New Directions for the Design of Virtual Reality Interfaces to E-Commerce Sites

Luca Chittaro
HCI Lab, Dept. of Math and Computer Science
University of Udine
via delle Scienze 206, 33100 Udine, Italy
+39 0432 558450
chittaro@dimi.uniud.it

Roberto Ranon
HCI Lab, Dept. of Math and Computer Science
University of Udine
via delle Scienze 206, 33100 Udine, Italy
+39 0432 558457
ranon@dimi.uniud.it

ABSTRACT

Virtual Reality (VR) interfaces to e-commerce sites have recently begun to appear on the Internet, promising to make the e-shopping experience more natural, attractive, and fun for customers. Unfortunately, switching to a desktop VR design for an e-commerce site is not trivial and does not guarantee at all that the interface will be effective. In this paper, we first briefly discuss the potential advantages of these interfaces, stressing the need for a better approach to their design. Then, we present the directions we are following to build more usable and effective VR stores, i.e.: (i) reformulating design guidelines from real-world stores in the VR context, (ii) exploiting VR to create user empowerments that meet both customer and merchant needs, and (iii) personalizing the VR store to better reflect customer's taste, preferences, and interests. For each of the three directions, we illustrate and discuss a detailed case study.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Interaction styles, evaluation.* H.1.2 [**Models and Principles]**: User/Machine Systems – *Human factors.* I.3.6 [**Computer Graphics**]: Methodology and Techniques – *Interaction techniques.* H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *Artificial, augmented, and virtual realities.*

General Terms

Experimentation, Design, Human Factors.

Keywords

e-commerce, virtual reality, 3D interfaces, navigation aids.

1. INTRODUCTION

One of the challenges of e-commerce is the design of web sites which effectively present products and are easy and pleasant to use for customers. Studies of the usability of current e-commerce sites are beginning to appear (e.g., see [15]), reporting major design problems. These result in customers failing to find what they are looking for, or abandoning the purchase even if they have found the product. Moreover, as pointed out by an analysis of e-commerce open issues from the HCI point of view [14], e-commerce sites should satisfy not only the needs (such as efficiency of product finding tools) of customers who have a rational style of buying, but also the needs (such as an appealing interactive experience) of customers who have an emotional style of buying.

Although almost all e-commerce sites use only traditional 2D user interfaces, some sites are currently making attempts at providing users with 3D interfaces (e.g., see [2][5][6]), allowing them to explore a Virtual Reality (VR) representation of the store. A VR store has some relevant advantages, if properly implemented: (i) it is closer to the real-world shopping experience, and thus more familiar to the customer, (ii) it supports customer's natural shopping actions (such as walking, looking around the store, picking up products,…), (iii) it can satisfy emotional needs of customers, by providing a more immersive and visually attractive experience, (iv) it can satisfy social needs of customers, by allowing them to meet and interact with people (e.g., other customers or salespeople).

Unfortunately, adopting a VR design for an e-commerce site is not trivial, due to the lack of design experience. For example, usability guidelines for designing e-commerce sites (e.g., [13]) do not deal at all with VR stores. Moreover, a VR design does not guarantee that the site will be effective, and determining what features will be effective with customers and how to design them are open research subjects.

VR stores have thus to face major challenges in order to gain wide customer and merchant acceptance. To this purpose, our research project aims at identifying new directions for VR store design. In our approach, we tackle the problem of designing more usable and effective VR stores by both mimicking and augmenting real-world stores. More precisely, we propose to proceed along three synergistic directions:

- identifying design guidelines for VR stores, by deriving them from real-world store design knowledge (e.g., shop layout, signs, product positions,…) and validating them in VR;
- taking advantage of the virtual nature of the store to add user empowerments (unavailable in real-world stores) that augment the customer's navigation and interaction capabilities;
- personalizing the VR store, so that it better reflects customer's taste, preferences, and interests.

In the following, we present these three research directions, and we discuss a detailed case study for each of them to provide a demonstration of how they can contribute to the design of more effective VR stores. Since we are concerned with today's e-commerce sites, in our work we use only hardware and software which is easily available to the average consumer. More specifically, we build desktop VR environments in VRML [8], and test them on the common 3D hardware accelerators which equip today's consumer PCs.

