Electronic Commerce Research and Applications 13 (2014) 409–422

Contents lists available at ScienceDirect

Electronic Commerce Research and Applications

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

Reputation mechanism for e-commerce in virtual reality environments

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ARTICLE INFO

Article history:
Received 2 September 2013
Received in revised form 2 May 2014
Accepted 5 August 2014
Available online 23 August 2014

Keywords:
Virtual reality environments
Reputation systems
E-marketplaces
Five senses
Subjectivity alignment

ABSTRACT

The interest in 3D technology and virtual reality (VR) is growing both from academia and industry, promoting the quick development of virtual marketplaces (VMs) (*i.e.* e-commerce systems in VR environments). VMs have inherited trust problems, *e.g.* sellers may advertise a perfect deal but doesn't deliver the promised service or product at the end. In view of this, we propose a five-sense feedback oriented reputation mechanism (supported by 3D technology and VR) particularly for VMs. The user study confirms that users prefer VMs with our reputation mechanism over those with traditional ones. In our reputation mechanism, five-sense feedback is objective and buyers can use it directly in their reputation evaluation of target sellers. However, for the scenarios where buyers only provide subjective ratings, we apply the approach of subjectivity alignment for reputation computation (SARC), where ratings provided by one buyer can then be aligned (converted) for another buyer according to the two buyers' subjectivity. Evaluation results indicate that SARC can more accurately model sellers' reputation than the state-of-the-art approaches.

1. Introduction

The Internet has become an inseparable part of our daily life nowadays. According to the Internet World Stats,[1] the number of Internet users worldwide has reached 1.97 billion by the end of September 2010, accounting for almost 30% of the global population. Consequently, people are becoming more willing to shop online other than going to traditional solid shops. Unfortunately, current e-commerce systems only provide users with a simple, browser-based interface to acquire details of products and services. This kind of interfaces has been confirmed to be difficult for customers to use, and thus resulted in the low online shopping revenue (Hoffman et al., 1999; Qiu and Benbast, 2005). One reason is the lack of effective interaction approaches, including communication channels and coordination methods between e-commerce systems and customers. Another more important reason is the limited understanding of social contexts, including social and behavioral issues, among which trust is one of the most important ones. Besides, the design of current e-commerce systems is quite constrained and not appealing.

On another hand, 3D technology is gaining popularity. Forrest report (Drive, 2008) acclaims that "within five years, the 3D Internet will be as important for work as the web is today." A technology guru at Intel Corp also predicts that "the Internet will look significantly different in 5 to 10 years, when much of it will be three dimensional or 3D" (Gaudin, 2010). Meanwhile, applications of virtual reality, such as immersing in 3D virtual communities, watching 3D movies and playing 3D games, are becoming part of ordinary life for people. As one of the important applications of virtual reality, virtual marketplaces (VMs) are referred to as the environments where virtual reality is used by sellers to virtually present their products or service in VR environments, and by buyers to virtually experience products with their five senses, make shopping decisions based on the experience and present the experience with the aid of virtual reality tools. They are proven to be effective in handling the above mentioned problems in traditional e-commerce. Some industrial representatives of virtual marketplaces are IBM's VR-commerce program (Mass and Herzberg, 1999), Second Life (secondlife.com), Active World (activeworlds.com), Twinity (twinity.com) and Virtual Shopping (virtualeshopping.com), etc.

Compared with traditional e-commerce environments, VMs have advanced characteristics such as stereoscopic 3D visualization, real-time interactivity, immersion and multisensory feedback (Stanney et al., 1998; Price et al., 2013), which make them more similar to realistic worlds. However, the same as traditional e-commerce systems, since buyers can only inspect products after purchased, there are also inherited trust problems for VMs. For

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[1] http://www.internetworldstats.com/stats.htm.

http://dx.doi.org/10.1016/j.elerap.2014.08.002
1567-4223/

instance, some sellers may be dishonest (*e.g.*, fail to deliver the products as what they promised), or some sellers may have different competency (*e.g.*, produce only low quality products). As reported by Luca et al. (2010), virtual objects can be created by copying the real products, such as using the 3D scanner to record visual information and using haptic devices to collect tactile information. With the aid of special equipments (*e.g.*, haptic gloves), users can also sense the virtual copies similar to the real objects, and can have the similar perceptions towards the attributes (*e.g.*, softness) of objects as in the real life. Thus, buyers can sense virtual products without time and space limitation compared to shopping markets in reality. However, this property of VMs does not solve the trust problems. For example, some sellers may cheat on the quality of products. They can always provide virtual objects copied from high quality products to attract buyers, but deliver lower quality real products. A few studies on designing reputation mechanisms for VMs (Huang et al., 2008) apply traditional reputation mechanisms where only simple numerical ratings, textual descriptions and 2D pictures are considered. They overlook the difference between traditional and VM environments.

