StoAR: Blending Physical and Virtual Shopping Experiences through Augmented Reality

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Abstract

Augmented reality (AR) systems allow designers to blend aspects of physical and virtual experiences; however, existing work provides little guidance for effectively merging parallel experiences. We use retail shopping as a case study to understand how user-centered design practices might enable designers to craft novel AR applications from existing parallel in-store and online experiences. Through a series of surveys, prototypes, and design evaluations, we work directly with target users to identify trade-offs of in-store and online shopping and derive a set of design considerations for how augmented reality might support consumer decision making in traditional retail environments. Our findings suggest that users perceive AR as an effective means for contextualized, at-a-glance access to critical information such as price comparisons and reviews, while retaining the convenience and immediacy of in-store shopping. We also found preliminary evidence of how blending existing parallel experiences might inspire novel immersive interactions that transcend traditional retail experiences.

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:-)

Author Keywords

Augmented Reality; Mixed Reality; Shopping.

ACM Classification Keywords

H.5.1 [Information interfaces and presentation]: Multimedia Information Systems: *Artificial, augmented, and virtual*

Introduction

Let's come up with a better opening sentence. = JRB– Yes, please! (No strong feelings on what that might be=DNS)

Many real world tasks can also be accomplished using technology. For example, we shop both in stores and online, converse both face-to-face and over video chat, and learn in both physical and virtual classrooms. However, virtual and physical experiences have unique affordances: shoppers in the real world can see and feel a product, while virtual shoppers can access more product information, such as reviews or offers from other retailers. Augmented reality technologies allow designers to craft applications that combine aspects of virtual and physical experiences. However, to effectively combine multiple existing experiences, designers must identify the critical aspects of parallel experiences and how to leverage their respective trade-offs.

In this work, we use retail shopping as a case study for understanding how to effectively craft mixed physical/virtual experiences from existing practices. Consumers have the option to do their shopping either through a physical store or the same store's online presence, and most consumers have experience with both methods [14]. While specific prior studies of online and in-store shopping have measured the importance of individual factors (e.g., price comparison [8], privacy [11], and convenience [2]), these studies generally model these factors with respect to isolated effects on consumer decision making rather than how they might inform new technologies for supporting consumers in practice.

JRB: I've given this note on all papers this week, but you need to be careful about tense. Different writing styles prefer past vs. present tense. Figure out from DS which should be used, and stick to it. DNS–Does this

Instead of focusing on in-store and online shopping per se, we took a generative approach towards understanding how systems might effectively leverage key components of online and in-store shopping. We applied a user-centered design approach to deriving new design considerations for AR from existing parallel experiences. We first conducted a survey to understand perceived trade-offs in in-store and online experiences. We then designed two low fidelity prototypes based on these experiences and assessed their potential utility through a formative design evaluation using a think-aloud study . The results of the evaluation informed the design of StoAR, a head-mounted virtual reality simulation of a traditional retail environment augmented with critical information according to surveyed users synthesized from conventional online retail experiences. Using this high fidelity prototype as a jumping off point, users provided feedback on the prototype itself in addtion to the potential of AR applied to shopping. Our analysis of user responses to the StoAR prototype provides preliminary design considerations for facilitating consumer decision making and how a design-based approach might inspire novel blended interactions unique to immersive applications.

JRB: What were of the survey? Di form the design?

JRB: Add citation because it is Clay and we love him.

Our results illustrate concrete trade-offs between online and in-store shopping experiences and how those trade-offs might inform the design of a mixed reality application. Specifically, we found that augmented reality can provide critical product information and visualizations. We identify preliminary evidence of the utility of head-mounted displays for these applications. Through the development of StoAR, we provide a preliminary, empirical groundwork for how designers might effectively merge norms of physical and virtual experiences into a hybrid mixed reality application.

