Development of a New Interface System for Elderly People in Daily Life

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***Abstract*— This report proposes a new support system that allows elderly people to live with a sense of security without the help of other people. In this system, it is possible to watch closely the condition of elderly people from a distant public institution by using sensors. Furthermore, this system presents the relevant information in order to maintain the physical condition of the elderly. By performing an experiment using this system, this paper proves that the proposed system would be useful for the support of elderly people.**

Keywords- Elderly; Elderly support system; Welfare technology; Remote sensing; Unwearable sensing; Human motion

I. INTRODUCTION

The number of elderly people is rapidly increasing in both developing and developed countries. It is necessary to establish methods for taking care of many elderly people through a social system. There are many reports about characteristics of human motions in daily life [1-3]. However, there are only a few reports on measurement of elderly people's behavior in daily life situations [4-9]. To establish more adaptable care systems for elderly people, it is important to attempt measuring and analyzing human behaviors and motions in daily life.

In our laboratory, we study the development of support systems for the elderly people. This paper proposes a new support system that analyzes human behaviors and motions and detects a change in the physical condition of an elderly human in the house. It is thought that it is important to research elderly people's behavior in daily life and investigate it thoroughly for developing and establishing a support system.

II. SYSTEM ARCHITECTURE AND QUESTIONNAIRES

The new support system is a Living Situation Monitoring System. The concept diagram of this system is illustrated in Figure 1. The system is fundamentally composed of sensor units, a controller unit and a supervisor unit. Several sensor units and a controller unit with two antennas were placed in the house of solitary elderly people.

Also, this support system has a communication tool. This tool was used when the Health Management Center sent the information of a local community event to elderly people. Figure 2 shows the operation screen of the Health Management Center when they send the information. Figure 3 shows the operation screen on the side of elderly people.

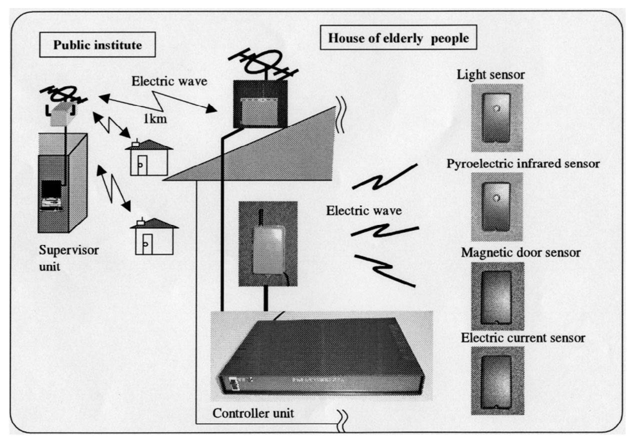


Figure 1. Concept of the monitoring system of living situation.

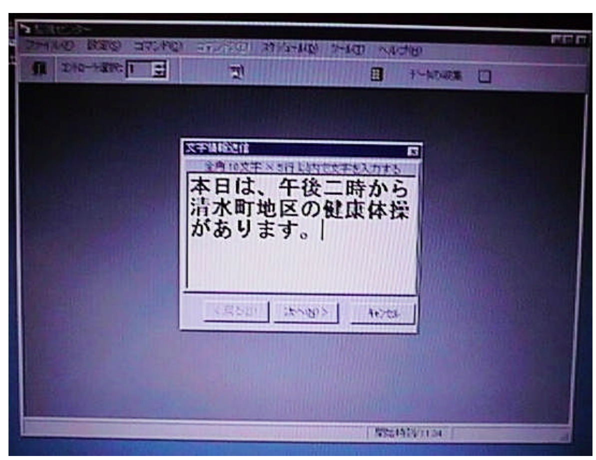


Figure 2. Operation screen on the side of Health Management Center.

Figure 3. Operation screen on the side of elderly people's house.

