

# Games Computers Play

Bart Massey  
Computer Science Dept.  
Portland State University  
[bart@cs.pdx.edu](mailto:bart@cs.pdx.edu)  
<http://www.cs.pdx.edu/~bart>

# 35 Years Ago...

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

# What Happened?

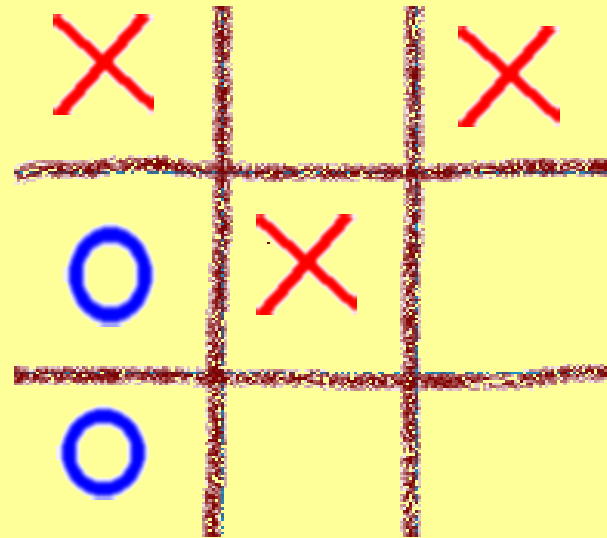
- Human players were underestimated
- Benefits of better computers overestimated
- Clever approach to computer game play!

# Overview

- How computers play games
- Survey of computer game play
- Lessons from computer game play

