Measurement Method of Posture and Movement for the Aged Person using an Accelerometer

Takao Sugimoto* and Kentarou Mori**

* Department of College of Science and Technology, Nihon University, Funabashi City, 274-8501, Japan.
(Tel: +085-047-469-5621: sugimoto@eme.cst.nihon-u.ac.jp)
** Graduate School of Science and Technology, Nihon University, Funabashi City, 274-8501, Japan
(Tel; +085-047-469-5626: g060156@eme.cst.nihon-u.ac.jp)

Abstract: High aged society is rapidly progressing in Japan. The rate of aged person more than 65 years old in the population are estimated 25 % in 2017 and rate of younger population will be decreased at same time. As a result, it is estimated that the human resources that is looking after or supporting for the aged person will be drained in Japan. In the other hand, the society has to provide high quality of life in order to be improved living environment for aged person. To decrease the share of nursing and caring for the aged person, it is required that new supporting systems for aged person have to build up as soon as possible. But it is required that various kind of measurement for posture and movement in activities with a simple and single detector for the aged person. The measurement instrument has to be lightweight and simple structure. The results give us a simple measurement method are classified that the posture of sitting down, lying down in stationary statuses and walking, running and going to up and down on the stairs in moving statuses. The detected data will plane to transmit to wireless mobile system to the host computer.

Keywords: posture measurement, accelerometer, stationary status, moving status

1. INTRODUCTION

The rate of aged person more than 65 years old in the population are estimated 25 % in 2017 and rate of younger population will be decreased at same time[1]. To decrease the share of nursing and caring for the aged person, it is required that new supporting systems for aged person have to build up as soon as possible. In previously the measurement methods for posture and movement of our living activities had studied [2, 3, 4]. And other study had done by M. Susumago using a barometer in order to estimate up and down on the stairs, but the deviation value of atmospheric pressure is very small due to up and down on the stairs [5]. It is required that various kind of measurement for statical postures and movements in activities with a simple and single detector for the aged person. The measurement instrument has to be lightweight and simple structure.

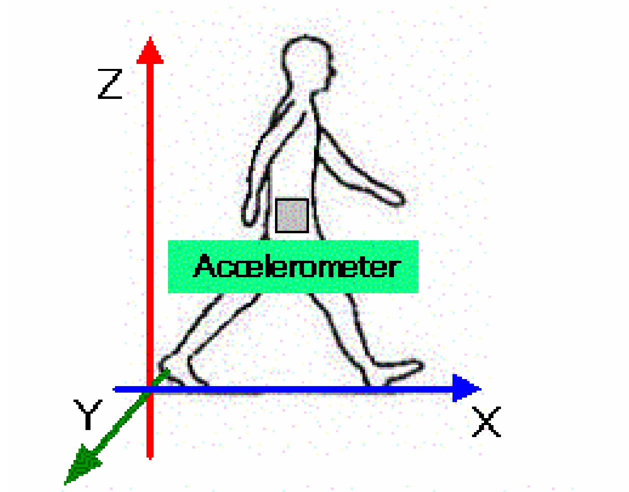


Fig. 1 Carrying an accelerometer on the ilium and its axis.

