

Min-Max Algorithm

The **Min-Max (or Minimax)** algorithm is a **decision-making algorithm used in two-player turn-based games** — especially games like **Tic-Tac-Toe, Chess, Checkers, Connect-4, etc.**

- One player is the **MAX player** (tries to maximize the score — wants to win)
- The other is the **MIN player** (tries to minimize the score — wants the MAX player to lose)

Min-Max is used by AI to **choose the best possible move**, assuming:

- ✓ Both opponents play **optimally**
- ✓ Both try to **win / avoid losing**

How Min-Max Works Step-by-Step

1. Generate all possible moves
2. For each move, simulate the opponent's best possible move
3. Continue until you reach a **terminal state** (win/lose/draw)
4. Assign a score to the terminal state
5. Backtrack and:
 - MAX player picks the **highest score**
 - MIN player picks the **lowest score**
6. The move that leads to the best score for MAX player becomes the chosen move

Example – When AI Plays in Tic-Tac-Toe

Suppose the AI is MAX and calculates the scores:

Move	Outcome	Score
A	AI wins	+10
B	Draw	0
C	AI loses	-10

Minimax will select **Move A** because it gives the **maximum score**.

Pseudocode

```
function minimax(node, depth, isMaximizingPlayer):
```

```
    if node is a terminal state OR depth == 0:
```

```
        return score of node
```

```
    if isMaximizingPlayer:
```

```
        best = -∞
```

```
        for each child of node:
```

```
            val = minimax(child, depth - 1, false)
```

```
            best = max(best, val)
```

```
        return best
```

```
    else:
```

```
        best = +∞
```

```
        for each child of node:
```

```
            val = minimax(child, depth - 1, true)
```

```
            best = min(best, val)
```

```
        return best
```

Minimax assumes:

- ✓ Opponent will not make mistakes
- ✓ Perfect and exhaustive calculation of future possibilities

Where It is Used in Games

You can apply minimax to create AI opponents in:

- Tic-Tac-Toe
- Connect-4
- Othello
- Chess (with improvements like Alpha-Beta pruning due to size)

To demonstrate Minimax clearly, the best example is:

Tic-Tac-Toe game where user plays against AI

The AI uses Minimax to decide its move and you can show:

- Generated scores for each move
- Highlighting which move was selected and why