ShelfTorchlight: Augmenting a Shelf using a Camera Projector Unit

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ABSTRACT

The search for a certain book in a library that contains many books can be a time-consuming task. Even if one finds the right shelf, one still has to browse an often huge area in the shelf. The same problem occurs when searching for a specific product in a supermarket shelf that fits one personal preferences (e.g. a allergic or diet profile). With *ShelfTorchlight* we present a prototype that aims to overcome the problems when searching for a book or a product in a shelf using a mobile camera projector unit. In addition we show the advantages of semantic zooms when projecting information into theses shelves. With the miniaturization of mobile projectors, also called pico projectors, the integration of these projectors into mobile phones is now possible. These phones allow a variety of new applications evolving from the ability to expand the interaction space of the phone to the environment. The prototype described in this paper, *ShelfTorchlight*, is such an application, trying to demonstrate the interaction possibilities of these new devices. A user can highlight the object she is looking for in the shelf and get additional information.

1. INTRODUCTION

In modern society mobile phones are the indisputable most widespread ubiquitous computing devices and used for a wide range of applications and services in a users every day life. These devices still have the main limitation of the small display, which is naturally limited by the fact that the devices should be mobile and portable. Modern mobile projectors have been miniaturized to the size of mobile phones and can be operated using batteries. The integration of such projectors into a mobile phone is no longer fiction. The first series production models are available for order. Mobile phones with an integrated projector are normally referred to as projector phones or mobile camera projector units (due to the integrated camera in most phones) and at the moment, two mobile phones of this kind are available for order. Additionally several prototypes by different manufacturers hint that more projector phones will follow in the near future. Projector phones can overcome the shortages of the small screen and expand the interaction space to physical objects by projecting large-scale information onto different surfaces in the real world. One main limitation is still that these projectors just have about 10-15 lumens. Therefore often the possibilities of pico projectors are demonstrated in indoor scenarios. While we think having more powerful projection units will allow many interesting outdoor applications we focus in this paper on the usage of a mobile camera projector unit to support the interaction with a shelf with different objects. In addition we highlight how the distance of the mobile projector camera unit can be used to project semantic annotation. Using two scenarios (book shelf and shopping scenario) we highlight those interaction techniques for mobile camera projector units.

Figure 1: *ShelfTorchlight* application is used for micro navigation in a supermarket shelf. This is done by categorizing the products taking the users personal profile into account.

The remainder of the paper is structured as follows: First we give an overview of existing work in the area of mobile projection interfaces, after that we will explain the concept of the *ShelfTorchlight* application in more detail and present our two scenarios: library and supermarket. Within these scenarios we show the possibilities of our interaction techniques. Furthermore in section 4 we discuss our implementation, and then we will conclude and present our current activities and future work.

2. RELATED WORK

Initial research in the field of mobile projection has been conducted by Raskar et al. [12]. While their first prototype, the iLamps, mainly focussed on creating a distortion free projection or combining several projectors to create a brighter or larger image, their follow-up prototype the RFIG Lamps [1] allowed initial interactions with objects in the environment. For example the RFIG Lamps where able to highlight products in a shelf where the date of expiration was closed to the actual date. This scenario is very similar to our scenario but for detecting the specific products they used active RFID tags integrated into the products. Our prototype in contrary uses optical tracking methods that are not only much cheaper but also they do not need any preparation of the shelf in the case of SIFT and are fully deployed on a mobile device. Still just a few fully mobile camera projector systems exist that can be tracked relative to their environment with 6DoF.

How a wrist worn projector can be used to explore webpages for example has been examined by Blasko et al. with a simulated projection using a short throw projector [2]. Cao et al. focussed on multi-user interaction with multiple mobile projectors tracking these in an instrumented environment [4]. First absolute mobile projector applications have been presented by Hang et al. [7], Schöning et al. [14] and Mistry et al. [9]. The major advantages of projected displays when exploring large-scale information like maps was the main aspect of the research of Hang et al. [7]. Our approach to augment real world objects with an additional overlay is very similar to Schöning et al. who used a mobile camera projector unit to augment a paper map with a projected overlay containing points of interest [14].