The sensor units consisted of four types of sensors: a pyroelectric infrared sensor, a magnetic door sensor, an electric current sensor and a light sensor. For example, a pyroelectric infrared sensor was able to perceive any human motion by detecting the IR emission from a human body. Also, using an electric current sensor, it was possible to record some actions in human life such as turning on/off the switch of a television, an electric heater, and so on. Using these sensor units, human behavior could be detected. These data were transmitted to the controller unit using a wireless telecommunication method. In the controller unit, these data were analyzed in order to check the physical condition of an elderly human in the house. Several sensors detected human motions in real time, and the detection results were stored in a controller unit. Furthermore, all data in the controller unit were sent to the supervisor unit. In the supervisor unit, the data were classified into each subject's database and were accumulated. A characteristic pattern for each person, including time series variation of detected values, was extracted from each person's data using only the pyroelectric infrared sensor.

As the new system was developed, preliminary experiments were performed to examine detection accuracy. The subjects were eight elderly people who lived in solitude away from their family.

In addition, questionnaires were developed to understand the elderly people's life style and validated. In the first questionnaire, there were about 70 questions about their daily life everyday for a month: wake-up time, bedtime, eating time, times of going out, and so on. In the second questionnaire, subjects were told to list every night what they actually had done on that particular day.

III. RESULTS AND VERIFICATION EXPERIMENTSD

3.1 System architecture and questionnaries

Figure 4 shows the detection results by pyroelectric infrared sensor with the characteristic pattern which was transmitted back to the controller unit. It was possible that, by comparing the measured data using the sensor units, the physical condition of the elderly people could be estimated continuously. As a result, it was possible that the sensors detected human motions like moving from one room to another, and actions like turning on/off the switch of a television.

Figure 5 shows the diurnal detection results by pyroelectric infrared sensor. This result shows exercise tendency of elderly people on several weeks.

Figure 6 shows the number of diurnal use of resting room during daylight, late-evening and first light. It was possible to understand the bcondition of elderly people.

Figure 7 shows the result which was time of gong out everyday.

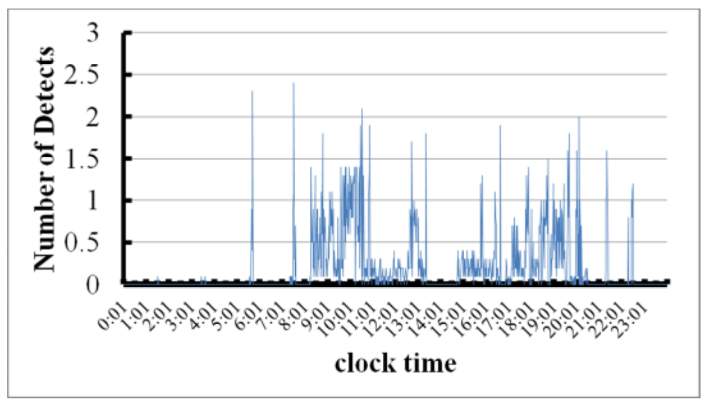


Figure 4. Number of detects in one day.

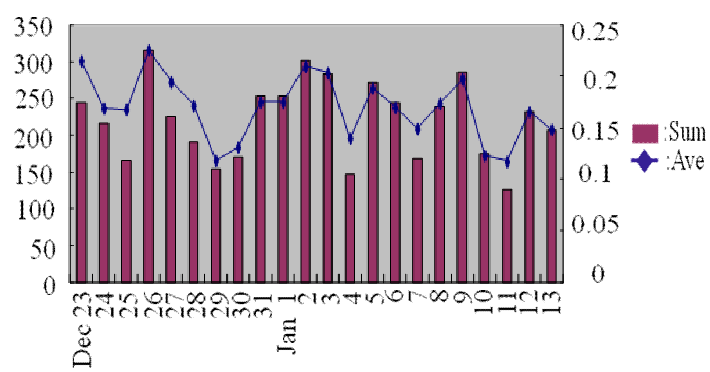


Figure 5. Amount of diurnal exercise.

