

## UNIT 13A

### AI: Games & Search Strategies

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## Artificial Intelligence

- Branch of computer science that studies the use of computers to perform computational processes normally associated with human intellect and skill.
- Some areas of AI:
 

Game playing	Knowledge representation	Robotics
Machine learning	Natural language processing	Speech & Vision
- Allen Newell and Herbert Simon (CMU)
 

General Problem Solver (GPS) in 1957

Received the Turing Award in 1975 for "basic contributions to artificial intelligence, the psychology of human cognition, and list processing."

Newell
Simon

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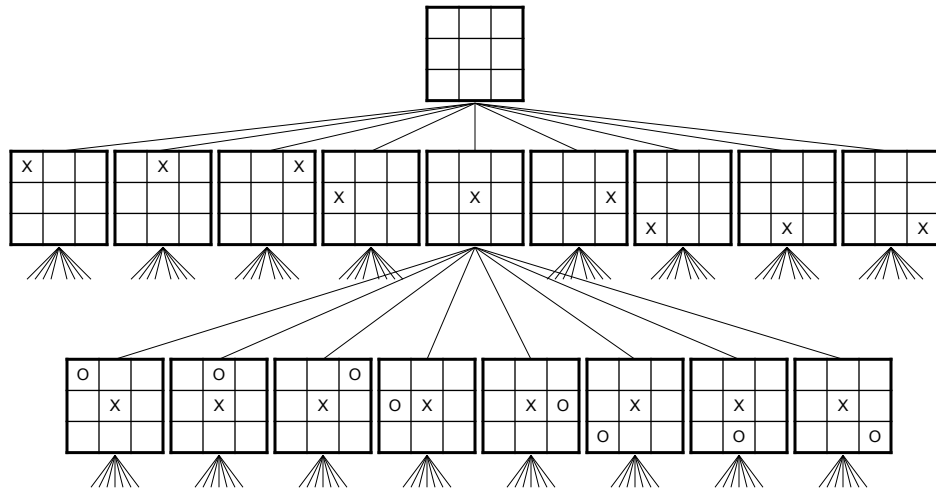
## A Cynic's View

- AI is the study of how to get computers to do things we don't understand.
  - “thinking”, “learning”, “creativity”, etc.
- When we do understand something, it's no longer AI: it's just programming.

## Game Trees

- For most games, the number of possible moves and potential outcomes is HUGE.
- An AI technique used to manage this computation is the use of a game tree.
  - A tree is built with a root node representing the current state of the game.
  - Child nodes are generated representing the state of the game for each possible move.
  - The tree is propagated down, building more child nodes for moves allowed by the next move, etc.
  - Leaves are terminal states of the game.

## Tic Tac Toe (Not Huge)



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## How Big is the Tic-Tac-Toe Tree?

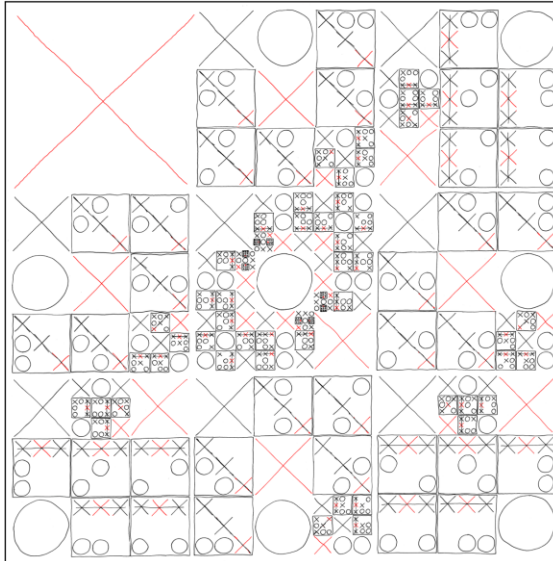
- Assuming that all nine positions must be filled before the game ends, how big does this tree get?
- Of course, in real Tic-Tac-Toe, a player can win without filling the whole board.
  - What is the first level of the tree where this can occur?
  - How big is this tree up to this level?

