or states
Edges: Moves or transitions

Nim Game Tree:
3 X’s for first move

Leaf node: Winner
Purple: X Wins
Red: O Wins

3 X's good move: All paths can lead to X winning
Computer Chess

Great website
http://www.computerhistory.org/chess/

Interactive Demo:
http://www.computerhistory.org/chess/interact/index_content.html

Minimax Algorithm: Game Tree

Associate values:
• 0: tie
• 1: computer win
• -1: opponent win

Strategy
• Assume each makes best move for itself
• Pick path to victory!

Algorithm
• Start at leaves
• Propagate max value before computer turn
• Propagate min value up before opponent turn
• Choose max path down
**Nim Game Tree: 3 X’s for first move**

Leaf node: Winner
Purple: X Wins
Red: O Wins

3 X’s good move: All paths can lead to X winning

Conclusion: Player 1 can always win with 7 objects by initially taking 3
Strongly Solve?

Nim and tic-tac-toe have relatively few board positions
  • Can exhaustively search every possibility
  • Can determine best strategy ahead-of-time and hard-code solution
Chess: too many board positions to exhaustively search
  • Can only search few moves ahead and/or some possibilities at each move
  • Determine strategy as play, based on observed positions

Today’s Summary

Game Strategies
  • Construct game tree to determine best moves for self and opponent
    - Minimax algorithm: Assume each makes best moves for self
Reading
  • 3 articles on computer chess
    • http://www.computerhistory.org/chess
Announcements
  • Exam 2 being graded
  • Sign up for Project 2 Demos! Comments done before!
  • Homework 8 available: Due 1 week