Interactive Care Wall

Chu-feng Lien, Hao-ji Wu, Hao-hua Chu

Graduate Institute of Networking and Multimedia
Department of Computer Science and Information Engineering
National Taiwan University
{p93007, b90007, hchu}@csie.ntu.edu.tw

Abstract. We propose a video-mediated interactive care wall as a way of supporting a face-to-face like care between elders and their remote caregivers. This interactive care wall attempts to interconnect two physically-disjoint spaces by linking one wall on the elder's living space and one wall on the caregivers' living space. To make this interconnection appears seamless, the care wall provides some mechanisms to allow caregivers to access the digital representation of remote objects (e.g., medicine bottles) across this virtual wall, as well as move digital representation of local objects (e.g., reminder notes) to remote spaces.

1. Introduction

Advance in healthcare has led to longer life expectancy and so-called aging population trend. Statistics in Taiwan have shown that the percentage of population over 65Y is expecting to increase steadily from 8.5% of population (1,895,000 persons) in 2000 to 9.9% of population (2,357,000 persons) in 2010. This population aging trend is concurring with yet another social, economical trend of young adults, traditionally the main caregivers of their elders in Taiwan, living and working apart from their elder family members. Statistics in Taiwan have also shown that the percentage of 65Y+ elder population living with their children has declined steadily from about 61% in 1992 to 51% in 2002.

These two social trends give rise to a need to utilize intelligent sensing, digital media, and networking technology to assist elder population to live independently, safely, and comfortably at their own home for as long as possible; at the same time, should provide remote family members the peace of minds to closely monitor and attend to physical and mental well-beings of their elders anytime, anywhere. It should be able to eliminate geological distance in the provision of physical and mental healthcare between elder population and their caregivers.

In order to reduce this geological distance, we propose an interactive care wall that can support face-to-face like care between caregivers (e.g., children) and their remote care-receivers (e.g., elders). This involves virtually interconnecting two (or more) physically-disjoint spaces through a digital see-through wall. This see-through wall is made up of (1) digital cameras and various types of sensors (e.g., microphone, temperature, light, etc.) to capture the contextual state (e.g., images, sound, light level, temperature, etc.) from two physically-disjoint spaces, (2) a networking infrastructure to exchange the contextual state between them, and (3) projectors and various types of actuators (e.g., audio speakers, air conditioners, lighting controls, etc.) to replay contextual state transmitted from remote spaces. The objective is to create a digital illusion that two physically-disjoint spaces are interconnected together. The quality of this digital illusion depends on the seamlessness of this virtual spatial interconnection, as perceived by users.

2. Challenges

There are many difficult technical challenges in the provision of a seamless spatial interconnection across a digital wall. This paper would like to address two of these challenges: *(1) accessing objects at remote spaces* and *(2) moving local objects to remote spaces*. The first challenge is about users (e.g., caregivers) on one side of the wall cannot grasp and retrieve remote objects located on the other side. For example, if a care-receiver is taking a new medication which is new to the caregivers, caregivers cannot physically retrieve that medicine bottle and examine its content and instruction. To address this limitation, the care wall is augmented with interactivity, so that objects shown on the wall, when annotated with their digital representations, can be made graspable by caregivers. Thus, caregivers can virtually grab, through hand gesture recognition, the images of medicine bottles shown on the care wall and digital information about the grabbed medicine bottles will be overlaid on the care wall. In other words, the care wall is not just a wall-size video conferencing system from which caregivers and care-receivers can converse face-to-face and in real-time, but also supports interaction over objects existed in this virtual interconnected space.

The second challenge lies in moving local objects to a remote space. This limitation also places restriction on the ability of caregivers. For example, it would be impossible for a caregiver to leave notes in the remote space of the care-receiver, reminding him/her to take medications on time, throw away food that will expire in the fridge in the next few days, or get ready for pick-up on a doctor appointment tomorrow afternoon. To address this second limitation, the care wall can capture the digital representation of any local objects and transmit it to a remote space. In the previous example, a caregiver can leave a note in a remote space by physically placing the note on a care wall. Then the digital representation of this reminder note is captured (e.g., from a camera), transmitted, and shown on the projector of the remote space.

