Measurement of Human Behavior and Identification of Activity Modes by Wearable Sensors

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Abstract: Recently, various researches in respect of the positioning technologies using satellites and the other sensors have made location-based services (LBS) more common and accurate. Consequently, concern about position information has been increasing.

However, since these positioning systems only focus on user's position, it is difficult to know the user's attitude or detailed behaviors at the specific position. It is worthy to study on how to acquire such human attitude or behavior, because those information is useful to know the context of the user.

In this paper, the sensor unit consisting of three dimensional accelerometer was attached to human body, and autonomously measured the perpendicular acceleration of ordinary human behaviors including activity modes such as walking, running, and transportation mode using transportation such as a train, a bus, and an elevator. Subsequently, using the classified measurement results, the method to identify the human activity modes was proposed.

Keywords: wearable sensor, human behavior, mode identification

1. Introduction

Recently, various researches on the positioning technologies have made position information services more common and accurate. Consequently, position information and associated technologies have been attracting public attention. Moreover, information of human activity has been strongly required by many fields such as information service according to user's situation (LBS: location-based services), decision support of the emergency activity, and personal routing and navigation services.

However, satellite-based positioning systems including GPS cannot work correctly in the urban area or inside of the room especially because there are many obstacles of the electric wave transfer. Although the applicability of Pseudolite and QZSS(Quasi-Zenith Satellite System) is being studied as the supplementary systems of satellite-based positioning, these systems also acquire the information from outside, which may limit the applicability. On the other hand, the autonomous positioning system based on the various kinds of sensors and map matching has been developed[1]. Furthermore, the research using the same kind of system was conduced to measure and identify the human activity[2].

In this paper, the sensor unit consisting of three accelerometers was attached to human body, and autonomously measured the ordinary human behaviors including activity modes such as walking, running, and riding vehicles such as a train, a bus, and even an elevator. Subsequently, using the classified measurement results, the algorithm of comparison and identification of activity modes was proposed.

2.Methodologies

2.1) Sensor system

Three dimensional accelerometer(Akebono brake industry Co' Ltd) used for this measurement is shown in Fig.1. The acceleration to a maximum of 100 [m/s^2] is measurable by 100 [Hz] about each axial direction respectively. Measurement can be conducted just by letting subject carry a bag containing this sensor with PC whose serial connection was made by RS-232C.

2.2) Data conversion (FFT)

The power spectrum in every second is drawn by Fast Fourier Transformation(FFT) from time-series acceleration. In that case, measurement data serves as a discrete value sampled by 100Hz, FFT can be calculated from this data directly. By setting time-domain value N

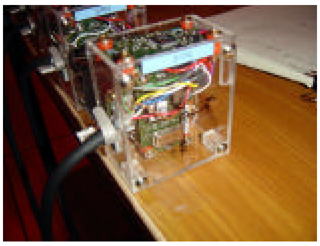

Fig.1: Three dimensional accelerometer

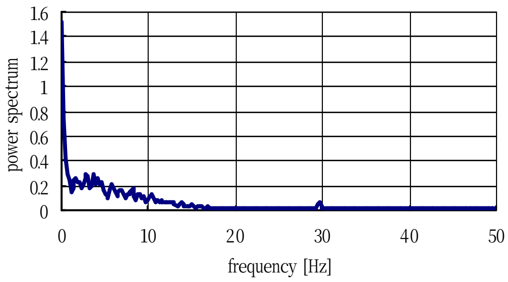

Fig.2: power spectrum of still standing

as 512(about 5 seconds) for FFT, high frequency resolution can be gained.

3.Experiments

3.1) Stable mode

Before measuring each mode, the power spectrum of a person standing still is measured as a basis of comparison with that of the other activity modes. This is used to determine "stillness" status. Fig.2 carries out the time average of the power spectrum obtained from still standing condition.

3.2) Human activity mode

Vertical acceleration was measured to determine the human activity modes such as walking, running, up-stairs, and down-stairs. The average of the power spectrum of each mode is shown in Fig.3.

Since the peak of a spectrum has all appeared in nearly 2Hz, it turns out that this frequency is the basic cycle of the human activity, i.e. the cyclic movement of legs or the walking frequency.

When seeing the peak value of the spectrum individually, the value at the running has appeared notably high. Therefore, this can be key in discriminating "running" mode. However, as other three are compared, the clear difference did not appear in both walking frequency and the power spectrum of the other frequency domain. According to these results, in walking, up-stairs, and down-stairs, just the peak of power spectrum of the perpendicular acceleration is not sufficient for judgment material.

