ARTIFICIAL INTELLIGENCE

GAME TREES

CS-632

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GAMES

- Competitive environments, in which the agents' goals are in conflict, giving rise to adversarial search problems—often known as games.

- Mathematical game theory, a branch of economics, views any multiagent environment as a game, provided that the impact of each agent on the others is "significant," regardless of whether the agents are cooperative or competitive.

KINDS OF GAMES

- Deterministic
- Turn-taking
- 2-player
- Zero-sum
- Perfect information

This means deterministic, fully observable environments in which two agents act alternately and in which the utility values at the end of the game are always equal and opposite.

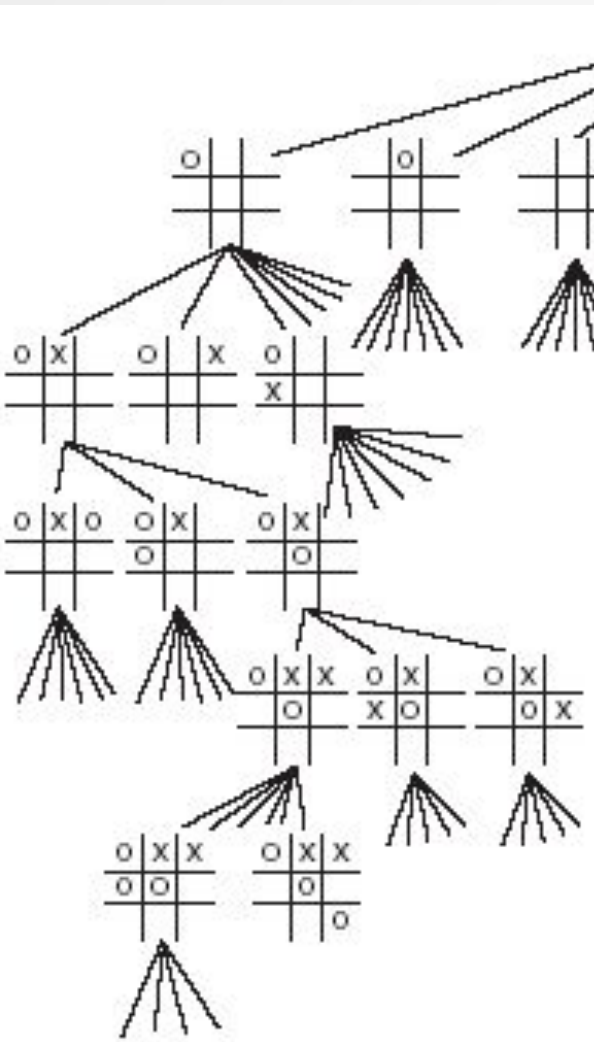
GAME AS SEARCH PROBLEM

- **Initial State:** board position and player to move
- **Successor Function:** returns a list of legal (*move*, *state*) pairs
- **Terminal Test:** determines when the game is over
- **Utility function:** Gives a numeric value for the terminal state

GAME TREES

- Game trees are used to represent two-player games.
- Alternate moves in the game are represented by alternate levels in the tree.
- Nodes in the tree represent positions.
- Edges between nodes represent moves.
- Leaf nodes represent won, lost or drawn positions.

GAME TREES



This is an example of a partial game tree for the game tic-tac-toe.
Even for this simple game, the game tree is very large.

