CS540 Introduction to Artificial Intelligence

Lecture 21

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Pirate Game Example

Quiz

Pirate Game Example Diagram

Quiz

Summary

Discussion

Tic Tac Toe Example

Motivation

Nim Game Example

Motivation

Minimax Algorithm

Description

- Use DFS on the game tree.

Minimax Example

Quiz

Minimax Performance

Discussion

- The time and space complexity is the same as DFS. Note that $D = d$ is the maximum depth of the terminal states.

$$T = 1 + b + b^2 + ... + b^d$$

$$S = (b - 1) \cdot d$$

Non-deterministic Game

Discussion

- For non-deterministic games in which chance can make a move (dice roll or coin flip), use expected reward or cost instead.
- The algorithm is also called expectiminimax.

Game Tree with Chance Example 1

Quiz

Game Tree with Chance Example 1 Diagram

Quiz

Pruning

Motivation

- Time complexity is a problem because the computer usually has a limited amount of time to "think" and make a move.
- It is possible to reduce the time complexity by removing the branches that will not lead the current player to win. It is called the Alpha-Beta pruning.

Alpha Beta Pruning

Description

- During DFS, keep track of both α and β for each vertex.
- Prune the subtree with $\alpha \geqslant \beta$.

Alpha Beta Example 1

Quiz

Alpha Beta Example 1 Continued

Quiz

Alpha Beta Example 2

Quiz

Alpha Beta Example 3

Quiz

Alpha Beta Example 4

Quiz

Alpha Beta Example 4

Quiz

Alpha Beta Example 4 Continued

Quiz

Alpha Beta Performance

Discussion

- In the best case, the best action of each player is the leftmost child.
- In the worst case, Alpha Beta is the same as minimax.

Static Evaluation Function

Definition

- A static board evaluation function is a heuristics to estimate the value of non-terminal states.
- It should reflect the player's chances of winning from that vertex.
- It should be easy to compute from the board configuration.

Linear Evaluation Function Example

Definition

- For Chess, an example of an evaluation function can be a linear combination of the following variables.

1. Material.
2. Mobility.
3. King safety.
4. Center control.

- These are called the features of the board.

Iterative Deepening Search

Discussion

- IDS could be used with SBE.
- In iteration d, the depth is limited to d, and the SBE of the non-terminal vertices are used as their cost or reward.

IDS with SBE Diagram

Discussion

Non Linear Evaluation Function

Discussion

- The SBE can be estimated given the features using a neural network.
- The features are constructed using domain knowledge, or a possibly a convolutional neural network.
- The training data are obtained from games between professional players.

Monte Carlo Tree Search

Discussion

- Simulate random games by selecting random moves for both players.
- Exploitation by keeping track of average win rate for each successor from previous searches and picking the successors that lead to more wins.
- Exploration by allowing random choices of unvisited successors.

Monte Carlo Tree Search Diagram

Discussion

Alpha GO Example

Discussion

- MCTS with $> 10^5$ play-outs.
- Convolutional neural network to compute SBE.

Summary

Discussion