



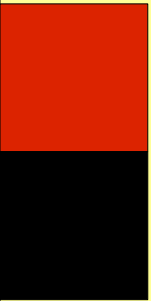
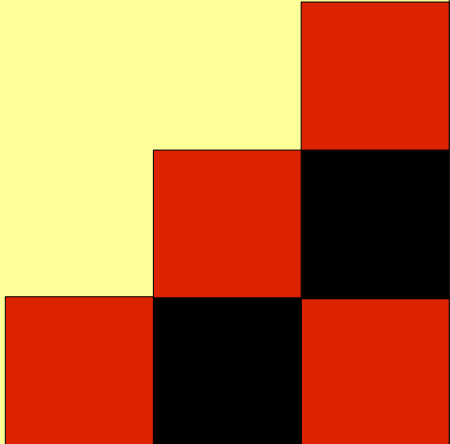
Games Computers Play

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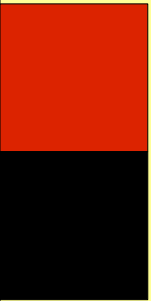
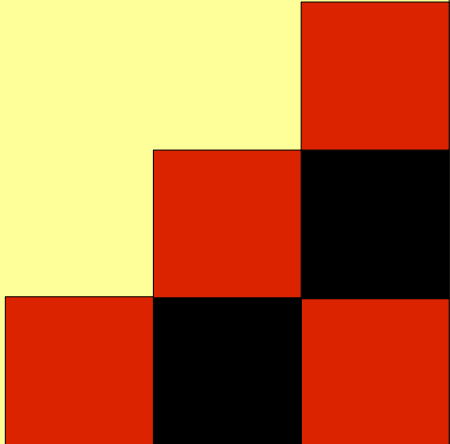


45 Years Ago...

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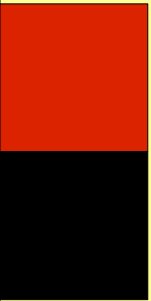
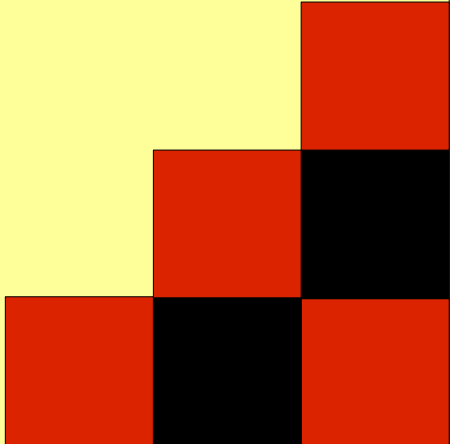


What Happened?

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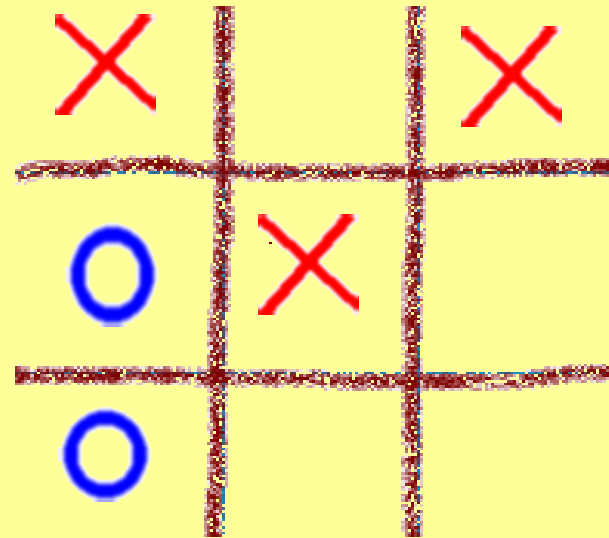


