Multi-user Multi-device Interaction with Large Displays at the Point of Sale: An Application Case

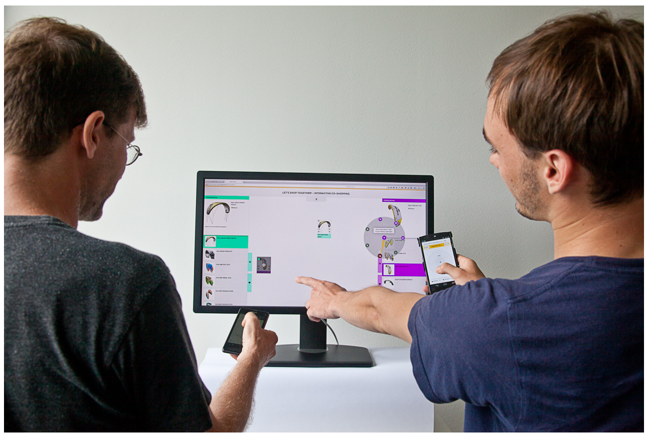

Figure 1: The system in use.

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Abstract
The internet raises challenges for retailers, since it provides a competing sales channel that allows effectively unlimited access to arbitrary products. In particular, this enables a phenomenon known as showrooming, where customers inspect products in local stores and subsequently order from arbitrary online shops. By combining large public displays in stores with personal mobile devices, our prototype multi-user shopping system has the potential to alleviate this: Store-specific shopping carts on the mobile bind customers even after they have exited the store. Significantly, the system is optimized to minimize attention switches between the devices by treating the mobile device as eyes-free remote control wherever possible, using the mobile display only for personal data. We report on interaction concepts, our prototypical implementation, and user feedback, contributing an initial iteration for best practices in this domain.

Author Keywords
Multi-display environment; cross-device interaction; large displays; mobile phones; point of sale; attention switches

ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces, Interaction styles

Introduction

Due to hardware advances, large public displays – both output-only and interactive – have become commonplace in retail. However, they are used primarily as additional marketing channel. Although some efforts have been made to establish them as direct sales mechanisms as well, this is still the exception. Also, public displays by themselves are inherently unable to preserve privacy when displaying personal information such as shopping cart contents. At the same time, showrooming (customers inspecting products in local stores and subsequently ordering from an arbitrary online shop) threatens sales in retail [1]. Multi-device interaction with mobile devices allows adequate display of private information. In the context of showrooming, it is also significant that it allows shoppers to take their shopping cart and preferences with them when they leave, thus making it very easy to buy from the retailer's own online shop if and when the decision to buy is made. Furthermore, shopping is often a group experience, and group shopping has the potential to increase the customer base and motivate shoppers [3].

In this work, we therefore present a system that supports two-person shopping in a multi-device environment (Figure 1). Significantly, the concept allows shoppers to preserve their shopping carts on their personal devices for later access and possible purchase. Since attention switches between displays have been shown to be disrupting (e.g., [5, 7]), our interaction design is specifically geared to minimize these. For menu selection in particular, we rely on a pie menu adapted to multi-device operation, where the mobile serves as input device and visual feedback is displayed on the public display.

The rest of the paper is structured as follows: After a short survey of related work, we present requirements. These form the basis of the system design that follows. In further sections, we describe relevant implementation details and informal user feedback we gathered.

Related Work

Research on public displays in general is a very wide and active research field. For space reasons, we therefore refer to Müller et al.'s overview on the subject [4]. In the following, we present a selection of relevant papers that cover multi-device shopping systems, handling of gaze switches and pie menus that separate input and output device.

She et al. have recently published a survey in the area of interactive displays combined with mobiles for advertising [6]. They review methods used at varying stages of interaction and assert that mobile devices "should be integrated" into the process. Yamaguchi et al.'s paper on SWINGNAGE [8] presents a multi-user shopping system that uses a gesture-based mobile interface for interaction. Device pairing is based on matching device accelerometer data with corresponding depth camera data when the user performs a gesture.

Gaze and attention switches as well as change blindness issues have been identified a number of times as obstacles in multi-device interaction. Significantly, Rashid et al. [5] quantify the costs involved and report a time loss of 1.8 seconds per gaze switch on average. von Zadow et al. [7] also find that gaze switches cost time in a multi-device configuration involving an arm-mounted device.

Pie menus have been found to be effective in multi-device contexts several times. In particular, Zhao et al. [9] use an iPod's circular touch pad for a radial menu whose items can be accessed by sliding or taps. The menu provides auditory feedback (reading out menu items + sounds).
A user study shows there is no significant difference between visual and eyes-free menu in terms of selection time

and accuracy. Also, in pieTouch, Ecker et al. [2] present a dwelltime-activated radial touch menu with auditory feedback for in-car information systems control and find faster performance and higher attractivness ratings than a simple touch interface in this particular setting.

