Design of a Reputation Mechanism for Virtual Reality: A case for E-Commerce

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Abstract. The interest in 3D technology is growing both from academia and industry, promoting the quick development of 3D e-commerce (i.e. e-commerce systems in 3D virtual environments). In view of this, we propose a reputation mechanism particularly for 3D e-commerce. Supported by 3D technology and virtual reality, it consists of four major components: feedback provision based on human users' five senses, reputation computation based on feedback, 3D representation of computed reputation, and automatic decision making based on reputation. A user study is conducted to evaluate the necessity and value of our proposed reputation mechanism, confirming that users prefer 3D e-commerce with our proposed reputation mechanism over that with traditional reputation mechanisms. And, our proposed reputation mechanism can effectively ensure user's trust in the e-commerce system and simultaneously greatly promote user's trust in other users.

Categories: Models and mechanisms of reputation, Application studies

Keywords: Reputation Mechanism, Virtual Reality, Five Senses, Stereotype Trust, Feedback Alignment, User Study

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 percent 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 [1]. 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,

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

among which trust is one of the most important issues. Besides, the design of current e-commerce systems is quite constrained and not appealing.

On another hand, 3D technology is gaining popularity. Forrest report [2] 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" [3]. 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. 3D e-commerce, which is e-commerce systems in 3D virtual environments, has also attained growing interests both from academia and industry. It is one of the approaches proven to be effective in handling the problems in traditional e-commerce. As shown in Figure 1[1], the research gap between e-commerce and 3D technology or virtual reality is becoming smaller year by year. This partly explains the increasing research trend of 3D mall. Some industrial representatives of 3D e-commerce are IBM's VR-commerce program [4], Google lively project (http://www.lively.com), Second Life (http://secondlife.com), Active World (http://www.activeworlds.com), Twinity (http://www.twinity.com) and Virtual Shopping (http://virtualeshopping.com), etc.

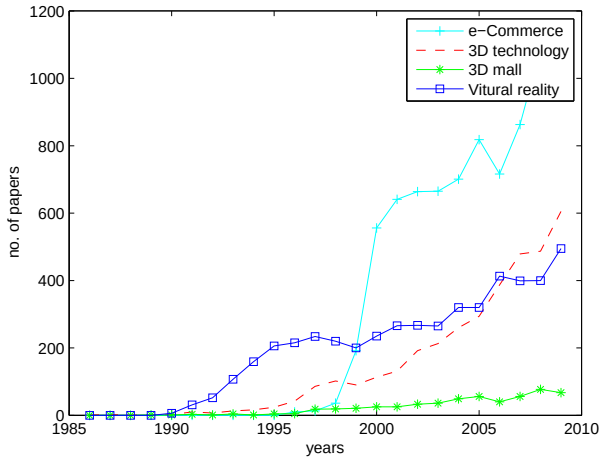

Fig. 1. Research Trend of E-Commerce, 3D Technology, Virtual Reality and 3D Mall

However, the same as traditional e-commerce systems, there are also inherited trust problems for 3D e-commerce. For one thing, some users may be dishonest. For example, sellers may not deliver the products as what they promised. For another thing, users may have different competency. For example, some sellers may produce only low quality products. Although there is the growing research interest towards 3D e-commerce, much research has been focused on either virtual reality technology adoption for e-commerce or behavioral science studies to confirm that 3D e-commerce environments like Active World can promote consumers' trust towards online shopping, without serious and quantitative consideration on how to construct effective trust and reputation

[1] Data was collected from the Web of Science on March 5, 2011

mechanisms in 3D e-commerce environments. For a few studies on designing reputation mechanisms for 3D e-commerce [5], they apply traditional reputation mechanisms where only simple numerical ratings, textual descriptions and 2D pictures are considered, overlooking the difference between 2D and 3D e-commerce environments.

To effectively address the trust issue in 3D e-commerce, we design a reputation mechanism specifically for 3D e-commerce environments. It is mainly built on buyers' feedbacks about their shopping experience with sellers and their subjective perceptions about products delivered by sellers. More specifically, in 3D environments, these kinds of feedback information can come from human users' five senses (vision, hearing, touch, smell and taste) enriched by virtual reality. We systematically study the four major steps of constructing the mechanism, namely feedback provision, reputation computation, reputation representation and decision making, by incorporating novel elements related to 3D e-commerce. We also conduct a detailed user study to compare our mechanism with traditional reputation mechanisms in 3D e-commerce environments. The results confirm that users prefer 3D e-commerce with our proposed reputation mechanism over that with traditional reputation mechanisms. Our mechanism can effectively ensure user's trust in the 3D e-commerce system and simultaneously greatly promote user's trust in other users. Our work thus represents a valuable first step of designing an effective reputation mechanism for promoting user participation in 3D e-commerce.

