# Adding Adaptive Features to Virtual Reality Interfaces for E-Commerce

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**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. Adaptivity is an important issue for these VR applications, because it would make them suitable for the 1-to-1 e-commerce strategies towards which sellers are increasingly driven. It is thus surprising that the introduction of adaptive features in VR stores remains a completely unexplored issue. This paper begins to face the problem, presenting and discussing ADVIRT, a first prototype of an adaptive VR store. In ADVIRT, a set of personalization rules exploits a model of the customer to adapt features of the VR store such as: (i) the display of different products in the store (e.g., shelf space, display spots, banners, audio advertising), (ii) the navigation aids available to the customer, (iii) the store layout, organization, and look.

## 1 Introduction

One of the recent research trends in e-commerce is to provide Web sites with a Virtual Reality (VR) interface that allows the customer to interact with the e-commerce service through a 3D representation of a store that supports natural actions such as walking, looking around, and picking up products from shelves. Although almost all e-commerce sites on the Internet use traditional 2D interfaces based on menus and links, a growing number of sites are deploying VR interfaces[1] to attract customers. A VR interface can bring relevant benefits, if properly designed: (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, (iii) it can satisfy the needs of customers who have an emotional style of buying, by providing a more immersive, interactive, and visually attractive experience, (iv) it can even satisfy social needs, by allowing customers to meet and interact with people (e.g., other customers or salespeople).

Although the idea is promising and can lead to more natural, attractive, and fun e-commerce sites, VR stores have to face major challenges in order to gain wide customer and seller acceptance. The first challenge is usability: guidelines for

[1] Some examples are @mart at www.activeworlds.com, Cybertown Shopping Mall at www.cybertown.com, Giftworld at www.leap.to/euro/enter.html.

designing usable e-commerce sites (e.g., [10]) do not deal with VR stores, and usability studies of e-commerce sites in the literature (e.g., [11]) have considered only traditional 2D interfaces. The second challenge is the suitability of VR stores for the 1-to-1 e-commerce strategies towards which sellers are increasingly driven. From this point of view, it is surprising that the introduction of adaptive features in VR stores is a completely unexplored issue in the literature.

In our research, we focus both on how to design usable VR stores, and how to obtain a personalized user interaction with them. In the following, we first briefly sketch our approach to VR store usability, then we discuss in detail how we are adding adaptive features for 1-to-1 e-commerce to our VR store.

## 2 Designing Usable VR Stores

In our approach, we tackle the problem of designing usable VR stores from two synergistic directions: (i) designing usable environments by following selected guidelines from real-world stores (e.g., store layout, signs, product positions,…), and (ii) exploiting the virtual nature of the store by providing users with empowerments (unavailable in real-world stores) to augment their navigation capabilities.

### 2.1 Store Design

To identify a proper set of design guidelines, we are proceeding as follows: (i) acquiring the guidelines used in real-world stores (extensive experience is available on the topic, and can be acquired through specialized literature and expert interviews), (ii) identifying the VR counterparts of real-world guidelines (some might be directly translated, some need adaptation, and some can be impossible to translate, e.g. those concerning scents), (iii) identifying the proper implementation choices to adequately apply the guidelines in VR, (iv) evaluating the effectiveness on users (a guideline which has been proven to work in real stores does not necessarily work in virtual ones). For example, we have determined with a between-groups experiment that the "massification" guideline adopted in real-world stores (i.e., increasing the number of items displayed for the same product to increase its visibility and sales) positively transfers to VR stores [5].

### 2.2 User Empowerments

Simply taking traditional VR navigation aids (such as electronic maps) and including them in the VR store is not the best solution, because it does not take into account seller needs. For example, when it comes to product finding, one seller priority (both in traditional 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 his/her way to the desired ones. The second goal is essential for sellers to increase 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 (impulse purchase). Moreover, sellers are also typically interested in increasing the likelihood that *specific* products are seen by the customer according to their merchandising strategies (e.g., Christmas' gifts in December, products being heavily advertised in the media, special offers,…).