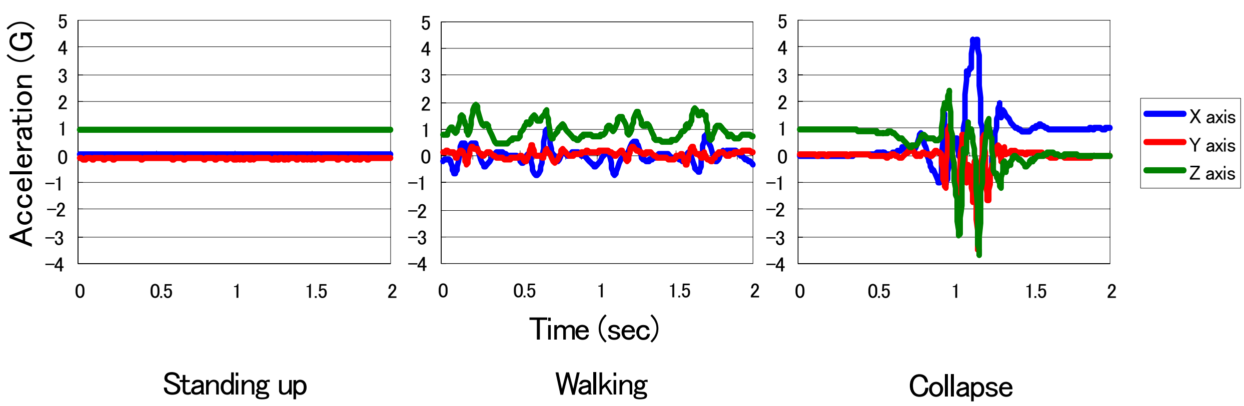


Fig. 2 An example of obtained data for stationary, safety movement and collapse

2. METHOD

The stationary postures and movement statuses are measured by an accelerometer of gravity with triple axis is installed on the integrated IC chip has applied in the study. The detective triple axis is right angle to each other as shown in Fig.1. The accelerometer is held on the ilium on examiner as shown Fig.1, have measured the inclination angle for acceleration direction to gravity for measurement of stationary statuses and values of deviation of the acceleration in progressing time and its periodicity is calculated in obtained data from accelerometer for movements of the person. The obtained data is calculated the deviation of acceleration, the value is larger than predefined value and the status is estimated to movement, other wise the status is stationary status. The dangerous movement is estimated that the deviations greater than predefined value and without periodicity in the data. Fig. 2 is an example of data obtained from triple axis accelerometer. Fig. 2 shows an example data for a position of standing up, walking and collapse. Fig.3 shows general procedure in the study. It is obviously different deviation values of acceleration progressing time, and then the peak to peak values of acceleration are calculated by these following equations, respectively.

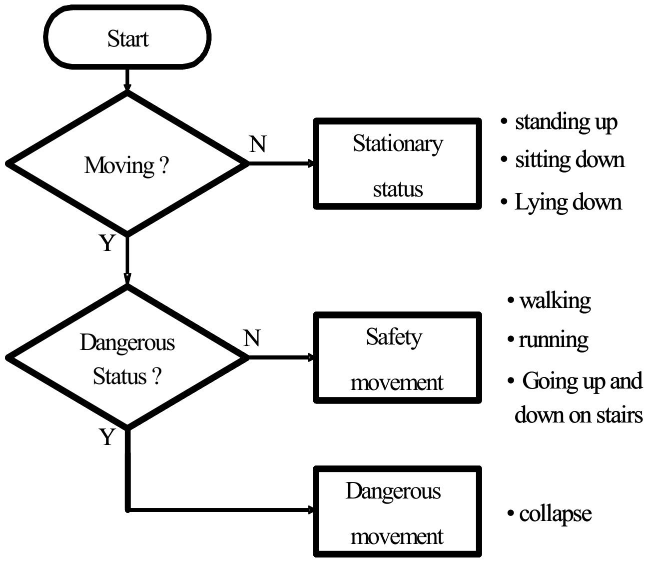
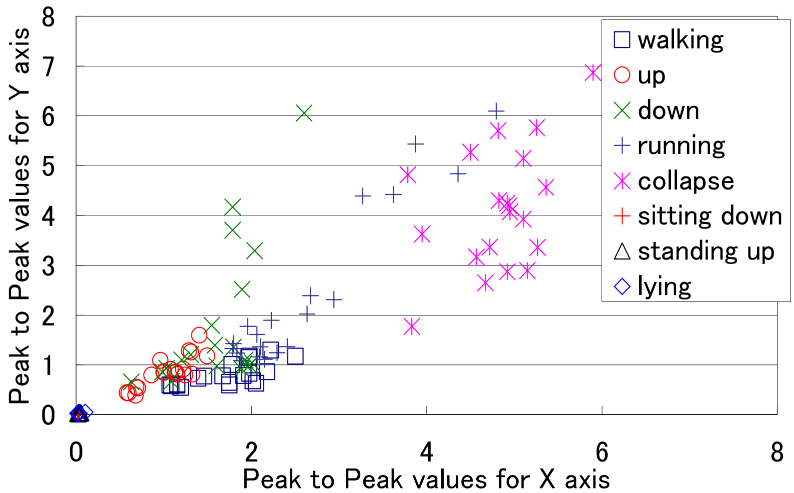


