Unconstrained and Noninvasive Measurement of Heartbeat by A Pneumatic Method for Intelligent Wheelchair

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***Abstract*—In Japan the aging society has become an acute problem now. Many elderly people should be weak in feet and have to use wheelchair in the future.**

It is thought that if the people in bed can be detected for their index for health care and recorded for their biomedical data, they seem to enjoy their life to act enjoyably.

This work proposes a system which can measure the biomedical data of the people in the wheelchair under the noninvasive and unconstrained condition. Currently the system can monitor such data on a wheelchair staying still but our study seems promising.

Keywords: heartbeat, air mattress, pneumatic method

I. Introduction

The population of aged people is increasing rapidly in Japan. It is estimated that in the year of 2015 the portion of the people aged over 65 will constitute around 25%. Thus Japan is becoming aged society earlier than Europe or US for 5 to 10 years [1].

In such society it becomes more important to develop a system which helps the aged people to go outside and enjoy the active life. In order to prevent the aged people to become those enforced to stay in bed due to the weakened feet, some equipment are being developed to assist such people to stay away from the bed.

Among the people who use the electric wheelchair, people of aged thirties dominate highest percentage of 26.0%. The average age is 40.3.

According as the Japanese society changes rapidly into an aged society, those people who use the electric wheelchair will be dominated by elderly people.

Survey shoes that 47.2% of the electric wheelchairs are used outdoors, 36.8% both outdoors and indoors, and 16.0% indoors. Electric wheelchairs are designed for heavily disabled people to move short or middle distance [2]. The objectives to use outdoors are to go shopping, walk, go to the hospital and join to social activities. The one-way distance the drivers move are such that 29.9% move 2 to 5km and close to 10% move more than 10km. For people who ride ona electric wheelchair for more than 20km, a comfortable wheelchair with less fatigue are required [3].

For aged people even a simple task such as going to the hospital becomes a hard job. In order to ensure the enough health care of a person, it is essential to measure biomedical data and monitor these data.

This work proposes a system which can measure the biomedical data of the people in the wheelchair under the noninvasive and unconstrained condition.

II. Measurement System

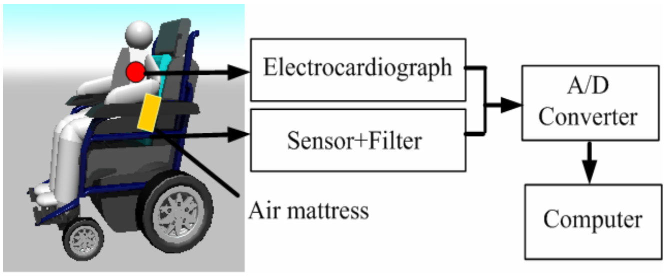

Figure 1 Measurement system

Figure 1 shows how the measurement was conducted.

An air mattress was situated onto the back of the driver's seat as shown in Figure 1. A highly sensitive pressure sensor attached to the mattress detects the minute vibrations caused by the driver's heart beat. The signals produced by the pressure sensor were amplified and filtered for transformation into a wave profile of the driver's heartbeat.

The driver can manipulate the wheelchair under unconstrained state since there is no need to attach any instrument to the driver.

The system is composed of three elements; air mattress, sensor and filter.

A. Air mattress

The air mattress is shown in Figure 2.

The air mattress repeated the experiment by various patterns in order to determine the optimal condition, and used the optimal thing. The noise increases as the size increases. The pressure distribution was then measured and was adjusted to match the size of the portion to which the seat is in contact with the body. The part in which the back contacts the seat is divided into two areas: the upper part of the back and the lower part of the back (Figure 3). The upper part which has separated is big for the fluctuation of the pressure by the body movements. We thus decided to use a moderate-size air mattress for the lower back position.

Figure 2 Air mattress

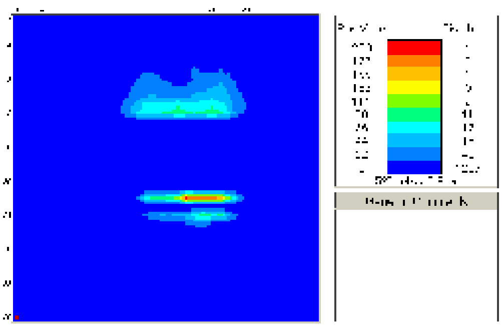

Figure 3 The pressure distribution diagram of the back.

B. Sensor

The pressure sensor is shown in Figure 4.