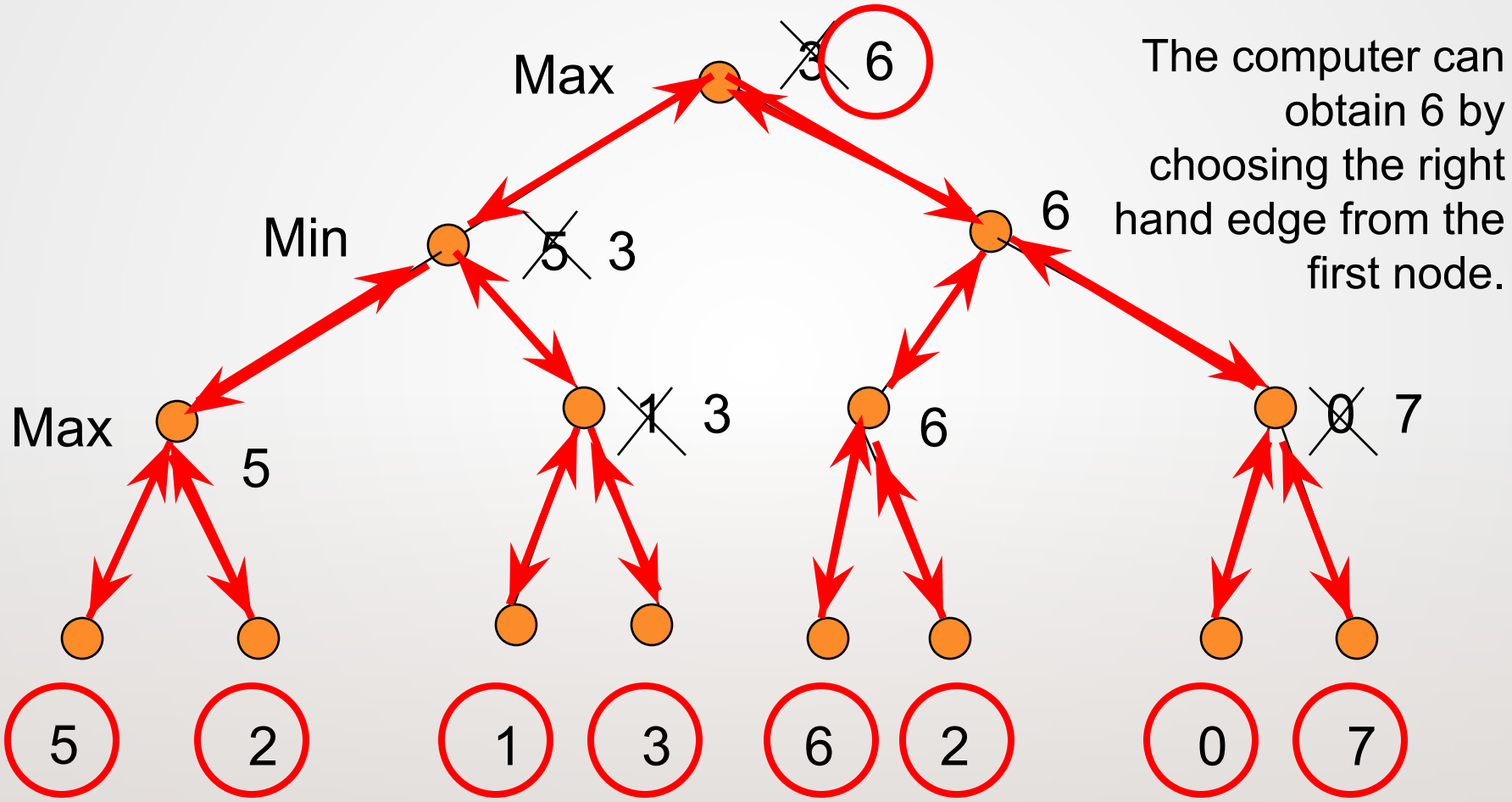
ASSUMPTIONS

- In talking about game playing systems, we make a number of assumptions:
  - The opponent is rational – will play to win.
  - The game is zero-sum – if one player wins, the other loses.
  - Usually, the two players have complete knowledge of the game. For games such as poker, this is clearly not true.

MINIMAX

- Minimax is a method used to evaluate game trees.
- A static evaluator is applied to leaf nodes, and values are passed back up the tree to determine the best score the computer can obtain against a rational opponent.

MINIMAX – ANIMATED EXAMPLE



The computer can obtain 6 by choosing the right hand edge from the first node.

MINIMAX FUNCTION

- MINIMAX-VALUE(n) =
  - UTILITY(n)

  if n is a terminal state
  - $\max_{s \in Successors(n)}$ MINIMAX-VALUE(s)

  if n is a MAX node
  - $\min_{s \in Successors(n)}$ MINIMAX-VALUE(s)

  if n is a MIN node

SEARCHING GAME TREES

- Exhaustively searching a game tree is not usually a good idea.
- Even for a game as simple as tic-tac-toe there are over 350,000 nodes in the complete game tree.
- An additional problem is that the computer only gets to choose every other path through the tree – the opponent chooses the others.

