NaviBeam: Indoor assistance and navigation for shopping malls through projector phones

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ABSTRACT

We present our concept of an indoor assistance and navigation system for pedestrians that leverages projector phones. Digitally enhanced guides have many advantages over traditional paper-based indoor guides, most of all that they can be aware of their current context and display dynamic information. That is why particularly shopping malls recently started deploying indoor assistance applications for mobile phones, which also include support for navigation. Moreover, as we show in the paper, projected interfaces offer additional distinct advantages over static guides and even traditional or augmented reality mobile applications. We describe five concepts for a shopping mall indoor assistance system based on projector phones, comprising support for shop selection, precise way finding, "virtual fitting" of clothes, and context-aware and ambient advertisements. We then apply the concepts to a typical shopping scenario, where users wear the phone at their belt and constantly project the interface in front of them. Expected benefits of our system are that people find their way quicker, easier, and less distracted from their usual shopping experience. Finally, we discuss the technical feasibility of our envisioned implementation and research questions we are particularly interested in.

INTRODUCTION

Navigation and location-based services for pedestrians recently gained a lot of attention and are becoming rapidly adopted. Very popular among these are applications for location-based places recommendations and turn-by-turn navigation. While these applications mostly focus on outdoor navigation, less attention has been paid to the opportunities for providing indoor assistance with mobile devices. Especially in large complex buildings, e.g. shopping centers, in most cases static signs, You-Are-Here maps, or paper flyer maps are still the only available navigation assistance for visitors. Preliminary observations and interviews we conducted in nearby shopping centers show that, at least in Germany, available navigational aids are still as insufficient as Levine reported them to be almost 30 years ago [8].

Despite a lot of research projects that explored indoor assistance over the last decade, it was not before the beginning of 2011 that we saw the first mobile shopping applications reaching consumer markets, such as the Sam's Club mobile application [1], which provides indoor navigation to specific items and/or shops in some selected American shopping malls. Similarly, some shopping centers in Asia introduced mobile AR applications for shopping assistance [2].

In our research group we study future application areas of projector phones, i.e. mobile phones with integrated projectors (see [11] for a detailed survey). We found projector phones to provide some distinguished advantages for indoor navigation assistance, e.g., that interaction can be hands-free and the projection can serve as ambient display, thereby not contradicting the traditional shopping experience. Further that the surrounding world can be directly augmented, freeing the user from mapping between mobile display and real world and that the output space is much larger than on mobile displays. And finally, that bystander can see and attach to the projected output.

RELATED WORK

We present relevant work dealing with mobile shopping, recommender systems, indoor positioning and navigation.

One of the first works on digital mobile shopping assistants has been done by Asthana et al. [3]. They presented main usage scenarios, e.g., telling people where to find certain products or informing them on discounts and special offers. Similar can be recognized in aforementioned mobile shopping applications and as well in recently filed patents, e.g. from Apple Inc. (US 2010/0198626 A1, US 2010/0191578 A1), which include navigation, service interactions (e.g., parking tickets), and support for social networking.

Yang et al. [15] developed a location-aware recommender system. It learns a customer's interests from previously visited product websites and continuously presents a list of products around the customer's current location, that are likely to interest him. The software also takes into account the distance to shops and is able to learn customer's preference between highly interesting products and far distances.

Butz et al. [4] present a hybrid indoor navigation system that is able to adapt route instructions to different output devices (screen resolution, device resources) and based on the precision of available location information. Results from [7,14] indicate that intelligent fusion of infrastructure techniques, e.g. GPS, GSM triangulation, and sensors like accelerometers, magnetometers, and gyroscopes, enables precise indoor location tracking with current commercially available smartphones in unaltered environments.

Kray et al. [6] explore the design space of routing instructions for pedestrians on mobile devices. Narzt et al. present a specific mobile application for augmented reality (AR) [10].

Alternative systems for pedestrian navigation are the Rotating Compass by Rukzio et al. [12], showing personalised navigation information on public displays and the CabBoots system by Frey [5], which guides users by means of tactile output in the shoes.

Aforementioned techniques, with the exception of the last two, rely on holding a handset device. However, we feel strongly inclined that holding a device in hand for a longer time does not fit well the traditional shopping experience. Negative side effects, e.g., arm fatigue, regular switching of the field of view, do not allow using the shopping assistance application as constant companion.

