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Semi-real-time ECG Transfer System using Mobile Phone

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Abstract— **In the home care, the data transfer using mobile phone is very important. Especially, real-time motion image transfer is necessary in the emergency. H However, almost mobile phones have no ability to transfer or display the motion image in real-time. I In this study, we proposed a technique to transfer the motion image of ECG in semi-real-time. In our proposal method, ECG signal is modified to the motion image of animated GIF format. The motion image could be downloaded and display every five seconds even via narrow band communication such as mobile phone communication, because the size of the motion image is enough small. We achieved the motion image browsing in anytime and anywhere for home care, using mobile phone.**

Keywords—**Mobile phone, ECG, animated GIF**

I. Introduction

In the clinical situation of home health care, to transfer the data is very important. Especially, simple data such as body temperature, blood pressure, heart rate, or ECG should transfer as soon as possible in emergency, because these data could be acquired easily and they are effective for rescue[1][2]. We have developed some data transfer systems using WWW framework[3][4]. In these systems, we adopted the PDA or the laptop computer. However, PDA is not popular in Japan. Mobile phone is always used in stead of PDA in Japan, because almost Japanese mobile phone has same function of PDA. In addition, the mobile phone has function of communication. Therefore, transfer of medical data using mobile phone is desirable in Japan.

By the way, numerical data such as blood pressure or body temperature can transfer by e-mail, and static image could be downloaded by WWW browser of mobile phone. However, it is sometimes difficult to transfer the motion image such as ECG, because almost mobile phone system has no ability for real-time visual communication. Therefore, we propose the technique to transfer the motion image in semi-real-time.

II. Method

We developed a browsing system of ECG signal using mobile phone. In Japan, there are several mobile phone companies and several systems of browsing HTML document on the internet are adopted. As the common specification, static HTML document such as text document and static image can be browsed by almost mobile phones. The motion image will be able to browse by the third generation mobile phones which adopt the CDMA communication system. Some mobile phones adopt a WWW browser equal with a WWW browser of PC. However, generic type of mobile phone has no ability to display a motion image such as mpeg or AVI format in real-time. In addition, almost mobile phones have no ability of multi-task processing. Therefore, to display a motion image in real-time is difficult, except by a some mobile phones which has abilities of video communication system. Thus, we develop the semi-real-time motion image transfer system. We acquire the ECG signal in every five seconds, and then make the ECG motion image by animation GIF format. This motion image is uploaded as soon as the ECG signal is acquired. The latest animation of five seconds can be browsed by pushing the reload button on the browser by the user on the user side.

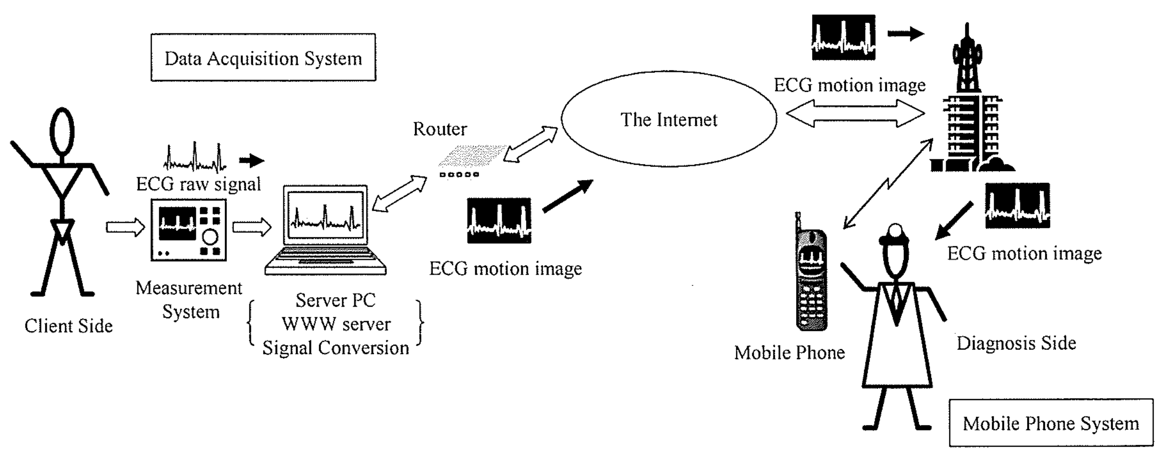

Fig. 1 Diagram of ECG transfer System

III. EXPERIMENT

We made the prototype system and we had an experiment for evaluation. We prepared the simulated ECG signal, and input the signal to the A/D converter of data acquisition system. The data acquisition system worked as the data server, and acquired ECG signal was converted to motion image of animated GIF format. The motion image of ECG was received by mobile phone. The mobile phone has the function to browse the animation GIF on the browser. The implemented browsing software was the customized for the mobile phone, and the software was different from generic type WWW browser such as the Internet Explorer or the Netscape. The specification of the system is shown as follows;

A. Data Acquisition System
A-1. PC: Laptop type (Vaio of Sony Corporation)
CPU: Pentium M 735 1.6GHz
Main Memory: 1GByte
Network: FTTH connection 100Mbps (Effective Speed 20Mbps)
A-2 A/D Converter: 12Bit A/D converter
Sampling rate: 256 Samples/s
Interface: USB1.0 Connection

B. Mobile phone System
B-1 Mobile phone: Toshiba A5504T CDMA One
Communication Speed 144kbps
B-2 Browser: Openwave Systems Inc, Mobile Browser Ver.6.2.0.6.2 KDDI-TS27
System diagram is shown in figure 1.

C. Motion Image
C-1 Size of Image: 200x120 pixels (Black and White)
C-2 Frame rate: 1 fps
Note: The life time of cache is set to zero.

IV. RESULT

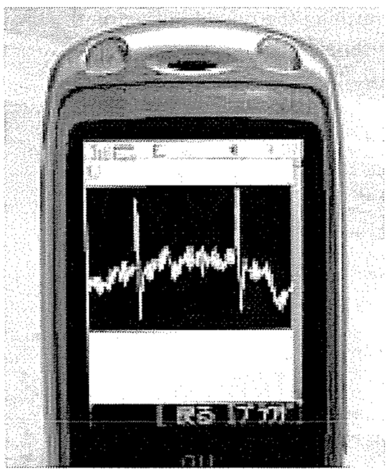

Fig. 2 Overview of transfer the ECG

The size of motion image was 10KByte to 20KByte. Because the communication speed was 144kbps, the motion image could download within 2seconds. As the result of the experiment, the browser could display the motion image of ECG signal. The captured image is shown in figure 2.

V. DISCUSSION

Japanese situation is different from another country. The user of the digital communication tool tends to prefer mobile phones to PDA, because Japanese mobile phone has several special functions. Almost mobile phone works as high resolution digital camera, and some of them has function to acquire the motion image of mpeg-4 format. However, almost mobile phone has limitation of processing and communication by ability of CPU, because most of them were designed as not a visual capturing tool but a telephone.

The real-time communication or real-time image transfer is very important, especially in emergency situation. However, the mobile phone does not have enough ability to real-time transfer of motion image in medical field. We consider that our proposal technique has advantages because the implementation is easy. In comparison with the mobile phones which have TV-phone function, proposal technique has some disadvantage in real-time communication. However, motion image in proposal technique is more clear than captured mpeg-4 movie, because almost ECG image is monochrome line image. In the future, any motion image such as the ultrasonic image will be able to transfer using proposal technique or similar technique, if Macromedia Flash format or another image compression technique are adopted.

VI. CONCLUSION

We proposed the technique to transfer the motion image for mobile phone in semi-real-time. As the result of the experiment for the evaluation, we confirmed the proposal technique is effective to transfer the motion image of ECG. Any motion image could be transferred and be displayed by mobile phone, using this technique

ACKNOWLEDGMENT

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An Easily Installable Monitoring System for Home Appliances

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Abstract—**This paper describes a sensor unit used in a behavioral monitoring system for ordinary houses. This unit has been developed to obtain information on the usage of home appliances, especially, the television set. The unit is ready for use by simply attaching it to an appliance. The sensor is configured to measure radio waves that were leaked from the appliance, and the unit employs a device that uses weak radio waves for transmitting the obtained data. A simple evaluation test to assess the applicability of the sensor unit revealed that the system could be easily installed by clients.**

Keywords—**Behavioral monitoring, television**

I. Introduction

Preventive medicine is one of the types of health care for the aged. Obtaining and utilizing biomedical or behaveioral information appear to be effective for maintaining and improving the quality of life [1–4]. Many behavioral monitoring systems have been developed so far. Most of them are installed when a house is newly built or reconstructed. However, for the elderly, we sometimes need to install such systems into their houses in case of sudden illness or emergency. Therefore, the system should be easy to install as well as remove [5, 6]. In order to save time for introducing such systems in ordinary houses, it is effective to employ a wireless or powerline LAN for data collection. However, the sensor units used in the system, e.g., magnetic devices fixed on drawers around the house and electric current detectors (for obtaining information on the usage of home appliances), still need to be installed by an engineer.

In this study, we built an adhoc wireless behavioral monitoring system that is technically similar to Mote [7]. In addition, we developed a television sensor. The sensor was designed to be usable by simply attaching it to a television set. The unit employs a device that uses weak radio waves for transmitting the obtained data and it detects whether television set is in use by measuring leaked radio waves from it. Therefore, engineering expertise is not needed to install the unit.

