One Jump Ahead

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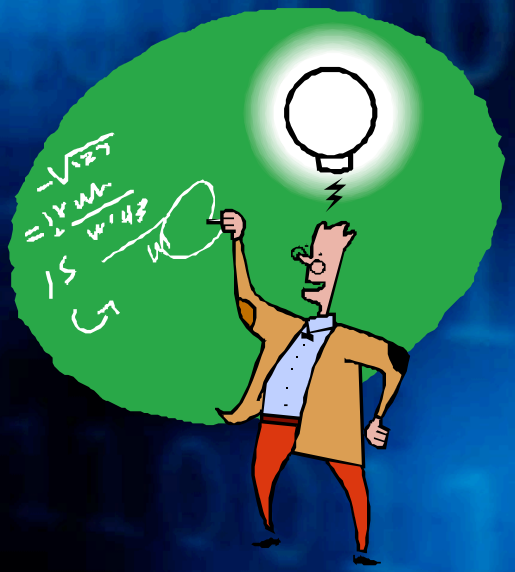
Research

Inspiration



Perspiration

1989 - 2007?

Games and AI Research

- Building high-performance game-playing programs was one of the initial "grand challenge" problems in AI research
- Major successes in Chess (Deep Blue), Othello (Logistello), Backgammon (TD Gammon), Scrabble (Maven)…
- What about checkers?
  - Simple but not simple
  - All the same research opportunities as chess
  - Neglected because of a single human oversight

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

- First publication in 1953
- Early research dominated by Samuel's seminal work
  - First public man-machine competition in 1963
  - Samuel "solved" checkers
  - Milestone in machine learning