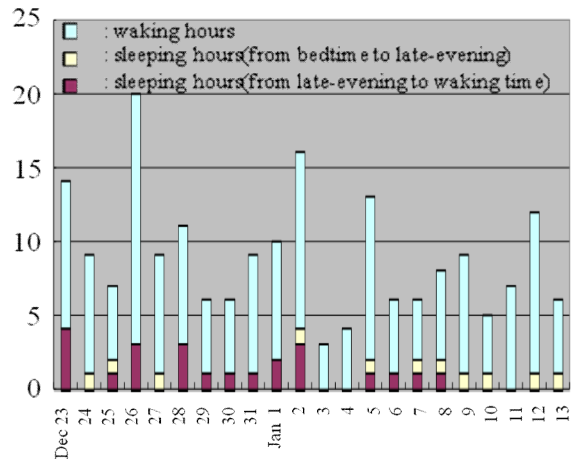


Figure 6. Number of diurnal use of resting room.

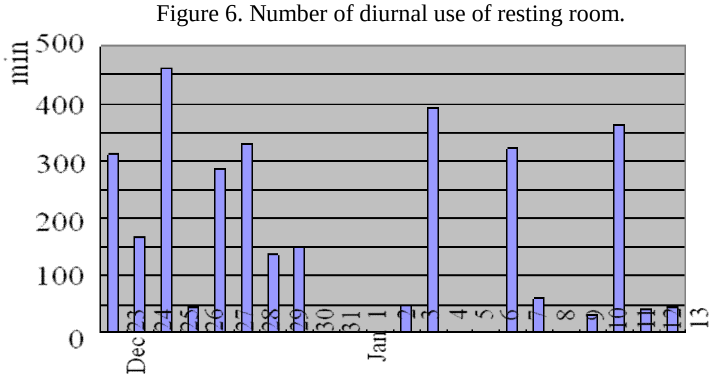


Figure 7. Diurnal behavioral record (time of outing).

From the results of questionnaires, there was evidence that the characteristic pattern was influenced by a change of the elderly people's individual life environment. It was necessary that the system could extract and keep in memory in the supervisor unit several characteristic patterns as the environment around the research subjects changed. Also, it was thought that the characteristic pattern was influenced by the change of an elderly individual's weekly life style. Most of the elderly had habits that given behaviors should be carried out on a certain day of the week. For example, elderly people periodically went to the bath of a public institution on particular day of the week.

In the experiments, several sensor units and a controller unit with two antennas were set up in the houses of solitary elderly people. The subjects were eight elderly people and the number of sensor units was about 15 in each subject's house. Figure 8 shows an illustration of the location of sensor units in an elderly person's house. The number of sensors increases or decreases depending on the number of rooms and the layout of the house. The experiment was carried out in two areas. The center of Takaoka City and Oyama Town were chosen, in order to examine whether the environment around the house was significant or not. In each area, there were four subjects and one supervisor unit. A supervisor unit was located at a public institution within 1 km of the subjects' houses in each area.

In addition to detected results, analysis was carried out with the measured data using sensor units and the results of the questionnaire. Then, using one result of the analysis, we constructed a mathematical model using the neural networks (NN). We investigated other result but one for constructing NN, and realized that the system conjectures one elderly individual's behavior of a day. The analyses using NN software (NEUROSIM: Fujitsu Co., Ltd) were used to conjecture whether subjects were out or at home and were awake or in bed. In analysis of subjects' going out, we used Hierarchical Neural Network including input layer, hidden layer, and output layer. Thirty-five input signals were composed of detection results from five pyroelectric infrared sensors at given times and around 30 minutes by 10 minutes. Output signal was the probability that subjects went out. In analysis of going to bed, we constructed hierarchical NN including input, output and two hidden layers. Sixty-six input signals were composed of detection results from five pyroelectric infrared sensors at given times, around 60 minutes by 10 minutes and clock time. Output signal was the probability that subjects were at rest.