II. Methodology

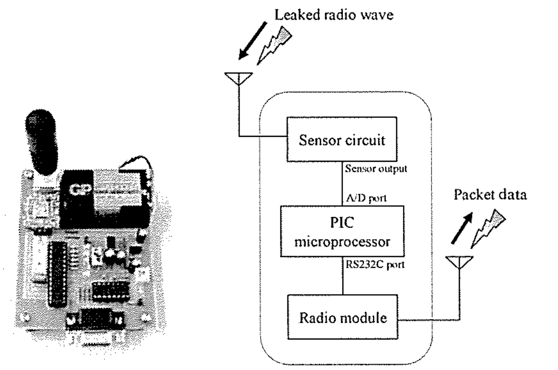
A. System structure

As a behavioral monitoring system, the system developed in this study has at least one data storage terminal (master server) and many measuring units. The units automatically sample the outputs of the sensors and transmit the obtained data to the server via radio waves. The radio network, i.e., data relay path, is automatically constructed and modified when a relay failure occurs. Another storage terminal (slave server) can be added to the system; if a unit has no path to the master server, it can attempt to send the obtained data to the slave server instead.

Fig.1 shows the circuit board and the schematic diagram of the sensor unit. Table I shows the specifications of the unit. The unit shown in Fig.1(a) has an RS232C-type communication port so that the unit can be directly connected to a personal computer (PC) (i.e., the unit can also be a radio interface for the server). The 1/4λ antenna (RH-3) increases the reliability of radio communication more effectively than the formerly developed pattern antenna [7].

B. Sensor circuit for the television set

The display of a television set is composed of a number of horizontal lines (scanning lines). By displaying different images at a certain framerate, the television displays a moving picture. The number of scanning lines and the frame rate of the television are defined in Table II. The horizontal scanning frequency f_H can be calculated as the product of the number of scanning lines and the frame rate.



(a) Circuit board (b) Schematic diagram

Fig. 1. Sensor unit

TABLE I
SPECIFICATIONS OF SENSOR UNIT

Item	Specification
Microprocessor	PIC16F876 (Microchip Technology Inc.)
Processor Clock	10 MHz
Radio Module	CDC-TR02B (Design Circuit, Inc.)
Radio Frequency	315 MHz
Radio Antenna	RH3 (120~900 MHz, Diamond)
Modulation	Amplitude Shift Keying (Manchester Coding)
Transfer Rate	115.2 kbps
Unit Weight	~250 g
Size (H × W × D)	100 × 65 × 35 mm (antenna is not included)

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The scanning in a conventional television set comprising a cathode ray tube (CRT) is carried out by moving an electromagnet near the electron gun in the CRT. Therefore, by obtaining the leaked electromagnetic (radio) wave from the television set, the information on the usage of the television set may be obtained.

Fig.2 shows the circuit diagram of the television sensor. The leaked radio wave from television set is amplified, and extracted at resonance frequency of 15.7 kHz. The amplified signal is filtered in order to determine whether the television set is on or off with just one sampling.

C. Experiments

To assess the applicability of the sensor developed in this study, we conducted simple experiments; a television on/off test and a data transmission test. The sensor unit was placed on the television set, and the master server (wireless data receiver) was placed ~2 m away. The output of the sensors were automatically sampled and transmitted to the server with a sampling frequency of 10 Hz. A simple handshake protocol was employed in this experiment. If a transmission error occurs, (when the sensor unit is unable to receive an acknowledge (ACK) packet from the server), the unit will retransmit, without any limitation to the number of retransmissions.

III. Results and Discussion

Fig.3 shows the signals at each point of the sensor circuit. Fig.3(a) shows the leaked radio wave that is obtained from the television set. The signal mainly consists of 15.75 kHz pulses. The component of 15.75 kHz is extracted by the resonance circuit, amplified, and then rectified (Fig.3(b) shows the result of the signal processing). Fig.3(c) shows the filtered output of the Fig.3(b). When the television set is in use, the sensor output increases to ~ 0.95 V.

Fig.4 shows the result of the television on/off test. During the experiment, on average, about 10 retransmissions and one data corruption occurred for each data transmission. Since the data recorded at the master server has several duplicate data entries from the sensor unit, most of the retransmissions appeared to be caused by packet loss. However, from the result, we can estimate the duration for which the television set is used; thus, the sensor unit is useful for practical use.

IV. Conclusion

In this study, we developed a sensor unit used in a behavioral monitoring system for ordinary houses with the objective of simple installation and removal. The television sensor developed in this study appears to be useful for practical use; however, investigating the cause of the data errors remains to be studied in the future.

TABLE II
VERTICAL RESOLUTION AND HORIZONTAL SCANNING FREQUENCY OF TELEVISION FORMAT

Format	Scanning line (Frame/Field)	Frame rate (Hz) (Frame/Field)	Horizontal Scan. Freq. (kHz)
NTSC	525/262.5	30/60	15.75
PAL	625/312.5	25/50	15.625
SECAM	625/312.5	25/50	15.625

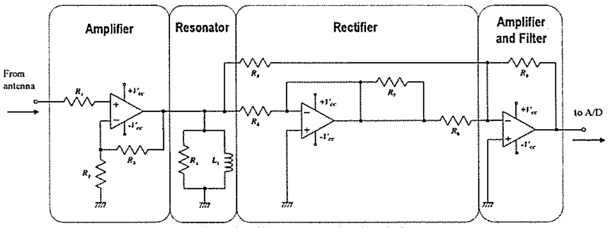
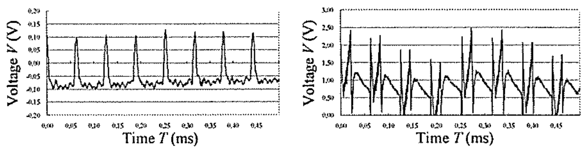
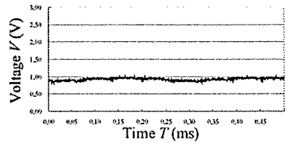


Fig. 2. Circuit diagram of television sensor



(a) Obtained leaked radio wave (b) Amplified and rectified



(c) Filtered output
Fig. 3. Signal processing

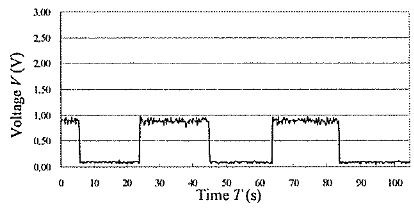


Fig. 4. Television on/off test

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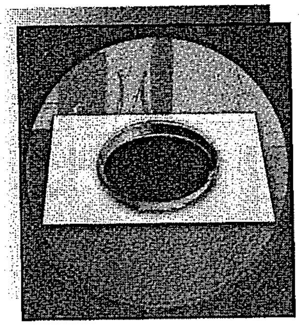

An Unconstrained Monitoring System for Home Rehabilitation

A Wireless Heart/Respiratory Rate Sensor Accessible to Home-Visit Therapists

BY YASUSHI MASUDA, MITSUYOSHI SEKIMOTO, MASAYUKI NAMBU, YUJI HIGASHI, TOSHIROU FUJIMOTO, KUNIHIRO CHIHARA, AND TOSHIYO TAMURA

With the shift to an aging society with fewer children, the role of home healthcare is becoming indispensable. In Japan, the Long-Term Care Insurance System has been introduced, which aims to help the elderly remain self-sufficient by providing benefits for home-visit care services [1]. Unlike hospital care, home care is difficult to plan, manage, and evaluate if a home is far from a hospital. Telemedicine support is expected to redress this distance problem.

Telecommunication technologies have improved rapidly over the past decade. Today, the telecommunication infrastructure provides multimedia communication facilities such as Web browsing and video-chat for personal use. Such an infrastructure includes wired media, such as subscriber telephones, cable television (CATV), or fiber-to-the-home (FTTH) networks as well as wireless media, such as mobile telephones, the personal handy phone system (PHS), wireless local area networks (LANs), or personal area networks (PANs). Wireless media, in particular, are rapidly improving; they are becoming more compact and expanding in terms of use. Pervasive computing, providing access to information services anywhere and at any time, has been realized through such devices as mobile telephone terminals and personal digital assistants (PDAs) integrated with wireless communication functionality [2].

Telemedicine studies have covered two major areas so far: tele-existence and medical information management. Tele-existence has focused on developing a system for remote diagnostics or treatment, for example, tele-echography or telesurgery. It requires high bandwidth and real-time communication, for example, at least a T1 (1.5 Mb/s) Transmission Control Protocol/Internet Protocol (TCP/IP) connection is required for real-time echography transmission, with requirements becoming stricter in order to handle time-critical interactions and/or additional data such as voice communication. On the other hand, the term *medical information management systems* refers to systems for archiving medical information, such as health records. It does not require the real-time ability but does require high bandwidth for sharing digitized medical images efficiently. It also requires huge storage integrated with work flow management facilities. These conventional frameworks share common characteristics.

- *Chiefly used by medical providers:* Usually, the user is specialized or well trained in the system.
- *High cost:* The total cost of the system is shared by the number of patients involved.
- *Large and complicated:* Hardware specialist(s) are required for the system, apart from the user.
- *Built on specialized infrastructure.* A high-speed fiber network is often used.

The home healthcare system, however, does not have the same requirements as the systems outlined above. For home healthcare support, development focuses on systems that can be used by a therapist to remotely monitor individual patients. Therefore, the performance requirements for the telecommunication infrastructure are relatively low. However, since such a system should be maintained daily, the running cost is strongly limiting. To conform to these requirements, we have designed a home healthcare framework with the following attributes:

- *Exploits existing telecommunication infrastructure:* Development of an alternative infrastructure specific to home healthcare is unreasonable.
- *Minimal measurement and transmission:* Excessive measurements confuse the user and increase cost.
- *Minimal and simple hardware:* Complex or highly integrated hardware increases costs for development and maintenance as well as the training of the user.
- *Nonconstraining and silent operation:* Constraining devices and noisy hardware cause unpleasantness for the user.