3.3) Transportation mode

Next, in a train, a bus, an escalator, and an elevator, the perpendicular acceleration was similarly measured supposing a subject just stands in a vehicle or a carriage. Fig.4 shows the time average of the power spectrum in each mode.

Comparing with the other cases of the human activity mode, each spectrum looks low except the case of bus. However, the feature appears as compared with the spectrum of still standing. About the case of train, the spectrum from 8Hz to 18Hz has not appeared in the

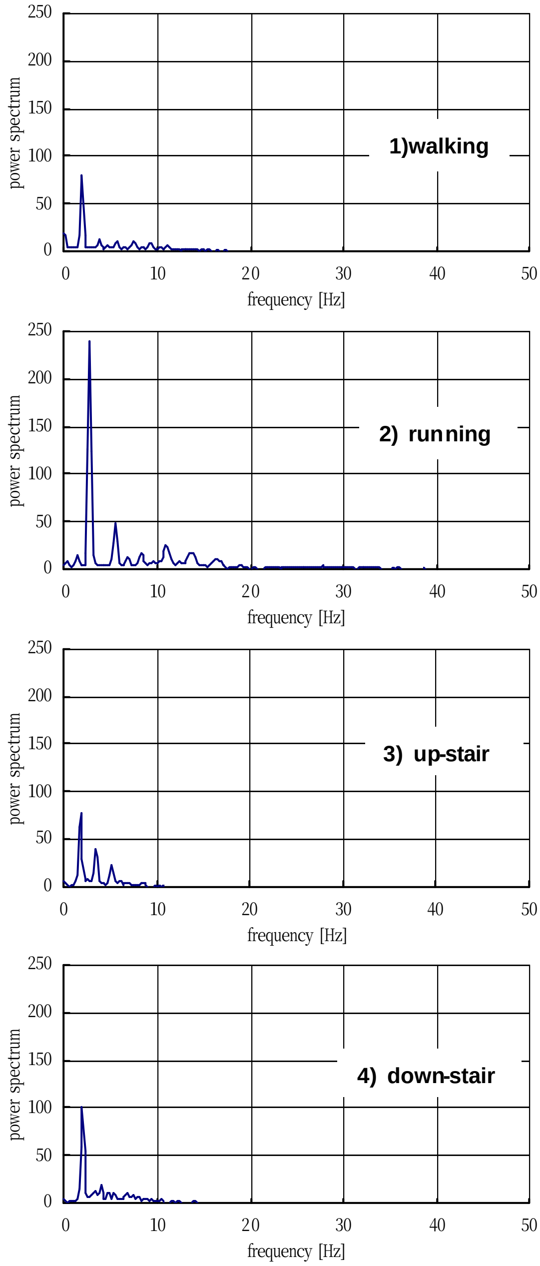

Fig.3: Power spectrum of human activity mode

still standing. The same feather can be found in other results of train measurements. Moreover, the same result puts on a bus which is from 10Hz to 20Hz, and an escalator which is from 3Hz to 8Hz.

On the other hand, in the power spectrum of an elevator, the spectrum value is quite close to that of still standing, and there is no peak characterizing the elevator mode. So only the peak power spectrum of perpendicular acceleration is inadequate for the material of the mode identification.

4.Discussion

From above experiment results, it is possible to distinguish each mode from the power spectrum of the alteration of the perpendicular acceleration except a up- and

