Shop-i: Gaze based Interaction in the Physical World for In-Store Social Shopping Experience

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Abstract
Gaze-based interaction has several benefits: naturalism, remote controllability, and easy accessibility. However, it has been mostly used for screen-based interaction with static information. In this paper, we propose a concept of gaze-based interaction that augments the physical world with social information. We demonstrate this interaction in a shopping scenario. In-store shopping is a setting where social information can augment the physical environment to better support a user's purchase decision. Based on the user's ocular point, we project the following information on the product and its surrounding surface: collective in-store gazes and purchase data, product comparison information, animation expressing ingredient of product, and online social comments. This paper presents the design of the system, the results and discussion of an informal user study, and future work.

Author Keywords
Gaze based interaction; Eye tracking; Visual attentive interface; Context-aware computing; In-store shopping experience.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Attentive User Interfaces [10] are a subset of context-aware computing [8], which use direct attention of the user as an input method. In particular, visual attentive interfaces [8] utilize eye contact as a primary input. Visual attentive interfaces have good affordances and efficiency; they use the natural behavior of human sight that does not need to be learned or memorized. Despite this benefit, most of visual attentive interactions in Human-Computer Interaction are restricted to screen-based interaction. Eye trackers have predominantly been utilized as evaluation devices in virtual environments [5] or as supportive tools for the disabled [7, 11]. However, recent development of cheap sensors, compact projectors, and displays allows visual attentive interface to be possible in physical world which led us to the following research question: How should we design such interface?

We explored gaze-based interaction with social information in a grocery store setting. In-store shopping is an ideal setting for gaze-based interaction because information on product packaging is constrained by package size and cannot update dynamically. As a result, shoppers now use their mobile devices to augment in-store information, with 84% of smartphone shoppers using their device to search for product information in a physical store [13].

We argue that visual attentive user interfaces can improve in-store shopping experiences. Gaze is an intuitive interaction modality particularly while shopping. In addition, this type of interface means stores can dynamically update information associated with a product to help users to make right purchase decision. However, it has to be delivered in physically natural and appropriate manner.

In this project, we developed an attentive user interface for socially augmented in-store shopping. The system presents social information on the product itself and on the space surrounding the product where the user may look. Current in-store shopping experiences lack information about how others have interacted with the product. Our system presents four types of information about a product in four areas respectively (Figure 1).

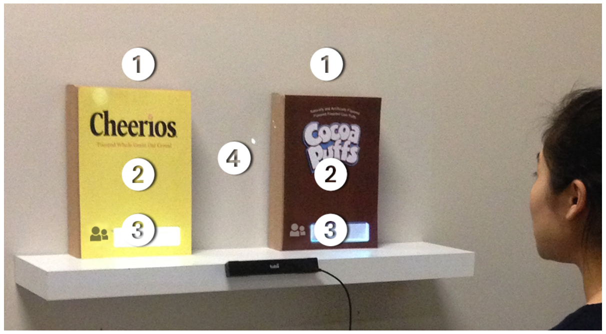

Figure 1. Interactive social shopping shelf: (1) the top: collective in-store gaze and purchase data, (2) the middle: an animation expressing ingredients, (3) the bottom: comments from a social network service and (4) information projection in the between the product: nutritional comparisons with adjacent products. Copyrights of the logos are held by General Mills.

Related work

Three threads of related work are relevant to our system: eye-gaze based interfaces, augmented reality displays, and HCI research on grocery shopping.

Eye tracking based interfaces

The majority of eye tracking studies focus on screen-based interfaces such as situated displays [12] or use eye tracking in usability evaluation [5]. Eye tracking has also been used for interfaces to support people with disabilities, such as text entry systems [7] or game interfaces [11]. However, a gaze-based interface with augmented display in a physical space has rarely been explored with few recent exceptions [3, 8]. We investigate eye-gaze based interfaces in the physical word and design a system to support the average user.

Augmented reality
In context-aware computing, any surface can become an information display. Much research has investigated different ways to augment surfaces of real products like kitchen furniture and appliances [2], retail displays such as showing which wines have been the most popular [4]. Our system makes this augmented reality interactive by using gaze-based interfaces.