In the following, we describe an unconstrained monitoring system of heart/respiration rates using wireless telecommunication as an application for home-visit rehabilitation therapists.

Application to In-Home-Visit Rehabilitation

Rehabilitation by a home-visiting therapist plays an important role in home healthcare; the service decreases the physical workload and risk on the part of patients who visit the hospital. The therapist can also arrange exercises suitable for residential life. To carry out effective physical therapy, the postexercise observation of a patient's health is desirable for a therapist to ensure that the patients are not overexerting themselves with an exercise. Additionally, the observed data allow

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The proposed system showed its usefulness for both the therapist and the patient in planning and evaluating daily rehabilitation training.

the therapist to plan and evaluate long-term rehabilitation schedules. Such observations can include heart rate, respiratory rate, and blood pressure because they are easy to acquire and record. Although these observations are easily performed in a hospital, a therapist in home-visit rehabilitation work cannot carry it out since he/she must visit separately located homes. While the therapists can interview an individual patient or the patient's caregiver (by telephone, for example) such information is not quantitative.

To redress the issues described previously, we have developed a system using a mobile terminal to help with home-visit rehabilitation. The system allows a nomadic home-visit therapist to acquire the health status information of a patient remotely—from anywhere at any time.

Methods

Figure 1 illustrates the proposed system. The system consists of a sensory system for the patient and a viewer system for the therapist. A TCP/IP network connects the subsystems using a physical communication infrastructure.

Home-Side Sensory System

The home-side system, as shown in Figure 2, consists of an air-filled mat, a measurement unit, and a bridge unit, which handles connections. When a subject lies on the mat, his/her heartbeat and respiratory movements cause perturbations in the air pressure in the mat. These perturbations are easily acquired by a pressure sensor and have robust frequency characteristics in a relatively lower frequency area compared with environmental noise. Thus, through an appropriate filtering process, both heart rate and respiratory rate are easily estimated. Although there are other methods to measure such information (such as the pulsemeters [3] that are widely used to determine heart rate and a computer vision-based system [4] proposed for determining respiratory rate) these methods introduce problems. Pulsemeters constrain the subject, decreasing their quality of life, and the vision-based system requires complicated imaging hardware. In contrast, our method can estimate heart and respiration rates simultaneously, with no constraints on the subject and using relatively simple hardware.

The analysis unit (Bio-Sensor Node BN-6 from Yokogawa Electric Corp., Tokyo, Japan) continuously monitors the estimates and stores them in HTML format in a built-in Web server. The stored data is accessible via an integrated Ethernet interface. To mediate the Ethernet and the incoming connections from the therapist-side system, we employed an embedded microserver unit (OpenBlockSS from Plat Home Inc., Tokyo, Japan). Since all units are integrated in fanless modules, they conform to the silence requirement described previously.

The choice of medium for telemetry networks is an important issue when considering practical use. In conceptual telemedicine, high-quality, wired connections like xDSL or FTTH are sometimes assumed as the medium. However, there still exist large gaps in the spread of such media to many localities. Thus, we decided to employ a wireless network using mobile telephone terminals for both ends of the connection. Since the hospital and patient do not have to provide a

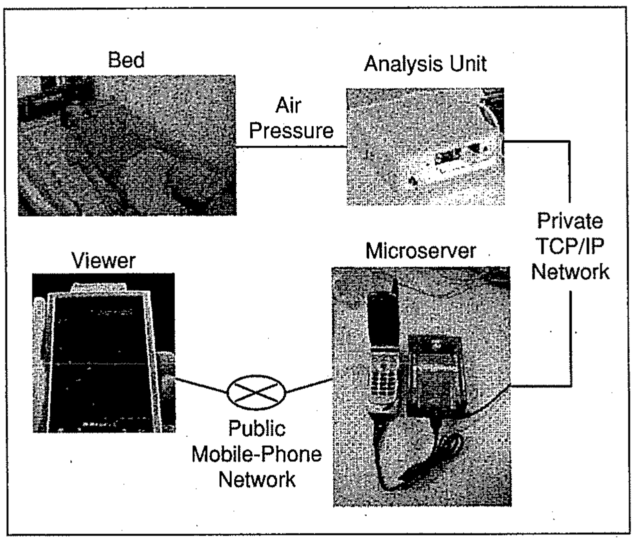

Fig. 1. A scheme of the monitoring system.

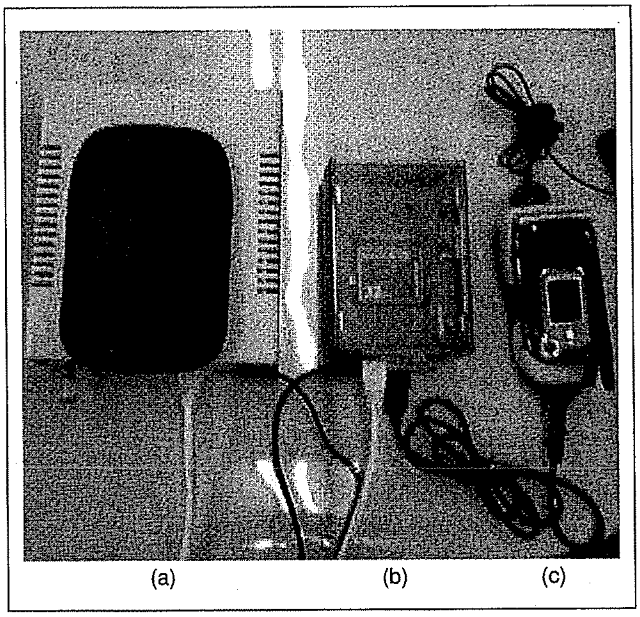

Fig. 2. Patient-side system: (a) analysis unit, (b) microserver, and (c) mobile phone.

The system allows a nomadic home-visit therapist to acquire the health status information of a patient remotely, from anywhere at any time.

wired medium, we can easily install and maintain the network. In our system, a mobile telephone (P504iS from NTT DoCoMo Corp., Tokyo, Japan) and a modem (MobileDP 2496P from NTT DoCoMo Corp., Tokyo, Japan) are used.

Therapist-Side Viewer System

Since the therapist does not necessarily have expert computer knowledge, the viewer system should have ease of set up, browsing, and report creating. Therefore, a PDA (Figure 3) is employed. Today's PDAs have browsers that allow access to Web-based information through wireless media. The mobile telephone and PDA are linked by an infrared modem attached to the communication port of the mobile telephone. With this viewer, the therapist can access the sensor node in an individual patient's home via the Web browser built into the PDA. Since the acquired information is shown as an image or text on the Web browser, the therapist can copy it and paste into a text editor on the PDA to track or record long-term transitions of a patient's status.

Connection

The performance and cost of the connection mechanism should be carefully balanced. In our framework, a therapist checks the estimated heart rate and respiratory rate at several time points after an exercise for each server of interest. The data, only a few kilobytes in size, are formatted in HTML for browsing from a PDA. In such a case, the framework is modeled as the server-client: servers providing data at an individual home and a client for a therapist to access those servers. Thus, the home-side system is implemented as a remote access server (RAS), and the connection is established using TCP/IP over PPP.

Security and Privacy

Security issues should be considered carefully [5]. First, the access rights to the measured data should be limited to a privileged group to protect patient privacy and to prevent data alteration caused by a malicious attack or accident. Second, the identification of patients should be correctly performed by a therapist to prevent malpractice. In our system, there are multiple layers for access control. Since the connection is established over a digital mobile telephone, strong data encryption is performed in the physical layer and an RAS regulates any incoming connection by the caller's telephone number; it uses challenge handshake authentication protocol (CHAP) for username/password authentication. Since an individual server is identified by the RAS telephone number and requires different passwords for authentication, a therapist can switch to the patient of interest easily and correctly. Further security improvement is possible using popular security mechanisms in the session/application layer such as the internet protocol security (IPSec) or the secure socket layer (SSL).

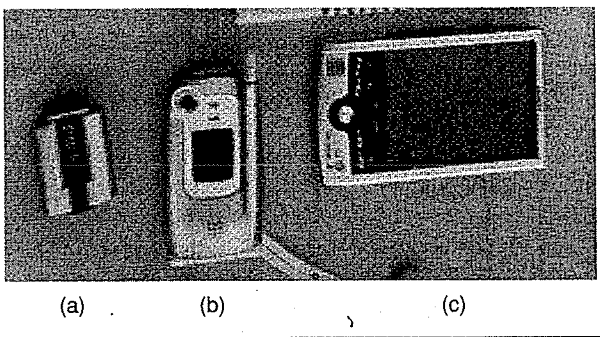

Fig. 3. The therapist-side system: (a) IR modem, (b) mobile phone, and (c) PDA.

Results

The proposed system was operated in practical clinical situations to evaluate its potential. The test was conducted in Miyazaki prefecture, Japan. A physical therapist from Fujimoto Hayasuzu Hospital and his three patients joined as subjects in the experiment. Before the experiment, the hospital's ethics council approved the experiment, and patients or their families gave both oral and written informed consent.

Subjects

Case 1

The subject is an old man with dementia. He is bedridden and requires acute care for all activities. Rehabilitation training by the therapist included joint flexion, muscle rebuilding, and mental support. He lives in suburban area, 5 km from the hospital. Only a mobile telephone is available for wireless communication in the area.

Case 2

The subject is an 83-year-old man who had been hospitalized for cerebral infarction with intercurrent aspiration pneumonia. After recovery, he and his family requested home-visit care. He is bedridden except at mealtimes and needs acute care including complete support for most daily activities. Rehabilitation training by the therapist included joint flexion, muscle rebuilding, mental support, and platform-to-wheelchair assistance. He lives in an intermountain area, 28 km from the hospital. Only mobile telephone service is available in the area.