Fig. 3 Procedure of discrimination for stationary and movement statuses

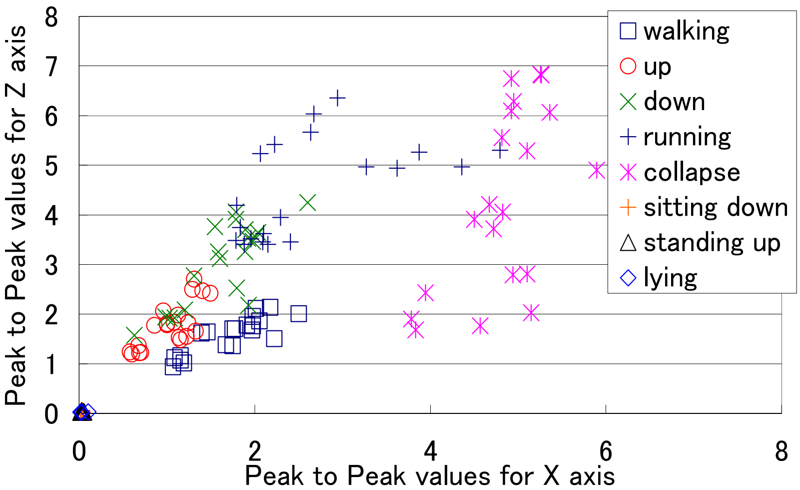
$$\frac{\Delta G_x}{\Delta t_1} \le G_1, \quad \frac{\Delta G_y}{\Delta t_1} \le G_2, \quad \frac{\Delta G_z}{\Delta t_1} \le G_3. \qquad (1)$$

$$\frac{\Delta G_x}{\Delta t_2} \le G_4, \quad \frac{\Delta G_y}{\Delta t_2} \le G_5, \quad \frac{\Delta G_z}{\Delta t_2} \le G_6, \qquad (2)$$

And all of obtained data are calculated in 5 s continuously. In order to get suitable value of $\triangle t_1$ and Δt_2 , several kind of times are examined, and then 0.5 s is adopted as $\triangle t_1$ to discriminate stationary statuses and moving statuses in first step. Those data also is calculated for 0.2 s as Δt_2 discriminate safety movements and dangerous movement, because waveform for dangerous movement is steeper than safety movements. After calculated during 5 s, obtained data is shifted 0.1s. And then data is calculated 5 s and repeated again up to end of data. The peak to peak values of G_1, G_2 and G_3 are calculated due to equation (1) in sliced time is 0.5 s, respectively. As the result, the statuses are estimated to stationary or movements. In next step, in order to estimate dangerous and safety movement, the



(a) X-Y plane



(a) X-Z plane

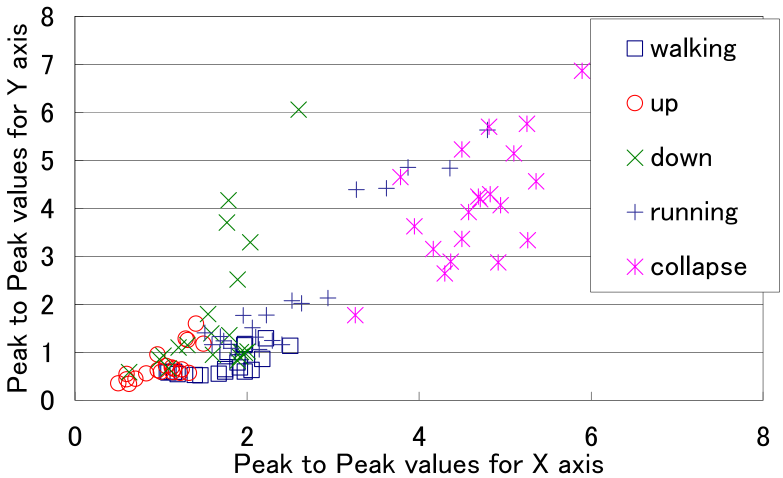
Fig.4 Distribution map for deviation of acceleration with 0.5 s.

