

Chapter 4

Nonmanipulable Collective Decision-Making for Games

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ABSTRACT

This chapter explores a new approach that may be used in game development to help human players and/or non-player characters make collective decisions. The chapter describes how previous work can be applied to allow game players to form a consensus from a simple range of possible outcomes in such a way that no player can manipulate it at the expense of the other players. Then, the text extends that result and shows how nonmanipulable consensus can be found in higher-dimensional outcome spaces. The results may be useful when developing artificial intelligence for non-player characters or constructing frameworks to aid cooperation among human players.

INTRODUCTION

Teamwork is important in many games. Whether they are human players or non-player characters (NPCs) or both, game entities must often work together to achieve goals. However, those goals do not always coincide perfectly, and, even when they do, players will not always agree on the best next course of action to take.

Much research (see especially Rabin, 2002, sec. 7) has explored effective decision-making for individual game agents, even in a multiagent context. By contrast, in this work, we assume that all agents have already individually decided which of the available outcomes (which are usually actions) they prefer over others, and we assume the agents desire to use those preferences to reach consensus for the group.

For an example game situation, imagine a team of wargame players with a common goal: band together to attack the western coast of a continent

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held by a common enemy. They could attack the coast's northernmost point, the southernmost point or anywhere in between, and each player has a different favorite attack point. If the players can be trusted to express sincere preferences, their preferred points could simply be averaged to give the consensus point. Averaging, however, can allow some players to gain a better outcome from their point of view by exaggerating their preferences, whereas other aggregation mechanisms may never reward such insincerity.

When a group of players aims to benefit all members of the group by coordinating their actions, a method of combining their preferences into a single outcome is useful, but the usefulness may disappear if individual players can manipulate the outcome by expressing insincere preferences. Here we present a set of nonmanipulable collective-decision-making methods that apply to a wide range of game situations.

In the sections below we review previous work that informs ours, look at several game situations that motivate our approach and present the ideas that provide an innovative solution.

BACKGROUND IDEAS

The core ideas of this chapter, while new, are based in extant work from fields such as computer science, mathematics, political science and economics.

Mechanism Design

Returning to the above wargame example, if a team of players is trying to agree on a coastal attack point, their preferred points could simply be averaged to give the consensus point, but doing so sometimes rewards insincerity on the parts of the players. The field of *mechanism design* (Nisan, 2007) has evolved to find decision-making mechanisms that satisfy particular properties, often some kind of immunity or resistance to strategic manipulation.

Strategic manipulation is a common problem in collective decision-making. It is well known that voters can gain advantage under most voting systems by voting insincerely (Gibbard, 1973; Satterthwaite, 1975). Examples include voting for an alternative that is not a voter's first choice and ranking alternatives untruthfully. Traditionally, this problem is discussed in political science, but more recently the techniques of computer science have been applied with success (Bartholdi, Tovey & Trick 1989, Conitzer & Sandholm, 2003; Elkind & Lipmaa, 2005; Procaccia & Rosenschein, 2006). In this chapter we explore a particular approach to creating manipulation-resistant mechanisms.

The Declared-Strategy Voting Framework

Declared-Strategy Voting (DSV) is a computationally-based response to manipulable voting systems (Cranor & Cytron, 1996; Cranor, 1996). Under DSV, each voter submits preferences over the available outcomes. The DSV system then uses those preferences to vote optimally (and, perhaps, insincerely) on each voter's behalf in a simulated election using some underlying voting method. It continues to cast optimal ballots on behalf of each voter until an equilibrium is found or some other stopping criterion is reached. The outcome at equilibrium is then taken as the DSV outcome, or the results of the voting rounds could be used by a policy-maker to reach a justifiable decision.

The hope is that, since the DSV system is attempting to vote strategically on each voter's behalf, no voter will have a reason to mislead the system by expressing insincere preferences—in fact, an attempt to mislead the system may easily backfire. DSV has been shown to be effective in transforming some manipulable voting systems into manipulation-immune ones with the same available outcomes.

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