Case 3

The subject is a 54-year-old woman diagnosed with muscular dystrophy. She has mobility impairment and has to move on her hands and knees. In addition to assistance with eating and toileting, she requires partial help with some activities of daily living. Rehabilitation training by the therapist included respiration aid, joint flexibility training, and muscular exercises.

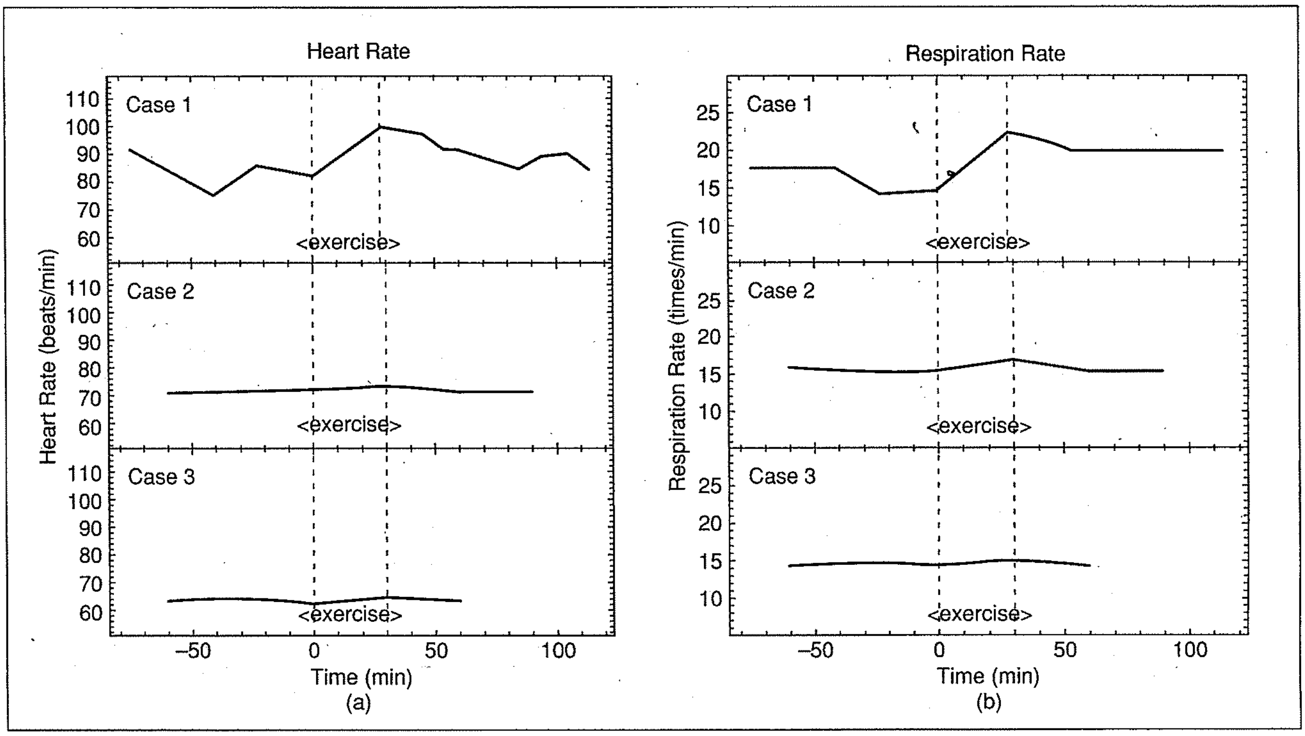

Fig. 4. Measurement results: transition of (a) heart rate and (b) respiration rate.

She lives in a city area, 3 km from the hospital. Both mobile telephone and PHS were available in the area.

Measurement

The system was placed in a briefcase for mobility and easy installation. Before the experiments, the therapist was given brief instructions for system installation and use. After the instruction, the therapist was able to install the system without help. For each subject, the system was installed 1–2 h before the experiment. All measurements were performed by the therapist. In each case, measurements were performed immediately before and after the exercise and the intermission during the exercise with the subject on the bed. Additionally, for Case 1, remote measurements were performed at several time points during the 60 min before and after an exercise session. Each operation took approximately 2 min, including about 40 s for HTTP data transmission. Although radiowave malfunction caused connection loss several times, the system recovered quickly by reloading via the Web browser. Acquired data were stored into a text document on the PDA for each subject. The measurement results are shown in Figure 4. In each case, heart and respiratory rates increased immediately after training and then recovered in 30 min to the status before the exercise. One to three hours after the exercise, the therapist visited subjects again to confirm their stability.

Discussion

In each case previously examined, the system successfully obtained data on patient status. Since the system structure was simplified and constructed of consumer devices, it was low cost, less than US$1,500 for a communication system, and easy to use, a therapist only had to plug in to start or stop the system. The time and cost of installation and maintenance were appropriate to our needs. Patients approved of the system's compact, silent, and especially nonconstraining nature.

In our implementation, a personal digital cellular (PDC) mobile telephone was employed for data transmission. Although this medium has relatively low bandwidth (9,600 b/s), it was possible to apply it for our purpose, as we limited the amount of data to 50 kB. The Web-based interface made the operations of browsing and creating reports easy to learn for our users.

With each measurement, the therapist, away from the bed, was able to confirm that the individual patient had not suffered overloading shock from the exercises. In addition, the logged data for Case 1 showed that the patient's status safely returned to normal following exercise. While it is difficult to evaluate postexercise transitions by interview, our system was able to provide quantitative information. Such data can be used not only for training evaluation but also for preventive medicine and quality control of home-visit rehabilitation services through long-term observations. Our test application for home-visit rehabilitation indicates the efficiency of a low-bandwidth telemetry framework for telemedicine in home care use.

Conclusion

This study described a niche telemedicine framework for home healthcare. The framework aims to transmit small but sufficient amounts of data for daily monitoring of residential subjects' basic health status. Using existing telecommunication infrastructure, it reduces the costs of both development and maintenance. As a proof of concept, we developed a system for remotely monitoring heart rate and respiration and tested it in several practical home-visit rehabilitation cases. The proposed system showed its usefulness for both the therapist and the patient in planning and evaluating daily rehabilitation training.

We are planning to integrate other measurement modalities into our framework in future development. First, blood-pressure measurement will be tried because it is known to be useful for understanding patients' status, and there are several commercial compact and low-constraining sphygmomanometers having data export functionality. Other possibilities are accelerometers or pedometers for activity and oxygen consumption for vitality.

Our telemedicine framework can contribute to preventive medicine. To reduce medical expense, which is an urgent issue, especially in Japan, daily healthcare service should be improved. Low-cost monitoring devices allow the correct transmission of health status that can be used for appropriate rehabilitation plans for individuals as well as for developing evidence-based medicine and healthcare.

Acknowledgments

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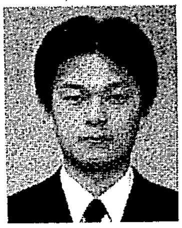

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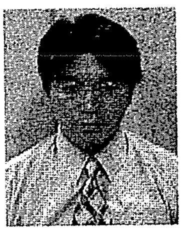

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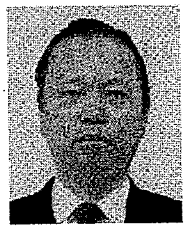

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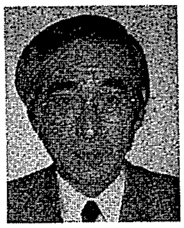

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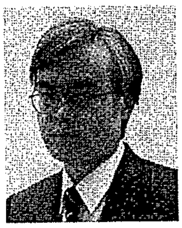

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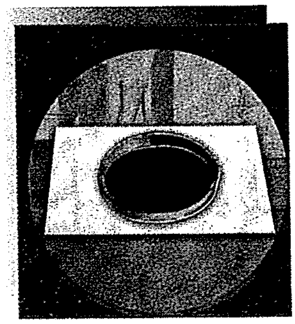

An Algorithm for the Automatic Detection of Health Conditions

An Image Processing Technique for Diagnosing Poor Health in the Elderly

BY MASAYUKI NAMBU, KAZUKI NAKAJIMA, MAKOTO NOSHIRO, AND TOSHIYO TAMURA

In this article, we describe the development of an algorithm for a health diagnosis system for the elderly that uses image processing. This algorithm reconstructs monochrome images from data of the time a subject watches TV and calculates the index for diagnosis of the subject's health condition from the entropy of the image. When this algorithm was applied to the data obtained for seven months, the result almost corresponded to the health condition of the subject. We assumed that this method can be used not only for diagnosis of a physical condition but also for diagnosis of a mental condition.

Several support systems of the daily life in the elderly, using the information network, are proposed [1]–[5], and one part has been put to practical use [6]. We also had proposed and operated, experimentally, the home healthcare system [7], [8], which is a combined system of the information network and biomedical sensor system. Systems such as the one we proposed acquire biomedical data from the elderly from which their functional health status can be analyzed. The main function of these systems is to urge the medical doctor to give a precise diagnosis to the elderly patient if the abnormal status is detected in the data, which had been acquired when the subject was healthy.

Because the elderly generally have low incomes, a significant investment to maintain the health condition of the quality of life (QOL) is not desirable. Moreover, it is undesirable for the running cost to be expensive because it is often paid by public assistance. However, the running cost is expensive in most existing systems because these systems need the simple manual diagnosis by the medical staff, including a medical doctor, for detecting the abnormal status [9]. To solve this problem, we propose the new algorithm, which applies the image processing technique for the automatic detection of an abnormal status of the health condition.

