Coalitional Game Simulation Platform

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Abstract. Some negotiation platforms have been designed for the negotiation research in the past decades. Few of them discuss the coalition game. In this paper, coalition game simulation platform -- an online real-time multilateral negotiation environment simulator-- is introduced. The negotiation domain for this platform is derived from the weighted voting game, an instance of coalition game. For the purpose of research, we equipped this platform with several good features, like human-agent negotiation, extensible API for negotiation agent development, configurable game parameters and game history data.

1. Introduction
Negotiation is a social behavior between two or more people or parties to resolve conflicts over some public issues to get beneficial outcomes for individuals or collectives. With the development of the negotiation research, varieties of automated negotiation platforms have been proposed for different type of negotiations. Most of negotiation platforms are aimed at the achievement of Pareto Optimality [1], but few for coalition game. The different negotiation form, coalition game, is distinguished from the traditional negotiation types. Its complex processes present a more complicated situation for the research [2]. Coalition game simulation platform (CGSP) is an original platform. Its goal is to simulate the multilateral online real-time coalition game environment. In this type of negotiation, the participants or players attempt to form a coalition to get rewards. However, they are limited by some resources, like weights or votes. In order to get a collective profit and finally individual reward, each player should corporate with others. We introduced here is a multilateral coalition game simulation platform. Furthermore, it possesses several good features for experiment and research as follows:

1. Distributed negotiation environments for remote players to negotiate together and stand-alone version for the purpose of testing automated negotiation strategy.
2. Properly support the negotiation between human and automated negotiation agent;
3. Friendly GUI for users to manipulate it. And in consideration of the shortage in computation for human players, the simulation platform provides visualized charts to facilitate human players to make decision
4. Easy-to-use API for developers to implement their own automated negotiation strategies and test their strategies based on the platform.
5. Opening negotiation domain and rule (protocol). The platform allows users to customize the negotiation rule and explore the negotiation form.
To simulate different negotiation forms and environments, various negotiation platforms have been designed and put into researches or competitions in the past decades. The GENIUS platform [3, 4] provides a testbed for automated agents that negotiate under multilateral multi-issue environments. It has been put into the negotiation competition, Automated Negotiation Agents Competition (ANAC) as part of the IJCAI competition track for several years.

A large number of results have been conducted based on the platform, GENIUS. [5] proposed a deduction based on the decision and utility updating and then make opponents model in accordance with the acknowledged information. Brzostowski and Kowalczyk supposed that opponent follows a time-based bidding strategy and is related to its behavior, then used the differential method to predict the opponents’ utility [6]. Chen and Weiss [7] use discrete wavelet transform and cubic spline smoothness to analyze opponent behavior and learn opponent strategy. GENIUS platform relies on the single form for the multi-issue domain and restrict the negotiators behavior with its provided interfaces. It’s hard to simulate the complex coalition negotiation environment based on this negotiation platform.

With the further study of negotiation, coalition game and human-agent negotiation have gained focus in the industry. In ANAC 2017, two new negotiation leagues, Diplomacy Strategy Game League [8, 9], Human-Agent Negotiation [1, 10], entered this competition and brought this international competition vigor and vitality. Diplomacy Strategy Game League simulates the corporation and merger of several counties. This platform opened its strategy API to allow user to design their own automated negotiation strategies. Human-Agent Negotiation is derived from the daily life situation where two persons carve up some resources. This platform provides human and agent interactive interface to make research for human-computer interaction.

Coalitional game can be used to describe problems in varieties of different situations from daily life, social activities or scientific research, such as the following two examples:

1. Infrastructure construction like airport game. To avoid to build unnecessary airport, several cities choose to share the cost to build a regional airport serving. Thus this situation can be modeled as a coalition to determine the cost for each city.

2. Minimum spanning tree game. A number of node need to directly or indirectly connect to a center node. What’s the minimum cost, or in other words, the shortest path for these connection? This problem can be modeled by coalition game.

2. Platform design

2.1. Weighted voting game
The platform is derived from weighted voting game. In weighted voting game, each participant has a certain number of votes or resources. To get the common or individual reward, a minimum quantity of resource, majority resource is required. Usually, a single party never satisfy the condition, majority resource. It’s necessary for parties to form coalitions with others to meet the requirement of the majority resource. Then the common rewards would be divided into several parts for parties in the coalition. Parties that excluded from the coalition structure will get zero reward.
Fig. 1. Trilateral coalition game sample

The typical weighted voting game occurs among three parties (refer with: Fig. 1). Party1, party2 and party3 hold the number of resources for 30, 40, 30. The number of majority resource is 60. To get the reward, each party should cooperate with at least one another. It’s possible that the rewards vary for different coalitions.

