Frequent Physical Health Monitoring as Vital Signs with Psychological Status Monitoring for Search and Rescue of Handicapped, Diseased and Eldery Persons

Kohei Arai [1]
Graduate School of Science and Engineering
Saga University
Saga City, Japan

***Abstract*—Method and system for frequent health monitoring as vital signs with psycholo9gical status monitoring for search and rescue of handicapped person is proposed. Heart beat pulse rate, body temperature, blood pressure, blesses and consciousness is well known vital signs. In particular for Alzheimer diseased persons, handicapped peoples, etc. it is very important to monitor vital signs in particular in the event of evacuation from disaster occurred areas together with location and attitude information. Then such persons who need help for evacuation can be survived. Through experiments wearing the proposed sensors with three normal persons including male and female, young and elder persons and one diseased person, it is found that the proposed system is useful. It is also found that the proposed system can be used for frequent health condition monitoring. Furthermore, physical health monitoring error due to psychological condition can be corrected with the proposed system.**

Keyword—-vital sign; heart beat puls ratee; body temperature; blood pressure; blesses; consciousnes; seonsor network

I. INTRODUCTION

Handicapped, disabled, diseased, elderly persons as well as peoples who need help in their ordinary life are facing too dangerous situation in event of evacuation when disaster occurs. In order to mitigate victims, evacuation system has to be created. Authors proposed such evacuation system as a prototype system already [1]-[4]. The system needs information of victims' locations, physical and psychological status as well as their attitudes. Authors proposed sensor network system which consist GPS receiver, attitude sensor, physical health monitoring sensors which allows wearable body temperature, heart beat pulse rates; bless monitoring together with blood pressure monitoring [5]-[7]. Also the number of steps, calorie consumptions is available to monitor. Because it is difficult to monitor the blood pressure with wearable sensors, it is done by using the number of steps and body temperature. In addition to these, psychological status is highly required for vital sign monitoring (consciousness monitoring). By using eeg sensors, it is possible to monitor psychological status in the wearable sensor. These are components of the proposed physical health and psychological monitoring system.

Such the proposed system also allows frequent monitoring. Even for every minute, or every second, it may monitor all the required items. Therefore it is applicable to the patients in ICU. Also, it may find Alzheimer patients who used to walk away from their house and /or hospitals together with physical health and psychological status. Furthermore, it may reduce physical health monitoring error due to psychological status changes. Even for the healthy persons, it may occur such errors. For instance, heart beat pulse rate and blood pressure is used to be increased when medical doctor or nurse measures. By using eeg signal analyzed results, such errors may be corrected or at least it can be omitted from the monitored data. These are kinds of bi-products of the proposed system.

Section 2 describes the proposed system followed by experiment method and results. Then conclusion is described together with some discussions..

II. PROPOSED MOTHOD AND SYSTEM

A. System Configuration

Figure 1 shows the entire system configuration of the proposed physical and psychological health monitoring system.

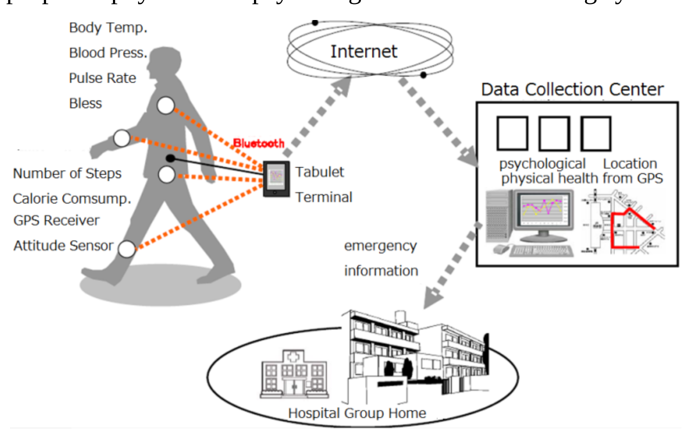


Fig. 1. Entire system configuration of the proposed wearable physical and psychological health monitoring system.

There are two types of stakeholders, patients (users) and volunteers who are responsible for evacuation, rescue, and help patients from disaster area as shown in Figure 2. Patients have physical and psychological health sensors and send the acquired data through Bluetooth and Internet to the Health Data Collection Center: HDCC server. On the other hand, volunteers receive health data of the previously designated several patients together with traffic flow information and appropriate route information. When something wrong occurs on the designated patients, HDCC provides information which required for rescue to the designated volunteers then the volunteers rescue patients in an efficient and an effective manner.

