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Automatic price negotiation on the web: An agent-based web application using fuzzy expert system

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ABSTRACT

A traditional internet auction is restricted by the limitation of time. It is necessary to conduct an internet auction in a certain time period. The final trading price is determined until this certain period ends. This study improves this situation by removing the time limitation. Based on the fuzzy inference theory, this paper proposes an agent-based price negotiation system for on-line auctions. Mainly, three agents are used in the study: a seller agent, a buyer agent, and a mediator agent. The proposed system provides an easy-to-use environment and good customizability for users (buyers or sellers) to customize their price negotiation strategies using user-defined fuzzy rules. The final negotiated price is immediately determined after the buyer sends his bids to the proposed system. This study develops a Java-based computer package to implement the price negotiation system where Model-View-Controller (MVC) design pattern is employed in design of the package. Unified Modeling Language (UML) is also utilized to describe the structures and behaviors of the package. To validate the proposed system, this study built an on-line auction website with the proposed price negotiation mechanism for internet users to buy or sell their merchandises. An evaluation was finally conducted to investigate the users' satisfaction with the proposed system.

Briefly, the proposed system is featured by: (1) instantly getting negotiated price without waiting; (2) conducting price negotiation at any time; (3) determining strategy rules easily, and (4) using customizable negotiation strategies defined by users.

1. Introduction

Recently with the rapid development of software technologies and the improvement of network bandwidth, more and more internet applications have been implemented for people to conduct their daily activities such as e-learning, e-service, and e-commerce. E-learning provides an unlimited learning environment in time and geometrical conditions. Users can engage their learning activities via internet whenever and wherever they need. E-service provides governmental services for people such as tax reports, traffic ticker payments, document services, etc. In addition, official document exchanging among governmental departments is also included in e-service. E-commerce conducts business activities via internet using web technologies. It includes three major models: business-to-business (B2B), business-to-consumer (B2C), and consumer-to-consumer (C2C). An internet auction is one of successful applications of C2C. There are currently more than 2600 internet auction companies on the web (WWW resource 2). Below, we introduce several typical auction types.

Basically, an auction is a business process to determine the merchandise trading price between a seller and potential buyers using bids (offered by the buyers) and asks (offered by the seller). Two main types of auctions are commonly used: one-sided auction and two-sided auction (He, Jennings, & Leung, 2003). In an one-sided auction, only one side (buyer or seller) is allowed to send his bids or asks to determine the price while in a two-sided auction, both buyer and seller can send the bids and asks to determine the price (He et al., 2003). Four kinds of one-sided auctions are often utilized in business including: English auction, Dutch auction, first-price sealed-bid auction, and Vickrey auction (He et al., 2003). Of the four auctions, the English auction and the Dutch auction are the most popular two auctions. In an English auction, the price starts from the lowest price and is consecutively increased by the bids offered by buyers. The process continues until no other buyers can offer a better price (WWW resource 1). The trading price in an English auction is determined by the last bid. Contrastively, in a Dutch auction, the price starts from the highest price and is continuously reduced by the asks offered by the seller until some buyer accepts the price (WWW resource 1). The trading price in a Dutch auction is determined by the last ask. The summary of the types of auctions can be found in He et al. (2003).

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Most of auctions are normally conducted without selling and buying strategies. Price negotiation is another mechanism to determine the trading price between a seller and a buyer. In a price negotiation, a seller utilizes his selling strategy to get his best trading price (the highest price). On the other hand, a buyer employs his buying strategy to obtain his best price (the lowest price). Since the two best prices (the highest one for the seller and lowest one for the buyer) conflict we then need a mediator to handle the price negotiation process with a neutral position.

Due to the rapid development in information technologies, many e-commerce applications use intelligent agents to perform business activities. An intelligent agent is basically a computer program designed for a certain purpose on behalf of its owner. Artificial intelligence techniques are commonly utilized to implement software agents such as fuzzy expert systems, neural networks, data mining, etc. In this paper, we used a fuzzy expert system to implement our agents for the price negotiation system.

A fuzzy expert system basically uses fuzzy logic to represent the concept of uncertainty. Traditionally, a crisp set uses binary values "0" and "1" to indicate if an element belongs to a set. Contrastively, a fuzzy set uses a matching degree μ (between 0 and 1) to represent the degree of how an element belongs to a fuzzy set. Fuzzification is a process to map a crisp value to a matching degree using a membership function. Mainly, two types of membership functions are often used: trapezoid function and triangular function. A trapezoid membership function is normally defined by four parameters: a, b, c and d, as indicated as follows (Yen & Langari, 1999):

$$Trapezoid \quad (x) = \begin{cases} 0, & x < a, \\ (x-a)/(b-a), & a \leqslant x < b, \\ 1, & b \leqslant x < c, \\ (d-x)/(d-c), & c \leqslant x < d, \\ 0, & x \geqslant d. \end{cases} \tag{1}$$

A triangular function is a special case of a trapezoid function where b is equal to c. Fig. 1 shows an example of fuzzy expression of "the temperature is moderate" using a triangular membership function where a = 18 °C, $b = c$ = 23 °C, and d = 28 °C. In the figure, the matching degree (μ) of the temperature of 20 °C is 0.4.