The rest of this paper is organized as follows. Section 2 provides an overview of related research on 3D e-commerce and reputation mechanisms. Section 3 illustrates our reputation mechanism for 3D e-commerce. The user study of comparing our mechanism with traditional reputation mechanisms in 3D environments is presented in Section 4. Finally, we conclude the current work and propose future work in Section 5.

2 Related Work

There are mainly two research directions on 3D e-commerce. The first direction concerns about adopting 3D technology and virtual reality into e-commerce, that is the construction of 3D e-commerce. This is also currently the major research towards 3D e-commerce. For example, Bogdanovych et al. [6] propose a mechanism called 3D E-Commerce Electronic Institutions and try to increase user's trust on e-commerce systems. The second direction mainly concerns about validating the effectiveness of 3D e-commerce in addressing the problems of traditional e-commerce. For example, Papadopoulou [7] demonstrates that a virtual reality shopping environment enables the formation of trust over conventional web stores, through a survey study based on a prototype virtual shopping mall. Nassiri [8] also explains the roles of 3D e-commerce environments in increasing user's trust and in improving profitability by the mechanisms such as Avatar appearance and Haptic tools. The research conducted by Teoh and Cyril [9] mainly focuses on the trust of 3D mall. They point out that presence and para-social presence assisted by virtual reality can affect trust, and users perceive the features of a 3D immersive online e-commerce store as being useful and practical but not a mere novelty. The weakness of the research mentioned above is that they focus only on enhancing trust through virtual reality. They do not consider how to improve

trust in 3D e-commerce by designing effective trust and reputation mechanisms. This is the focus of our current work.

In recent years, a lot of research have been carried out on reputation mechanisms in traditional 2D e-commerce, and have achieved a huge success, while one of well known reputation systems is run by eBay (www.ebay.com). EBay's reputation system, also as one of the earliest online reputation systems, gathers feedbacks from buyers of each transaction in the simple form of numerical ratings together with a short text description. There are other successful commercial and live reputation systems [10], such as expert sites like Askme (www.askmecorp.com), products review sites like Epinions (www.epinions.com), and scientometrics related sites. However, there are only a few studies on designing reputation mechanisms specifically for 3D environments. Huang et al. [5] propose a reputation mechanism based on peer-rated reputations for 3D P2P game environments where the reputation of each user is computed based on other users' subjective opinions during their interactions, which is similar to eBay's reputation mechanism. It earned some advantages on reputation evaluation, storage, query and reliability, but no simulation has been conducted to validate its advantages. Its major weakness lies in the fact that there is no consideration of differences between 3D environments and 2D environments. In contrast, our reputation management makes good use of virtual reality to allow the provision of feedback information from human user's five senses. The other components of our reputation mechanism also follow such a design principle of fully utilizing the important features offered by virtual reality.

3 Reputation Mechanism for 3D E-Commerce

As mentioned in the previous section, current research focuses mainly on virtual reality technology adoption. Limited research on reputation mechanisms for 3D e-commerce however overlooks the differences between 2D environments and 3D environments. For a traditional reputation mechanism, buyer feedback often consists of only a positive, negative, or neutral rating, along with a short textual comment. Reputation of sellers is computed based on the ratings and perhaps those comments left by buyers, and is often in a form of a continuous numerical value. The computed reputation values will be used to make decisions for buyers on which sellers to do business with in the future.

Our reputation mechanism is specifically designed for 3D e-commerce environments. It is composed of four components: feedback provision, reputation computation, reputation representation and decision making. These components are supported by virtual reality and 3D technology, details of which will be explained in the subsequent subsections.

3.1 Feedback Provision

Feedback provision, as the key component of our reputation mechanism, tries to solve two major problems: what kind of user feedbacks to collect and how to collect feedbacks in 3D e-commerce environments. There are five senses - vision, hearing, touch, smell and taste, which express the *subjective perceptions* of human being. People have

the ability to sense the environment and objects with these five senses, and further provide themselves better understanding of the environment. 3D e-commerce is a virtual environment generated by computer and other tools, such as head-mounted displays, headphones, and motion-sensing gloves, to enable users to feel realism through interaction that simulates five human senses. In traditional e-commerce mechanisms, only vision is regularly incorporated in simple forms like 2D pictures and textual descriptions. As human users' perception of an environment is influenced by all the sensory inputs, in order to accurately and completely express user's experience, all the five senses should be well expressed. With the development of virtual reality and augmented reality, the perception of human users not only can be realistically simulated, but also can be expanded by using instruments like 3D Glasses.

