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Game Theory as a Theory of Conflicts

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At the beginning of the XX century E.Lasker, E.Zermelo, E.Borel put forward the idea of a mathematical theory of conflict of interest: game theory.

Game theory is a branch of mathematics that studies formal models of optimal decision-making in conflict conditions. At the same time, a conflict is understood as a phenomenon in which different parties participate, endowed with different interests and opportunities to choose actions available to them in accordance with these interests. Some mathematical questions concerning conflicts have been considered (since the 17th century) by many scientists. The systematic mathematical theory of games was developed in detail by American scientists J. Neumann and Fr . Morgenstern (1944) as a means of mathematical approach to the phenomena of competitive economics. In the course of its development, I.T. has outgrown this framework and turned into a general mathematical theory of conflicts. Within the framework of I.T., in principle, military and legal conflicts, sports, "salon" games, as well as phenomena related to the biological struggle for existence can be mathematically described[1,2,3].

In a conflict, the enemy's desire to conceal his upcoming actions generates uncertainty. On the contrary, uncertainty in decision-making (for example, based on insufficient data) can be interpreted as a conflict of the decision-making subject with nature. Therefore, I. T. is also considered as a theory of optimal decision-making under conditions of uncertainty. It allows you to mathematize some important aspects of decision-making in engineering, agriculture, medicine and sociology. The approach from the positions of I. T. is promising . to the problems of management, planning and forecasting.

Basic in game theory. is the concept of a game, which is a formalized representation of the conflict. An accurate description of the conflict in the form of a game therefore consists in indicating who and how participates in the conflict, what are the possible outcomes of the conflict, as well as who and in what form is interested in these outcomes. The parties involved in the conflict are called coalitions of action; actions available to them are their strategies; possible outcomes of the conflict are situations (usually each situation is understood as the result of the choice of each of the coalitions of action of some strategy); the parties interested in the outcome of the conflict are coalitions of interests; their interests are described by the preferences of certain situations (these preferences are often expressed by numerical gains). The concretization of the listed objects and the connections between them generates a variety of private classes of games.

If there is a single coalition of action in the game, then the strategies of this coalition can be identified with situations and then no more mention of strategies. Such games are called non-

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strategic. The class of non-strategic games is very extensive. These include, in particular, cooperative games.

An example of a non-strategic (cooperative) game is a simple game consisting of the following. A variety of situations in it are all kinds of distributions (divisions) between players of a certain amount of homogeneous utility (for example, money). Each division is described by the amounts that individual players receive at the same time. A coalition of interests is called a winning one if it can, even in the face of opposition from all other players, appropriate and share among its members all the available utility. All coalitions that are not winning cannot assign any share of utility at all. Such coalitions are called losers. It is natural to assume that the winning coalition prefers one division to another if the share of each of its members in the conditions of the first division is greater than in the conditions of the second. Losing coalitions cannot compare divisions by preference (this condition is also quite natural: a coalition of interests, which itself is unable to achieve anything, is forced to agree to any division and is deprived of the possibility of choosing between divisions).

If there is more than one coalition of action in the game, then the game is called strategic. An important class of strategic games are non-coalition games in which coalitions of actions coincide with coalitions of interests (they are called players), and preferences for players are described by their winning functions: a player prefers one situation to another if he gets more winnings in the first situation than in the second.

One of the simplest examples of a non-cooperative game can be "morra" in its next version. Three players show 1 or 2 fingers each at the same time. If all three players show the same number, then everyone's winnings are zero. Otherwise, one of the players shows a (= 1 or 2) and gets b from some source (for example, from a bank formed by pre-payments), and the other two players showing the same b (≠ a) get nothing.

If two players participate in a non-competitive game, and the values of their winning functions in any situation differ only in signs, then the game is called an antagonistic game; in it, the gain of one of the players is exactly equal to the loss of the other. If in an antagonistic game the sets of strategies of both players are finite, then the game is called a matrix game due to some specific possibility of its description.[4-8]

Another example of a non-cooperative game is chess. This game involves two players (white and black). The strategy of each of the players has a conceivable (although practically impossible to describe in detail) rule for choosing in each possible position a certain move allowed by the movements of the pieces. A couple of such rules (for white and for black) constitute a situation that completely determines the course of a chess game, including its outcome. White's winning function has a value of 1 on winning games, 0 on tied games and -1 on losing games (this method of scoring points practically does not differ from the one adopted in tournament and match practice). The winning function of black differs from the winning function of white only by a sign. From what has been said, it can be seen that chess is among the antagonistic and, moreover, matrix games. In chess, strategies are not chosen by the players before the start of the game, but are implemented gradually, move by move. This means that chess belongs to positional games.

Game theory is a normative theory, that is, the subject of its study is not so much the models of conflicts (games) themselves, as such, as the content of the principles of optimality accepted in games, the existence of situations on which these principles of optimality are

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implemented (such situations or sets of situations are called solutions in the sense of the corresponding principle of optimality), and, finally, ways to find such situations. The objects considered in I. T. — games — are very diverse, and it has not yet been possible to establish the principles of optimality common to all classes of games. In practice, this means that a single interpretation of the concept of optimality has not yet been developed for all games. Therefore, before talking, for example, about the most advantageous behavior of a player in a game, it is necessary to establish in what sense this profitability is understood. All the principles of optimality applied in I.T., with all their external diversity, reflect directly or indirectly the idea of the stability of situations or sets of situations that make up solutions. In non-coalition games, the main principle of optimality is considered to be the principle of goal feasibility, leading to equilibrium situations. These situations are characterized by the property that any player who deviates from the equilibrium situation (provided that the other players do not change their strategies) will not increase their winnings.

In the particular case of antagonistic games, the principle of goal feasibility turns into the so-called Maximin principle (reflecting the desire to maximize the minimum gain).

The principles of optimality (initially chosen intuitively) are derived on the basis of some of their predetermined properties, which have the character of axioms. It is essential that the various principles of optimality applied in IT may contradict each other.

Existence theorems in I.T. are proved mainly by the same non-constructive means as in other branches of mathematics: by using fixed-point theorems, by separating convergent subsequences from an infinite sequence, etc., or, in very narrow cases, by intuitively specifying the type of solution and then finding the solution in this form.

The actual solution of some classes of antagonistic games is reduced to solving differential and integral equations, and matrix games — to solving a standard linear programming problem, approximate and numerical methods for solving games are being developed. For many games, the so-called mixed strategies are optimal, that is, strategies chosen randomly (for example, by lot).

Game theory, created for the mathematical solution of problems of economic and social origin, cannot generally be reduced to classical mathematical theories created for solving physical and technical problems. However, a wide variety of classical mathematical methods are widely used in various specific I. T. issues. In addition, Game Theory is connected with a number of mathematical disciplines in an internal way. The concepts of probability theory are systematically and essentially used in Game Theory. Most problems of mathematical statistics can be formulated in the language of Game Theory. The need for quantitative consideration of uncertainty in the analysis of the game determines the importance and thereby the relationship of Game Theory. with the theory of information and through it — with cybernetics. In addition, game theory, being a theory of decision-making, can be considered as an essential component of the mathematical apparatus of research operations).

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