2. DERIVING GUIDELINES FROM REAL-WORLD STORES

The approach we adopted to proceed in the first direction is organized into four main activities: (i) acquisition of the guidelines used in real-world stores (extensive experience is available on the topic, and can be acquired through specialized literature and by interviewing experts), (ii) identification of the VR counterparts of real-world guidelines (some might be directly translated, some need adaptation, and some cannot currently be translated, e.g. those concerning scents), (iii) identification of the proper implementation choices to adequately apply the guidelines in desktop VR, (iv) evaluation of effectiveness (a guideline which has been proven to work in real-world stores does not necessarily work in VR ones).

As part of the first activity, we are interviewing a local manager of a leading European department stores company, eliciting the *merchandising guidelines* they follow, i.e. how they present and group products in their stores to motivate customers. An effective product presentation has indeed to consider many choices ranging from space allocation to product positioning and visual presentation. In the following, we focus on one elicited guideline concerning the number and grouping of items for the same product, and discuss its application and validity in VR stores.

2.1 The "massification" guideline

The term "*massification*" is used in merchandising to indicate the display of a mass of several identical instances of the same product. When the number of displayed items for a product in a department store is below a given minimum (which varies with the product), it is empirically known that there will be negative effects on sales of that product. This seems to happen for reasons such as: (i) customers are more motivated if they have the impression of a "rich" store (e.g., imagine how unattractive could be a department store where just one item of any product is on display), (ii) displaying many identical items of a product makes the product more visible (on the contrary, when too few are displayed, store managers say the product "disappears"), (iii) customers prefer to pick up one item from a group of identical items (e.g., contrast the feeling of picking up a bottle of milk in a supermarket with just one bottle vs. a lot of bottles on the shelf).

The considered guideline prescribes thus a "massified" display of products: *several instances of the same product have to be displayed together*. As any guideline, this has an exception. More specifically, it does not apply to shops (such as boutiques or painting galleries) which sell exclusive, very expensive products, where the customer needs to feel that (s)he is buying an unique piece.

2.2 "Massified" display of products for VR stores

While traditional 2D e-commerce sites typically show only one instance of each product in their menu-based organization, it is interesting to see that the new emerging 3D sites are not making a different choice. This is probably due to considerations such that there is no difference in choosing one instead of another identical item, or worries about decreasing rendering speed. However, the first kind of considerations does not take into account psychological aspects such as those mentioned in the previous section, while effects of implementation choices on rendering speed should be instead taken into proper account.

Implementing the "massification" guideline in a VR store is easier than in a real store, because there are less restrictions imposed by physical constraints, and there is no need for personnel to monitor and keep the shelves full. We tested different solutions for visualizing "massified" versions of various products in a VR store. Using only flat 2D pictures of products (as some 3D stores on the Web do) kept rendering requirements low, but resulted in a insufficient level of realism for many categories of products. On the other hand, using full 3D models of products resulted in considerable improvements in visual impact but placed a too heavy burden on the graphics engine. The solution which provided the best compromise, keeping rendering requirements at a manageable level without sacrificing the appeal of the visualization, has been obtained with texture-mapping, i.e. we used simple solids (such as boxes and cylinders), and mapped product pictures over them. For example, to build a 3D DVD player, we mapped a texture of its front and rear panels into two sides of a gray box. The product visualization we adopted can be seen for a sample product in Figure 1 (before applying the guideline) and Figure 2 (after applying the guideline).

2.3 Experimental evaluation

We have evaluated with a between-groups experiment if the effectiveness of the guideline transfers to VR stores. Two groups of subjects shopped in two versions of the store: a control version where no product was displayed as "massified", and a version where some of the previous products were "massified".