A traditional auction is conducted in a certain time period and a certain location. An internet auction improves this situation by removing the limitation of location. But it is still necessary to conduct an internet auction in a certain time period. Normally, an internet auction specifies a certain time period (e.g., 5 days for the internet auctions on Yahoo in Taiwan). The final trading price is determined after the certain period ends. The seller and the potential buyers can not get the trading price immediately after they send bids or asks for the internet auction. They have to wait for the final trading price until the time period for this auction ends.

In this paper, based on a fuzzy expert system, we propose a price negotiation mechanism (system) to remove the time limitation of the existing internet auctions using intelligent agents. In the proposed system, the final trading price (negotiated price) is immediately determined right after the buyer sends his bids for the auction.

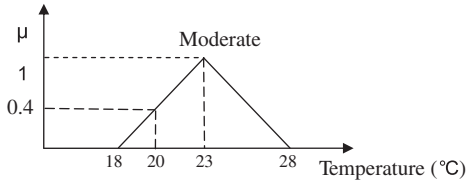

Fig. 1. The triangular membership function of the fuzzy expression of "The temperature is moderate".

Mainly, three agents are used in the study: a seller agent, a buyer agent, and a mediator agent. The seller agent allows a seller to determine his pricing strategies for selling merchandise. Similarly, the buyer agent allows a buyer to determine his pricing strategies for buying merchandise. The mediator agent serves to handle the price negotiation procedure for both sides (seller and buyer) with a neutral position. The price negotiation procedure consists of three rounds. Each round includes a bid for the buyer and an ask for the seller. In each round, the buyer can select his price negotiation strategies expressed by fuzzy rules. Similarly, the seller can determine his price negotiation strategies using fuzzy rules.

We built an on-line auction website based on the proposed system. On the website, sellers can sell their merchandises based on their customized selling strategies. Similarly, buyers can buy the merchandises according to their customized buying strategies. In addition, a mediator was employed to fairly handle the price negotiation process for the sellers and buyers. The proposed system and the website were implemented by Java. Model-View-Controller (MVC) design pattern (Bushmann, Meunier, Rohnert, Sommerlad, & Stal, 1996) was employed in design of the software package used in this study. In addition, we utilized Unified Modeling Language (UML) to describe the structures and behaviors of the software package. Finally, we conducted an evaluation to investigate the satisfaction of using the proposed price negotiation system.

Briefly, the proposed system is featured by: (1) instantly getting negotiated price without waiting; (2) conducting price negotiation at any time; (3) determining strategy rules easily, and (4) using customizable negotiation strategies defined by users.

2. Related works

A software agent is basically a computer program acting as a delegate on behalf of its owner with autonomous and interactive properties (He et al., 2003). Five stages are used in agent-based B2C e-commerce including need identification, product brokering, buyer coalition, merchant brokering, and negotiation (He et al., 2003). In the negotiation stage, the agent engages automated negotiation to get the maximum benefits for its owner. Negotiation strategies are usually determined by negotiation protocols which define the "rules of encounter" (He et al., 2003). The responsibility of an auction agent is to screen the auction progress, gather and analyze market information, and determine the trading timing to get the maximum benefits for its owner (He et al., 2003). Protocols and data exchanging formats define the information communication standards among computers. He et al. (2003) summarized the protocols and data changing formats used in agent-based software. In addition, the platforms, tools, and technologies for developing agent-based computer packages were also discussed in He et al. (2003). Louta, Roussaki, and Pechlivanos (2008) presented an agent-based intelligent negotiation strategy with multi-lateral negotiation model to fast reach agreement among agents. Based on the analyses of negotiation requirements, Lei and Feng (2004) proposed a framework to integrate agents into a negotiation support system providing different negotiation mechanisms and value-added service. Su, Huang, and Hammer (2000) developed a negotiation framework with a constraint satisfaction processor and an event-trigger-rule server. In their framework, the constraint satisfaction processor served to check negotiation conditions, and the event-trigger-rule server allowed users to dynamically create or modify their strategy rules (Su et al., 2000). They also developed a prototyping for supply chain management systems to validate their negotiation mechanism (Su et al., 2000). Lo and Kersten (1999) studied several types of agent-based negotiation mechanisms and depicted a web-based architecture for implementing negotiation support systems. They furthermore discussed the main