This subdivision of a navigation task in to two steps is also referred to as macro- and micro-navigation. In [16] Stahl et al. defined macro-navigation as a task "in which the navigational goal is beyond the user's perception of the current environment", in our case the way to the shelf. The change of the focus to a certain spot within the users perception - in our case the user facing the shelf and searching the desired object - is a micro-navigation task [16]. The micro-navigation problem and concepts was also the focus of the Searchlight prototype by Butz et al. [3] (also in a same domain).

Also the idea to use projection for augmenting a shelf was presented by Pinhanez et al. [11]. The Searchlight system uses a steerable projector that is integrated into an instrumented environment, which makes their system more static in contrast to our mobile solution. On the other hand their approach provides brighter projection and may not lead to visual pollution, which may arise when multiple users are operating their mobile camera projector units at the same time. However multi-user interaction is only supported by the Searchlight system if multiple steerable projectors are available whereas *ShelfTorchlight* only requires that each user is equipped with a camera projector unit. To augment a bookshelf using a projector was also done by Crasto et al. [5]. This was done by a static camera-projector unit consisting of two camera and one standard projector. The cameras are aligned to both sides of the projector facing the shelf, which allows the system to calculate the plane created from the book spines. A state change of the bookshelf (book added or removed) can also be detected by an RFID reader integrated in to the shelf. The advantage of this system is the ability to detect the different planes of the shelf and therefore enabling it to correctly project on these planes. *ShelfTorchlight* in comparison determines the planes using the information in the visual markers. Besides the static setup, one additional drawback is the need for extra RFID tags for each book. The idea of projecting additionally information regarding different products has been realized by Spassova et al. [15] using a steerable projector as well. For their Product Associated Displays a 3D Model was needed, which is not the case in our approach.

3. INTERACTION CONCEPTS

The basic interaction concept we apply is similar to the torchlight metaphor that for example Schöning et al. [14] used. By sweeping the camera projector unit over the shelf additional information is projected onto the objects and next to them. We extend this interaction technique with further interactions. In addition to the search functionality (later described in the library scenarios) we developed a semantic zoom for both application scenarios. Modjeska describes a semantic zoom in contrast to a physical as follows "A physical zoom, on the one hand, changes the size and visible detail of objects. A semantic zoom, in the other hand, changes the type and meaning of information displayed by the object." [10]. In our case a physical movement closer to or away from the object changes the kind of information that gets projected. The closer the user is to the object the more detailed the information becomes. To illustrate the function of the semantic zoom in combination with the micro navigation we picked two scenarios for our applications, on the one hand the search for a specific book in a library on the other hand the search for a product that matches the users needs.

3.1 Library Scenario

There are two different techniques in this case. First there is the basic search for a book in the shelf, where the system knows which book the user is looking for and thereby supporting the macro navigation task at the shelf. When one moves the camera projector unit over the shelf the desired books are getting highlighted with a white rectangle that matches the spine of the book. If the user draws closer to the shelf and with that activating the semantic zoom, he gets additional information when he added it to the list and why he is looking for this specific book projected onto the edge of the shelf (compare figure 2). If the user is not seeking for a specific book and only wants to browse the shelf, the average user rating retrieved from http://amazon.com is projected onto the spine. The semantic zoom will project in this case the concrete reviews of the book on to the edge of the shelf.

3.2 Retail Scenario

In the retail scenario the products get compared to the personal profile of the user, that contains all her allergies, gusto, the shopping list, etc.. And maybe not only the profile of the user but also of her whole family when she does the family shopping. Standing farer away from the shelf and moving the camera projector unit over the products, *ShelfTorchlight* projects green, yellow or red circles indicating how suited the product is taking the personal profile into account (see figure 2). For example a product that contains an ingredient which leads to an allergic reaction by the user or one of her family members gets a red circle projected onto the packaging. The semantic zoom will then reveal an explanation why the product got categorized in this way in this example it will tell the user that the product contains the specific ingredient. Since allergies are private information the semantic zoom show this only when the user is close to the shelf and maybe able to shield the projection. While the projection of the red circle only indicates that the user should not buy this product, uninvolved can not draw conclusions what reason leads to this advice since it could also be a personal preference.

Figure 2: Interaction techniques of *ShelfTorchlight* application: (Library Scenario) The book a user is searching for gets highlighted (left) or the rating of the book gets projected beside the book (middle-left). (Retail Scenario) Onto the facing of the product the user gets a projection on how suited a product is taking his personal profile into account (middle-right) and the semantic zoom reveals the reason for the classification (right).