Grocery shopping experience in HCI
A lot of brick-and-mortar shopping experience research in HCI is either context-aware [1, 9] or social [4, 6]. Context-aware shopping experiences in grocery stores mostly focus on in-store guidance through a contextual object like a shopping cart [1, 9]. These systems were designed by much of shopper's cognitive process [9] of shopping, and it supported users to find and purchase products better [1]. However, equipping every cart with an expensive device was unreasonable and limited useful resources in small screen seemed inefficient. Our system takes advantage of recent technological advances in sensing that have decreased sensor and mobile device cost.

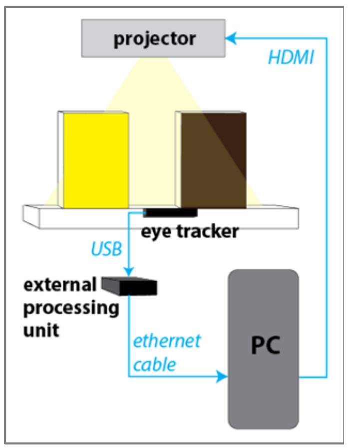

Figure 2. System diagram.

Smartphones make social shopping possible at a distance and seeking remote shopping advice using mobile devices is an emerging trend [6]. On the other hand, 45% of smartphone shoppers use personal mobile devices to find product reviews on electronics [13]. Our system makes the best use of social network services (SNS) as a helpful resource of product review, but we minimize direct interaction with the SNS (e.g. no support for posting) to keep the shopping experience natural.

Designing gaze-based interaction for in-store shopping experience
The design goal of this project is to expand the capability of brick-and-mortar stores in order to support people with shopping while preserving the physical value. We chose cereal boxes as our test product, because it is a general product that people of all ages can relate to.

Set up
The system consists of an eye tracker (Tobii X2-60) [14], an eye tracker external processing unit, a projector, and a PC that is both a server and a client (see Figure 2).

Interaction design
Package design: Current designs often can be text heavy. We removed excessive message on the box to deliver vital information based on the user's eye gaze.

Physical information space: Space is divided into three interactive zones. User's eye gazes constantly move, so the separation of space was important to distinguish each type of information. Every space is divided by the contextual relationship with the product: the top of the product where figuratively overviews the entire row of the product is for collective data of view and purchase. The center of the product, given the most attention, is devoted to the animation of the product. The bottom of the product receives less attention and is for social comments, which is subsidiary information. The area between two adjacent products is a shared area and is used for comparison information.

Selection, action, and feedback: A dot follows the user's eye gaze as an indicator. When the user looks at any of the three zones on the product, the dot follows to notify the user that the system is synced with her eye gaze. When the user fixates on any of the areas for 5 seconds, information rapidly appears and the dot disappears. Some information, such as comments, gets updated every 10 seconds. However, accurate fixation is difficult to define in the current system because the user could blink or have a wandering gaze. We decided to leave the information present for 3 seconds to account for mistaken gaze movements.

Information design

Collective in-store gazes and purchase data: One of the frequent in-store assumptions is that an empty shelf signals product popularity. This cue is used in part because it is the only visible cue of others' shopping behaviors. However, stores could more accurately provide information about popularity using purchase data accumulated in point of sales (POS). This data can be utilized to convey popularity information to users in response to their gaze. In our system, we reveal purchase history above the product, so it can help people to make accurate popularity assessments (Figure 3). In-store gaze data indicates how many times users stared at the product on that day, and purchase data indicates how many times the product was sold on that day. If a new user is detected, the number of gazes increases.

Animated ingredients: Current cereal box designs have static images and are often overloaded with text. In our system, we eliminated images from the box and made

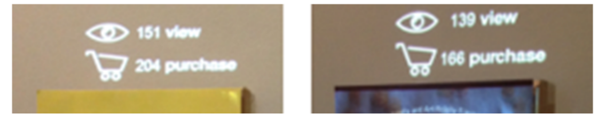

Figure 3. Collective data.

a lively animation to represent the physical product inside the box to better engage the customer (Figure 4). The system presents an animation of cereal falling into the box to visualize its appearance and taste by showing the ingredients. The logo gets highlighted so people at a distance will also notice the product and even attract them to get closer and explore the product.