In [4], we proposed a navigation aid for e-commerce that takes into account the above mentioned merchandising considerations. The aid is based on 3D animated representations of products (called *Walking Products*, *WPs* for short) that move through the store and go to the place where the corresponding type of products is. A customer in a VR store sees a number of WPs wandering around (see Figures 1 and 2): 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 takes 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 him/her to the original destination.

WPs have several advantages over the navigation aids adopted in current VR stores, i.e., signs and maps. Signs do not give a detailed enough indication of product location, while maps impose on the customer a translation effort from their exocentric perspective to his/her egocentric one. 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 store; (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 need for interactive experiences typical of emotional customers.

A more thorough presentation of the WP aid is provided in [4]. In one of the following subsections, we will instead extend the WP idea to the context of the adaptive VR store.

## 3 ADVIRT: The Adaptive VR Store

While increasing and guaranteeing usability is one of the current top priorities for VR e-commerce sites, one has to take into account that an increasing competitive factor among Internet sellers is the possibility of offering personalized services to each customer (1-to-1 E-commerce). Some research effort is being devoted to this need, but is limited to traditional 2D sites. In this Section, we first briefly survey related work on building customer profiles for adaptive e-commerce, then we present in detail our ADVIRT (Adaptive VIrtual Reality sTore) prototype, which is able to personalize a VR store using the profile of the customer who is visiting it. The type of stores we focus on are department stores, selling many different product categories.

### 3.1 Related work on Adaptive E-commerce

Techniques to build customer profiles in e-commerce have been recently proposed in the user modeling literature. In particular, the approach by [1] combines *form filling* with *stereotyping*: it asks the customer to fill a form about herself, and then assigns him/her a stereotyped profile by matching the form data with a database containing an hierarchical taxonomy of stereotypes clustering the properties of homogeneous customer groups. A different approach is adopted in [7,8]: the system tries to tailor future presentations of products by *monitoring past customer choices* in terms of kind of medium presentation chosen (e.g., text, graphics, video,…), downloading time (e.g., does the customer interrupt downloading of pictures?), and content (e.g., time spent by the customer on specific presentation elements).

As we will show in the following, we build customer profiles by using a combination of the three above mentioned techniques. No research instead exists on exploiting customer profiles for adapting a VR store, so the approach we discuss represents a first attempt at tackling the problem.

### 3.2 Acquisition of customer profiles in ADVIRT

Our approach to building the customer profile mixes three different techniques:

- Have the buyer fill an initial form that asks for typical information (such as buyer's gender and year of birth), and some specific information (such as product categories of interest among the list of categories available in the store). Since only a limited amount of information can be acquired in this way (customers might not be able or might not like neither to fill large forms, nor to provide some personal details and preferences), the approach we follow is to present the customer with a limited number of fields to fill and to let him/her decide which fields (s)he is willing to fill (if the customer does not provide information about his/her interests, it can be derived by using the other two techniques).
- Exploit demographic profiles (available on the market) that give detailed and readily available information on the different categories of buyers, and can be used to make predictions about consumer interests (e.g., a customer in the 16-24 age range is very likely to be interested in the latest models of cellular phones), preferences (e.g., if the above mentioned customer is female, she is very likely to prefer cellular phones with a stylish and colorful design), and behavior (e.g., a customer who is more than 65 years old is very unlikely to change often his/her cellular phone because new models have appeared).
- Dynamically update the model by considering data (e.g., purchases made, number of visits,…) recorded on past visits to the VR store.

These three techniques complement each other, allowing one to obtain a more complete customer model. In the following, we present the detailed information we acquire, specifying which techniques are employed for each type of data.

### 3.3 Contents of customer profiles in ADVIRT

The information contained in the customer models of our prototype is organized in three parts: (i) biosketch, (ii) consumer aspects, (iii) interaction aspects.

**Biosketch**

The information contained in the biosketch part of the customer profile concerns typical information about the customer (i.e., *gender*, *year of birth*, *occupation*, and *level of education*). The primary way to get the information for the biosketch is by having the customer fill the corresponding fields in the above mentioned initial form.