3. Design and Implementation

The design of our care wall is shown in Figure 1. It consists of the following components: a camera-projector system, hand motion detection, object recognition, and information display. They are described in more details as follows.

The camera-projector system uses a high-resolution camera placed in the center of a care wall and a projector mounted on top of a ceiling pointing at a care wall. Since this digital wall separates two physically-disjoint spaces, a separate camera-projector system is needed in each of the two interconnecting spaces. The camera-projector system works as follows. First, the center-of-wall camera captures live video of what is going on in front of the wall in one space. Second, this live video is streamed through the high-speed Internet to a projector on a remote space. Lastly, the projector displays the live video on the remote space.

The hand motion detection is used to track the position of hand motions touching (or grabbing) objects shown on the care wall. This enables users situated in one space to access digital representation of remote objects shown on the care wall. The hand motion tracking is implemented by using two additional digital cameras placed on the center-top and center-right of a care wall boundary. Hand motion silhouette is then acquired by computing differences in successor frames from cameras. Images from the center-top (center-right) camera are used to track the horizontal (vertical) position of hands touching the wall. A *touch event* is triggered whenever a valid hand motion near

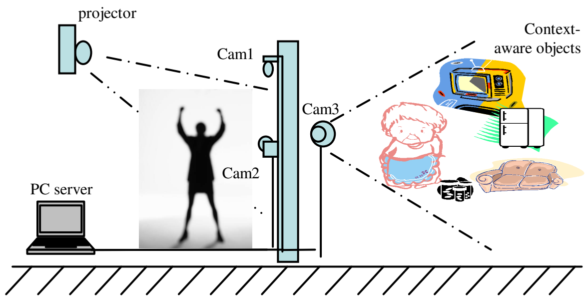

Figure 1: Care-wall System Configuration

the care wall is detected.

Object recognition is implemented by adopting Haar-like feature classifiers, provided by the Intel OpenCV libraries [6]. Object classifiers can be obtained through the Adaboost training method, in which each object is trained independently with its own classifiers. The classifiers are then applied to recognize objects on real-time images captured from a camera [7]. When an object is recognized, a rectangle area enclosing the object is also identified on the care wall. This information is used in conjunction with the hand motion detection to associate any remote objects with a touch event. In addition, it is used to recognize a *tag event*, meaning that a local object (e.g., a reminder note, a picture, etc.) has been placed on the care wall for display on a remote space.

When a touch-remote-object event or a tag-local-object event is recognized on a care wall, an information display shows the digital information about the touched object for 10 seconds duration on the corresponding care wall.

4. Related Works

Digital Family Portrait [4] and Carenet Display [5] provide good demonstrations of healthcare solutions for elder people. However, they lack interactions with remote peers. Neustaedter *et al.* discuss the trade-off between awareness and privacy on video systems with blur filtration [1]. Summet *et al.* discuss projection technologies and classify them into four categories [2]. Nakanishi et al. propose EnhancedDesk and

EnhancedWall, in which they employ computer vision and other sensor technologies to augment the desk and the wall with intelligences.

5. Discussion

This work raises questions of what caregivers & care-receiver expect from a smart wall, whether they have different expectations, and whether they just want to support care, communication, or something beyond them. We would like to conduct more user studies to answer these questions.

Since the care wall involves using cameras, privacy becomes an important issue [1]. Since the care wall interconnects home of private spaces, it is important that the communication channel is secure such that only family members living in these private spaces have access to the information display on the care wall. There is a privacy concern when a remote family member is accessing local objects (e.g., check out the content of a medicine bottle). To address this issue, the access action will be displayed on the care wall to remind local family members of this action.

We are also exploring new ways of accessing and moving digital representation of physical objects more seamlessly across this virtual wall. This is also a key direction of our future works.

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