Enhancing Layers of Care House with Assistive Technology for Distributed Caregiving

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Abstract
Care homes for persons with dementia are being designed so that caregivers can easily observe and therefore respond to the needs of people with dementia. However, the layout of care homes can then become overly restrictive for its residents, for example, by not supporting intermediate spaces where people can come across one another and start a conversation. We report a case study where a video monitoring system was deployed into a purpose-built care home to help caregivers to observe activities in the blind spots pertaining to the layout. We had carried out a study prior to and subsequent to the deployment of video monitoring in order to understand its impact. We found that both the caregivers and the residents benefitted from video monitoring, provided it is deployed sensitively. Furthermore, the deployment of video monitoring enables the design of more beneficial physical layouts. The deployment of video monitoring goes along with the physical layout of care homes.

Introduction
Dementia care is becoming increasingly important as the elderly population grows (United Nations Population Division 2008; World Health Organization and Alzheimer’s Disease International 2012). Elderly people with dementia require special attention because they are vulnerable to changes and events in their environment, and become uncomfortable when they do not recognize their surroundings. Thus, caregivers need to create a peaceful environment. Caregivers need to be well-trained and experienced; they need to pay special attention to the needs of people with dementia. Person-centered care (Kitwood 1997; Kitwood and Bredin 1992) is an approach to dementia, whereby the person cared for is central to the activities; the caregiver is keen to observing and communicating with that person to determine what he/she wants to do and why.

Care homes are designed so that caregivers can easily observe, and therefore respond to, the needs of people with dementia. However, the layout of care homes can then become overly restrictive for its residents, for example, by not supporting intermediate spaces where people can come across one another and start a conversation. This paper explores the relationship between the spatial layout of a care home and the use of a video monitoring system in the environment to enhance collaborative care. Two research questions (RQ) were asked to investigate the relationship, as follows:

RQ1 How does the video monitoring system affect the collaboration amongst caregivers?

RQ2 How does the video monitoring system enable people with dementia and their caregivers to identify opportunities to change the spatial layout to strengthen care?

To answer the RQs, we carried out case studies of a video monitoring system deployed in a care home and analyzed its spatial layout.

We briefly explain in the next section related work in architecture and assistive technologies, then present the findings from our case studies, which were carried out at two group homes. The paper concludes with a broader discussion.

Smart Home as Assistive Technology
Smart Home is a home into which a sensor network is installed. Its goal is to create assistive environments such as homes that can sense caregivers and residents to enact the mappings between the physical world and the remote monitoring and intervention services (Demiris et al. 2004; Helal et al. 2005). When the concept is applied to a care home, we obtain a smart home that enables caregivers to
monitor the whereabouts of residents. When a smart home is inhabited by people with dementia, the home helps caregivers sense the risks involved in the residents’ unusual behaviors such as wandering and agitation.

Arcelus et al. describe sensors integrated into a home as a health monitoring system, and the resulting alarm system communicates any abnormalities found (Arcelus et al. 2007). A smart home based on Infra-Red sensors was built, which detected abnormal behaviors of the elderly with Alzheimer (Campo and Chan 2002). A framework called Open Service Gateway Initiative was proposed and adopted to develop a system integrating Mobile Patient Care-Giving Assistant, General Reminder System, and Augmented Awareness System (Helal et al. 2003). A bedside monitoring system was developed to predict when staff should engage in a form of therapy, highlighting specific areas for attention (Hope and Waterman 1997). A sensor network was developed to localize users via signal strength measurements, which consists of user badge nodes, several image sensor nodes, a node with a modem, and additional optional wireless nodes (Tabar, Keshavarz, and Aghajan 2006). A decision support system was developed based on machine learning technique of Alzheimer Disease’s daily behavioral patterns (Zhang et al. 2008).

Referring to the issue of spatial layouts for caregivers and residents, we have to find some other solution rather than resorting to the layouts because conflicts between needs for physical safety and needs for personhood will never be solved by changing the plan of houses. We propose in what follows to separate the flow of information and the spatial relationship between caregivers and residents by deploying assistive technologies to care homes. By separating information flow and the spatial relationship we are able to load different functions onto them, attributing the former to caregivers and the latter to residents.

**Case Study of a Video Monitoring System**

**Overview**
Overview of these case studies is shown in Table 1. We investigated two group homes, which we refer to as GH-C and GH-D, by means of interview and video observation. We deployed a video monitoring system in both group homes. In the following, we describe and analyze the impact of the systems, which prompts us to raise some architectural issues.