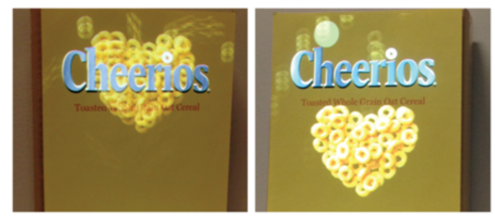

Figure 4. Animation. Copyright of the logo is held by General Mills.

Online Social comments: Shoppers seek product reviews in physical stores using their smartphones [13]. In our system, we incorporated Twitter messages, where people actively comment about products and share their thoughts. The Twitter section of our display is designed to stream positive and negative opinions about the product in real time as it is discussed online. In the system, Twitter messages randomly change every 30 seconds. The messages are pre-categorized by whether they are good or bad, but the system can detect the difference by keyword matching in the future. An angry or smiley face icon easily informs the user whether the comment is bad or good (Figure 5).

Figure 5. Bad comment(top), good comment(bottom)

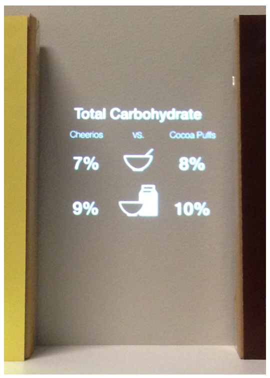

Figure 6. Comparison information

Product nutritional comparison information: During our field research at a local grocery store, we noticed that people look attentively at nutrition information; it is an important element in the purchase decision. In our system, we made nutrition information more visible (larger and more visually salient) than on a printed box and support comparison with the adjacent product in response to gazing at the area between the two products. Nutrition facts are divided into two parts: with and without milk. Information such as vitamin content is compared every 30 seconds (see Figure 6).

Informal user study

We tried our system with 15 users for 3 to 5 minutes each. Because this system was intended to be walk up and use, the calibration stage was eliminated. Instead, we estimated the center gaze point by calculating the average value of the left eye and the right eye. The system worked great for some people but the accuracy was low for others due to lack of calibration.

Overall participants in our exploratory study had a positive reaction to the system. Most people particularly thought the product comparison feature was useful. Also, users felt that using the physical environment as a display was more natural than using an additional wearable device, such as Google Glass, to accomplish the same goal. Our user study identified several interaction design challenges with gaze-based augmented shopping interactions, described below.

Interaction design challenges
Learnability: How can we communicate better that this is a gaze-based interface? A dot indicator that follows the user's gaze was added, but it was still not enough to communicate to people who are not familiar with such an interface. We will explore adding audio instructions to point out the eye-gaze interface when a user is passing by.

Distance: Should we provide different depths of information based on user distance from the product? In physical shopping, people tend to go closer to the product they are interested in and pick it up to get whatever information they seek. In our system, we can offer different levels of information, from general information to personalized or specific information as the user's distance from the product decreases.

Controllability: Should one person control the interface, or should multiple users cooperate? Several people in front of the same product is a normal scenario in a real store. We can limit the number of people who can control the interface, and the system can allow them to use it freely. If more than one person is looking at same information, like an animation, it can show more dynamic movement as the number of gazes add up.

Future work

The current system is not programmed to receive real-time Twitter messages, but it will be updated to stream messages using keyword and hashtag search to get comments about a product as they appear. Also, user's eye gaze detection accuracy will be improved. This work also opens up many future study opportunities. More research should be done to design basic interaction patterns for gaze-based interaction. This includes functionalities such as cancel, drag, hover, and zoom in and out, which has not been defined in gaze-based interaction. Another area is personalization and integration with other devices' ecosystems. Smartphones or other gesture sensors can be combined with our system to provide personalized information and even make suggestions based on the user's diet, health, and so on. These research topics can upgrade our system to accommodate various user populations, such as people with low vision or allergies, and help them shop more conveniently, reduce purchase mistakes, and elevate their shopping experience.

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