Methodology

We obtained the approval of experimental protocol from the ethics committee of Welfare Techno-House Mizusawa, and before the experiment, written informed consent was obtained from the subject who participated in this study.

We attempted to extract an index showing health condition from the data of the system that is experimentally operated by a cooperative subject. We assumed that the activity of the subject would be less or the pattern of the activity would be different from its usual condition if the subject has contracted a disease.

The system has a running monitor of electric appliances or door switches. We browsed the frequency of the use of electric appliances (the acquired data are shown in Table 1). Normally, there are many electric appliances and doors in the home, even if the resident lives alone. Therefore, there are many types of data that can be acquired. As shown in Table 1, there were door switches for the refrigerator, the electronic oven, and the kitchen and a running monitor of the television. We tried to analyze the health condition of the elderly using whole data that we acquired. However, it was difficult, because most data have no correlation to each other. Moreover, it is not a global method, because the number and kinds of sensors are different in each home, and the custom of daily life is different in each subject. Therefore, the diagnosis depends on the subjective evaluation by medical staff in existing home care systems.

We tried to develop the diagnosis method using one type of data, which was selected carefully. It is necessary that the data for the diagnosis are common to most subjects and are capable of showing not only the physical condition but also the mental condition of the subject. Finally, we selected the data from the

Table 1. Sample data of home care system (excerpt).

Refrigerator (Upper)	Refrigerator (Lower)	Electronic Oven	Kitchen Door	Television
7:00	8:19	8:17	9:23	7:13
8:08	11:52	8:19	11:34	11:46
8:10	12:02	16:52	11:43	14:12
8:22	12:03	16:56	14:32	16:49
11:54	12:03	17:53	15:41	17:00
12:06	12:25	17:56	15:43	18:15
12:24	12:31			19:10
12:27	14:16			

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We assumed that randomness of the reconstructed image increases if the rhythm of daily life collapses and there is a bad health condition.

running monitor of a television. We considered that the custom of watching television always depends on the program, and the custom is strongly influenced by the physical and mental condition of the subject. Figure 1 shows the data that were acquired from the running monitor of the television for 30 consecutive days. Figure 1(a) shows the data of a month in which the subject did not appear to be in bad health. Figure 1(b) shows the data of a month in which the subject appeared to be in bad health. On 26 July, which was the last day of the experiment, the subject was diagnosed with a bad kidney function condition and was hospitalized. From Figure 1, we assumed that the subject watched the television at roughly fixed times if he/she was healthy.

At first, we tried to diagnose the health condition of the subject from a change in the start time of television viewing; we assumed that the subject watched the same program repeatedly. However, we confirmed the subject did not necessarily begin watching television at the same time of day or at the same time of week, as shown in Table 2. Then we tried to convert the graph into the image and diagnose the health condition of the subject from the feature of the image.

We reconstructed the monochrome image from data. Every start time for watching a TV program was recorded to the data. Therefore, we divided the 24 h by 15 min, and we assumed that we could obtain a 30 × 96 pixel monochrome image. If the starting time was recorded within a 15 min interval, we set the pixel of the image to black (Figure 2).

In the image obtained from the data of the month when the subject was healthy, there is an area in which the pixels are concentrated. On the other hand, the pixels are distributed randomly in the image obtained from the data of the month where the subject appeared in bad health. We assumed that randomness of the reconstructed image increases if the rhythm of daily life collapses and there is a bad health condition.

When randomness of the image is high, it means the information content (entropy) is large. In other words, the information content of the reconstructed image obtained from the data of the month where the subject appeared in bad health is relatively high. Therefore, the health condition of the subject can be diagnosed from the entropy of the reconstructed image, which is obtained from the data of the beginning time of watching television.

Evaluation

We diagnosed the health condition of the subject by using actual data to evaluate whether the proposed technique was effective. The data had been acquired in a continuous period of seven months (January–July 2000). The subject was a 78-year-old female who lived alone.

Preprocessing

Sometimes the subject went out and was absent all day to visit the home of her children or to go on a short trip during the evaluation period. In this case, the data were empty and influenced the diagnosis as noise. Therefore, the data of absent days were intentionally deleted. The data at the time when no television program was broadcast were similarly deleted.

In addition, the subject turned the power switch of the television on and off frequently in the month she appeared to be in bad health. Most of these operations would be an origin of noise

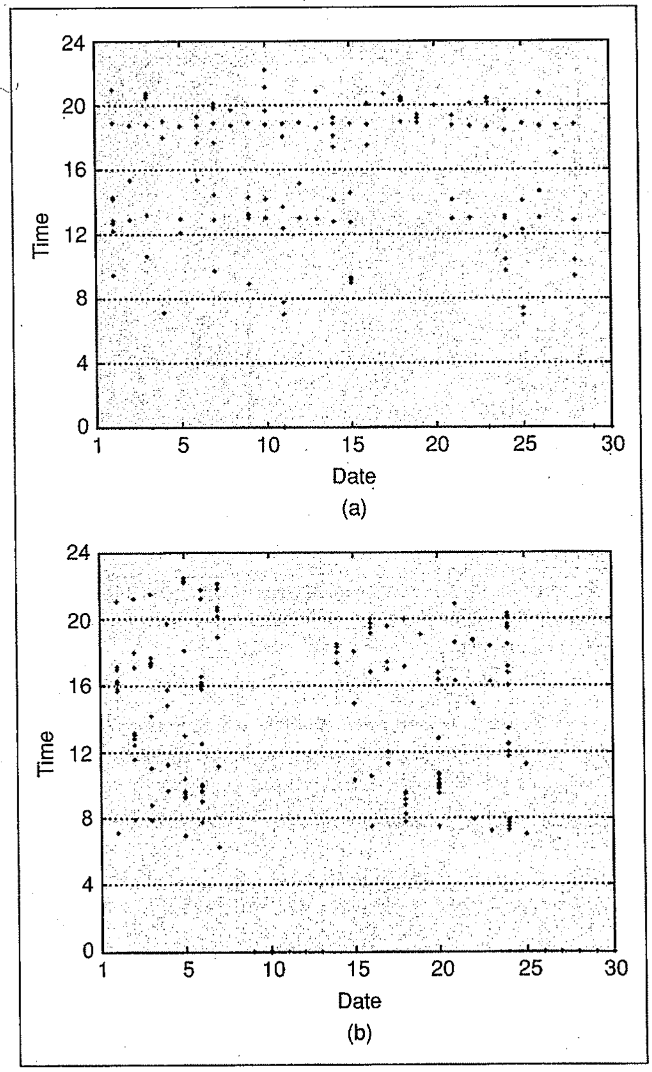

Fig. 1. Start time of watching the television: the subject's condition is (a) healthy and (b) not healthy.

Table 2. Original and compressed image size.			
Case	Original (Byte)	Compressed (Byte)	Index (Compression Rate)
Healthy 1	374	309	0.826
Healthy 2	398	317	0.796
Healthy 3	338	286	0.846
Healthy 4	386	284	0.736
Healthy 5	326	282	0.865
Healthy 6	290	273	0.941
Not Healthy	302	310	1.026

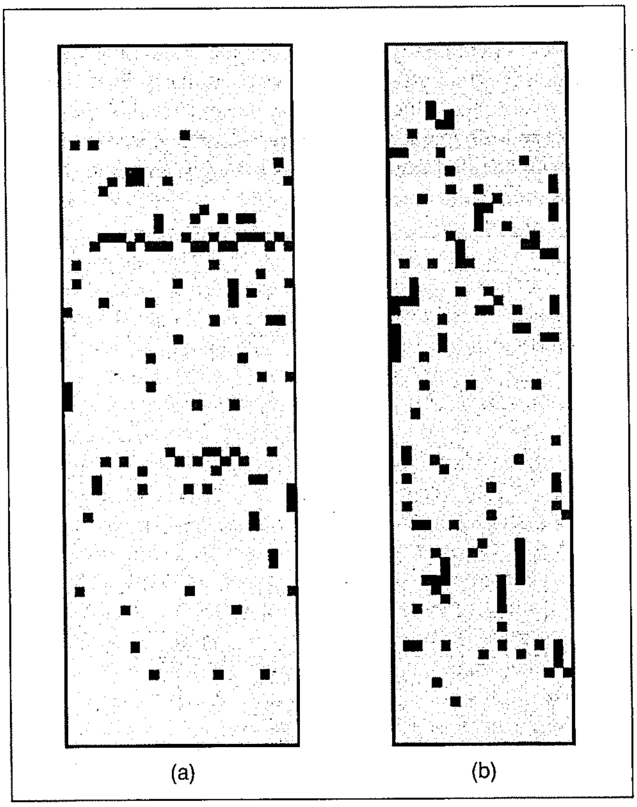

Fig. 2. A reconstructed monochrome image. The black pixels represent the start time of watching television: (a) healthy and (b) not healthy.

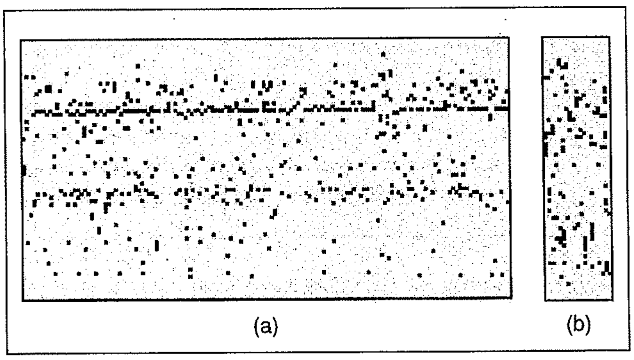

Fig. 3. Reconstructed image of (a) healthy six months (January–June) and (b) a not-healthy month (July).

on the data. We sampled the data in every 15 min interval according to the broadcasting of the television program and reconstructed the image for diagnosis.