Our purpose is to investigate how the spatial layouts of care houses affect care giving, and more specifically the effects on the communication between caregivers and residents. We compare the caregiving at GH-D, a renovated care house from a traditional Japanese style house, with those at GH-C, a newly built care house, to see the effects of spatial layouts. We also investigate the effects of a video monitoring system by comparing the ways of caregiving before and after the deployment as for GH-C.

**Research design**

**Group home.** We focus on a small type of care home called group home in what follows. Group homes in Japan are categorized into two types from an architectural standpoint. One type is converted from an old house that was built for a family, and not originally intended to be used as a care home. This type of home tends to have many blind spots. The other type of home is purpose-built to accommodate the elderly with dementia. This type of home is built to eliminate as many blind spots as possible on safety grounds.

**Video monitoring system and its deployment.** We designed the system as simple as we could because the caregivers in GH-C were not familiar with computers. The system consisted of five wireless cameras, a portable monitor, and a laptop PC functioning as server. Visual data from the cameras were gathered on the server and were displayed on a Web browser. A down-scan converter was employed to turn the information displayed on the Web browser into TV signals, which were emitted to a portable monitor. Possible malfunctions due to mishandling by the caregivers or residents were reduced to the minimum because it was impossible for them to operate the system through the monitor.

A preliminary investigation was carried out to identify blind spots in the group home, GH-C, and to identify the system’s requirements. The manager and the caregivers were concerned with the privacy issue and were especially keen to avoiding any unwanted effects due to video recording, so we paid particular attention to protecting residents’ privacy. We decided to set cameras in common spaces only, such as the entrance hall, the corridor, and the living room. In our discussion with the manager of GH-C, we discovered that five spots were often difficult to observe. Furthermore, we decided not to include any video recording functionality in the system. Deployment of the

| Table 1 Overview of case studies |
|---------------------------------|-----------------|
| **Type of buildings**           | GH-C            | GH-D            |
| **Number of residents**         | 9               | 9               |
| **Number of informants**        | 5 caregivers and 2 managers | 9 caregivers and 1 manager |
| **Caregivers in daytime**       | 2 or 3          | 2 or 3          |
| **Caregivers in nighttime**     | 1               | 1               |
| **Residential areas**           | first floor     | first floor     |
| **Start of system operation**   | March 2008      | September 2010  |
| **Time of interview**           | before November and December 2007 | August and September 2009 |
| **Time of video observation**   | before March 2008 | December 2010 |
| **observation**                 | after December 2008 | December 2010 |
system at GH-D was conducted similarly.

**Interview.** A series of semi-structured interviews were carried out before and after the system had been deployed in GH-C and GH-D. We interviewed five caregivers and two managers, asking them what they thought of the system and which aspects they regarded as the most valuable in terms of dementia care.

All the interviews were recorded with an IC recorder and were fully transcribed for ease of reference. The constant comparison was used to analyze the transcriptions as follows. The transcriptions were repeatedly read as many times as possible to identify any commonalities and differences among the data, and the similar data were classified into the same category. In this process, when a category was recognized to be similar to another one, these were integrated to one category. This analyzing process was repeated until no new categories were found.

**Video observation.** We observed behaviors of the caregivers and the residents by recording them. The caregivers and the managers allowed us to record their images with two extra video cameras, which were not part of the camera system. We carried out the data collection for one day before installation and another day after installation. We analyzed behaviors of a caregiver and residents observed in the corridor and in the living rooms and dining rooms to concentrate our investigation to the events closely related to daily activities such as the assistance in the lavatory.

**Ethical Considerations.** In this study, we strictly observed informed consent guidelines in asking individual caregivers and managers of the group homes for data collection. Likewise, a letter of consent was obtained from the residents' families. Video cameras were never set in private residential areas such as inside a resident's room, the washroom, *furo* (Japanese-styled bathroom), etc., to maintain privacy.

**Findings**

From the results of interviews and video observations, we found two behavioral changes as follows.

**Establishing roles of the watcher and the doer.** It turned out that the monitoring system made caregivers' roles clearer to them. A caregiver working in the kitchen, where one of the video monitors was placed, took the role of watcher while other caregivers were involved in household chores. Those caregivers outside the kitchen were helped by the caregiver in that they could take things under control even if they could not see several areas themselves. Caregivers felt that the system had improved their work styles significantly because it enabled them to focus on the tasks at hand, such as helping some other resident to use the lavatory.

The role of watching residents from the kitchen indicates that they started specifying tasks more clearly than before. They had to move to places to see what had happened when they noticed something unusual. There is no need for coordination as long as the person receives information on the spot, and reacts to an incident involving a resident. The video monitoring system enabled them to see those places without coming to the places, bringing about the role of just watching an incident remotely. It is worth noting that there were no such cases that a caregiver watches an incident without being there before the introduction of the system.

