Expert Systems with Applications 41 (2014) 4035–4042

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

A utility concession curve data fitting model for quantitative analysis of negotiation styles

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ARTICLE INFO

Keywords:
Utility concession curve
Negotiation style
Reciprocal function
Data fitting
Data mining
Negotiations

ABSTRACT

A reciprocal function is proposed for defining the utility concession curve of a negotiation participant. The curve has only one free parameter and can fit the complete range of negotiation styles from extremely competitive to extremely collaborative. Various equations are derived, including the definition of a utility concession curve center which permits intuitive quantifying of a utility concession curve. Subsequently, an optimization model is proposed to fit the curve to a set of offers. Using the proposed model, a set of negotiations is mined for utility concession curves which are then used for clustering and hypothesis testing. Three negotiations styles seem to emerge from the data; slightly collaborative, neutral and quite competitive. It is also shown quantitatively that the level of competitiveness of the counterpart is negatively correlated with the agreement rate, and this is validated against the experimental treatment. Additionally, by the use of an experimental treatment, it is shown that the level of competitiveness of the counterpart has a positive causal impact on the negotiator's style, causing him to become more competitive or collaborative. The data fitting model can also be used for incrementally fitting the curve in real-time during a negotiation to provide an estimate of the negotiation style which may help in the negotiation process.

1. Introduction

Negotiations represent a flexible and rich family of exchange mechanisms by means of which economic parties may engage in search of acceptable solutions to support their respective operations. Unlike catalogue-based transactions, where the fixed offers are posted by one party and the decision by the other is reduced to binary one (accept/reject), negotiations allow for dynamic determination of the value of the transacted good/services along several issue dimensions. Furthermore, unlike auction systems, where strict structure is imposed by the design of auction rules, in negotiations both parties take active part by exchanging offers and, if necessary, expanding the search space through adding new issues dynamically.

Electronic negotiation systems (ENSs) are Information Technology (IT) artifacts incorporating at their core negotiation mechanisms that allow the parties to exchange offers over the internet (Kersten & Noronha, 1999a). Since parties interact via a digital medium, this not only allows any-time/anywhere mode of interactions, but also facilitates organic involvement of decision support tools that help making decisions related to preparation and conduct of negotiations. These tools could allow the parties to express their preferences regarding various issues involved in the negotiations, assess the received offers from the counter-parts in light of these preferences, and help in preparing counter-offers. More advanced support may involve providing active advice, critique, and even complete automation of the negotiation process with the help of negotiation software agents.

Notwithstanding the potential promises of ENS-hosted negotiations, their real-life usage has been limited. Catalogues and auctions remain the pre-dominant forms of mechanism in the online realm. One possible explanation to this phenomenon is a relatively high cognitive load associated with managing negotiation processes. The very flexibility of the negotiation mechanism is a double-edged sword: on one hand it promises search for better (not achievable by other mechanisms) solutions, yet on the other it requires extensive analysis and decision-making in the presence of multiple negotiation issues, which may evolve with time. While software agents may alleviate the problem of cognitive effort by assisting negotiators, or even automating negotiation process, their adoption depends on the employment of effective negotiation tactics which would be acceptable and transparent to their human principals.

Multi-issue negotiations allow for the discrepancy between the importances of different negotiation issues to one party vs. the other party. This discrepancy makes it possible to search for

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http://dx.doi.org/10.1016/j.eswa.2013.12.029

mutually beneficial solutions (Rangaswamy & Shell, 1997), i.e. conducting "integrative" negotiations (Kersten & Noronha, 1999b). The preferences can be represented in the agent model using some form of aggregation function with different weights reflecting the importance of the issues. Thus, with properly captured preference structure a software agent can evaluate any given offer in terms of its utility to a principal. A concession that an agent makes in the course of a negotiation can thus be calculated in terms of utility an agent is willing to forgo at given point in the process. Rules, followed by an agent in determining how to make concessions, constitute agent tactics (sometimes also called "strategies" in the literature). When a concession-related decision depends on the current point in time within the period allocated for a given negotiation, such family of tactics is called time-dependent (Faratin, Sierra, & Jennings, 1998).

While time-dependent tactics in concession-making have been proposed in the past, little work has been done to model such tactics based on empirical data. In particular, while various time-based types of negotiation behavior have been proposed for agents, whether such types of behaviors are present in actual online negotiations remains an open question. The major motivation behind the current work is to derive a model for time-based concession-making and apply it to empirical negotiation instances. Based on the model parameters obtained empirically various negotiation behavior types can be elicited using cluster analysis. Such a model would allow researchers to: build agent negotiation tactics based on empirical data; simulate human negotiators in testing various tactics and strategies; provide a measure for testing hypotheses about negotiation behavior.