Requirements

In an initial step, we gathered requirements based on the one hand on our survey of related work above and on the other hand on experiences with a previous shopping system[1]. We will refer to the requirements throughout the paper as R1-R5:

- (R1) Walk-up-and-use: System usage should be self-explanatory. There should be no need to install additional software on the user's mobile device, as this was found to deter users in the previous system; Yamaguchi et al. have similar findings [8].
- (R2) Minimal hardware requirements: It should be possible to use existing public displays connected to the internet. This precludes using touch functionality on the public display. It also makes it impossible to use bluetooth or NFC for networking.
- (R3) Support collaboration: The system should support more than one user to take advantage of the potential of group shopping [3].
- (R4) Respect privacy: Personal information such as shopping cart and wish-list should not be publicly visible.
- (R5) Minimize attention switches: Attention switches are associated with high time costs and cognitive disruption and should therefore be avoided [5, 7].

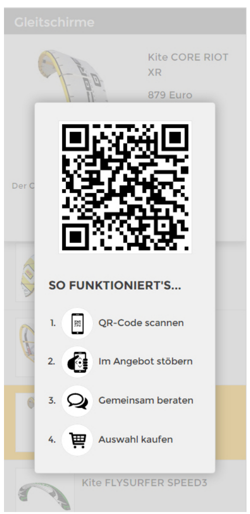

Figure 2: User-specific part of standby screen with QR code used to connect to mobile.

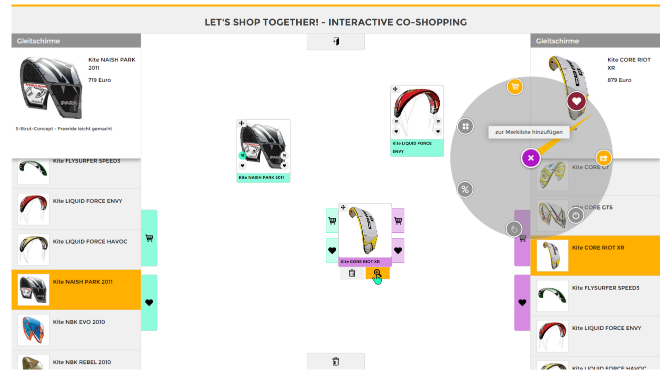

Figure 3: Main application screen: The left user is in item selection mode, the right user has an active menu. Three items are visible in the central discussion area.

System Design

Our system supports browsing through a product list, selecting products and putting them in a personal wish list, a personal shopping cart or a shared discussion area. The large public screen is divided into workspaces for each user on the sides as well as a large central area for shared discussion (Figure 3). As a general principle, visual feedback is delivered on the large screen where possible to avoid an attention switch (R5), while the mobile shows only a minimal interface that can be ignored once usage has been understood (Figure 4). Exceptions are made only for private data such as the user's shopping carts (R4). Mobile device vibration is used as an additional user-specific feedback channel. Furthermore, the mobile device screen orientation is locked to portrait mode to avoid interface rotation while the user is not looking at the mobile.

In idle state, the screen displays QR codes in the user workspaces (Figure 2) that can be used to connect a mo-

[1] ZMOSH by SALT Solutions: http://www.salt-solutions.de/blog/index.php/das-elektronische-einkaufsregal/

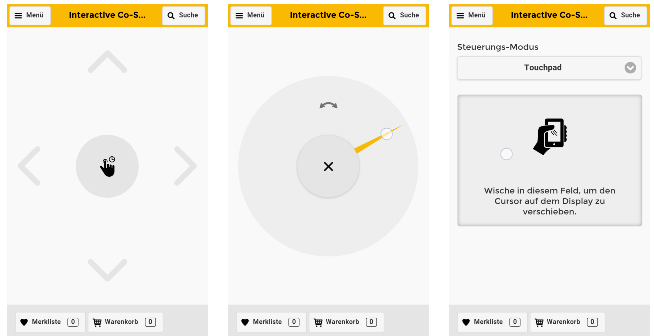

Figure 4: Mobile user interface: List navigation, pie menu control and cursor control. Note buttons that activate wish list and shopping cart views at the bottom border.

bile device (R2). Once a user has connected, the user workspace switches to show a product list. In this mode, the mobile can be used to scroll through the list and select an item using standard gestures (Figure 4, left). Additionally, a long press on the mobile activates a pie menu that enables the user to add the current item to the shared space, her wish list or her shopping cart, switching to a separate discussion mode, or exiting the system.

The pie menu is shown on the large display as well (R5). At the same time, an abstract circle is displayed on the mobile for orientation (Figure 4, center). Primarily, the pie menu (Figure 5) displays color-coded menu items (1) as well as a selection pointer in the form of a clock hand (2) that snaps to the item selected. In addition, the menu shows an abort button in the center (3) as well as tooltips (4) that give information about the current menu item. Significantly, we added a finger position indicator (5) after an initial iteration revealed that users otherwise do not know where the center of the menu is on the mobile display and thus have no way of moving the selection in a circle around it.

