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Workbook: Adversarial Search

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Learning objectives

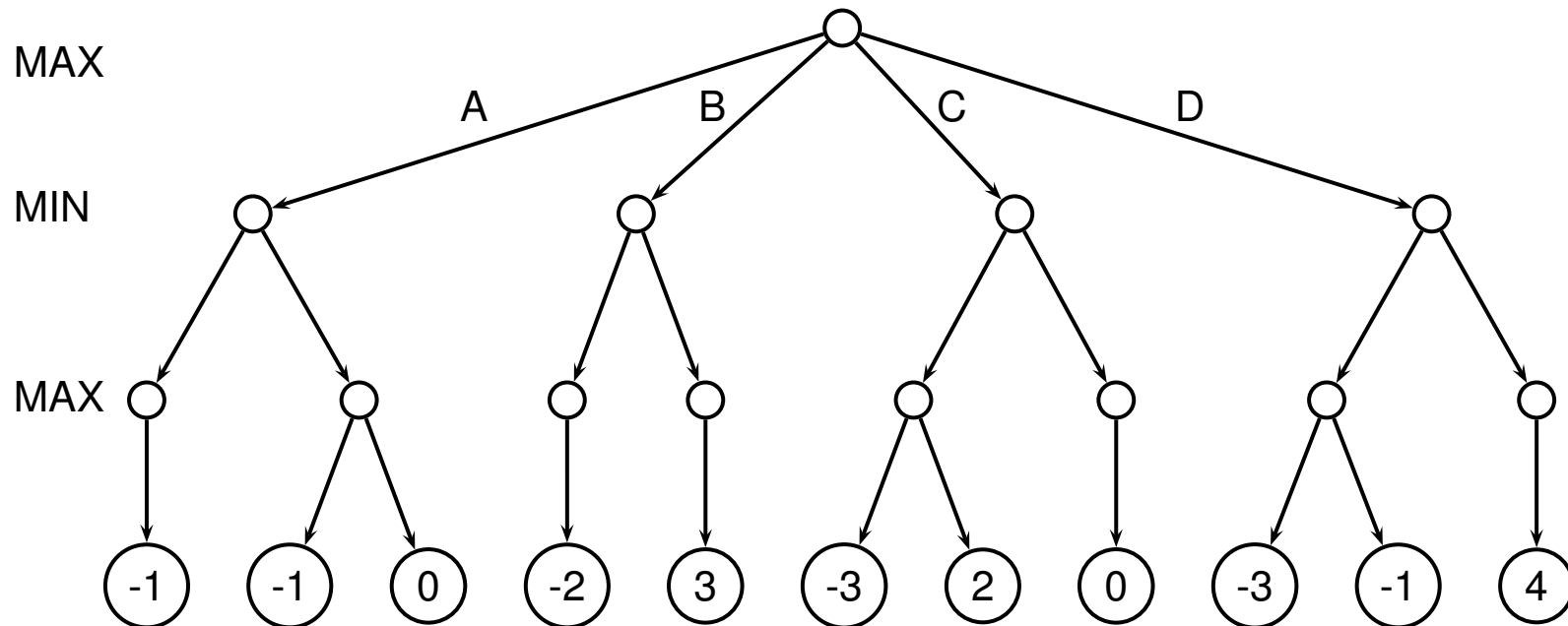
- ▶ To know the basics of adversarial search.
- ▶ To apply the *minimax* algorithm and *alpha-beta* pruning.

Minimax algorithm and alpha-beta pruning

```
mm( $s, d, max$ )           // state, depth,  $max$ ="Does MAX move?"  
if  $s$  is terminal: return utility for  $s$   
if  $d = 0$ :               return heuristic value for  $s$   
if  $max$ :  $v = -\infty$ ;  $\forall n \in \text{succ}(s)$ :  $v = \max(v, \text{mm}(n, d - 1, \text{FALSE}))$   
else:    $v = \infty$ ;    $\forall n \in \text{succ}(s)$ :  $v = \min(v, \text{mm}(n, d - 1, \text{TRUE}))$   
return  $v$ 
```

```
 $\alpha$ - $\beta$ ( $s, d, \alpha, \beta, max$ )  
if  $s$  is terminal: return utility for  $s$   
if  $d = 0$ :          return heuristic value for  $s$   
if  $max$ :  $v = -\infty$   
         $\forall n \in \text{succ}(s)$   
             $v = \max(v, \alpha\text{-}\beta(n, d - 1, \alpha, \beta, \text{FALSE}))$   
             $\alpha = \max(\alpha, v)$ ;   if  $\beta \leq \alpha$ : break //  $\beta$  cut  
else:    $v = \infty$   
         $\forall n \in \text{succ}(s)$   
             $v = \min(v, \alpha\text{-}\beta(n, d - 1, \alpha, \beta, \text{TRUE}))$   
             $\beta = \min(\beta, v)$ ;   if  $\beta \leq \alpha$ : break //  $\alpha$  cut  
return  $v$ 
```

- **Question 1:** Draw the search tree of applying the *minimax and alpha-beta pruning* algorithm to the search space of a game shown in the following figure:



- **Question 2:** What is the best move from the root node applying the *minimax and alpha-beta pruning* algorithm to the previous search space?

- **Question 3:** How many nodes are not generated applying the *minimax and alpha-beta pruning* algorithm instead of the basic minimax algorithm?
- **Question 4:** What value should store the “question” node so that the cut does not happen?

