A User Interface Design for the Elderly using a Projection Tabletop System

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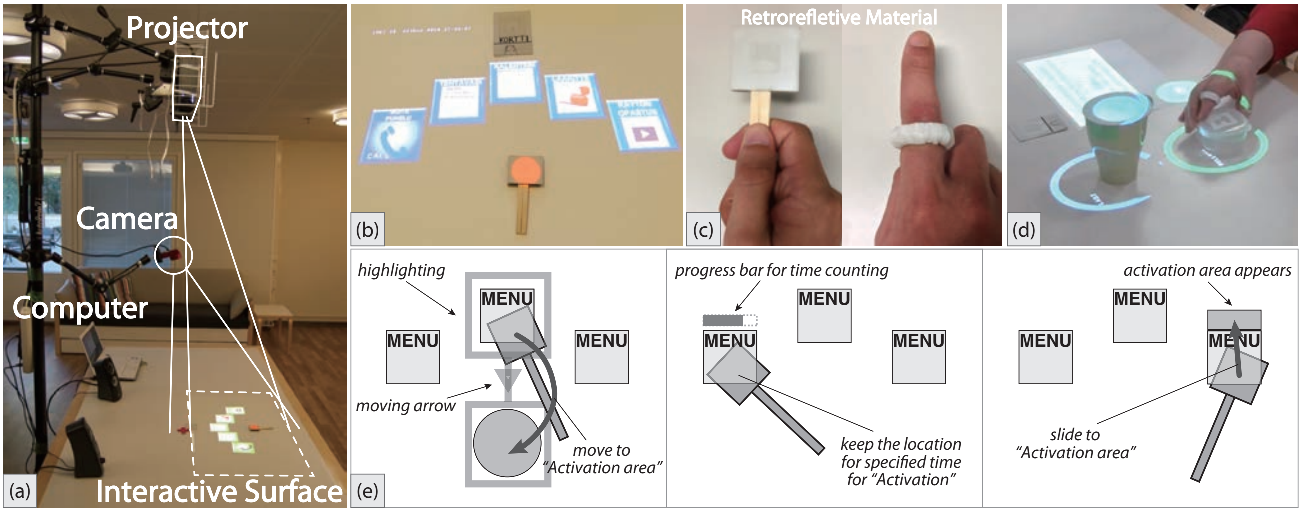

Figure 1: How can we support the indoor daily lives of the elderly by installing (a) a projection tabletop system? (b) a table can be an interactive surface with graphical user interface with (c) input tools; paddle and ring. (d) the system can also provide corresponding information to the objects on the table. (e) our selected interaction methods; left, center, and right ones are "two-step", "hover", and "slide", respectively.

Abstract

We present a design of a user interface on a projection tabletop system for the elderly. Nowadays, the population imbalance between the elderly who require daily care and caregivers is being one of global social issues since the population aging advances. Additionally, if the amount of the elderly with memory problem increases, the imbalanced situation makes the elderly worse because of few caregivers, then a negative chain reaction would be occurred. In order to avoid the worst situation, we believe that it is important to support the daily lives of the elderly persons at the early stage for reducing aging effects. In this research, we challenge to develop the internet-connected assistive system to support their daily lives individually in order to help them manage their time without the need for caregivers support on location.

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We focus on projection technology to display visual information onto physical surfaces such as tables or walls especially for indoor use. The projection technology does not require embedding other displays such as LCD into tables or walls that the users have already owned, and to hold or wear the special devices in hands or on heads. Also we apply interactive functions for the design that lets the users think and decide by themselves, since the quality of lives of the elderly needs to be considered to keep them from just following the given instruction without thinking. Finally, we have decided three designs of graphical user interface on the projection tabletop system through a brief user test. In this paper we show the thee different interaction methods based on the graphical user interface designs and one of augmented reality applications as an example of a practical use of the system.

