

The Games Computers Play ... Perfectly

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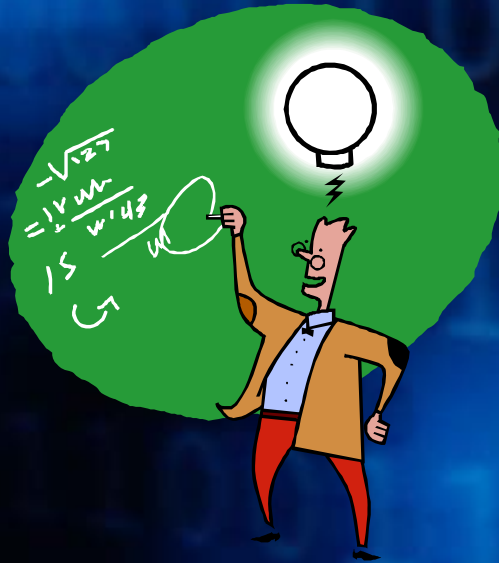
GAMES Research Group

- Largest AI research group using games
- Classic Games
 - Chess, checkers, go, hex
 - Poker, hearts, spades
- Commercial games
 - Role-playing (Bioware)
 - Sports (Electronic Arts)
 - Real-time strategy



Research

Inspiration



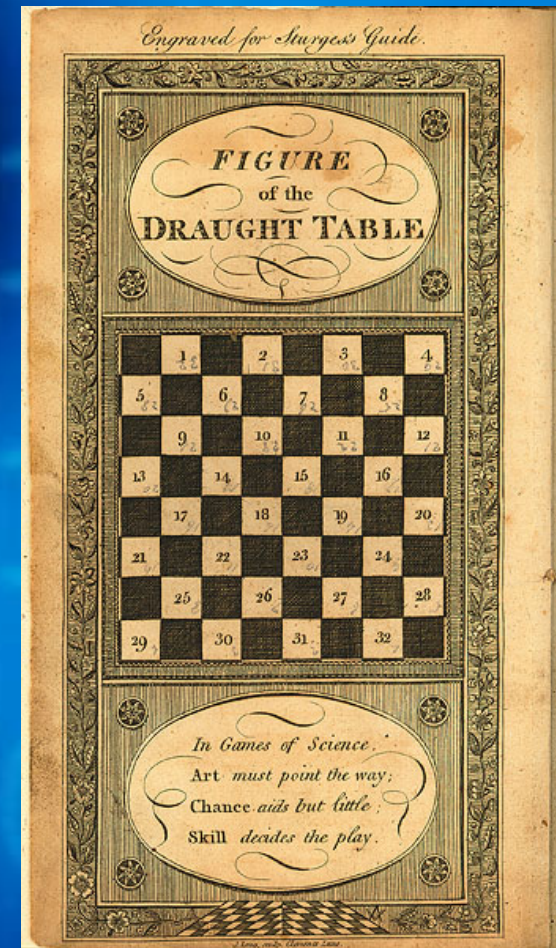
Perspiration



1989 - 2007?

Checkers

- Popular in North America and former British Commonwealth
- Rules:
 - Played on an 8x8 board
 - Checkers: one square diagonally forward
 - Kings: one square diagonally
 - Can jump over pieces
 - Checker on last rank becomes a king
 - Play until a side has no pieces/moves



Computer Checkers

- One of the original AI “grand challenge” problems
- First publication in 1953
- Early research dominated by Samuel’s seminal work
- First public man-machine competition in 1963



Realizing Samuel's Dream

- Man versus Machine for the World Checkers Championship
- Challenger:
 - Chinook, a computer program
- Champion:
 - Marion Tinsley, a human program

The Challenger

- Project started at the University of Alberta in 1989
- Chinook wins 1989 Computer Olympiad
 - 1st place
 - 4-piece database: 7 million positions
- 1990 checkers conference
 - master-level performance
 - 5-piece database: 149 million positions

Surprise!

- 1990 Mississippi State Championship
 - 6-piece databases: 2.7 billion positions
- 1990 U.S. Championship
 - 2nd place, undefeated
 - drew a 4-game match with the World Champion
 - a computer program was now the official challenger for the human World Championship

The Champion

- World Champion
 - 1952-1958 (retired)
 - 1975-1991 (retired)
- Since 1950, Tinsley...
 - ➔ finished first in every tournament
 - ➔ won every match
 - ➔ crushed the opposition

Man or Machine?