Five Senses: Vision is the ability to interpret information of what is seen from the environment, and can be expressed in the form of 3D pictures and videos in virtual reality. Therefore, in 3D e-commerce, buyers can present the real product they purchased in the form of 3D picture or animation with less distortion. Users can view the 3D object from various angles, which is more persuasive and vivid than simple 2D pictures or textual descriptions. **Hearing** is the ability to perceive sound from the environment, and can be simulated by auditory displays. Same as vision, there have been numerous works on auditory research. In 3D e-commerce, some characteristics such as tone quality of digital products are more appropriate to be presented in the form of audio. Audio is able to contain plentiful information at a time, and relatively favored and easily accepted by human users. In this sense, it is necessary to collect this kind of information. **Touch** is one of the sensations processed by the somatosensory system, and has been known in the physical world to increase initial trust. As a major part of research in virtual reality, it focuses on scanning the behaviors of objects in the physical world and incorporating similar behavior into virtual objects [11]. We have previously done some research on touching textile [12]. Touch perception can be simulated using instruments like Haptic device. Virtual touch can be supported in 3D e-commerce so that buyers can measure the characteristics of different materials and attach touch information to reputation feedback as guidance for other buyers. **Taste** refers to the ability to detect the flavor of substances such as food and minerals. Humans receive tastes through sensory organs called taste buds. The sensation of taste traditionally consists of some basic tastes such as sweetness, bitterness, sourness and saltiness. Taste can also be implemented in virtual environments. Iwata et al. [13] design a food simulator to simulate the multi-modal taste of food through a combination of chemical, auditory, olfactory and haptic sensation. Through this simulator, buyers can provide experience about the taste of products they purchase online. **Smell** refers to the ability to perceive odors. In 3D environments, devices like the olfactory display can be applied to generate various odors and deliver them to user's nose. For the purpose of presenting odors with a vivid sense of reality, the olfactory display, which has already been applied to 3D games and movies, is expected to generate realistic smells relevant to specific environments or scenes [14]. In 3D e-commerce, they can be realistic smells related to specific products such as fresh smell of fruits. Buyers can then sense a product's real smell through other buyers' feedbacks instead of textual descriptions about smells.

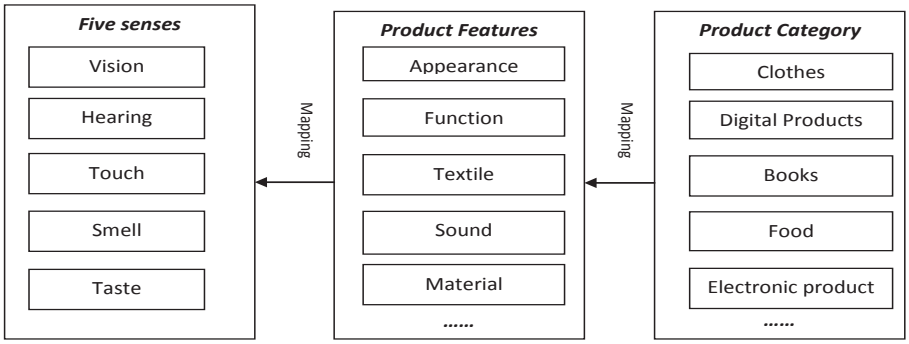

Fig. 2. Feedback Provision based on an Five-Sense Oriented Approach

Five-Sense Oriented Feedback Provision: As illustrated above, while concerning about buyers' historical experience with one seller, feedbacks can be expressed as human perceptions about the products and transaction experience. These subjective perceptions can be simulated by virtual reality. Therefore, towards 3D e-commerce environments, we propose a five-sense orientated approach to implement feedback provision as part of our reputation mechanism. The detail of the approach is illustrated in Figure 2. Consider a 3D e-commerce community providing products of different categories. According to the five-sense orientated approach, a product may belong to some specific product categories such as "Clothes" or "Books". Products in the same category have some common product features, such as "Appearance" and "Textile". Each product feature can be presented by some of the five senses - vision, hearing, touch, smell and taste simulated by virtual reality as mentioned earlier. Thus, given a product, the necessary senses will be simulated in feedback. For example, a user has purchased a sweater from a seller in a 3D e-commerce system. For feedback provision, the buyer can provide a 3D avatar model to express the appearance of the sweater sold by the seller. Besides, the touch feedback can also be simulated to show the textile and material used to make this sweater. Such information shared among buyers can be compared with the 3D avatar model of the product provided by the seller to compute reputation of the seller.