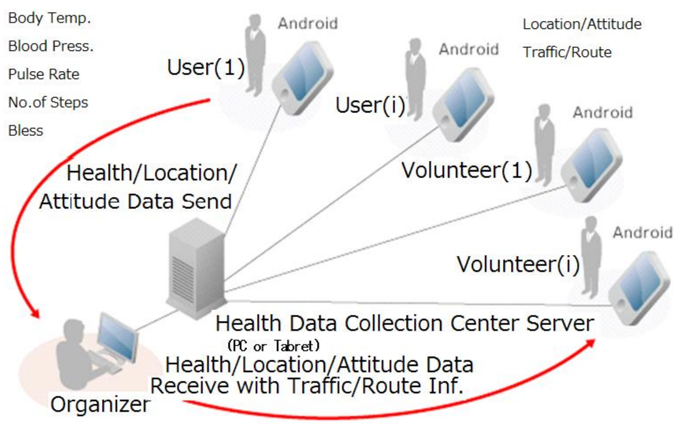


Fig. 2. Major components of the Proposed System

B. Sensor and Communication Ssystem

In order for evacuation and rescue, victims' location and attitude is important. Therefore, GPS receiver and accelerometer are added to the aforementioned measuring sensors for body temperature pulse rate, blood pressure, bless, and eeg, emg. All sensors should be wearable and can be attached to ones' tall forehead. Acquired data can be transmitted to mobile devices in ones' pockets. Through WiFi network or wireless LAN connection, acquired data can be collected in the designated information collection center. Then acquired data can be refereed from the designated volunteers who are responsible to help victims for evacuation and rescue.

III. EXPERIMENTS

A. Experimental Method

1) Patients

Four patients are participated to the experiments. The difference due to gender can be discussed through a comparison between patients A and C while the difference due to age can be discussed through a comparison between patients B and C. Meanwhile, the difference due to the degree of Alzheimer can be discussed through a comparison between patients B and D as shown in Table 1.

Experiments are conducted for eight hours a day for almost every working day (Monday to Friday) for six months starting from May 2012. Measuring time intervals are different by the measuring items. GPS location can be measured every two seconds while accelerometer data can be obtained every 10 seconds. Meanwhile, body temperature, pulse rate can be measured every one minutes while blood pressure is measured every one hour together with eeg and emg signals. The number of steps is measured when the walking event happened.

At the end of day, four patients evaluate their physical and psychological conditions which are listed in Table 2.

TABLE I. FOUR PATIENTS

Patient	Male/Female	Age	Remarks
A	Male	37	Good in Health
B	Female	47	Good in Health
C	Female	39	Good in Health
D	Female	91	Weak Alzheimer

TABLE II. SELF EVALUATION ITEMS

A1	Feel fever
B1	Loosing thinking capability
A2	Feel tiredness
B2	Could not sleep well
A3	Get tired after exercise
B3	Feel bad
A4	Muscle hurt
B4	Unconfident about health
A5	Feel depression
B5	Do not want to work
A6	Limper hurt
B6	Cannot remember something
A7	Head ach
B7	Loosing balance
A8	Cannot recover after sleep
B8	Cannot think deeply
A9	Throat hurt
B9	Loosing concentration
A10	Joint hurt
B10	Sleep for too long time

