An Ambient Display for the Elderly*

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Abstract. The demand for systems to assist in the care of the elderly is continually increasing. We propose an ambient display that allows casual and implicit interaction with an elderly user. The display system recognizes the user and measures the distance between the user and the display using information from an RFID reader and an ultrasonic sensor. It uses this information to adjust the level of detail of the displayed information. If the user is far from the display, a black-and-white image is displayed that does not attract attention. But when the user's approach is recognized, the display provides three-dimensional spatial navigation through the image space. When the user is very close to the display, they can interact directly using the touch screen. In the event of an emergency, LEDs attached around the display call the user's attention by flashing the light.

Keywords: ambient display, implicit interaction, ubiquitous computing.

1 Introduction

As ubiquitous computing becomes increasingly available, new computing environments that take into account the physical capabilities of the elderly are the subject of current research. In particular, demand for health care systems that relate to the everyday life of the elderly is increasing. Such systems need to provide an interface suitable for elderly people who are not accustomed to the computing environment. In this paper, we present an ambient display system that reacts to the behavior of elderly people, without requiring excessive attention from the user.

Together with an analysis of elderly people's behavior, systems using a digital frame-type display have been studied in projects relating to ubiquitous health care, such as at Georgia Institute of Technology and Intel Research Center in Seattle. In the AwareHome project at Georgia Tech, indirect interactions with remote family members are facilitated using the Digital Family Portraits display [1]. This display looks like a picture, but can provide family members who live at a distance with information about their elderly relative's everyday life, including their health,

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environment, relationships and activities. Such information is summarized every week and gives the user a feeling that they are talking to the distant family members through the frame. The CareNet display [2] developed by Intel enables the user to access information directly by operating the menus of a touch screen, and it also allows images to be edited.

These existing picture-like displays do not necessarily capture the interest of the elderly, because they only show pictures and permit only explicit interactions, for instance through the menus of a touch screen. Additionally, visually small and complicated interfaces, like that of the CareNet display make it difficult for elderly people to find the information they require.

We are proposing a display system enhances the user's memory of the people shown in pictures, and adequately captures the interest of elderly people. This system can be operated by explicit interaction methods, such as a menu or by implicit interaction, which is derived by the behavior of the elderly person. The user is identified by means of an RFID reader, and based on this it will show pictures of a particular individual (see Section 3). In addition, the system can adjust the level of detail of the display interface depending on the user's proximity by measuring the distance between the user and the display using the ultrasonic sensor.

The rest of this paper is made up as follows: Section 2 briefly explains the proposed system; in Section 3, the equipment and methods used for implicit interaction by the elderly are explained; in Section 4, methods of generating a three-dimensional space from a two-dimensional picture, as an aid to memory, are presented, together with results, and lastly we draw some conclusions and future work.

2 An Ambient Display System

Main components of the proposed system are a radio-frequency identification tag and reader for user recognition, an ultrasonic sensor for detecting proximity, a touch screen monitor for displaying pictures, and an illuminated frame for indicating urgent situations. The RFID reader identifies the user who is approaching the display and shows them an appropriate image. The ultrasonic sensor measures the distance between the display and the user, and provides images with an appropriate resolution.

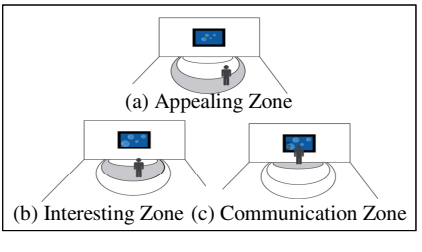


Fig. 1. Display zones corresponding to user proximity

Measurements of user proximity are divided into three ranges, which correspond to different scenarios as follows:

In the Appealing Zone, the ultrasonic sensor reacts to the presence of a user, and the display changes from black-and-white to color. Nevertheless, the picture-like display does not demand excessive attention, although explicit interaction using an air mouse can be provided if necessary.

In the Interesting Zone, both the ultrasonic sensor and the RFID recognize the user, and the image on the display becomes three-dimensional. Display of the image includes a navigation function that zooms in and out depending on the closeness of the user and his/her direction of movement.

In the Communication Zone, the user is very close to the display, and explicit interaction becomes possible. The user can operate menus directly using the touch screen, and access detailed information.

When the user is outside all three zones, the system looks like a framed picture, and shows black-and-white images, but it can also delivers urgent information regardless of the user's location. If a situation critical to the user or environment occurs, the lamps light up and a warning message is displayed on the screen.

If an elderly person is hurt in a fall, or exhibits unusual behavior such as failing to get up in the morning, the display system can inform a relative at a remote location. The relative can properly react using a phone call and let other visit the elderly person.

3 Implicit Interaction

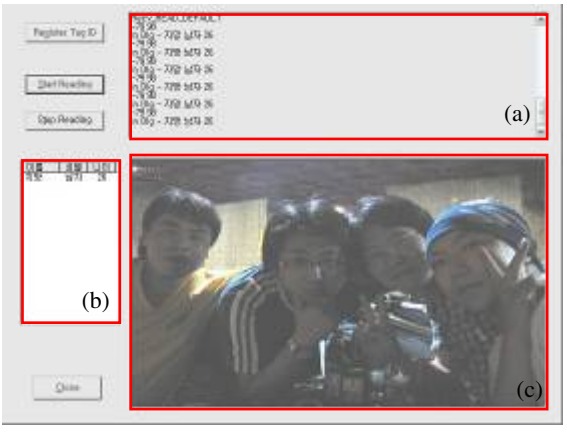
The ubiquitous computing environment is being developed through studies of implicit interaction techniques, such as user recognition, and on non-standard explicit interactions. This work is built on sensor techniques, including computer vision, RFID, ultrasonic, infrared, and gyro sensors. Non-standard explicit interactions are more suitable for the elderly, who do not find a keyboard and mouse easy to use. We provide navigation uses implicit interaction when a user is too distant for explicit interaction.