ALPHA-BETA PRUNING

- A method that can often cut off a half the game tree.
- Based on the idea that if a move is clearly bad, there is no need to follow the consequences of it.
- alpha – highest value we have found so far
- beta – lowest value we have found so far

ALPHA-BETA PRUNING (CONT.)

- In Minimax search algorithm, the number of game states are exponential in depth of the tree.
- We cannot eliminate the exponent, but we can cut it to half.
- Hence pruning is a technique by which without checking each node of the game tree we can compute the correct minimax decision.
- This involves two threshold parameter, Alpha and Beta for future expansion.
- So, it is called alpha-beta pruning or Alpha-Beta Algorithm.

ALPHA-BETA PRUNING (CONT.)

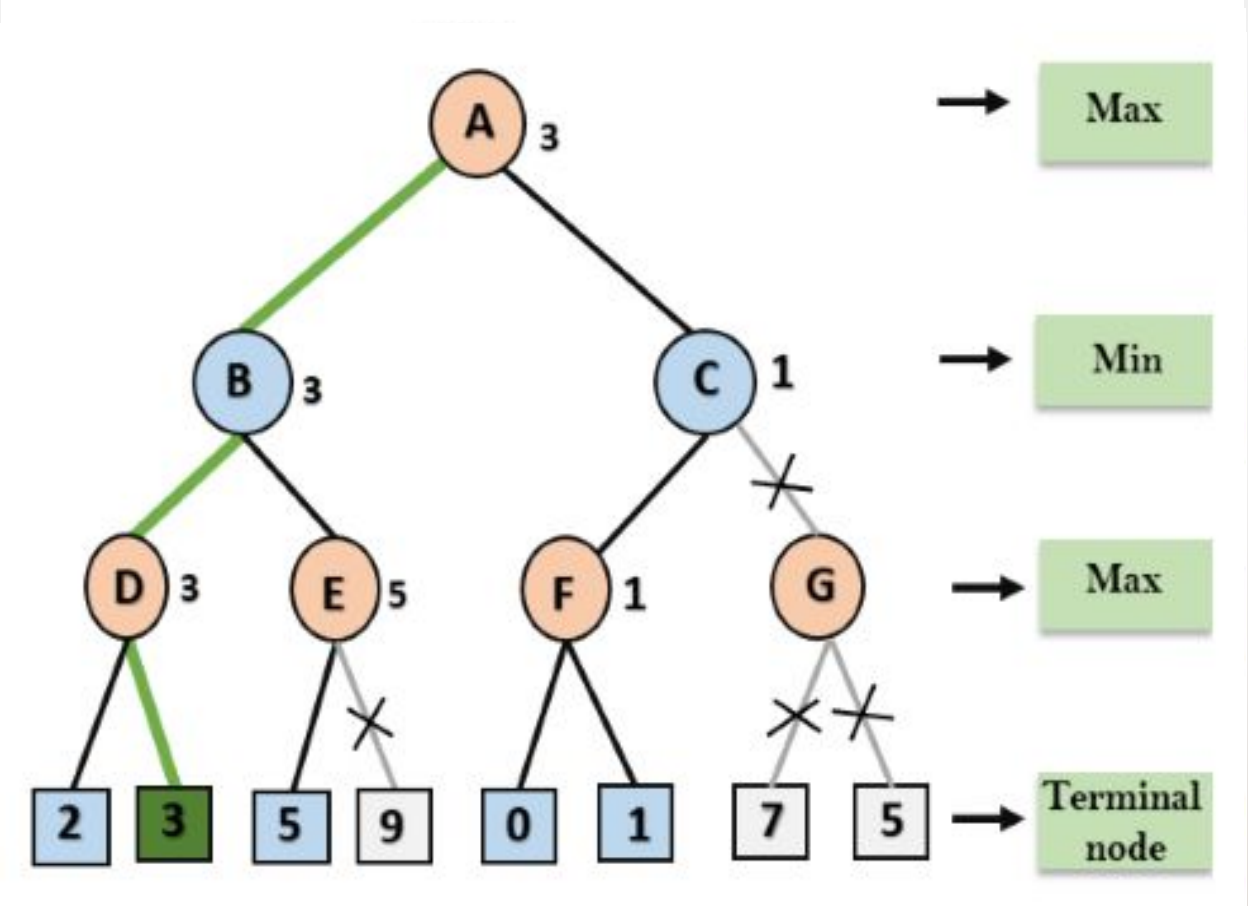
- **Alpha:** The best (highest-value) choice we have found so far at any point along the path of Maximizer. The initial value of alpha is **-∞**.
- **Beta:** The best (lowest-value) choice we have found so far at any point along the path of Minimizer. The initial value of beta is **+∞**.