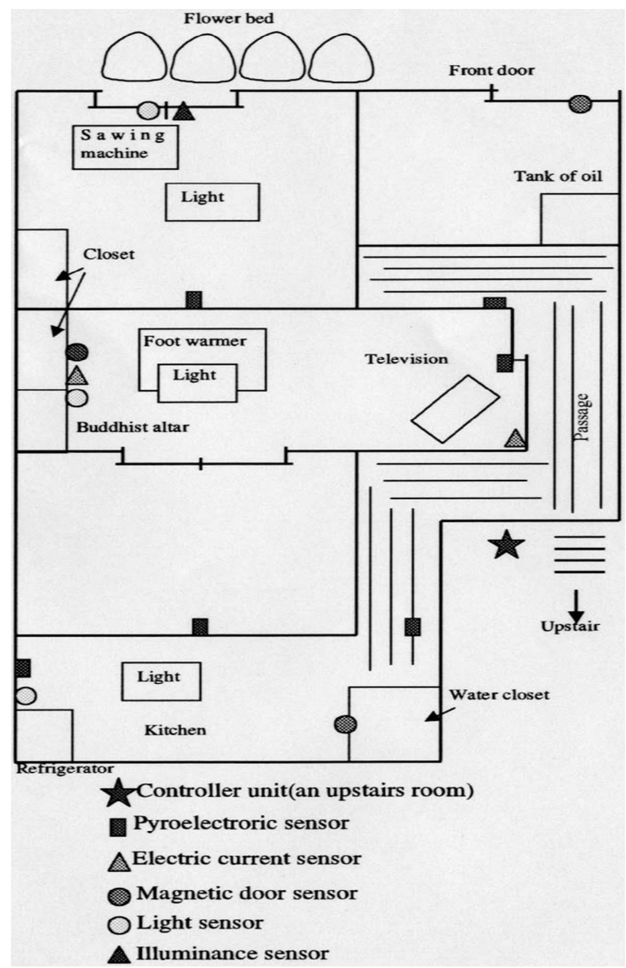


Figure 8. Disposition of sensor units.

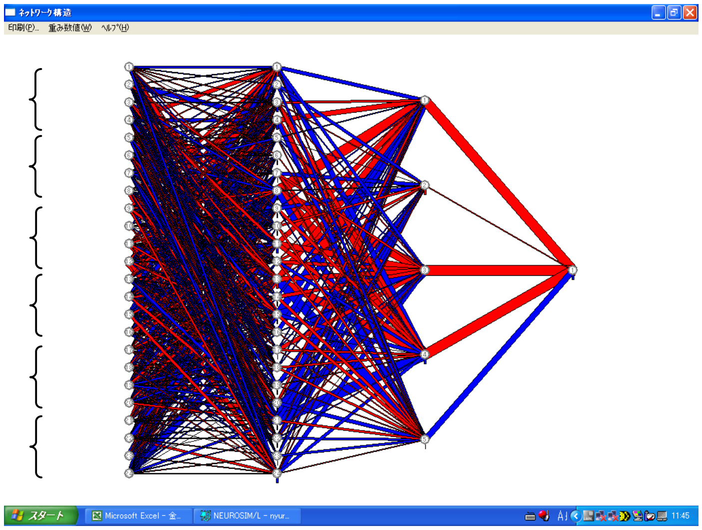
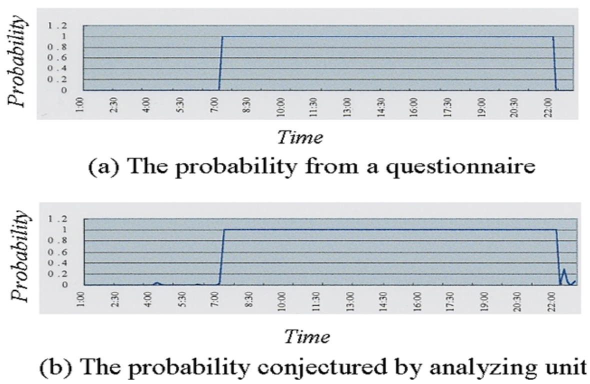


