Games Computers Play

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35 Years Ago...

- Computer world chess champion: "soon"
- Widespread agreement on this!
- Other games sure to follow...
- Big lessons about human reasoning!
What Happened?

- Human players were underestimated
- Benefits of better computers overestimated
- Clever approach to computer game play!
Overview

- How computers play games
- Survey of computer game play
- Lessons from computer game play
How To Play Tic-Tac-Toe

- Game characteristics:
  - ``zero sum''
  - two player
  - alternating
  - terminating
  - no ``luck''
  - no ``hidden info.''

[Image of Tic-Tac-Toe game]
How Humans Play Tic-Tac-Toe

- Identify and block immediate wins
- Set up two-way traps
- Try something new
- Soon learn how to force a draw
How Computers Play Tic-Tac-Toe

- Game tree search
- Minimize opponent maximum
- Must play every possible game out!
How Computers Play Chess

- Cannot try every possible game
- Play for "a while", then evaluate
- In practice, deeper is better
- Opening book, endgame code
How Well Does Search Work?

- Easy to program
- Better for simple games
- Better for faster computers
- Not good enough?
  Tough...
Computers Play These Perfectly

- "Solved" games
  - Tic-Tac-Toe
  - 3D 4x4 Tic-Tac-Toe (Qubic), Gomoku, Connect Four
  - Mastermind
  - awari
  - Features
    - Small search
    - regular structure
Checkers

  - Powerful parallel computer (very deep search)
  - Retrograde “endgame”
  - "Must-read" book: *One Jump Ahead* (Springer-Verlag)

- Checkers *solved!!* Schaeffer April 29 2007; it's a draw
Chess

- *Deep Blue* (IBM team) beats Kasparov, February 1997 (3.5-2.5, experts dispute significance)


- Kramnik accused of using *Fritz 9* in match against Topalov, September 2006
Scrabble

- *Maven* (Brian Sheppard) was roughly par with top human players (e.g. GM Adam Logan), though now stronger

- What does this mean?
  - Top human players know most words
  - More strategy
  - "Luck": randomization (draw) tough for computers
Backgammon

- *TD-Gammon* (Gerald Tesauro, 1990s) roughly par with top human players (e.g. Malcolm Davis)
- Performance near optimal
- Program *learns* by playing (neural nets)
- Handles "luck" (probability) surprisingly well
Go

• Current top programs are worse than 5 kyu?
• 1997: Janice Kim beats *Handtalk* in demo with 25-stone handicap!
• Go is hard because
  - large branching
  - hard posn eval
A Giant Leap in Go

- 7 August 2008 – MoGo running on an 800-node Belgian supercomputer cluster defeats US Champion Myungwan Kim...at PSU!
  - 9-stone handicap :-)  
  - Maybe 8-stone?  
  - Stochastic search breakthrough  
  - How will it scale?
Bridge

- *GIB* (Ginsberg) was world computer champion
- = good club player
  - Bidding so-so
  - Play usually strong
- 2006 programs not way better
How GIB Plays Bridge

• Bidding: rules from *Meadowlark* + *Borel Simulation* (guess rest of auction)

• Play: *Monte Carlo* analysis
  - was *double dummy*, but not now
  - Deal, make sure deal consistent with bidding, known cards
  - Run minimax
  - repeat many times
Poker

- Schaeffer et al *Polaris* vs Phil Laak / Ali Eslami July 2007
  - Humans win heads-up duplicate match
- Probability, hidden information, multiplayer, expectimax: truly challenging
- Big payoffs from online play (fading?)
- Currently quite interesting
The Near Future

- Games of chance (poker, CCGs)
- Hidden information (poker, Stratego)
- Learning
Longer Term

- Multiplayer
- Better strategic play
  - planning
  - pattern recognition
- Not just games any more!
  - military, economic tool
  - general problem solving techniques
AI Lessons From Computer Games

- AI does not scale well with computer size/speed
- Intelligence and game playing ability not necessarily related
- "Pride goes before destruction, and a haughty spirit before a fall." — Proverbs 16:18
General Lessons From Computer Games

- Old view: John Henry, Frankenstein, R.U.R., HAL, Terminator
- New view: Adding machine
  - Complementary skills
  - Solve *specific* problems
Things To Learn

- Search basics
- Adversary search basics
- Hidden information and probability
- Games-specific tricks and SE
- Theory and formal analysis
CS 442/542
Combinatorial Games

- 10-week version of brief segment on how to build an adversary search engine
- Optional “funsies” tournament
- Bring
  - algorithm, data structure clues
  - out-of-class time
  - solid programming skills
- Spring 2009