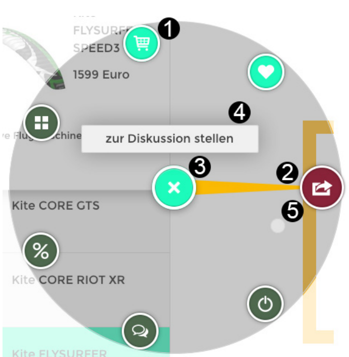

Figure 5: Pie menu interface, showing menu items (1), selection pointer (2), abort button (3), tooltip (4), and finger position indicator (5).

After opening the menu using a long press, the user simply drags and releases her finger (that is still touching the mobile) to select a menu item - or, if desired, the abort button in the center of the menu. While dragging, the selection pointer, the finger position indicator and the tooltips all give appropriate feedback. In addition, selection changes are accompanied by haptic feedback.

Users can switch to a separate discussion mode using a menu item. In this mode, all interaction takes place in the central area of the large screen; the mobile functions similar to a standard notebook touchpad that moves a cursor in this area. Using the cursor, users can move items in the discussion area, view details, and add them to their wish lists or shopping carts as desired. This is possible using drag-and-drop as well as dedicated tool buttons. If both users switch to discussion mode, they each control a separate cursor. Cursors are color-coded to avoid confusion.

To access the wish list or the shopping cart, users switch their attention to the mobile device and press the appropriate button. These modes have a standard web interface (Figure 6).

Realization

The system described in the preceding section is realized entirely using web technologies. This allows operation on user's smartphones without an additional installation step, allowing immediate use (R1). It consists of a mobile client that is displayed on the smartphone, a public display client for the large display, and an application server. The application server handles connection of user's smartphones to the appropriate side of the large display and handles message forwarding from and to the large display.

The client-side components both use HTML5, CSS3, and JavaScript as base technologies. The mobile client is based

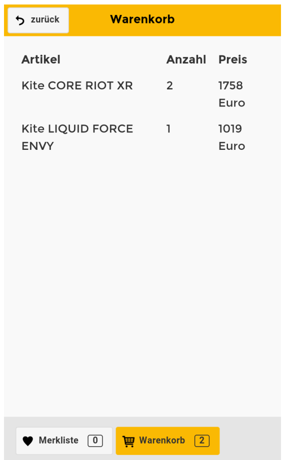

Figure 6: Shopping cart interface.

on jQuery mobile (including fine-grained touch event handling using JQuery touch events), with vibration feedback handled using the HTML5 vibration API. Similarily, the public display client is a jQuery-enhanced web page.

The server is written in JavaScript using node.js as base library. It is not involved in interaction, nor does it track application state. Instead, it just forwards event messages from client to client. This is realized using event-oriented realtime communication via WebSockets using socket.io.

User Feedback

As an initial validation step, we gathered qualitative user feedback from three interaction experts and four regular users. Participants were asked to perform an application walkthrough and select items to buy after an initial description of the application context. Except for one of the interaction experts, participants were not aware of the application concepts before using the system, thus simulating an actual 'walk-up-and-use' situation.

In general, participants were able to use most application features without prompting or hints. There was significant social interaction between participants, with many interaction issues solved by collaboration between the users.

Connection establishment using QR codes was not an issue. Also, gaze switches were not an issue in general, confirming the decision to keep visual feedback on the large display where possible. The use of the smartphone as a remote control was easy once understood by the participants. However, it is unfamiliar; this resulted in a short initial confusion by several participants that expected an interface to be displayed on the smartphone. The pie menu proved to be usable without issues.

Conversely, some participants viewed the mobile as completely passive control pad and were surprised to find the wish list and the shopping cart there. Once this was understood, however, interaction proceeded without issues. We also assume the required attention switch could easily be hinted at when adding items to these lists. Alternatively, a separate application mode for these lists could be activated on the public screen, deactivating the public screen for the current user and displaying an appropriate hint there.

Furthermore, the mode switch to discussion mode proved to be an issue. The function of the corresponding menu item was not obvious to all users, and the change in modes disrupted the flow of interaction. In a future version, we therefore intend to experiment significantly with the discussion mode, possibly replacing the free-form area with a list-based interface.

In summary, while there are issues in details and the discussion mode is subject to redesign, we believe that the study validates the general design, especially concerning attention switches and the pie menu.

Conclusion

In this paper, we presented a prototype multi-user multi-device system for interaction at the point of sale. By using mobile devices, users are able to save their shopping carts and revisit them at a later time, potentially preventing showrooming. The interface of the system is optimized to avoid attention switches between mobile device and large display. To do this, all information is presented on the large display where possible, switching to the mobile display only when personal data needs to be displayed. Significantly, we believe that this principle may be a good basis for interaction involving large displays and mobiles in general, since it avoids gaze switches almost entirely while allowing appropriate interaction with personal data.

Acknowledgements

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