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# XKCD's Optimal Tic-Tac-Toe

MAP FOR X:



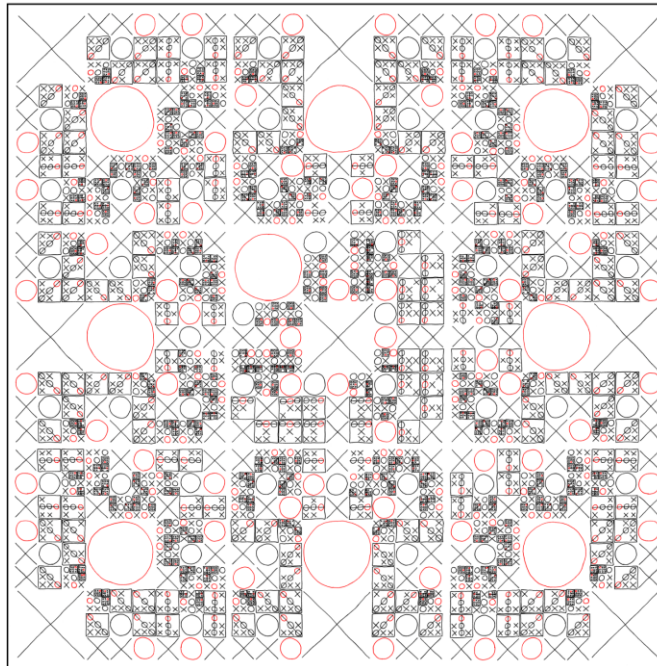
COMPLETE MAP OF OPTIMAL TIC-TAC-TOE MOVES

YOUR MOVE IS GIVEN BY THE POSITION OF THE LARGEST RED SYMBOL ON THE GRID. WHEN YOUR OPPONENT PICKS A MOVE, ZOOM IN ON THE REGION OF THE GRID WHERE THEY WENT. REPEAT.

<http://xkcd.com/832>

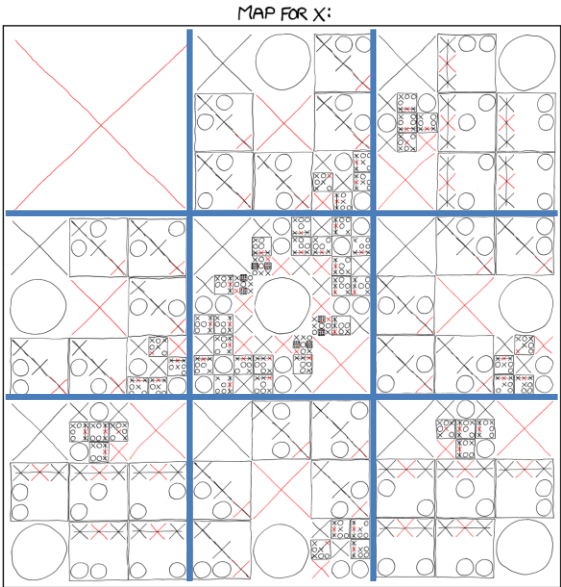
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MAP FOR O:



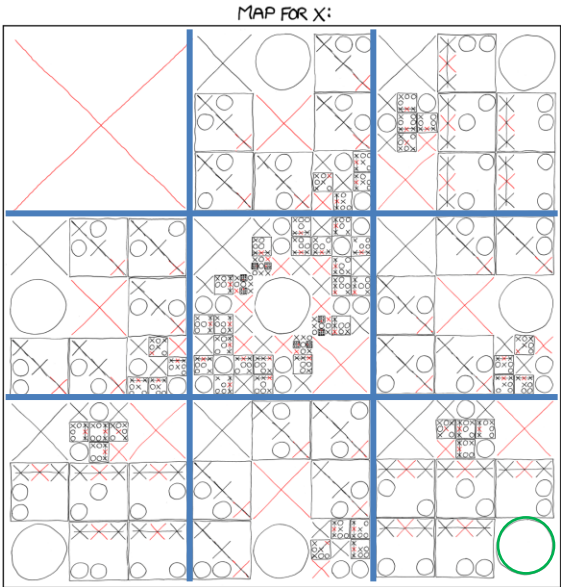
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# X Move 1