Index for Diagnosis

The entropy [10] $H(X)$ of the data X is defined by

$$H(X) = -\sum_{k=1}^{n} p(k) \log_2(p(k)) \ldots, \qquad (1)$$

where $X = \{a(1), a(2), \ldots a(n)\}$, $p(k)$ is the probability of the appearance of $a(k)$.

It is necessary to convert or normalize it into the index to be able to compare it simply and understand it easily for the practical diagnosis. In addition, we tried to obtain the index from two-dimensional (2-D) images. Then, we assumed the ratio of the size of the file before and after compression to be an index by compressing the image using the maximum entropy method (MEM). If the entropy of the image before compression is large, compression is not effective, and the size of the file after the compression must be larger than that before the compression because the information for the compression is added.

Result

The reconstructed image from the data of the subject is shown in Figure 3. As for the data of the subject in July, by which time she had a bad health condition, it seems to be distributed unlike any other data of the previous six months. Reconstructed images from the data of each month are shown in Figure 4. Table 2 shows the size of the original images and the compressed images. Only in July's data is the file size after compression larger than that of the file before compression.

In addition, to evaluate the method statistically, we obtained the reconstructed image from each continuous two weeks. Figure 5 shows the average of the index. As the result of the t-test, there is a significant difference between the data when the subject is healthy and when the subject is not healthy (a significant level of 5%).

Discussion

As a result of the evaluation, our index represented the health condition of the subject according to our assumption. Especially in the month she appeared to be in bad health, the subject seemed to operate the switch frequently. We consider that this behavior represents not only a bad physical condition but a bad mental condition as well. In this time, the randomness of the pattern of the activity in daily living became larger when the subject was not healthy. We assumed that the cause of such a result was having used the data of the television reception. Because the TV program was broadcast at a fixed time, it was a trigger of daily living. Therefore, the trigger would not be as effective when the subject was in poor health. It is not certain that our proposal method could be applied to every elderly person. However, this method can be applied to the data from the activity of daily life in the elderly. For instance, it is possible to apply it to anything that begins at a fixed time, such as a meal.

This method will be used for the evaluation of a simple diagnosis for the prevention of disease; the final diagnosis by a medical doctor is necessary. Unfortunately, in Japan, public insurance is not applied to preventive medicine at this time

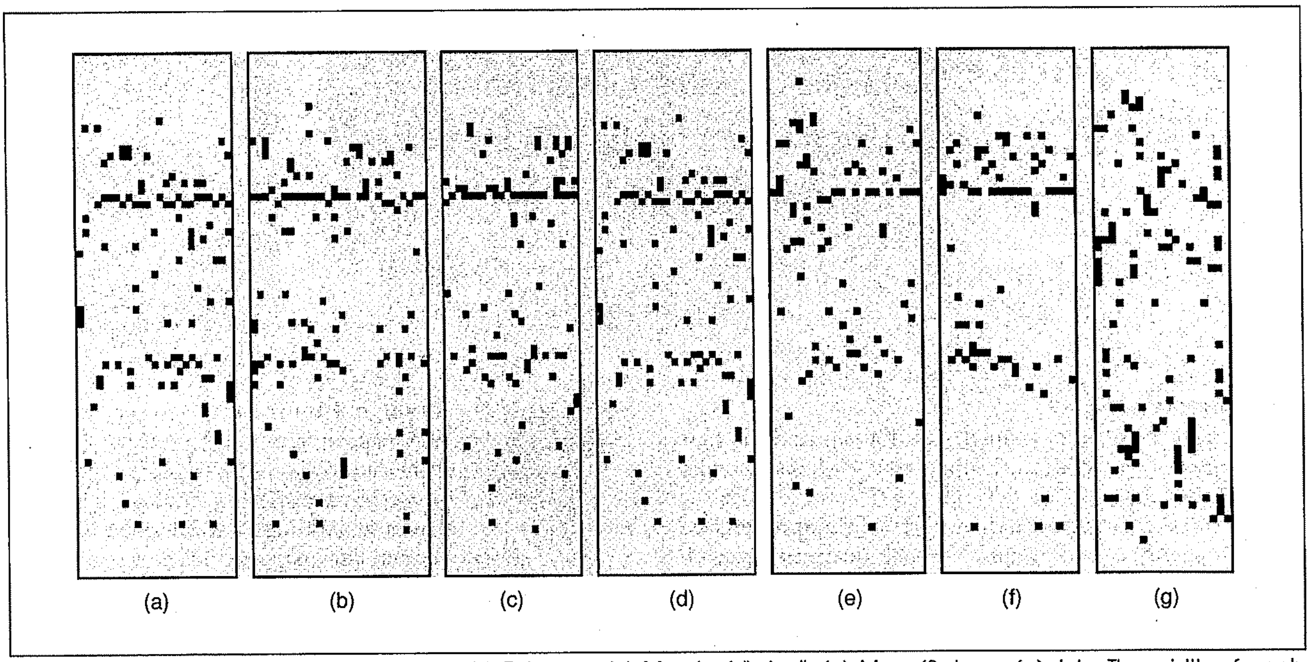

Fig. 4. Reconstructed images: (a) January, (b) February, (c) March, (d) April, (e) May, (f) June, (g) July. The width of each image is different because data from when the subject went out were removed.

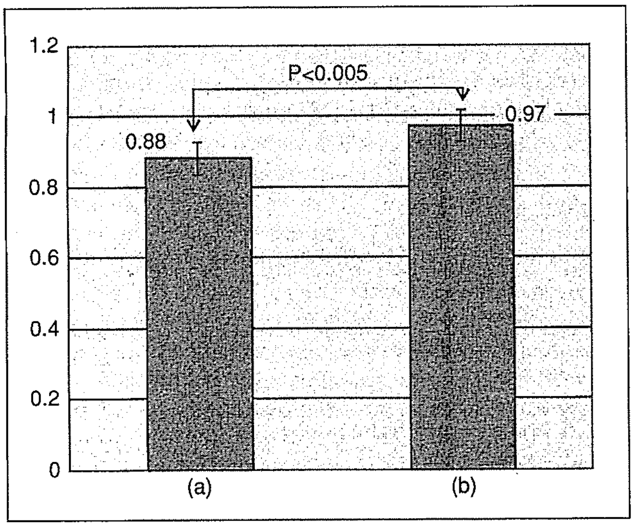

Fig. 5. Average of index: (a) healthy and (b) not healthy.

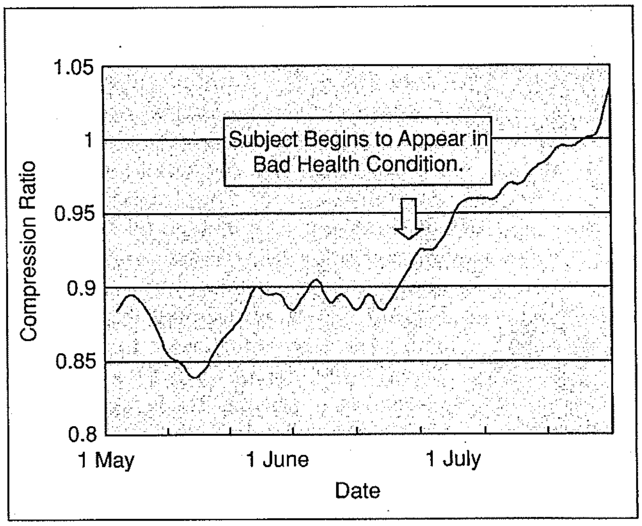

Fig. 6. The continuous change of the compression rate.

[11]. However, we believe that the total medical expense will decrease if public insurance is applied to this type of home care system in the future because the medical expenses for the elderly will decrease.

Long-term data such as one month is needed for this system because this system uses the character of 2-D data as an image. We confirmed the effect of this method by discrete data each month. However, we should also confirm whether this method is effective for rapid changes in the health condition of the elderly. Therefore, we set the data window at one month and acquired the index in each data window by moving this window. The result is shown in Figure 6.

The abnormal condition was found at the end in June (Figure 6). We confirmed (through a prior questionnaire investigation) that the subject appeared to be in bad health after a short trip in the middle of June, and the result represents this change in health condition. Therefore, we can diagnose the daily change using the proposed method.

Conclusion

We proposed a new algorithm for diagnosing the health condition of elderly persons living alone. As a result of the evaluation, we consider this algorithm to be effective according to the subject. In addition, this method was economical because the algorithm needed only simple data acquired from simple sensors. In the future, an automatic diagnosis will be available using this algorithm. Finally, total medical expenses will be reduced if this system is practical.

The health condition of the subject can be diagnosed from the entropy of the reconstructed image.

Acknowledgments

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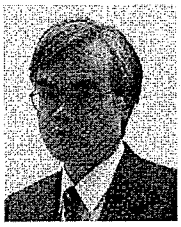

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高齢者の健康管理—見守り，疾病予防から疾病管理

Health care for the elderly-monitoring,prevention and care of diseases.