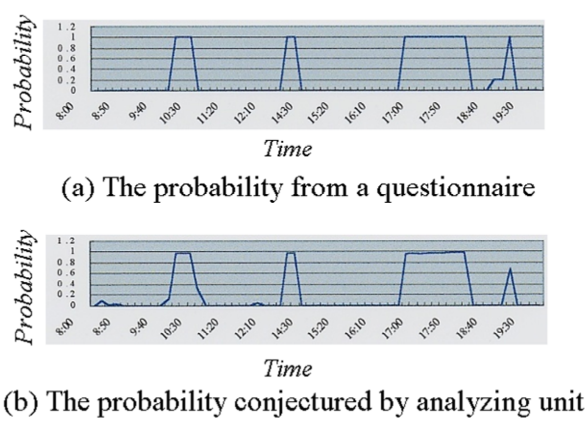
Figure 9. The example of neural network model.



(a) The probability from a questionnaire

(b) The probability conjectured by analyzing unit

Figure 10. The probability that a subject has gotten up in one day.



(a) The probability from a questionnaire

(b) The probability conjectured by analyzing unit

Figure 11. The probability that a subject has gone out in one day.

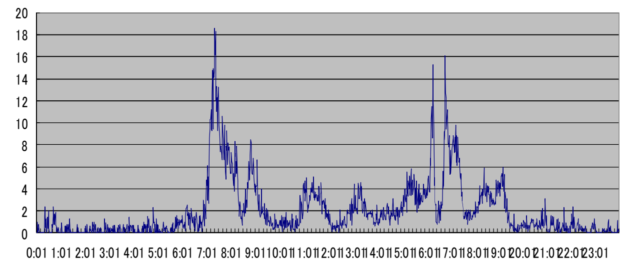


Figure 12. Good condition data from March 14 to April 29 in 2000.

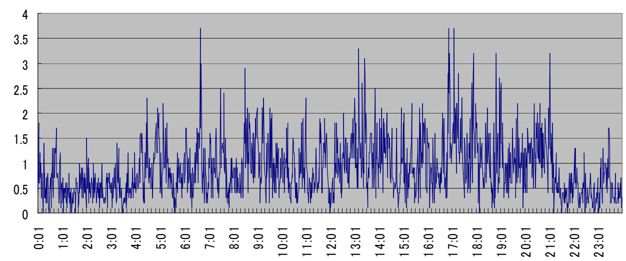


Figure 13. Bad condition data from May 1 to May 26 in 2000

3.2 Results of verified experiments

Figure 9 is the example neural network model to analyze for the probability of human behavior based on detections. The neural network was constructed by three layer model. The first layer contained 24 inputs. The second layer contained 24 nods. The third layer contained 2 nods. The neural network model was learned by data for two month for each subject.

Figure 10 shows a result for the probability that a subject has gotten up in one day. Upper Figure 10(a) shows the probability form only questionnaire. Lower Figure 10(b) shows the probability form a neural network model similar to Figure 9. In the questionnaire of the same day, the subject got up at 7:10AM and went to bed at 10:00PM. The probabilities were about 0.003 at 7:00AM, 1.000 at 7:10AM, 9.999 at 10:00PM, and 0.009 at 10:10PM. But the probability at 10:20PM was 0.289. Figure 11 shows one that a subject has gone out in one day.

