International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 2 Issue 8, August 2021

Game Theory and Its Applications: An Overview

K Swetha[1], Dr. Sonal Bharti[2]
Research Scholar, Sri Satya Sai University of Technology and Medical Sciences, Sehore, Madhya Pradesh, India[1]
Professor, Sri Satya Sai University of Technology and Medical Sciences, Sehore, Madhya Pradesh, India[2]

Abstract: *Game theory is a one of the area of mathematics which is used in social sciences, engineering, most considerably in economics, as well as in biology, political science, international relations, computer science and philosophy. In this research paper, we looks into Game Theory while massively addressing the historical background of this theory. It also emphases on mixed strategies, widespread games with auction bidding, both perfect and imperfect information, and their pertinent practical application.*

Keywords: *Game Theory, Applications, Political Science, Economics, International Relations, Philosophy.*

1. Introduction

Game theory is a mathematical branch that uses the structure and analysis attempts to predict the outcome of the behaviors and decisions of teams, called players, who have the right to make decisions in collaboration with each other. Rock-paper-scissors hand game is a well-known example of this type of interactive game (multiplayer, multiple rules, selection and specific effects for each situation). Suppose you go to a market with a friend and you buy some fruit. Your friend is losing market share. There are two ways you can wait for your friend to return or go where your friend may have gone. But which is the best option? Depending on your friend's options! You also have two options, and here the game theory has a two-player solution (you and your friend also get along) and multiplayer games. Game theory seeks to simplify the complexities in which animals, people, organizations, businesses, economics, and countries meet, to identify the basic game of that interaction. By identifying available options, those that are scarce, and then trying to predict the goals and priorities of those involved, as well as the rules and success of the game, as well as the chances for each of them. Game theory can be used to better understand and analyze existing situations whenever there are limited resources, different decision options, different outcomes from different options, and the opportunity to collaborate or compete between players.

1.1 Game

'Game' is something to learn from a sports lesson. The complete set of rules defines the game. Play is an example of a game. Many games are played for fun, entertainment and entertainment. When someone answers too much, we sometimes say 'it's just a game'. Checkers, chess, soccer, judo, and squash and thousands of other official competitions are examples of games where there are players or two teams. Most of these games have only one champion after playing [1]. But, there are many other situations that can be established such as sports. The game follows as follows:
The game is a mysterious phenomenon, defined as the official definition of a strategic situation. Any communication that involves strategies involves two or more players (players), each with two or more strategies (strategies), such that the outcome depends on the choice of strategy for all players. Each player has well-defined meanings among all the possible outcomes, enabling matching resources (benefits) to be given. The game makes clear the rules that govern players 'communication, players' appropriate strategies, and their preferences rather

than results [2]. Every game has three key elements - players, strategies, benefits. Therefore, the game in standard form contains:

a) Number of players (estimated). P = {1,2,3…., N}, {P1, ……, Pn}
b) The strategy set by Si is given to each player: {S1,…, Sn}
c) Help / gain function - set players to gain: {U1,…, Un}

1.2 Game setting

To define the game setting, it is necessary to specify the following elements:
The number of players: the involved parties of the game, each having at least two strategies. Strategies per player: a chain of actions that the player can take at different stages of the game. Sequential game: which player adopts moves in each stage of the game?
Perfect information: what information can every player know about his opponent's moves and preferences at each moment of the game?
Outputs of the game: What are the results when the game is over?

1.3 Types of Games in Game Theory

In the game theory, different types of games help in the analysis of different types of problems and are formed on the basis of the number of players involved in a game, the symmetry of the game, and cooperation among players. The different types of games are listed below:

- Cooperative and Non-Cooperative Games: In cooperative games, through negotiations and agreements, players are convinced to adopt a particular strategy. On the contrary, in non-cooperative games, players decide on their own strategy to maximize their profit.
- Normal Form and Extensive Form Games: In Normal Form games, a matrix of game description is made to help identify the dominated strategies and Nash equilibrium. However, in extensive form games, a decision tree is made to represent events that can occur by chance.
- Simultaneous Move Games and Sequential Move Games: In simultaneous games, two players make simultaneous moves (strategies), without any prior knowledge of the other party's move. But in sequential games, players have knowledge about the other players' moves.
- Constant Sum, Zero Sum, and Non-Zero Sum Games: Constant Sum is when the sum of each outcome is always zero. Poker, for example, is a constant sum game. On the contrary, in the Zero Sum game, the gain or loss of each player is exactly balanced by those of the other players. However, non-zero sum games demonstrate a situation where one player's gain or loss is independent of the other players' gain or loss.
- Symmetric and Asymmetric Games: In symmetric games, strategies and moves adopted by all players are the same. In this game, the players' decisions are dependent upon the strategies used, not on who is playing them. However, in asymmetric games, the players' adopted strategies are different.

2. Background and impact of Game Theory

Game theory is widely known as an important tool in various fields. Game theory development has greatly improved. The first discussion of theatrical theory took place in a book written by James Waldegrave in 1713. In this book, Waldegrave offers a solution to a mixed strategy in a two-person version of the card game Her. James Madison has done what we now consider as a conceptual analysis of the mechanisms that can be expected to behave under a different tax system. The first example of a formal analysis of the play-theoretic dupopoly study by Antoine Cournot in 1838. His book Researches into the Mathematical Principles of Theory of Wealth presents a restricted translation of the Nash equilibrium [3]. The official view of the play was proposed by mathematician Emile Borel in 1921, which was further developed by mathematician John Von Neumann in the "stage play theory" of 1928.
John Von Neumann and Oskar Morgenstern published Theory of Games and Economic Behavior in 1944. It presents the economic foundation and statistics of the sector we now call 'Game theory'. The book contained many basic words and problem-solving settings that are still in use in recent times. Von Neumann and Morgenstern have developed a field in which economic and social questions can be defined as mathematical models of appropriate strategic games. This great work provides a way to find compatible solutions for two-person two-person games [1]. Corporation after World War II. The R, D and D) was a private company that was expelled from the US Air Force at the end of the war and was deeply concerned about the prospects for international nuclear war. Game theory was clearly associated with this work and as a result the organization funded its development by hiring like mentors Von Neumann and others who were instrumental in developing Game theory, such as John

Nash, Duncan Luce and Howard Raiffa [4]. In 1950, the theory of the play developed dramatically, when John Nash developed the tools and ideas of the conventional theory of non-coherence theory and co-op theory. He introduced the so-called "Nash equilibrium" of the 1951 strategy game. Game theory was theoretically expanded and applied to the problems of political science and philosophy in the 1950s and 1960s. British philosopher R. As a special view of the field game it was founded by great mathematicians and economists, in the last quarter of the twentieth century and early 2000s. Theory of the play gained special attention in 1994 with the presentation of the Nobel Prize in Economics to: John Harsanyi, John Nash and Reinhard Selten. Athletes Thomas Schelling and Robert Aumann were awarded the 2005 Nobel Prize. Schelling worked on dynamic models, the first examples of the theory of evolution. Aumann for enhancing our understanding of conflict and cooperation through the analysis of theoretical concept. In 2007, Roger Myerson, along with Leonid Hurwicz and Eric Maskin, were awarded the Nobel Prize in Economics for "laying the foundations for the design of machinery" for the game program and its design. Alvin E. Roth and Lloyd S. Shapley were awarded the Nobel Prize in Economics for "the vision of sustainable distribution and market design" in 2012. Also, in 2014 the Nobel Prize went to the Jean Triole theory. Eleven game theorists won the Nobel Prize in Economics and John Maynard Smith was awarded the Crafoord Prize for his use of game theory. [5].

