ALBidS: A Decision Support System for Strategic Bidding in Electricity Markets

Demonstration

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ABSTRACT

This work demonstrates a system that provides decision support to players in electricity market negotiations. This contribution is provided by ALBidS (Adaptive Learning strategic Bidding System), a decision support system that includes a large number of distinct market negotiation strategies, and learns which should be used in each context in order to provide the best expected response. The learning process on the best negotiation strategies to use at each moment is developed by means of several integrated reinforcement learning algorithms. ALBidS is integrated with MASCEM (Multi-Agent Simulator of Competitive Electricity Markets), which enables the simulation of realistic market scenarios using real data.

KEYWORDS

Multi-agent simulation; electricity markets; decision support systems; machine learning

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1 INTRODUCTION

Current worldwide electricity markets are strongly affected by the increasing use of renewable energy sources, which has led to a restructuring of the power sector. The restructuring made the market more competitive, but also more complex, placing new challenges to the participants, which increases the difficulty of decision making. This is exacerbated by the new market types that are being implemented to deal with the new challenges. Therefore, the intervenient entities are forced to rethink their behaviour and market strategies in order to cope with such a constantly changing environment [1].

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So that these entities can deal with the new challenges, the use of decision support tools becomes crucial. The need for understanding the market mechanisms and how players' interaction affects the outcomes of markets has contributed to the emergence of several simulation tools [2]. Multi-agent-based software is widely adopted, as this paradigm is suitable to analyse dynamic systems with complex interactions among its elements. Current tools allow studying different market mechanisms and analysing the relationship between market entities; however, they are not prepared to provide suitable decision support to market players' negotiations [3].

This gap motivates the development of this work, which provides a solution to support players in electricity market negotiations. ALBidS (Adaptive Learning strategic Bidding System) is a decision support system that includes a large number of distinct market strategies, and learns which should be used in each context in order to provide the best expected response [4]. ALBidS is integrated with MASCEM (Multi-Agent Simulator of Competitive Electricity Markets), which enables the simulation of real data-based scenarios [5]. Demonstration video available: https://youtu.be/pc1gJV3ndSo.

2 MAIN PURPOSE

The literature offers a large variety of strategic approaches that aim at providing decision support in auction-based electricity market negotiations [2]. However, none of the proposed strategies has shown to be clearly better than the others, i.e. strategies that have performed well in one situation may have mediocre performances in different circumstances – the "no free lunch" theorem.

The main goal of ALBidS is to take the most advantage out of the alternative market strategies that have been introduced in the literature. With this purpose, the general concept behind ALBidS is the integration of as many distinct market strategies as possible, whose performance is evaluated under different contexts of negotiation. This evaluation is used to learn which strategies are the most adequate and present the highest chance of success in each different context.

The learning process is undertaken by means of reinforcement learning algorithms [6], namely the Roth-Erev algorithm and an algorithm based on the Bayesian theorem of probability. Additionally, an Efficiency/Effectiveness (2E) balance management mechanism enables ALBidS to adapt the execution time of the system to the purpose of each simulation. ALBidS incorporates a large variety of market decision support strategies with different natures and perspectives, such as data mining techniques, forecasting methods [7], artificial intelligence methodologies, application of electricity market directed strategies, mathematic approaches, economic theory-based models, the adaptation of physics theories, game theory [8], metalearners, among others. This way, the system is able to take advantage of the characteristics of each approach whenever they show to be advantageous. The system is, thus, prepared to deal with different contexts and scenario situations, guaranteeing a large scope of approaches, which offer a greater chance of having appropriate responses even in very distinct situations.

The context awareness capabilities of ALBidS are provided by the context analysis methodology proposed in [9]. Different characteristics of each negotiation period and day are analysed so that different negotiation contexts are identified and defined. This methodology enables the learning process of ALBidS to be dependent on the negotiation context by adapting the responses to each current context. Strategies can, this way, be evaluated and chosen depending on their performance in each context.

The interaction with the MASCEM electricity market simulator provides the means for experimenting the developed decision support methods under realistic simulation conditions. MASCEM makes use of the RealScen scenarios generator [10], to create simulation scenarios that are the representation of real markets. RealScen uses real data that is available online, which is gathered in real time, as soon as it is made available by each different source, using an automatic data extraction tool.

3 DEMONSTRATION

ALBidS is connected with the MASCEM simulator, providing a response to the negotiating players when they require intelligent support to act in the market. The connection between the two systems is managed by the Main Agent. This agent acts as an intermediary between the two systems. It receives requests from the negotiating players when they require decision support and provides them the corresponding answers. These answers are provided after managing the ALBidS internal mechanism, including the interactions with the strategy agents.

ALBidS enables choosing the desired reinforcement learning algorithm and defining its parameters. It is also possible to define the 2E balance preferences and to set up the context analysis. In the strategy panel, it is possible to select the strategies to use, and define their parameters. Fig 1 presents the user interface of ALBidS, which allows defining the inputs and analyzing the outputs of the system.

From Fig. 1 it is visible that ALBidS enables choosing the desired reinforcement learning algorithm and defining its parameters. It is also possible to define the efficiency/effectiveness balance preferences and to set up the context analysis. In the strategy panel, it is possible to select the strategies to use, and define their parameters.

After all parameterizations are defined, and the simulation is started, the ALBidS interface displays the graphs presenting the simulation data. The interface displays two types of graphs: the global stats, providing a global view of the simulation; and the strategy individual graphs, presenting the information regarding each of the strategies. In the global stats panel, three graphs are displayed, presenting: all strategies' bids and the actual market price, comparing the different strategies' proposals; the performance of each strategy; and the comparison of the execution times of all strategies. The second panel presents the individual strategy graphs, displaying for each one the bid prices and profits.

4 CONCLUSIONS

This paper presents a demonstration of ALBidS, a multi-agent system created to provide decision support to market negotiating players. ALBidS considers several different methodologies based on very distinct approaches, to provide alternative suggestions of which are the best actions for the supported player to perform. The approach chosen as the players' actual action is selected by the employment of reinforcement learning algorithms, which for each different situation, simulation circum-stances and context, decides which action is the one with higher possibility of success.

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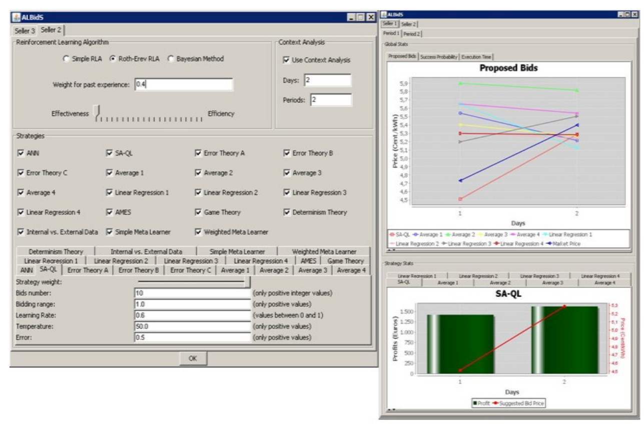

Figure 1: ALBidS user interface

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