Monitoring System for Detecting Decrease of Living Motivation Based on Change in Activities of Daily Living

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Abstract—The one of initial symptom of dementia is "Decrease of Living Motivation". The previous study has proved that a living motivation has a positive correlation with activities of daily living. In this study, the authors developed a system based on Internet of Things platform to monitor change in activities of daily living for elderly people who living alone and verified three hypotheses on a relationship between decrease of living motivation and change in activities of daily living. We made experiment with one subject who lives alone for 10 weeks to monitor activities of daily living every day and conducted a questionnaire to measure the subject's living motivation once a week. From the experiment, the results were supported two hypotheses. With this result, we consider that the decrease of living motivation can be detected by monitoring the change in going out time.

Keywords—monitoring system, living motivation, activities of daily living, dementia, internet of things

I. INTRODUCTION

In recent years, lifespan has increased in Japan, and it is the aging society with the highest population aging rate among advanced countries [1]. According to Statistics Bureau of Japan, the population over 65 years old exceeds 35 million, the ratio is 27.7%, and it is the highest in the history [2]. On the other hand, Japan is trending of nuclear families, the increase in the number of elderly people who live alone aged over 65 for both men and women. According to the transition of the number of households and future estimation of the elderly people listed in the white paper on annual report on the aging society in 2017 edition, it is estimated that the total number of them is approximately 6.7 million in 2020 [3]. In addition, future estimates of the dementia patients will exceed 6 million in 2020 [1]. And future estimates of the prevalence rate of elderly people aged over 65 expected to be about one in five in 2025 [1]. It is common that early detection of dementia is often suspected by families living together noticed changes in the behavior of the elderly. However, in the case of the elderly people living alone, there are risk that the symptoms may progress without being aware anyone because they are no one who live together. With dementia, the earlier treatment can be expected to be effective, because it can delay the progression. Therefore, it is desirable to detect initial symptoms. The one of initial symptom of dementia has "Decrease of Living Motivation", also known as "Apathy". It has proved from previous study [4] that a living motivation has a positive correlation with activities of daily living. The activities of daily living are the minimum behavior necessary to live daily life, like behavior of movement, eating, excretion, bathing, sleeping, etc. It is used as an important indicator for measuring the physical ability and daily life level of elderly and disable people.

In this study, we aim to develop a system to detect "Decrease of Living Motivation" from the change in activities of daily living for elderly people living alone. As mentioned above, we know that there is a positive correlation between the living motivation and the activities of daily living. But in the previous study [4], the authors evaluated the living motivation and the activities of daily living by questionnaires. In this, we developed a system to monitor the change in activities of daily living for elderly people living alone, after that we verified the following three hypotheses on the relationship between living motivation and activities of daily living.

- Hypotheses I
  "Going out time is decreasing when the living motivation decreases"

- Hypotheses II
  "Watching TV time is increasing when the living motivation decreases"

- Hypotheses III
  "Sleeping time is increasing when the living motivation decreases"

II. DEVELOPED SYSTEM

A. Internet of Things Platform

This system was developed based on the internet of things (IoT) platform shown in Fig. 1. This platform is divided into a sensing part and an analyzing part. And also this platform consists of device, gateway, and service application. They are configured with area networks and access networks as networks for connecting these elements. The composition of this system included the use of Arduino, Raspberry Pi, and Amazon Web Service. Also, the system network was constructed using the ZigBee protocol for the area network and the MQTT protocol for the access network.

![IoT Platform](image)

Fig. 1. IoT platform used for system development

This work was supported by JSPS KAKENHI Grant Number JP15K00929 and JP19K0315.
B. System Design

The developed system design is shown in Fig. 2. Table I shows the correspondence between the activities of daily living monitored by this system and the kinds of sensors. The sensing devices will be installed in a house of elderly people living alone to monitor the multiple activities of daily living and send a sensing data to a server on internet through a gateway device. This system is capable to estimating a daily behavior time and behavior count for each activity of daily living. This system consists of a following 3 units. The functions of each unit are described below.

