

Title	Development of RFID Mat Sensor System for Person-Centered Care in Group Homes
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Citation	
Issue Date	2007-11
Type	Conference Paper
Text version	publisher
URL	<a href="http://hdl.handle.net/10119/4077">http://hdl.handle.net/10119/4077</a>
Rights	
Description	The original publication is available at JAIST Press <a href="http://www.jaist.ac.jp/library/jaist-press/index.html">http://www.jaist.ac.jp/library/jaist-press/index.html</a> , KICSS 2007 : The Second International Conference on Knowledge, Information and Creativity Support Systems : PROCEEDINGS OF THE CONFERENCE, November 5-7, 2007, [Ishikawa High-Tech Conference Center, Nomi, Ishikawa, JAPAN]

# Development of RFID Mat Sensor System for Person-Centered Care in Group Homes

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## Abstract

We have developed a system with a flexible RFID (Radio Frequency IDentification) antenna mat to assist caregivers in a group home. In Japan, a group home is a type of home-based care service for elderly persons who suffer from dementia. The caregivers working in the group home must always pay attention to such persons. Since the level of dependency of each elderly person is different, the caregivers must check whether the person requires support or not. However, the checking demands extra efforts on part of the caregivers in addition to the support tasks. To simplify this task, we introduce a system consisting of RFID antenna sheet sensors and RFID tags embedded in inner shoes or slippers of the elderly persons. The system can assist the caregivers to monitor the activities of the persons with dementia by specifying whether the person passed through the sheet on the corridor. It not only helps the caregivers to understand such persons by reviewing their activities but also keeps them informed about the person's ongoing activities.

**Keywords:** cognitive impairments, elderly person with dementia, caregivers, RFID

## 1 Introduction

Japan is one of the fastest aging countries. There are approximately 2 million people with cognitive impairments, and 7% of the population consists of elderly persons (over 65 years). As the requirements of elderly care services have increased and are different, the number of “group homes” for people with dementia has increased. The group home is a relatively small facility based on the principle of *normalization*, and it

offers family-like care to enrich the quality of life by respecting the personalities of elderly persons. Group homes offer advantages in terms of hospitality and humanity, but caregivers often find it stressful to pay attention to elderly persons in daily life.

To assist the caregivers and improve the quality of nursing care, we have developed a sensor system with RFID technology. Our system can provide information to the caregivers about the activities of a person after detecting the approach of the person in a specified area. In this paper, we present the design and implementation of this sensor system.

## 2 Design

Our research group has investigated nursing-care support systems by introducing ubiquitous sensing technology. Firstly, we built a facility named AwareRium [1] to simulate an experimental environment similar to that in the group home. AwareRium also serves as a showroom of advanced sensing technologies; it consists of built-in sensors such as ultrasonic position detectors, active RFID readers, and floor-pressure sensors. Although these advanced sensors are effective in augmenting the rooms of the group home, it is difficult to install them in real group homes. Moreover, the floor-pressure sensors can detect events such as the approach of a person in a particular area. However, it cannot recognize the individual, unless extra tags are attached to him/her.

In order to supplement the abovementioned sensors, we have designed a system with an RFID sensor mat. The primary objective of the system is to monitor the activities of each person.

## 2.1 Merits

Understanding a person's activities is crucial for person-centered care. The caregivers usually assist the elderly persons by considering their ability and personality. The understanding of personal activities is advantageous to the caregivers as follows:

1. At midnight, some elderly persons frequently go to the restroom. The notification along with identification helps the caregivers to determine whether he/she requires assistance or not. In addition, the caregivers can find out when he/she returns from the restroom.
2. Several persons perform inadequate activities such as brushing teeth every 10 minutes. If the system generates the activity log of a person, the patterns could be obtained, and the patterns will be helpful for considering the basic state of mind and devising countermeasures.
3. An irregular action often represents a state of high emotion. Some persons will roam around or walk down a corridor with high speed. Our system can detect these irregular actions and inform the caregivers.
4. Basically, the caregivers have to take care notes to record activities. The activity log generated by our system could be used as fundamental data for the notes.

## 2.2 Criteria

In this section we describe the criteria of our sensor system.

1. The use of devices worn or attached to the elderly person's body should be avoided. In particular, the use of battery-powered devices should be minimized because changing or charging the battery involves additional efforts.
2. The device should be suitable for installation in existing group homes without major renovations.

In order to fulfill the criteria, we have decided to develop RFID sheets. If we can reduce the thickness of the RFID reader antenna, it can be deployed easily in rooms or corridors. We have also decided to embed RFID tags in slippers or inner shoes. In group homes in Japan, the elderly persons always wear slippers or inner

shoes while walking around the rooms. They seldom lose their slippers since these are personal belongings, and they are careful about not losing their slippers. The passive RFID tag sheets attached below the slippers can be identified by the RFID antenna sheet and reader. Since the passive RFID tag sheet does not require additional treatments such as charging batteries, it is suitable for conventional group homes.