2) Subjective Evaluation of Physical and Psychological Health Conditions

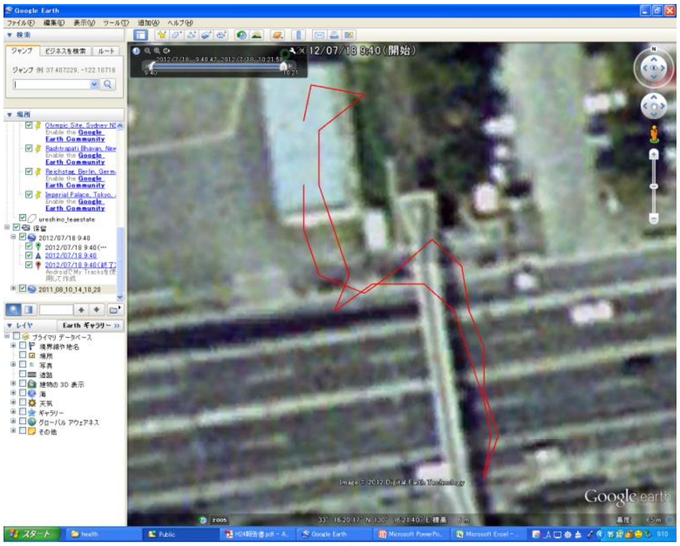
The 20 items listed in the Table 2 are questionnaires for four patients. In the Table, Ai is questionnaire for physical health while Bi is questionnaire for psychological health. The patients respond to the questionnaire above with five levels range from 0 to 4 grades. Total Score is defined as sum of the aforementioned self evaluation of 20 items including physical and psychological health items.

B. Experimental Results

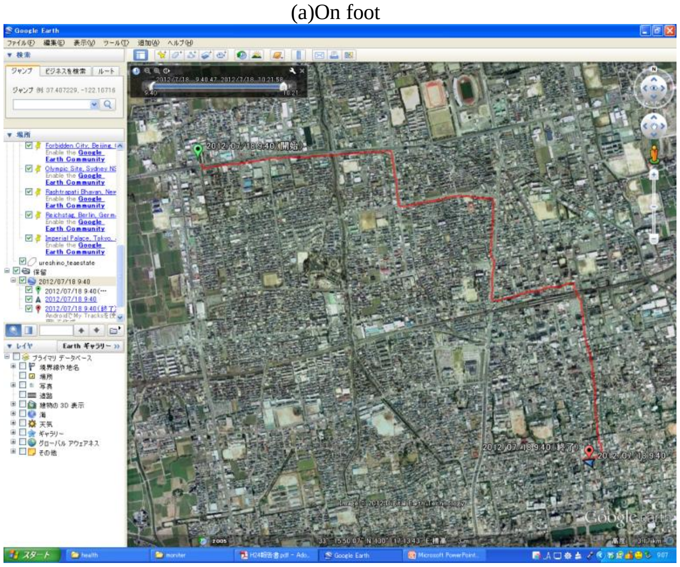
1) Traced Route

Example of traced route measured with GPS receiver on GIS map is shown in Figure 3. Figure 3 (a) is traced route when patient walks on foot while Figure 3 (b) shows the traced route when patient moves by car, respectively.

Figure 4 shows the traced route locations data in the database of the HDCC. A couple of meters of the estimated location error are observed. Also Figure 5 shows an example of measured attitude data in directions of x, y, and z. It is not so easy to estimate the patients' situations (sit, stand up, walking, lay down, etc) from the attitude data derived from the single accelerometer data. As mentioned later, it is much easier to estimate the situations using eeg and emg sensor data.