![Monitoring system to estimate activities of daily living data for elderly people living alone](image)

**Fig. 2. Monitoring system to estimate activities of daily living data for elderly people living alone**

1) Sensing Data Collection Unit

This unit is composed of multiple sensing devices installed in the house. The unit collects sensing data and sends to Sensing Data Storage Unit to monitor activities of daily living for elderly people.

2) Sensing Data Storage Unit

This unit receives the sensing data sent by Sensing Data Collection Unit and stores the sensing data for use in Activities of Daily Living Data Estimation Unit.

3) Activities of Daily Living Data Estimation Unit

This unit calculates activities of daily living using an estimation algorithm and the sensing data stored in Sensing Data Storage Unit.

<table>
<thead>
<tr>
<th>Activities of Daily Living</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Going out</td>
<td>Magnetic, Motion</td>
</tr>
<tr>
<td>Eating</td>
<td>Magnetic</td>
</tr>
<tr>
<td>Sleeping</td>
<td>Motion</td>
</tr>
<tr>
<td>Toilet</td>
<td>Magnetic</td>
</tr>
<tr>
<td>Watching TV</td>
<td>Current Transformer (CT)</td>
</tr>
<tr>
<td>Using water</td>
<td>Tilt</td>
</tr>
</tbody>
</table>

**TABLE I**

<table>
<thead>
<tr>
<th>No</th>
<th>Positions</th>
<th>Targets</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Entrance</td>
<td>Door</td>
<td>Magnetic</td>
</tr>
<tr>
<td>2</td>
<td>Kitchen</td>
<td>Refrigerator</td>
<td>Magnetic</td>
</tr>
<tr>
<td>3</td>
<td>Toilet</td>
<td>Door</td>
<td>Magnetic</td>
</tr>
<tr>
<td>4</td>
<td>Room1</td>
<td>TV</td>
<td>CT</td>
</tr>
<tr>
<td>5</td>
<td>Kitchen</td>
<td>Faucet</td>
<td>Tilt</td>
</tr>
</tbody>
</table>

III. Experiment

A. Environment of Experiment

This experiment was conducted for 10 weeks from November 1st, 2018 to January 9th, 2019. A subject is 87 years old man. The sensor devices were installed in this experiment subject’s house and collected sensing data for each activity of daily living using Sensing Data Collection Unit and Storage Unit. After that, we estimated activities of daily living data using Activities of Daily Living Data Estimation Unit. The position of the room where sensor devices were installed is shown in Fig. 3. Table II shows the correspondence between the position where the sensors were installed, their targets, and the kinds of sensors.

![The position of the room where sensor devices were installed](image)

**Fig. 3. The position of the room where sensor devices were installed**

**TABLE II**

<table>
<thead>
<tr>
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<td>Kitchen</td>
<td>Faucet</td>
<td>Tilt</td>
</tr>
</tbody>
</table>

B. Mood Check List-Short Form

During this experiment, in order to measure the subject's living motivation, Mood Check List-Short Form [5], which was used to evaluate the living motivation in previous study, was conducted once a week. This questionnaire consists of three items: "pleasure", "relaxation" and "anxiety" and question is 12 items.

In the verification of this study, the height of the score for this questionnaire was matched the height of the living motivation. The total point of the answers for each week was calculated, and the total score was taken as the score of living motivation. In case of multiple answers for one question, the point obtained by dividing the total point of the answer by the number of answers was used as the point.
IV. RESULT AND DISCUSSION

A. Score of Living Motivation

Figure 4 shows a graph of score of living motivation that is the result of conducted Mood Check List-Short Form once a week. The changes in living motivation occurred four times during this experiment. The decrease of living motivation appeared two times, during 2nd to 3rd week and during 5th to 6th week. Also, the increase of living motivation appeared two times, during 1st to 2nd week and during 4th to 5th week.