Related Work

Previous work applying augmented reality to retail shopping has focused on how designers and system architects properly utilize this novel technology. Ahn et al. employed augmented reality to promote health-oriented shopping[1], and similarly, Cenieros et al. focused on environmentally-conscious shopping [6]. These and other works [7, 15] dis-

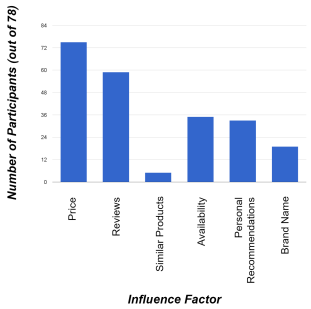

Figure 1: Phase One respondants identified price and reviews as the most critical factors in making their shopping decisions, while product comparisons—identified in later phases as "highly useful"—were initially rated as least important.

cuss the influence augmented reality can have in a store environment. Context-awareness is a useful affordance provided by augmented reality. Designers find that this ability to visually associate digital content with products increases customer empowerment, user efficiency in gathering information, and system influence [9, 12, 17]. Augmented reality application work has additionally focused on collaborative experiences and visualizations [7, 13, 15, 16]. These efforts highlight the importance of context-awareness and visualization provided by augmented reality in providing new functionality. However, we engage in a user-centered design process to identify aspects of existing parallel experiences in order to merge those experiences to one that is useful and familiar.

Much of this previous work has focused on mobile augmented reality (MAR). However, MAR systems suffer from a number of limitations for retail shopping such as insufficient processing power, required use of hands and an intermediate screen, and a field of view constrained by screen size [5]. Head-mounted displays (HMDs) such as Microsoft's Hololens offer opportunities to overcome these limitations, and the ability to synchronize data with head movements may allow consumers passive access to visual information in context. In this work, we explore how systems might effectively leverage HMDs to provide product information in context for traditional retail environments.

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Other work has introduced spatial augmented reality (SAR) systems and applications. SAR applications employ ubiquitous computing to project context-aware digital content into the user's physical environment [3, 4]. Technical advantages of a SAR system include removing the need for users to wear or carry often cumbersome equipment and a non-restricted field of view. However, one limitation of SAR systems is that they require a static, controlled environment to be used effectively due to the use of fixed displays [5].

DNS: yep, really might be good to blend with the previous paragraph and leave some space to talk about design since that is a contribution of the work

In this paper, we take a user-centered design approach to testing how the grounding of design principles derived from this previous work on mobile and spatial augmented reality applies to HMD-based augmented reality. We also examine how HMD-based AR may combine some of the benefits of these approaches while removing some of their limitations. Our work iterates on this approach in three distinct development phases: an open-ended survey, a low fidelity prototype, and a high fidelity prototype.

Phase 1: Online Survey

We conducted a preliminary survey across 78 participants over social media to identify important aspects of customers' in-store and online shopping experiences. We asked participants to respond to a series of open-ended and multiple selection questions to identify the three most important pieces of information involved in their shopping decisions (Fig. 1), what they did and did not like about existing in-store and online shopping experiences, and ways they currently use mobile technology as part of their existing shopping experiences. We used the responses from our online survey to isolate factors of in-store and online shopping that were most important to our participants.

We clustered responses based on similarity and found that participants appreciate the immediacy and physical interaction with products in a store. Cited drawbacks of in-store shopping included the inability to comparison shop, to get the lowest or most appropriate price, and store staff trying to influence purchase decisions. Participants shopping online appreciate low time-to-purchase and the ability to shop any time from practically any location, but disliked the associated shipping charges and delivery wait times. These findings provided a foundation from which we engage in our

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(a) Context-aware paper prototype

(b) Menu-based paper prototype

Figure 2: Phase Two compared perceptions of a context-based and menu-based approach to augmenting traditional retail shopping with important factors of online shopping identified by participants in Phase One.

design work in Phases Two and Three.

Phase 2: Low Fidelity Prototype

We used the results from our preliminary survey to inform our initial design work. Our focus on AR allowed us to explore how critical factors of online experiences from the original survey, such as access to reviews, could be brought into the store environment while preserving critical aspects of in-store decision making, such as being “hands-on with the product” and “leaving the store with the product.”

We hypothesized that an augmented reality application that supplemented a traditional in-store experience with immediate access to core aspects of online shopping would improve consumers’ confidence in their purchasing decisions. We used the results from our survey to design two sketch-based low fidelity prototypes of an AR system. The prototypes, shown in Figures 2a and 2b, consisted of online content drawn as AR menus on transparency sheets and overlaid onto an image of an electronics store. We used the prototypes to compare hierarchical menu-based content and context-aware virtual overlays for accessing information about price, review, rating, and product specifications. We collected feedback on our designs through a think-aloud with three participants.

