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Proposal of system for detection of dangerous state in epilepsy fit using acceleration sensors

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Abstract

In epilepsy fit, lost of consciousness of patients is very dangerous according to happening places and situations and it is necessary to detect and inform to related person. But the existing systems are expensive, difficult to install. It also does not always detect it. In this research, in order to reduce an unexpected accident, it is proposed that the dangerous state detection system can detect the epilepsy fit at any time in daily life. It uses acceleration sensor system for fit detection. It is cheap and portable so, it can be installed easily to human body.

Keywords: Epilepsy; convulsion; consciousness; fit; acceleration sensor; fall; dangerous state; tremor; daily life; brain wave

1. Introduction

Epilepsy is a sick of a variety of kinds of fits caused by an abnormal excitement of nerve cells in brain. The fit that loses consciousness suddenly especially unconsciously accompanies a lot of dangers. For instance, it is fatal dangerous that such fit happens when blocked something in the throat, bit the tongue, wash in the bath room or step on the stairs. Therefore, it is necessary to always detect the happening of such a fit, and to inform someone else of it. There is equipment that detects the fit by measuring the brain wave as an existing system now (Anami, 2003; Uchiyama et al., 2006). However, the device is expensive and difficult to install. Moreover, for the method of detecting the fit with the mat by a piezo-electric measurement (Nakamura, 2008), it is difficult to always detect the fit in daily life because the place has been limited.

In this study, the case that is the convulsion with losing consciousness happening is distinguished as a danger state of the fit of epilepsy. In order to detect the danger state defined here, a cheap device was made using an acceleration sensor. This sensor is portable size, so it can be installed easily to human body. The present study proposes the dangerous state detection system aimed to the epilepsy fit. Moreover, the dangerous state can be detected at any time by overseeing daily life.

2. Epilepsy fit detection system

In this research, the convulsion with losing consciousness happening is defined as a danger state of the fit of

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epilepsy. In many cases the patient falls when the losing consciousness fit occurs, and it will have convulsions in 10~20 seconds (Shizuoka epilepsy and nerve health center, n.d.). Therefore, from the inclination of person's body and the movement of the hand, the fit that loses consciousness can be detected. The convulsion sensor that detect the movement of the convulsion and the hand sensor that detect the person fall were produced. Figure 1 shows the composition of the system and the photograph of the fall sensor and the convulsion sensor. Figure 2 shows the installation chart of the fall sensor and the convulsion sensor. Two acceleration sensors are used here to construct convulsion sensor and the fall sensor respectively. A microcomputer is used here to judge if the fall state is “Normal” or “Fall”, and to judge if the convulsions state is “Normal” or “Convulsion”. The "Dangerous state" was finally determined when the judgment of convulsion and fall is "Convulsion" and "Fall" respectively.

2.1. Fall detection sensor

The fall detection sensor detects the inclination of person's body using gravity (Kisimoto et al., 2005).

2.1.1. Composition of sensor

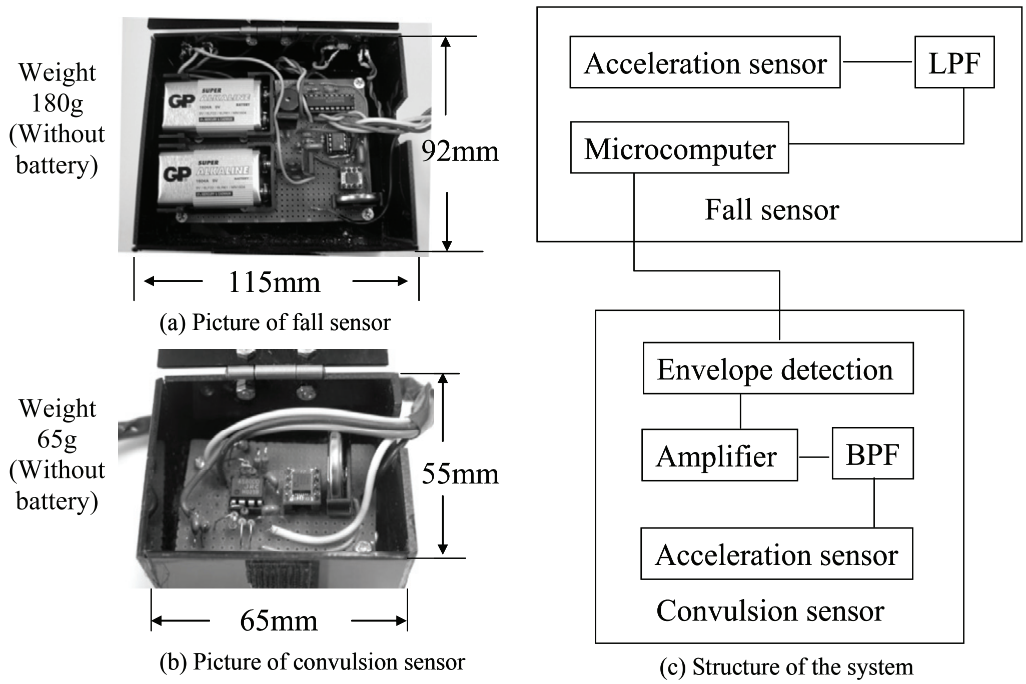


Figure 1. Picture of sensor and structure of the system.

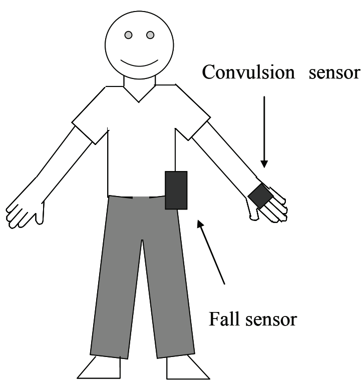


Figure 2. Chart of installed sensor.