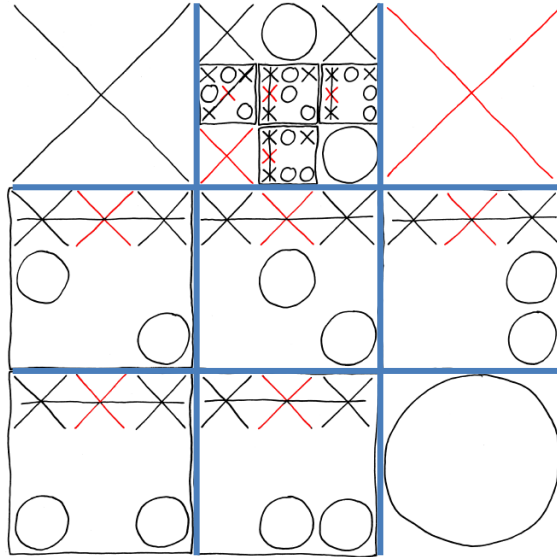
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# O Move 1



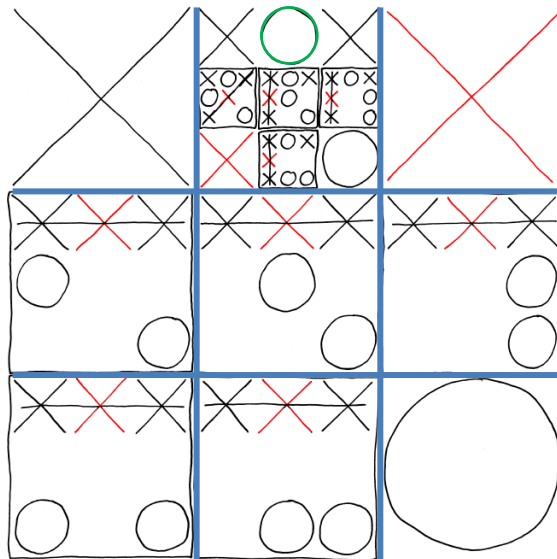
10

## X Move 2



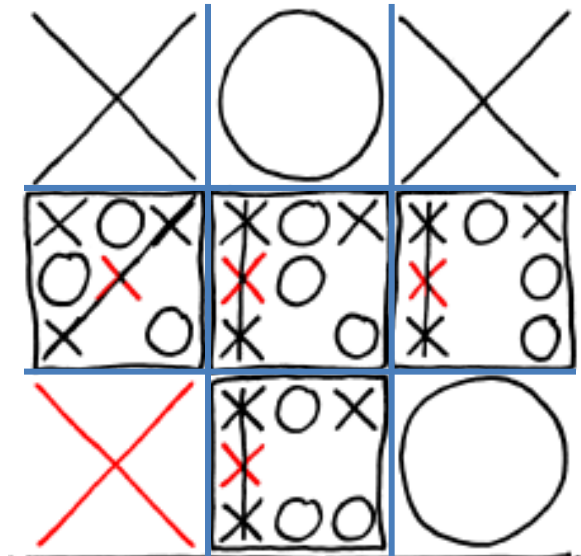
11

## O Move 2



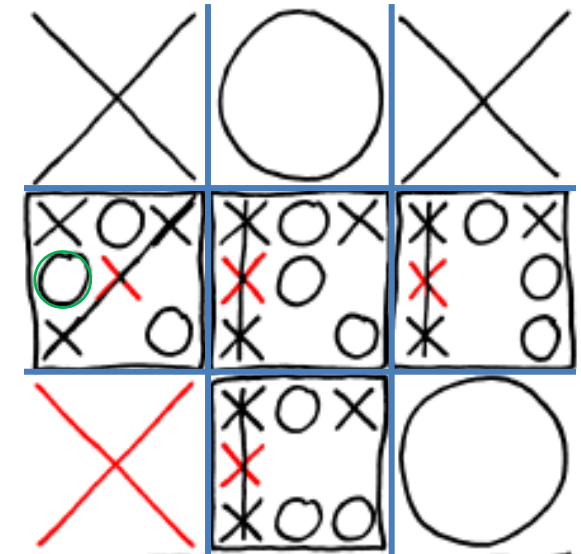
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### X Move 3