CONCEPT

In our envisioned prototype, people wear their projector phone on their belt, projecting a display right in front of their feet (Figure 1). In the following we present five concepts for mobile shopping assistance that are enabled by projector phones. Later we apply these concepts to a typical shopping scenario.

Shadow Interaction

Since our concept expects people to wear the projector fixed to the belt most of the time, direct interaction with the mobile device would not be sufficient as the only interaction technique. Audio is not an alternative because of the noisy environment in a shopping mall. This leaves users with the option to directly interact with the projection, either by feet or hands (or gaze in the future). In preliminary studies we discovered that foot-based interaction is not well suited due to the fact that foot movement inherently involves movement of the body at the same time, which makes interaction cumbersome. We found interacting with the shadow of a finger in front of the projection a much more promising solution. Figure 2 shows the stroke of the resulting shadow on the projection. With the tip of the shadow, all points on the projection can be reached. Items should be highlighted once the shadow reaches their bounding box to give adequate feedback to the user. Although the tracking of the finger's height to enable traditional press/release behaviors would be possible, this would require the user to maintain a complex mental model of dif-

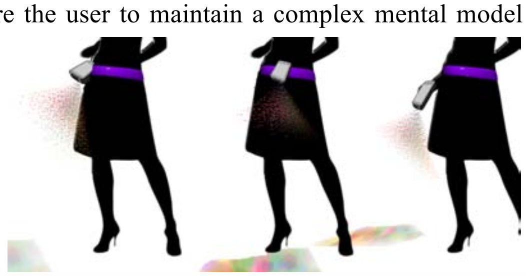

Figure 1: The projector is worn at different locations on the belt (left and middle) and can optionally be taken into hand to change the angle of the projection (right).

Figure 2: The user interacts with his radar of recommendations through the shadow of his finger. The orange outline shows the shadow, the left red circle the fingertip that, for clicking, can be changed independently of the finger's middle knuckle (right circle) or the rest of the hand's shape.

ferent finger height levels. Instead, our concept builds on the fact, that the tip of the index finger can be moved well without changing the shape of the rest of the hand or even the middle knuckle of the index finger. Thus, to select an item, a user moves the index finger to point on the desired item and then bends the index finger and unbends it again. Alternatively, one could use the finger's dwell time as in Microsoft's Kinect. To the best of our knowledge, shadow interaction with projections has not been reported before.

Radar of Recommendations

Another concept that is particularly useful with projected navigation is a radar of recommendations. Building on [15], we want to constantly show and update a personal radar of products the user might be interested in (Figure 2). Based on the information available from accounts with online stores (e.g., Amazon) and items recently explored with our system (see fourth concept), users see offers of nearby stores in front of them and can select these items to start a navigation in the middle of the circle. The size of an item conveys the expected interest of the user, the distance from the middle depicts the walking distance (not air path) from the user's current location. The size of the radius of interest (distance to shops and items) can be adjusted by slightly changing the angle of the projector, similarly to looking further ahead. Different from [15], the projection provides a much larger output space and the radar serves as ambient display in the user's periphery.

Projected (augmented) Navigation

When the user selected an item or shop he is interested in, the assistance system starts a projected navigation. In outdoor navigation, turn-by-turn navigation is still the most prominent, though we have seen augmented reality been used in research [10]. Especially for indoor navigation, where there are more tight and subsequent turns or small decision spaces (take the left stairs up, not the right stairs down) our experience is that turn-by-turn navigation does not work well. Therefore, we want the user not to follow this type of directions, but instead simply follow a blue line projected in front of her (see Figure 3). Since the projector phone is spatially-aware, both in terms of location and orientation, the blue line is projected as a static augmentation of the real world, i.e. movement of the projector does not move the line and the arrows on the line pass beyond while walking on the line, which gives the user feedback on the working status of the system. A high quality location system presumed, the blue line can precisely overlay existing infrastructure, including stairs, escalators and lifts. Since the projector is only a window into the world layered with the blue line, the user can change the angle of the projection to seamlessly switch the field of view between directly upcoming and briefly following directional instructions, thereby exploring the course of the blue line as far as the light intensity of the projection allows.

