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)
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
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
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
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
  - $5 \times 10^{20}$ 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

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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!

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…
“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