One of the difficulties in dealing with the elderly with dementia lies in the fact that they may perform activities unexpectedly. Caregivers thus have to pay attention to the residents all the time. They cannot however always watch them. They have to take a resident to the lavatory, for example, and may not watch others while being engaged in the task. The video monitoring system decreases the moments at which no caregiver pays an attention to residents by providing them with a wider view, thus increasing the chances that caregivers respond to residents' sudden unexpected behaviors.

**Alleviating Stresses.** The series of interviews revealed that the system reduced caregivers' physical and mental stresses, as previously reported (the details were reported in (Sugihara et al. 2008; Sugihara and Fujinami 2011)). Caregivers reported that some areas became blind spots at night because fewer caregivers are available to work overnight. The video monitoring system was most effective during nighttime, and specifically, the time from midnight to early morning. Caregivers who worked during the night were very anxious about blind spots. They were afraid that some residents might be seriously injured, for example, suffer a bone fracture, if they fell down.

Such accidents are always a possibility, but they must be avoided because being injured and confined to a bed may further cognitively impair the person. Caregivers were so worried of accidents that they would get anxious in the evenings.

During both the daytime and nighttime shifts, caregivers reported that the camera system helped them make decisions. For instance, when a resident appears from his/her room and walks toward the washroom at night, caregivers in the kitchen may not be aware of the event. If they notice that a resident is heading toward the washroom, they leave their work and take any necessary action.

Two caregivers and a manager said that it was easy for them to observe residents entering or exiting the washroom day and night.

Before the introduction of the monitoring system, residents' activities were restricted in order to secure their physical safety. On the other hand, both residents and caregivers were under fewer restrictions while the system was in place. A veteran caregiver reported that the elderly
residents’ peace of mind improved in response to the increased level of caregiver attention.

Comparing a Renovated Care House with a Newly Built Care House

Analysis for Spatial Layouts of Group Home
The architectural plans of a newly built care house, GH-C (Figure 1), and a renovated care house, GH-D (Figure 2) were analyzed on the basis of the space syntax (Hillier 1985). The analysis was conducted by a researcher of architecture, the fourth author, who is a professional architect and an assistant professor at a university.

Space syntax is a combination theory and technique to analyze spatial configuration of urban areas, hospital, etc. It is useful method to grasp spatial functions of group homes. First, the two group homes were separated along with the compartments on designs. Individual compartments were categorized into four groups: space for personal use (e.g. resident’s rooms), space for accessed by the general public and used for multi-purpose (e.g. living room, dining room), space for accessed by the general public and used for specified purposes (e.g. lavatory, kitchen, Japanese-styled bathroom), and space for move (e.g. corridor, entrance).

Second, the relationship among the categories was described for understanding the nature of them. Functions of each compartments were then rendered in detail from the standpoints of how residents and caregivers use usually, how connecting points, e.g. doors, work to link the other compartments, and what kinds of functions the each compartments have for visually and auditory.

Results
GH-C consists of two components, one of which extends from north to south and the other of which from east to west. These two components are adjacent to each other and

the former includes common facilities such as kitchen and dining room, while the latter includes individual rooms.

The plan of GH-C (Figure 1) shows that the central corridor joins the common facilities and individual rooms, which are arranged at both sides of the corridor. The width of the corridor is set for a person in a wheel chair to pass and no activity is expected to occur there except for a resident’s passing. The architectural planning only exhibits two sorts of spaces, that is, private or public. There is no gray area in between such as an alcove. The residents have therefore few options concerning their whereabouts and are rarely induced to small group activity such as chatting between them.

GH-D is a renovated care house converted from a family house (Figure 2). The house consists of common facilities and individual rooms which are connected by a crooked corridor. The reason why the corridor is not straight is sought into its origin, that is, the house was built for a family. The crooked corridor produces blind areas, which are not ideal for caregiving, but produces a place for communication among a small number of people who come across each other. This sort of space allows residents for a greater variety of behaviors, but is not preferred by caregivers because it makes it difficult for them to monitor residents. The common facilities of GH-D are also a problem because caregivers cannot look around the corners if they are in either the living room or common room.
From the caregivers’ point of view, the layout makes it difficult to coordinate themselves and includes many blind areas. As the result, each caregiver tends to deal with residents by herself, which leads to restricting residents’ behaviors to be located near her.