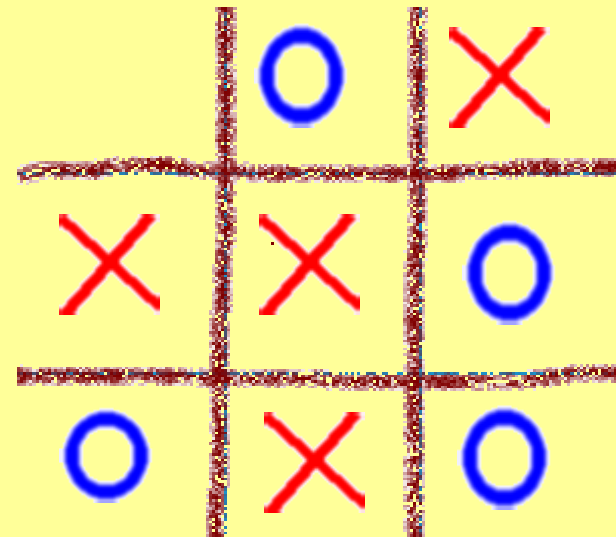
# How To Play Tic-Tac-Toe

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



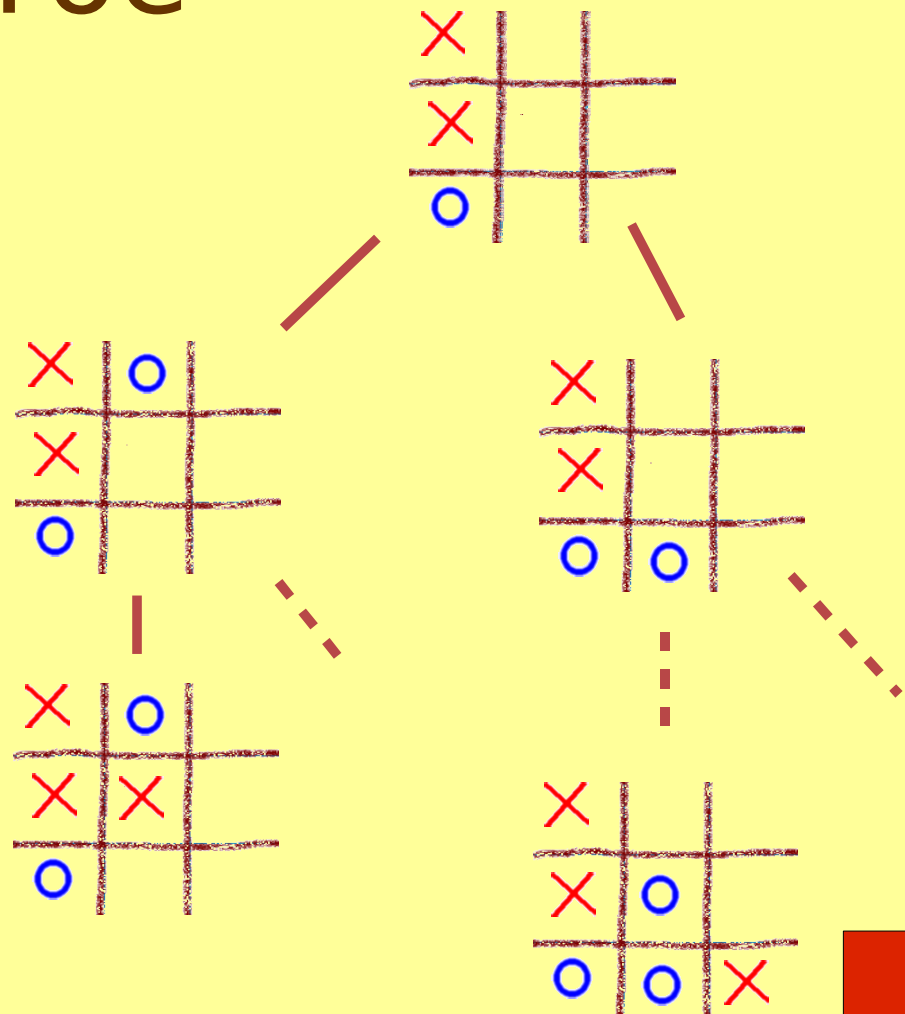
# How Humans Play Tic-Tac-Toe

- Identify and block immediate wins
- Set up two-way traps
- Try something new
- Soon learn how to force a draw