2.3.1 Subjects

A total of 44 subjects was involved in the experiment. The subject population was chosen to be very diverse as the audience of e-commerce sites is. Age ranged from 19 to 45, averaging at 28. The population was equally split between males and females. Occupations of the subjects ranged from clerks to high school teachers, engineers, and students. In particular, 68% of the subjects were students from different faculties (Arts, Business, and Computer Science). The ability of subjects with computers was rated by asking them how frequently they use them: 16 subjects used computers very rarely or never, 7 subjects spent from one to three hours a day using computers, and the remaining 21 spent more than 3 hours a day. About one third of the population had some familiarity with 3D videogames. Finally, half of the population was familiar with at least one e-commerce site, while the other half was not.

2.3.2 Experimental Setting and Task

Interaction with the virtual environment took place through keyboard and mouse. The four arrow keys on the keyboard were used for movement inside the VR store, while the mouse was devoted to point and select products. The hardware used for the experiment was a standard 19 inch Trinitron monitor and a 450MHz Pentium III PC equipped with a Nvidia TNT2 Ultra graphics board. The full screen was devoted to present the view of the visited VR store.

Prior to the experiment, subjects filled out a brief demographic questionnaire. Next, they were instructed about how to interact with the VR store via keyboard and mouse, using a training store with just two shelves.

After completing the training phase, the experiment started. It concerned a purchasing task where the subjects were asked to freely wander around a VR store and buy three products of their choice among 40 different products on display. The products were organized into 10 different categories (cakes, DVD players, pastas, portable stereos, shoes, snacks, soft drinks, teas/coffees, toys, and wines) with 4 different products in each category. The VR store was structured as a rectangular room containing 5 two-sided shelves (see Figure 3), with each side of any shelf displaying only one category of products (as it is typical of real-world department stores).

After the experiment, the subjects filled out a second questionnaire where they were asked to describe the store with some adjectives of their choice and add free comments.

2.3.3 Experimental Conditions

Subjects were split into two groups of 22 persons each. The first group (CTRL group) used a version of the store where no product was "massified" (see Figure 1 for an example of "non-massified"

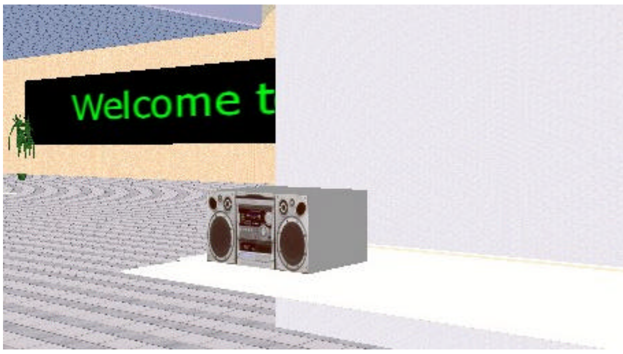

Figure 1. A product in non-"massified" format.

Figure 2. Same product of Figure 1, but in "massified" format.

Figure 3. Map of the VR store (MSFD condition).

display in the experiment). The other group (MSFD group) used a version of the store which differed only in how a minority (10 out of 40) of products was displayed. More precisely, the two stores contained the same products in the same positions, but in the MSFD version of the store one product in each category was displayed in "massified" format (i.e., more than one instance of the same product, grouped together in the given shelf position, as shown in Figure 2), while the other three products in each category were displayed exactly as in the first version (a large empty space was kept between the four products so that the possibility of choosing among four possibilities in each category was clearly perceived). Figure 3 illustrates a miniature map of the employed VR store, graphically illustrating that 10 products were massified in the MSFD condition.

The goal of the experiment was to test if "massification" of some products could increase the purchases of those products with respect to the control condition. Products in the experiment are thus implicitly divided into two classes: the first (NO-CH products) contains the 30 products whose display technique did not change in the two experimental conditions (they were always "non-massified"). The second one (CH products) contains the minority of those 10 products whose display technique changed in the two experimental conditions (i.e., they were "non-massified" in the CTRL condition and "massified" in the MSFD condition).