peak to peak values of G_4, G_5 and G_6 are calculated due to equation (2) in sliced time of 0.2 s, respectively. In the 2nd steps, although the dangerous movement data is not periodically, but also the data for safety movement statuses are periodically. In order to make sure for estimating safety movement statuses and dangerous movement, the basic frequency in obtained data are calculated by FFT method.

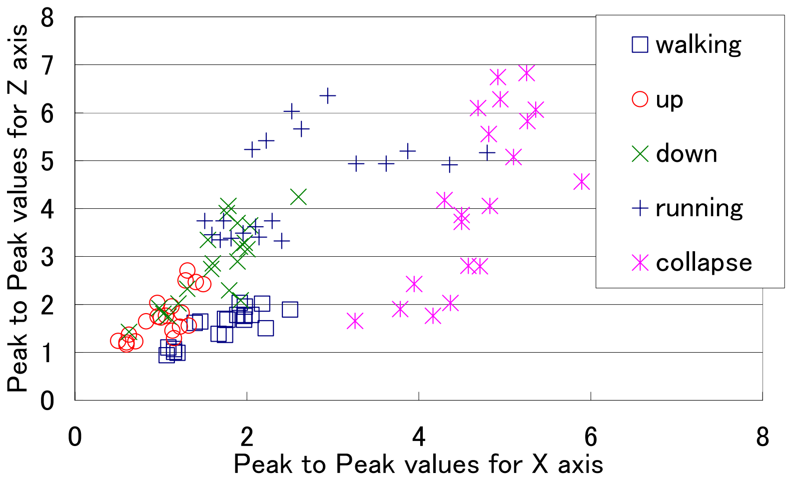
3. RESULTS

3.1 Estimation of the statuses

In first step of this study, well-being persons are adopted in order to easy get data of this study, and in second step the weak person will be adopted to make sure this study. The results are concerning to well-being person. The examiners are 12 persons who are well-being and age are 22 to 24. First step, the peak to peak values of acceleration for gravity obtained from triple axis accelerometer are calculated during each 0.5 s as Δt_1 in order to estimate stationary statues and movement statuses. The peak to peak values of acceleration in Δt_1. And the results are plotted for X-Y plane in Fig.4 (a), and for X-Z plane in Fig.4 (b). As the results, the stationary statuses are distributed within 0.1 G in all axes and the movement statuses are distributed larger than 0.1 G in all axes. And second step, The peak to peak values of acceleration are calculated for sliced time is 0.2 s as Δt_2 to discriminate for safety movement or dangerous status. And the results are plotted for X-Y plane shown in Fig.5 (a), and for X-Z plane shown in Fig.5 (b). In dangerous status, the peak to peak values of G_4, G_5 and G_6 ought to have large values than stationary statuses, because obtained data of frequency component is higher than safety movement. Further, the data is not periodically. Other wise, in safety movements, obtained data is periodically.



(a) X-Y plane



(a) X-Z plane

Fig.5 Distribution map for deviation of acceleration with 0.2 s for moving statuses.

3.2 Estimation of the stationary statuses

In stationary statuses, the peak to peak values of G_1, G_2 and G_3 are plotted within 0.1 G. Fig. 6 shows various kind stationary statuses, Horizontal axis shows data from X axis and vertical axis shows data from Z axis, respectively. The most detectable data for stationary status is combination of X and Z axis but other combination is not detectable for various kind of stationary status. The output from accelerometer shows that dependence on the angle between accelerometer angle and gravity, then after collapse, the person does not move, and then obtained data should not have the frequency component. The measured values show that result makes to understand to estimate easily the statuses. The blue zone is shown lying down, red zone is shown sitting down and black zone shows standing up, respectively. The statuses are estimated stationary statuses. Although, in the results are examined by well-being persons, but almost same data will be obtained between well-being and weak person, because it is not depending on the ages, spry and handicapped for those statuses.