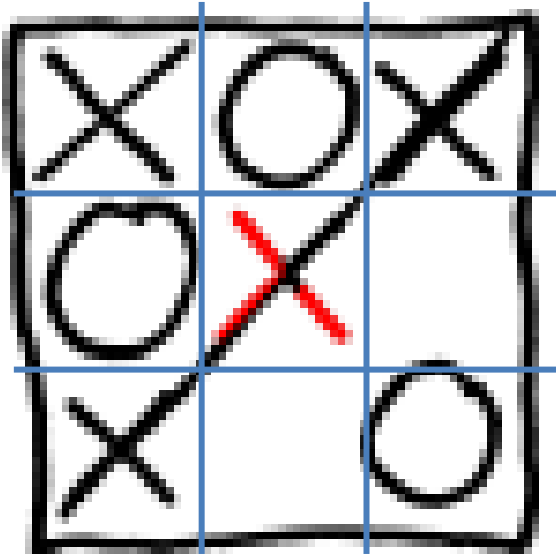
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### O Move 3



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## X Move 4 To Win



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## Tic-Tac-Toe Is Completely Searchable

- For the first move, pick a square at random.  
(Always picking the same square would be boring.)
- For subsequent moves:
  - Using recursion, grow the entire game tree with the current board state as the root (fewer than 5000 nodes).
  - For each child of the root, count how many games below that child end in a win.
  - Pick the child with the most wins.



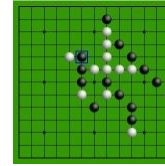
## Dealing With Huge Search Spaces

- How does a computer program that plays chess or go deal with the huge size of the game trees that can be generated?
  - In chess, the average number of possible next moves is around 35, and the average number of moves in a chess game is around 100, so the number of possibilities a computer must check is about  $35^{100}$ , which is beyond hope, even for our fastest computers!
- These programs use heuristics to narrow the search space in the tree that must be examined

## Heuristics

- Human thought is not purely deductive. It often relies on approximations or analogies.
- A heuristic is a “rule of thumb” that may not always be correct but usually gives useful results.
- Heuristic algorithms are helpful because they can find a reasonably good solution to a problem without requiring excessive search.

## AI Opponents

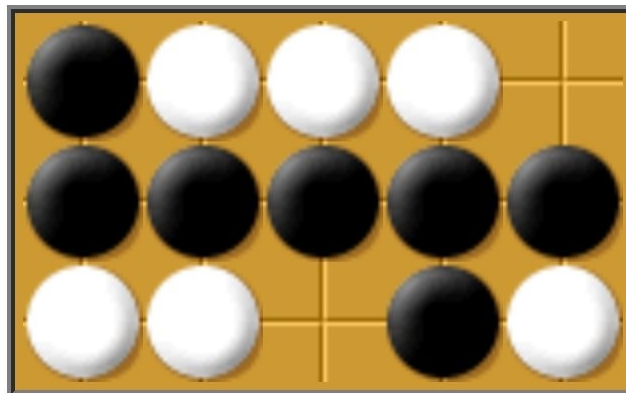


- Consider the game of Pente.
  - Players alternate, placing their stones on the game board at the intersection of lines, one at a time.
  - The object of the game is to be the first player to either get five stones in a straight line or capture 5 pairs of stones of the other player.
  - “Capture” means two adjacent stones surrounded by opponent stones. Captured stones are removed.
  - If we were write a computer program to play Pente against a human player, how does the computer calculate its moves when there are a huge amount of possibilities to consider?

