Computational Aspects of Cooperative Game Theory (Synthesis Lectures on Artificial Intelligence and Machine Learning)

Georgios Chalkiadakis, Edith Elkind, Michael Wooldridge

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Cooperative game theory is a branch of (micro-)economics that studies the behavior of self-interested agents in strategic settings where binding agreements among agents are possible. Our aim in this book is to present a survey of work on the computational aspects of cooperative game theory. We begin by formally defining transferable utility games in characteristic function form, and introducing key solution concepts such as the core and the Shapley value. We then discuss two major issues that arise when considering such games from a computational perspective: identifying *compact representations* for games, and the closely related problem of *efficiently computing solution concepts* for games. We survey several formalisms for cooperative games that have been proposed in the literature, including, for example, cooperative games defined on networks, as well as general compact representation schemes such as MC-nets and skill games. As a detailed case study, we consider weighted voting games: a widely-used and practically important class of cooperative games that inherently have a natural compact representation. We investigate the complexity of solution concepts for such games, and generalizations of them.

We briefly discuss games with non-transferable utility and partition function games. We then overview algorithms for identifying welfare-maximizing coalition structures and methods used by rational agents to form coalitions (even under uncertainty), including bargaining algorithms. We conclude by considering some developing topics, applications, and future research directions.

Table of Contents: Introduction / Basic Concepts / Representations and Algorithms / Weighted Voting Games / Beyond Characteristic Function Games / Coalition Structure Formation / Advanced Topics

"This manuscript was a pleasure to discover, and a pleasure to read -- a broad, but succinct, overview of work in computational cooperative game theory. I will certainly use this text with my own students, both within courses and to provide comprehensive background for students in my research group. The authors have made a substantial contribution to the multiagent systems and algorithmic game theory communities." --Professor Jeffrey S. Rosenschein, The Hebrew University of Jerusalem, Israel

"With the advent of the internet, the computational aspects of cooperative game theory are ever more relevant. This unique and timely book by Chalkiadakis, Elkind, and Wooldridge gives a concise and comprehensive survey of the subject, and serves at the same time as a one-stop introduction to cooperative game theory." --Professor Bernhard von Stengel, London School of Economics, UK

"In recent years, research on the computational aspects of cooperative game theory has made tremendous progress, but previous textbooks have not included more than a short introduction to this important topic. I am excited by the thorough treatment in this new book, whose authors have been and continue to be at the very forefront of this research. Newcomers to the area are well advised to read this book carefully and cover to cover." --Professor Vincent Conitzer, Duke University, USA

"Cooperative game theory has proved to be a fertile source of challenges and inspiration for computer scientists. This book will be an essential companion for everyone wanting to explore the computational

aspects of cooperative game theory." --Prof Makoto Yokoo, Kyushu University, Japan

"An excellent treatise on algorithms and complexity for cooperative games. It navigates through the maze of cooperative solution concepts to the very frontiers of algorithmic game theory research.The last chapter in particular will be enormously valuable for graduate students and young researchers looking for research topics." --Professor Xiaotie Deng, University of Liverpool, UK

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