Participants were asked to choose which laptop they would purchase for each condition based on the available information, with system type randomly ordered. They walked us through the factors in their decision making processes, including how they would use each prototype in making their decision and absent features that would help formulate the decision. We recorded these responses and used them to inform the next phase of our work.

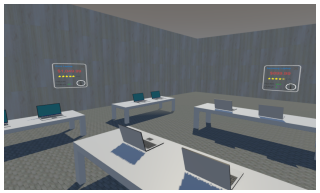
Generally, participants were more receptive to concise information in the overlays than to the navigation-heavy menus. Participants felt the overlay was less obtrusive, better contextualized in the physical location of the products, and required less interaction to retrieve the necessary information. Participants felt that this would lead to faster and more confident decisions than a menu-based approach. Participants also requested the ability to compare information about multiple products in one view, to toggle the displayed content, and to engage with visual product demonstrations for increased efficiency and more empowered decision making.

While our online survey suggested that people wanted access to more information, the paper prototype study enabled participants to envision the system in more detail and allowed us to identify how in-store and online experiences could be merged beyond simply taking the best features from each. For example, rather than simply more informaion and reviews, we found that participants wanted concise visual summaries of product ratings and specs. Simulated product demonstrations would leverage hands-free viewing to provide consumers with a tailored, hands-on experience in-store. We used these findings to synthesize design features from that balance the important aspects of virtual and physical experiences while also considering the trade-offs of AR platforms in retail environments. We did this by designing a context-aware approach to content delivery in the final phase of our design process.

Phase 3: High Fidelity Prototype

We used the insights generated in the first two phases to design a fully immersive StoAR prototype for use in head-mounted displays. Because we did not have access to a retail testing environment, we simulated a retail display in virtual reality based on configurations found in a local retail outlet. We then added an augmented reality interface to the simulation to provide concise visual summaries of rating and price information (Fig. 3). While our use of a VR store

(a)



(b)

(c)

Figure 3: In Phase Three, we designed a simulated retail environment augmented with supplemental augmented reality panels of product information. We then measured participant responses to this StoAR prototype to provide preliminary data about aspects of an augmented shopping experience that would best support consumer decision making.

simulation removes immediate access to real life products found in a real store, the fully immersive environment allowed us to closely control the relationship between the prototype AR interfaces and simulated products.

We recruited 20 participants from a local research expo to evaluate our prototype. Participants first freely navigated the virtual representation of a store augmented with static content containing information about each device. After navigating the scene, participants completed a short survey that asked for their perceptions of the prototype's usability, potential impact on decision-making, utility of individual design components, perceived trade-offs compared to existing technologies, and potential limitations of the approach. They also provided feedback on additional applications where they envisioned using mixed reality experiences for decision making. As with the initial online survey, we analyzed the qualitative feedback provided by users by clustering their responses into common themes.

Participants envisioned using this platform for comparison shopping; rapid access to reviews, prices, and product specifications; and for visual demonstrations of product use. However, participants also felt minimizing the amount of visual information was key for reducing potential distractions and for a more streamlined retail experience. Participants also desired several novel interactions with the provided content, including the ability to keep information "pinned" within a single view for comparing non-proximal products and to compare prices of a product against other stores' prices on-demand.

Our findings also helped us to outline preliminary ways designers can leverage the trade-offs of AR platforms when crafting blended experiences. In open-ended responses, many participants commented on the utility of the system for decision making in other contexts, for example in situations with aesthetic considerations, such as home furniture purchases, and for "flipping" the in-store buying process by allowing online shoppers access to simulated products on-demand from anywhere. Additionally, while some participants were concerned with the form factor of the HMD, open-ended responses showed a preference for the passive-viewing and contextualized information presented through the HMD compared to using mobile phones to access online information about a product in-store.

Discussion

Merging Physical & Virtual Experiences

We found preliminary evidence that AR can merge online and in-store experiences to benefit the consumer by preserving aspects of in-store shopping that people enjoy while adding preferred aspects of online experiences. In the initial survey, participants cited the ability to find the best price and access reviews as the most important reasons to use technology in shopping. However, the participants who interacted with the StoAR prototypes indicated that it would allow them to better analyze product specs *in situ*, compare reviews and ratings against their own experiences, and mediate their interactions with physical products through virtual demos.