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~~

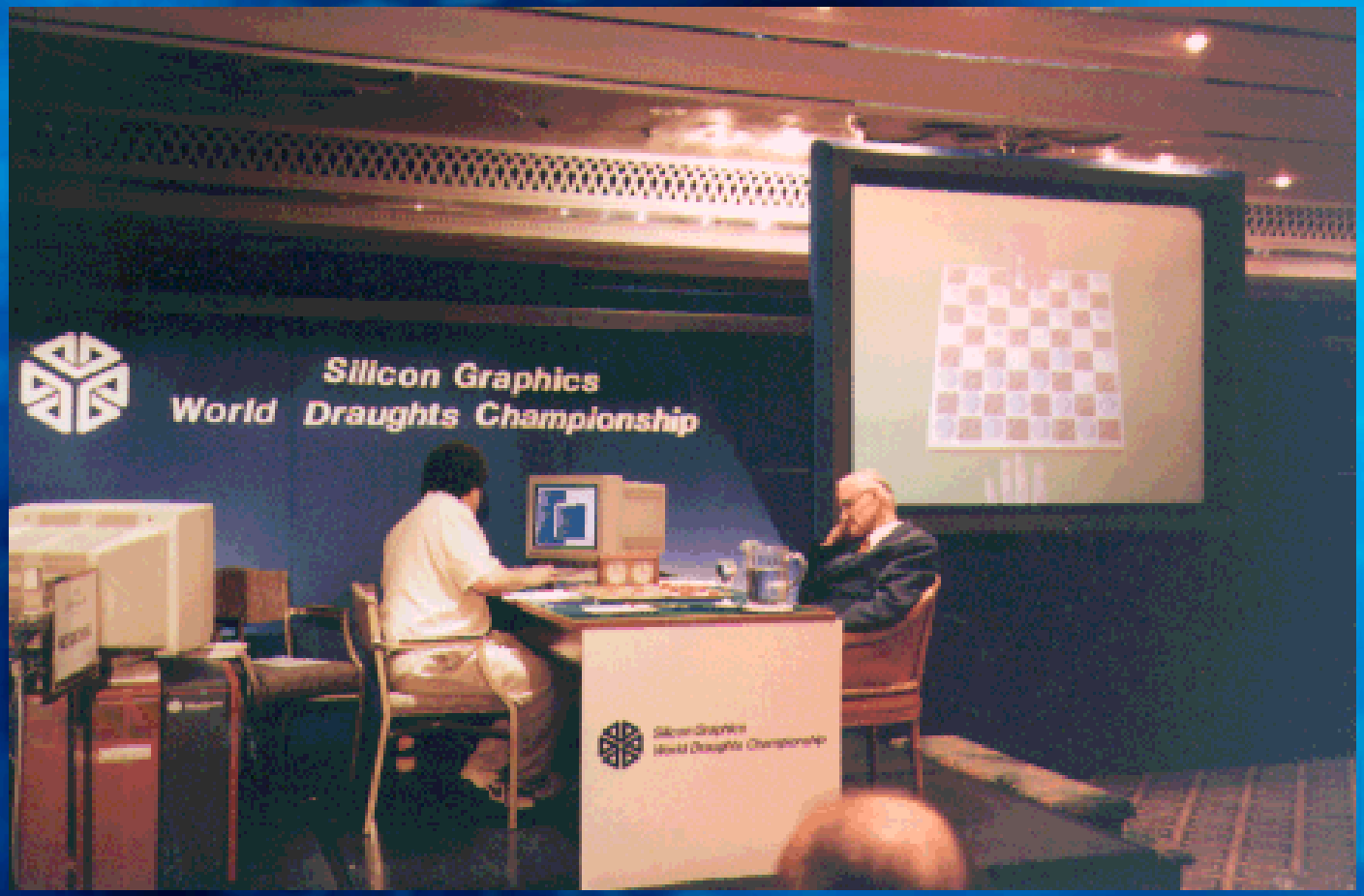
~~d) 51 games~~

~~e) 88 games~~

Prelude to the Match

- Tinsley defeats Chinook 7.5 - 6.5
  - “I feel like a teenager again”
- 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



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

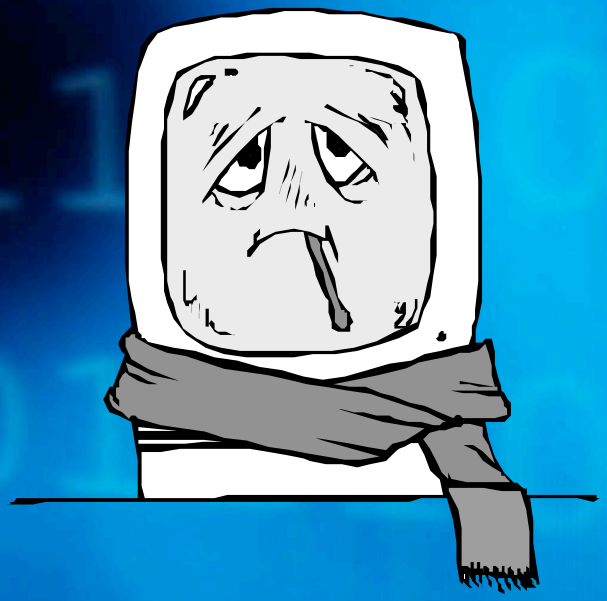
1992 Championship (2)

- 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

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

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


SiliconGraphics
CHECKERS CHAMPIONSHIP
SiliconGraphics
WORLD
CHECKERS
CHAMPIONSHIP

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)