The pressure sensor is made from a capacitor microphone, and measures the pressure change in the air mattress. This sensor is a highly sensitive pressure sensor, and can measure even the very low frequency band of 0.1Hz.

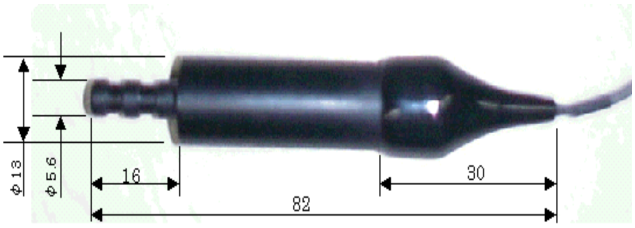

Figure 4 Pressure sensor

C. Filter

In the filter circuit, the cutoff frequency is 5-10Hz which is the harmonic component of a heartbeat signal. Amplification and detection is then carried out. Following this, the heartbeat waveform is output by passing BPF (the 0.5-3Hz cutoff frequency).

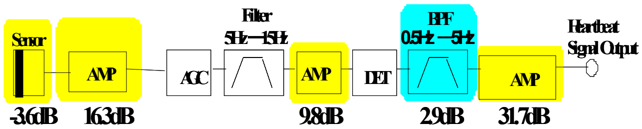

Figure 5 Filter

III. PLOBLEMS

This system can obtain an exact heartbeat signal from a form that sits in a chair. However, noise generated by road vibration can be problematic to the system.

Wheelchair vibration and noise are the result of a combination of various phenomena. Source of vibration and the transfer system combine variously in fact. These combinations of phenomena shift in various ways, resulting in a wide range of effects. The unevenness of a road surface expresses regular change and random input. Generally this load noise is random noise and has a wide frequency range. It consists of irregular signals that constantly change. In the proposed system, the low frequency component of this noise becomes a problem.

IV. Comparison Examination

Comparison with the results of an electrocardiogram was used to verify whether a heartbeat signal can be correctly outputted in an idling vehicle and in a moving vehicle. Data was monitored at 0.01s time intervals for every one minute and stored.

A. Measurement in an idling vehicle

Figure 6 shows the data obtained in an idling vehicle.

The upper line is the wave profile obtained by the proposed system and the lower line is the electrocardiogram measured simultaneously for comparison. The horizontal axis shows time[s]. Figure 7 shows FFT-treated data of a heartbeat wave profile for 1minute. The upper diagram is the wave profile obtained by the proposed system and the lower diagram is that obtained by the electrocardiogram.

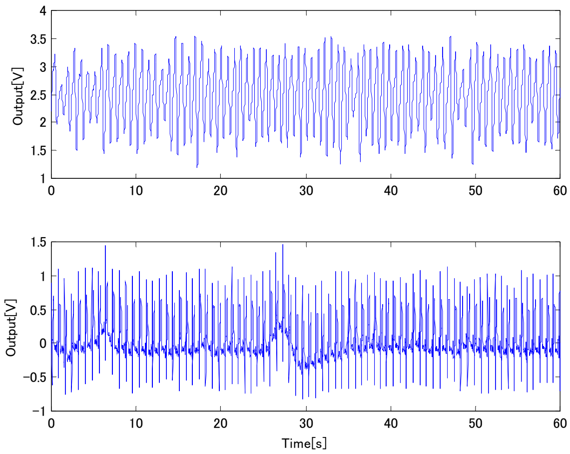

Figure 6 Heart beat

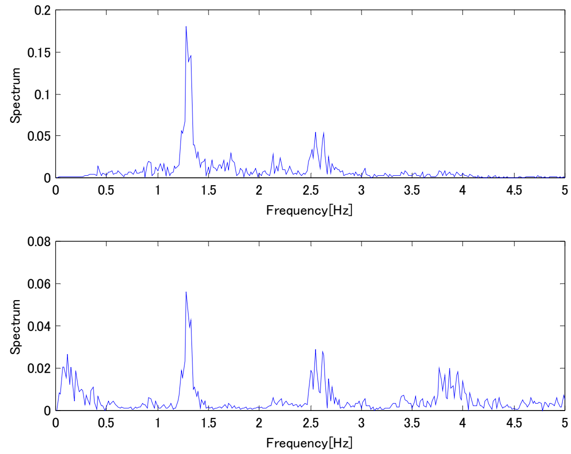

Figure 7 FFT-treated heart beat wave profile

Since different physical data were measured, the wave profiles of the two data sets differed each other. However, FFT treatment showed that the peak values of both physical data sets correlate with each other. It was proved that reproducible heartbeat values were obtained in an idling vehicle.