To effectively address the trust issues in VMs, we design a five-sense oriented feedback provision approach (Fang et al., 2011) especially for reputation mechanisms in VM environments. It is mainly built on buyers' feedback about their shopping experience with sellers and their subjective perceptions (*e.g.*, ratings) about products delivered by them. More specifically, in VMs, these kinds of feedback information can come from human users' five senses enriched by virtual reality, namely, *vision*, *sound*, *touch*, *taste* and *smell*. For example, with the assistance of haptic devices (*e.g.*, virtual glove), a buyer can render a virtual teddy bear with its objective *softness* information to represent his purchased real teddy bear, instead of describing it as *very soft* in text, and thus other buyers can percept the virtual teddy bear directly to assist their shopping decision making. We then conduct a detailed user study to compare our mechanism with traditional reputation mechanisms in VMs. The comparison was based on two criterions: "institutional trust" (user's trust in the mechanism) and "interpersonal trust" (user's trust in other users with the existence of reputation mechanisms). We measure the two kinds of trust by the framework of general trust – benevolence, competence, integrity and predictability (McKnight and Chervany, 2001). A questionnaire survey on 40 subjects is conducted. The results confirm that users prefer VMs with our proposed reputation mechanism over traditional reputation mechanisms. Our mechanism can effectively ensure user's trust in the virtual marketplaces system and simultaneously promote user's trust in other users.

In our reputation mechanism, five-sense feedback is objective and buyers can use it directly in their reputation evaluation of target sellers. However, there may be some scenarios that users are reluctant or inconvenient (*e.g.*, the lack of virtual reality devices) to provide the detailed five-sense feedback, but to provide a rating (or a rating for each of the five senses) about their past experience. The ratings concluded from human users' five senses may involve users' own subjectivity. Subjectivity difference may come from two sources if we analyze the scenario of a buyer providing a rating from both psychological and behavioral perspectives:

Intra-attribute subjectivity: When the buyer evaluates her satisfaction level with a transaction, she considers each attribute related to that transaction. Although the information about each attribute is *objective*, the evaluation (*i.e.*, satisfactory level) of the attribute value may be subjective and change from user to user. This is referred to as *intra-attribute subjectivity* in this paper. For example, a product may be *inadequately soft* for buyer *a*, while *adequately soft* for buyer *b*.

Extra-attribute subjectivity: When the buyer assigns a satisfaction level to a transaction, she may consider some attributes of the transaction more heavily than others. This is referred to as *extra-attribute subjectivity*. For example, a buyer with better economic conditions may consider a product's *quality* more heavily, while another buyer with worse economic conditions may concern more about the *price* of the product.

The definitions and differences of these two kinds of subjectivity can be summarized as follows: (1) intra-attribute subjectivity: users' subjectivity in evaluating the same attribute; (2) extra-attribute subjectivity: users' subjectivity in evaluating different attributes. These two aspects together contribute to the subjectivity difference among buyers. Due to the subjectivity difference, it may not be effective if a buyer directly takes other buyers' subjective ratings towards a seller and aggregates the ratings to compute the reputation of the seller. Otherwise, the computed reputation values may then mislead the buyer in selecting business partners.

To effectively address the subjectivity difference problem, we propose a subjectivity alignment approach for reputation computation (SARC) (Fang et al., 2012). In our approach, each buyer is equipped with an intelligent (buying) agent and virtual reality simulators. At the beginning of her interactions with the reputation system, a buyer *a* is required to provide her buying agent with both a single rating and a detailed review[2] containing values of the objective attributes of transactions with sellers, such as *price* and *softness*,[3] for each of a few transactions. Based on these rating-review pairs, the buying agent applies a proposed Bayesian learning approach to model the correlations between buyer *a*'s each rating level and the value of each objective attribute involved in the transactions. The learned correlation function, which represents buyer *a*'s *intra-attribute subjectivity*, will then be shared with the agents of other buyers. The agent of buyer *a* also applies a regression analysis model to learn the weight of each attribute for buyer *a*, representing her *extra-attribute subjectivity*. This information will not be shared with other buyers. After the learning phase, buyer *a* only needs to provide ratings for her interactions with sellers, not detailed reviews. When another buyer *b* just shares a new rating (without detailed reviews) of her transaction with a seller (buyer *b* is acted as an advisor in our context), the agent of buyer *a* will first retrieve a rating level for each attribute of the transaction based on the shared rating and the *intra-attribute subjectivity* of buyer *b* shared by the agent of *b*. The rating levels of the attributes will then be aggregated according to buyer *a*'s *extra-attribute subjectivity* learned by the agent of *a*. In this way, the rating shared by buyer *b* is aligned to that can be used by buyer *a* for computing the reputation of the seller. To evaluate the performance of our SARC approach, we simulate a virtual marketplace environment involving a number of buyers with different subjectivity in evaluating products and a set of sellers selling products with different attribute values. Experimental results confirm that our SARC approach provides sufficiently good performance in a general setting. It can more accurately and stably model sellers' reputation than the representative competing approaches of BLADE (Regan et al., 2006) and TRAVOS (Teacy et al., 2006).

The rest of this paper is organized as follows. In Section 2, we summarize the related research in the literature. In Section 3, we elaborate our proposed reputation mechanism for VMs in details, and present the user study of comparing our mechanism with traditional reputation mechanisms in VMs environments. In Section 4, we address the subjectivity difference problem for virtual marketplaces and propose our SARC algorithm. Finally, we conclude our work in Section 5.

[2] The review can consist of both textual information and rendered virtual objects with corresponding five-senses information.

[3] Value of objective attributes related to touch, smell or taste sensory like softness are provided by virtual reality simulators automatically in the form of virtual stimuli.