Interactive Care Wall

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Abstract

As a result of aging population, an increasing number of elder people live in their home without the companion of their young children. This raises the issue of healthcare and the peace of mind of their children. Traditionally, people would make a phone call to express their care with their elder relatives. In this work, we try to create a "care wall" for both physically distant sides to communicate in real time as if they were live next door. By projecting realtime video clips to a plan wall or surface, people can see the instant images of their loved ones through the wall. In addition to videoconference-like features, people can interact with the care wall to acquire extra information and deliver specific objects.

1. Introduction

While population of elder people grows up and the wishes of elder people to live independently in their private home, instead of moving to an institutional care setting, it brings social and healthcare problems that the elder people who live alone are in high risk upon incidences. In this paper, we design a "care wall", which uses projectors and cameras to virtually connect 2 physically separated places as if they are neighbors. It embodies the function of video conference, and augments the contents of video clips with context-aware objects. Besides seeing and talking to each other in real time, people can intuitively touch the projected images on the wall to acquire extra information from context-aware objects, simply by their hands (see Figure 1). Furthermore, we are interested in how to transfer physical objects to the remote side with their digital representatives.

2. Related Works

Mynatt et al. design the Digital Family Portrait [4], which mapping the elder relatives' health condition to a portrait. Their extended family members can thus know the accumulated physical and psychological statistics of their elder relatives. Consolvo et al. propose the Carenet Display [5], which uses a tablet PC to emulate a picture frame and display the remote one's health condition. The 2 papers provide a good demonstration for healthcare problem that we are interested in this work. However, they lack of interaction with the remote peers.

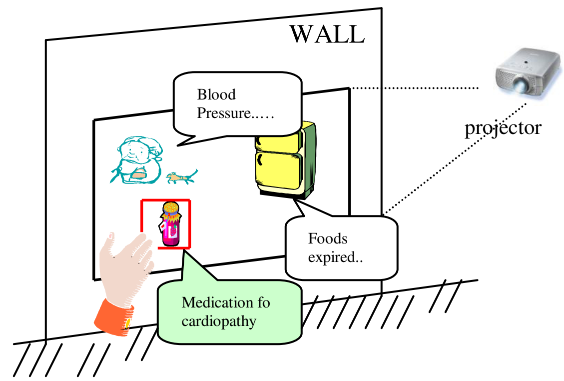

Figure 1: A projected screen with context-aware objects for remote manipulation (hand touch).

Neustaedter et al. discuss the trade-off between awareness and privacy [1]. Blur filtration is thought to be a way to mitigate privacy concern while always-on video works as a medium providing rich awareness for co-worker separated by distance. But in their experiment, they found blur filtration is not sufficient for balancing privacy and awareness in home media space situations. People begin to abandon the filtration technique with increased privacy risk. Blur filtration by itself is much too limiting of a technique to be used in actual practice. In our work, we intend to connect two spaces and make the communication between family members who lives far away. The one who stands at one side of the care wall can watch the live images from the other side. These spaces may be living rooms or dining rooms, but not the private spaces where we might be naked. We think the privacy concern in our work is not as much as situation mentioned in the paper.

Summet et al. classifies projection technologies into four categories [2]. Rear projected displays could be very large, but the high cost and installation requirements are their limitations. Front projected displays have problems shadows and occlusions. Warped front projection uses a single front projector which is mounted off of the normal axis of the projection screen, in an attempt to minimize occlusion of the beam by the user. Virtual rear projection uses multiple redundant projectors to eliminate shadows. Two front projectors are mounted on opposite sides of the normal axis to redundantly illuminate the screen. They design a study to determine how user feel and cope with the shadow problem, and to see if the improving projection system increases user performance. In their study, they found though users adapt to occlusions and shadows quickly, they don't like it. Besides, warped front projection could reduce occlusion. And virtual rear projection had the highest user preference. Our work may face the same problem as mentioned in the paper [2]. Although shadows don't affect our hand-tracking, the user will be annoying with the noisy shadow images while clicking the objects on the wall. However, since in our work the user does not need to face the projector, the blinding problem may not be as serious as in paper [2].

Nakanishi et al. proposes two systems, EnhancedDesk and EnhancedWall, with computer vision and augmented reality technologies [3]. EnhancedDesk is an augmented desk where can direct manipulate both real and projected objects with our hands and fingers. EnhancedWall is an interactive wall display that allows users to specify some information item of current interest, show the specified item in detail, and provide context by displaying the remaining items in successively less detail. It utilizes face-tracking, focus+context, and gazed-tracking techniques.

3. System

Our system adopts two projectors, one on each side. Three cameras are used in each side for realtime images display and hand motions tracking.

3.1. Scenario

It is evening time. The elder mother, Mary (sitting in her kitchen) and her daughter Molly (standing in her living room) are having a conversation over the care wall. During their conversation, Mary is taking a new medication which Molly is not aware of. So Molly asks her mother - "what is this new medicine?". Mary said that this is a new medication from which the doctor gave her to control her diabetes. Molly is curious to find out more info about this medication, so Molly touches the medication bottle shown on the care wall, and the info about the medication is displayed on wall. Molly is curious about why the doctor gave this new (stronger) medication to Mary, so she enquires her mother about her recent diet. To find out more about her mother's diet, Molly checks the content of her mother's fridge. Mary grasps the fridge on the care-wall, from which the content of the fridge is shown (assume a camera is installed inside the fridge). Mary browses through the contents of the fridge (juice bottle, milk, fruits, etc.) Molly identifies that the juice that her mother is drinking contains too much sugar, so she advises her mother about this.