3.2 Trust/Reputation Computation

Here, we assume that each buyer (i.e., its agent) can produce a feedback for the product delivered by a seller. This feedback is based on the five senses of the consumers and represented using an *ontology* [15, 16] that contains a rich set of concepts, properties and individuals to represent the perceptions of the buyers. This representation allows decidable reasoning over the feedbacks using off-the-self ontology reasoners [17]. The seller has a description of the product in the virtual reality setting. Hence, a consumer receiving this description can use his five senses to evaluate the product via the simulated reality (e.g., using olfactory display). However, the actual product delivered by the seller may be different than the described product. In most of the existing models, to evaluate the trustworthiness of sellers, consumers use the information about their past

transactions with these sellers. However, a consumer may not have enough number of historical information about many of the sellers. This disallows him to evaluate a seller based on his direct interactions. In such situations, we may evaluate the trustworthiness of sellers based on the available information such as personal features of sellers (e.g., location) or information from other consumers (i.e., their feedbacks).

Exploiting Features of Sellers To estimate trustworthiness of sellers, we can use a stereotype-based trust model [18] based on a rich set of seller features in virtual environments. That is, using the personal interactions with previously encountered sellers, the buyer can derive some rules that allow him to characterize other sellers with specific features as less or more trustworthy. Existing stereotypical trust models learn rules using the features of the sellers and their products. For instance, in [18], these rules are learned using regression trees. Each rule maps sellers with specific features onto a trust value in the range [0,1]. However, [18] assumes only numerical features, while many of the features in real-life settings are nominal (i.e., categorical). The reason behind this assumption is the fact that decision or regression trees cannot make generalization or induction over nominal values. To address this issue, we can extend C4.5 decision trees [19] by exploiting domain knowledge during tree induction. That is, nominal values of attributes are generalized using taxonomy of attribute values, which can easily be derived from domain ontologies.

Figure 3 shows an example decision tree built based on a buyer's interaction history with sellers and the feedback from other buyers, using C4.5 algorithm with domain knowledge. From this decision tree, the buyer creates stereotypes such as 'seller from Europe cannot provide products with raw taste, but they may provide products with barbecue smell'. Hence, for a seller who sends a description of a product with a raw taste, the buyer may not trust the seller. As the buyer experiences more about sellers and receives new feedbacks, he updates his stereotypes based on the new information by building new decision trees.

Note that, personal interactions with sellers are very costly; hence we assume that buyers have little direct information with the sellers. However, once the buyer interacts with a specific seller, he can build a fine grained trust evaluation of the seller based on these personal interactions. On the other hand, in the absence of personal interactions or feedbacks about a specific seller, stereotypes help the buyer to evaluate the seller. In other words, stereotypes are used to bootstrap trust towards a specific seller, but then the trustworthiness of the seller is computed using other methods based on feedback about and direct interactions with this specific seller. For instance, subjective logic [20] and the Bayesian network-based trust model [21] can be used to compute the trustworthiness based on the evidence about the seller.

Exploiting User Feedbacks Existing e-commerce systems like e-bay[1] allow consumers provide feedbacks in the form of ratings and reviews. The ratings are aggregated by the system to compute reputation of the sellers. Then, the reputation of sellers guides consumers while deciding on a specific seller among alternative. We believe that similar ideas can also be used in virtual reality environments. That is, to be sure that a specific

[1] http://www/ebay.com

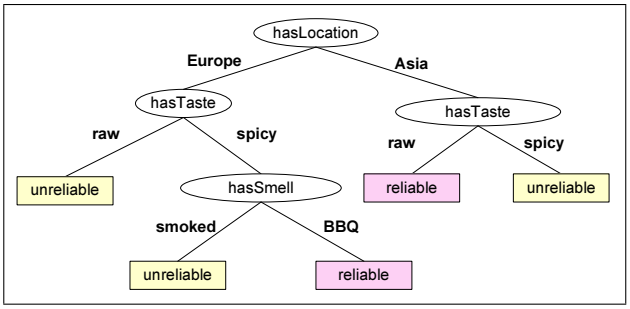

Fig. 3. A Decision Tree Example to Derive Simple Stereotypes

seller will provide the described product, the buyer may collect feedbacks of other buyers about the *same* seller. However, these feedbacks should be more expressive than ratings; they should contain context, sensory information provided by the seller before the transaction, and *subjective* evaluation of the actual product by the buyer. The provided sensory information, context and evaluation of the product can be mined using pattern recognition techniques [22] to learn critical information about the correlations of the advertised product features and the actual ones. The learned correlations can be exploited to reason about the reliability of sellers, given the sensory information they provide for a specific product. Here, an important problem is the subjectivity of the evaluations in users' feedbacks. Evaluations based on five senses such as tactile sensations are subjective. This means that a product evaluated as *too soft* by a user can be evaluated as *adequately soft* by another consumer. This brings the necessity of aligning subjective evaluations in feedbacks.

