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

Authors' choice; of terms; separated; by semicolons; include commas, within terms only; required.

ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]:

Miscellaneous; See [http://acm.org/about/class/1998/]: for full list of ACM classifiers. This section is required.

Introduction

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 into a single application, 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. The retail industry has shifted more of its commerce online. 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 [13]. Retail shopping also aligns well with theoretical guidelines for effective AR applications. While specific prior studies of online and in-store shopping have measured the importance of individual factors (e.g., price comparison [7], privacy [9], 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.

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 an iterative, 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 synthesized from conventional online retail experiences.Our analysis of user responses to the StoAR prototype provides preliminary design considerations for effectively blending online and in-store shopping experiences to facilitate consumer decision making and how a design-based approach might inspire novel blended interactions unique to immersive applications.

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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. We found that the benefits of each experience generally mirror the drawbacks of the other. Specifically, we found XXXand identify preliminary evidence of the utility of head-mounted displays for these applications. Through the iterative development of StoAR, we provide preliminary an empirical groundwork for how designers might effectively merge norms of physical and virtual experiences into a hybrid mixed reality application.

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Related Work

Previous work applying augmented reality to retail shopping has focused on how designers and system architects properly utilize this novel technology [1, 8, 10, 12, 14, 16]. 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. Other AR application domains focus on collaborative experiences and visualizations [6, 11, 15].

DNS: Pull out a few of these citations into specific examples. E.g., "For example, Ahn et al. did something interesting. Olsson et al. did something else. These efforts highlight the importance of context provided by AR for consumer decision making. However, they don't do something that we do..."

DNS: Do we have any insight into how current systems are designed? That may be a nice transition from conventional systems and this approach.

cite source? DNS: Yes, please!

DNS: Should add a note here on what specifically they tell us about this application

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.

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.

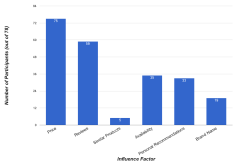

Figure 1: Phase One respondants identified price and reviews as the most critical factors in making their shopping decisions, while product comparisons—identified in later phases as "highly useful"—were initially rated as least important. **DNS: Axis labels please!!! Turn into vertical chart s.t. it's legible as a margin fig. Also use full labels rather than ellipses. May have to reconstruct in powerpoint or inkscape**

In this paper, we take a user-centered design approach to testing how the theoretical grounding 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

Methodology

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 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 identify 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 shoppinig 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

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findings provided a foundation from which we engage in our design work in Phases Two and Three.

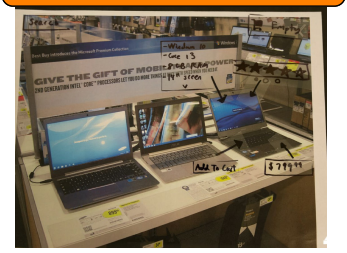
Phase 2: Low Fidelity Prototype

Methodology

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 identified in the original survey, such as access to reviews, could be brought into the store environment while preserving aspects of in-store decision making, such as being "hands-on with the product" and leaving the store with the product.

DNS: Is there a quote that can go here?

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 consumer's confidence in their purchasing decisions. We used the results from our survey to design two sketch-based low fidelity prototypes of an AR system containing aspects of in-store and online shopping experiences that survey participants from Phase One identified as important. 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 two prototypes to make a comparison between hierarchical menu-based content and context-aware virtual overlays of product information. We collected feedback on our designs through a think-aloud with three participants.



(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.

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what specific AR components were tested here (e.g., reviews, product comparisons, specs, etc.)? What were your measures here (e.g., confidence in the decision, time to decision, etc.)

JRB: How did you the data from this

Generally, participants were more receptive to quick and less information than to the fuller, menu-based approach. Participants stated that the ability to compare the specifications of two different laptops in the same view is valuable in decision-making. Participants also expressed a desire to toggle display of content. One participant identified demos as a useful application of augmented reality in retail.

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Phase 3: High Fidelity Prototype

Methodology

We used the insights generated in Phase Two 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 review and price information (Fig. 3).While our use of a VR store simulation removes immediate access to real life product found in a real world store, the fully immersive environment allowed us to closely control the relationship between the prototype AR interfaces and simulated products.

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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 usabil-

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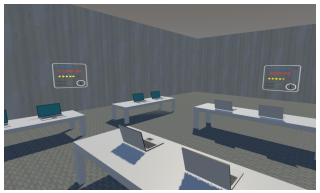

(b)

(c)

Figure 3: In Phase Three, we designed an immersive simulated retail environment augmented with supplemental AR menus. We then measured participant responses to this StoAR prototype to provide preliminary data about what aspects of an augmented shopping experience might best support consumer decision making. **DNS: Please revise this wording :-)**

JRB: Clarification please.

ity, 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 said they envision using this platform for comparison shopping, quickly seeing reviews, prices, and product specifications, and visual demonstrations of product use. Lower depth of product information was provided as a trade-off of the system. Participants expressed concern about digital content distracting them from the physical environment.

We prompted participants for additional features they would like to have in a retail augmented reality system. Participants detailed several desired interactions with the provided content. In line with feedback from the low-fidelity prototypes, participants wanted to keep information “pinned” within a single view such that they could comparison shop, rather than needing to physically navigate between products, as implemented in our prototype. Participants also wanted to compare prices of a product against other stores’ prices.

JRB: Same comment as Phase 2. This is a list of what they told you. Can you take it one step further and tell us what this means? What are the implications of these comments? You said you did this – "We explored how understanding the trade-offs of parallel physical and virtual experiences could inform mixed reality applications in the context of retail shopping." – so tell me what the results of this phase told you about those trade-offs. DNS– Yes, please! Especially look how things evolved from the first phase until here. Also, for Phase 2 & 3, the idea of new applications, such as Demos came up. Those should be brought up in the findings as evidence of consumer thinking evolving with the design prompts–a big win for this type of methodology.

Discussion

We explored how understanding the trade-offs of parallel physical and virtual experiences could inform mixed reality applications in the context of retail shopping. Participants perceived mixed reality experiences offer more rapid access to information about products while preserving the physical interactions offered by in-store experiences. Using a design-based methodology allowed participants 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, such as 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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Merging Physical & Virtual Experiences

We found preliminary evidence that AR can merge online and in-store experiences to benefit the consumer, preserving aspects of in-store shopping that people enjoy, while

adding preferred aspects of online experiences. While participants first identified the ability to find the best price and understand reviews as the most important aspects of using technology in shopping, participants reported that StoAR 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 when compared to conventional retail shopping.

These findings align well with prior studies in e-commerce, which demonstrate the utility of price and product comparison in online shopping; however, our findings also show that blending benefits of online shopping with traditional retail outlets may provide additional benefits not accessible online. Our design-based approach did to identify confirm important aspects of online shopping. 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.

New Opportunities for Blended Experiences

better section title

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 ready access as you navigate 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 tradition 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, people frequently commented on the need for carefully limiting 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 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 glace.

Future systems will benefit from better understanding the balance between information presented and visual space consumed. Our findings identify a need to understand how AR systems might balance communicative power with inter-

action 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. 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.

are there other examples we can cite of prototyping ar in vr we can cite?

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 consuming information 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

write this :-)

We did a thing, it was interesting, we learned from it.

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