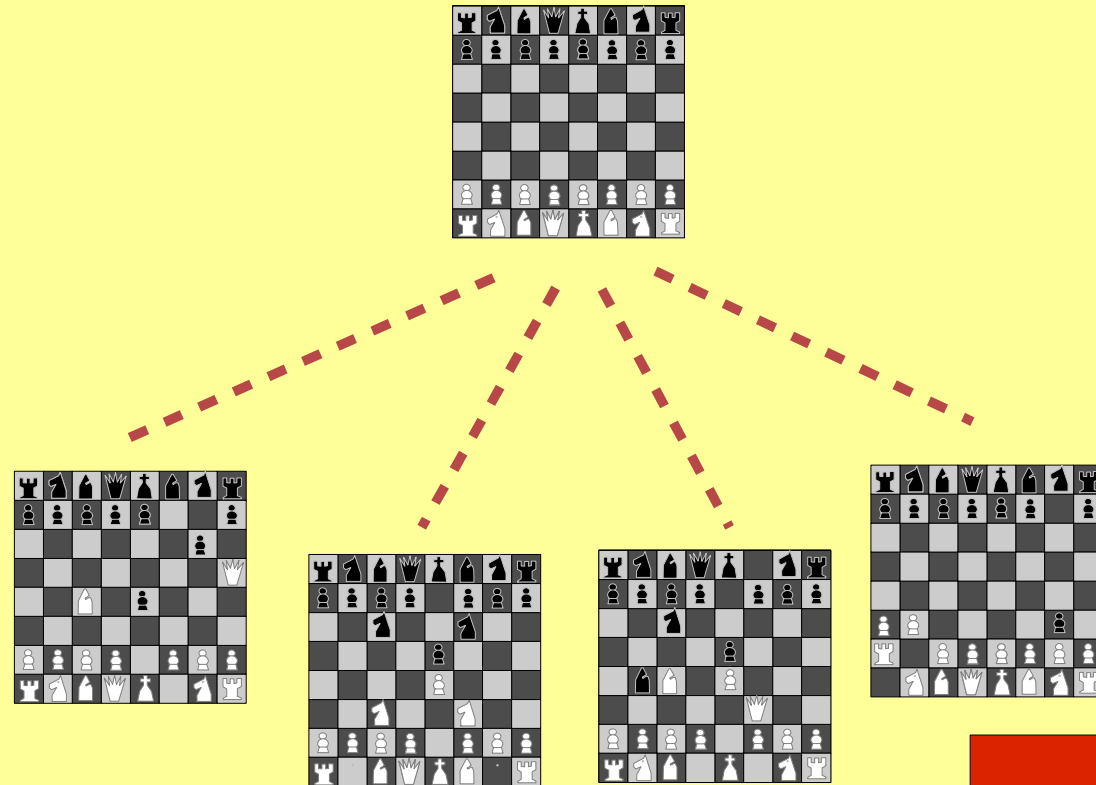
# How Computers Play Tic-Tac-Toe

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

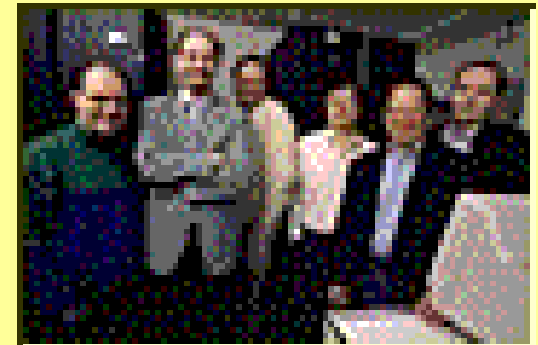
# Checkers

- *Chinook* (Jonathan Schaeffer) 1989 world human-machine champion, now *Nemesis* (2002)
- Characteristics
  - Powerful parallel computer (very deep search)
  - Huge opening book, endgame database
- "Must-read" book: *One Jump Ahead* (Springer-Verlag)



# Chess

- *Deep Blue* (IBM team) beats Kasparov, February 1997 (3.5-2.5, experts dispute significance)
- *Deep Fritz* draws Kramnik, Oct. 2002 (4-4); *Deep Junior* draws Kasparov, Feb. 2003)
- Kramnik accused of using *Fritz 9* in match against Topalov, September 28 2006



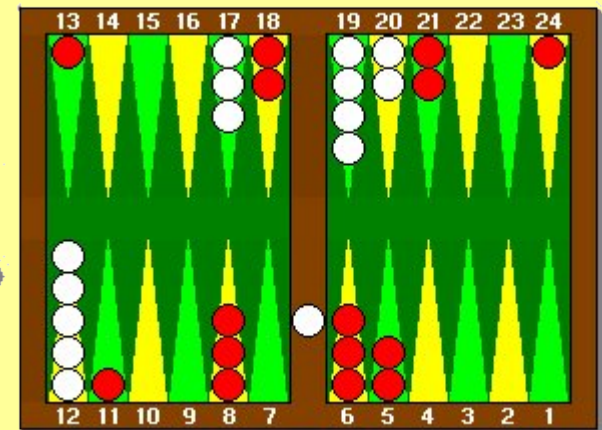
# Scrabble

- *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



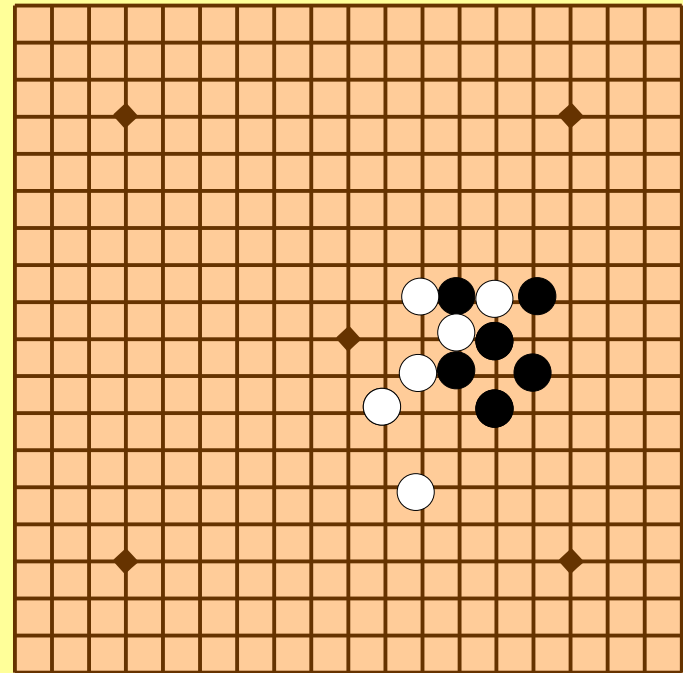
# Backgammon

- *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



# Bridge

- Zia Mahmood 1991-1997: £1M bet
- *GIB* (Ginsberg) was world computer champion
- = good club player
  - Bidding so-so
  - Play usually strong
- 2006 programs not way better