The hypotheses were verified based on changes in going out time, watching TV time, and sleeping time when there was decrease of living motivation. Also, we discussed below changes in going out time, watching TV time, and sleeping time when there was increase of living motivation.

B. Verification for Hypotheses I

Figure 5 shows a change in the going out time when the living motivation decreased and increased. It appeared that the going out time decreased about 489 minutes at first term (during 2nd to 3rd week) when the living motivation decreased. At second term (during 5th to 6th week) when the living motivation decreased, the going out time decreased about 23 minutes. Therefore, hypotheses I, "Going out time is decreasing when the living motivation decreases" is correct.

Also, it appeared that the going out time increased about 234 minutes at first term (during 1st to 2nd week) when the living motivation increased. At second term (during 4th to 5th week) when the living motivation increased, the going out time increased about 295 minutes. From this result, it was appeared that the watching TV time increased and decreased when the living motivation increased, From the above verification, it is regarded that there is not a correlation between the living motivation to the watching TV time. Therefore, it is considered that the decrease of living motivation is difficult to be detected by monitoring the change in going out time.

C. Verification for Hypotheses II

Figure 6 shows a change in the watching TV time when the living motivation decreased and increased. It appeared that the watching TV time increased about 603 minutes at first term (during 2nd to 3rd week) when the living motivation decreased. At second term (during 5th to 6th week) when the living motivation decreased, the watching TV time increased about 39 minutes. Therefore, hypotheses II, "Watching TV time is increasing when the living motivation decreases" is correct.

Also, it appeared that the watching TV time increased about 5 minutes at first term (during 1st to 2nd week) when the living motivation increased. At second term (during 4th to 5th week) when the living motivation increased, the watching TV time decreased about 1422 minutes. From this result, it was appeared that the watching TV time increased and decreased when the living motivation increased, From the above verification, it is regarded that there is not a correlation between the living motivation to the watching TV time. Therefore, it is considered that the decrease of living motivation is difficult to be detected by monitoring the change in watching TV time.
D. Verification for Hypotheses III

Figure 7 shows a change in the sleeping time when the living motivation decreased and increased. It appeared that the sleeping time decreased about 73 minutes at first term (during 2nd to 3rd week) when the living motivation decreased. At second term (during 5th to 6th week) when the living motivation decreased, the sleeping time decreased about 192 minutes. Therefore, hypotheses III, “Sleeping time is increasing when the living motivation decreases” is incorrect.

Also, it appeared that the sleeping time decreased about 59 minutes at first term (during 1st to 2nd week) when the living motivation increased. At second term (during 4th to 5th week) when the living motivation increased, the sleeping time decreased about 101 minutes. From the above verification, it was appeared that the sleeping time decreased when the living motivation increased or decreased. It is regarded that the sleeping time no related to the change in the living motivation. Therefore, it is considered that the decrease of living motivation cannot be detected by monitoring the change in sleeping time.

![Graph showing change in sleeping time](image)

Fig. 7. The change in sleeping time when living motivation decreased and increased

V. CONCLUSION

In this paper, the authors developed a system based on IoT platform to monitor change in activities of daily living for elderly people living alone and verified three hypotheses on a relationship between decrease of living motivation and change in activities of daily living. We made experiment with one subject who lives alone for 10 weeks to monitor activities of daily living every day and conducted a questionnaire to measure the subject's living motivation once a week. As the verification, the hypotheses, “Going out time is decreasing when the living motivation decreases” and “Watching TV time is increasing when the living motivation decreases”, were supported, while other hypotheses were not supported. From this result, it is regarded that there is a positive correlation between the living motivation to the going out time. And also, it is regarded that there is not a correlation between the living motivation to the watching TV time. From the above, we consider that the decrease of living motivation can be detected by monitoring the change in going out time.

The sample data collected from current study is small. In future work, we will collect more sample data and prove a correlation of living motivation and going out time. In addition, we need to analyze a relationship between other activities of daily living and the living motivation to increase the parameters to more efficiently detect the decrease of living motivation.

REFERENCE