These findings align well with prior studies in e-commerce, which demonstrate the utility of price and product comparison in online shopping. Our design-based approach confirmed important aspects of online shopping shared by participants in the initial survey. We also found that people's perceptions of how AR might benefit their decision making evolved as the prototypes grew more sophisticated. These shifting perceptions suggest that using prototypes as design prompts is beneficial for helping people envision how AR experiences might differ from conventional methods.

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New Opportunities for Blended Experiences
We also found evidence that AR might enable unique kinds of decision support that neither physical nor virtual experiences alone can provide. For example, our high fidelity prototype provided static summaries of the product data identified as critical in the low fidelity study, similar to those accessible through a product specification sheet. However, in the high fidelity prototype, participants expressed an additional desire to interact with the system, such as the ability to virtually "pin" relevant information for easy access as they navigated the store or access to specific details on demand.

Participants also reported a desire to use AR to simulate their own at-home context or use case for a particular product, particularly room design and game previews. They felt such features would allow them to "look at products without being at a brick and mortar store," prioritizing the convenience of online shopping. The ability to explore these simulations to virtually unbox a product would provide additional information inaccessible in traditional experiences.

These findings collectively suggest that designing mixed reality applications is not as simple as blending the best aspects of both the virtual and physical experiences. AR technologies allow new methods for supporting decision making not afforded by purely physical or virtual methods. Instead, designers must critically reflect on how AR may effectively mediate novel kinds of interactions to transcend traditional approaches and provide consumers with new forms of decision support. Future work can explore how the capabilities of these technologies and properties of the target domain and task might inform novel AR experiences.

Designing for Effective Communication
In our final questionnaire, participants frequently commented on the need to carefully limit the amount of information provided by the interface. Participants want to be empowered with pertinent information, but it must be easily accessible and digestible to avoid interfering with the immediacy of the in-store experience. They expressed some concern about trying to process too much information and about the display being too distracting, inhibiting their ability to navigate the physical store. Instead, participants preferred sparsely presented information in-context, allowing them to access relevant review and product information at a glance.

Future systems will benefit from a better understanding of the balance between information presented and visual space consumed. Our findings identify a need to understand how AR systems might balance communicative power with interaction to deliver necessary information at a glance. A lack of consensus amongst participants as to what information is "necessary" suggests opportunities for designing intelligent interfaces and customized experiences not available in real world environments in order to support individual decision making.

Limitations & Future Work
Our high fidelity prototype used a simulated store display rather than a real world environment. While this approach allowed us to conduct a preliminary evaluation of the prototype application without the added complexity of instrumentation or physical obstacles, it also limits our ability to fully characterize the affordances of our prototype in practice. Previous work such as et al. [10] deals with effectively prototyping augmented reality experiences. Prototyping in the intended medium, in our case an augmented reality head-mounted display, yields a more rapid prototyping process than a separate device or framework. While we believe that the design guidance provided by our work can inform effective blended experiences, we also realize that further refining and implementing StoAR in full AR is a critical next

step.

In our first survey, many participants reported that they use their mobile devices to engage in online shopping while in a physical store. While this approach allows for people to retrieve in-depth information *in situ*, it also generally requires significant effort to locate and compare relevant information on the fly. Participants reported that they "like the idea of hands-free/ambient information" offered by HMDs over mobile devices, but were also concerned about the legibility of the information presented in AR. Our future work will directly compare traditional mobile devices to the StoAR approach to better understand the trade-offs of blended and parallel methods for decision making.

Conclusion

We explored how understanding the trade-offs of parallel physical and virtual experiences could inform mixed reality applications in the context of retail shopping. Our findings suggest that participants appreciated the ability of mixed reality experiences to offer more rapid access to information about products while preserving the physical interactions offered by in-store experiences. Using a design-based methodology allowed potential users to envision ways that AR technologies might enable new experiences beyond those offered by physical or virtual methods alone, such as mediating evaluative interactions with products like guided demos or simulated placement. Our findings, gathered throughout the design process, highlight the potential for AR in retail environments and open new avenues for understanding how we might effectively derive new AR experiences from existing processes.

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