(a)On foot



(b)With car

Fig. 3. Example of traced route measured with GPS receiver on GIS map

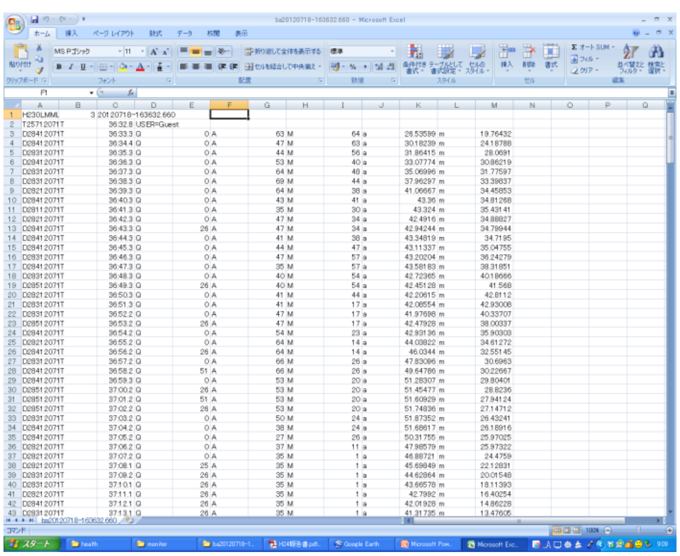


Fig. 4. Traced location in the database of the HDCC

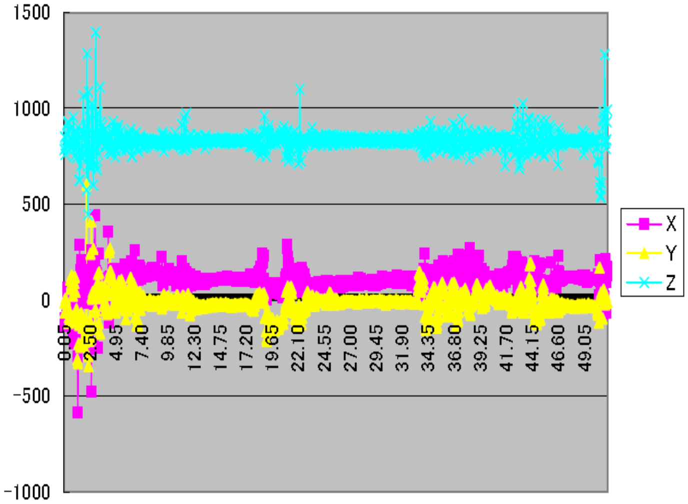


Fig. 5. Example of attitude data (x, y, and z axis movement)

2) Measured Physical Health Conditions

Relation between the measured physical health condition and the self evaluation of physical and psychological health conditions (Total Score) for the patient of weak Alzheimer is plotted in the Figure 6. Total Score denotes sum of the scores of the self evaluation items which are listed in Table 2.

Figure 7 (a) and (b) shows physical health data of the weak Alzheimer of patient at the minimum and maximum total scores, 5 and 8, respectively.

For both minimum and maximum total score cases, the weak Alzheimer patient walks for 10 minutes (one unit time equals to one hour) for five times every one and half hours. High total score implies high physical and psychological damages. Although blood pressure and pulse rate are increased in accordance with increasing of the number of steps for the minimum total score case, these are not so increased for the maximum total score case.

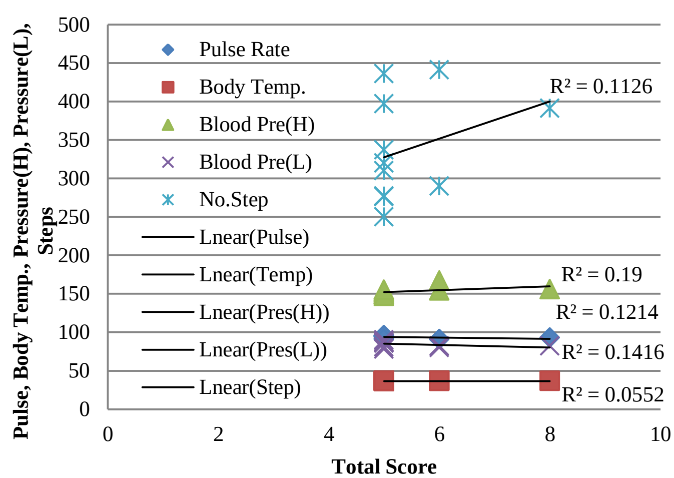
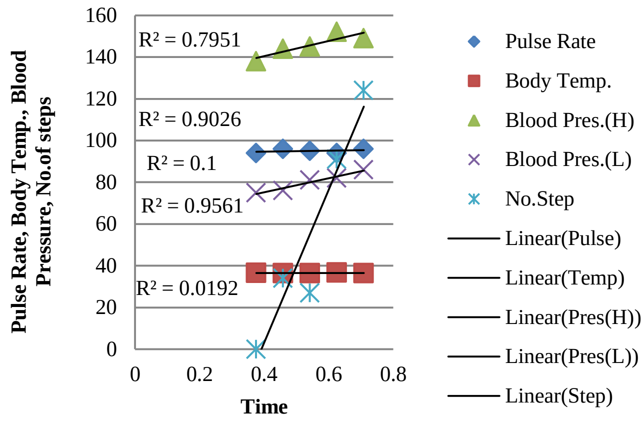
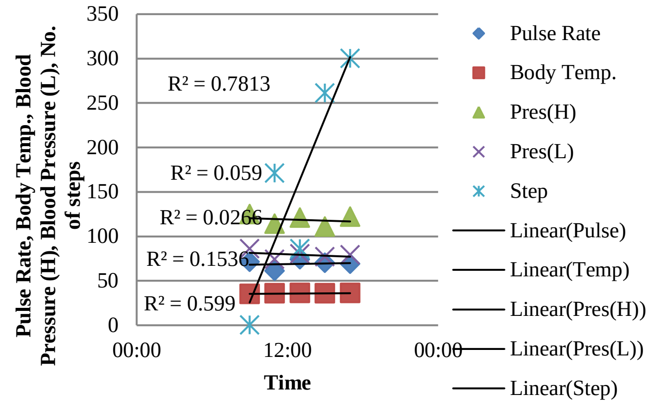