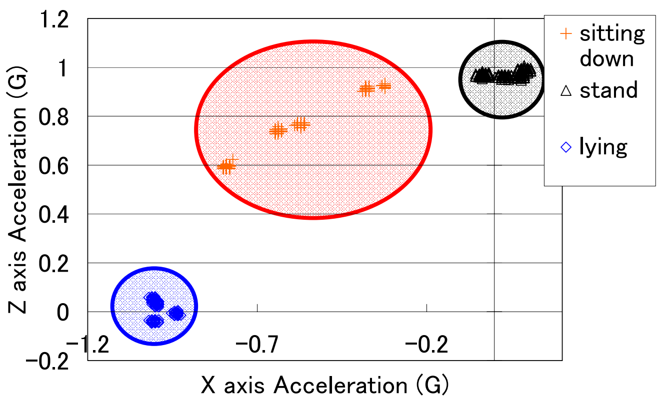


Fig. 6 Distribution map for stationary statuses.

3.3 Decimations of dangerous movement and Safety movement

The condition of estimation for safety movement statuses like working, running, going up and down on the stairs, the peak to peak values for G_1, G_2 and G_3 are plotted larger than 0.1 G from obtained data and has periodically. Then obtained data is calculated the peak to peak values in Δt_2 is applied 0.2 s. Fig.5 shows it is difficult to estimate to be dangerous movement or safety movements. Fig.7 (a), (b) and (c) show results for X, Y and Z axis that obtained data are processed by FFT. The data obtained from safety movements are plotted on larger than 0.5 Hz, but for dangerous movement like collapse has not frequency components except in a moment of collapse. And in a moment of going to collapse, the frequency components might get higher component because the peak to peak values for G_4, G_5 and G_6 might have large values in a moment, but after collapse, there are direct current component. The data obtained from dangerous like collapse are mostly located as following region shown in equation (3) from Fig.5 (a) and (b).

$$\frac{\Delta G_x}{0.2} \geq 3.0G,\ \frac{\Delta G_y}{0.2} \geq 1.5G,\ \frac{\Delta G_z}{0.2} \geq 1.0G \qquad (3)$$

Thus, it is estimated that in dangerous movement, the values of G4, G5 and G6 shown equation (3) and there are no frequency component, only direct current component. There are several data which has frequency component as shown in Fig. 8. The reason is caused in a moment of going to collapse.

3.3 Estimation of safety movement statuses

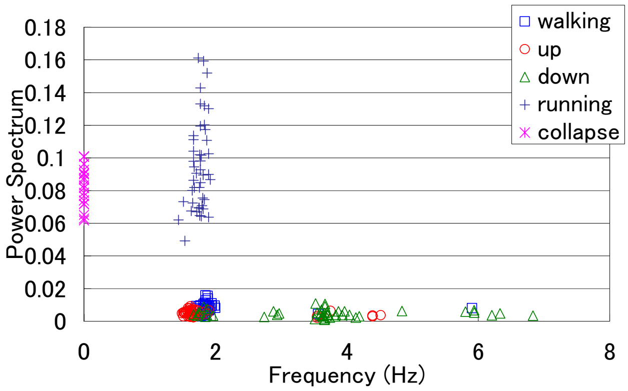
There are several kinds of statuses. Those are walking, running, going up and down on the stairs. In order to estimate various kinds of movement statuses, obtained data are processed by FFT method. Fig.8 (a), (b) and (c) show relation between frequency and those power spectra. Fig.8 (a) shows data for Y axis. Fig.8 (b) shows data for Y axis and Fig.8. (c) shows data for Z axis, respectively. But obtained data from X axis is not suitable to estimate safety movement statuses. It can get data from the status of going up on the stair in Fig.8 (a) indicated red zone, and also Fig.8 (b) get data from the status of going down on the stair indicated green zone, respectively. And data from status of walking are distributed in low power spectra on Fig 8 (a) and (b), respectively. Fig.8 (c) shows running status indicated dark blue zone for Z axis, but in the status, the value of power spectra are higher. Further, frequency is shifted to higher region.