Purchases were only simulated: users were asked to proceed as if they had really the opportunity to buy three products of their choice, but they were aware that they were not going to actually obtain them. This could raise the objection that the behavior of a customer who is only pretending to buy might be different from the real purchase scenario. This is likely to be true for product categories (e.g., since subjects are only pretending to buy, some of them might focus on the product categories that attract more attention or they might concentrate on which categories are considered to be status symbols, regardless of the categories they would really choose if they were to pay for it) and prices (e.g., after considering a product category, a customer who is only pretending to buy might not apply the same price criteria that she normally follows to choose a product in the category). We were not worried by category choices, because we were investigating the possible tendency to prefer "massified" items to "non-massified" ones after any category is chosen (for this reason, we always kept three products in each category in "non-massified format", and only one product became "massified"). To minimize the probability that price aspects could play a role in subjects' choices inside a product category, price information was omitted from products and four products of similar price were displayed in each category.

2.4 Results

For each subject, we recorded how many of the three purchased products belonged to each class (NO-CH or CH). Table 1 shows customers' purchasing behavior in the two groups, by indicating how many subjects bought a majority (2 out of 3, or 3 out of 3) of NO-CH products and how many bought a majority of CH products. In the CTRL group, 18 subjects oriented their purchases mainly to NO-CH products, and 4 subjects to CH products (this is consistent with the fact that there were many more products in the NO-CH class). However, when CH products become "massified" (MSFD group), customers' shopping behavior changes: 11 subjects oriented their purchases mainly to NO-CH products, and 11 subjects to CH products. The Chi Square Test ($\chi^2(1)=4.5$, $p<0.05$) on the table confirms that the effect of "massified" display on customers' behavior is statistically significant. Sales of the same subset of products in the same position significantly increase when those products are displayed in "massified" format.

Qualitative visual impressions collected with questionnaires gave further indication that a "massified" visualization encounters a much more favorable response than a "non-massified" one: subjects in the CTRL group often described the store as "poor", "empty", "bare", and "spare", while subjects in the MSFD group used these adjectives rarely.

Table 1. Purchasing behavior of the two groups.

	NO-CH products	CH products
CTRL Group	18	4
MSFD Group	11	11

3. EMPOWERING CUSTOMERS

The design of a VR store inevitably presents all the HCI problems that have to be faced in the design of any kind of VR environment (e.g., user disorientation). Although one can generally try to face them following the same generic solutions adopted for VR environments (e.g., an electronic map to help orient the user), these generic aids are not contextualized to the ecommerce scenario and cannot fully satisfy neither the needs of customers nor the needs of merchants. The provided aids should indeed both enhance the customer's shopping experience (and this is hardly achieved with solutions that appeal mainly to the rational side of users, and are not related to shopping actions and objects) and also take into account marketing and merchandising strategies of the merchant (and this cannot be achieved with a generic tool). We illustrate these ideas in more detail, by considering one of the major problems of VR environments (i.e., navigation) which requires to provide proper aids to users, and showing how we designed a navigation aid specifically devised for the considered e-commerce context.

3.1 Navigation: a general perspective

Navigation can be informally defined in a general way as "the process whereby people determine where they are, where everything else is, and how to get to particular objects or places" [10]. In the case of VR environments, people find navigation to be more difficult than in real environments, and often become disoriented and tend to get lost. This is due to many factors such as fewer spatial cues, fewer locomotive cues, and absence of peripheral vision [12], making navigation support a relevant usability issue.

An inadequate support to user navigation is likely to result in frustrated customers, and customers leaving the VR store before finding the products of interest. The navigation issue can be tackled from two synergistic directions: one is to design a navigable environment (e.g., following the guidelines used for real-world stores as described in section 2), the other is to take advantage of the virtual nature of the store by providing users with navigation aids unavailable in real stores (as we will show in the following).

3.2 Navigation: a merchant perspective

When it comes to navigation and product finding, one merchant priority (both in brick-and-mortar and electronic commerce) is to achieve the best compromise between two (often conflicting) goals: (i) allow the customer to find the desired products quickly and easily, and (ii) make the customer take a look also at other products while on her/his way to the desired ones. The second goal is essential for merchants to increase their sales. It is indeed well-known that a substantial part of purchases are not planned in advance before entering a store, but occur as an impulsive response to seeing the product (the reader might be familiar with the experience of going to a supermarket and buying more things than planned). Moreover, merchants are also typically interested in increasing the likelihood that *specific* products are seen by the customer according to their merchandising strategies (e.g., swimsuits when summer is approaching, Christmas' gifts in December, products being heavily advertised in the media, special offers,…).

