

# Foundations of Artificial Intelligence

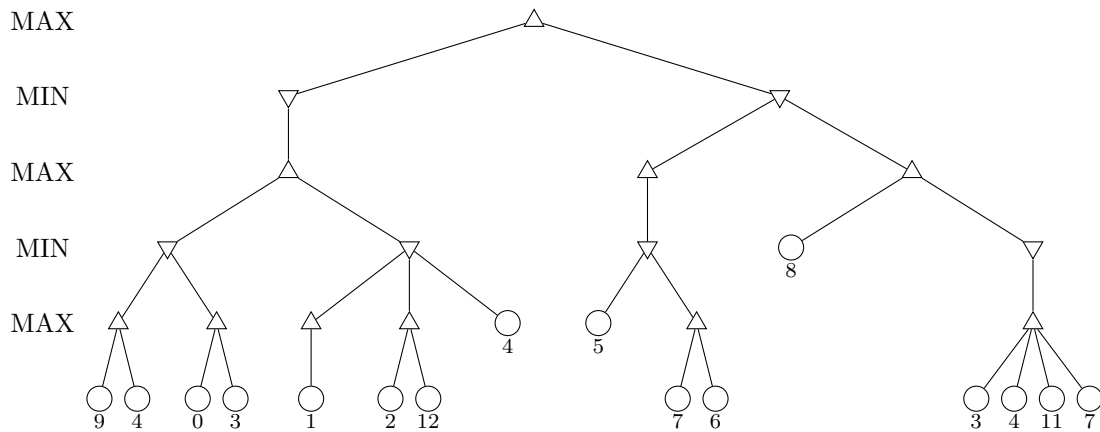
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## Exercise Sheet 12

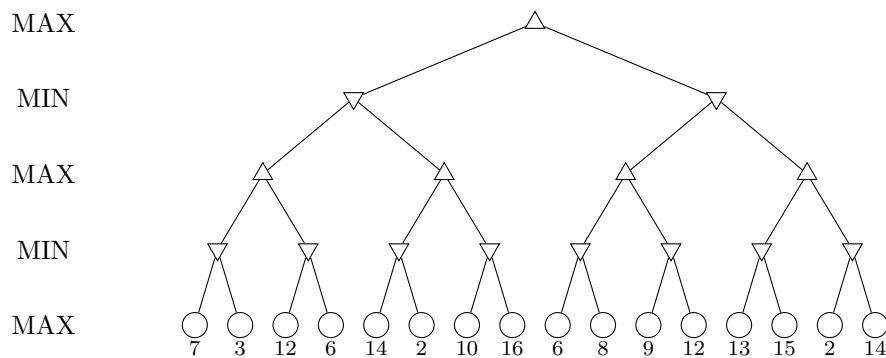
Due: May 26, 2021

### Exercise 12.1 (4 marks)



Apply alpha-beta search to the game tree depicted above, considering successor nodes from left to right. Annotate all considered nodes with the returned value as well as the (last) alpha and beta values, and show which parts of the tree can be pruned (e.g., by drawing cut lines through edges which lead to subtrees that do not need to be considered).

### Exercise 12.2 (3 marks)



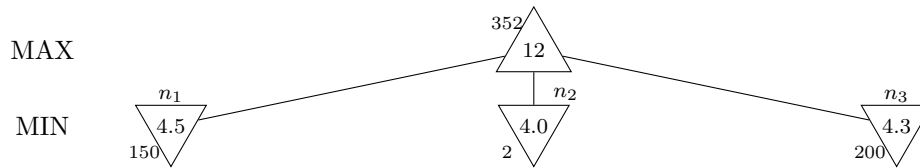
Apply the first 4 iterations of Monte Carlo Tree Search with the following policies:

- tree policy: For MAX nodes select the successor with highest utility, for MIN nodes select the successor with lowest utility.
- expansion: Always pick the left child first.
- default policy: Always pick the right child.

Estimate updates calculate the average of all utilities that were backpropagated through that node. Given a node  $n$  with (old) utility  $u$ , (updated) visit count  $v$  and  $r$  being utility of the terminal node that was reached in the simulation phase, we can efficiently calculate the updated utility for  $n$  with  $u + (r - u)/v$ .

**Exercise 12.3** (1+1 marks)

Assume we are in the middle of the Monte-Carlo selection phase and need to select between 3 MIN nodes  $n_1$ ,  $n_2$  and  $n_3$ :



- (a) Compute the probabilities of selecting each child when using Softmax with  $\tau = 5$ .

*Hint: To compute the probabilities, first compute  $x_{n_i} = e^{\frac{\hat{u}(n_i)}{\tau}}$  for all nodes and then divide  $x_{n_i}$  by the sum of all  $x_{n_i}$ .*

- (b) Which child would Upper Confidence Bound select? Provide  $\hat{u}(n_i) + B(n_i)$  for all children.

**Exercise 12.4** (1 mark)

Is the tree policy used in AlphaGo asymptotically optimal? Justify your answer (you do not need to formally prove it).

**Submission rules:**

Upload a single PDF file (ending .pdf). If you want to submit handwritten parts, include their scans in the single PDF. Put the names of all group members on top of the first page. Use page numbers or put your names on each page. Make sure your PDF has size A4 (fits the page size if printed on A4).