Lab session 4: Adversarial search

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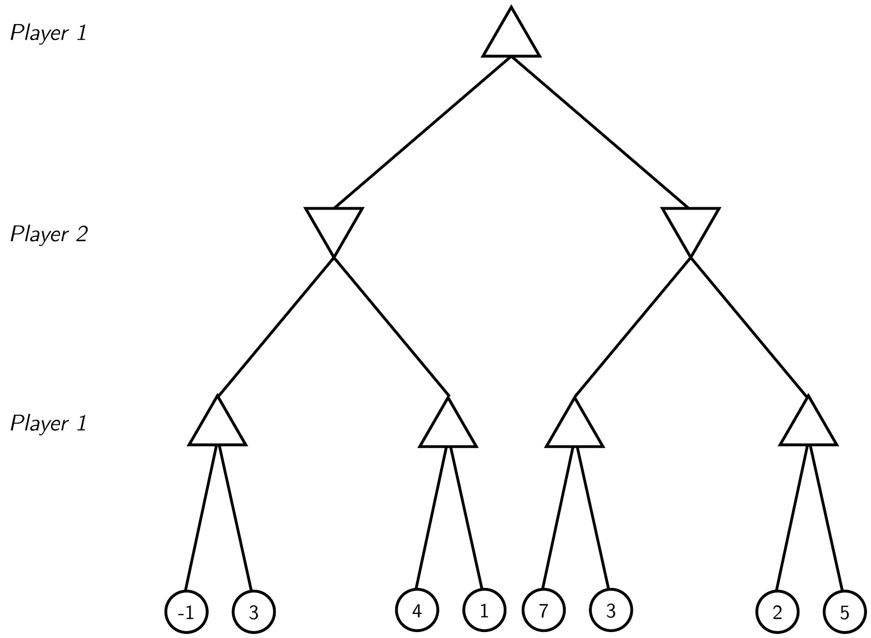
1 Applying the Minimax algorithm

Question 1. What is the optimal strategy for Player 1 in the following sequential game?



2 Nim

Nim is a 2 player game, where the players have to remove objects from a pile initially containing N objects. Players take turn, and can remove only 1, 2 or 3 objects at a time. We call the player who makes the first move Max, and the other one Min. The winner is the one removing the last object.

Question 2. In the case where $N = 4$, write the game tree and show that Max is guaranteed to lose if Min plays rationally.

In the file `nim.py`, there is an implementation of Nim.

Question 3. Implement the MINIMAX algorithm by completing the functions `minimax_search`, `max_value` and `min_value`. Play some rounds of the game against the MINIMAX-opponent by calling the function `interactive_game`. Can you win? Also try different values of N.

Question 4. Implement another function `maximin_search`, which should return an optimal action for MIN. Use your implementation of `minimax_search` as a basis. Let the two rational agents play against each other by calling the function `optimal_game`. Who wins? Try it for different values of N and look for a pattern.

Question 5 (optional, 1 + 1 bonus points)**.**

a) Show that, whenever N is a multiple of 4, MAX is guaranteed to lose if MIN plays rationally.

b) Show that, in all other cases, MIN is guaranteed to lose if MAX plays rationally.

Submission deadline for question 4: Wednesday, May 8, 2024

3 Tic-tac-toe

Another well-known two-player game is tic-tac-toe. Both players play on a 3×3 grid, with MAX placing crosses ($\times$) and MIN placing noughts ($\circ$). An implementation is found in `tic_tac_toe.py`.

Question 6. Complete the functions `alpha_beta_search`, `max_value` and `min_value`. Play against the agent by executing the `interactive_game` function. Can you win?

After each move by MAX, the number of explored nodes is printed. By commenting the lines responsible for breaking the for-loop over all actions, you will see that the number of explored nodes is substantially larger and, consequentially, the search becomes slower.

Question 7. Alter the code of `max_value` and `min_value` to change the order that the actions are searched in. You can make use of `random.shuffle()` from the Python standard library for this. Does it have an effect on the number of on the number of recursive calls? If so, why?