The interview showed that caregivers often bring residents into the dining room or living room. The dining room was the place where it is easy to play something recreationally and to watch them from kitchen. The living room was used to prevent wandering by showing TV. It was however difficult to keep an eye on their actions from the kitchen because of the wall. Finally part of the wall was penetrated (as shown in a point X in 2) or eliminating blind areas on living room. A door of dining room was removed as well.

Discussion

Stewart Brand points out that buildings consist of six layers, that is, site, structure, skin, services, space plan and stuff (Brand 1994). Each layer has different longevity derived from the nature of them. Site, which signifies the geographical settings, the urban location and the legally defined lot, is the most long-lasting layer. The reason why people do not expect to change the structure layer is to reduce the risk of deterioration and because of the cost of the change. Skin, i.e. exterior surface, changes every twenty years due to updates with fashion and/or technological trends. Services involve all the building facilities such as electrical wiring, plumbing etc., and they are replaced every seven to fifteen years. Space plan is the layer for interior layouts: the space changes every three years or so. Stuff such as chairs, pictures, books, etc. is frequently changed, nearly every day.

The introduction of the monitoring system gives rise to a new layer, which we call the information layer, which exists in addition to the physical layer, the building itself. Before the introduction of the system, the physical layer defines the information layer, that is, the structure of the building determines the information layer. Caregivers have to grasp all the information about resident’s physical and mental condition, and detect signs of unexpected behavior out of their line of sight. They also have to coordinate their tasks on the basis of this restricted sight. At least, they changed the layer of structure to enhance their sight and to coordinate easily.

The information layer enabled caregivers to coordinate themselves in dealing with the residents. A caregiver in kitchen can figure out not only resident’s actions but their companion’s one without changing the structure layer. From the standpoint of owner of the care homes, to introduce such assistive technologies can cut the cost of change. Deploying an assistive technology means changing the layer of the services and the space plan; this is a lot cheaper than changing the structure. The addition of the information layer also helped caregivers to clarify their roles, resulting in a division of labor, i.e., the watcher and the doer. The clarification decreased work stresses (Kahn et al. 1964) of caregivers because their responsibilities were specified. Role stress, especially role ambiguity and role conflict, is a well-known predictor of burnout (Rizzo, House, and Lirtzman 1970). In healthcare settings, several studies show that role ambiguity and role conflict are play to be causally related to emotional exhaustion (ex. (Barber and Iwai 1996; Schaefer and Moos 1996; Moniz-Cook et al. 1997)).

Role ambiguity and role conflict arose adjacent to blind spots in these case studies. The blind spots plunge caregivers into confusion about whether they have to go to resident’s help, how do they prioritize the order of their tasks and how do they collaborate with their companions. In other words, they did not have any alternatives to chose between other than who are the watcher and the doer. The means to accomplish goals was delineated and contributed to easing their work stresses.

The addition of the information layer also benefits the residents in that the care homes can be designed more flexibly. That is, the structure does not determine caregivers’ line of sight; at those places that are not observable by the eye, they can be seen with the video monitoring system. Given this flexibility, the house can physically be designed to suit residents’ needs. The house may include gray areas, the areas that are partly public and partly private. The enriched structure of houses contributes to making the residents’ lives more comfortable.

It is essential to consider privacy issues for the concept of the information layer. However, the relationship among privacy issues, assistive technologies and person-centered care (Niemeijer et al. 2010). Considerably more work will be needed to integrate privacy controls into the information layer.

Conclusion

We have presented an exploration of the architecture and information of care homes and have explained the result of our case studies carried out at two group homes to investigate the effects of information layer added to one of the group homes. Explicit introduction of an information layer to the home enabled caregivers to monitor residents remotely, leading them to clarify their roles, i.e., the watcher and the doer. The clarification contributed to decreasing their stress levels by disambiguating assignments of tasks.

Our idea of separating the information layer from the physical layer will help caregivers to coordinate their care
of elderly people with dementia using the system. Answers for RQs are:

**Answer for RQ1** The video monitoring system enables caregivers to clarify their roles, i.e. the watcher and the doer, and to facilitate coordinating their work by the clarification. It also alleviates their stress levels.

**Answer for RQ2** The system shows that by not changing the physical layout and deploying the information layer, the quality of care is sustained, if not improved.

There are two noteworthy limitations of this study: data collection and external validity. Although we mainly collected data using semi-structured interviews and short-term video observation, it would have added to the validity of the findings if we had also carried out follow-up observational studies. We also have to consider the different architectural contexts. Houses in Japan are usually made from wood, soil, paper and ceramic, whereas European houses are made of wood, brick or stone. We would need to carry out comparative studies in the future to understand the implications of using different materials and different styles of spatial layout in order to extend the scope of the findings of this study.

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