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Design of the PromoPad: an Automated Augmented Reality Shopping Assistant

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Abstract: Augmented reality technologies as a new way of human computer interaction make possible real-time modification of our perception of reality without active user interference. This paper introduces the prototype of an augmented reality shopping assistant device, the *PromoPad*, based on a hand-held Tablet PC allowing see-through vision with augmentations. While this new interaction utilizing augmented reality that places products into contextual settings can enhance shopping experience and suggest complementary products, it also has challenges and issues to be used in a public environment such as a store setting. This paper discusses the design and implementation of the *PromoPad*, and addresses the issues and possible solutions. The concept of dynamic contextualization is further investigated in this setting with a list of possible context modifications and their relation to advertising and the psychology of consumer purchasing.

Keywords: Augmented reality, human computer interaction, dynamic contextualization

1. Introduction

This paper presents the design of the *PromoPad*, an Augmented Reality shopping assistant that provides a new way of human computer interaction in a new setting. Augmented reality technologies have been enhancing people's perception interaction with the real world using computer generated virtual objects. Further more, augmented reality technologies change the way that people interact with computer, and the real world. By the new way of human computer interactions, users interact and manipulate with

the real world and real objects with the aid of computers without users' active operation of keyboard or mouse. Considerable amount of research work has been conducted in the area of augmented reality and human computer interaction in various application domains[1-3]. The shopping environment, however, poses more challenges but not yet well explored. First, a friendly user interface and negligible user interference are essential characteristics for such a system. Second, the amount of information that can be delivered to the user is vast, so that how to effectively prov

ide most relevant information to the user without cluttering his/her view becomes a major concern. Cluttering the display can significantly degrade the quality and performance of the tasks that the user is performing and the PromoPad is performing [4]. Third, the users of the system come from different background and possess difference skill levels. They might not use the system as our laboratory staff; they might use and move the system arbitrary as they move around. Hence, robustness and stability are other key points that lead to the success of this design. These challenges are deliberated throughout the design and implementation of the system and will be addressed iThe application of augmented reality in store settings is promising too. Given the fact that 70 percent of purchase decisions are made in the store

[5] and retail grocery shopping in the U.S. alone is a \$450 billion business [6], the PromoPad can be an important tool that can affect both planned and potential purchase decisions. Recent research in advertising shows that a virtual experience simulating in 3-D product visualization results in more product knowledge, better brand attitude, and elevated purchase intention relative to traditional advertising [7]. This work draws on technical capabilities in the augmented reality community in combination with theoretical concepts from consumer response to advertising in order to demonstrate and evaluate the concept of dynamic contextualization.

The PromoPad system, build on the concept of *dynamic contextualization* [8], uses Tablet-PCs as a see-through display [9] to provide personalized assistant information to individual customer. Using dynamic contextualization, the PromoPad not only actively discovers and takes advantage of the context of the user and the environment at a single point [10], it also modifies the context to allow owners direct users' interests in real time using augmented reality technologies. These discoveries and modifications of the context are means to improve human computer interaction and enrich user experience. Augmented reality, as distinct from virtual reality, is the modification of the perception of reality. In this system, the Tablet PC is equipped with a small camera on its back and the display presents the camera image as if the tablet were transparent. Because the image is processed, augmentation graphics can be used to add to the visible context and erasures or occlusions can be used to remove context by diminishment; all of these operations occurring in real time [11]. Several empirical studies on the effectiveness of augmented reality technologies in term of human computer interaction provide sufficient evidence that augmented reality systems improve the operational performance in an instructing assembly task, training, and tourism guide [12-14]. This work explores the benefits of augmented reality in a more natural and more user-centric setting, i.e. a shopping environment. Moreover, the design principles of this system can be easily adapted to other application domains that require negligible user interference, automated context-related information presentation, and friendly usage in public environment.

The PSA [15], MyGrocer [16], and Project Voyager [17] are all prototype shopping assistant that product reviews, promotions, and pricing information. Our PromoPad system addresses different issues from different point of view and hence, proposes different solutions. In addition to providing assistant information, the PromoPad focuses on provide most relevant information to improve shopping experience.

This paper discusses the design issues of the PromoPad system. An analysis of user studies will be included in a separate work.

