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Nash equilibrium for collective strategic reasoning

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ABSTRACT

In multi-player games, the Nash Equilibrium (NE) profile concept deserves a team for selecting strategies during a match, so no player – except in own prejudice – individually deviates from the team selected strategy. By using NE strategy profiles, the way a baseball team increases the possibilities to a match victory is payoff-matrices-based analyzed in this paper. Each matrix entry arrange each player's strategies by regarding the ones from mates and adversaries, and posterior to a NE-profile-selection, the matrix from all players strategies can support the manager's strategic decision-making in the course of a match. A finite state machine, a formal grammar and a generator of random plays are the algorithmic fundament for this collective strategic reasoning automation. The relationships to e-commerce, social and political scopes, as well as to computing issues are reviewed.

1. Introduction

For the team' successes in a game match the design and usage of a team's strategy as a positive combination of individual strategies is a requisite. On decision making being supported by computer tools, for single or multi-player games, Game Theory (GT) formal approach is of upward interest. GT or Theory of Games seminal foundation was made by Von Neumann and Morgenstern (1944), having as major purpose the economics modeling on markets, trade and financial issues; from now on, it has been applied to a growing number of areas such as politics, biology, sociology, as well as to information technologies and engineering.

The formalization of a game match is for modeling the adversaries' alternate plays inside a competitive situation, hence determine the each player's course of actions during the match that could guide the success possibilities. The benefit to apply one among all of the available plays following the selected tactics and strategies is evaluated by means of a mathematical payoff function (Aumann & Hart, 1992; Osborne, 2004; Ross, 2008). To uphold the analysis, the rules and end of the game should be unambiguously determined. Zero-sum describes a game situation such that the gain or loss of a participant is exactly balanced by the losses or gains of the other participants (Aumann & Hart, 1994). Some games are played regarding perfect information hence following deterministic rules like Chess and Go, but other games follow random-like rules as Poker and Bridge. All the before mentioned games are deployed by single players confronted and have been formally analyzed since decades ago.

Interest on the formal modeling of multi-player sport games played in a field like baseball or American football have been recently growing, particularly by the need of strategic reasoning to play it. Due to the need of team players' coordination among, a multi-player game modeling is of high complexity, and the strategic analysis should include a huge amount of parameters for a convincing automated decision-making support. Moreover, beyond multi-player sport games, GT methods for selecting a course of actions for strategic planning in diverse kinds of organizations is on intense review nowadays. The NE baseball strategic reasoning can be placed on multi-player decision making perspective for social matters like on the policies for tax income, or on trades for economy, finance and e-markets; as well, for task load-balance and balanced distribution processing on computer clusters, as is discussed in Section 5.

Baseball is a zero-sum multi-player game that victory is entirely based on the appropriate strategies being practiced. Actually, this world popular team game is strategies thoughts obligated for playing (Bjarkman, 2004), and the strategic decision-making is crucial to obtain the match success (McGrew & Wilson, 1982). The strategies, as a set of organized plays are indicated by the team's manager regarding the specific profile of all the players hence each one's potential actions, as well the specific match circumstance; from all mentioned information the manager could select some strategies amid to obtain the most benefit. Baseball is at the time, cooperative from manager's perspective and, sometimes, uncooperative from players' perspective: team's members are encouraged to act individually, but must cooperate for team's benefit too.

NE concept allows typifying a team's strategy such that no player individually deviates by the selected collective strategy, because it will be prejudice for the player (Nash, 1951). In this paper NE deserves for identifying the team's strategies to apply

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throughout a baseball match, either on offense or defense role, for pushing up the probabilities of success by NE-strategies-based playing, each baseball player's potential actions is according to own profile given the current position at field, joint to the other players' profile and positions, in addition to the innings, number of outs and score, all integrated for supporting the manager's decision making at any moment during the match. Baseball NE formal modeling is by means of payoff matrix. The computer baseball simulator is based on: one formal Regular Grammar (set of rules), one FSM (finite state machine) to recognize the language generated by the grammar, one random generator of baseball plays, and the NE algorithm for finding competitive match collective strategies.

Next Section is for reviewing strategy games, particularly the qualitative and quantitative baseball antecedents, joint to motivate the worth of NE strategic reasoning for successful playing a baseball match. The formal model is presented in Section 2, and the algorithms and payoff matrices to NE strategy profiles calculi are in Section 3. Experiments and the analytical comparison of results are in Section 4. Since the baseball strategic reasoning, on its relevance to e-commerce, social and political scopes, a decision-making discussion follows, being completed by computer task load-balance and processing balanced distribution are presented in Section 5. Conclusions are in Section 6.

