ANALYSIS OF ACTIVITIES OF DAILY LIVING FOR ELDERLY PEOPLE IN A NURSING CARE CENTRE USING A MONITORING SYSTEM

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Abstract: We researched using a remote monitoring system to identify the activities of elderly people in a nursing care centre. The subjects were three elderly people. A single infrared sensor installed on the ceiling in each subject's room provided digital output when the subject moved. The accumulated data were transferred over the Internet to a server once a day. The subjects' activities of daily living patterns were established from self-completed questionnaires over seven days. We defined the periods of daily indoor living activities as sleeping, getting up/eating breakfast, indoor activities/going out, and eating dinner/going to bed. The mean ± 2 SD of the sensor outputs each day for each period of indoor living activities was used to determine the pattern of daily living. On days when sensor outputs were outside the established pattern, the day was regarded as atypical. The atypical days were identified for each subject over a 28-day period. We could not confirm the subjects' physical condition on these atypical days. We consider that the analysis of daily living for elderly people in a nursing care centre is possible with an infrared sensor and monitoring system.

Introduction

Togawa[1] has stated that daily health monitoring is important for maintaining the health of elderly people. Therefore, it is expected that the information necessary for health administration could be obtained using automated procedures, without disturbing the daily life of older people.

To measure activities of daily living (ADL), such as sleeping, the monitoring system used sensors installed in the dwelling rooms. In our previous study, data from the system monitoring elderly people living alone were evaluated.[2,3]

In the current study, we examined whether we could identify the activities of elderly people in a nursing care centre from the sensor outputs of the monitoring system.

Materials and Methods

The subjects were two men (Subject 1: 66 years old, Subject 2: 83 years old) and a woman (Subject 3: 90 years old) in the nursing care centre. The subjects signed an informed consent form, and the local ethics committee approved the study.

An infrared sensor with a built in transmitter (TX-105, Takenaka Engineering, Japan) and a receiver (RX-400A-S, Takenaka Engineering, Japan) were used. An infrared sensor was installed on the ceiling in each subject's living room and detected all areas in the living room except the toilet (Figure 1). It provided digital output at one-minute intervals, and when a subject moved in the monitored area. The digital outputs were collected using a monitoring program. Once a day the data were transferred over the Internet to a server.

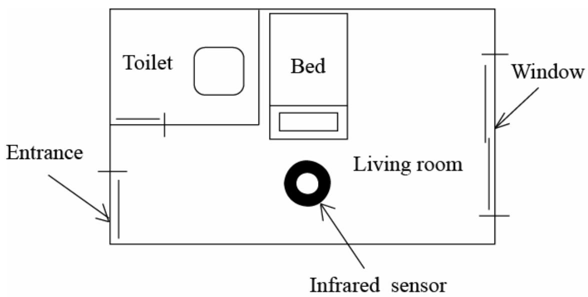

Figure 1: The installation location of the sensor in the subject's room.

To establish the subject's ADL pattern (sleeping, getting up, going to bed, taking meals, taking a bath, going out and coming home) and the subject's physical condition (good, usually and not good), they were asked to complete a daily questionnaire over a 7-day period. If the subject's physical condition was not good, the data were excluded.

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After recording questionnaire data, and sensor outputs during the initial 7-day period, we then recorded only the sensor outputs over a further 28-day period.

Results

1. The period of daily indoor living activities

There was no day when the subjects' physical condition was not good, so the data was not excluded.

An hourly timetable of daily activities (sleeping, getting up, going to bed, taking meals, taking a bath, going out) was constructed from the 7-day questionnaire. The getting up/eating breakfast period was determined from the earliest time of getting up to the latest time of eating breakfast. In the same way, the eating dinner/going to bed period was determined from the earliest time of eating dinner to the latest time of going to bed. The rest of the time was assigned to sleeping and indoor activities/going out. Therefore, we defined four times for the period of daily indoor living activities: sleeping, getting up/eating breakfast, indoor activities/going out, and eating dinner/going to bed (Figure 2).

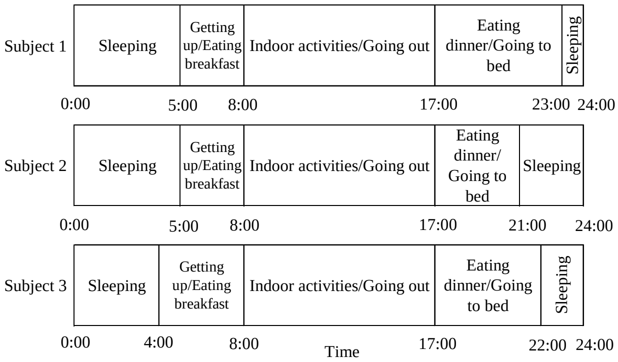

Figure 2: The period of daily indoor living activities.