During the period 1950 - 1992, Tinsley lost:

a) 3 games

b) 5 games

~~c) 37 games~~

~~d) 51 games~~

~~e) 88 games~~



Prelude to the Match

- Tinsley defeats Chinook 7.5 - 6.5
- ACF/EDA refused to sanction the match
 - Tinsley resigned his title and then...
 - ... signed on to play Chinook
 - Tinsley given title World Champion Emeritus
- World Man-Machine title created
- World Championship match held August 1992 in London (Silicon Graphics)

London 1992

A thick, horizontal yellow brushstroke with a textured, painterly appearance, extending across the width of the slide below the title.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

1992 Championship (1)

- Tinsley presses in game 1 but the endgame databases save the day
 - 7-piece databases: 37 billion positions
- Tinsley wins game 5
- Tinsley misses a win in game 7
- Consensus?

Chinook is going to get crushed

1992 Championship (2)

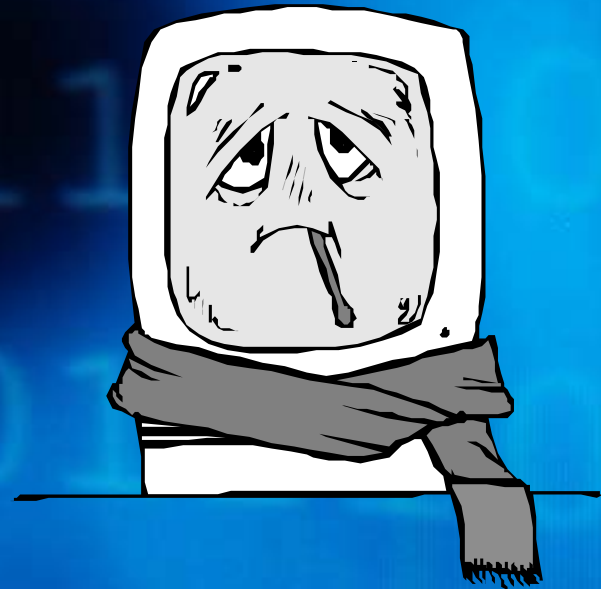
- Chinook stuns Tinsley with a win in game 8
 - First time a computer has defeated a World Champion in a non-exhibition game
- Chinook scores again in game 14
 - First time since 1958 that Tinsley has had to come from behind
- Consensus?

Chinook is going to win

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

1992 Championship (3)

- Fateful game 18...
- Software problem?
- Hardware problem?
- Hotel problem?
- Consensus?



It's a toss-up.

1992 Championship (4)

- Tinsley “accidentally” wins game 25
- Error in book knowledge
- Chinook pulls goalie in game 39 and loses

QuickTime™ and a
TIFF (Uncompressed) decompressor
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Final score:
Tinsley 20.5
Chinook 18.5



Waiting for Revenge

- Spend two years preparing for a re-match
- Chinook 1994:
 - Search: deeper searching
 - 17-29 moves deep!
 - Openings: massive openings effort
 - Knowledge: thorough testing
 - Endgames: 8-piece databases
 - 406 billion positions!

Boston 1994



1994 Championship (1)

- Tinsley upset that “God loves Jonathan too”
- Chinookitis
- Chinook comes close to victory in game 2
- First six games are drawn
 - Chinook’s play has been flawless
 - Opening moves lead to endgame databases
- Consensus?