3.3 3D Visualization for Reputation Representation

Visualization is used to present reputation results of users. Traditional reputation mechanisms use visualization of 2D objects such as a simple rating score or characteristics descriptions in the form of text or 2D pictures, which is far from being effective and provides only limited information. We apply a 3D visualization approach, aiming at presenting a rich set of reputation related information in an appealing and natural way. In this way, users will be assisted to make more informed decisions and their trust in the reputation mechanism will be increased. 3D visualization to present reputation should follow some general principles and visualization requirement [23]. First, it should support users to achieve self-efficacy. Each user has an attractive reputation model, which can be built and enhanced further with the growing reputation. The growing process should be dynamic and be expressed in real time with the assistance of the time dimension. Secondly, the reputation of users should be easily recognized that there is a common criteria for reputation comparison. Thirdly, the visualization should support micro and macro reading. It refers to that user's overall reputation value can be easily identified. The details of user's reputation, such as reputation of specific product category or characteristics, should be displayed clearly.

3.4 Decision Making

Since a large number of sellers provide many similar products, it may take a lot of time for buyers to browse and search for the most suitable sellers. Our reputation mechanism will provide recommendations to buyers according to the computed reputation of sellers as well as buyers' preferences. For example, some risk-taking buyers may prefer low price of products and be willing to accept doing business with relatively low reputation of sellers. Some other buyers may care more about sellers' reputation.

4 User Study

In this section, we present a user study on comparing our proposed reputation mechanism with traditional reputation mechanisms in the same environment of 3D e-commerce. Since reputation computation and decision making are invisible to users, our study is concentrated on the feedback provision and reputation representation components.

4.1 Design of the Study

The comparison was based on two criterions. One is called "institutional trust" referring to user's trust in the mechanism, while the other is called "interpersonal trust" referring to 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 [24]. Based on this guidance, a questionnaire survey is conducted. Figure 4 presents the overall structure of the questionnaire.

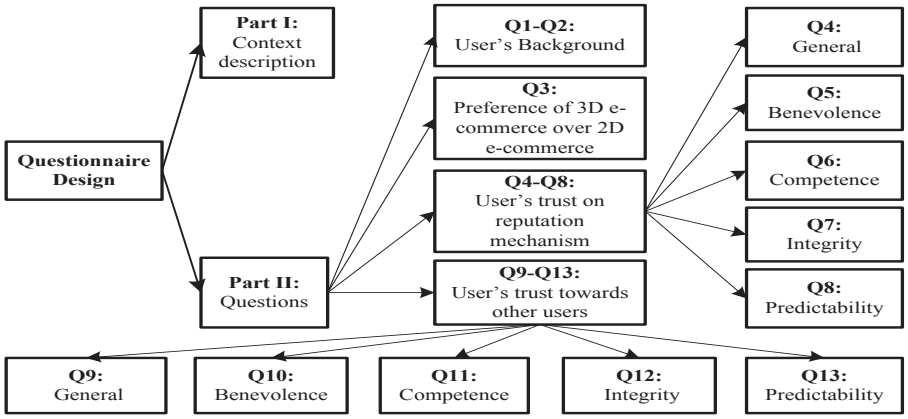

Fig. 4. Questionnaire Design for Data Collection

The questionnaire is divided into two main parts: context description part, which provides users the detailed description of our reputation mechanism and traditional reputation mechanism within 3D e-commerce environments; and questions part, consisting of 13 questions in total. In the context description, participants are presented with a set of images about what they will experience in the 3D e-commerce environment with our proposed reputation mechanism and that with the traditional reputation mechanisms. Besides, one researcher is responsible for the Q&A part in the process of questionnaire

filling. Regarding the questions, Q1 and Q2 ask for the information of participant's background, including gender, age, nationality, current residency and online shopping background; Q3 aims to study user's preferences on 3D e-commerce versus 2D e-commerce; Q4-Q8 focus on studying user's trust on reputation mechanisms, referring to general trust, benevolence, competence, integrity and predictability of reputation mechanism respectively. Some examples are "Do you agree that compared with traditional reputation mechanisms, the proposed reputation mechanism provides you with more confidence in believing that 3D e-commerce is well-organized and the stores are benevolent to their customers?" and "Do you agree that the proposed reputation mechanism performs better in reducing fraud behaviors than traditional reputation mechanisms?"; Q9-Q13 try to explore user's trust in other users with the reputation mechanisms, and the structure is similar to Q4-Q8. The answers for each question can be chosen from the following five levels: "5-Totally agree", "4-Partially agree", "3-Neither Agree nor Disagree", "2-Partially disagree" and "1-Totally disagree".