**Consumer aspects**

The information contained in the consumer aspects part aims at characterizing the customer with attributes directly related to purchases and shopping behavior.

During each visit to the VR store, the following four kinds of time-stamped data are recorded by monitoring customer actions:

- *Seen Products*. While the customer wanders around the store, (s)he voluntarily or involuntarily looks at the products which fall in her field of view. We keep a record of which products have been seen by the customer. Unlike 2D e-commerce sites, where it is often assumed that every product in a downloaded page has been seen, a 3D environment allows one to track better what products the customer is seeing, by verifying that two conditions hold: (i) the customer has to be near enough to the product in the 3D space, and (ii) the virtual head of the customer must be oriented towards the product.
- *Clicked Products*. When the customer wants to know more about a product, (s)he clicks on it to get the product description. We keep a record of which products have been clicked by the customer.
- *Cart Products*. The product description allows the customer to put the product in the shopping cart for a possible later purchase. We keep a record of which products have been put in the shopping cart.
- *Purchased Products*. If a product in the cart is later purchased, we record the event, and keep track of which products have been purchased.

In particular, the above described data allow one to obtain a precise quantitative measurement of which brands, product categories, specific products, price categories, and special offers have been respectively seen, clicked, put in the shopping cart or purchased by the customer.

Another information contained in this part of the model is the *product interest ranking*, which tries to list product categories in the order that is more relevant to the customer. An initial ranking is determined in two different ways: (i) the initial form allows the customer to fill fields about his/her products of interests: if (s)he chooses to do it, the information is used to initialize the ranking, (ii) if the customer does not provide product interests in the form, the system tries to predict them by using a demographic profile. Regardless of the quality of the initialization, product interests will be continuously updated by exploiting some of the data described above, i.e. each purchase, cart insertion, and click at a product increases (with different weights) the level of interest in the product category.

Finally, this part contains preferences on *preferred music genres*, if the customer has agreed to enter them in the initial form.

**Interaction aspects**

The information contained in the interaction aspects part aims at characterizing the customer with attributes directly related to his/her preferences and behavior in using the interface to the e-commerce site. It contains information about the preferred *type of interface* (2D or 3D), the preferred store organization features (*size*, *style*, *assistance*), *number of visits* (i.e., the number of times the customer has used the interface), and if (s)he likes *background music* (if she likes music, the music played is possibly chosen according to the *preferred music genres* in the consumer aspects part). At present, the *number of times* information is automatically recorded, while the other data are acquired by graphically showing different possibilities to the user in the initial session (e.g., to determine the preferences about *size* and *style* of the store, the user can click on thumbnails representing different kinds of stores).

More advanced possibilities are at study (e.g., to switch the state of *background music*, 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 world to get an estimate of his/her 3D navigation ability and tailor the animation of navigation aids to it.

### 3.4 Creating a personalized VR store in ADVIRT

The adaptation of the appearance and content of the VR store depends on three sources of information: (i) the customer profile, (ii) current merchandising strategies (e.g., promoting special offers) of the seller, and (iii) current products in the seller's catalog. The adaptation is performed by *personalization rules* which influence the parameters describing the state of the VR store. A simple example is the direct association between the user preferences about *size* and *style* of the store and specific 3D models for the virtual building.

We now discuss in detail the personalization rules mechanism using a more complex example concerning the exploitation of the customer profile to change product exposure in the VR store. The level of exposure of each product can vary the product visibility and attractiveness, e.g. by increasing its space in the store or adding banners advertising it. We call `ExposureLevel(X)` the parameter which represents the level of exposure for product `X`. The value of `ExposureLevel(X)` is determined by five more specific parameters:

- `ShelfSpace(X)` indicates the space assigned to product `X` on the shelf. It can take four different values: higher values make `X` more visible to the customer, increasing `ExposureLevel(X)`. The products in the Figures 1 and 2 show different possible allocations of shelf space.
- `DisplaySpot(X)` is false if product `X` is displayed only on its shelf (together with other products of its category), while it is true if product `X` is displayed also in a separate display spot in a prominent place.
- `Banner(X)` is true if there is a banner advertising product `X` in the store.
- `AudioMessage(X)` is true if audio advertisements for the product are played.
- `WP(X)` is true if there is a WP representing product `X` in the store.

