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."
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
  - 3D 4x4 Tic-Tac-Toe (Qubic), Gomoku, Connect Four
  - Mastermind
  - Awari
  - Checkers [*]
• Features
  • Small search
  • regular structure
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 28 2006
Checkers

- *Chinook* (Jonathan Schaeffer) 1989 world human-machine champion

- Characteristics
  - Powerful parallel computer (very deep search)
  - Huge opening book, endgame database

- "Must-read" book: *One Jump Ahead* (Springer-Verlag)
Checkers “Solved”

- 2007: Schaeffer et al at U. Alberta show that Checkers is a draw
- Not entirely constructive: computer cannot play perfectly from any position
- Perhaps the largest adversary search ever
- Culmination of 20 years of research
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
Bridge

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

- Four players (NSEW)
- NS and EW partners
- All 52 cards dealt
- Bidding: set # of tricks to take
- Play tricks, score

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Why Is Computer Bridge Interesting?

• Four player team game: must cooperate
• Hidden information, including teammate's
• "Luck" via random deals (duplicate reduces this)
• Requires several skills:
  - bidding
  - declarer play
  - defender play
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
Go

- 2005 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
MoGo and the New Generation

• Recently, parallel stochastic (Monte Carlo) “rollout” search

• Fundamental advance in Go
  – At PSU 2009, MoGo on supercomputer defeats US Champ at 9-stone handicap

• Fundamental retreat from pure adversary search
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
- Be careful in claims about the future
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 443/543: Single-Agent Search

- Winter 2012
- Course in “single-player games”, with emphasis on scheduling
- A fundamental necessity for the complete computer person
- Lays the foundation for adversary search
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 2013