A total of 40 subjects with the average age of 24 years old participated in the study. They were selected based on the stratified random sampling methods with respect to their gender and current residency. 21 of them are males. 21 of them are currently living in Asia, and 19 of them in America. Besides, all of them are experienced Internet users, but only 14 of them are within technology background, while 26 of them with the background of social science, management or related. 38 of them have purchased products online at least once a year, while 30 of them at least twice a year. The e-commerce systems they went shopping most often are Taobao (www.taobao.com), Amazon and eBay. One point should be emphasized here is that since the 3D E-Commerce per se is quite revolutionary, this study mainly focuses on the young generation mostly within the age of 22 years old to 26 years old, who are believed to be the major participants of 3D e-Commerce. The basic statistical information about the participants is summarized in Table 1 and 2. In addition, 26 (65%) of participants preferred 3D e-commerce over 2D e-commerce, while only 5 of them are willing to stay at 2D e-commerce sites, and 9 of them hold neutral attitude towards the preference of 3D e-commerce and 2D e-commerce.

Table 1. Statistical Information about the Participants I

	Gender		Nationality		Current Residency		Often Shopping Site		
	Male	Female	Asian	American	Asia	America	Taobao	Amazon+eBay	Others
Counts	19	21	24	16	21	19	16	17	7
Percents	47.5%	52.5%	60%	40%	52.5%	47.5%	40%	42.5%	17.5%

Table 2. Statistical Information about the Participants II

	Technology Background		Age Diversity					Attitude of 3D E-Commerce		
	Yes	No	18-21	22-23	24	25-26	27	Positive	Neutral	Negative
Counts	14	26	3	14	11	11	1	26	9	5
Percents	35%	65%	7.5%	35%	27.5%	26.5%	2.5%	65%	22.5%	12.5%

4.2 Data Analysis and Discussion

According to the trust framework of McKnight and Chervany [24], a good reputation mechanism promoting high trust of users should also assure users' beliefs such as benevolence, competence, integrity and predictability towards the reputation mechanism. Accordingly, a high degree of one perspective of the trust framework should also indicate a high degree of other perspectives. Based on these criterion and the collected data, we compute the pairwise correlation between trust and its four perspectives - benevolence, competence, integrity and predictability. Firstly, trust value of each participant is computed as the average value of Q4 and Q9. In the similar way, benevolence, competence, integrity and predictability values of each participant are computed according to participants' answers to Q5 and Q10, Q6 and Q11, Q7 and Q12, and Q8 and Q13 respectively. Each value is referred to participant's preference of our proposed reputation mechanism over traditional mechanisms. Then, the correlation analysis among each factor is conducted (See Table 3). By viewing the coefficient values, we find that trust is relatively highly correlated with each perspective (coefficients are all around 0.7000), especially for the correlation between trust and predictability (0.7449), indicating that people believe that 3D e-commerce with our proposed reputation mechanism would be competitive in the e-commerce market compared with that with the traditional reputation mechanisms. Additionally, the four perspectives are also relatively highly correlated with each other, which confirms that the trust framework in [24] can be applied to reputation mechanisms in 3D e-commerce.

In order to comprehensively compare our proposed reputation mechanism with traditional reputation mechanisms, we explore these 40 participants' evaluation towards the four perspectives of trust typology with respect to both their trust in the reputation mechanism (Institutional trust) and their trust in other users (Interpersonal trust). For Q4-Q13, the answers of "Totally Agree" or "Partially Agree" is treated as positive evaluation of our proposed reputation mechanism, "Neither Agree nor Disagree" as neutral evaluation, and "Partially Disagree" or "Totally Disagree" as negative evaluation. Table 4 presents the participants' specific evaluations (positive, neutral or negative) of each perspective concerned with each kind of trust regarding our reputation mechanism compared to those of conventional reputation mechanisms.

Table 3. Correlation between Trust related Variables

Variables	**Trust**	**Benevolence**	**Competence**	**Integrity**	**Predictability**
Trust	1.0000				
Benevolence	0.6970	1.0000			
Competence	0.6950	0.5939	1.0000		
Integrity	0.6985	0.7279	0.6241	1.0000	
Predictability	0.7449	0.7494	0.6441	0.6197	1.0000

User's Trust in the Mechanism According to the results in Table 4, to sum up, most (72.5%) of the participants showed stronger (institutional) trust in 3D e-commerce with our reputation mechanism than that with the traditional reputation mechanisms. In most

of the participants' belief, our proposed reputation mechanism performs better in reducing fraud behavior (competence), provides them more confidence to believe in the 3D e-commerce (benevolence), and 3D e-commerce with our proposed reputation mechanism has greater possibility to achieve success (predictability) in the fierce competition.