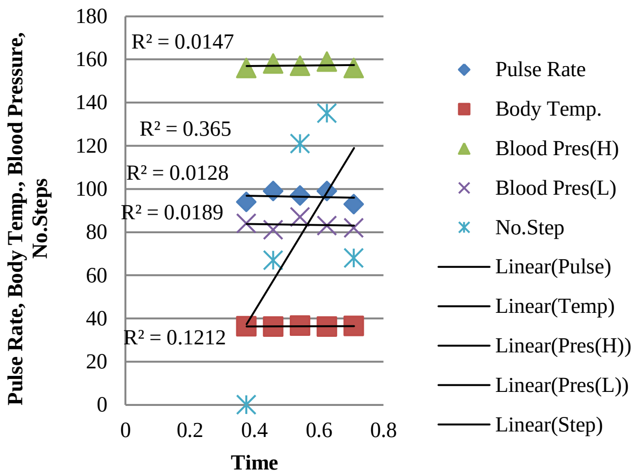
Fig. 6. Relation between the measured physical health condition and the self evaluation of physical and psychological health conditions (Total Score) for the patient of weak Alzheimer



(a)Minimum total score of 5

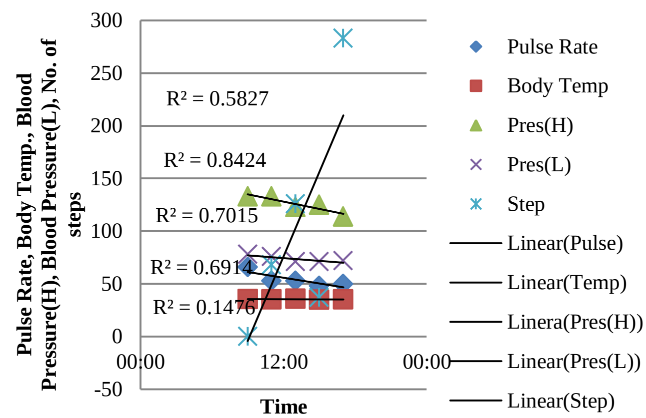


(b)Minimum total score



(b)Maximum total score

Fig. 7. Physical health data of the weak Alzheimer of patient at the minimum and maximum total scores, 5 and 8, respectively.



(b)Maximum total score

Fig. 8. Physical health data of the patient who is good in health at the minimum and maximum total scores, 7 and 11, respectively.

On the other hand, Figure 8 (a) and (b) shows physical health data of the patient who is good in health at the minimum and maximum total scores, 5 and 8, respectively. For both minimum and maximum total score cases, the patient who is good in health walks for 10 minutes (one unit time equals to one hour) for five times every one and half hours. Although blood pressure and pulse rate are quite stable in accordance with increasing of the number of steps for the minimum total score case, these are decreased for the maximum total score case.

As the results, the followings are concluded,

- Body temperature is relatively stable for a day
- In accordance with increasing of the number of steps, blood pressure (High and Low) is increased
- Even if the number of steps is increased and when blood pressure is stable, then physical and psychological health condition is good in health
- Even if the number of steps is increased and when blood pressure is decreases, then physical and psychological health condition is excellent in health
- There is a correlation between blood pressure (High and Low) and a combination of pulse rate and body temperature

3) Relation Between Blood Pressure and the OtherMeasured Physical Health Conditions

Using all measured physical health data, linear regressive analysis is conducted. Table 3 shows correlation matrix among physical and psychological health conditions. There is relatively large correlation between blood pressure and body temperature and pulse rate.

Therefore, the coefficient body temperature and pulse rate multiplied by their correlation coefficients is proposed for regressive analysis. The result from the regressive analysis is shown in Figure 9. Although it is not so easy to measure blood pressure with small size of sensors, it can be estimated with measured body temperature and pulse rate.