Our system uses a 900MHz RFID reader (Infinity 210 UHF: SIRIT) to recognize a user. When the user enters the sensor reaction zone, the RFID reader recognizes the tag (Class 1 Generation 2) and confirms their identity using the ID on the tag. The tag can be a bracelet or a small sticker which can be worn without inconvenience. The reaction zone of our RFID extends about 2.4 meters from the display, if an external antenna is deployed.

When more than one user is recognized, the RFID sensor can differentiate between them. The user wearing the tag that reacts most strongly to the RFID reader receives the highest priority (see Fig. 2).

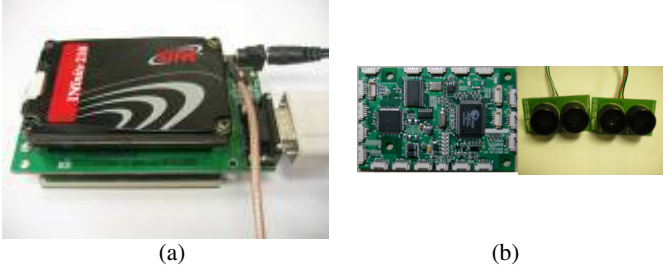
The distance between the display and the user is in measured by the RFID and an active ultrasonic sensor, which reads a pulse in the direction of the priority user. The distance is calculated from the round-trip time of the ultrasonic wave, and the direction in which the user is moving can also be determined from a sequence of

measurements. The images on the display are modified as the user moves closer or farther away. The maximum detection range of the ultrasonic sensor is about 5 meters, which includes all three display zones.



(a) RFID reader (b) Priority of recognized IDs (c) Picture related to the highest-priority ID

Fig. 2. User recognition and picture selection by the RFID reader



(a) (b)

Fig. 3. RFID reader (a) and ultrasonic sensor (b)

4 Picture-Based Three-Dimensional Spatial Navigation

When a user enters the Interest Zone, the display begins three-dimensional navigation within the scene being displayed. We use the "Tour into the Picture (TIP)" method first proposed by Horry [5], and subsequently developed to apply to many document types of images and videos.

TIP is based on three kinds of images as shown in Fig. 4: an original image, a mask image and a background image. In our system, a three-dimensional model is derived from the mask image in order to separate the foreground and background. The vanishing point or vanishing lines in the two-dimensional image, and the coordinates of the four corners, are used to find the coordinates locating the foreground model within the background model.

(a) Original image (b) Mask image (c) Background image

Fig. 4. Processing an image using vanishing-line information

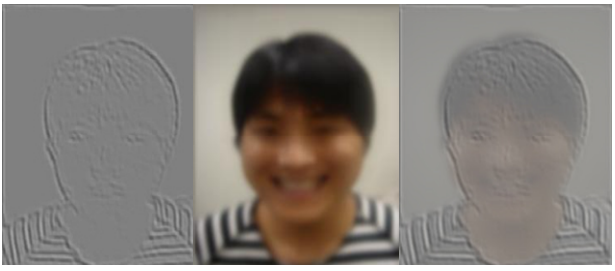
The three-dimensional space that is created in this way provides navigation inside the Interest Zone based on the changing the distance between the user and the display. As the user approaches the display, the foreground image within the three-dimensional space comes to meet them.

Fig. 5. Three-dimensional spatial navigation

Fig. 5 shows what happens as a user approaches the display. The user gets the feeling that they are actually moving within images that are displayed by this method of navigation. Such a system is likely to induce the curiosity of an elderly person and help their memory of the situation.

We also use the hybrid images technique [9] to achieve a variety of interaction effects based on the position of the user. Two images, referred to as hybrid images, are combined into a single image by applying low-frequency to one image and high-frequency filtering to the other. We use this technique alternate between different images, depending on the location of the user.

Fig. 6 shows the application of the hybrid images technique to a foreground image from the three-dimensional spatial navigation system. The two facial images show the same face with different expressions. One image is converted to a high-frequency image using the Fast Fourier Transform and the other to a low-frequency image using a Gaussian filter. The facial expression of the person can then be changed by image morphing as the user moves nearer to, or farther from, the display. This technique can also be applied to other images and to text, allowing different information to be provided as the distance between the user and the display changes.



(a) Fast-Fourier Transformed image | (b)Gaussian filtered image | (c) Hybrid image (a)+(b)

Fig. 6. Utilization of hybrid image

5 Conclusion

We have presented an ambient display to help the memory of the elderly. It operated on the basis of implicit interactions such as user recognition and closeness of approach. We have used the TIP method that enables a flat picture to be perceived as a three-dimensional space, through the interaction of many kinds of sensors.

In the near future, we plan to test the usability of this system using the elderly persons, with both pictures and information delivery. For information that has no connection with the display zones, we will explore methods of structured delivery that are suitable for different kinds of information.

As the number of elderly people living alone increases, this sort of display will become increasingly useful. By allowing information about the wellbeing of an elderly person, and the medicines they are taking, to be acquired by the display, further application areas are opened up, including the ubiquitous health care which is likely to develop in years to come.

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