Index Terms: K.4.2 [Computers and Society]: Social Issues—Assistive Technologies for person with disabilities H5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces—Interaction Styles;

1 Introduction

Populations in most nations are rapidly aging. The situation creates an imbalance between the amount of young and elderly that leads to undesired living environment for both because burden per caregiver increases or the elderly cannot get enough onsite support. In order to break away from this negative situation, the realization of the elderly having independent lives without onsite support from caregivers is needed. It is difficult to support the elderly who have severe aging impairments. On the other hand, the elderly who are in the early stages of aging such as Age Associated Memory Impairment (AAMI) or Mild Cognitive Impairment (MCI), needs less assistance to have an independent life. If the aging problems of even in the early stage can be slowed down or assisted, it would also reduce a population increasing of the elderly who need someone to take care of them all the time. Seen from this perspective, to develop an ambient assisted living environment based on information technology for taking care of the elderly is a very important challenge.

We focus on a user interface design of tabletop assistive system in order for the elderly to live independently. Since the system should be interactive in order to keep the elderly from just following given instruction or navigation, a well-designed input interface which is friendly to the elderly is required. Additionally, we select a projection method to provides visual information because it does not require carrying devices with the users unlike smartphones, tablets, or smart glasses. However, the user friendliness is not yet know as a projection system is an almost unknown technology for the elderly in general. Thus we are challenging to find best practices for interface design for a tabletop system.

2 Related Work

Age-related problems in motor skills affect the precision of hand movements and cognitive decline also affects mouse manipulation negatively [9, 7, 11]. While these previous have often used traditional input methods such as mice or keyboards, some works have reported the elderly characteristics with touchscreen interfaces [2, 5]. On the other hand, we focus on projection method that has not been considered extensively as a technology for the elderly. Although it might be unfamiliar to the current elderly, we are challenging to develop a projection assistive system and to get new findings. A projection system also can have Augmented Reality (AR) applications which are intuitive and easy to understand because of a strong correlation to the physical objects in real world.

Since nowadays augmented reality is getting expected technology for work support, there are several researches that aim to develop support applications and to make the elderly characteristics by user interface comparison test with the elderly [8, 1]. In addition, Yamamoto et al. [14] developed a projection assistive system for the elderly indoor daily lives as a wearable type and confirmed the usability of a tapping interface with visual icons which are projected onto the walls by a wearable system. Although most of these systems require the user to hold or wear the devices during the support, we believe that projection system installed on lighting locations in the celling make the user feel more comfortable, especially for indoor activities.

Recently, a projection system has become advanced as a practical technology. A depth sensor is one of key devices for intuitive interactive projection system since it can detect and track a user's hands or fingers in realtime [12], while our system provides finger tracking by using a ring as a marker for capturing since it works stably. In addition, several works have reported applications working at kitchen in order to support cooking [4, 10]. From a perspective of assistive system for the elderly, a user interface for remote caregivers has been developed in order to support the elderly by instructing remotely via the Internet onsite projection information [4, 13].

3 Our Projection Tabletop System

We aim to obtain knowledge how to design graphical user interface on a projection tabletop system for daily use of the elderly at home. A projection method does not require a user to hold a device, and it provides visual information anywhere where space is limited such as kitchen, living room, and dining room in an indoor space. Since the other displaying methods including smartphones or smart glasses require a user to hold or wear, they bother a user with occupying a hand or a face and also a user might feel anxiety that the user should not loose it. In general, however, a projection method is still not a common technology for most of the general population. Hence, we devise several types of graphical user interface designs for the projection method, which could be accepted by the elderly.

In this section, we explain the overview of our tabletop projection system. Subsequently, the paper describes basic interactions.

3.1 System Structure

Our system consists of a camera, a projector, and a computer, which is a standard structure of a projection-camera system, as shown in Fig. 1 (a). We also use audio speakers for giving feedback sounds to the user. Since we assume for experiment case that the situation is at a dining table which would be an everyday used place, the camera and the projector are installed on an upper location close to the celling like a room lamp, and downwards onto the tabletop surface. The projector provides graphical information on the table surface, and the camera detects the location of the target objects that are trigger cards for showing a graphical menu and input tools such as a ring and a paddle as shown in Fig. 1 (c). These tools are used to realize the two kinds of interaction ideas that are a finger operation such as on a touch panel and a tool-based operation such as stylus, respectively. In our system, we use an OptiTrack FLEX: V100 camera, which can switch between two alternative modes: a color mode for calibration and infrared mode for tracking markers.