Realtime augmented item information

Once the user has entered a shop, the user can hold products in front of the system's camera (the one used for finger tracking) and have the system add the item to his personal list of favorite items as well as project additional information onto the floor or the product, the latter being similar to [9]. Additional information might include prize, available sizes and well-suited related products in the same shop.

Projected fitting

Finally, in our concept we envision the system to aid the user in deciding for clothes and accessories to try on. The current practice in deciding for items has several shortcomings. To decide for a set of clothes or accessories, people typically try holding them in front of themselves in front of a mirror. Not only do clothes not fit well then, but this technique is in most cases also limited to two items at the same time. Further, existing clothes of the visitor, if not intentionally brought with them, cannot be included in the decision process.

With the projected fitting, we envision shops to have a few special locker rooms designed for projected fitting. These rooms have dimmed light, a huge mirror, and provide a white, very lightweight cape (similar to a full-length bathrobe), which the shopper puts on. Then the visitor starts fitting mode on the projection and from a list of recently explored items (cf. previous section), selects a set of clothes she want to virtually try on. She points the projector towards the mirror, and sees the selected set of clothes superimposed on her reflection in the mirror (Figure 4). Since room has a plain background, CG algorithms can easily extract the shape of the visitor and the projected clothes can be fitted precisely. Besides, shoppers can also bring their own clothes to the virtual fitting. For sure, the virtual fitting cannot replace actual, physical fitting, but it can help in decision making which clothes and combinations (including already owned clothes) are worth the real fitting (which many people report to be one of the most hassles in shopping, especially in winter times when there are a lot of clothes to undress and put on again).

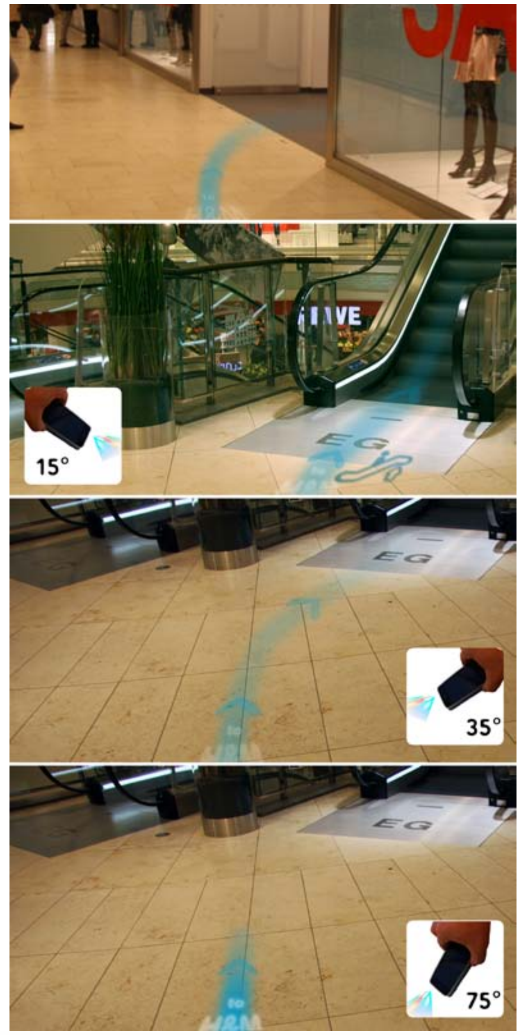

Figure 3: Envisioned navigation. From bottom to top: (1) The user follows the blue line. (2) She explores the line further to see which escalator to take. (3) The line "runs up" the escalators and (4) leads directly into the desired shop.

Compared to fixed AR installations [2], which we assume can provide the easier and visually better fitting experience so far, projected fitting has two significant advantages. First, costs for installation can be comparably neglected. Second, with projected fitting, shoppers can also take the clothes home without buying them and "try them on" at home again to ask partner or friends about their opinion. This only requires a standard mirror and the white cape (shops could sell that for take-away). Moreover, the same would be possible with "clothes-downloads" from online stores, providing to some extent the physical product experience people often miss when shopping clothes online.