Overview

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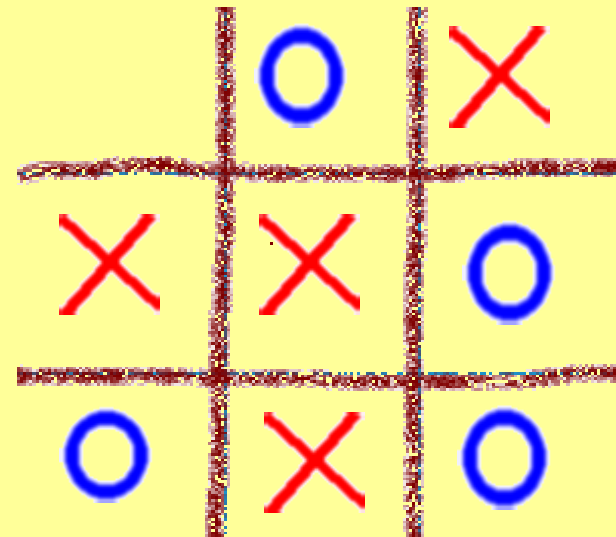
How To Play Tic-Tac-Toe

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



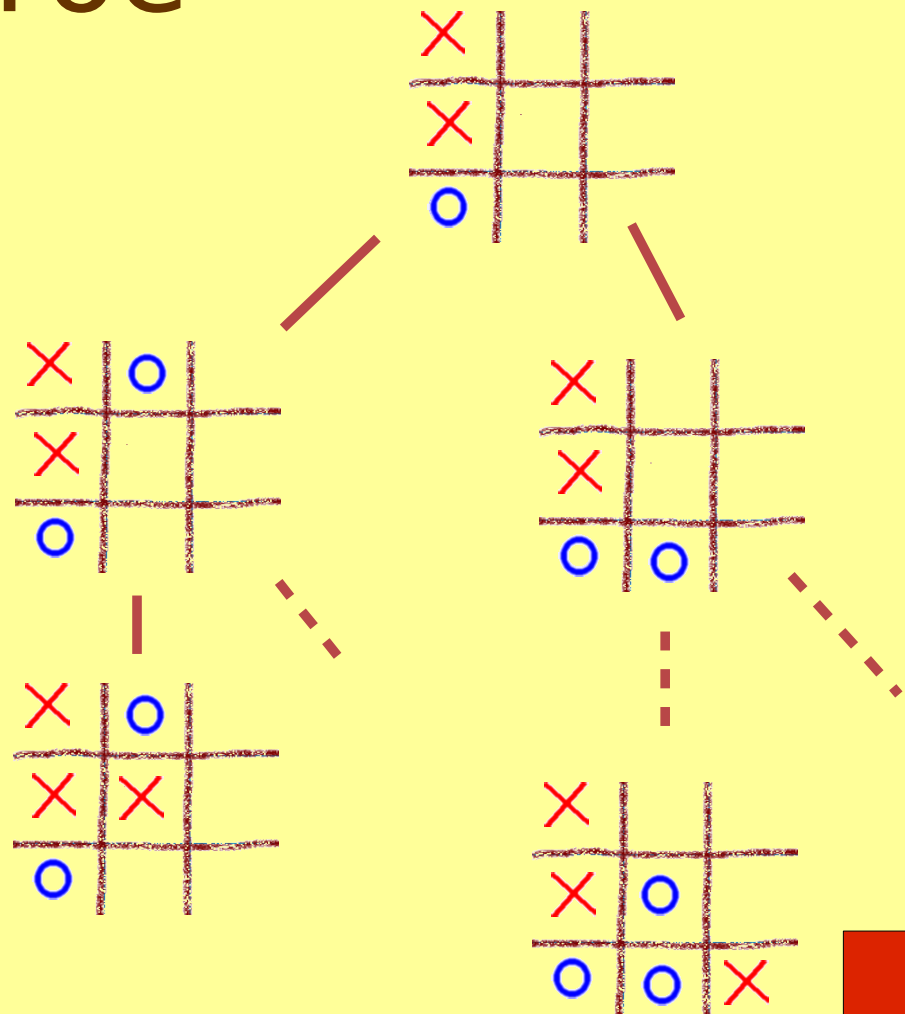
How Humans Play Tic-Tac-Toe