A navigation aid for e-commerce sites should thus take into account the above mentioned merchandising considerations. This is done in traditional 2D interfaces with (often annoying) banners appearing through the pages the customer examines while s(he) looks for a product. A VR interface has the potential of providing more discreet, pleasant and attractive solutions, as we will now show.

3.3 The proposed aid: 3D Walking Products

Traditional ways of indicating where a product is in real-world stores are signs, maps, and verbal indications by employees. The navigation aid we designed can indicate product position in an easier, clearer, and more engaging way for the customer. We propose to use 3D animated representations of products that move through the store and go to the place where the corresponding type of products is. In particular, the animated products we implemented *walk* towards their destinations and will thus be called *walking products* (WPs) hereinafter. A customer in the VR store sees a number of WPs wandering around: if (s)he is looking for a specific type of products, s(he) has just to follow any WP of that type and will be quickly and easily lead to the desired destination. The specific path followed by the WP to accompany the customer to his/her destination is chosen by taking also into account the merchandising strategy of the store. If the customer wants to stop along the way and take a look at other products, s(he) can count on the fact that WPs will be always available to lead her/him to the original destination. This can be achieved in different ways, e.g. the followed WP can wait for the customer, or a flow of WPs can be guaranteed so that the customer knows that (s)he can abandon a WP without problems, because other WPs for the same type of product will pass by in a few seconds. We preferred the second solution, because we found that having a WP waiting for us was less encouraging with respect to store exploration.

3.4 Designing Walking Products

In designing WPs, we aimed at keeping rendering and file download requirements low, without sacrificing visual impact. In particular, (i) the body of a WP is a simple solid (box, cylinder or sphere) into which a texture depicting the corresponding product is mapped, (ii) legs and arms of the WP adopt a cartoon-like shape and typical simplifications useful for animation (e.g., hands have only 3 fingers), (iii) movement of legs and arms (identical for any WP), as well as the different paths traveled by WPs, are pre-computed. Details of a WP geometry are shown in Figure 4.

Another design goal was to give the impression of a "live" environment inhabited by WPs actively wandering all around. From this point of view, one must guarantee that the customer sees an adequate number of WPs in every part of the store: design choices concern the number of paths for WPs, the length and starting points of such paths, the number of WPs for a product and the total number of WPs in the store at any instant. A proper balance between these factors and the store dimensions is needed. Further design choices are concerned with making WPs visually attractive and enjoyable, e.g., we paid attention to obtaining a funny style of walking and introducing unexpected behaviors which contribute to emotionally engage the user. For example, sometimes a WP can stumble, fall, and then rise up and resume walking. Figure 5 shows an instant of a falling WP animation.

3.5 Experimental evaluation

We carried out a between-groups experiment concerning a product finding task. The purpose of the experiment was to test if customers would actually use WPs in the VR store, and if this would improve their performance. A total of 24 subjects was involved. The subject population was very similar to the one described in the "massification" experiment. Subjects were split into two groups of 12 persons each. The VR stores visited by the two groups differed only in the presence/absence of WPs: the first group had WPs available in the store, the second was a control group. The adopted hardware and software configuration, the way of interacting with the virtual environment, the initial questionnaire, and the training environment were the same of the "massification" experiment. Subjects in the first group had also WPs available in the training store, and were told that "walking products in the store go to the shelve where the corresponding product is located", but no suggestion or request to follow WPs was made.

The task assigned to subjects in the experiment was to find a specific product (i.e., a book) in a VR store. The store was organized as a rectangular room with four rows of four two-sided shelves each. The store contained 16 different categories of products, and one WP was associated to each category. The initial position of every subject was the center of the store, while the product to find was located in the front-left corner, hidden from the initial subject's view by other shelves. The initial position of WPs along their routes was random for each subject. After the experiment, subjects in the WP group filled out a second questionnaire where they were asked to qualitatively rate their subjective impressions about WPs, and could add free comments.