Figure 12 shows a summation of detection when a subject's condition was good in one day using the new support system. In this result, the subject starts daily exercise at about 7:00 AM every day. Especially, the behavior pattern was detected after 7:00 AM using the new support system. For another subject, behavior pattern was detected each subject using the system. These behavior pattern varied, but the behavior pattern was unified by each subject like in Figure 11. Also, it seems that the various related not environments but subjects. On the other hand, Figure 13 shows a summation of detection when the same subject's condition above result was bad, because this results were recorded just before this subject was hospitalized. In this

 ISBN: 978-1-61208-243-1

result, it is not sure when the subject starts daily exercise and shows that the count of detection is lower level than the result of Figure 12; but another behavior pattern was detected using the new support system. For other subjects, behavior patterns were detected each subject using the system. In Figure 13, the behavior pattern is not the same to the behavior pattern in Figure 12 about the same subject. So, we ensure that a difference between a behavior pattern for good health condition and a behavior pattern for a bad health condition was detected using this system. So, it is considered that it is possible to make a judgment about elderly people's health condition.

IV. DISCUSSION

Using the new support system, it was possible to detect elderly motions in life. The most important thing in this system was to detect elderly ones with non-wearable sensors. In addition, play-out and uplink of detected data were performed by wireless connection between both sensor units and controller unit, and between controller unit and supervisor unit. After experiments, we constructed the neural network, and conjectured elderly motion and individuals' particular patterns. Results from neural network analysis were correlated to detected motions and questionnaire responses.

Recently, many companies have become interested in remote sensing for elderly people's healthcare and conducted remote sensing with wearable sensors [10,11]. But, in this case, there was physical limitation, and the elderly went about their daily life with inconvenience and uncomfortable feeling. It was an important advantage in this system that remote sensing was performed by non-wearable sensors. In addition, we challenged experiments with novelty, and measured many data at the same time. Hence, this system was put to practical use, and we obtained a patent for this system.

However, it has been pointed out that this result in sensing humans was still not adequate. It is necessary to measure motions more precisely, because what were detected in this experiment were just motions. In terms of detecting going out, waking up, and going to bed, it was thought to achieve a certain level of result. However, it is requisite to measure subjects' behaviors and movements to observe heir daily life in the real sense of the term. At the same time, human motion was not always considered as measuring changes in their physical condition. In addition, this system was developed with the aim of long-term health management, which is detecting before deterioration of health. This system appears very useful for daily checking based on this standpoint. Additionally, it is thought to detect troubles in about ten minutes by comparing usual patterns which was stored in the controller unit. Furthermore, a system corresponding to emergencies, for example falling, is still being developed. It is absolutely imperative to upgrade this system for detecting the physical condition.

In our laboratory, we are continuing research and development on the system to detect biological signals, for example, heart rate, sphygmus, and body temperature by remote sensing. By translating this system into practical applications, there is a possibility that it would appear that early symptoms in disorders can be detected by remote sensing. Thus, system managers and the elderly themselves can prescribe measures. Currently, we are working practical trial into operation, and lead to the final step in this trial.

V. CONCLUSION AND FUTURE WORK

For the purpose of practically applying our new system for elderly people, questionnaires and two experiments were carried out. From the results of the questionnaires, we realized that the characteristic pattern was influenced by a change of the elderly' individual life environment. Therefore, it was necessary that several characteristic patterns be extracted and kept in the memory of the supervisor unit in case the environmental changed. In addition, from the experimental results, it was ascertained that this support system could measure and analyze elderly people's behaviors. According to these results, it was possible to watch closely the condition of the elderly people from a distant public institution. These results indicated that the system was useful for an elderly support.

Now, some functions of this system are used in at least 20,000 houses of the elderly people in Japan, and is playing significant part in their life. Meanwhile, research on detecting elderly's physical condition by this system continues in our laboratory [11].

ACKNOWLEDGMENT

Shunji Matsuoka, Kazuo Yoshida, and Kaoru Iketani at Tateyama System Co., Ltd are deeply acknowledged. Hideto Taya and Hajime Ogi at Advanced Industrial Science and Technology and Kazuo Nakamura, professor at Nagaoka University of technology also gratefully acknowledged for their useful advise to this study. The study was supported by a grant from New Energy and Industrial Technology Development Organization.

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