TABLE III. CORRELATION MATRIX AMONG PHYSICAL AND PSYCHOLOGICAL HEALTH CONDITIONS

Body Temp.	Blood Pres.(H)	Blood Pres.(L)	Heart Beet	No.Steps	TotalA	TotalB
-0.0104	0.463	-0.245	0.133	-0.348	-0.171	0.809
	0.122	-0.166	-0.231	0.0321	0.0237	0.440
		-0.504	-0.0562	0.502	-0.482	-0.186
			0.161	0.198	-0.282	-0.420
				-0.387	-0.149	0.0421
					0.340	-0.0180
						0.0784

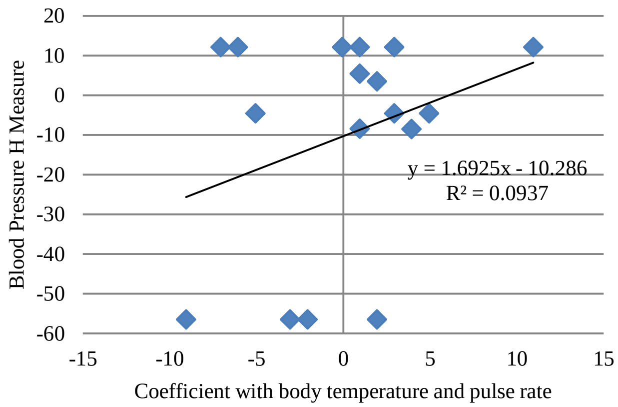


Fig. 9. Results from the regressive analysis between blood pressure high and the coefficient composed with body temperature and pulse rate

4) Measured Psychological Health Conditions

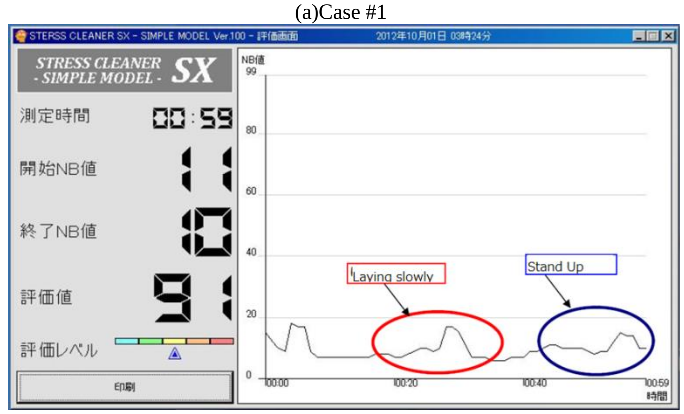
By using EEG analyzer tools, we analyze the fatigue effect between the condition when user is looking at one point and condition when user is looking at four points. In order to analyze fatigue effect, we use Peak Alpha Frequency: PAF [8]-[11] It is possible to measure psychological status by using PAF derived from EEG signal.

Psychological health condition is measured with Bio Switch MCTOS of Brain Wave Measuring instrument (BM-Set1) manufactured by Technos Japan Co. Ltd. every one hour. Figure 10 shows an example of the measured data of relax indicator, NB value which is derived from eeg and emg signals. Figure 11 (a) shows the NB value for the patient's action, sit down quickly and then stand up rapidly while Figure 11 (b) shows that for the patient's action of lay down slowly and the stand up normally. Meanwhile, Figure 11 (c) shows NB value for the patient's action, stand up, lay down slowly, stand up and then sit down slowly.

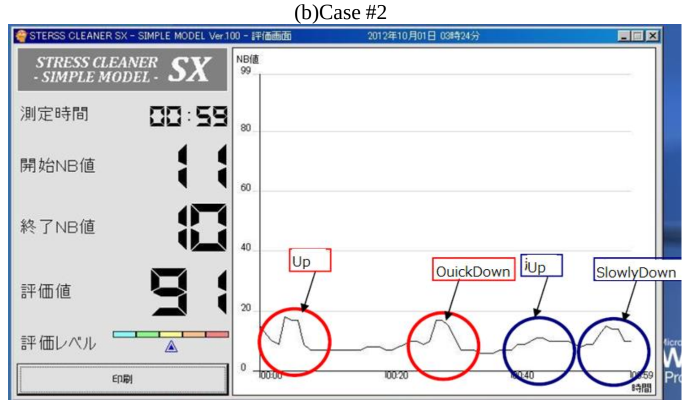
NB values change for the every event of the patient's action. It is found that the NB value changes for slow action are smaller than those for quick action. It is also found that the NB value changes for standup action is much greater than those for lay down and sit down actions as shown in Figure 12. These NB value change characteristics are almost same for patients A, B, and C. There are the different characteristics between A, B, C, and D as shown in Figure 13. Figure 13 (a) shows NB value changes for the patient A while Figure 13 (b) shows those for the patient D.