File Setup Display Actions Help

Contract: 4H  
Declarer: South  
N/S Tricks: 0  
E/W Tricks: 0

North (dummy)

West (GIB) vul

East (GIB) vul

South (matt)

N/S IMPs: 0.0  
E/W IMPs: 0.0

The screenshot displays a bridge hand interface. At the top is a menu bar with 'File', 'Setup', 'Display', 'Actions', and 'Help'. Below the menu, the contract is '4H' and the declarer is 'South'. The number of tricks for North/South and East/West is shown as 0. The cards are arranged as follows: North (dummy) has K♥, 10♠, K♦, A♣; South (matt) has A♥, 9♥, 7♥, 2♥, 9♠, 6♠, Q♦, 9♦, 5♦, 4♦, 2♦, K♣, 2♣; West (GIB) and East (GIB) are shown with their hands hidden behind blue patterned cards. IMP scores are 0.0 for both sides.

# Bridge In Two Minutes

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

♠AKQT3 ♥752 ♦AJ ♣AK7	♠J8764 ♥KJ3 ♦QT9 ♣83	♠952 ♥A ♦8754 ♣QJT54
	<div style="border: 1px solid black; width: 100px; height: 100px; margin: 0 auto;"></div>	
	♠ ♥QT9864 ♦K632 ♣962	

W	N	E	S
1♠	-	2♣	4♥
4x	-	-	-

# 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

# The Near Future

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

# Longer Term

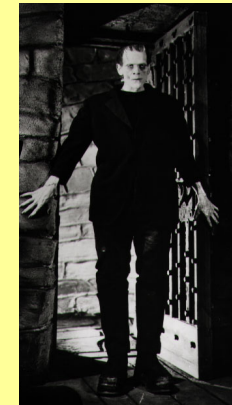
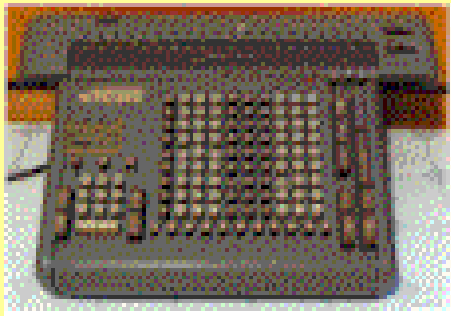
- Multiplayer
- Better strategic play
  - planning
  - pattern recognition
- Not just games any more!
  - military, economic tool
  - general problem solving techniques

# 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

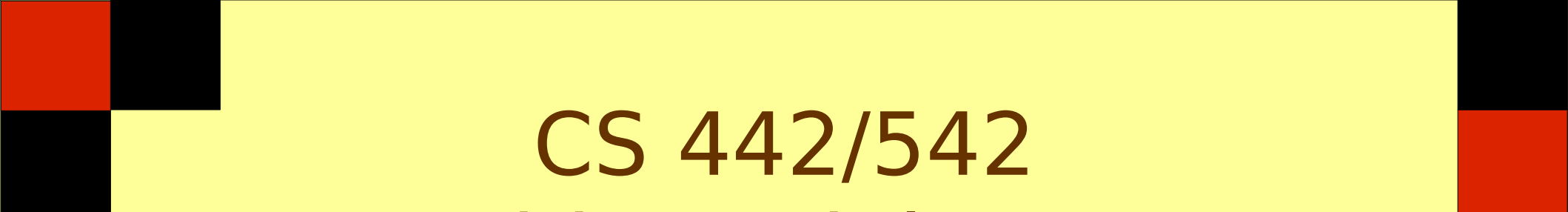
# General Lessons From Computer Games

- 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 2007
- 