Figure 4. Example of a walking product (WP).

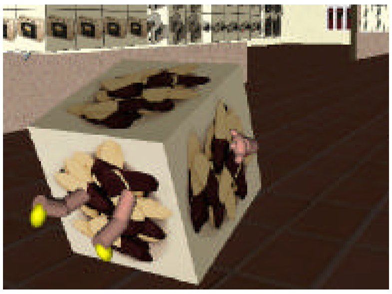

Figure 5. Example of unexpected behavior.

3.6 Results

From the point of view of WPs usage, *every* subject in the first group followed WPs to perform the task.

From the point of view of user performance, we measured the time spent to complete the product finding task. A one-way analysis of variance (ANOVA) has been performed, considering presence of WPs as the independent variable, and time as the dependent variable. The result ($F(1,22)=7.04$, $p<0.05$) indicates that the effect was significant. Table 2 contains the average times for the completion of the product finding task, showing that customers are able to effectively exploit the presence of WPs (the time spent by subjects in the first group is less than half the time spent in the second group).

Tables 3 and 4 summarize subjects' impressions of WPs, collected from the first group of subjects, showing that they score favorably both at rational (usefulness) and emotional (fun) attributes.

3.7 WPs vs. other navigation aids: some remarks

WPs have several advantages over the navigation aids adopted in current VR stores, i.e., signs, maps, and teleporting. Signs do not give a detailed enough indication of product location; maps impose on the customer a translation effort from their exocentric perspective to her/his egocentric one; teleporting (i.e., being taken immediately to product location, e.g. by choosing from a menu) brakes the continuity of the shopping experience and limits the possibility of looking at other products. On the contrary, WPs: (i) support product finding in a easy, natural way: one has just to follow the WP as (s)he would do with a friend or a salesperson in a real shop; (ii) increase the number of products seen by the customer, especially those which are relevant for current merchandising strategies, (iii) convey the feeling of a "living" place and contribute to satisfy the needs of customers with an emotional style of buying, which are more motivated by the interactive experience than hard facts [14].

Table 2. Mean completion times for the finding task.

Group	Mean Completion Time
WPs available	77 sec.
WPs not available	182 sec.

Table 3. Qualitative Impressions (usefulness).

Extremely useful	7
Quite useful	3
Neutral	2
Quite unuseful	0
Extremely unuseful	0
MEDIAN	Extremely useful

Table 4. Qualitative Impressions (fun).

Extremely funny	7
Quite funny	3
Neutral	1
Quite boring	1
Extremely boring	0
MEDIAN	Extremely funny

4. PERSONALIZING THE VR STORE

An increasing competitive factor among Internet merchants is the possibility of offering personalized services to each customer (1-to-1 E-commerce). Some research effort (e.g., [1], [9]) is being devoted to build adaptive interfaces for this need by exploiting customer models, but is limited to traditional 2D sites.

Therefore, to proceed with the last of the three research direction we have described, we had first to face a number of problems of a technical nature, because no general architecture for the personalization of Web 3D content was available. We thus built our own architecture, called AWE3D (Adaptive WEb 3D), which is described in detail in [4]. AWE3D allows one to: (i) acquire information about user's preferences and interests by tracking user's actions in the VR world; (ii) record the acquired information into a user profiles database; (iii) exploit the user profile to derive a number of personalization choices for the VR world and better match user's interests, (iv) dynamically assemble a VRML world based on the personalization choices.

We applied the AWE3D architecture to the VR store. In the following, we briefly summarize the main choices we took to make the store adaptive. User evaluation of these adaptive aspects is being planned, following the indications given by [3].


Figure 6. A first adaptation of our VR store.

Figure 7. A second adaptation of our VR store.

4.1 Acquiring and maintaining customer models

We combine three techniques which complement each other to acquire and maintain a more complete customer model.

First, an initial form asks for typical information (i.e., gender, year of birth, profession, and level of education), and some specific information (i.e., interest in product categories, preferred style and size of the store, presence/absence of music in the store and preferred genres to be played).