3.4 Running status

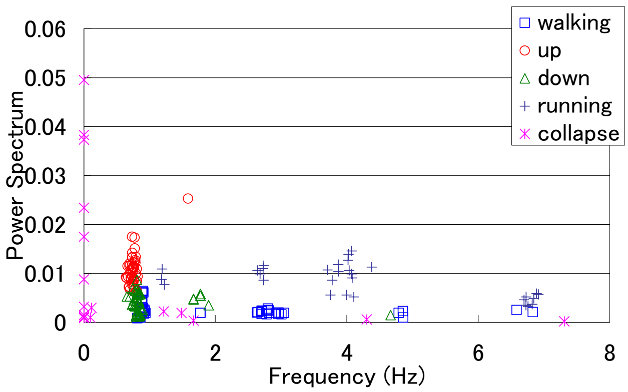
Fig.9 shows obtained data from Z axis. Fig.9 (a) shows running status, and (b) shows status for going down on the stairs. It is remarkable view point for the running status, G values across 0 G line, because, 0 G means free falling. But even status of going down on the stairs, acceleration values are not exceed to 0 G line without falling down. The results make sure to discriminate between running and going down status.

4. DISCUSSION

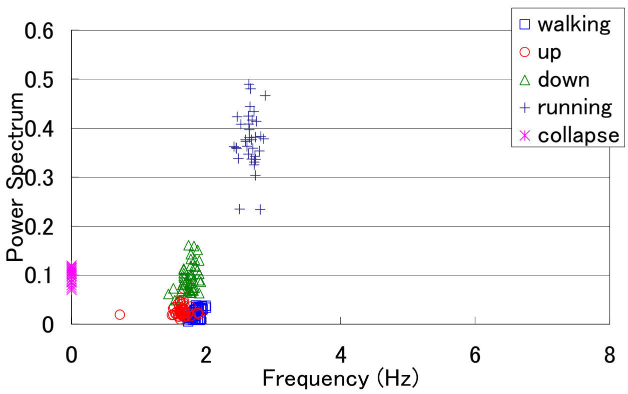
The stationary posture and movement statuses can estimate using a simple gravity accelerometer. Due to applied triple axes for the accelerometer, it can estimate moving statuses between walking and up and down on the stair. In the study, it is important to estimate the statuses between walking and up and down on the stair. It is available to estimate various kinds of statuses in X axis and Z axis for stationary statuses and Y axis and Z axis for safety movement statuses. To make sure to detect dangerous movement like collapse for the weak person, obtained data will transmit by mobile instrument to make to know for caring station. More detail estimating procedure will be required to apply to aged person.