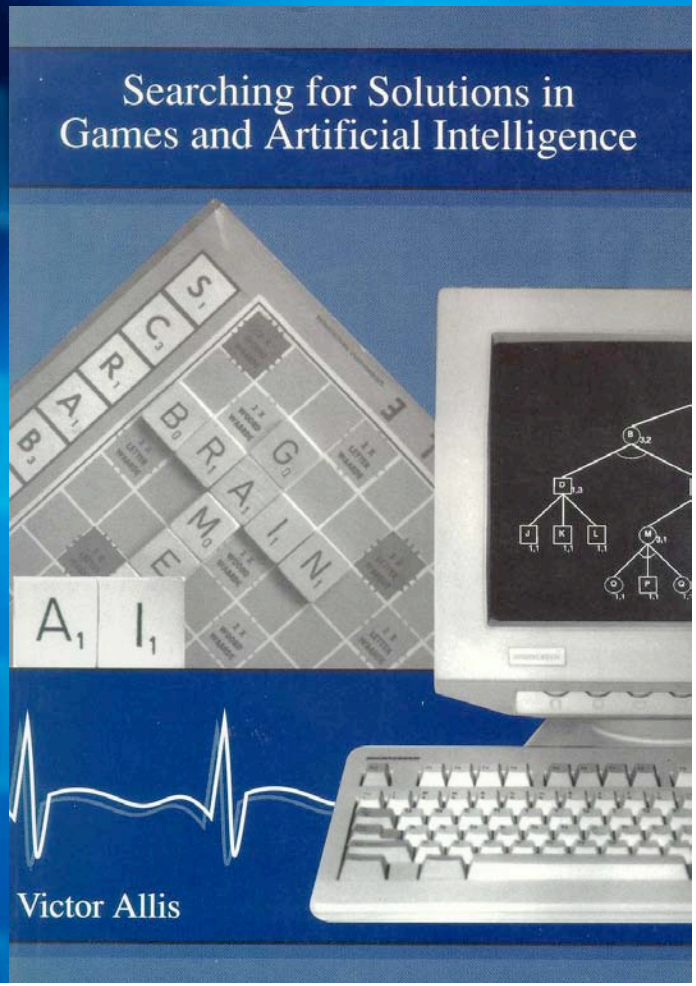
- Lots of accolades came our way
  - “First World Champion” — Guinness Book of World Records
  - Trivial Pursuit question (‘90s Edition)
  - Who Wants to be a Millionaire ($16,000 question)
- But still there was a sense of unfinished business

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)



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

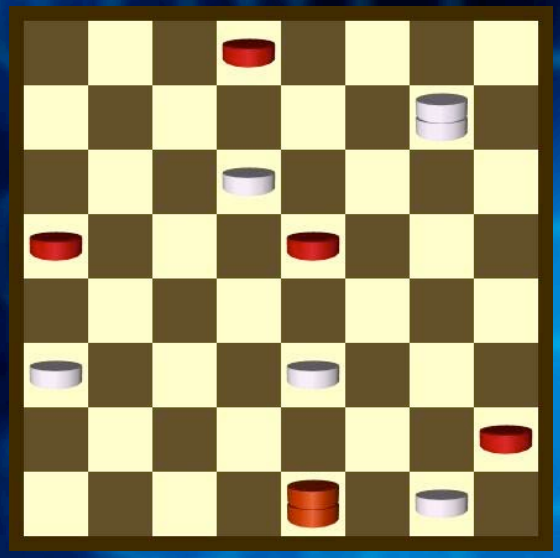
Endgame Databases (1)

- Use retrograde analysis to solve positions near the end of the game
- Perfect win, loss, draw information
- Began computing in 1989!
- Solve all positions with 10 or fewer pieces

#	POSITIONS
1	120
2	6,972
3	261,224
4	7,092,774
5	148,688,232
6	2,503,611,964
7	34,779,531,480
8	406,309,208,481
9	4,048,627,642,976
10	34,778,882,769,216
	39,271,258,813,439