A true value for any of the last four boolean parameters increases `ExposureLevel(X)`. Personalization rules first suggest changes to exposure level 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 (e.g., if a shelf is full, shelf space for products in it cannot be increased).

We now examine some examples of personalization rules, and how they relate to the information recorded in the customer model. Suppose that a product `X` has never been seen by the customer, or that changes in the *product interest ranking* show an increasing attention towards the product. In both cases, a seller would like to increase

**Fig. 1.** A first adaptation of ADVIRT.

**Fig. 2.** A second adaptation of ADVIRT.

the exposure of the product (in the first case, to give the customer the opportunity of seeing the product; in the second case, to better match customer interests). The rules that implement the two cases can be expressed as follows (`seen(X)` is the recorded number of times a product has been seen, `ProductInterest(X)` is the rank in the *product interest ranking*, `NumberOfVisits` is the number of times the user has visited the store):

```
IF seen(X)=0 AND NumberOfVisits>3 THEN goal(IncreaseExposureLevel(X))
```

```
IF increasing(ProductInterest(X)) THEN goal(IncreaseExposureLevel(X))
```

The following rule considers the case when the purchase of a specific product `X` is an indicator of a likely future interest for related products, e.g., if a customer buys a computer and has never purchased a printer, s(he) could be soon interested in a printer. In this case, the rule dynamically updates the user model (`purchased(X)` is the recorded number of times a product has been purchased, `lastVisit` extracts the value of data considering only the last visit to the store, and `RelatedProduct(X,Y)` relates products exploiting associations provided by the seller):

```
IF lastVisit(purchased(X))>0 AND RelatedProduct(X,Y)
AND purchased(Y)=0 THEN increase(ProductInterest(Y))
```

As an effect of the increasing product interest, the second rule examined above will then suggest an increase in the exposure level of related products which have not been purchased yet. Note that the `RelatedProduct` relation cannot be used transitively, because this could lead to uneffective merchandising strategies, e.g. an ink cartridge is obviously related to a printer, and a printer is obviously related to a computer, but it does not make sense to increase the exposure level of ink cartridges if a customer has purchased a computer but not a printer.

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 a virtual store is not too different from 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 ADVIRT 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.

A limit is also imposed on the maximum value that `ExposureLevel(X)` can take for any given `X`, in order to avoid overexposure of products, which would have a negative effect on the customer.

In the following, we provide an overview of all the features which can be personalized in ADVIRT.

**Type of interface**

While a VR interface can be appealing to customers who have an emotional style of buying, and useful for 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 (s)he 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. We thus believe that a VR store should be provided in addition to a more traditional interface to an e-commerce site. The preferred *type of interface* information in the customer profile is used to choose which interface (2D or 3D) is started[2]. The following personalization features we discuss refer to the 3D interface.

### Store Layout, Organization, and Look

The preferred *size* and *style* information provided by the customer are used to choose store layout and look of the 3D representation of the store. For example, the stores in Figures 1 and 2 show two different sizes and styles 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).

As described in detail in a previous section, the organization of the store (product placement, product space, banners) is dynamically personalized.

### Set of WPs

The navigation aid we have previously presented (WPs) is tailored to the customer profile. A first basic choice is about WPs presence or absence in the virtual store. This choice is left to the customer and stored in the *assistance* field of the customer profile (presence is the default, but can be changed at any moment by the customer). The specific WPs shown in the virtual store are chosen by personalization rules, to increase the exposure level of specific products. For example, the two stores in the Figures contain significantly different sets of WPs. Adding this adaptive dimension to the WP navigation aid allows it to gain the following benefits which were not available in its non adaptive version described in [4]:

*Dynamical WP set.* Since the choice of WPs is affected by the evolution of the customer profile, the members of the set of WPs change over time. This allows one to: (i) save store space and rendering resources which would be wasted by less interesting WPs, (ii) introduce in the set new WPs which can attract the customer towards potentially promising purchases, (iii) create a continuously evolving environment that keeps customers' attention alive (a static environment could easily become boring after some visits for customers with an emotional style of buying).