2. Baseball as strategic game

2.1. Cooperation

A favorable outcome in a game match frequently depends upon cooperation among teamers. While the decision to cooperate bears some risks due to uncertainty and loss of control, not cooperating can mean giving up potential benefits (AL-Mutairi, 2010). Cooperation games highlight a positive participation among team players as the basis of a strategy to get a match success (Mintzberg & Ghoshal, 1991), but a loss of every player's individual protagonist is needed as well as the presence of strategies for an efficient cooperation making.

Strategies are a set of organized and weighted actions being practiced for obtaining the best as possible benefit, leading the maximum profit up to the minimum effort (Bell, Raiffa, & Tversky, 1999; Dutta, 1999; McMillan, 1996). Regarding the game set of rules, a player is willing for set up the strategies that determine the order and preference of actions throughout the game. In the evolution of such preferences, each player should consider the other players' strategies; actually, each player should consider the threat embodied in the others' strategies for trying to give the best response (Redondo, 2000).

Nash Equilibrium induces a stable strategic situation to avoid harmful results to the team due to any participant's unilateral deviation from the team selected strategy. For a multi-player game, in some circumstances the NE concept allows identifying strategies profiles being the best solution for all the team players at the time – even less good for some players. NE profiles should be one good mutual answer from each player's strategies by regarding the others' ones (Nash, 1951). However, this last statement implies a rationality guess: in the real life can occur that a collective match running is handicapped by a player's individually defraud action, even she/he has promised to cooperate with the others.

2.2. Toward Nash equilibrium: the prisoner's dilemma

There are circumstances where the players can get a better result cooperating, as illustrates the prisoner's dilemma that describes when the police capture P_1 and P_2, as suspicious people of a crime, without sufficient evidence to charge any of them. Questioned by the police, the possible both prisoners' dilemma strategies profiles to answer can be: (*silence*, *silence*), (*silence*, *confess*), (*confess*, *silence*) and (*confess*, *confess*). Separately, police offer the same deal: if one confesses but the accomplice not, the accomplice is ten years jail sentenced but confessor is released, so (3, 0) or (0, 3); if both silence (deny it) all the police can do is locking them up for six months due to a misdemeanor charge, (1, 1); if both confess five years jail is for each one (2, 2). The summary of prisoner's dilemma and the payoff matrix are shown in Table 1.

Condition to observe to fit a NE profile strategy is that no prisoner will be in losing risk or in a worst position since the other player's profits. So, (*confess*, *confess*) is NE profile for both prisoners as long as any rational prisoner not deviate from, except to the risk to be negative affected: by keeping silence a prisoner can be twice jailed that if confesses.

In Prisoner's Dilemma games, a compensation mechanism where all players' payments pairs with mutual cooperation, it fits NE (Charness, Fréchette, & Qin, 2007); mutual cooperation is substantially more likely with payment pairs that bring the payoffs closer together, but if these payments are not permitted cooperation is much less likely. The players' mutual advantages by cooperation in baseball are next analyzed.

2.3. Qualitative analysis

In a strategy game, the intelligent planning mostly allows driving to victory [36]. Baseball is a multi-player top strategic game, bat-and-ball play at a field (Bjarkman, 2004; Bradbury, 2008; Williams, 2005). Team is compound by 9 players and the match is 9 innings initially, but if there is not winner at the ninth, additional innings are allowed. The game basic rules by the offensive are simple (Dickson, 1999): the offensive team's members take turns at the bat for attempting to hit the ball so thrown pitched from some distance and locating it away from adversaries in front of home plate. The runs are scored by the offensive team when a player, after bat ball sequentially advances from home plate to first, second and third base then back to home plate without being out by the defense team. The team scoring most runs throughout all the innings gets the victory. The team continues at the bat until three outs are made by the defensive team then switch the offense/defense team's roles.

The main offensive strategy is the appointment of the batting order before the game start, so the team's manager does the 9 players pre-set positions at bat. Usually, the best players are first at bat for having more opportunities to hit than those at the list end. Furthermore, at first two places put quick legs people trying as simple as possible to get them into the bases; then, the best hitters on 3rd and 4th position trailers to home with a home run or a good hit to give the players on bases enough time to move forward. In addition, if one or more runners stay on any base a relevant offensive strategy is to intent to advance the runners, either by base stealing or by connecting a hit. If there are fewer than two outs, the sacrifice-plays-based strategy to advance runners is an option though could involve an out, as analyzed in Section 4.2.

While the team at bat is for trying score runs, defensive team is for attempting record outs; the best defense strategy is to get the more outs as possible hence do not receive too many pitches and

Table 1
Prisoners' payoff matrix.

P_1	P_2	
	Silence	Confess
Silence	P_1, P_2, 6 month jailed **Profile (1, 1)**	P_2 release, P_1 10 year jailed **Profile (0, 3)**
Confess	P_1 release, P_2 10 year jailed **Profile (3, 0)**	P_1, P_2, 6 year jailed **Profile (2, 2)**