The rest of the paper is organized as follows. Section 2 gives a brief introduction of the PromoPad's user interface. Section 3 discusses the context-aware automated shopping assistance and dynamic contextualization in detail. Section 4 talks about the methods to evaluate the PromoPad system. In Section 5 we conclude and discuss the direction of future work.

2. Interface design

As we mentioned in Introduction, the first challenge of such a system is that it has to be user friendly and requires no active user interference. The PromoPad possesses these characteristics inherently as it is designed to provide a natural and intuitive computing device. Unlike conventional users of computing devices, users of the PromoPad are not required to actively operate the system by legacy input devices. Without interrupting the shopping process, the system provides consumers useful information at a glance, as natural as seeing a physical sign in the store. On the other hand, if the shopper intends to inspect a particular product, she can instantly access additional information through the system.

The target design of the PromoPad is a light-weight device that can slip into a cradle in the shopping cart and be portable by the user for easy shopping assistance. The primary focus of the PromoPad project is operation when removed from the cradle as an augmented reality shopping assistant. The system consists of a front-end client component and a back-end server component.

The front-end client component is the component that the users interact with. It includes a Tablet PC and a camera that is attached to the back of the Tablet PC. The front-end is designed to track the 3-D position, orientation and context of the consumer, to track shelf and cart stock, and to generate and display graphical information utilizing information retrieved from the back-end server. The Tablet PC is used as a mediated device to deliver graphical information because it is lightweight and its large display can provide both user convenient and rich information. With a camera attached to the back, the Tablet PC works as a video see-through display and is aware of the position and orientation of the customer in the store [18]. What the consumer will see on the display is determined by the user's current location in the store, the user's shopping preference and history, and the product context retrieved. Figure 1 shows a typical usage of the front-end component.



Figure 1 Using the PromoPad in a store setting

The back-end component can be one or more servers that contain store inventory databases, customer profiles and business logic, from which information in the databases is filtered and returned to the front-end component.

3. Automated context-aware assistance

Using augmented reality in a shopping environment, the information that can be delivered to the user's attention can be vast. It can range from the introduction of a new product, a sales sign, or direction to the related product. We would have no trouble to clutter the user's view in the Tablet PC with large amount of information. This makes the user unable to interact with the real world, which breaks the principle of augmented reality technologies. Thus, how to selectively display the most interesting and important information of each individual user becomes a major concern. The system must filter the information stream and provide relevant information that can be accommodated in the tablet display. For example, if the system chooses to flood the user with large amount of promotion information, price comparison, and in-store advertising, then the system accomplishes little more than what could be accomplished by handing the customer a thick flier. The new capability of the PromoPad is that it can selectively display information that is related to the product under inspection and information that is tailored to individual needs. In other words, the information that is presented to the user is highly related to the context of the

user, and the product under inspection. We develop three criteria to determine the relevance of a piece of information to a specific user at a single point in the store:

1. User's location and orientation
2. User's previous shopping history and pattern
3. Product complementary in the store database

We discuss the detail of these three criteria in this section.

3.1 User's location and orientation

User's location and orientation determine what products the user is inspecting. When the consumer is using the PromoPad during her shopping trip, it is reasonable to assume that the position and the orientation of the Table PC are a reasonable approximation of the position and orientation of the consumer as well. A variety of AutoID systems are in development that will allow high-quality tracking of product relative to the PromoPad and knowledge of purchase (cart insertion) decisions.

With an in-store tracking system the PromoPad is aware of its 3-D position relative to store shelves and products. Considerable on-going research has been exploring the use of ultrasonic, RFID, infrared, and vision-based technologies to achieve location-awareness [19, 20]. The tracking method for such a system, however, is challenging. The quality of the tracking system directly determines the robustness and scalability of the whole system. A vision-based fiducial system and its improvement proposed by Owen, Xiao, and Middlin [21] is robust (high correlation), fast (consistently under 2ms). The fiducial images serve as visual clues that accurately tell the system where the camera is looking at. But 256 possible fiducial images are not scalable enough to identify all the necessary products in a typical store setting. Therefore, we use a hybrid tracking system that uses RFID to track down the approximated position of the user and vision-based fiducial system to determine the accurate position and orientation of the user. Figure 2 shows our experimental shelf with several fiducial images on the bottom.