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Toshiyo TAMURA

Abstract

With the aging of society, the improving the quality of life is an important for the elderly population. In this paper we summarized three systems such as human behavior monitor, telemedicine and telecare. Human behavior was monitored as a mean to promote health care during daily life. Telemedicine and telecare included mobile phone technology were presented. The mobile technology applied to dermatological studies and home-rehabilitation

キーワード：見守り，遠隔診療，在宅健康管理，在宅酸素療法，居宅リハビリテーション

1 はじめに

少子高齢社会を迎え，高齢者の健康管理，疾病の早期発見，疾病後のQOLの向上など多くの課題が残されている．高齢者の多くは，介護が必要になっても自宅での生活を望んでいる（図1）．すなわち，

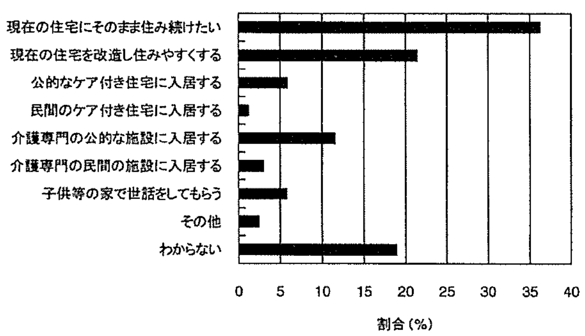

図1 高齢者が虚弱したときに望む居住形態（内閣府 「平成12年度 高齢者の住宅と生活環境に関する意識調査結果」 平成13年9月）

高齢者の約6割が介護施設に入居するより自宅をバリアフリーな環境に改造して住み続けることを希望している．これからの高齢社会においては，高齢者が例え看護・介護を必要とする段階になっても，そのヒトらしい生活を自らの意思で送ることができるよう，高齢者の尊厳を支える技術が必要になってきている．

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これらの条件を鑑み，情報技術を応用した高齢者支援がここ数年盛んに行われている．まず，高齢者が，例え独居になったとしても進んで社会参加ができるような環境作りであり，さらに高齢者が健康で長寿を全うできるような支援技術，すなわち疾病を予防する技術が開発されている．さらには，遠隔診断技術の普及と在宅ケアへの応用がある．ここでは，高齢者支援の現状と将来について述べる．

2 高齢者の見守り

高齢者，特に独居高齢者の見守りについては多くの機器開発，研究さらには市販システムも稼働している．簡単なシステムとしては，ペンダントを携帯し緊急時対応をすることである．いくつかのシステムが稼働しているが対象者がペンダントを携帯しないなどの問題が生じている．成功している例では，端末機に工夫がなされている．端末機は緊急ならびに相談ボタンを有した据え置き型端末機と緊急ボタンのみを有するペンダント型端末機から構成される．端末機は電話回線と接続され，システムを販売しているセンターのオペレータと接続される．高齢者はペンダント形の端末機を携帯し，緊急時には，ペンダントの緊急ボタンを押す．その場合は，センターから救急車の手配を行う．また，相談があるときには，据え置き型端末機の相談ボタンを押す．相談や生活支援の場合は協力員の手配や助言を行うことができる．この相談ボタンがあることにより利用者の

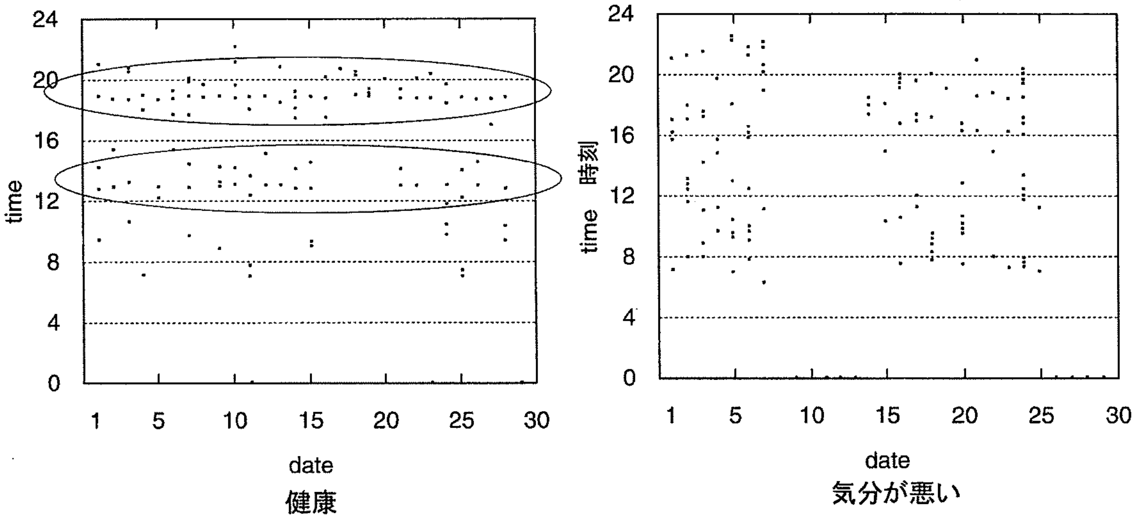

図 2 数週間にわたるテレビの On/Off 状態．左は健康状態が良好なとき，右は健康状態が悪いとき．途中，居宅を離れている時期があるが，記録が停止された時期に入院した．遠隔医療への病院．診療所の対応

利便性をはかっている[1)]．また，温水ポットの利用，すなわち独居高齢者宅にポットを起き，その利用をモニタする方法がとられている[2)]．そのほか実証実験としてはペット型ロボットを使用した福祉支援情報通信システム[3)]や転倒モニタなどがある．

各種物理センサを用いてヒトの行動を見守り日常生活活動を把握しようとする試みがある．ヒトの動きを焦電型赤外線センサで，ドアの開閉，冷蔵庫などの開閉をマグネットスイッチで検出し，そのほか，水の使用量，電気の使用量などを連続的にモニタして独居高齢者の安否の確認や生活習慣の把握，緊急事態に対処する方法である．現状では，まだまだ実用化には問題が残るが数多くの試みがある．焦電型センサや圧力センサを内蔵した玄関マット，テレビや照明器具のスイッチの on/off から独居高齢者の生活動態を測定している例は数多くある[4)−10)]．

そのなかで汎用性があるものとして電灯線を通信回線として使用した例を取り上げる[9)]．

独居老人の家庭内における生活リズムを，宅内の既存の電灯線に接続した焦電型赤外線センサ及びテレビや照明器具の使用状況を検知する動作モニタなどにより検出し，ホストシステムに通知するというものである．システムの特長として電灯線を利用しているので，必要な場所への後付けが簡便にできる．同時に水道の遠隔検針や電力，ガスの消費量も監視している．被介護者にペンダント型の送信機をもってもらい緊急時に対応する緊急通報システムに比較して，被介護者を拘束しない利点があり，被介護者が装着を拒否した場合でも計測が可能となる．また，家族，ヘルパー・看護婦・医師等の地域福祉・医療に関わる人々の有効なシステムになるものと期待できる．

これらの日常生活の長期間データ収集から健康状態が実際に判別できるであろうか．テレビの on/off 信号から健康状態を推定できるという報告がある[11)]．テレビの on/off を経時的 2 次元的に表し，そのエントロピィを算出することにより健康で定常的な生活を営んでいるか否かを判別する (**図 2**)．

この方法においては，健康状態の非日常性が一週間単位で推定できるという．健康状態の把握は蓄積したデータから，意味のある相関関係やパターンなどを発見するデータマイニングの技術が必要であり，統計的手法としてヒストグラム，隠れマルコフ過程など種々の方法がとられている．

これらはシステムとしての技術的完成度は高い．さらに昨今の通信事情の多様化により運用は容易となっている．しかしながら，システムを受け入れる社会的基盤，例えば，データ送信先の対応，通信コストの負担などを解決しなければシステムが一般に普及するのは難しい．

3 遠隔医療

「遠隔医療」とは，映像を含む生理情報を患者から伝送し，遠隔地から診断，指示などの医療行為及び医療に関連した行為を行うことをいう．疾病管理のための遠隔医療の実施例は，国の補助事業として広く実証実験が行われたが，最近の調査によると遠隔医療をこれからも継続あるいは新規に導入を予定していく病院，診療所は多くはない．図**3**は，医療分野におけるIT化実態調査報告である．

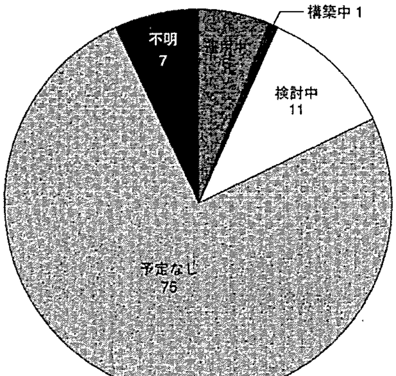

図3 医療施設における遠隔診断システムの導入状況（病医院におけるIT化実態調査　MEDIS　2004年3月）

1992施設のうち運用中は6%，検討中は11%で，予定なしは75%となっている．理由としては，費用の負担，運用時間などがあげられる．伝送と医療行為とが即時に行われる必要性は生じないが，例えば夜間に大量のデータを伝送し，伝送先の装置に蓄積し，専門医が時間のある時にこれを読んで結果を返すという形態では，X線の読影など専門家がまとめて読影する場合は問題にはならないが心電図や脈波などの連続した生理データをまとめて読むことは不可能に近い．安価で高品質ブロードバンドの普及，携帯電話の普及に伴い，新しい形態の遠隔医療システムの構築が考えられる．

特に高齢社会を迎えるにあたっては，在宅介護は大きな課題となる．したがって，遠隔医療も幅を広げて福祉との接点をも扱うことを想定しておかなければならない．この行為を行う主体も医師に限らず，歯科医師である場合もある．また，看護師，検査技師，薬剤師などがそれぞれ許される範囲で遠隔地から指示を与える場合も考えられる．