3. Application of Game Theory

3.1 Rational Behavior and Decision Theory

Game theory is a useful and potential tool for the understanding of human affairs. Game theory has been expounded as a part of a general theory of Rational Behavior. Rationality is a normative concept, which indicates to what we should do in order to attain a given end or objective. When we are thinking of behavior involving a choice of the best means available for achieving a given end that is 'rational behavior' (Harsanyi, 1980). Rational behavior models are widely used in game theory. According to Von Neumann and Morgenstern:
'We wish to find the mathematically complete principles which define 'rational behavior' for the participants in a social economy, and to derive from them the general characteristics of that behavior' [6]. Game theory as a theory of rationality advices what agents (players) should do in specific interactive situations, given their preferences. Decision theory is the analysis of the human behavior, which concentrates on identifying the 'best' decision option to decision maker. Decision theory provides the rationality of decisions in the light of preferences over outcomes and beliefs about the likelihood of outcomes. Game theory is closely related to decision theory, which studies inter-actions between self-interested players. Game theory along with decision theory analyzes interdependent decision problems between rational, strategic agents. The basic difference between the two that: Decision theory treats all outcomes as exogenous events, 'moves of nature'; whereas in Game theory the prime source of uncertainty for an agent is the way other agents will behave [7]. After analyzing some of the application of the game theory in philosophy we assumed that, game theory has been the object of philosophical inquiry.

3.2 Game Theory and Philosophy

Game theory and philosophy are intertwined.
Game theory has been used as a tool in philosophical discussions. Philosophers are prominently attracted to the concept of play as it provides a way to interpret the concept of Philosophers. There are various areas of Philosophy that blend in a fruitful way with the concept of the game.

3.3 Evolution of cooperation

Game theory is used to analyze many natural phenomena that seem unattractive to biology. The emergence of cooperation is a fundamental problem in biology because unselfish, self-sacrificing actions are clearly at odds with Darwin's choice. Game theory contributes to the context of evolution, becoming a very important tool for dealing with the emergence of collaborations. The most notable ways of co-operation are direct and indirect reconciliation with spatial structure [8]. The concept of co-operation and self-sacrifice - as explored by evolutionary biology - is close to the concept of 'Tit for Tat' which is a successful strategy first introduced by Anatol Paport. He is trying to show that the people he loves will work together to improve their overall interest. Robert Axelrod (1984) attempts to show the possibility of the evolution of revenge and cooperation with each other in the complex Tit game for the dilemma of game.

3.4 Economics and Business

Game theory is an important strategy used in mathematical and business economics to model the behavioral patterns

of interconnected agents. According to P. Samuelson and W. D. Nordhaus:
Economic life consists of many situations with good interactions between firms, households, governments or others. Game theory analyzes how two or more teams, working together in a field-like field, select actions or strategies that collectively affect all participants. Economists use 'Game Theory' as a tool to analyze economic competition, economic conditions such as negotiations, machinery, auctions, voting ideas; experimental economics, political economics, ethical economics etc. Game theory is used to discover different strategies in the business world. It provides important tools for solving strategic problems. Many business strategies are short- or long-term strategies to achieve sustainable profits. An entity can successfully stay in the market with the right strategies and the business will suffer over time with the wrong strategy. Organized behavior occurs frequently among managers, executives and investors in the business world. They have to decide whether to enter new markets, start new products, invest now or lose the opportunity to invest and make price and purchase decisions. Game-theoretic models are great tools for analyzing solid decisions. Game theory models force each player to consider the actions of others when choosing their strategy, in which one player can respond to the departure of a competitor. It provides significant benefits to the decision maker [1].

3.5 Game Theory in Politics

Game theory is widely used in political issues, focusing mainly on international political areas, military strategy, war negotiations, public opinion theory, strategic voting, political economy etc. Game theory is a tool that works in the hands of strategists and politicians to analyze any conflict situation between individuals, companies, provinces, political parties. Character layout and strategy selection is one of the basic concepts of game theory. Game theory seems to be a useful tool for terrorist research because it captures the interaction between the targeted topic and the terrorist organization, where the steps are interdependent and therefore cannot be analyzed separately [9].

4. Game Theory Technology

Game theory is best applied in circumstances where various agents are interdependent [10]. This section mainly focuses on game theory with great emphasis on the dominance, Nash equilibrium, mixed strategies, max-min strategies, and extensive games, both with perfect and imperfect information, bidding in auctions, computation, and lastly, zero-sum games.