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## Black Wins With 5 In A Row



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## Capture in Pente

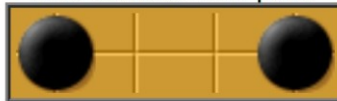
To capture stones



bracket your opponent



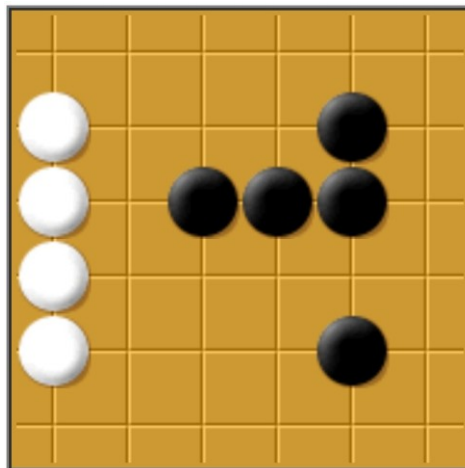
and remove the pair.



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## Black To Move; White Will Win

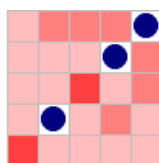
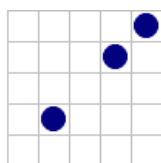


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## Heuristics

- Important board features to look for in Pente:
  - Check for x-pieces in a row.
  - Check for capture possibilities.
  - Check for x-pieces in a row for opponent.
  - Check for opponent's potential to make a capture.
- Compute a feature score and choose squares with high value:



0
1
2
3

**Example: threat score.**  
Code each cell based on number of opponent pieces in same row, column and diagonal.

<http://www.generation5.org/content/2000/boardai.asp>

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## "Deep Blue"



- IBM's "Deep Blue" computer beats Gary Kasparov in a chess match in 1997.
- Heuristics values:
  - The value of each piece. (1 for pawn up to 9 for queen)
  - The amount of control each side has over the board.
  - The safety of the king.
  - The quickness that pieces move into fighting position.
- For more info:
  - <http://www.research.ibm.com/deepblue/home/html/b.html>
- Is Deep Blue intelligent?

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## “Chinook”



- Created by computer scientists from the University of Alberta to play checkers (draughts) in 1989.
- In 2007, the team led by Jonathan Schaeffer announced that Chinook could never lose a game. Checkers had been solved!
- Chinook's algorithms featured:
  - a library of opening moves from games played by grandmasters
  - a deep search algorithm
  - a good move evaluation function (based on piece count, kings count, trapped kings, player's turn, “runaway checkers”, etc.)
  - an end-game database for all positions with eight pieces or fewer. and other minor factors.
- Is Chinook intelligent?

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## The Imitation Game (Turing Test)

- Proposed by Alan Turing in 1948.
- A human interrogator communicates with two players via teletype.
  - One player is human, the other a machine.
  - Each tries to convince the interrogator that he is the human.
- If the interrogator can't tell which player is human, the machine must be intelligent.

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## From Turing's Paper

Shakespeare's  
Sonnet 18



- **Interrogator:** In the first line of your sonnet which reads "Shall I compare thee to a summer's day," would not "a spring day" do as well or better?
- **Computer:** It wouldn't scan.
- **Interrogator:** How about "a winter's day"? That would scan all right.
- **Computer:** Yes, but nobody wants to be compared to a winter's day.

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- **Interrogator:** Would you say Mr. Pickwick reminded you of Christmas?
- **Computer:** In a way.
- **Interrogator:** Yet Christmas is a winter's day, and I do not think Mr. Pickwick would mind the comparison.
- **Computer:** I don't think you're serious. By a winter's day one means a typical winter's day, not a special one like Christmas.



Dickens character

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## “Watson”



- IBM's “Watson” computer beats champions Ken Jennings and Brad Rutter in a 2-game match on Jeopardy! in 2011.
- Watson parsed clues into different keywords and fragments.
- Watson had 4TB of data content but was not connected to the Internet during the game.
- Watson executed 1000s of proven language analysis algorithms concurrently. The more algorithms that pointed to the same answer, the more confident Watson was and the more likely it would buzz in.
- Is Watson intelligent?