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



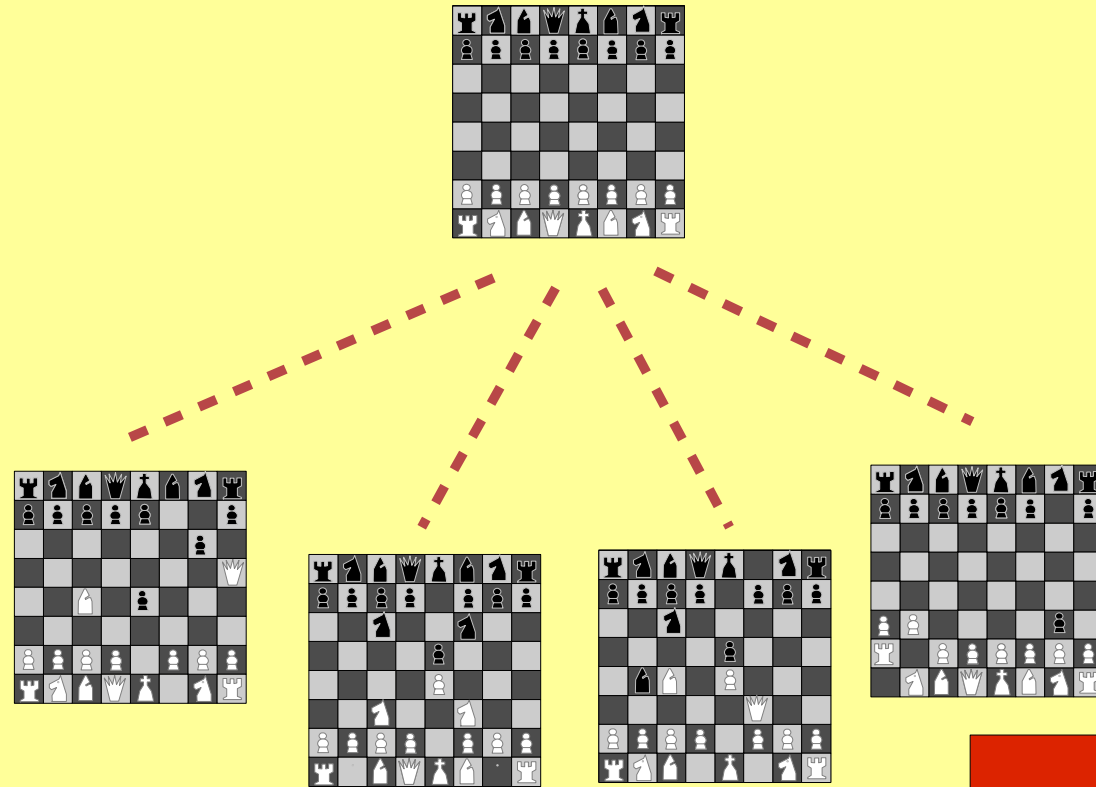
How Computers Play Tic-Tac-Toe

- 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



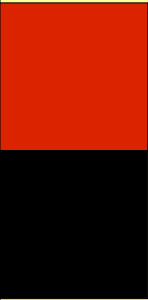
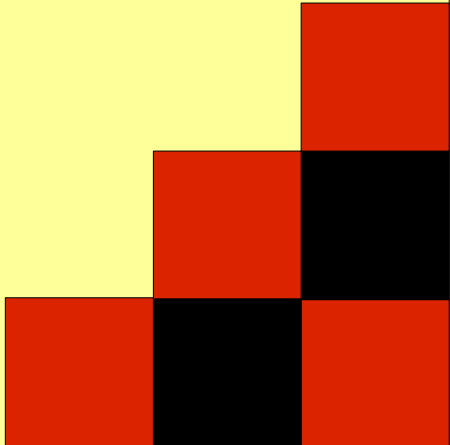


How Well Does Search Work?