4.1 Dominance

Considering that all the players in the game are considered intelligent, the choices they make should lead to the desired outcome given the actions of their opponents. In such a case, these players are said to be highly sophisticated. Strategic strategies refer to the most appropriate option for any player given all the options by the opposing player [11]. Payment for a key strategy is such that apart from the choices made by other players, no other strategy is more profitable. Dominance in the game's theory is best illustrated by the idea of the Dilemma of Prisoners which was first introduced in the mid-20th century by Tucker. The game, according to Kerk, shows a great deal of disagreement with people and team actions and their consequences, which may be the result of their actions. In the case of a prisoner's dilemma, Davis describes what the two criminals were thinking committing crimes together after arrest they were taken to different police cells. Police are gathering enough evidence to convict both of them unless the other party informs the other party. This means that each party is facing a choice of consent or silence, and the whole party is aware of the consequences of its action. Police give both of them the opportunity to say that if they both agree and agree, both are serving a 10-year prison sentence and if one of them agrees, he gets one year in prison and the other is twenty-five. In a case where neither of them agrees, then both face up to three years in prison. The situation described by Avinash and Nalebu in 1991 can be well documented and summarized as follows. [12]

Prisoner 1/Prisoner 2	Admit	Hold out
Admit	10 years	25 years
Hold out	1 years	3 years

Table 1: Prisoner's Dilemma

The table shows that a prisoner gets 10 years in prison if he pleads guilty and 25 years if he does not. This means that if the second prisoner decides to confess, it is best that the first prisoner agrees. On the other hand, if the second prisoner is adamant, the best choice for the first prisoner is to admit that he still has a minimum of one year in prison. These decision-makers have great strategies where, apart from the choices made by other players in the game, no

other strategy will offer the maximum benefit. In this case, the right solution is not in the case of both prisoners.

4.2 Imperfect Information Extensive Games

Since the payment of one player is affected by the action of the other, then the preferred strategy of each player may also depend on other decision-makers. Therefore, these are games that are believed to be completely undetectable [13]. The player, in this case, needs to be unaware of the actions what some players have taken before in the event of a wide range of incomplete games. According to Gilpin and Sandholm (2007), step-by-step decisions may not be made in the right way at the same time as not considering other decisions at all times because such decisions have a significant impact on current provincial opportunities.

4.3 Zero-sum Games and Computation

This mathematical representation refers to the scenario where a player's utility gain or loss balances with the gains and losses of the competing participant. It is the case whereby upon the summation of all gains and negation of all losses of a certain participant total up to zero, and hence the zero-sum game title [14]. A case of two players with completely conflicting interests demonstrates and extreme case of this game. In this case, one team must win while the other completely lose without any in-betweens and hence a closed system, as stated by the theory by Neumann and Morgenstern. In a mathematical representation of a two-player game, every set of payoffs sums to zero.

4.4 Auction Bidding

One of the greatest accomplishments of game theory is seen in the analysis and design of the auction process. Theory on Auction, which was stipulated by the economist William Vickrey, assisted in auctions generating billions of dollars in mobile telecommunication. The Combination of strategies emanating from a set of decision-makers apply set strategies presented to every individual and come up with a payoff vector enhancing maximum utility and profits. Practically, in auctions, a valuable object is placed where bidders signal their willingness to pay with perfect knowledge of the set rule of assigning the object. The object is assigned to the optimal bidder following the set rules, about which all bidders had perfect information. Von Stengel describes an English auction or an open ascending auction as the situation where an object is put up for sale in the presence of all buyers and price keeps rising as long as there are at least two or more interested bidders [15]. The winning bidder gets the object at the last price at which the last bidder dropped.

4.5 Nash Equilibrium

This is the concept of an economic theoretic game solution involving two or more players in which each decision-maker has final knowledge of the equality strategies of the other players, and there is nothing to gain from each strategy change. Any match can have several Nash equalizations as defined by Myerson, although it can be considered unreliable compared to the expected outcome of any match [16]. Numerous studies show that this major concern equates the expected choice of actions by players in any game. Decision makers should be fully aware of the opponents' preferences, and for this to happen, the concept of common sense for all players becomes ineffective. Alternatively, when the statistical details of the previous gaming status are available and reliable, then the game blends well. Another example of the hardships of the prisoner and Nash Equilibrium in the cases of the buyer-seller transaction. Consumers, in this case, appear to be working once or more often and anonymously with any seller. The actions of each buyer are based on their belief in the actions of the other party.