B. Measurement in a moving vehicle

Figure 8 and Figure 9 show the data obtained in a moving vehicle. The speeds of the wheelchair were around 0.6m/s and 0.8m/s respectively.

The upper line is the wave profile obtained by the proposed system and the lower line is the FFT-treated data of a heartbeat wave profile for 1minute.

The reference frequency obtained by electrocardiograph was plotted on the horizontal axe in a red spot.

Figure 7 and Figure 8 indicate that according as the speed of the wheelchair increases, the amplitude of the heart beat signal becomes greater. This shows that the noise becomes greater in proportion to the speed of the wheelchair.

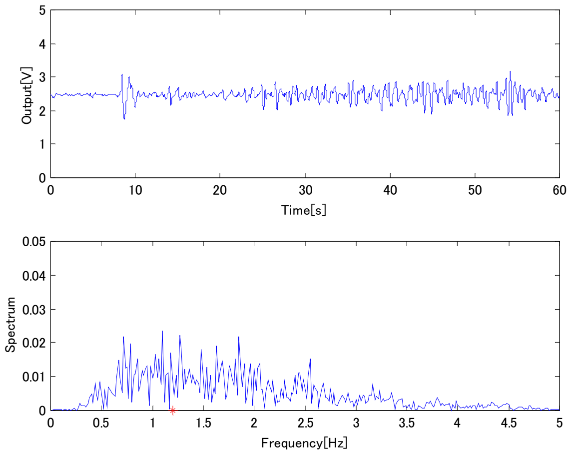

Fig.7 Signal of heartbeat in a moving vehicle

(The speeds of the wheelchair were around 0.6m/s)

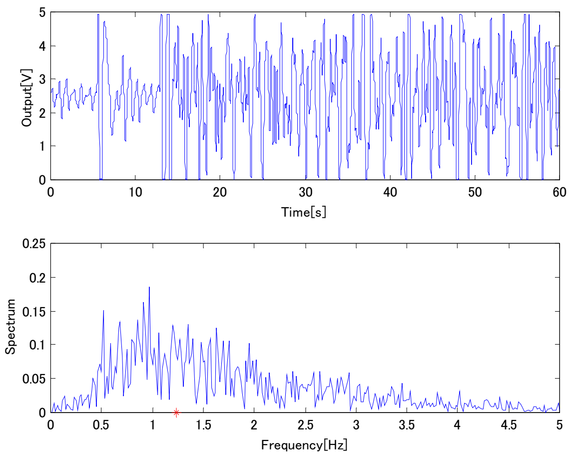

Fig.8 Signal of heartbeat in a moving vehicle

(The speeds of the wheelchair were around 0.8m/s)

Heartbeat does not appear in the waveform of this proposed system. The FFT peak value is not in agreement with the heartbeat signal. However, although the correlation of a FFT peak value has not been obtained in a moving wheelchair, it turns out that the spectrum of a heartbeat signal exists. During an experimental run, vibration noise is larger than the heartbeat signal, and the heartbeat signal is not found in the waveform. Thus, it seems possible to detect the spectrum of the heartbeat by using FFT processing.

V. CONCLUSION

Heart rate values could be obtained in an idling vehicle. The present work showed that the frequency spectrum of the heart rate could be detected by employing FFT treatment.
It is of great value even if the system of the present work can measure the heart beat of a person on the wheelchair in a limited condition of stationary state.

In addition, the present system will not pick up the signal only in case that a person is on the bed. Therefore this system is capable to apply to the sensor to catch the chance when the person steps away from the bed or the wheelchair.
In order to develop an equipment to assist aged or handicapped people to go out and act actively, it is essential to establish a system to measure the biomedical data on the bed or the wheelchair.

The present work will be continued to improve the proposed system to be able to obtain the heartbeat rate data with more accuracy.

REFERENCES

[1] Toshiyo Tamura, Instrument, Control Engineering and Information Technology Applied for Gerontechnology, Journal of the Society of Instrument and Control Engineers, vol.40, No.5, pp.331-336, 2001.

[2] Chikara Aoki, Minoru Suzuki, The survey about the use situation of an electric wheelchair, The Journal of Japanese Physical Therapy Association, p136, 1998.

[3] Hiroki Yonekawa, Hiromu Aihara, Yoshiyuki Matsuoka, Relation between Vibration and Evaluation on the Wheelchair Transporting Apparatus, BULLETIN of JSSD, Vol.47, No.1, 2000.