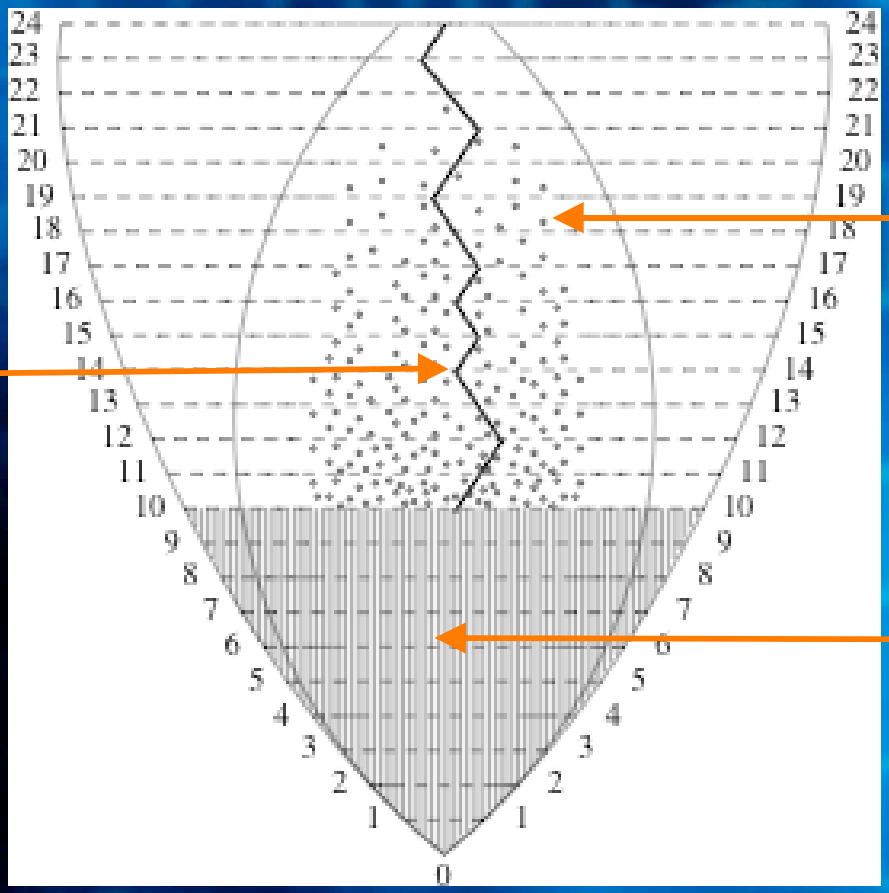
Endgame Databases (2)

The 100-Year Position
Human analysis for 100 years… win!



One database lookup… draw!
The 197-year position

Solving Process



Master: main line of play to consider

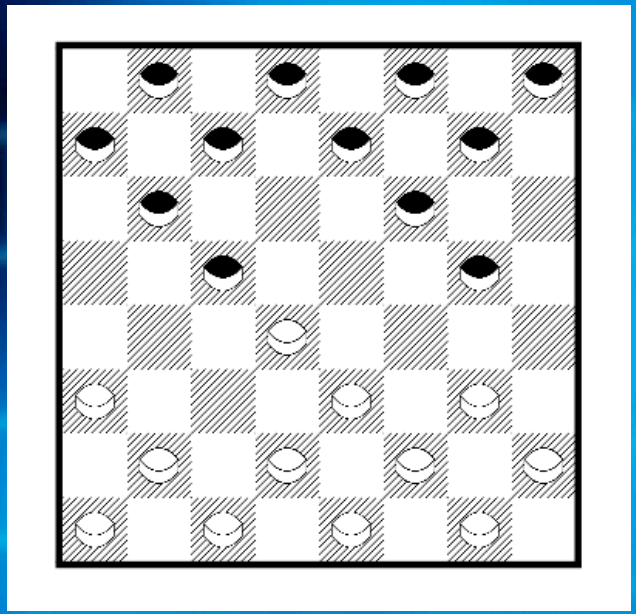
Workers: positions to search

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!



Solving Checkers

- Fifty machines working in parallel on the problem
- Only 19 of 200ish openings needed to solve checkers!
- Proof complete: Black to play cannot lose
- Proof remaining: Black to play cannot win?

Proof Stats

- Longest line in proof tree (154 ply)
- At end is a position that has been searched to possibly >= 30 ply
- At end is a database positions which could have been searched to >= 250 ply

Efficient Search?

- Positions:
  - 10^{20}
- Data solution:
  - 10^{18} disk and $\approx 10^{21}$ computations
- Compute solution:
  - 0 disk and $>=10^{23}$ computations (optimistic)
- Our hybrid solution:
  - 10^{11} disk and 10^{14} computations

Final Result?

- Article on the result submitted for publication
  - Getting the result in the media before the publication happens will result in withdrawal of the article
  - Need to keep the result quiet until I hear if the article has been accepted
- Sorry, but I cannot announce the final result today

Consequence

Possible result…

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

(new web site to debut with the announcement)