4.6 Perfect Information Extensive Games

These games address the representation of all movements in any game and are well defined in the form of a decision tree. Players in this situation get to choose their various favorite strategies without knowing before other players' choices [17]. However, over time, players can gain information about the actions of the decision-makers, and that is why the status of the full details emerges over time as all players know about the opponents' previous options. In this mode of communication, only one player moves at a time with a bid to avoid movement at the same time. Players in this situation have the opportunity to learn not only the opponent's movements at the beginning but also at any point in the game. There is a limit to the progress of the game in progress because every player chooses his or her action plan permanently, hence one unable to process his or her initial decision with the application.

4.7 Mixed Strategies

According to Turocy and Von (2001), strategic form games may not necessarily have a Nash equilibrium whereby one of the parties gets to choose one of the

strategies. However, decision-makers have to utilize certain probabilities as a basis of their random strategic selection. Simply, this can be described the distribution of probabilities over the specified combination of actions. Alternatively, some scholars viewed this strategy as other players' belief in a specific player's action [18].

5. Conclusion

This paper presents the overview and background of game theory that is one of the area of mathematics that is also used in many areas such as economics, statistics, philosophy, international relations. We also discusses the various game theory technologies such as Nash equilibrium, auction bidding, dominance etc. It has been a powerful analytical tool to help us understand the phenomena that can be observed when decision makers interact. Game theoretic models have become increasingly sophisticated and in consequence, much more powerful and useful.

References

[1] Geckil, Ilhan, and Anderson, Patrick, "*Applied Game Theory and Strategic Behavior",* London: CRC Press 2010.
[2] Bicchieri, Cristina, and Sillari, Giacomo, "Game Theory and Decision Theory", In Borchert, Donald (ed.) 2005. *The Encyclopedia of Philosophy*, 2nd ed., Detroit: Macmillan.
[3] Crider, Lucrecia. "*Introducing Game Theory and its Applications*", Delhi: Orange Apple Publication, 2012.
[4] Heap, Hargreaves, and Varofakis, Yanis, "Game Theory: A Critical Introduction" London: Routledge, 1995.
[5] Aumann, R. "Game Theory" In Eatwell John, Milgate Murray, and Newman Peter (eds.). The New Palgrave: A Dictionary of Economics, London: Palgrave Macmillan, 1991.
[6] Neumann, John von and Morgenstern, Oskar. "The Theory of Games and Economic Behavior", Princeton: Princeton University Press, 1944.
[7] Bicchieri, Cristina. "Game Theory: Some Personal Reflections", In V.F. Hendricks and P.G. Hansen (eds.), Game Theory: 5 Questions, Copenhagen: Automatic Press, 2007.
[8] Hotz, Heiko. "A Short Introduction to Game Theory", Retrieved on 21.09.2017 from: http://www.theorie.physik.lmu.de/
[9] Sandler, T, and Arce M, Daniel "Terrorism and Game Theory", vol. 34, issue 3, International Simulation and Gaming Association (ISAGA), 2003
[10] DRESHER, M., SHAPLEY, L. S., & TUCKER, A. W. "Advances in game theory", Princeton, Princeton U.P. 1964.
[11] STRAFFIN, P. D. "Game theory and strategy", 2010.
[12] Avinash, D. & Nalebu , B., "Thinking Strategically". New York: Norton & Co, 1991
[13] RAPOPORT, A., ORWANT, C. J., & CHAMMAH, A. M. (1965). Prisoner's dilemma: a study in conflict and cooperation. Ann Arbor (Mich.), University of Michigan Press.
[14] CARMONA, G., "Existence and stability of Nash equilibrium", Singapore, World Scientific, 2012.
[15] ICHIISHI, T. "Game theory for economic analysis",. First edition, New York: Academic Press, 1983.
[16] Avinash, D. & Nalebu , B., "Thinking Strategically", New York: Norton & Co, 1991.
[17] ZAGARE, F. C. "Game theory: concepts and applications", Beverly Hills, Sage Publications, 1986.
[18] HEIFETZ, A. "Game theory: interactive strategies in economics and management", Cambridge, Cambridge Univ. Press, 2012.