Second, if the user does not enter all the requested information, we exploit stereotypes (that can be derived using information available from marketing databases) to make predictions about consumer interests, preferences and behavior (e.g., a customer in the 20-30 age range is very likely to be interested in the latest models of cellular phones, and to change often his cellular phone.

Third, we dynamically update the model by considering clickstream data recorded on the customer's past visits to the VR store. In particular, we record the typical shopping actions (which products have been seen, clicked-through, put in the basket, purchased). This data allows us both to measure the merchandising effectiveness [7] of the personalized store and improve the classification of customer's interests in the model over time. It is interesting here to note that a VR interface allows one to track what products the customer has seen better than traditional 2D approaches. While the latter have often to assume that the customer sees all the products in the pages s(he) downloads, a 3D world allows one to additionally check both that the customer is near enough a product in the 3D space, and also that his/her virtual head is properly oriented towards the product. We use each purchase, basket insertion, and click-through event to refine the classification of consumer's interest in product categories.

4.2 Personalization of VR-specific features

The adaptation is performed by *personalization rules* which change the parameters describing the state of the VR store. Some rules are simple direct association between user preferences and features of the store, while others perform a more elaborate reasoning activity.

A first basic choice (left to the customer) is about using the VR interface or a traditional 2D interface. While a VR interface can be appealing to customers with an emotional style of buying or to customers who are not expert in using search tools, it must also be clearly said that it is definitely not suited for some other categories of customers. For example, the customer could be very experienced in the use of computers and prefer to use an advanced search engine, or she can be a rational customer who prefers to see plain text tables of product features, or (s)he can be using a very slow computer which does not support graphics at a reasonable speed. A VR store should thus be provided as an addition not a substitution of more traditional interfaces to e-commerce sites.

Other choices which are directly controlled by the user concern *size* and *style* of the store, for which there is a direct association between user preferences and specific 3D models for the virtual environment. For example, the stores in Figures 5 and 6 show two different styles and sizes available. In this way, the customer can visit a VR store which is closer to the ones (s)he chooses in the real world (or safely experiment with stores she would like to try in the real world, but avoids, e.g. for emotional reasons such as fear of judgement).

The personalization mechanism is more complex in the way product display and presentation are organized to seek customer's attention. For example, `ExposureLevel(X)` is a parameter we use to indicate how many store resources are devoted to attract the attention towards product `X`. The value of `ExposureLevel(X)` is determined by more specific parameters describing the use of store resources, e.g. how much space is assigned to product `X` on its shelf, the presence of product `X` on a display spot on its own, the presence of a banner advertising `X`, the presence of a WP representing product `X` in the store.

Personalization rules first suggest changes to `ExposureLevel(X)` by asserting increase or decrease goals for specific products. Then, they focus on achieving those goals, by changing one or more of the above described parameters, according to the availability of store resources. In general, to prevent an excessive number of changes to the store from one session to another (which would confuse the user), a limit is imposed on their number for any given session. In this way, the experience of returning to the VR store is consistent with the familiar experience of returning to a known real-world store: (i) the store layout, organization, and style remain essentially the same (these parameters are indeed under user control, and are not changed autonomously by the interface unless the user explicitly modifies its preferences about size and style), and (ii) a limited number of changes concern what products are displayed, and how the attention of the customer towards those products is sought.

5. CONCLUSIONS AND FUTURE WORK

This paper has proposed novel directions to approach the design of VR stores, and illustrated the ideas with case studies. We are currently concentrating on many research goals to further improve our VR store along the three directions described in the paper.

With respect to the design guidelines direction, we will proceed in translating, implementing, and evaluating other real-world guidelines such as those concerning positions of products in the store space (planograms), typical customers' flows in the store, effective use of audio (e.g., messages and music).

With respect to customer empowerments, we will concentrate on how the effectiveness of the VR store can be augmented with features which would be very difficult or impossible to obtain in a real store (e.g., automatic rearrangement of products in shelves according to different criteria, such as function, price, brand, chromatic similarities, or customer model). We will also explore the possibility of extending the abilities of WPs, enriching them with further user assistance functionalities such as the capability of performing product presentations [11].