Fig. 10. Example of the measured data of relax indicator, NB value which is derived from eeg and emg signals.

(a)Case #1



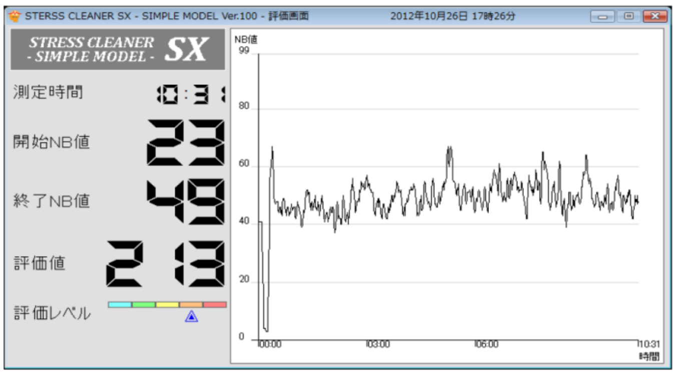
(b)Case #2



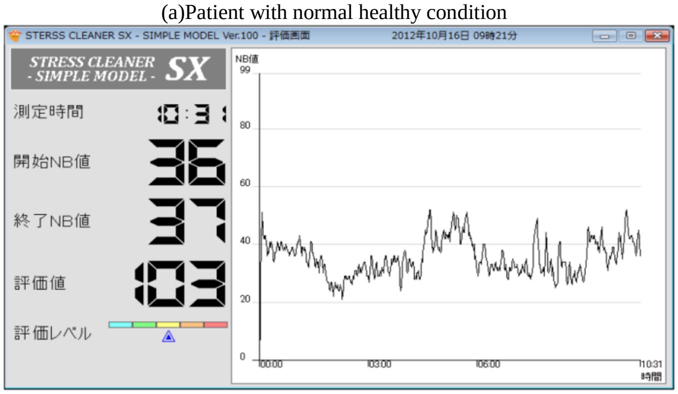
(c)Case #3

Fig. 11. NB values for the different patient's actions.

Fig. 12. Example of NB value changes for the patient action, sit down quickly, standup, slowly sit down and then standup.



(a)Patient with normal healthy condition

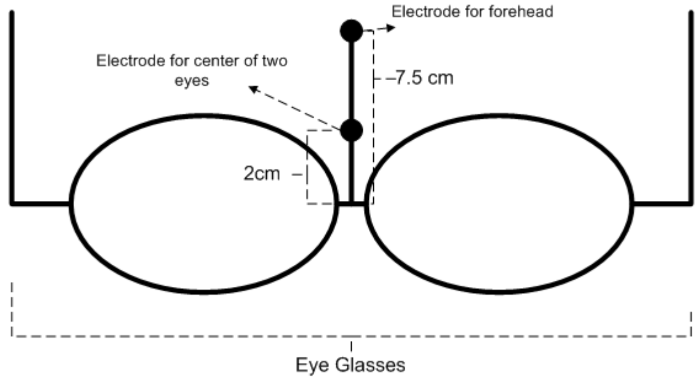


(b)Patient with weak Alzheimer

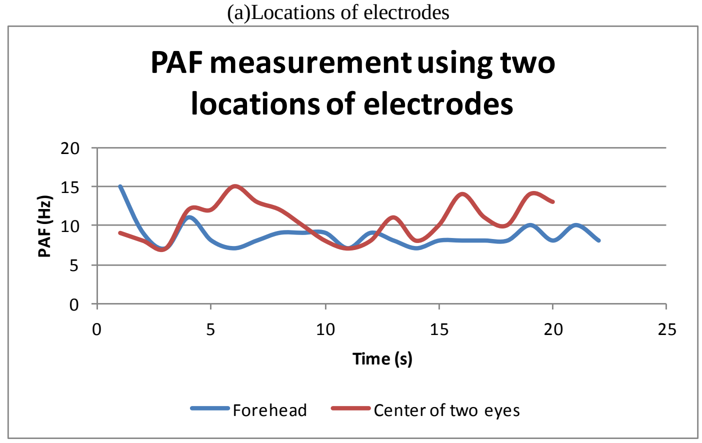
Fig. 13. NB value changes for the patients

