

CS 4100/5100: Foundations of AI

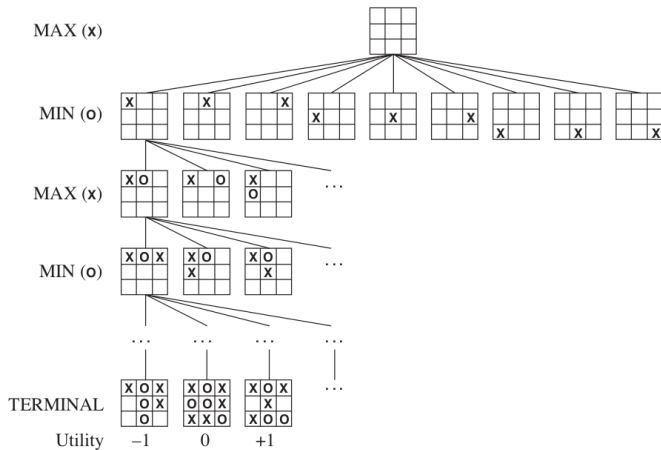
Adversarial search

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Game tree for tic-tac-toe



Minimax search

```
function MINIMAX-DECISION(state) returns an action  
  return  $\arg \max_{a \in \text{ACTIONS}(s)} \text{MIN-VALUE}(\text{RESULT}(\text{state}, a))$ 
```

```
function MAX-VALUE(state) returns a utility value  
  if TERMINAL-TEST(state) then return UTILITY(state)  
   $v \leftarrow -\infty$   
  for each a in ACTIONS(state) do  
     $v \leftarrow \text{MAX}(v, \text{MIN-VALUE}(\text{RESULT}(s, a)))$   
  return v
```

```
function MIN-VALUE(state) returns a utility value  
  if TERMINAL-TEST(state) then return UTILITY(state)  
   $v \leftarrow \infty$   
  for each a in ACTIONS(state) do  
     $v \leftarrow \text{MIN}(v, \text{MAX-VALUE}(\text{RESULT}(s, a)))$   
  return v
```

Alpha Beta search

function ALPHA-BETA-SEARCH(*state*) **returns** an action
 $v \leftarrow \text{MAX-VALUE}(\text{state}, -\infty, +\infty)$
 return the *action* in $\text{ACTIONS}(\text{state})$ with value v

function MAX-VALUE(*state*, α , β) **returns** a *utility value*
 if TERMINAL-TEST(*state*) **then return** UTILITY(*state*)
 $v \leftarrow -\infty$
 for each a **in** $\text{ACTIONS}(\text{state})$ **do**
 $v \leftarrow \text{MAX}(v, \text{MIN-VALUE}(\text{RESULT}(s, a), \alpha, \beta))$
 if $v \geq \beta$ **then return** v
 $\alpha \leftarrow \text{MAX}(\alpha, v)$
 return v

function MIN-VALUE(*state*, α , β) **returns** a *utility value*
 if TERMINAL-TEST(*state*) **then return** UTILITY(*state*)
 $v \leftarrow +\infty$
 for each a **in** $\text{ACTIONS}(\text{state})$ **do**
 $v \leftarrow \text{MIN}(v, \text{MAX-VALUE}(\text{RESULT}(s, a), \alpha, \beta))$
 if $v \leq \alpha$ **then return** v
 $\beta \leftarrow \text{MIN}(\beta, v)$
 return v