Different Types of Games

- How many players?
  - One
  - Two
- Element of chance?
  - Deterministic
  - Nondeterministic
- Outcome
  - Zero sum (what one player wins, the other loses)
  - Non-zero sum

<table>
<thead>
<tr>
<th></th>
<th>Deterministic</th>
<th>Nondeterministic</th>
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<tr>
<td>One Player</td>
<td>Tower of Hanoi</td>
<td>Solitaire</td>
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<td>Two Player</td>
<td>Chess</td>
<td>Backgammon</td>
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<td></td>
<td>Tic-Tac-Toe</td>
<td>Poker</td>
</tr>
<tr>
<td></td>
<td>Go</td>
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</tbody>
</table>
Using hill climbing for one player games

Game Tree for two person game

Game Tree

+1 = I win    -1 = you win
Perfect decisions with two player games

- Each player will make the best decisions possible:
  - Player A: maximize score (higher scores better for A)
  - Player B: minimize score (lower scores better for B)

The Minimax Procedure

1) Work upwards, 2) B will always pick minimum, and 3) A will always pick maximum

What does Minimax predict A will do?
Fighting Combinatorial Explosion

- limit branching factor
- pruning the search tree
**Alpha-Beta Pruning**

AT LEAST 7

AT MOST 6
no need to visit other branches below this node

Some states do not need to be searched!
The alpha-beta method cleverly eliminates large part of the search space

**Perfect Play with Connect 4**

- Play the game against the computer
  - [http://www.fantafar.com/games/connect_four/](http://www.fantafar.com/games/connect_four/)

- Perfect play – the game of Connect 4 can be planned to the end

- the first player can force a win by starting in the middle column. Starting in the two adjacent columns allows the second player to reach a draw; starting with the border columns even allows the second player to force a win.

- Why play the game if the outcome is already known (assuming perfect play)?
Complexity of Game Trees

• Most games cannot be planned to the end -> combinatorial explosion

• Number of states to search = \((N)^D\)
  – Branching factor \((N)\): number of legal moves at each position (on average)
  – Depth \((D)\) = number of moves till the end

Branching factor

• Chess:
  Branching factor = about 35 moves/positions
  Depth = about 100 moves total
  \((35)^{100} = (10)^{35}\) number of positions to search

• Intelligent Search: decrease the branching factor
  \((35)^2 = 1225\)
  \((35)^6 = 1,838,265,625\)
  \((5)^2 = 25\)
  \((5)^6 = 15,625\)

Chess Computers

• 1997: IBM’s Deep blue played world champion
  Gary Kasparov
  
  Deep blue: 250,000,000 positions/sec
  Kasparov: ?? positions/sec

• Brute force vs. Intelligent search
Comparing Brains & Computers

<table>
<thead>
<tr>
<th>BRAINS</th>
<th>COMPUTERS</th>
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<tr>
<td>Neurons/organic</td>
<td>Silicon/Metallic</td>
</tr>
<tr>
<td>Parallel computation</td>
<td>Serial Computation</td>
</tr>
<tr>
<td>Distributed Memory</td>
<td>Localized Memory</td>
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<tr>
<td>Unreliable parts</td>
<td>Reliable parts</td>
</tr>
<tr>
<td>Resistant to damage</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Not understood</td>
<td>Understood</td>
</tr>
<tr>
<td>Conscious/Intelligent</td>
<td>??</td>
</tr>
</tbody>
</table>

Ask Yourself

Do you consider your own mind to be a bunch of software programs?

Probably not!

Turing's challenge was this:

*Can you really say what the difference is between the mind of a human being and the artificial 'mind' of a computer which simulates a human mind?*

Turing Test

1. Interrogator
2. Human
3. Computer Program

Interrogator tries to determine who is the human and who is the Computer program
Loebner Prize

JUDGE: Is it April or May?
ENTRANT: Um. I believe it's April.
JUDGE: Why do you say that?
ENTRANT: That's a very good question. Because months and days and so on are arbitrary - I suppose.
JUDGE: It seems you are taking a certain tone with me. An agitated, human tone.
ENTRANT: Really? You are somewhat reticent yourself.
JUDGE: I never said you were reticent.
ENTRANT: I know.
JUDGE: Smug.
ENTRANT: Moi*?
JUDGE: I think you might be human.

Some clever programs

– Computer therapist ELIZA:
  • [http://www.ai.ijs.si/eliza/eliza.html](http://www.ai.ijs.si/eliza/eliza.html)

– Modern chatter boxes:
  • [http://cogsci.ucsd.edu/~asaygin/tt/btest.html](http://cogsci.ucsd.edu/~asaygin/tt/btest.html)
  • [http://www.abenteuermedien.de/jabberwock/](http://www.abenteuermedien.de/jabberwock/)

– Computer programs that learn: 20 Questions
  • [http://y.20q.net:8095/btest](http://y.20q.net:8095/btest)