- 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
- 
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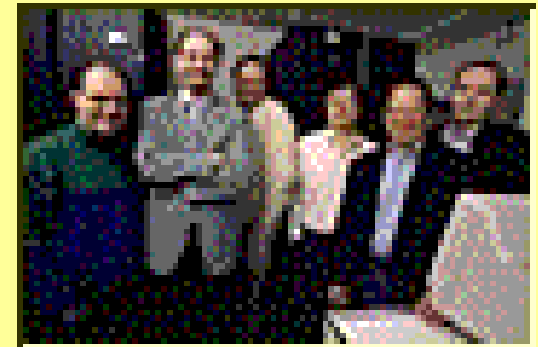
Checkers

- *Chinook* (Jonathan Schaeffer) 1989 world human-machine champion, solved Checkers 2007 (draw)
- 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



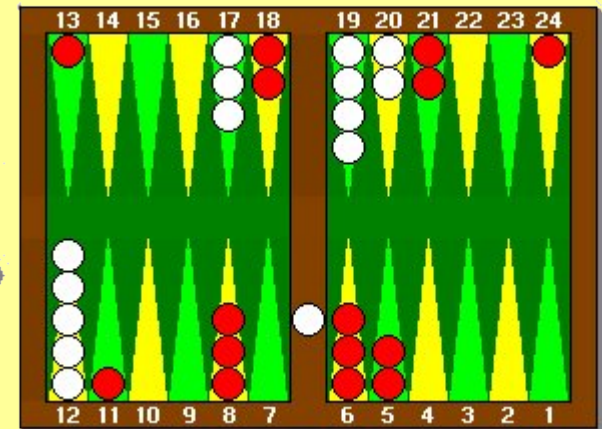
Scrabble

- *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



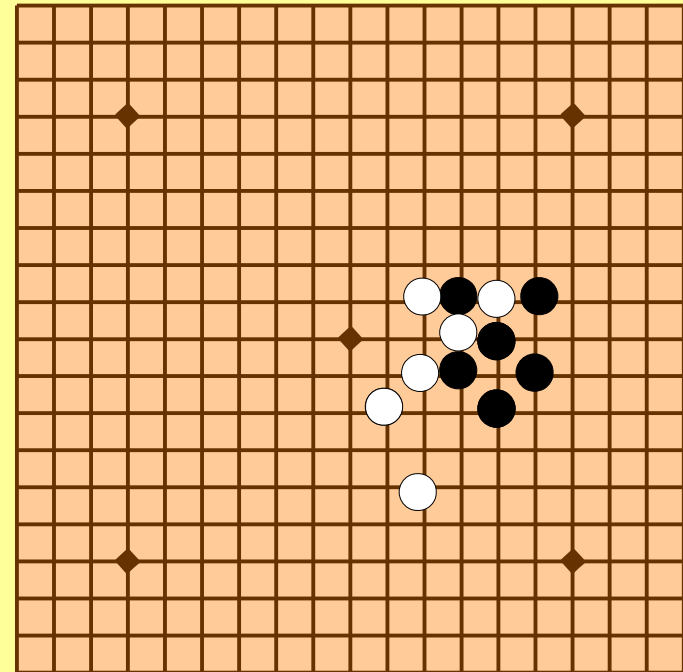
Backgammon

- *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



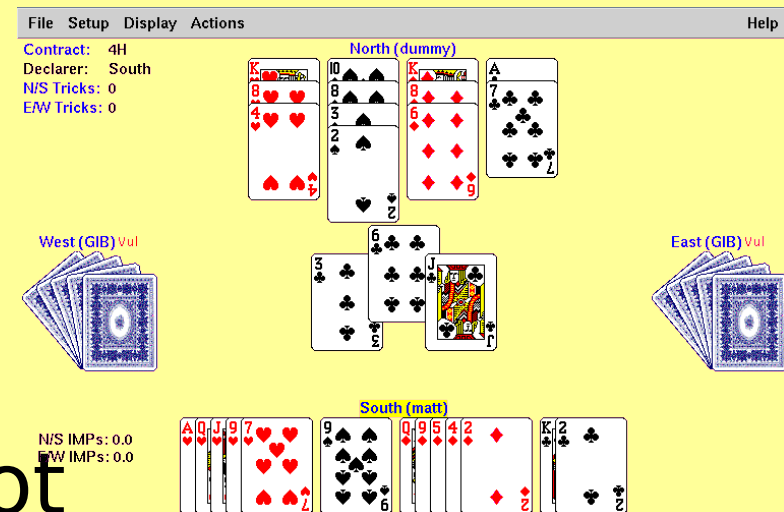
Go

- 1997: Janice Kim beats *Handtalk* in demo with *25-stone* handicap!
- 2010: MoGo beats US champ with 9-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
- Current 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