The schedules in the nursing care centre were breakfast at 7:30, lunch at 12:00, and dinner at 17:00. Therefore, the mealtimes were constant in the three subjects, but the times of getting up and going to bed were different. Also when the subjects went out, they did not eat lunch in the nursing care centre.

2. The pattern of daily living

The average sensor outputs per hour in the period of daily indoor living activities were compared with the maximum, minimum and mean ± 2 SD of the sensor outputs. The mean ± 2 SD of sensor outputs were within the limits of maximum and minimum in the three subjects (Figure 3, Figure 4, Figure 5). Therefore, the mean ± 2 SD of the sensor outputs each day for each period of indoor living activities was used to determine the pattern of daily living.

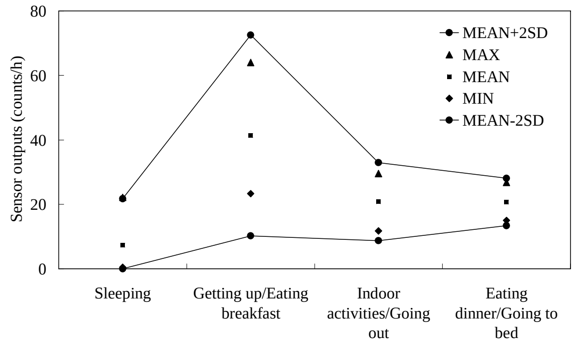

Figure 3: The pattern of daily living for Subject 1

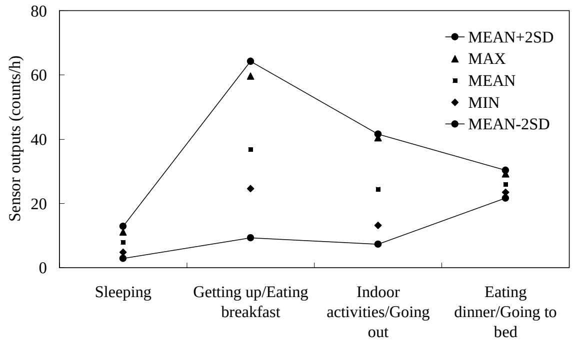

Figure 4: The pattern of daily living for Subject 2.

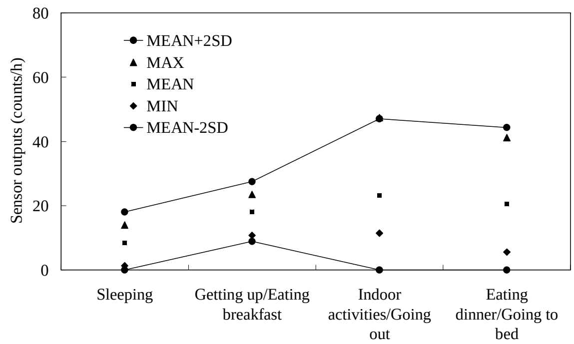

Figure 5: The pattern of daily living for Subject 3.

The form of the pattern of daily living was similar to subject 1 and subject 2. The sensor outputs for sleeping were less than for the other periods. Peak sensor outputs occurred during the getting up/eating breakfast period.

3. Sensor outputs over 28 days

On days when the sensor outputs were beyond mean ± 2SD, the day was assumed to be atypical. To compare the pattern of daily living, the days with sensor outputs beyond mean ± 2SD over 28 days were also extracted as atypical days (Figure 6).

Table 1: Result from extraction of atypical days.

(a) Subject 1

Day	S	G/E	I/G	E/G
Day 1				
Day 2			M	
Day 3			M	M
Day 4			M	M
Day 5				M
Day 6				M
Day 7				M
Day 8				M
Day 9				L
Day 10				L
Day 11				L

(b) Subject 2

Day	S	G/E	I/G	E/G
Day 1	L			
Day 2	L			
Day 3	L			
Day 4			L	L
Day 5			L	L
Day 6				L
Day 7				L
Day 8				L
Day 9				L
Day 10				L
Day 11				L
Day 12				L
Day 13				L
Day 14				L
Day 15				M

(c) Subject 3

Day	S	G/E	I/G	E/G
Day 1	M			
Day 2	M			
Day 3		M	M	
Day 4		M		
Day 5		M		
Day 6		M		
Day 7		L		
Day 8			M	
Day 9			M	
Day 10				M

S: Sleeping
G/E: Getting up/Eating breakfast
I/G: Indoor activities/Going out
E/G: Eating dinner/Going to bed
M: More than mean + 2SD
L: Less than mean – 2SD