4. IMPLEMENTATION

For our approach a mobile camera projector unit is needed where the projected image is totally covered by the camera image. This will avoid blind spots, where the camera is able to detect a obejct, but the projection cannot reach it at the same time. Due to the unavailability of sophisticated projector phones with such an alignment of camera and inbuild projector, we used for our prototype a Nokia N95 8gb connected to an Aiptek T30, a mobile projector with a maximum resolution of 640x480 and a weight of 137g. Both, the projector and the phone where connected through an aluminium construction and the car mount for the Nokia N95. All together the prototype has a weight of under 350g and is therefore good to handle (see figure 3). The projector produces only 15 lumens, which is enough for our indoor scenario but can be hard to read especially when projecting more than just symbols on the spine of an already visually cluttered book or the facing of a product. Therefore we project more detailed information like text on the edge of the shelf while the books and products get highlighted with a colored shape directly onto the spine respectively the facing of the product. *ShelfTorchlight* is fully implemented for Symbian S60. In a first attempt we tried to use the feature tracking of the metaio Unifeye Mobile SDK [8]. After the first tests we experienced that the SDK is unsuitable for more than 3 different markers since the memory of the mobile device is to small to process the image data. Therefore we used instead the Visual Codes by Rohs et al. [13]. In our case the codes contain the ISBN of the books respectively the EAN of the products and were positioned on the spine of the books respectively the facing of the product. Typically books in a library are tagged with a barcode, just like products in a supermarket shelf so that these tags can easily replaced, with the tags we used.

Besides the use of Visual Codes, the problem could also be solved by a different algorithm (or implementation), for example Google Goggles [6] already allows visual search for a huge variety of objects on mobile phones. Also the future development of mobile devices with increasing memory and processing power will help to overcome this problem. For the semantic zoom the distance to the books is calculated by determining the size of the marker of the object in the camera image. According to this distance also the needed position for the projection is calculated considering the angle of aperture of projector and camera.

For data input like keywords etc. two different ways exist. At first, a user can use the keys of the N95 using T9 for input. On a projector phone, one can use the standard QWERTY keyboard of the device if available, or a touchscreen keyboard. The second way for user input is dedicated for spontaneous and repeating tasks and uses a combination of marker recognition and pressing the keys of the device as input. An application scenario for this would be selecting the object, which is in the focus of the camera and also highlighted by the projection, to add it to a shopping basket for instance. The display of the mobile device could be used for private information that is not supposed to be readable for others.

Since libraries often contain several hundred books a feature algorithm or even a marker-based tracking would have to compare huge accumulation of data if one want to browse information about the books. But because normally at least the books that are contained in one shelf are known, the amount of data that has to be compared can be reduced by first positioning the user in the library which narrows down the search space. This perfectly ties in the macro and micro navigation principle. Such an approach could make the conversion of the application to mobile devices possible earlier. Thereby another functionality could be realized, if a user wants to put back a certain book, the shelf where it should be located could be highlighted as well.

5. CONCLUSION & OUTLOOK

In this paper we presented a prototype called *ShelfTorchlight* that utilizes a mobile camera projector unit to alleviate the search for a desired object in a shelf. Additionally it allows the projection of additional information about this object in a suited area around it using a semantic zoom technique. With that prototype we outline the potential of mobile camera projector units in two different scenarios. We tie this problem in micro- and macro-navigation and show that it can support user interaction and how semantic zoom can enrich the user interaction and also address privacy issues that appear when a user is projecting into a public space with his personal mobile camera projector unit.

One major advantage of the presented prototype is that it is lightweight and mobile. It does not need a huge amount of auxiliary infrastructure (e.g. an instrumented environment or a 3D model of the ambit) and all the needed information is retrieved from the web. We think that this is very important to build successful application for mobile camera projector units. Of course, still technical drawbacks (e.g.

Figure 3: The Prototype used for *ShelfTorchlight*: Nokia N95 8gb and an Aiptek T30

low brightness of the projection) of mobile camera projector units exist but these may be overcome in the future but still have to be taken into account when designing applications for these devices.

In our future work we plan to conduct a user study investigating the performance and acceptance of the system. On the one side we want to compare our system with traditional searching using the information from the library-system and on the other side to a stationary setup such as the Searchlight system [3]. We think that comparing against other setups is very important to investigate the real advantages of mobile camera projector systems.

6. REFERENCES

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