Table 4. User Evaluation of our Reputation Mechanism over Traditional Reputation Mechanisms

Dimension		Positive		Neutral		Negative	
		Counts	Percents	Counts	Percents	Counts	Percents
User's trust in the mechanism	General	29	**72.5**%	3	7.5%	8	20%
	Benevolence	24	**60**%	8	20%	8	20%
	Competence	27	**67.5**%	10	25%	3	7.5%
	Integrity	17	**42.5**%	11	27.5%	12	30%
	Predictability	23	**57.5**%	8	20%	9	22.5%
User's trust in other users	General	23	**57.5**%	8	20%	9	22.5%
	Benevolence	20	**50**%	7	17.5%	13	32.5%
	Competence	25	**62.5**%	6	15%	9	22.5%
	Integrity	16	**40**%	12	30%	12	30%
	Predictability	27	**67.5**%	8	20%	5	12.5%

User's Trust in Other Users For the interpersonal trust, compared to traditional reputation mechanisms, users mostly hold a positive attitude towards our reputation mechanism. They are more confident that other users in our reputation mechanism are more trustworthiness (57.5%), while sellers would not only care more about buyers (50%) and more likely meet the quality requirement of the products as expected (62.5%), but also be more consistent with their behavior (67.5%) over time.

What should be noted is the integrity perspective both for institutional trust and interpersonal trust. Integrity refers to that sellers always provide high quality products and buyers always give truthful feedbacks. The integrity values of this study, although still positive, are relatively smaller (42.5% and 40%) compared to others, partly indicating that users worry about online shopping. Through interviewing the participants who expressed negative or neutral attitude towards our reputation mechanism, we found that they were just reluctant to use 3D e-commerce based on the technology limitations, but had less concern about reputation mechanisms.

Cultural Differences In addition, based on the user evaluation, the cultural differences between subjects living in Asia (mostly living in Singapore) and subjects living in America was also evaluated and the result was shown in Table 5. It demonstrates that, on the whole, both of them prefer our proposed reputation mechanism over traditional reputation mechanism, regarding the positive percents and negative percents. However, it should also be noticed that People living in Asia generally hold much more confident of our proposed reputation mechanism than people living in America. This can be explained that virtual reality has been greatly developed in Singapore and has many

Table 5. Comparison of People's Attitude towards our Reputation Mechanism over Traditional Reputation Mechanisms in Asia and America

Dimension		Positive		Neutral		Negative	
		Asia	America	Asia	America	Asia	America
User's trust in the mechanism	General	90.4%	52.6%	0%	15.8%	9.5%	31.6%
	Benevolence	76.2%	42.1%	14.3%	26.3%	9.5%	31.6%
	Competence	76.2%	57.9%	14.3%	36.8%	9.5%	5.3%
	Integrity	61.2%	**21.1**%	19%	36.8%	19%	**42.1**%
	Predictability	57.1%	57.9%	23.8%	15.8%	19%	26.3%
User's trust in other users	General	66.7%	47.4%	23.8%	15.8%	9.5%	36.8%
	Benevolence	57.1%	42.1%	19%	15.8%	23.8%	42.1%
	Competence	76.2%	47.4%	14.3%	15.8%	14.35%	31.6%
	Integrity	42.8%	36.8%	33.3%	26.3%	23.8%	36.8%
	Predictability	85.7%	47.4%	9.5%	31.6%	4.8%	21.1%

realistic applications, such as Virtual Singapore[1] and 3D Virtual World for 2010 Youth Olympic Games[2], while for America, it already has profound and mature development of traditional e-commerce websites, such as Ebay and Amazon, and the applications of 3D virtual world is relatively weak compared to those in European and some Asian countries. More cultures diversity, especially the attitude of people living in European, should be included in the further research.

5 Conclusion and Future Work

This paper proposes a reputation mechanism for 3D e-commerce by systematically studying the four steps of constructing reputation mechanisms, namely, feedback provision, reputation computation, reputation representation and decision making. We incorporate novel elements of 3D technology and virtual reality into these main steps. For feedback provision, a five-sense orientated approach is applied to provide buyers' feedbacks of products they have purchased in the form of five human senses simulated by virtual reality. For reputation computation, a multi-dimensional trust model and a stereotype-based approach may be applied to compute the reputation of sellers. 3D visualization is used to present computed reputation values. The proposed reputation mechanism can also effectively help users make purchase decisions. A user study is conducted to compare our mechanism with traditional reputation mechanisms in 3D e-commerce environments. The questionnaire survey with a stratified sampling method mainly focuses on user's trust in the mechanism (institutional trust) and user's trust in other users (interpersonal trust) respectively based on the four perspectives of trust typology - benevolence, competence, integrity and predictability. The findings illustrate that: (a) users prefer shopping in 3D e-commerce with our proposed reputation mechanism over that with traditional reputation mechanisms; (b) compared with traditional

[1] http://www.singaporevr.com/

[2] http://www.singapore2010odyssey.sg/

reputation mechanisms, our reputation mechanism can not only effectively ensure user's trust in the mechanism, but also greatly promote user's trust in other users.

