MaxMin Heuristic in Game Theory

By: Tushar Thakral (IMT2016059)

Abstract: This essay gives an introduction to Maxmin heuristic or the Maxmin/Maximin strategy in game theory. The essay also talks about the advantages and disadvantages of this strategy.

What is Maximin strategy?

A **maximin strategy** is a strategy in game theory where a player makes a decision to maximize one's own minimum gain. Basically, a decision taken according to the maximin strategy ensures smallest loss. It's kind of a pessimistic or conservative strategy in which a player tries to maximize one's own minimum payoff.

For a given player *i* in a game with *j*, the maxmin heuristic for player *i* is:

$$s_i^* = \max s_i \min s_j \, u(s_i, s_j)$$

where: s_i -> strategy of player *i*; s_j -> strategy of player *j*; and

$u(s_i, s_j)$ -> payoff for the corresponding strategies.

Let's understand it using a simple example. Consider this game:

P1 / P2	Invest	Don't Invest
Invest	$20, $20	-$100, $0
Don't Invest	$15, $15	$10, $10

Now, if both the players act rationally, the optimal solution is both of them choosing to *Invest*. Since, *Invest* is P2's dominant strategy, he'll always choose *Invest*. Let's verify this:

- If P1 chooses *Invest*, P2 would choose *Invest*.
- If P1 chooses *Don't Invest*, P2 would still choose *Invest*.

Considering that P2 would always choose *Invest*, it's best for P1 to choose *Invest* as well. So, the optimal solution is both the players choosing *Invest*.

Now, let's check what is the solution using **Maximin strategy**.

For P1:

- If P1 chooses *Invest*, in the worst-case scenario, P1 will receive a payoff of -$100.
- If P1 chooses *Don't Invest*, in the worst-case scenario, P1 will receive a payoff of $10.

Comparing the worst-case payoffs, the maximin strategy for P1 would be to choose *Don't Invest*.

For P2:

- If P2 chooses *Invest*, in the worst-case scenario, P2 will receive a payoff of $15.
- If P2 chooses *Don't Invest*, in the worst-case scenario, P2 will receive a payoff of $0.

Comparing the worst-case payoffs, the maximin strategy for P2 would be to choose *Invest*.

So, the new equilibrium becomes P1 choosing *Don't Invest* and P2 choosing *Invest*. Note that using this strategy, both the players have lost $5 as compared to the optimal solution. This strategy is used when there's a lack of trust or the fear of the other player playing irrationally and the assumption is that the other player wants to cause the greatest harm.

Advantages:

- Since it maximizes the minimal outcome, it guarantees a minimal payoff.
- Because this strategy increases the probability of minimum outcome, it reduces the risk factor. Hence, it's a low risk strategy.
- There's no requirement of a rich scale, an ordinal scale is enough to make the decision, because we only need to rank the choices and then choose the worst/best.

Disadvantages:

- This strategy is applicable only to the games consisting of two players.
- The equilibrium reached using this strategy is not stable.
- This strategy is inefficient because it discourages taking any risks, no matter how big the reward may be.
- It does not use the information available judiciously but uses it rather partially.

References:

- *Introduction to Multi-Agent Systems* by Prof. Srinath Srinivasa.
- Article on MaxiMin strategy from: http://econ101help.com/maximin-strategyminimax-strategy/
- Article on Max Min strategy from: http://mlwiki.org/index.php/Max_Min_Strategy

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