♠J8764

♥KJ3

◆ QT9

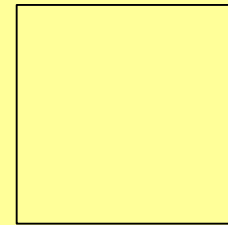
♣83

♠AKQT3

♥752

♦ AJ

♣AK7



♠952

♥ A

♦ 8754

♣QJT54



♥QT9864

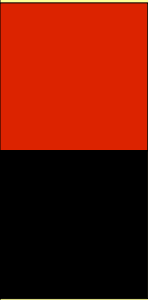
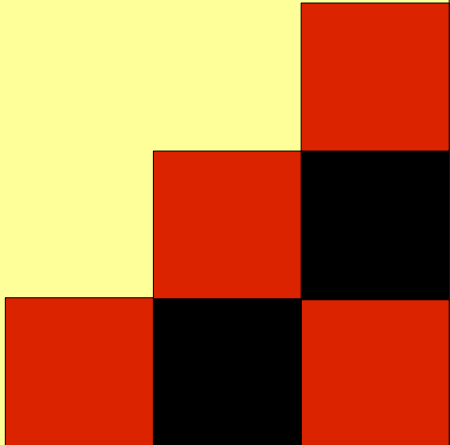
◆ K632

♣962

W	N	E	S
1♠	-	2♣	4♥
4×	-	-	-



Why Is Computer Bridge Interesting?

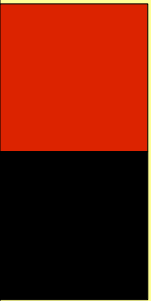
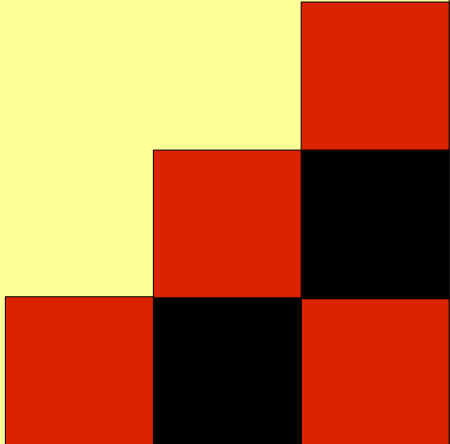
- Four player team game: must cooperate
 - Hidden information, including teammate's
 - "Luck" *via* random deals (*duplicate* reduces this)
 - Requires several skills:
 - bidding
 - declarer play
 - defender play
- 
- 

