GLOBAL JOURNAL OF ENGINEERING, DESIGN & TECHNOLOGY
(Published By: Global Institute for Research & Education)
www.gifre.org

IMPERFECT INFORMATION GAMES-AN AMATEUR APPROACH

[1]Naveen Verma & [2]Sunil Kumar
[1]M.Tech (AI & ANN), University of Petroleum and Energy Studies, Dehradun
[2]Assist. Prof in CIT, University of Petroleum and Energy Studies, Dehradun

Abstract

The representational structure of game theory as a tree derives multiple paths from starting node to successive nodes which may leads to dead states or goal states. While exploring these paths, users are unable to find an exact move which gives a perfect solution. In any game, these situations reflect the property of imperfect games.In this paper, after discussing the various game types, we will differentiate between perfect and imperfect information games along with state space structure.

Keywords— Game theory, perfect information games, Imperfect information games

Introduction

A. Game theory- Game theory is a formal study of conflict and cooperation. Concept of game theory provides a language to formulate structure, analyse and understand strategic scenarios. As a mathematical tool for the decision-maker, the strength of game theory is the methodology it provides for structuring and analysing problems of strategic choice. The object study in game theory is game. Game is a formal model of interactive situation. [1]

B. Game tree-Game tree is a directed graph whose nodes are positions in a game and whose edges are moves. Complete graph for a game tree is the tree starting at an initial position & containing all possible moves from each position. The number of leaf nodes in complete game tree is the number of possible different ways the game can be played. [2]

Monte Carlo heuristic provided a lot in the field of game theory community, but not in case of AI community. It provides us with after N iterations the heuristic function makes a move which may be correct or incorrect. When we consider $\lim_{n\to\infty}$,[4] the heuristic's possible behaviour when examining a tree are –

- Convergence on a correct answer.
- Convergence on an incorrect answer.
- Not Convergence on an answer while flip-flopping between two correct answers.
- Not Convergence on an answer while flip-flopping between two incorrect answers.
- Not Convergence on an answer while flip-flopping between correct or incorrect answers.[5]

Types of Games

While exploring the topic game theory, we have a long list about the games types:-

- Cooperative and non-cooperative
- Symmetric and asymmetric
- Zero-sum and non-zero-sum
- Simultaneous and sequential
- Perfect information and imperfect information
- Combinatorial games
- Infinitely long games
- Discrete and continuous games
- Differential games
- Many-player and population games
- Stochastic outcomes
- Metagames

According to our point of view, some of important game types are shown in the diagram-

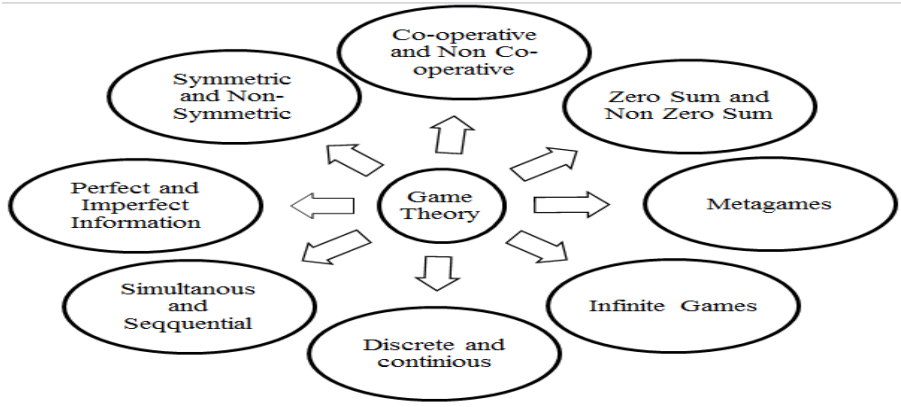

FIGURE 1.1. DIAGRAMMATICALLY REPRESENTATION OF GAME TYPES

Let us discuss the elements of figure 1.1 of game theory in detail

- Cooperative and non-cooperative
- Symmetric and asymmetric
- Zero-sum and non-zero-sum
- Simultaneous and sequential
- Discrete and continuous games
- Infinitely long games
- Perfect information and imperfect information
- Metagames

Definitions

A. Cooperative & non-cooperative

A game is cooperative if the players are able to form binding commitments, whereas non cooperative games are able to model situations to the finest details, producing accurate results.

