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"History and impact of game theory for a Zero-Sum Perfect Information Game"

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Abstract

The internal consistency and mathematical foundations of game theory make it a prime tool for modeling and designing automated decision-making processes in interactive environments. For example, one might like to have efficient bidding rules for an auction website, or tamper-proof automated negotiations for purchasing communication bandwidth. There is a "classical" game theory with applications in economics which is very different from combinatorial game theory. The games in classical game theory are typically formal models of convict and cooperation which cannot only be lost or won, and in which there is often no perfect information about past and future moves.

1. INTRODUCTION

Zero-sum games of perfect information are those where every player knows all the moves. Examples include chess, checkers, go and nougats and crosses. Such games are particularly amenable to computation because in theory, a perfect game (i.e. where a player can either force a win or at least never lose) is possible by analyzing the game tree. In noughts and crosses for example, it is quite easy for a computer to play so that it never loses or at worst draws since the game tree is rather small. In checkers, chess and go however, it gets much larger. Even so, there is much that computers have been able to achieve there. This research was intended to see if a primarily aesthetic but never the less important concept like economy could also be evaluated in a game like this. Economy essentially refers to the efficient use of resources in the game to achieve a particular objective.

2. METHODOLOGY

The object of study in game theory is the game, which is a formal model of an interactive situation. It typically involves several players; a game with only one player is usually called a decision problem. The formal dentition lays out the players, their preferences, their information, the strategic actions available to them, and how these influence the outcome. Games can be described formally at various levels of detail. A coalitional (or cooperative) game is a high-level description, specifying only what payoffs each potential group, or coalition, can obtain by the cooperation of its members. What is not made explicit is the process by which the coalition forms. As an example, the players may be several Parties in parliament. Each party has a different strength, based upon the number of seats occupied by party members. The game describes which coalitions of parties can form a majority, but does not delineate, for example, the negotiation process through which an agreement to vote en bloc is achieved. Cooperative game theory investigates such coalitional games with respect to the relative amounts of power held by various players, or how a successful coalition should divide its proceeds. This is most naturally applied to situations arising in political science or international relations, where concepts like power are most important. For example, Nash proposed a solution for the division of gains from agreement in a bargaining problem which depends solely on the relative strengths of the two parties' bargaining position. The amount of power a side has is determined by the usually inefficient outcome that results when negotiations break down. Nash's model fits within the cooperative framework in that it does not delineate a septic timeline of offers and counteroffers, but rather focuses solely on the outcome of the bargaining process.

On the basis of the available information, certain economic features were determined. The first is the number of pieces used to achieve checkmate. If more pieces are involved, the less economical a position is considered to be. By 'involved', it means participating directly in the checkmate. Removing a piece that is involved would therefore invalidate the mate. The second feature is the value of the chessmen. Chessmen include the king, queen, rook, bishop, knight and pawn. In the course of a real game, a piece's value may fluctuate depending on how effective it is in a particular position

3. DISCUSSION

The strategic form (also called normal form) is the basic type of game studied in non cooperative game theory. A game in strategic form lists each player's strategies, and the outcomes that result from each possible combination of choices. An outcome is represented by a separate payoff for each player, which is a number (also called utility) that measures how much the player likes the outcome. The extensive form, also called a game tree, is more detailed than the strategic form of a game. It is a complete description of how the game is played over time. This includes the order in which players take actions, the information that players have at the time they must take those actions, and the times at which any uncertainty in the situation is resolved.

A game in extensive form may be analyzed directly, or can be converted into an equivalent strategic form.

The story behind the name “Prisoner’s Dilemma” is that of two prisoners held suspect of a serious crime. There is no judicial evidence for this crime except if one of the prisoner’s testifies against the other. If one of them testifies, he will be rewarded with immunity from prosecution (payoff 3), whereas the other will serve a long prison sentence (payoff 0). If both testify, their punishment will be less severe (payoff 1 for each). However, if they both “cooperate” with each other by not testifying at all, they will only be imprisoned briefly , for example for illegal weapons possession (payoff 2 for each). The “defection” from that mutually beneficial outcome is to testify, which gives a higher payoff no matter what the other prisoner does, with a resulting lower payoff to both. This constitutes their “dilemma.”Prisoner’s Dilemma games arise in various contexts where individual “defections” at the expense of others lead to overall less desirable outcomes. Examples include arms races, litigation instead of settlement, environmental pollution, or cut-price marketing, where the resulting outcome is detrimental for the players. Its game-theoretic justification on individual grounds is sometimes taken as a case for treaties and laws, which enforce cooperation.

Game theorists have tried to tackle the obvious “in efficiency” of the outcome of the Prisoner’s Dilemma game. For example, the game is fundamentally changed by playing it more than once. In such a repeated game, patterns of cooperation can be established as rational behavior when players’ fear of punishment in the future outweighs their gain from defecting today.

4. STRATEGIC AND EXTENSIVE FORM GAMES

The strategic form (also called normal form) is the basic type of game studied in noncooperative game theory. A game in strategic form lists each player’s strategies, and the outcomes that result from each possible combination of choices. An outcome is represented by a separate payoff for each player, which is a number (also called utility) that measures how much the player likes the outcome. The extensive form, also called a game tree, is more detailed than the strategic form of a game. It is a complete description of how the game is played over time. This includes the order in which players take actions, the information that players have at the time they must take those actions, and the times at which any uncertainty in the situation is resolved.

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5. CONCLUSIONS

In this article, an economic evaluation function for chess was proposed based on economic features explained in chess literature. Properties of the chessboard and chess pieces were used as a metric for the function. Four experiments conducted suggest that the function is able to correctly discern between good and poor economy in checkmate positions for both compositions and in real-games. It also had a good positive correlation with human perception of economy. Further testing with minor modifications on individual positions showed that the function mirrors these economic changes consistently as well. However, due to the many different aspects of economy taken into account, this is sometimes less obvious in certain positions. The evaluation function can easily be implemented in any chess program to automatically identify checkmate positions that are economical. Such positions usually result from sound play and are useful to human players not only for instruction but also aesthetic appreciation. Chess databases that contain millions of professional games are a good resource for this purpose. Even though most of these games end with one player resigning rather than actually being checkmated, game engines are often able to trace the line of forced play that would otherwise have ensued and still return an economic search query. The evaluation function could also serve as a component in larger aesthetic models of chess. New research suggests that computers are able to recognize aesthetics in the game of chess by evaluating numerous aesthetic principles that include heuristic violations, themes and economy . Subsequently, this could contribute to automatic problem composition by computers, which currently employ only certain chess problem conventions and do not address economy or aesthetics. There has also been research into using beauty heuristics as a more effective approach to computers playing chess. Although the results are promising in terms of solving chess problems, it remains speculative whether it could actually drive an actual game. The concept and evaluation of economy in that research however had only been incorporated rudimentarily and it is possible a better implementation such as the one presented in this paper would help.

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