Figure 2 the experimental shelf with fiducial images

The location information required for the PromoPad is considerably more rigorous than that of traditional context-aware computing systems. Owen, et al. [22] discuss many issues relative to augmentation of imagery for AR applications such as the PromoPad. Augmented reality requires modification of the camera image. Achieving pixel-resolution registration of computer graphics with store shelf contents requires high-accuracy knowledge of the location and orientation of the PromoPad. Visual fiducial systems provide sufficient accuracy for high-quality image modifications.

With the tracking system, the PromoPad is aware of the 3-D position and orientation of the consumer relative to the product and store shelves. It then sends a query to the back-end server and displays feedback on the Tablet PC. For example, when the consumer is in the dairy products aisle, the server returns the promotional information for various milk brands.

3.2 User profile

User profile includes such data as brand preference, buying history, shopping pattern, and preference. User profile also includes individual and aggregate behaviors based on shopping habits and demographics. Each time the consumer checks out, purchases are recorded in the store membership database. These systems are already common in many stores that include *loyalty cards* and there is evidence that many consumers utilize these systems [23]. From loyalty card systems or future, automated variations, stores can create personal profiles based on the previous purchases that the consumer has made. For non-member consumers, a generic profile with demographic manipulations can be used.

The consumer will scan her member card or login in as a member before using the PromoPad. Based on history information, the system applies business logic at the database inquiry. The system is able to answer questions like “How likely is it that the customer buy a carton of milk on this visit?”, “How interested is this customer in some toys for 2-3 years old girls?”, “Will the customer like this brand of frozen pizza?” Carefully applying data mining techniques and planning business logic, the system can even predict more sophisticated conditions [24]. Answers to these questions help the system to predict whether or not the consumer will be interested in certain classes of information. If the answer is affirmative, then system will consider that the consumer is definitely interested in this information and delivers it to the consumer using store directions and emphasis of the product on the shelf. If the answer is moderately positive, then it can consider this information may trigger an *impulse purchase*. If the answer is strongly negative, then it interprets that the consumer doesn't like this information or related products, and hence the system will not bother the consumer at all.

3.3 Product Context

Product context is the set of *complementary products* that are associated with the focal product or the product under inspection. A complementary product is a product that enjoys an associative relationship with the focal product. By contextualizing the focal product with a matching product, image or symbol, the consumer's attitude toward the focal product can be influenced. Product contextualization can include functional, aesthetic, or sociocultural complements of the focal product [25].

Functional complementary products are products that can be consumed jointly in order to facilitate some operational relationship. For example, golf clubs can be functionally complemented by golf balls, bag, shoes, etc. A user purchasing hot dog buns is likely to purchase the hot dogs to place in them. Hence, functionally complementary products can have very close relationships that influence simultaneous purchase.

Aesthetic complementary products are products that are consumed because they form an inherently pleasant relationship with each other. Consumers' motivation in using these products is the aesthetic pleasure derived from their juxtaposition. For example, a baroque painting in a baroque designed house gives aesthetic complementary to the house. Aesthetic complementary is often highly subjective; hence it is not currently included in our experiment design, though use of experts may allow for aesthetic suggestions [26].

Sociocultural complementary products are group of products that involve consumption activities and/or products that hold little or no inherent relationship to each other, but are instead related through a sociocultural process of association and ascription of meaning. Groupings are valued for the ability to communicate social messages within a particular culture at a particular historic moment. For example, we may easily socioculturally associate BMWs with MBAs, Rolex watches, etc. And tie-dyed t-shirts are always socioculturally associated with patched blue jeans, army fatigue jackets etc. Table 1 lists some examples of product complementarity as used in the base PromoPad evaluation products database.

Table 1 Product complementarity examples

Focal Products	Functional Complementarity	Sociocultural Complementarity
Digital camera	Photo papers, memory card, printer for digital camera, picture-editing software	Vacation package, plane ticket, ball park tickets
PDA	PDA keyboard, PDA software, Wireless Internet access, memory	Tie, pen, cell phone, laser pointer pen
Perfume	Body wash, deodorant, antiperspirant	Jewelry, candles
Pen	Notebook, highlighter, pencil jar	Hair tie
Candy bar	Soda, popcorns, ice cream	Ball park tickets, Big 'n' Tall clothes or shoes
Wine	Wine stand, cork screw, glasses	Crystal container, romantic dinner, travel package to winery
Shampoo	Conditioner, hair dryer, hair gel, body wash	Fruits, herbs
Detergent	Fabric softener, stain remover	Glass cleanser, floor cleaner