The negotiation is arranged in an alternative order. At the beginning of the game, a party would propose its expected coalition structure and the pre-allocation plan of common reward for every partner in the coalition structure. Then the each party in this coalition structure would make a decision that whether cooperate with the proposer or not, and make a response, accept or reject the coalition proposal. When all the parties in the negotiation structure accepted this proposal, the proposal would become effective. Thus coalition formed and every party in the coalition would get the pre-allocated reward. Negotiation session ended. While anyone in this coalition rejected the proposal, the proposal would be announced invalid. Negotiation continue. The next participant would come up with its coalition proposal. Negotiation session goes round by round.

To make the abstract negotiation domain more significant, we add two extra novel traits, represented as follows:

1. Rewards vary from different resources. It denotes that different coalition structures with various number of total resources would get different amount of rewards. It’s reasonable that the more resources a coalition holds; the more rewards it gains in general.

2. Private individual parameter. In our negotiation platform, we call the parameter cost. Once the reward was allocated to each party of the coalition, the real reward for individual can be deduced from that, the allocated reward minus the private individual parameter (cost).

2.2. Platform architecture and game frame

The architecture of our platform can be decomposed into three layers. The explanation for each layer is presented as follows:

1. Platform/framework infrastructure. In this layer, the fundamental communication facilities for game, such as socket-based and pipeline-based communication, is implemented. The basic game protocol, message manager, data persistence and so on are all designed in this layer.

2. Abstract domain and negotiation strategy interface. Based on the platform infrastructure, we abstract the domain and provide a set of interface to implement more different negotiation domains.

3. Coalition game instance and automated negotiation agent strategies. We abstracted the coalition game from weight voting game and defined the basic behavior for both human and agent player to make negotiation.
The platform (CGSP) is developed with JAVA technique. It is naturally equipped with the good feature of cross-platform and distributed system. The negotiation simulation platform is design in client-server (C/S) architecture. Users can launch the server on a center machine. Then each player connects to the server by a client terminal to make joint negotiation. Our platform also supports the stand-alone mode simulation environment. It’s helpful for users to develop their automated negotiation strategies and test their agents on their computers.

While all the required players entered the game room, a coalition game begins automatically. Human player makes counter offer or response through the client interface. The two visualized statistics charts are contributed to make decision. The platform API for automated negotiation agent design is presented in next section.

2.3. Platform API for automated negotiation agent
Our simulation platform (CGSP) provides five main abstractive behaviors (interfaces) for users to implement the automated negotiation strategy, which are listed below:

1. Initialization. This method provides agent with some necessary information of its own and opponent players to initialize itself.
2. Receive proposals. When a player comes up with a coalition proposal, everyone in the negotiation game would get it through this method.
3. Make proposals. A player can present its expected coalition proposal, which contains its expected allies and allocation for each player in the coalition.
4. Make responses. A player would make responses (agree or reject) for others proposals through this method.

The behaviors are essential for negotiation agents design. Usually, most of automated negotiation agents would be equipped with independent opponent modeling modules to learn opponents’ behaviors or characters to assist to make decision.

2.4. Configurable game parameters and data persistence
To make further study for the coalition game for researchers, our platform provides two extra features. One is the configurable game parameters, another is negotiation history data persistence.

We abstracted the main behaviors for general players of coalition games and defined the interfaces for users to manipulate their roles in the game. Then we extracted the related parameters into different configuration files, such as the number of required participants, the number of resource (weight) each participant holds, majority resources, the rewards for each coalition structure, private individual parameters and so on. These parameters controlled the main information for the game or participants and are all defined in four configuration files. It is convenient for users to apply their own parameters through these files to customize their personal game configurations.

3. Conclusion and future work
Collation game simulation platform (CGSP) we designed is derived from the weighted voting game on the purpose of the coalition game research. We significantly make some extension for the weighted voting game, such as private individual parameters. Otherwise, based on the platform human and agent can make negotiation together. We abstract the behaviors of the player in coalition game, and provide developers with the API to implement their own automated negotiation strategies.

In future work, we will extend the platform for the following three aspects:
1. Improve the platform GUI. Provide users with more fascinating interface to promote user experience.
2. Try to decompose the negotiation agent interface into several different modules. For example, separate acceptance strategy from the original API as an independent module. It is significant for negotiation strategy developers to share their strategies and make the design of negotiation agent more flexible.
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