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

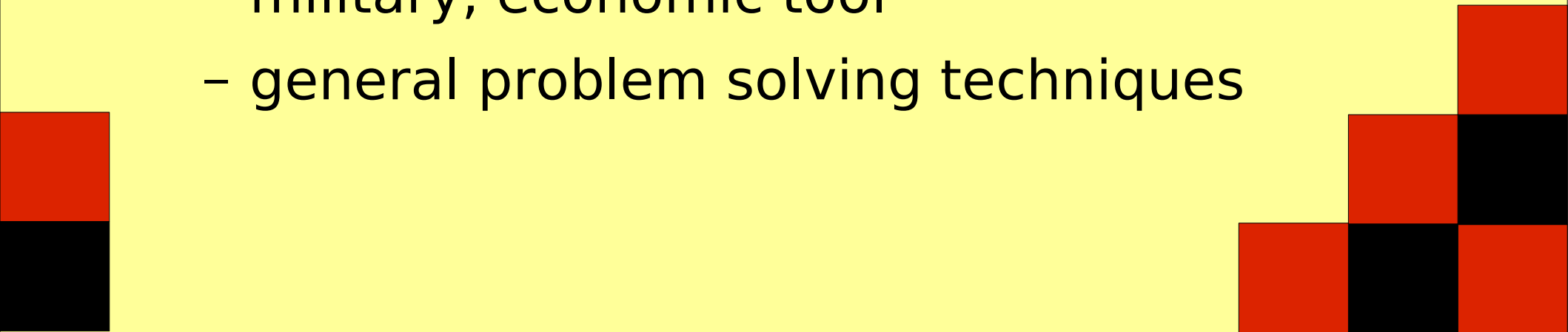


The Near Future

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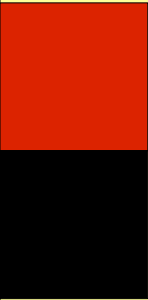
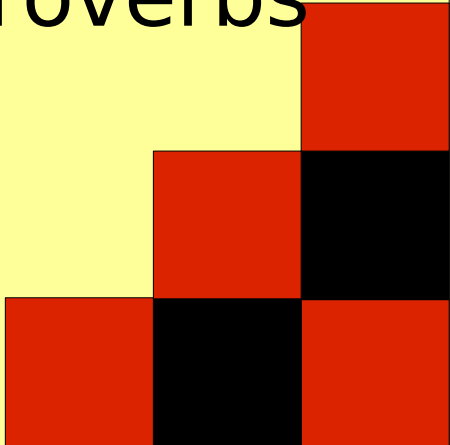


Longer Term

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

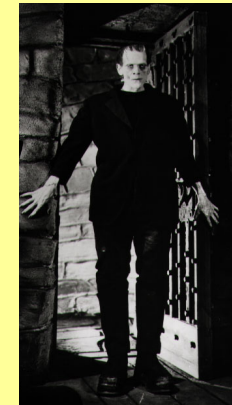
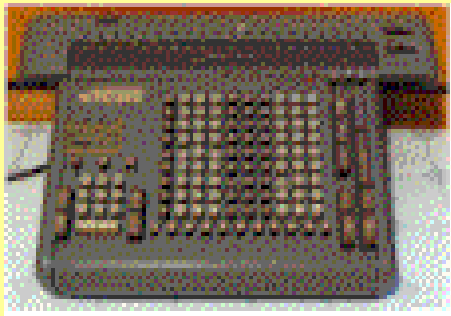


AI Lessons From Computer Games

- 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
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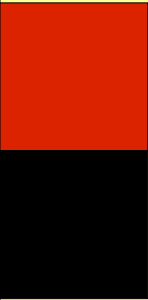
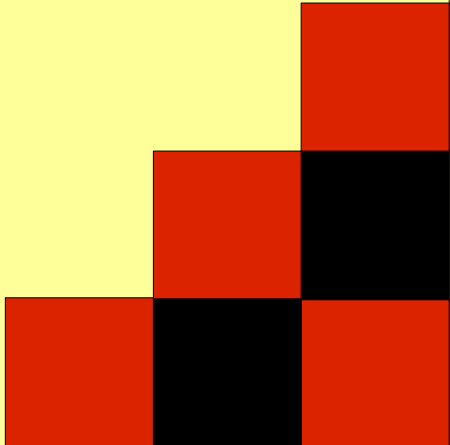
General Lessons From Computer Games

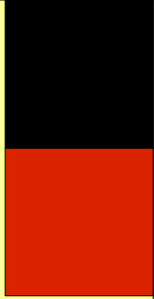
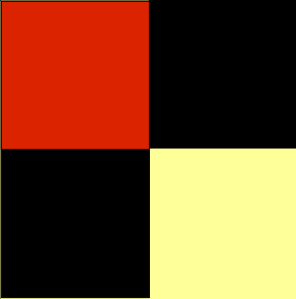
- Old view: John Henry, Frankenstein, R.U.R., HAL, Terminator
- New view: Adding machine
 - Complementary skills
 - Solve *specific* problems





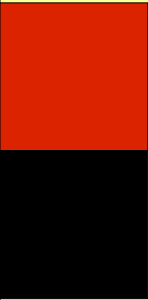
Things To Learn

- Search basics
 - Adversary search basics
 - Hidden information and probability
 - Games-specific tricks and SE
 - Theory and formal analysis
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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
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