3.4 Dynamic Contextualization with Augmented Reality

Dynamic contextualization is a process of contextual information rendering in multimedia form in response to cognitive needs of users when they are interacting with real objects in a changing physical environment. It is an extension of the concepts: *product contextualization* and *virtual product contextualization*. Researchers define product contextualization as the placement of the product in a particular setting that will resonate with the consumers and make clear that product's consumption practices [25]. Product contextualization is often seen in store displays and advertisement. In electronic

commerce, product contextualization can be easily simulated with 3-D visualization, which can offer a variety of ways for the consumer to arrange a focal product with other complimentary products on the computer screen. Researchers use virtual contextualization to refer to the placement of complimentary products along with a focal product in 3-D visualization in order to affect the user's perception of the focal product [27]. For example, the user can arrange a set of furniture in different settings in 3-D on a website to select the preferable combination. Research demonstrated that virtual contextualization can lead to better consumer experience, brand attitude, and hence influences purchase intention [28].

Dynamic contextualization is superior to virtual contextualization in that it is a combination of both direct experience and virtual experience, resulting in an enhanced product experience. Augmented reality lies between the real world and completely virtual reality [9]. Users can add virtual objects to their perception of the real world to create an augmented reality. Although consumers can view various combinations of a focal product with different complimentary products in virtual contextualization, their product experience is simulated and virtual in the sense that they have no direct contact with a real focal product. In dynamic contextualization using augmented reality technologies, consumers can inspect a real focal product in a virtual context that is simulated to meet their cognitive needs. Consumers can not only see the real product but also instantly access additional product information on the Tablet PC, such as complimentary products and background information of the focal product. Such an enhanced consumer experience in dynamic contextualization is even richer than merely a direct product experience.

Dynamic contextualization modifies the user's perception of the reality by either augmenting context or diminishing context. The latter is referred to as diminished reality in the literature [22].

3.4.1 Augmenting context

Augmenting context is the most common implementation of augmented reality systems, as suggested by the name of augmented reality. By adding context to the focal product, the PromoPad is able to give consumer more information about the focal product that is not possible in traditional media. Theoretically, the added context can be coupons, advertisements or complementing products as discussed in previous section. Based on the advertiser's needs, these pieces of information could be 2D pictures or 3-D objects that appear beside, in the foreground, or in the background of the focal product or immerse into the shelf display. It is actually possible to have content in the display with depths deeper than the physical shelf, allowing a virtual extension of the store space. Figure 3 illustrates the augmentation of a box of spaghetti with an image of cooked spaghetti with sauce.



Figure 3 Augmenting the box of spaghetti with cooked spaghetti and sauce

Likewise, the PromoPad can place information such as complementary settings of the product into the background of the focal product. Although it may not draw the consumer's active attention, the new information affects the consumer's attitude towards this product. The immersive setting will function in a similar fashion. Putting the augmentations in the background or immersing into the layout is more technically challenging. The contour of the front objects needs to be determined and modeled using an occlusion model so that the front objects accurately occlude the virtual object in the background. In an immersive setting, the depth of the virtual object needs to be compared with all the real objects or other virtual objects that may occlude it. Figure 3(2) gives an example of augmenting the background. A comparison of store brand and name brand appears at the background.



Figure 4 Augmenting the background

3.4.2 Diminishing context

Whereas augmenting context highlights the focal product by delivering augmented virtual objects to the consumer, diminishing context emphasizes the focal product by hiding the surrounding product items, most likely non-complementary products or competing brands. Figure 5 illustrates this idea by virtually removing the competitions from the surrounding settings. Removing the competition gives more room to display information for the product that the retailer plans to introduce to the consumer or increase the sales volume at that period of time.



Figure 5 Diminishing context

Both augmentations and diminishment allow retailers to apply business strategy and direct user's interests. Table 2 lists several possible examples of augmentations and diminishment to the focal products, which are listed in Table 1, other than coupons and sales offer.