Figure 1. Our RFID antenna sheet



Figure 2. Slippers patched with passive RFID tag sheet

## 3 Implementation

Figure 1 shows the prototype of our hand-made RFID antenna sheet. The antenna sheet had a width of 900 mm, height of 450 mm, and thickness of 2 mm. This size is suitable for a corridor or a conventional floor mat. The circuit of the antenna was made by sticking copper tape on a thin felt sheet. In this prototype, we used a Welcat

RFID reader (EFG-400-01<sup>1</sup>, 13.56MHz, compatible Tag-it HF-I, I-CODE SLI tags). In this configuration, the reader can detect tag sheets within a range of 5-10 cm. Since the stride length of an elderly person is generally short, the performance of the selected reader will be sufficient for group homes.

An RFID tag sheet (OMRON V720SD13P01) was attached to the bottom of the slippers (see Figure 2). Figure 2 also shows the typical deployment of the RFID antenna sheet.

We developed a simple event-logging application that monitors the detection events of the RFID tags (see Figure 3). When an RFID tag is detected by an RFID reader, a data pair (tag ID, reader ID) is generated and is registered as an “enter” event. When the tag leaves the field, the event “exit” is registered. To prevent irrelevant detections or missing events, the user can set “timeout” by the slider. By pressing the “register tag” button, the user can label the tag. The application also has functions to log the data in MySQL, email when the detected pattern matches preloaded rules, and notify the caregivers by alarm. The system will be provided with a rule editor that enables the caregivers to modify the conditions and trigger events easily.



Figure 3. Event Logging Application

## 4 Related Study

The requirement for an augmented home environment has been investigated. The Aware Home Research Initiative [2] is a pioneer in this field. RFID technology is becoming popular to realize the augmented home environment and sensor networks, even in the case of elderly

healthcare systems [3]. iWalker [4] is a rollator-mounted wayfinding system for elderly persons with cognitive and visual impairments. The rollator is installed with an encoder and a digital compass to guide the user. A small RFID antenna is attached at the bottom of the rollator, and it detects the RFID tag placed on the floor to decrease the localization error. Kawsar et al. have introduced sentient artifacts [5], which represent sensor-augmented objects used everyday, such as toothbrushes, mirrors, and chairs. Fogarty et al. have attached microphone sensors to water pipes, and recognized the daily activities based on the patterns of water usage [6].

Chen et al. have investigated the problem of detecting the social interaction patterns of elderly persons in a nursing facility using audio/video records [7]. Since they focus on the recording of social interaction and events, the video recognition technology is not applicable to our requirement of individual recognition. De Silva et al. have presented a system for the retrieval and summarization of activities in a ubiquitous home environment by using footstep sensors [8]. This approach can be helpful for browsing and recalling the past scene of events, but it cannot be used for identifications. We have focused on a person-centered care system that can distinguish between individuals.

Several studies have been conducted to investigate the possibilities of improvement of the quality of life in terms of memory aid. Hawkey et al. have reported the result of interviews of caregivers and people with dementia with regard to repetitive questioning behaviors [9]. The MAPS (memory aiding prompting system) [10] has introduced a hand-held device that enables people with dementia to recall procedures of tasks based on a prescribed scenario. This framework has been expanded by introducing collaborative aspects with distributed support [11]. The Guide Me project [12] also employs a hand-held device similar to a GPS cellphone to communicate in the case of an emergency. In our study, we eventually address indoor activities so as to reduce the anxiety of caregivers, particularly at midnight.

## 5 Conclusion and Future Work

We have designed and developed a sensor system with RFID technology and demonstrated scenarios for augmenting person-centered care by ap-

<sup>1</sup><http://www.welcat.co.jp/products/rfid/efg40001/>

plying the system to group homes.

For future study, we intend to enhance the prototype for installing the sensor sheets in actual group homes. figreftomarigi shows the floor map of the group home and our plan for the deployment of the sensor sheets. We will evaluate the effectiveness of the sensor sheets in practice.

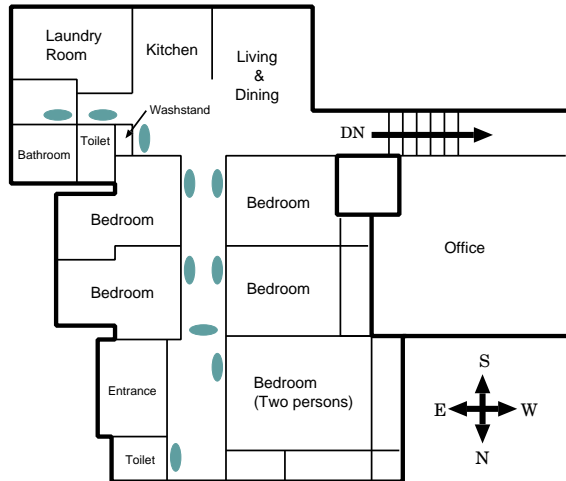


Figure 4. Floor map of Group Home *Tomarigi*

## Acknowledgment

Our research was partly supported by the Ministry of Education, Culture, Sports, Science, and Technology, Japan, under the title “Cluster for Promotion of Science and Technology in Regional Areas.”

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