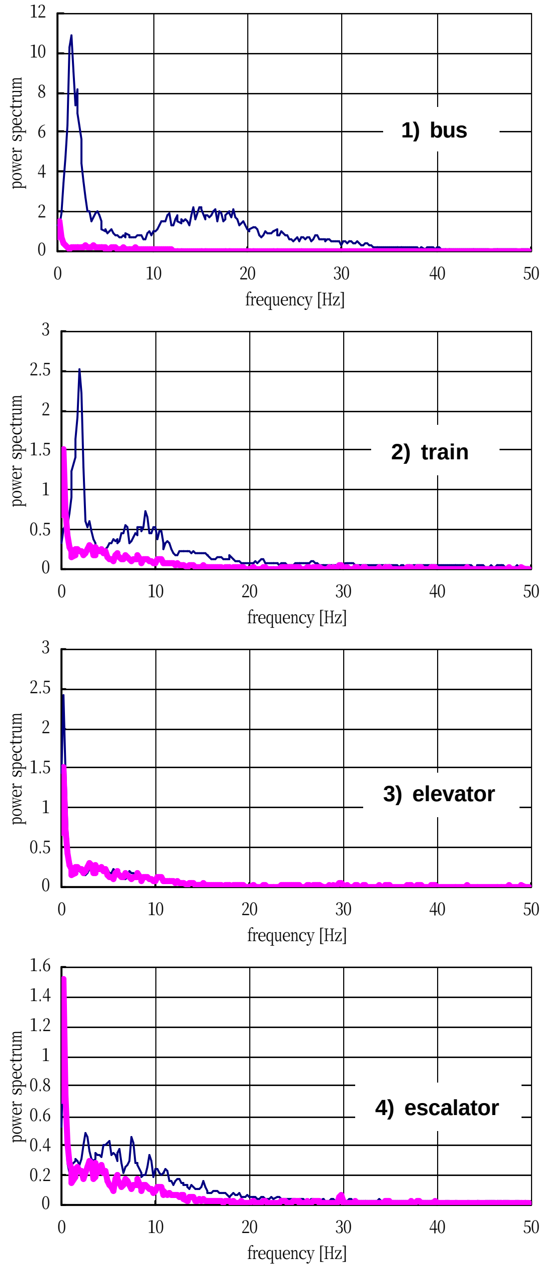

Fig.4: Power spectrum of transportation mode

down-stair and an elevator. Among them, about a bus, a train, and an escalator which have the characteristics in the frequency, the identification will be made possible by taking the sum of the power spectrum of each frequency band and comparing with the sum of the power spectrum of the still standing mode in the same band.

On the other hand, with respect to the up- and down-stair and the elevator that cannot be distinguished by the power spectrum, because each movement results in the changes of height, each mode may be distinguished by acquiring the height information from the sensor which can acquire the height associated information such as a barometer. The flowchart to discriminate the activity modes by using these measurement data is shown in Fig.5.

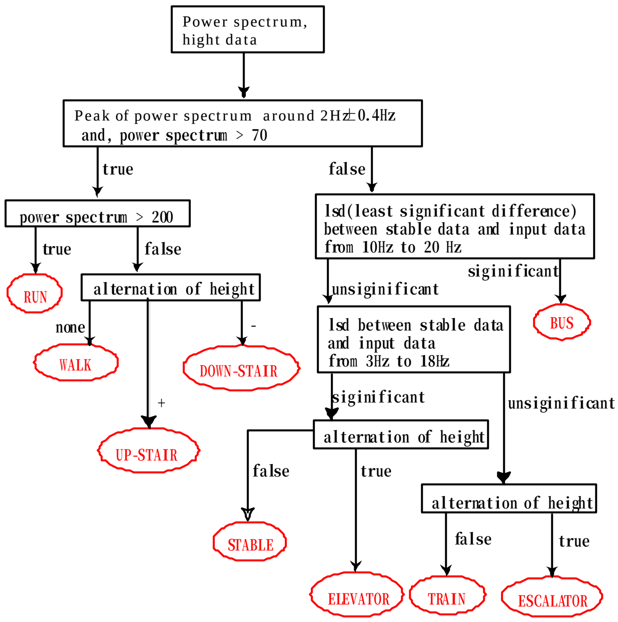

Fig.5: Flowchart for mode distinction

5. Conclusions

Human activity modes and transportation modes though there are some exceptions among them, can be distinguished by obtaining the power spectrum of the perpendicular acceleration. The modes which cannot be judged only by the power spectrum may be also distinguished by acquiring the height information.

6.Future Works

As for the future works, firstly, it is necessary to investigate whether the flowchart created in this paper is statistically relevant because this data are from the limited numbers of samples.

In addition, since two or more modes may happen simultaneously, the identification of the duplicated modes should be made.

Moreover, it is also necessary to survey the influence on the identification conditions in the different number of the FFT domain.

Finally, the automatic mode identification will be realized after each verification using sufficient number of samples.

References

[1] Yusuke KONISHI and Ryosuke SHIBASAKI, 2001. Development of an Autonomous Personal Positioning System. http://shiba.iis.u-tokyo.ac.jp/~konishi/res/positioning.php

[2] Akiko OGAWA, Yusuke KONISHI, and Ryosuke SHIBASAKI, 2002. Identification of Human Activity Modes with Wearable Sensors for Autonomous Positioning System. Geoinformation forum Japan 2002, Student forum, paper list http://www.chikatsu-lab.g.dendai.ac.jp/s_forum/list2002.html