The projector camera system shows projected information at the location where the corresponding marker is on the tabletop, based on geometrical calibration between the camera and projector screens on the tabletop. The calibration can be done instantly by displaying a checkerboard pattern on the table surface with the projector and capturing it with the camera in color mode upon the program start-up. In advance, a coordinate of each feature point of the checker board pattern on projector screen coordinate system is know as (x_{pi}, y_{pi}) for point i. Also a coordinate of each corresponding points on camera screen coordinate system can be estimated by image processing with one acquired image as (x_{ci}, y_{ci}) for point i. The homography H_{cp} between camera and projector screen coordinate systems can be calculated using these corresponding points. We can also use the same homography H_{cp} for the geometrical relation between a infrared camera and a projector because physically the camera is same one. For developing a simplified projection camera system, we selected two dimensional calibration. If the camera and projector are installed to have almost same optical axis direction, the homography is available to show visual information onto three dimensional marker-attached objects on the table with a few off from the correct position as shown in Fig. 1 (d).

For estimating the coordinates of the trigger card or the input paddle, we use an AR marker that is a standard marker for ARToolKit[6], with retroreflective material. Using the homography, a graphical menu corresponding to the trigger card can be projected onto the exact location where the card is in the real space. To avoid jittering of the projected graphical menu due to a different estimation in each frame, we apply a low pass filter and a threshold as a stabilization of the projection appearance. Since the paddle location also can be estimated in each frame, the system can handle pointing events with the paddle. On the other hand, we use a different approach in order to detect the ring because it is not easy to apply a detectable AR marker on a finger. The ring also has retroreflective material on the surface, which is captured and extracted clearly in infrared region. The extracted area is measured in eccentricity and ratio between width and height of a bounding rectangle along the axis of the orientation. Fingertip tracking can be done with deciding these parameter through several experiments.

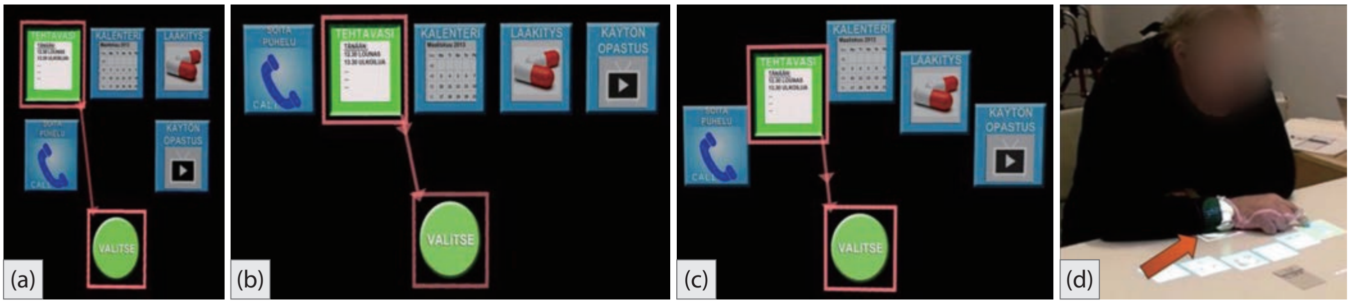

Figure 2: Design of icon layout; (a) tile style, (b) straight style, and (c) arc style. (d) an elderly participant's arm blocks projection information.

4 Design of User Interface

In general, most elderly have their own mental model from previous experiences of using physical buttons and switches for operating machines. On the other hand, new input methods such as a touch or hand gestures are not familiar to them yet because the new methods have less haptic feedback effects unlike conventional ones. Especially, a projection display method requests a totally different way since it changes a physical surface of an everyday object into an input interface. Although currently it might look different for the elderly, we have to consider the advantages that a projection method offers, so that the elderly of the near future can use these newer methods and that the projection system is a powerful tool for them. Hence, we focus on development of a graphical user interface for supporting the daily lives of the elderly.