Chinook looks impressive

1994 Championship (2)

- “Let me suggest the unthinkable”
- Tinsley concerned about an upset stomach
- Doctors give him the OK but do X-rays as a precaution
- Tinsley agrees to continue

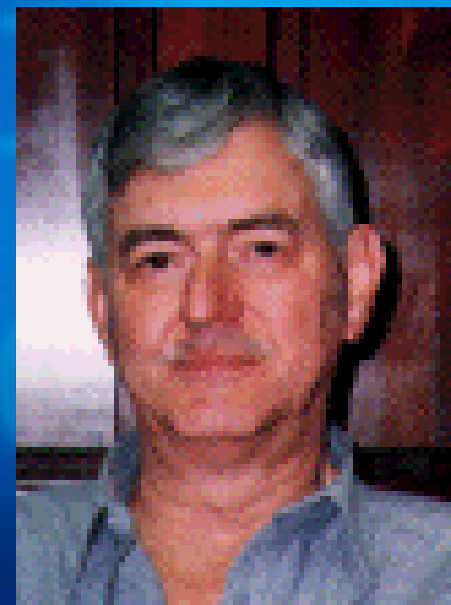
1994 Championship (3)

- Tinsley resigns the match and title
- Agrees to postpone announcement until X-ray results known
- Chinook wins World Championship on forfeit



Aftermath

- 1994 draw a match with Grandmaster Don Lafferty to retain the title
- Threatened legal action
- Anti-Chinook Internet campaign
- 1995 defend title against Lafferty
- Tinsley dies in April 1995
- Chinook crushing all in 1996



Aftermath (2)

- Lots of accolades came my way
- “First World Champion” — Guinness Book of World Records
- But still there was a sense of unfinished business

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Who Is Better?

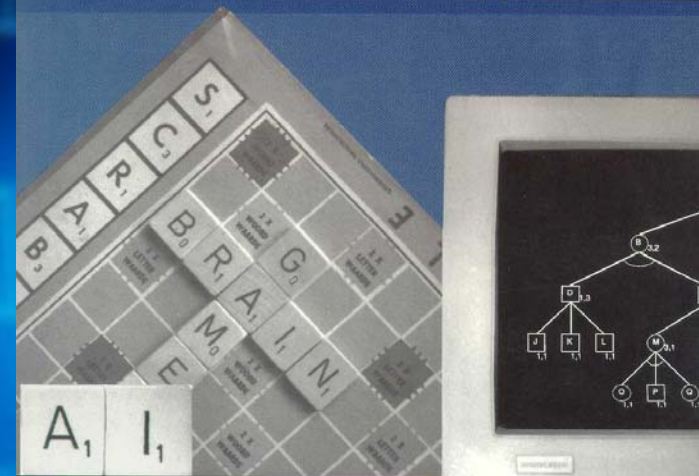
- “Chinook doesn’t hold a candle to Tinsley”
- “In his prime, Tinsley would crush Chinook”
- There is only one way to “prove” that machine is better than man...



Solving Games

- Connect-4
- Go Moku
- Qubic
- Nine Men's Morris
- Awari
- Hex (small boards)

Searching for Solutions in
Games and Artificial Intelligence



Victor Allis

Solving Checkers?

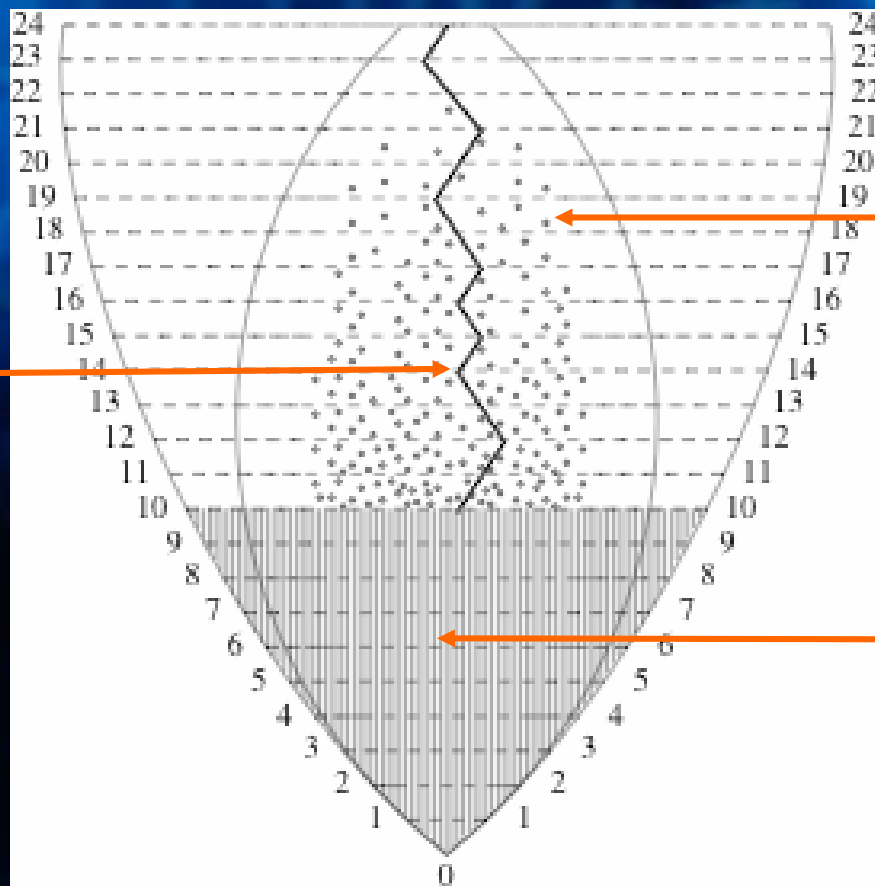
- All solved games have smaller search complexity or decision complexity than checkers
- Search complexity
 - 5×10^{20} positions
 - 500,995,484,682,338,672,639
 - Do you know just how big this number really is?
 - Over 10^7 times bigger than awari
- Decision complexity
 - Long games, multiple move choices, non-trivial decision-making required