It is concluded that the patient with weak Alzheimer feels much stress due to the actions rather than the patient in normal healthy condition. It also is found that there is no difference of psychological health condition due to age. There is no psychological health condition difference due to gender.

Example of raw eeg signal is shown in Figure 14. Figure 14 (a) shows the locations of electrodes and Figure 14 (b) shows the examples for the different two locations of eeg.



(a)Locations of electrodes



(b)Examples of eeg signals

Fig. 14. Locations of electrodes and examples for the different two locations of eeg

Obviously, eeg signals detected at the forehead is much greater than that from the center of two eyes. It is confirmed that it may reduce physical health monitoring error due to psychological status changes. Even for the healthy persons, it may occur such errors. For instance, heart beat pulse rate and blood pressure is used to be increased when medical doctor or nurse measures. By using eeg signal analyzed results, such errors may be corrected or at least it can be omitted from the monitored data.

IV. CONCLUSION

Method and system for frequent health monitoring as vital signs with psycholo9gical status monitoring for search and rescue of handicapped person is proposed. Heart beat pulse rate, body temperature, blood pressure, blesses and consciousness is well known vital signs. In particular for Alzheimer diseased persons, handicapped peoples, etc. it is very important to monitor vital signs in particular in the event of evacuation from disaster occurred areas together with location and attitude information. Then such persons who need help for evacuation can be survived. Through experiments wearing the proposed sensors with three normal persons including male and female, young and elder persons and one diseased person, it is found that the proposed system is useful.

It is also found that the proposed system can be used for frequent health condition monitoring. Furthermore, physical health monitoring error due to psychological condition can be corrected with the proposed system.

Wearable physical and psychological health monitoring system is proposed. All the sensors which allows monitoring blood pressure, body temperature, pulse rate, measuring sensor for the number of steps, calorie consumption, eeg, GPS receiver, WiFi or Wireless LAN receiver for location estimation, accelerometer are attached to the human body.

Measured data are transferred to the mobile devices through Bluetooth. Mobile devices are connected with Internet terminals through WiFi, or Wireless LAN. Thus these physical and psychological health data are collected in the Information Collection Center. Thus those who are wearing the sensors can get a help from the designated volunteer when evacuation from disaster areas.

From the experimental results, the followings are concluded,

- Body temperature is relatively stable for a day
- In accordance with increasing of the number of steps, blood pressure (High and Low) is increased
- Even if the number of steps is increased and when blood pressure is stable, then physical and psychological health condition is good in health
- Even if the number of steps is increased and when blood pressure is decreases, then physical and psychological health condition is excellent in health
- There is a correlation between blood pressure (High and Low) and a combination of pulse rate and body temperature
- It is concluded that the patient with weak Alzheimer feels much stress due to the actions rather than the patient in normal healthy condition. It also is found that there is no difference of psychological health condition due to age. There is no psychological health condition difference due to gender.

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AUTHORS PROFILE

Kohei Arai, He received BS, MS and PhD degrees in 1972, 1974 and 1982, respectively. He was with The Institute for Industrial Science and Technology of the University of Tokyo from April 1974 to December 1978 also was with National Space Development Agency of Japan from January, 1979 to March, 1990. During from 1985 to 1987, he was with Canada Centre for Remote Sensing as a Post Doctoral Fellow of National Science and Engineering Research Council of Canada. He moved to Saga University as a Professor in Department of Information Science on April 1990. He was a councilor for the Aeronautics and Space related to the Technology Committee of the Ministry of Science and Technology during from 1998 to 2000. He was a councilor of Saga University for 2002 and 2003. He also was an executive councilor for the Remote Sensing Society of Japan for 2003 to 2005. He is an Adjunct Professor of University of Arizona, USA since 1998. He also is Vice Chairman of the Commission "A" of ICSU/COSPAR since 2008. He wrote 30 books and published 442 journal papers