B. Symmetric and asymmetric

A symmetric game is a game where the payoffs for playing a particular strategy depend only on the other strategies employed, not on who is playing them, whereas asymmetric games are games where there are not identical strategy sets for both players.

C. Zero-sum and non-zero-sum

A game is said to be zero-sum if for any outcome, the sum of the payoffs to all players is zero, while in case of non-zero-sum games, the outcome has net results greater or less than zero. Informally, in non-zero-sum games, a gain by one player does not necessarily correspond with a loss by another.

D. Simultaneous and sequential games

Simultaneous games are games where both players move simultaneously, or if they do not move simultaneously, the later players are unaware of the earlier player's actions, whereas sequential games are games where later players have some knowledge about earlier actions.

E. Infinitely long games

Games that last for infinitely many moves, with the winner not known until after all those moves are completed.

F. Discrete and continuous games

Discrete games, that have a finite number of players, moves, events, outcomes, etc. whereas continuous games allow players to choose a strategy from a continuous strategy set.

G. Metagames

It is used the development of the rules for another game, the target or subject game. Metagames seek to maximize the utility value of the rule set developed. The theory of Metagames is related to mechanism design theory. The term Metagames analysis is also used to refer to a practical approach developed by Nigel Howard (Howard 1971) whereby a situation is framed as a strategic game in which stakeholders try to realize their objectives by means of the options available to them. Subsequent developments have led to the formulation of confrontation analysis.

Perfect / Imperfect Information Games

In this paper, we are only going to discuss the last important part of game type i.e. perfect and imperfect information games, to continue in this section firstly we have basic definition of perfect and imperfect games with their game structure and some related game example which clearly show that the game is perfect information game or imperfect information game.

A. Perfect Information Games

A game is one of perfect information if all players know the moves previously made by all other players. Thus, only sequential games can be games of perfect information or you can say this is a perfect game. A triple (A, B, ϕ), where A and B are abstract sets and ϕ: A x B $\rightarrow \bar{R}$, where $\bar{R}$= R $\cup$ {-∞, ∞} and R is the set of real numbers, is called a game. A is called the set of strategies of player I and B the set of strategies of player II. This game is played as follows: player I chooses $a \in$ A and player II chooses $b \in$ B. Both choices are made independently and without any knowledge about the choice of the other player. Then II pays to I the value ϕ (a,b). [Of course ϕ (a, b) < 0 means that II gets from I the value |ϕ (a, b) |] [3]

Game structure of perfect information game:-

A game structure with perfect information is a tuple G = (Q, Σ, Δ, q_o, F) where Q is a set of total number of states Σ is the input values , Δ is transition from one state to another, q_o ,is the starting state, F is a final state.

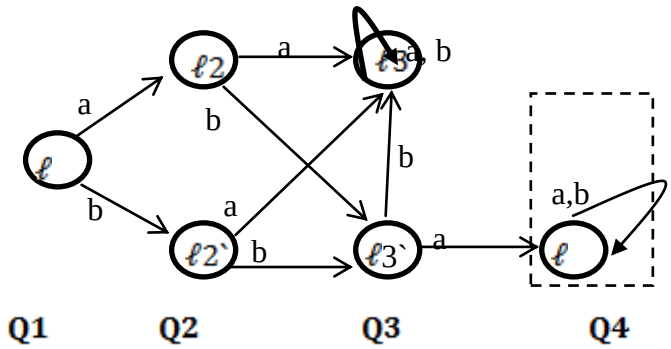

FIGURE 1.2 GAME STRUCTURES WITH PERFECT INFORMATION

B. Imperfect Information Games

In imperfect information game, a player does not know everything about game's state. Typically unknown information is the exact position of the opposing player(s). for example poker, bridge. [7]