We apply a common graphical user interface concept to our projection system. When a user puts preregistered cards or objects on the interactive area, a graphical menu appears at the corresponding location where the card or object is. The projection interactive area provides several virtual buttons and icons using figures and text. The basic interaction with the system is to touch the icons intuitively by the finger wearing the ring or the paddle as input tools. In order to let a user notice easily where he or she interacts in realtime, the system shows a red circle at a corresponding location where the fingertip or the paddle is in. In addition, the system plays sounds from the speakers when interaction events happen.

For developing a useful interface, layout is also one of the important elements. Since a projection system does not have a clear border, various design can be possible with different sizes or different shapes. In this research, while we can change sizes or shapes of the icons and virtual buttons, we have tried to design several layouts with the size and shape fixed icons and virtual buttons as shown in Fig. 2 (a) - (c): tiled alignment, straight alignment, and arc alignment, respectively. Using these layouts, we have had pilot user tests with the elderly participants. Through these user tests, we found several problem for the elderly, and Fig. 2 (d) shows one of the problems where the elderly blocked the projection information by his own arm. Considering human motor's kinematics (easily reachable due to arc shape) and based on the observation of the elderly behavior during the pilot test (less errors for accidentally selecting nearby icons if a straight layout is used, etc.), we have chosen the arc alignment style for the basic layout on our projection system.

To interact with the icons, we need two processes that are SELECT and ACTIVATE. Figure 1 (e) shows our final design of interaction methods. The first one has a activation button at the center bottom of the menu. When the user select one of the items, the item icon and the activation button will be highlighted and an arrow appears between the two while a pointing animation emphasizes the user to complete the selection by moving to the center area icon. The second one is hover method with progress bar for time, by keeping the position on top of the desired icon until time is up, the selection will be completed. The third one is a slide activation method where the activation button appears on top of each menu icon when hovered over. To complete a selection, the user slides a finger up towards the activation button from the desired menu icon. The system can switch between these three methods using the same layout.

We have developed several applications for our system based on our previous work [3], especially for the elderly with memory impairments. Figure 1 (b) shows the default menu, and the user can launch sub applications, which are video calling, to do list, calendar, medical instruction, and watching a guidance video for the user interface. If the calendar has schedule to remind the user, the reminder pops up by interrupting the current action. While these applications are related to one special start menu card, the system can use the different objects and show corresponding information onto the real object as shown in Fig. 1 (d). Using augmented reality, the system can guide the user in which cup or medicine the user needs to take besides displaying instruction information on the table.

In a pilot test, we found several differences between computer literate users (CLU) and the elderly. One of them is that the elderly move their hands during thinking while the CLU participants move after they decide what they do. It seems that coordination of hand and eye for the elderly is stronger than for the CLU. The coordination would increase the certainty of their actions.

5 Conclusion

We developed a projection tabletop system as a novel assistive tool for the elderly. Using a simplified system structure and process, the system can provide interactive surface onto any table surface. Through several trials with the elderly and taking into account knowledge of human motor's kinematics, we decided to use arc alignment style for the default layout of icons as shown in Fig. 1 (b). In addition, we designed three interaction methods; two-step, hover, and slide to find out which interaction styles would be suitable for a projection system. We created several applications and confirmed that users can operate these three interaction methods as well as be able to follow a specific task of taking medication using projections on objects as an assistive tool.

Our aim is to find good designs for a user interface for the elderly using a projection tabletop system, thus we have user tests of our proposed interaction methods with the elderly compared with computer literate users in the future. We believe that our system can help the elderly to keep their quality of lives by letting them manage their daily lives by themselves and that they would be able to keep their memory conditions better. Additionally, we focus on intuitive interaction using augmented reality that provide visual cues and information onto corresponding physical objects in real world. Moreover, we will consider the integration with remote assistant functions in order to support daily lives of the elderly by caregivers remotely.

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