The Alpha-beta pruning to a standard minimax algorithm returns the same move as the standard algorithm does, but it removes all the nodes which are not really affecting the final decision but making algorithm slow. Hence by pruning these nodes, it makes the algorithm fast.

ALPHA-BETA PRUNING (CONT.)

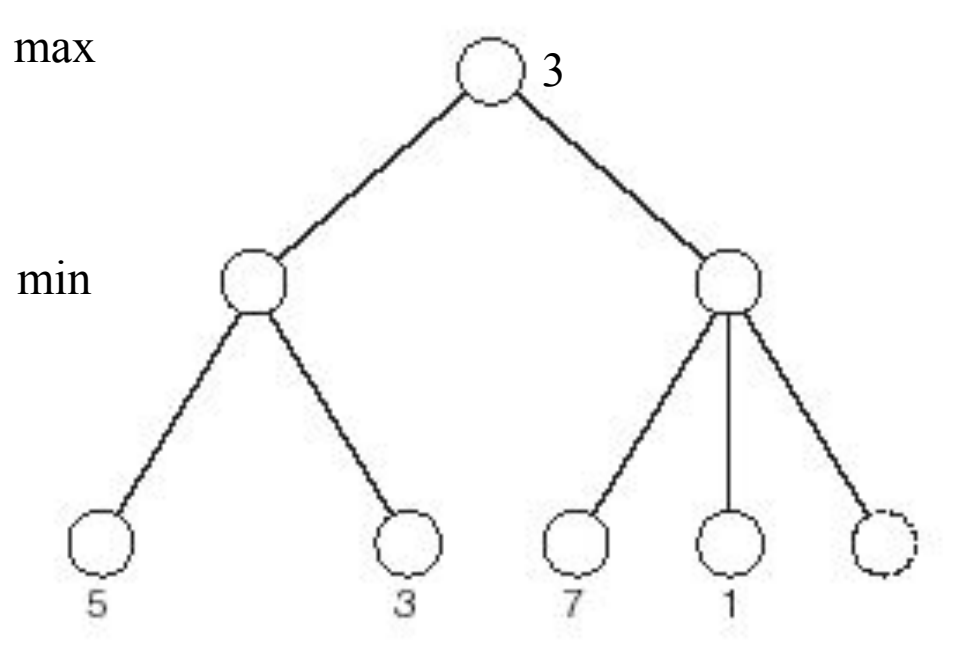
- The main condition which required for alpha-beta pruning is: α>=β
- The Max player will only update the value of alpha.
- The Min player will only update the value of beta.
- While backtracking the tree, the node values will be passed to upper nodes instead of values of alpha and beta.
- We will only pass the alpha, beta values to the child nodes.

ALPHA-BETA PRUNING (CONT.)



https://www.javatpoint.com/ai-alpha-beta-pruning

ALPHA-BETA PRUNING – EXAMPLE.



- In this tree, having examined the nodes with values 7 and 1 there is no need to examine the final node.

CHECKERS

- In 1959, Arthur Samuel creates a computer program that could play checkers to a high level using minimax and alpha-beta pruning.
- Chinook, developed in Canada defeated the world champion:
  - Uses alpha-beta pruning.
  - Has a database of millions of end games.
  - Also has a database of openings.
  - Uses heuristics and knowledge about the game.

CHESS

- In 1997, Deep Blue defeated world champion, Garry Kasparov.
- This has not yet been repeated.
- Current systems use parallel search, alpha-beta pruning, databases of openings and heuristics.
- The deeper in a search tree the computer can search, the better it plays.

GO

- Go is a complex game played on a 19x19 board.
- Average branching factor in search tree around 360 (compared to 38 for chess).
- The best computer programs cannot compete yet with the best human players.
- Methods use pattern matching or selective search to explore the most appropriate parts of the search tree.

GAMES OF CHANCE

- The methods described so far do not work well with games of chance such as poker or backgammon.
- Expectiminimax is a variant of minimax designed to deal with chance.
- Nodes have expected values based on probabilities.

Thank You