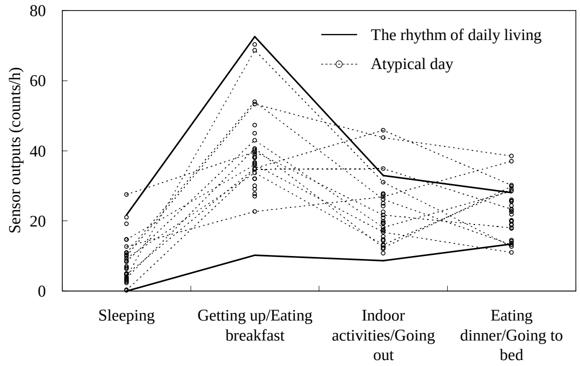

Figure 6: Sensor outputs over 28 days for Subject 1.

Subject 1, 11 atypical days (8 days: more than mean + 2SD, 3 days: less than mean – 2SD) were extracted. On two days the sensor outputs were more than mean + 2SD for both the periods of indoor activities/going out and eating dinner/going to bed.

Subject 2, 15 atypical days (1 day: more than mean + 2SD, 14 days: less than mean – 2SD) were extracted. On two days the sensor outputs were less than mean – 2SD for both periods of indoor activities/going out and eating dinner/going to bed.

Subject 3, 10 atypical days (9 days: more than mean + 2SD, 1 day: less than mean – 2SD) were extracted. On one day the sensor outputs were more than mean + 2SD for both the period of getting up/eating breakfast and indoor activities/going out (Table 1). We could not confirm the subjects' physical condition on these atypical days: the atypical days were indicated by the atypical sensor outputs alone.

4. The histogram of atypical days

The histogram shows that the sensor outputs in the period of sleeping were more than the mean + 2 SD for subject 1 (Figure 7). The high sensor outputs were at 1:00 and 2:00, but on the previous day, the sensor outputs were normal, especially for the period of sleeping.

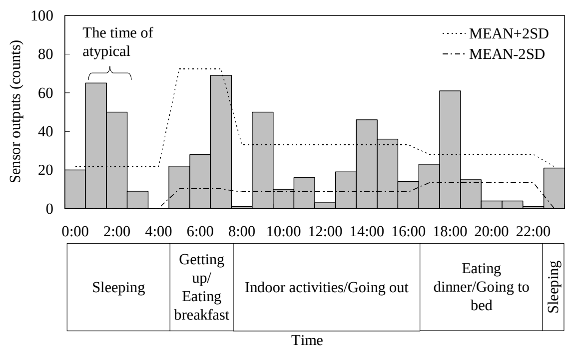

Figure 7: Histogram of sensor outputs on an atypical day (Subject 1).

The histogram shows that the sensor outputs in the period of sleeping were less than the mean – 2 SD for subject 2 (Figure 8). The low sensor outputs were at 0:00, 2:00, 3:00 and from 21:00 to 23:00, but on the previous day and the following day, the sensor outputs were normal, especially for the period of sleeping.

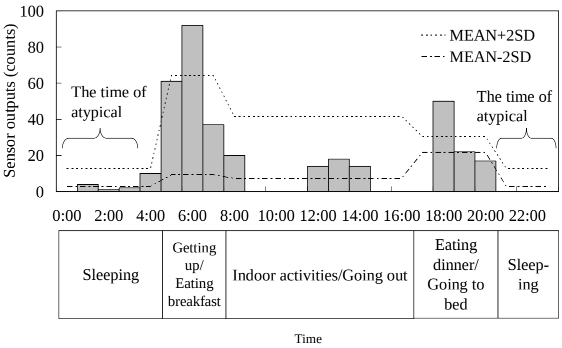

Figure 8: Histogram of sensor outputs on an atypical day (Subject 2).

The histogram shows that sensor outputs during the period of getting up/eating breakfast and indoor activities/going out were more than the mean + 2 SD for subject 3 (Figure 9). The high sensor outputs were at 4:00 and from at 14:00 to at 16:00. On the previous day, the sensor outputs were normal, but on the following day, the sensor outputs during the period of sleeping were more than the mean + 2 SD.

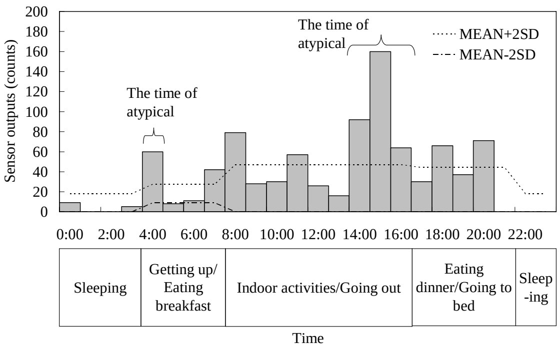

Figure 9: Histogram of sensor outputs on an atypical day (Subject 3).