*WPs as tailored hypermedia links.* The customer has been given the possibility to automatically run to the proper shelf by clicking on the corresponding WP. In this case, since the products displayed by some WPs correspond to the products the customer purchases more frequently, WPs partially act also as a "favorites" list of products which can quickly lead to product purchase.

Features of WP animation could be also adapted to user profile. For example, it would be possible to vary WPs speed (e.g., slow for the first visits, then progressively faster; or, as we are planning, adapted to the measured movement ability of the customer in 3D space), and WPs paths (e.g., dynamically determining them according to the parts of the store that are more likely to interest the customer, and the locations of products which the seller wants to promote).

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[2] An additional possibility would be to offer also a third (hybrid) solution, exploiting the 2D approach for product finding and the 3D approach for product display and examination.

**Audio**

In the case of store background music, unlike real stores, we have the possibility to choose genres according to the customer's *preferred music genres* data.

Background music can be interrupted by voice messages as in real stores (e.g., advertising a special offer), if the `AudioMessage(X)` is set by personalization rules. Unlike real stores, the chosen voice messages can be targeted to the specific customer, both in the promoted product, in the type of voice, and in the choice of words (e.g., a teenager and a elder customer prefer very different kinds of message style, voice, and emphasis).

## 4 Implementing Adaptive VR Stores

A good discussion of the different modules needed by an architecture for traditional adaptive e-commerce sites is provided in [2]. In this section, we briefly add some considerations on the further technical needs imposed by the implementation of an adaptive VR store.

First, there is the need of a language for describing the 3D scenes that could be easily supported by the customer’s browser. Although proprietary technologies are being proposed by some companies, VRML is the only language whose plug-in has already been distributed in tens of millions of free copies, and is regulated by an international ISO/IEC standard [6]. We thus considered the choice of VRML as mandatory for delivering 3D content on the Web.

Second, since VRML is mainly a 3D scene description language, it does not offer sufficient programming capabilities. When, as in our case, there is the need for controlling the virtual world with non trivial programs, the more natural choice is to integrate VRML with Java. For a brief and clear introduction on how the two languages can support each other to provide both interactive 3D graphics and complete programming capabilities, we refer the reader to [3].

Third, architectures like the one described in [2] need to be augmented with additional modules devoted to take personalization decisions about 3D content (as already seen in previous sections) and to implement them by properly assembling different 3D models into a single virtual store and tailoring their attributes. This second task is performed by a *VR Store Creator* module. At the beginning of each ADVIRT session, this module considers: (i) the preferences of the customer about store style, size, music, assistance, and (ii) the changes decided by personalization rules. Then, it implements them by assembling a proper VRML world. The VRML file does not change during the same session to avoid the need for multiple downloads (and resulting waiting times). Decisions for future adaptations will be taken off-line after the session has ended, and will affect the VRML world in the next session.

## 5 Conclusions and Future Work

This paper has examined the current features and mentioned the short term ones of our adaptive VR store. A more long term goal is to explore the possibility of significantly extending the abilities of WPs, enriching them with further user assistance functionalities besides that of leading customers to specific parts of the store. These extended animated characters would be closer to store assistants, capable for example of addressing simple customer questions, taking the customer to any product shelf, and then performing product presentations. Some issues in adding animated presentation characters to a Web interface are discussed in [9].

A recent trend in 3D e-commerce sites is to allow customers to meet and interact in VR stores to satisfy their social needs and build a sense of community. We intend to investigate the impact of this possibility on ADVIRT: it is indeed interesting to note that adding this social dimension can conflict with personalization 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 several features mentioned in this paper cannot target anymore the specific profile of a single customer. Trying to find the best compromise which maximizes the match with the different user profiles 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.

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