Table 2 Examples of augmentations and diminishment

Focal Products	Augmentations	Diminishment
Digital camera	Picture slideshow, feature demonstration, accessories	Outmoded models, security locks and latches, film camera
PDA	PDA keyboard, PDA software, Wireless Internet access, memory	Security locks and latches, laptop computers
Perfume	Flowers, romantic pictures	Disliked brands or scent of the consumer*
Pen	Notebook, grade report, back to school picture	Crayon, scissors
Candy bar	Cartoon characters, ice cream	Mint drops, energy bar
Wine	Glasses, roses, picture of a grand banquet	All other than the bottle under inspection
Shampoo	Hair dryer, fruits, picture of model with beautiful hair	Hair dye
Detergent	Picture of silk or wool, movie clip shows the effect after use	Unfavorable ingredient varieties*

* This is determined by user profile, hence it is user dependent.

4. Evaluating the PromoPad system

The design and development of the PromoPad prototype has focused on development of the appropriate technologies for implementation and acquisition of the theory in support of dynamic contextualization as discussed in this paper. The feasibility of applying augmented reality on Tablet PC as a shopping assistant will next be assessed in lab and field experiments, so as to determine the real benefit of dynamic contextualization. As a multidisciplinary project involving researchers from both Computer Science and Advertising, research questions of this user study include (1) whether direct experience can be significantly enhanced with virtual experience that is simulated by real-time rendering 3-D objects during a typical shopping process; (2) how direct experience with different types of products (geometric, material or mechanical) can be affected by different complimentary associations (functional, aesthetic or sociocultural); (3) what is the role that consumer product knowledge and needs for cognition

play in the formation of enhanced product experience; (4) what obstacles exist for the Tablet PC to be used as an effective shopping assistant in a store setting; (5) how participants assess the human computer interaction provided by the PromoPad; (6) how efficient and accurate the tracking and information retrieval are in the system; (7) whether the system is ergonomics friendly; and (8) how realistic the rendered imagery is perceived to be.

A shopping setting will be created in the lab where participants will be invited to test the PromoPad system. Example physical products that were selected from pretests (as reported in Section 3.3EF_Ref48503130 \r \h |3.3}) will be used in pilot studies. Based on pilot study results, research questions, design of the system and measures will be revised and further tested with a sample of consumers in a real store environment to increase the external validity of the study.

Three kinds of data will be collected in experimental sessions. First, the shopper's interaction with all objects on the screen will be tracked and the patterns of interaction will be analyzed to reveal what information is of interest to the shopper, how long it takes for the shopper to process the information and what sequences the shopper follows to access different product information. The tracking data also can help examine the usability of system design. Second, the shopper's overall experience with the products and the shopping process will be measured, along with several dependent variables such as presence, brand knowledge, brand attitude, purchase intention and decision confidence. Third, quality of the system design will be assessed by examining variables such as reaction time, accuracy of data, and user friendliness.

The internal and external validity and the reliability of all measures will be assessed before scale scores are used for analysis. To answer the research questions, a series of statistical analyses will be conducted.

5. Summary

This paper presents the concept of a shopping assistant that utilizes augmented reality technologies to provide personalized advertising and in-store shopping assistant based on dynamic contextualization. This PromoPad system is a step towards ubiquitous computing in the highly lucrative grocery shopping segment. The development goal is to offer a pleasant and inviting shopping experience that is mediated by an augmented reality-based Tablet PC. Beyond traditional context awareness, this paper developed the concept of dynamic contextualization, which suggests the modification of context to direct the interest

flow of users. Dynamic contextualization, the real-time modification of context, can be enabled by augmented reality technologies with augmentations and diminishments. Dynamic contextualization is based on, but extends beyond, the spatial and temporal context of the user. Location context, user context, and product context are integrated in this design to address the requirements of an intelligent context-aware shopping assistant.

The design methodology of the PromoPad system can be extended to other circumstances such as tourism guides, training assistants, etc. Nevertheless, designers of other systems need to deliberately consider the context factors based on the requirements of an application domain.

Although this article has addressed several important issues in designing the PromoPad, it has not discussed the privacy issue in the project. The privacy issue arises when the retailers collect the consumption activities and try to predict the consumer's interest based on her previous shopping behavior. It is necessary to balance the tradeoff between automation and privacy to meet the needs of both retailers and consumers. Consumers may be willing to sacrifice certain degree of their privacy in return for certain value, and retailers definitely should respect the privacy of their customers. The goal of this study is to maximize the automation and the privacy issue is beyond of the scope of this article.

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