Discussion

Celler *et al*.[4] experimented with monitoring systems and used several types of sensors in an elderly person's home, but the data were not provided. Banerjee *et al*.[5] installed eight infrared sensors in a hospital room and compared data from staff observations of the patient's behaviour at midnight with data recorded by sensor outputs.

In this study, we examined whether we could identify the activities of elderly people in the nursing care centre using data from infrared sensor in a monitoring system.

Monk *et al*.[6] reported that the daily pattern of elderly people is steady. To establish our subjects' daily patterns, they were asked to complete a questionnaire over a 7-day period. The pattern of subjects' activities was indeed steady, and we were able to identify the period of daily indoor living activities (sleeping, getting up/eating breakfast, indoor activities/going out, and eating dinner/going to bed). Also, we were able to identify the pattern of daily living from sensor outputs during the period of daily indoor living activities.

In our previous study, the total steps taken indoors and total sensor outputs were highly correlated, suggesting that changes in sensor outputs per day reflected changes in the activity at home.[2] The pattern of daily living was different between subject 1, subject 2 to subject 3. We showed differences in the activity patterns of the three subjects during the period of daily indoor living.

On days when the sensor outputs were outside mean ± 2SD, the day was assumed atypical and extracted as an atypical day. We could not confirm the physical condition of subjects on these atypical days: the atypical days were indicated by the atypical sensor outputs. We determined that a histogram of the sensor output counts for each hour could visually confirm an atypical day.

Habte-Gabr *et al*.[7] reported that sleeping pattern is an indicator of health condition. Kelly-Hayes *et al*.[8] reported that the time of day when strokes most frequently occur is between 8am and noon. We believe that the health condition of elderly people can be estimated from the periods of sleeping to getting up/eating breakfast. Therefore, we suggest that the state of sleeping and disease (e.g., strokes) could be detected at an early stage from the sensor outputs. The analysis would also be able to detect the wandering habits associated with dementia.

Conclusions

We consider that the analysis of daily living for elderly people in a nursing care centre is possible with a single infrared sensor and monitoring system, rather than the eight infrared sensors used by Banerjee *et al.* [5] If the monitoring system was set up in the nursing care centre office, staff would be able to confirm the atypical patterns of the residents.

Our next plan is to conduct a long-term observation in the nursing care centre and to detect atypical days from sensor outputs using the monitoring system.

Acknowledgements

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References

[1] TOGAWA T., MIZUKAMI H., TAMURA T. (1992): 'Physiological monitoring techniques for home health care', *Biomed. Sci. Instrum.*, **28**, pp. 105–110

[2] SUZUKI R., OGAWA M., OTAKE S., IZUTSU T., TOBIMATSU Y., IZUMI S., IWAYA T. (2004): 'Analysis of Activities of Daily Living in Elderly People Living Alone: Single-subject Feasibility Study', *Telemed. J. E. Health*, **10**, pp. 260–276

[3] SUZUKI R., OGAWA M., TOBIMATSU Y., IWAYA T. (2001): 'Time-Course Action Analysis of Daily Life Investigation in the Welfare Techno House in Mizusawa', *Telemed. J. E. Health*, **7**, pp. 249–259

[4] CELLER B.G., EARNSHAW W., ILSAR E.D., BEDBEDER-MATIBET L., HARRIS M.F., CLARK R., HESKETH T., LOVELL N.H. (1995): 'Remote monitoring of health status of the elderly at home. A Multidisciplinary project on aging at the University of New South Wales'. *Int. J. Biomed. Comput.*, **40**, pp. 147–155

[5] BANERJEE S., STEENKESTE F., COUTURIER P., DEBRAY M., FRANCO A. (2003): 'Telesurveillance of elderly patients by use of passive infra-red sensors in a 'smart' room', *J. Telemed. & Telecare*, **9**, pp. 23–29

[6] MONK T.H., REYNOLDS C.F. 3rd., MACHEN M.A., KUPFER D.J. (1992): 'Daily social rhythms in the elderly and their relation to objectively recorded sleep'. *Sleep*, **15**, pp. 322–329

[7] HABTE-GABR E., WALLACE R.B., COLSHER P.L., HULBERT J.R., WHITE L.R., SMITH I.M. (1991): 'Sleep patterns in rural elders: demographic health and psychobehavioral correlate', *J. Clin. Epidemiol.*, **144**, pp. 5–13

[8] KELLY-HAYES M., WOLF P.A., KASE C.S., BRAND F.N., MCGUIRK J.M., D'AGOSTINO R.B. (1995): 'Temporal patterns of stroke onset. The Framingham study', *Stroke*, **26**, pp. 1343–1347