Mary thinks of a picture taken earlier this year with her new friends. She wants to share it with Molly and puts the picture on the wall. The system searches for its digital representatives and then has the projector in the remote side to project the digital images on Molly's care wall display.

3.2. Implementation

System implementation is divided into the following sections (See Figure 2 for implementation configuration.).

Projector and Cameras deployment

In the 1st stage, we implement a simple scenario to touch the wall by a user's hand. We use three cameras for the purpose. They are put in the right, upper, and mid of the projected screen. The camera, which put in the center of the wall, is for realtime image capture, while the right and upper cameras are used for hand motion tracking and interpretation of hand coordinate, x-axis and y-axis respectively.

Hand motion detection

Hand motion silhouette is acquired by calculating their differences in successor frames. Once we have the silhouette images, we then calculate their relative coordinate in the space and transfer the data to corresponding x and y-axis on projected screen. The "touch" event will be trigger once a valid motion is detected.

Object Recognition

Object recognition is achieved by adopting haar-like features, provided by Intel OpenCV libraries [6]. We obtain objects classifiers by Adaboost training method and apply them on real time images [7]. Each object is trained independently with its own classifiers, which we will use later for recognition. Once an object is recognized inside the images, our program will draw a rectangle area, embodying

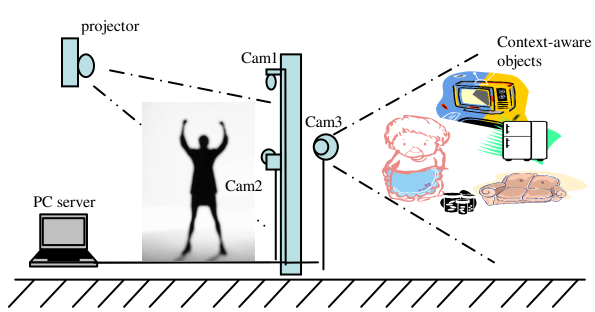

Figure 2: Care-wall System Configuration

the object. The area will be recorded for use in visual tracking module.

Information Display

When a valid hand motion is detected and the coordinate is within range of context-aware objects. The object information will be displayed directly on top of the projected screen for 10 seconds for sake of not affecting the real time communication.

3.3. Physical vs. digital representation

Another component of interaction in this work lies on the transmission of physical objects. In real lives, we may just pass the physical objects to our neighbors via the windows, but in digital world, we do not have such a machine to actually do the same thing. Therefore, we have to find out some objects which can be transferred properly with their digital counterparts. We find the following scenarios which may be suitable for the application:

Short note delivery

As electronic paper pervades, we can design a mechanism to read the electronic paper which is attached to the care wall and transfer the text/image contents to its remote peer.

Picture sharing

When the users want to share a picture, they can just attach the picture to the wall, and the picture can be displayed on the other side.

Video/audio transmission

People can share video/audio contents since they can be easily digitized and transferred to the remote side.

Remote control

By adopting infrared sensor on the wall, users can use the remote control to select TV channels for the other peer if they want to share something on the TV channel. This can also apply to air conditioner and microwave..etc.

3.4. Privacy

As already mention in [1], there are always privacy issues when using a camera. Nonetheless, the design may cause less privacy issue because we define the scenario in the home, where the space is always treated privately. We assume no strangers will be able to see those image frames in ordinary conditions.

Concerning the privacy leakage when the remote peer is accessing local objects (fro ex: refrigerator), the screen will show this action in the bottom right corner of the projected screen to remind users of this behavior.

3.5. Limitation

A frequent light changing may produce noises for camera tracking and result in false positives. Since we adopt front projector in this scenario, it is inevitably that the shadow of the user will occlude the remote images. The problem can be minimized by well deployment.

Context acquisition is another challenge in this scenario. However, this is another key topic so we skip it in this paper, but just assume we can have the information by a certain means.

Another limitation with the care wall is that the caregivers cannot physically grasp and touch the objects on care-receiver's side. This limitation can place a restriction on the ability of the caregivers to provide care to the care-receivers. To solve this kind of problems, we will have to design a mechanism for physical/digital transition and try to mimic this kind of scenario as mentioned in chapter3.3.

4. Summary and Future Works

The 1st implementation described in this paper shows the feasibility of such an idea. The stereo cameras can adequately interpret the coordinate where a user's hand touches. And the information can be displayed properly on the wall once the event is detected.

4.1. What we expect from the care wall

The work raises the question of what we expect from a "wall". What kind of an augmented wall that we might need? Whether we just want to provide healthcare or something beyond that? In additional, whether our elder relatives tend to see and know something from the wall as we do? It takes time and more user studies to answer the questions.

4.2. Future Works

By using two cameras to track hand motions without autonomous calibration, current system can provides a coarse positioning of coordinates. We will keep on improving the accuracy and designing an effective algorithm for autonomous coordinate calibration.

After that, we would like to conduct a field trial with our current system and then collect some user feedbacks for system improvement.

The mechanism for physical / digital transition is also a key direction of our future works. We are interested in design a mechanism to seamlessly transfer objects between 2 physical spaces.

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