SCENARIO

It is Saturday and Jane decided to go to her favorite shopping center. On entering she heads for the information display as she has not yet decided to which shop to go first. Additionally, the shopping center is too huge and all stories look too similar that she could possibly remember the loca-

Figure 4: Projected fitting. A red sweatshirt, blue jeans, and a brown belt are projected on a white cape in front of a mirror (manually aligned).

tions of the shops, though she has been here before. On the public display she sees an advertisement for the new shopping assistance application, especially supporting projector phones. By scanning the QR code on the public display with her projector phone's camera, she downloads and installs the application. She starts the application and puts the projector phone back to her belt.

The application projects an interface in front of Jane and starts by asking if Jane wants to allow the application to connect with her various shopping accounts to receive her personal recommendations. Jane grants the right by clicking "Yes" through *shadow interaction*. The shopping application aggregates Jane's shopping history with real-time stock information and offers from the shopping center provider and then presents Jane her *radius of recommendations*.

Subtly influenced by the recommendations, Jane starts strolling around in the shopping mall, sometimes paying attention to context-aware advertisements the projection shows in front of shops. The display is constantly updated with context-aware information, including recommendations, advertisements of nearby stores, and information about nearby friends connected through social networks.

After some minutes of walk, an amazing skirt displayed on the projection catches Jane's attention. Again she interacts with the projection through the shadow of her fingers to select the skirt and start *projected navigation* to the product. The main parts of the interface remain the same, but in the middle Jane sees the blue line she now just has to follow. To reach the desired shop Jane has to go two stories upwards. The application decides to lead her via the closest escalator. When arriving at the escalator, Jane does not need to know if she has to go up- or downward. The blue line precisely leads her towards and up the right escalator (which go upstairs) and then 180° right onto the second escalator upwards. Because Jane wants to know in advance in which direction she will have to leave after the first escalator (to avoid people rushing into her from behind), she changes the angle of her projection upwards to explore the course of the blue line 'til the end of the escalator.

Finally, Jane arrives at the store with the skirt offer. Since the shop provides in-store location information, Jane is navigated further up front the skirts. After exploring the skirt, Jane continues walking through the store, holding items (i.e. their barcodes) she likes in front of the projector phone's camera. The projection *augments additional information* like different sizes and colors available, stock information and well fitting related clothes of the same store. After some time, Jane has added some to her personal list (all items she has scanned) and wants to try on some of them. Since Jane does not like trying on clothes, she wants to eliminate unpromising combinations beforehand. Thus, she goes to the projection locker room, throws over a white cape and explores different combinations, sizes, and colors of her favorite items in the mirror through *projected fitting*. Whenever she is content with an outfit, she marks the outfit for physical fitting. Finally, the assistance system shows Jane the list of items she wants to try on physically.

RESEARCH QUESTIONS

Currently we are developing a prototype that supports the proposed concepts to evaluate these techniques in user studies. We are interested in answering the following questions:

- Does the projection work as ambient display, so that people are not disturbed by the projection (at least not by their own), but only refer to it when desired?
- Is projected indoor navigation faster, easier (less errors, less confusion), and more comfortable to use than indoor navigation with paper guides or compared to mobile AR navigation applications.
- How is the social acceptance of using the projection for "personal recommendations" (public to bystanders), navigation, augmented product information, and projected fitting?
- How much added benefit do people see in or experience with the system and can that benefit account for expected concerns regarding the social acceptability?

ENVISIONED IMPLEMENTATION

The presented concepts are implementable with current technology. Although light intensity of current pico projectors, let alone projector phones, are still comparable low, they are already usable indoors. When analyzing the lighting conditions in nearby shopping centers we found out that values of 500 lux are typically not exceeded outside of shops. As can be seen on Figure 5, information can be projected sufficiently with current technology. We assume that integrated projectors will soon reach better light intensity.

Shadow interaction (also cf. [13]) can be implemented with existing finger or motion tracking methods. For the system to work as presented, projector and camera have to point in the same direction. As [11] pointed out, currently available projector phones do not support this setup at the moment, as it does not fit the envisioned main usage scenarios of manufacturers. We argue that future projector phones should have camera and projector on the same end of the device, allowing for 180° rotation. This way the phone would allow for most of in research proposed projector applications *and* standard media showcasing and at the same time would

Figure 5: Lighting conditions in a nearby shopping center. Left: Blue arrow with yellow background in dark environment (ca. 200 lux). Right: Yellow projection in comparable bright environment (ca. 400 lux). Projector: Aiptek Pocket Cinema

render a second front facing camera needless. For the prototype, we are going to use a wireless IP camera that tracks objects/fingers in front of the projector phone.

