Chapter 8.2
A Survey on Neural Networks in Automated Negotiations

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INTRODUCTION

Automated negotiation is a very challenging research field that is gaining momentum in the e-business domain. There are three main categories of automated negotiations, classified according to the participating agent cardinality and the nature of their interaction (Jennings, Faratin, Lomuscio, Parsons, Sierra, & Wooldridge, 2001): the bilateral, where each agent negotiates with a single opponent, the multi-lateral which involves many providers and clients in an auction-like framework and the argumentation/persuasion-based models where the involving parties use more sophisticated arguments to establish an agreement. In all these automated negotiation domains, several research efforts have focused on predicting the behaviour of negotiating agents. This work can be classified in two main categories. The first is based on techniques that require strong a-priori knowledge concerning the behaviour of the opponent agent in previous negotiation threads. The second uses mechanisms that perform well in single-instance negotiations, where no historical data about the past negotiating behaviour of the opponent agent is available. One quite popular tool that can support the latter case is Neural Networks (NNs) (Haykin, 1999).

NNs are often used in various real world applications where the estimation or modelling of a function or system is required. In the automated negotiations domain, their usage aims mainly to enhance the performance of negotiating agents in predicting their opponents' behaviour and thus, achieve better overall results on their behalf. This paper provides a survey of the most popular automated negotiation approaches that are us-

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ing NNs to estimate elements of the opponent's behaviour.

The rest of this paper is structure as follows. The second section elaborates on the state of the art bilateral negotiation frameworks that are based on NNs. The third section briefly presents the multilateral negotiation solutions that exploit NNs. Finally, in the last section a brief discussion on the survey is provided.

NEURAL NETWORKS IN BILATERAL NEGOTIATIONS

In (Zhang, Ye, Makedon, & Ford, 2004) a hybrid bilateral negotiation strategy mechanism is described that supplies negotiation agents with more flexibility and robustness in an automated negotiation system. The framework supports a dynamically assignment of an appropriate negotiation strategy to an agent according to the current environment, along with a mechanism to create new negotiation rules by learning from past negotiations. These learning capabilities are based on feedforward back-propagation neural networks and multidimensional inter-transaction association rules. However, the framework is not adequately described and defined and the neural networks are not specifically instantiated. Additionally, there are neither quantitative nor qualitative experimental results for real world cases. Finally, the format of the input to the generic network that is presented is ambiguously described.

In (Zeng, Meng, & Zeng, 2005), the authors employ a neural network to assist the negotiation over very specific issues from a real world example. The network is trained online by the past offers made by the opponent, while both the buyer and the seller agent have the ability to employ the proposed network. However, the experimental data sets are very restrictive and do not address the diversity of those that can be arisen in real scenarios. Additionally, the authors do not present the actual size of the hidden layer, a parameter that is extremely crucial with regards to the appropriateness to use such a network in a real time negotiation procedure by an agent with limited resources.

Furthermore, in (Rau, Tsai, Chen, & Shiang, 2006), the authors studied the negotiation process between a shipper and a forwarded using a learning-based approach, which employed a feedforward back-propagation neural network with two input data models and the negotiation decision functions. Issues of the negotiation were the shipping price, delay penalty, due date, and shipping quantity. The proposed mechanism was applicable to both parties at the same time and the network architecture was chosen based on past similar attempts, following a very restrictive pattern for the number of the hidden layer's neurons. The conducted experiments showed an overall improvement of the results for both negotiating parties, while the framework was proven stable and with small deadlock probability. However, as its authors support, further experimentation is required especially with regards to a wider variety of strategies and possibly more suitable network architectures for the hidden layer.

In (Carbonneau, Kersten, & Vahidov, 2006), a neural network based model is presented for predicting the opponent's offers during the negotiation process. The framework was tested over a specific set of experimental data collected from other existent frameworks and it is highly adjusted to these data. The purpose of this solution is not only to predict the opponent's next offer, but also the perception for the specific procedure, i.e. an overall vision on why everything is happening and where the procedure is led. Thus, the prediction of the opponent's next round offer is only a part of the network's output. However, the chosen experiment set is constrained and doesn't examine the effectiveness of the framework on diverse strategies as those proposed in the very first steps of the area and are now mainly used (Faratin, Sierra, & Jennings, 1998). Additionally,

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