A game with incomplete information G = (Θ, S, P, u) consists of:

1. A set Θ = Θ1 × ... × Θi, where Θi is the (finite) set of possible types for player i.
2. A set S = S1 × ... × Si, where Si is the set of possible strategies for player i.
3. A joint probability distribution p (θ1, ..., θ_i) over types. For finite type space, assume that p (θi) > 0 for all θi ∈ Θi.
4. Payoff functions ui : S ×Θ → R.[6]

Game structure of imperfect information game:-

A game structure with imperfect information is a tuple G = (L, Σ,Δ ,Q,F) Q is a set of total number of states Σ is the input values, Δ is transition from one state to another, qo ,is the starting state, F is a final state. . [6]

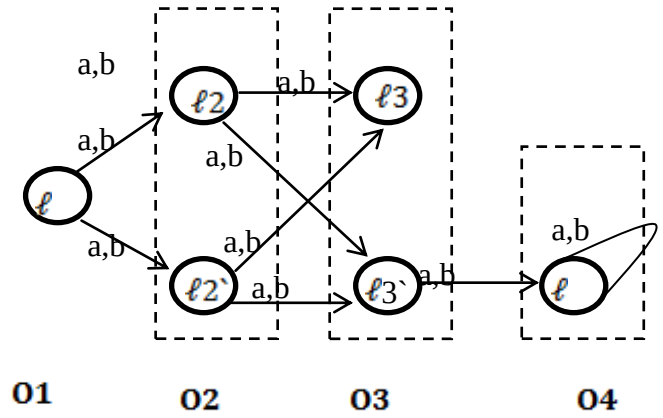

FIGURE 1.3 GAME STRUCTURES WITH IMPERFECT INFORMATION

While exploring the topic imperfect information game, Figure1.3 clearly shows that there are multiple moves form one state to next state. Transition function in imperfect information games behaves very similar as in Non deterministic finite automata. In the imperfect informational games, because of the existence of multiple paths, user can apply heuristic approach to find optimal path form source to destination.

TABLE I
GAME EXAMPLES WITH INFERENCES

Game	Perfect / Imperfect Information game	Inference
Chess	Perfect	Each player can see all of the pieces on the board all times.
Tic tac toe	Perfect	User available with restricted state space and moves
Poker	Imperfect	There are many unknown variables. A player does not know his opponent's cards and may not know their style of play.
Hearts	Imperfect	Players with different moral standards.

Conclusion

In game theory, the tree representation of any game shows number of paths i.e. from starting node to final or dead node. Along with some different game types we mainly focused on perfect and imperfect information games. Table clearly differentiates between the perfect information that exhibits a definite set of states and an imperfect information game comprises of a wide range of states with unpredictable move at any state.

It is possible to convert imperfect information games to perfect information games. But in the imperfect information game, there exist number of possible moves from starting node to success node and because of the multiple paths, conversion of perfect to imperfect information games is still a challenge.

References

[1] Theodore L. Turocy, Bernhard von Stengel, "CDAM Research Report LSE-CDAM-2001-09 on Game Theory", October 8, 2001.
[2] http://en.wikipedia.org/wiki/Game_tree
[3] Jan Mycielski , Chapter 3 "GAMES WITH PERFECTINFORMATION".
[4] Solving Imperfect Information Games Using the Monte Carlo Heuristic, Howard James Bampton, August 1994, page 23.
[5] William Feller . An Introduction to Probability Theory and Its Application, Volume 1. John Wiley & Sons, New York, Third edition, 1968.
[6] Games of Incomplete Information, Jonathan Levin, February 2002, page 3.
[7] Solving Imperfect Information Games Using the Monte Carlo Heuristic, Howard James Bampton, August 1994, page8.