Endgame Databases (1)

• Use retrograde analysis to solve positions near the end of the game	<u>#</u>	<u>POSITIONS</u>
	1	120
	2	6,972
	3	261,224
• Perfect win, loss, draw information	4	7,092,774
	5	148,688,232
	6	2,503,611,964
• Began computing in 1989!	7	34,779,531,480
	8	406,309,208,481
• Solve all positions with 10 or fewer pieces	9	4,048,627,642,976
	10	<u>34,778,882,769,216</u>
		39,271,258,813,439

Solving Process

Master:
main line of
play to
consider



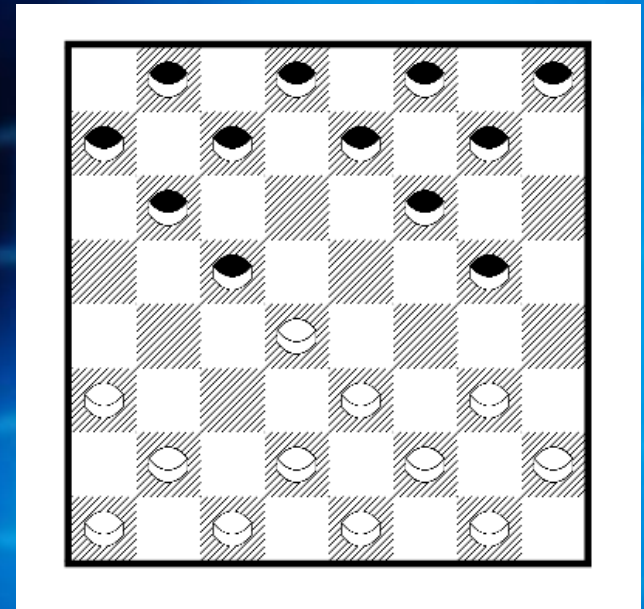
Workers:
positions to
search

**Endgame
databases
(solved)**

Log of Search Space Size

Results

- Checkers tournament games randomly choose a 3-move opening
- Solve one opening at a time
- White Doctor is one of the most challenging for humans to play
- January 2005 -- draw!



March 9:
14 openings
solved

Solving Checkers

- Fifty machines working in parallel on the problem
- 19 openings needed to solve checkers!
 - 14 are completed
 - 2 are almost done
 - 3 are computing now
- Proof complete: Black to play cannot lose
- Proof ongoing: Black to play cannot win

Solving Checkers (3)

- Barring any errors...
- Expect to announce that checkers is solved in 3-5 months

Theorem: Perfect play leads to a draw

Corollary: Chinook will never lose

Implication: Even Tinsley occasionally made a mistake. Therefore...

Last Word

1989 to 2007

“It’s been 18 years!
...obsessive-compulsive
behavior...not normal...
Get a life, Jonathan.”

Stephanie Schaeffer

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www.cs.ualberta.ca/~chinook