(a) X axis values

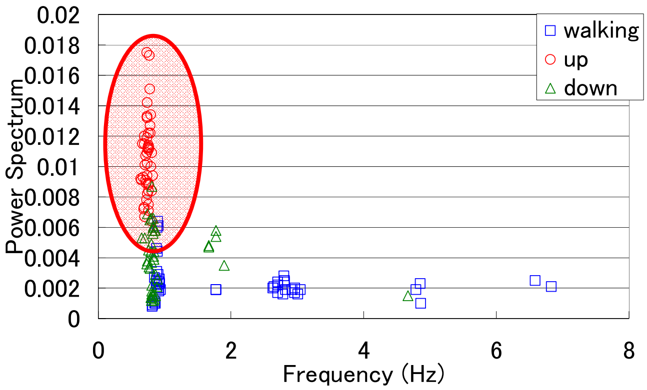


(b) Y axis values

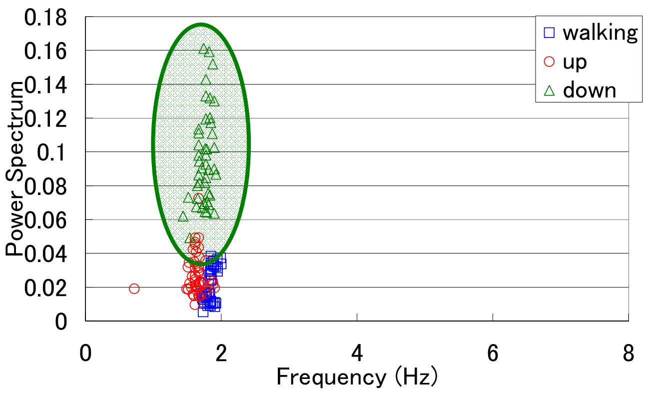


(c) Z axis values

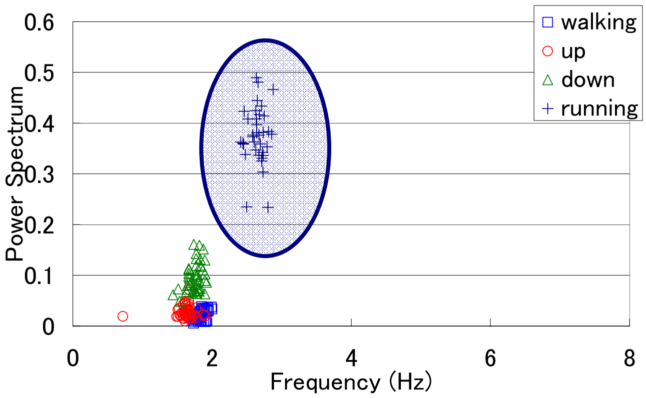
Fig. 7 The result of FFT for safety movement and dangerous status



(a) X axis

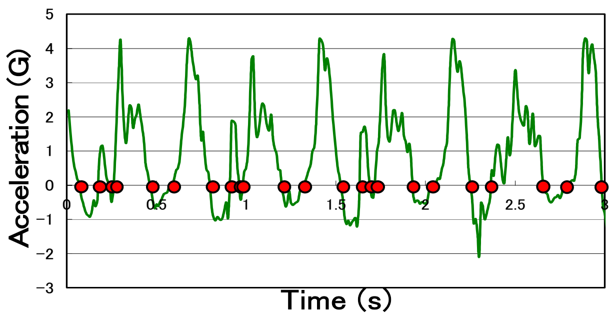


(b) Y axis

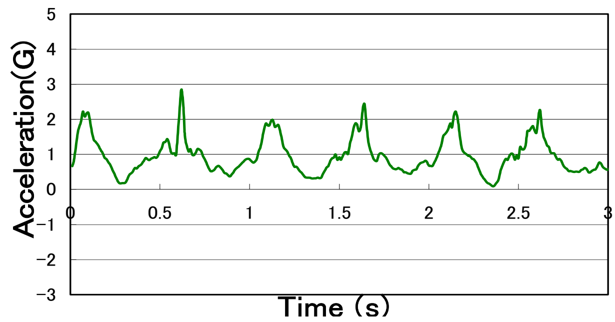


(c) Z axis

Fig.8 The result of FFT for safety movement statuses



(a) Running status.



(b) Going down on the stairs.

Fig.9 Acceleration values obtained from Z axis

5. CONCLUSION

In order to estimate stationary posture and movement statuses using small detector for aged person or weak person can detect and has performed in the study. Although, the obtained data for the movement statuses are seldom overlapped walking and going up and down to stairs, but also to adopt triple axes accelerometer, it make sure more easily to estimate both statuses. And also providing to going to be more dangerous movement or consumption of energy for our body in order to estimate between walking and going up and down statuses. The movement statuses are enough evidence for spry living status. In the stationary statuses, the obtained data have particular coordinates and make to estimate the statuses in stationary. The results make sure to contribute to expand activities for the aged or weak person and improve the quality of life.

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