Obviously, the proposed system requires a very accurate indoor positioning system that works with off-the-shelf mobile phones. Infrastructure supported positioning systems (e.g., using WLAN fingerprinting, GSM triangulation) have been successfully used in shopping centers, with first applications available on mobile application stores. Besides, the advent of accelerometers, magnetometers, and most recently gyroscopes in mobile phones enables several relative positioning systems reported in the literature [7]. Especially when these techniques are combined [4,7,14], very precise indoor navigation is feasible today.

CONCLUSION

Despite the limited brightness of current pico projectors, these are already well usable indoors in normally lit environments. Currently, there is only little digital and personalized support for shoppers in malls and also in large complex buildings in general. Emerging mobile navigation and even AR systems suffer from the small display of mobile phones and the requirement of holding the device in front of oneself all the time. In contrast, the projected interface we presented has a much higher resolution, leaves users hands-free and works as ambient personal display, and can directly augment the real world, useful for navigation as well as projected fitting. Having an always on, publicly visible interface might raise some people's concerns, but at the same time enables by-standing people to see for which items or shops other people are heading, thereby potentially serving as advertisements and personal recommendations for each other and helping to get in touch easily.

We expect the concepts we presented to significantly improve and facilitate typical shopping scenarios, and as well to provide us much deeper insights into users' acceptance of projected interfaces in everyday scenarios like shopping.

REFERENCES

1. Sam's Club (http://www3.samsclub.com/mobile). Accessed Jan. 2011.
2. Augmented reality in Japanese shopping malls (http://www.physorg.com/news179569499.html). Accessed Jan. 2011 .
3. Asthana, A., Crauatts, M., and Krzyzanowski, P. An Indoor Wireless System for Personalized Shopping Assistance. *WMCSA*, (1994), 69-74.
4. Butz, A., Baus, J., Krüger, A., and Lohse, M. A hybrid indoor navigation system. *Proceedings of the 6th international conference on Intelligent user interfaces*, (2001), 32.
5. Frey, M. CabBoots: shoes with integrated guidance system. *TEI*, ACM (2007), 245–246.
6. Kray, C., Elting, C., Laakso, K., and Coors, V. Presenting route instructions on mobile devices. *Proceedings of the 8th international conference on Intelligent user interfaces*, ACM (2003), 117-124.
7. Ladetto, Q. and Merminod, B. Digital magnetic compass and gyroscope integration for pedestrian navigation. *9th International Conference on Integrated Navigation Systems, St. Petersburg*, (2002), 111–120.
8. Levine, M. You-Are-Here Maps. *Environment and Behavior 14*, 2 (1982), 221 -237.
9. Mistry, P., Maes, P., and Chang, L. WUW-wear Ur world: a wearable gestural interface. *27th CHI extended abstracts*, (2009), 4111–4116.
10. Narzt, W., Pomberger, G., Ferscha, A., et al. Pervasive information acquisition for mobile AR-navigation systems. *Mobile Computing Systems and Applications, 2003. Proceedings.*, (2003), 13-20.
11. E. Rukzio and P. Holleis, "Projector Phone Interactions: Design Space and Survey," in *Workshop on Coupled Display Visual Interfaces*, 2010.
12. Rukzio, E., Schmidt, A., and Krüger, A. The rotating compass: a novel interaction technique for mobile navigation. *CHI'05 extended abstracts on Human factors in computing systems*, (2005), 1761–1764.
13. Shoemaker, G., Tang, A., and Booth, K.S. Shadow reaching. *Proceedings of the 20th annual ACM symposium on User interface software and technology - UIST '07*, (2007), 53.
14. Siebel, N. and Maybank, S. Fusion of multiple tracking algorithms for robust people tracking. *Computer Vision—ECCV 2002*, (2006), 373–387.
15. Yang, W., Cheng, H., and Dia, J. A location-aware recommender system for mobile shopping environments. *Expert Systems with Applications 34*, 1 (2008), 437-445.