Based on the above motivation, the main objectives of this work include developing a model for specifying time-dependent tactics in a simple, intuitive, yet powerful fashion, and then extending it to a data fitting model which permits quantification of concession patterns. A quantitative measure of a concession pattern can subsequently permit a multitude of quantitative analyses, including data mining, clustering, and hypothesis testing of actual negotiator behaviors captured in a sequence of real-world offers. Finally, the proposed model also aims to provide empirical grounding for designing the conventional time-dependent tactics used in software agent-enhanced negotiation research.

The paper is organized as follows. The discussion of the background and relevant past literature is provided in the next section. Next, the requirements for modeling concession behavior are defined, and the mathematical form of the model is developed. Next section describes how the data from real experiments with human subjects has been used to fit the model to their concession behavior and extract a measurement for each negotiator. This measurement is used in the subsequent section for testing hypotheses. The paper ends with conclusions, including the discussion of possible future research directions.

2. Background

Electronic negotiation systems allow for the organic incorporation of decision support, negotiation assistance and automation tools in the process of interaction between parties involved (Kersten, Kowalczyk, Lai, Neumann, & Chhetri, 2008). While decision support tools facilitate improved outcomes in negotiations (Rangaswamy & Shell, 1997), software agents can negotiate deals on behalf of human principals. In fact, software agent-based decision support frameworks have been proposed in the literature (Hess, Rees, & Rakes, 2000).

Past research on automated negotiations involving software agents as interacting parties has been extensive (see e.g. (Beam & Segev, 1997; Chavez & Maes, 1996; Faratin et al., 1998)). Examples of agent-enhanced business negotiation research targeted Consumer-to-Consumer (C2C) (Chavez, Dreilinger, Guttman, & Maes, 1997; Chavez & Maes, 1996), Business-to-Consumer (B2C) (Huang & Lin, 2007), and Business-to-Business (B2B) (Wang, Wang, Vogel, Kumar, & Chiu, 2009) contexts of exchange. Since this work is concerned with modeling of time-dependent negotiation tactics, it will focus on concession-making schemas used in negotiations, rather than on a thorough review of past work on agent-based negotiations.

Concession-making patterns have long been recognized to have significant effects on negotiation outcomes (Slusher, Sims, & Thiel, 1978). Faratin et al. have introduced families of models to be used in driving negotiation tactics in software agents (Faratin et al., 1998). Tactics, according to the authors, are used to decide on what offer to make at a given point in the negotiation process. Strategies are used to emphasize the choice of tactics based on history, context, and other variables.

The tactics were divided into three categories: behavior-dependent, time-dependent, and resource-dependent. The first family bases its choice of offer on the moves made by the parties. Various forms of tit-for-tat tactics had been presented in this category. Time-dependent tactics model concession-making as a function of time elapsed between the beginning of negotiation and the estimated ending point. The underlying functional form included polynomial and exponential expressions. Functions that dictated small concessions in the beginning (negative second derivative over time) corresponded to more competitive behavior, and were named boulware tactics. Those that implied early large concessions were named conceder tactics. Resource-dependent tactics aim at adjusting concession levels based on a given resource depletion.

There are several problems with the proposed exponential and polynomial functions. The first is that there is no guidance for choosing one over the other. In fact, they behave similarly in an inverse fashion, however neither is symmetric in terms of the concession patterns throughout the time period. Additionally, the β coefficient used in the models varies non-linearly with the negotiation style, which makes subsequent numerical analysis difficult as well as making its interpretation non-intuitive. Furthermore, a $\beta = 1$ (as well as any other β) represents a more competitive style for the exponential function that for the polynomial function.

Fatima et al. have analyzed tactics functions advanced by Faratin et al. in order to derive optimal negotiation strategies for agent in different information states (Fatima, Wooldridge, & Jennings, 2002). Matos et al. have used genetic algorithms to evolve strategies in terms of tactics selected as well as the related parameters (Matos, Sierra, & Jennings, 1998). Lee & Chang have provided extensive theoretical and simulation-based analysis of agent tactics (Lee & Chang, 2008). They have expanded the tactics for simulations to multi-issue negotiations. Their simulations performed over multiple artificial two-issue cases suggested the overall superiority of tit-for-tat tactics, although in some cases boulware tactics had performed best.

In Sánchez-Anguix, Valero, Julián, Botti, and García-Fornes (2013) an approach to agent negotiations in the context of ambient intelligence has been proposed. Agents in this approach follow the k-alternating protocol to send and receive offers. The work considers cases with complex multi-issue utility functions. The authors propose to use genetic algorithm in the pre-negotiation phase to sample negotiator's own utility function, and in the negotiation phase to combine the elements of the offers of both parties.

An early work on agent-populated Kasbah marketplace have included time-dependent agent tactics (Chavez & Maes, 1996; Chavez et al., 1997). The agents were involved in negotiations including a single issue: price. Thus, their utility reflected solely this single issue. Three concession patterns were introduced: frugal, corresponding to boulware tactic introduced above;