Our current work represents an important initial step for confirming the necessity and value of our proposed reputation mechanism. For future work, we will first develop a concrete reputation computation method for our reputation mechanism and implement a 3D visualization scheme for reputation representation. A prototype of our reputation mechanism will be built to further study user's responses to 3D e-commerce with our proposed reputation mechanism, and more comprehensive user study, considering age diversity, shopping background and cultural differences, will be conducted.

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References

1. Hoffman, D.L., Novak, T.P., Peralta, M.: Building consumer trust online. Communications of the ACM **42** (1999) 80–85
2. Drive, E.e.a.: Getting real work done in virtual worlds. Forrest Research (2008) http://www.forrester.com/rb/Research/getting_real_work_done_in_virtual_worlds/q/id/43450/t/2.
3. Gaudin, S.: Intel guru says 3-d internet will arrive within five years. Computer World (2010) http://www.computerworld.com/s/article/9175048/Intel_guru_says_3_D_Internet_will_arrive_within_five_years.
4. Mass, Y., Herzberg, A.: Vrcommerce- electronic commerce in virtual reality. In: Proceedings of the 1st ACM Conference on Electronic Commerce. (1999) 103–109
5. Huang, G.Y., Y., H.S., R., J.J.: Scalable reputation management for p2p mmogs. In: Proceedings of the International Workshop on Massively Multiusers Virtual Environment. (2008)
6. Bogdanovych, A., Berger, H., Simoff, S., Sierra, C.: Narrowing the gap between humans and agents in e-commerce: 3d electronic institutions. In: Proceedings of the 6th International Conference on Electronic Commerce and Web Technologies (EC-Web). (2005) 128–137
7. Papadopoulou, P.: Applying virtual reality for trust building e-commerce environment. Virtual Reality **11** (2007) 107–127
8. Nassiri, N.: Increasing trust through the use of 3d e-commerce environment. In: Proceedings of the ACM symposium on Applied computing. (2008) 1463–1466
9. Teoh, K. K.and Cyril, E.U.: The role of presence and para social presence on trust in online virtual electronic commerce. Journal of Applied Sciences **16** (2008) 2834–2842
10. Josang, A., Ismail, R., Boyd, C.: A survey of trust and reputation systems for online service provision. Decision Support Systems **43** (2007) 618–644
11. Pai, D.K.e.a.: Scanning physical interaction behavior of 3d objects. In: Proceedings of the 28th Annual Conference on computer graphics and interactive techniques. (2001)
12. Magnenat-Thalmann, N., Volino, P., Bonanni, U., Summers, I.R., asco, M.B., Salsedo, F., Wolter, F.E.: From physics-based simulation to the touching of textiles: the haptex project. The International Journal of Virtual Reality **6** (2007) 35–44
13. Iwata, H., Yano., T., Uemura, T., Moriya, T.: Food simulator: A haptic interface for biting. In: Proceedings of Virtual Reality (VR). (2004) 51–57

14. Brkic, B.R., Chalmers, A.: Virtual smell: Authentic smell diffusion in virtual environments. In: Proceedings of the 7th International Conference on Computer Graphics, Virtual Reality and Interaction in Africa. (2010) 45–52
15. W3C OWL Working Group: OWL 2 Web ontology language document overview (2009) http://www.w3.org/TR/owl2-overview.
16. Kern, S.: Olfactory Ontology and Scented Harmonies: on the History of Smell. The Journal of Popular Culture **7** (1974) 816–824
17. Sirin, E., Parsia, B., Grau, B.C., Kalyanpur, A., Katz, Y.: Pellet: A practical OWL-DL reasoner. Web Semant. **5** (2007) 51–53
18. Burnett, C., Norman, T.J., Sycara, K.: Bootstrapping trust evaluations through stereotypes. In: Proceedings of the Eighth International Conference on Autonomous Agents and Multiagent Systems. (2007)
19. Quinlan, J.R.: C4.5: programs for machine learning. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA (1993)
20. Jøsang, A., Bhuiyan, T.: Optimal trust network analysis with subjective logic. In: Proceedings of the International Conference on Emerging Security Information, Systems and Technologies. (2008) 179–184
21. Wang, Y., Vassileva, J.: Bayesian network-based trust model. In: Proceedings of the International Workshop on Trust, Privacy, Deception and Fraud in Agent Systems. (2003) 372–380
22. Chen, C.: Handbook of Pattern Recognition and Computer Vision (4th Edition). World Scientific Publishing Co. Pte. Ltd (2010)
23. Erickson, T.: Designing visualizations of social activity: six claims. In: CHI'03 Extended Abstracts on Human Factors in Computing Systems. (2003) 846–847
24. McKnight, D., Chervany, N.: What trust means in e-commerce customer relationships: An interdisciplinary conceptual typology. International Journal of Electronic Commerce **6** (2001) 35–59