Artificial Intelligence for Robotics Homework 9

Duy Khoi Tran

June 4, 2017

1. Answer the following questions with no more than three sentences.

   - What is a strategy?

     A strategy specifies what an agent will do in every possible situation depending on what percepts are received. A strategy can be pure (deterministic) or mixed (probabilistic).
   - What is the goal of the Max agent?

     The goal of the Max agent is to maximize its expected utility at terminal state.
   - What is the goal of the Min agent?

     The goal of the Min agent is to minimize Max's expected utility at terminal state.
   - What is the Minimax Theorem?

     There exist strategies s* and t* , and a number VG called G's minimax value for a two-person finite zero-sum game G participated by Max and Min so that if Min uses t*, Max's expected utility will not surpass VG. And if Max uses s*, Max's expected utility will always exceed VG.
   - How do we construct an strategy for Max?

     To construct a strategy for Max we may use the game tree. We choose one branch for each node where it's Max turn to move and include all branches for nodes in which Min move. This method constructs a pure strategy.
   - How do we construct an strategy for Min?

     To construct a strategy for Max we may use the game tree. We choose one branch for each node where it's Min turn to move and include all branches for nodes in which Max move. This method constructs a pure strategy.
   - How do we find the best strategy?

     We can use brute force to construct a set of all of all Max's and Min's pure strategy and then choose t* and s*. Another way is to use Minimax Algorithm that compute the game's minimax value recursively from the minimax values of its subgames. The maximum minimax value is returned when it's Max move and the opposite when it's Min move.
   - How does the Minimax algorithm work?

     The Minimax algorithm compute the minimax value of the game recursively from the minimax values of its subgames. In the minimax function, the utility of Max is returned when it is at the terminal state. Else, it recursively find the maximum minimax when it's Max's turn and the opposite when it's Min's turn.
   - Is the Minimax algorithm affordable for chess? Why?

     For chess, the branching factor is around 35 and the height is close to 100. Thus there are about 35^{100} nodes which about 10^{55} more particle in the universe. So Minimax is not affordable for chess.
   - What is alpha-beta pruning?

     Alpha-beta pruning is a pruning technique that eliminate parts of the minimax tree from consideration. In alpha-beta pruning, Max will ignore any branch that generate payoff lower than the highest value Max found in the successors and Min will ignore any branch that generate value higher than the lowest value Min found in the successors.

- Is the alpha-beta pruning affordable for chess? Why?
  Alpha-beta can help cut the number of nodes in half which is about 35^{100}, which is unfortunately still impossible [RN05].

2. Backtracking search implementation

   The number of evaluations according to ordering strategies and scenarios can be seen in the table below. The path length is shown in the program.

	Line number	Euclidean	Deadline
Scenario 1	305	46	87
Scenario 2	157215	4538	60122
Scenario 3	2994	532	5706
Scenario 4	325655	325655	325655
Scenario 5	608394	95487	126

   In overall, the program can find solution for every scenario except for 4, which reaches its maximum number of evaluations. For scenario 1 and 3, the solution path are the same for every strategy but not for 2 and 5. It can be seen that the Euclidean ordering strategy consistently requires less evaluations than the other two and which of the other two is better cannot not be determined as one might be better for this scenario but not for the other scenario. In case 5, the deadline ordering strategy achieve the solution with significantly few evaluations. This might be due to a potential correlation between the rise in accumulated duration and accumulated distance in this ordering.

References

[RN05] Stuart Russell and Peter Norvig. Ai a modern approach. *Learning*, 2(3):4, 2005.