With respect to personalization, we will explore how to give more interactive control to the customer over adaptation aspect (e.g., to switch background music on and off, and to determine music genres preferences, an interactive 3D jukebox can be included in the store). We are also considering recording the average speed at which the customer is able to move in the virtual environment to get an estimate of her 3D navigation ability and tailor the animation of navigation aids to it.

Finally, a recent trend in VR worlds over the Web is to allow users to meet and interact. We intend to investigate the impact of this possibility on VR stores. From the personalization point of view, it is interesting to note that adding this social dimension can conflict with adaptation aspects, limiting the possibilities of 1-to-1 e-commerce. For example, if multiple users have to walk together and interact in the same VR store, the customization of the features mentioned in this paper cannot target anymore the specific model of a single customer. Trying to find the best compromise which maximizes the match with the different customer models can be a possible solution, but it would not be easy to implement, considering that the set of customers in the stores would continuously change.

6. REFERENCES

[1] Ardissono L., Goy A., Meo R., Petrone G., Console L., Lesmo L., Simone C., and Torasso P. A configurable system for the construction of adaptive virtual stores, World Wide Web Journal, 2(3), 1999, 143-159.

[2] @mart, www.activeworlds.com

[3] Chin, D. Empirical Evaluations of User Models and User-Adapted Systems. User Modeling and User Adapted Interaction, 11(1-2) (2001), 181-194.

[4] Chittaro L., Ranon R. Dynamic Generation of Personalized VRML Content: a General Approach and its Application to 3D E-Commerce, Proceedings of Web3D 2002: 7th International Conference on 3D Web Technology, (Tempe, AZ, USA, February 2002), ACM Press, 145-154.

[5] Cybertown Shopping Mall, www.cybertown.com

[6] First 3D Mall, http://www.first3dmall.com

[7] Gomory S., Hoch R., Lee J., Podlaseck M., and Schonberg E. E-Commerce Intelligence: Measuring, Analyzing, and Reporting on Merchandising Effectiveness of Online Stores. Technical Report, IBM Institute for Advanced E-Commerce, Yorktown Heights, NY, www.ibm.com/iac/papers/eabs3.pdf

[8] International Standard ISO/IEC 14772-1:1997, *The Virtual Reality Modeling Language*, www.vrml.org/Specifications/VRML97/

[9] Joerding T. A Temporary User Modeling Approach for Adaptive Shopping on the Web, in Proceedings of the 2nd Workshop on Adaptive Systems and User Modeling on the WWW (Bannf, Canada, June 1999), wwwis.win.tue.nl/asum99/joerding/joerding.html

[10] Jul S. and Furnas G.W. Navigation in Electronic Worlds. SIGCHI Bulletin 29, 4 (October 1997), www.acm.org/sigchi/bulletin/1997.4/jul.html

[11] Rist T., André E., and Muller J. Adding Animated Presentation Agents to the Interface, in Proceedings of the IUI97 Conference on Intelligent User Interfaces, (Orlando, FL, USA, January 1997), ACM Press, 79-86.

[12] Ruddle, R.A., Payne S.J and Jones, D.M. Navigating Buildings in "desk-top" virtual environments: Experimental Investigations Using Extended Navigational Experience. Journal of Experimental Psychology: Applied 3, 1997, 143-159.

[13] Serco Ltd. How to Design a customer friendly on-line store, http://www.usability.serco.com/research/susshopguide.pdf

[14] Steiger S., Stolze M., and Good M. Beyond Internet Business-as-Usual. SIGCHI Bulletin 30, 4 (October 1998), www.acm.org/sigchi/bulletin/1998.4/steiger.html

[15] Tilson R., Dong J., Martin S., and Kieke E. Factors and Principles Affecting the Usability of Four E-commerce Sites, in Proceedings of the 4th Conference on Human Factors and the Web (Basking Ridge NJ, June 1998), www.research.att.com/conf/hfweb/index.html