3.1 携帯電話により皮膚疾患診断

携帯電話を用いたEメールの画像送信により慢性創傷の遠隔医療が可能であることが，報告されている[12]．電話で医師に診断を求める際，携帯電話のカメラで撮影した下腿潰瘍の写真があれば，大半の患者で評価および治療のための十分な情報が得られ，患者が病院まで移動する手間および経費を節約することができるという．慢性下腿潰瘍患者52例を対象に，対面式の評価と携帯電話による遠隔評価とを比較検討した．患者は対面式の評価後に，標準カメラが装備された携帯電話を用いて下腿潰瘍部位の通常光による写真を2枚撮影し，担当医師2名にEメールで送付した．担当医師によれば，写真の品質が診断するのに十分であると感じられたのは5例中4例，また遠隔評価は研究者による直接診察の診断とほぼ同じであることが判明した．これまで特に皮膚科領域では圧縮された画像に対する評価は低かったが，遠隔医療の可能性が示唆されたことは興味深い．この方法は，今後病院などに患者を搬送する方法に取って代わるとともに，医療システム経費の節減にもつながるであろう．

3.2 在宅管理では酸素療法 (Home oxygen therapy HOT)

肺機能の低下が進むと，普通の呼吸だけでは十分な酸素を得ることができない呼吸不全という症状に陥る．呼吸機能が低下して，継続的に酸素補給が必要な患者，すなわち，運動中や睡眠中に低酸素状態になる患者が，在宅酸素療法の対象となる．健康保険が適用される場合もあり，在宅療法として普及している．

カニューラの装着や取り外しは自由にできる．最近は，外出や旅行もできる携帯用の酸素供給器具が普及し，生活の質を損ねることなく過ごすことができるようになった．眼鏡フレームから，目立たない無色のカニューラを鼻に送る方法も開発されている．酸素吸入は常時行うのではなく，酸素飽和度をパルスオキシメータ*で常時モニターしており，その数値

*パルスオキシメータ (Pulse Oxymeter)]　体外から非侵襲

が90に近づくと酸素を吸入する形で利用している．酸素の残量は電話回線を利用し遠隔監視システムで行っている．

鼻カニューラという細いチューブを鼻に装着し，コンパクトな酸素供給器具から鼻へ，酸素あるいは酸素濃度の高い空気を送り込む (図4)．

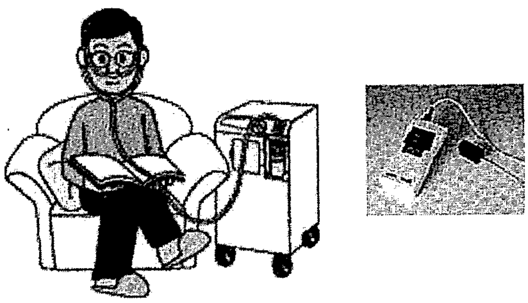

図4 在宅酸素療法：パルスオキシメータを指に装着し連続して酸素飽和度を測定し，その値により酸素を供給する出展：copd情報ネット

3.3 居宅リハビリテーション

寝たきり高齢者を対象として居宅リハビリテーション時のバイタルサインを測定し遠隔地で受信できるシステムが試作されている[13]．システムの概要は対象者にセンサを装着することなく無意識のうちに生理情報を収集するシステムとしてベッドにエアマットレスを装着し，マットレスのエアの変動から周波数解析によって心拍数，呼吸数を推定している．

データは，PCの機能をもつが，表示機能を持たず，計算とデータ伝送のみの機能をもつマイクロサーバに保存する．保存されたデータは，一定時間ごとに更新する．データの閲覧は，医師や医療従事者が希望する場所，時間に携帯電話を用いて行うことが可能となっている．在宅側のサーバからは積極的にデータを送信することは行わない設計としている．

セキュリティはWeb-baseでのデータのやりとりを行うことにより安全性に配慮している (図5)．

に血液中の酸素飽和度（血液がどれだけ酸素化されているか）を測る装置．2波長のLED（光源）とフォトダイオードがセットになっていて，2波長の血液吸光度の違いから動脈中のヘモグロビン動脈の酸素飽和度を計算する．

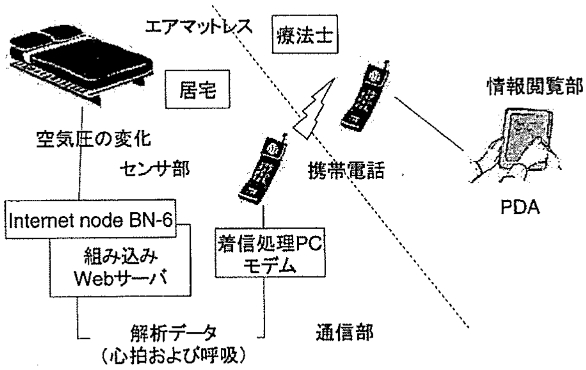

図5 携帯電話を利用した居宅リハビリテーション

臨床実験の一例を図6に示す．トレーニング直前直後の確認に加え，トレーニング開始前，トレーニング終了後100分間の心拍数，呼吸数を患家より離れた地点よりPDAにて確認している．

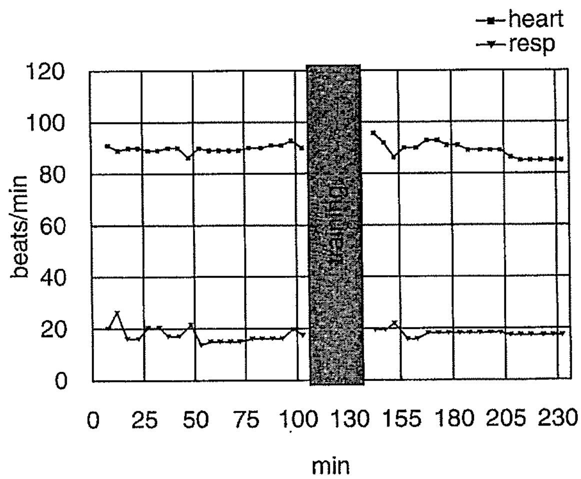

図6 実施例

電話料は，医療従事者側が負担し，在宅側はマイクロサーバやセンサ駆動のための電気料を負担するのみで，さらにデータ収集も在宅側の特別の協力を得ることがなく，無意識のうちに行うことができるという．

このシステムの稼働により図6に示した例では，被介護者の心拍数と呼吸数はトレーニング開始前，後安定して推移していることが確認できている．それと同時にトレーニングの負荷量はその確認時間の範囲内では安全であることが確認されたという．このシステムは，在宅リハビリ対象者の，健康管理と

状態改善に伴うトレーニング負荷量設定の判断材料として有用である事が推察された.

このようなシステムが実用化されれば，へき地に居住する在宅患者に対し，個人の情報に基づいた客観的な看護・介護や遠隔診断が可能となり，訪問診断の代替となることで，在宅患者のQOL向上が期待される．また，このようなシステムにより開発されるユーザインターフェースは，コンピュータの介在を意識させないことを前提とし，コンピュータの操作に不慣れな利用者にも容易にシステムの活用が可能となる．また重要な個人情報を悪意の第三者に漏洩することなく共有する技術も同時に開発する．このようなシステムが実用化によりへき地における在宅医療の効率が向上し，医療費の低減も期待できる.

4 おわりに

高齢者の生活の質を高め，よりよい生活を営むために，様々な提案がなされ，研究がされている．健康管理を行なう中心の場として，家庭が重視され，さらに子どもや高齢者にも利用しやすい，簡単なインターフェースの開発が必要であることは云うまでもない．費用負担，法律・規制など解決しなければならない問題も多くあるが，少子高齢社会で高齢者のQOLを向上させ，尊厳を守るためにより一層の研究開発が望まれる.

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健康長寿社会を支える医工学技術

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長寿医療

わが国は戦後，国民の平均寿命が急速に伸長し，世界一の長寿国とされている．さらに今後，諸外国を大幅に上回る速さでいっそうの高齢化が進むことが予測され，全人口に占める65歳以上の割合が，2025年(平成37年)には27.4％にまで増大すると推計されている．こうした来るべき超高齢社会においても，高齢者の疾病や障害をできるだけ軽減し，自立を促進して，健やかに生活できる「健康長寿社会」を実現することが重要である．そのため，従来から行われてきた老年学研究，一般的老人医療に加え，新しい長寿医療関連技術の開発や高齢者に特有な疾病に対する適切な医療の実践など，さらなる長寿医療の充実が必須であり，かつ急務である．

長寿医療とは，老化の機序の解明，高齢者特有の疾病の原因究明と予防・診断・治療，さらには高齢者の社会的・心理的問題の研究など，高齢者や長寿社会に関し，自然科学から社会科学に至るまでの幅広い分野を，総合的・学際的に研究する学問ならびにそれを応用した医療と定義される．高齢者特有の疾病として認知症(痴呆)が挙げられる．ここでは，認知症への新しい取り組みを紹介し，次に血管の加齢に伴う変化を，いかに速やかに診断できるかの可能性を述べる．最後に，生活習慣病を防ぎ，健康で長寿を全うするためのホームヘルスケアの現状に触れる．

認知症の早期発見，診断に向けて

認知症は，アルツハイマー病と脳血管性認知症に大別される．これらの診断にはCTやMRIなどの診断機器が用いられ，精度の高い診断が行われている．認知症の原因や状態によっては，適切な診断・治療によって，症状の改善するものや進行を遅らせることも可能である．認知症の初期には症状が目立たないこともあるが，できるだけ早期に発見し適切な対応をすることが，高齢者の状態の安定と家族の負担を軽減することにつながる．

認知症の診断を確実にする目的で画像診断が行われるが，CTやMRIでは形態診断となる．アルツハイマー型では脳萎縮が顕著で，脳血管性では梗塞や出血などの病巣が低吸収域として認められる．

機能検査としてはPETがあるが，アルツハイマー型では，脳内の中枢性コリン作動性神経の変性が認められる．コリン作動性神経では，アセチルコリン(Ach)が神経伝達物質として働いており，神経接合部