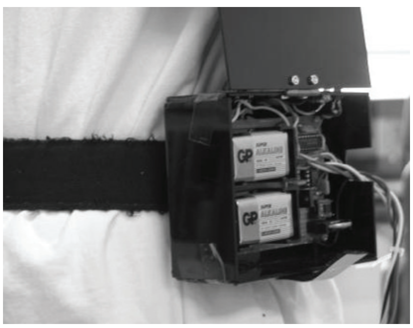
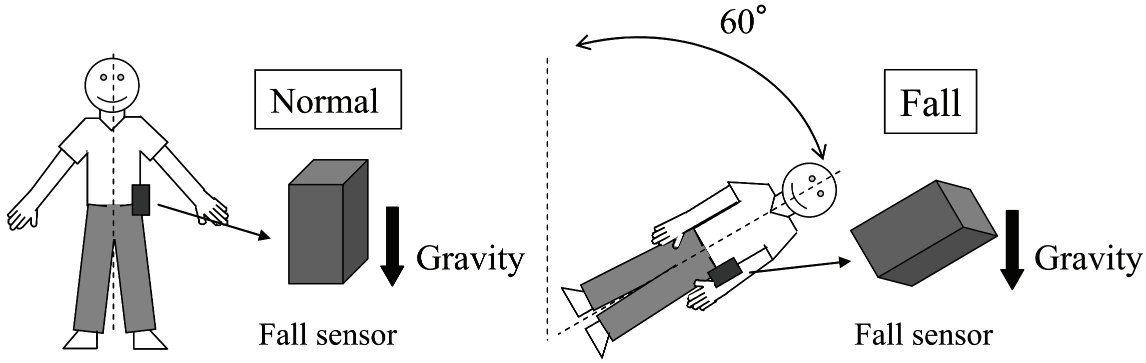


Figure 3. Picture of installed fall sensor.



(a) Normal (b) Fall

Figure 4. Distinction of fall sensor.

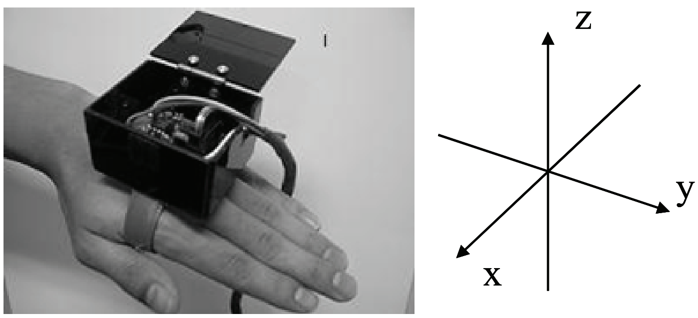


Figure 5. Relation between picture and axis of installed convulsion sensor.

The frequency of 1Hz or less is extracted by using LPF to extract only gravity to z axis of three axis acceleration sensor (made by the [kaionikusu] company and KXM52-1050). The output from sensor is acquired in the microcomputer every 20 millisecond. The instrument was installed in the waist with a little movement and influence of the inclination. Figure 3 shows the photograph of the installation.

2.2. Convulsion sensor

The convulsion sensor distinguishes the convulsion by using movement of the hand trembles.

2.2.1. Composition of sensor

Generally, the convulsion appears remarkably at the hand and the foot ahead. Three axis acceleration sensor (made by the [kaionikusu] company and KXM52-1050) is installed in the back of the hand because the influence of the shake by walking and vehicle is few. Figure 5 shows the relation between the axes and photograph when the convulsion sensor is installed.

Figure 6 shows the shape of waves of the hand movement in each direction of three axes. Observing hand convulsion, the movement of the y axial direction is small though the movement of x and z axial direction is large as shown in Figure 5 when the sensor of the convulsion is fixed. Therefore, only the acceleration of x axis and z axis is used.

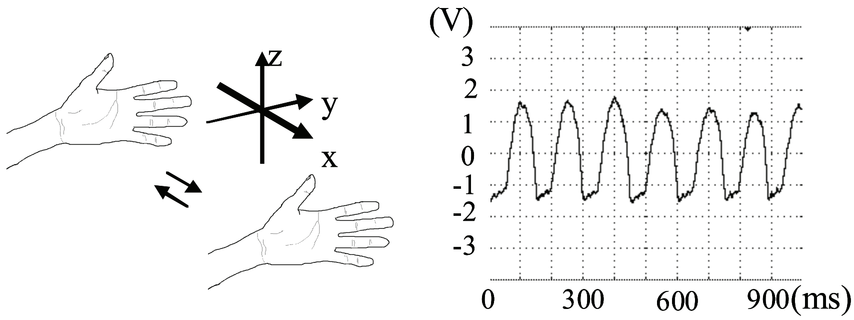
Moreover, in order to avoid error detection causing by the movement in daily life or by the shake of the vehicle, only the frequency of the movement comes from the convulsion is extracted using BPF. Similar to convulsion, there is a symptom of tremor in one of the involuntary movements that the hands and feet trembling. It is known from reference literature (Kimura et al., 1996) that 4.9±1.2Hz as for the tremor of the Parkinson's disease, and 5.7±1.7Hz as for the essential tremor. Moreover, The hand was vibrated purposely in a small amplitude as quick as possible for five seconds per each of ten testees, and the average was 7.5Hz every 5.2 ~10Hz when the frequency was measured. It is defined that the above mentioned movement and the convulsion is almost the same movement in the present study. Therefore, extract the frequency from 3 to 10Hz, then detect the envelope curve of outputs of two axes, and the larger one is assumed the output of the convulsion sensor. The acquiring time span of microcomputer is 20 milliseconds.

2.2.2. Distinction of convulsion

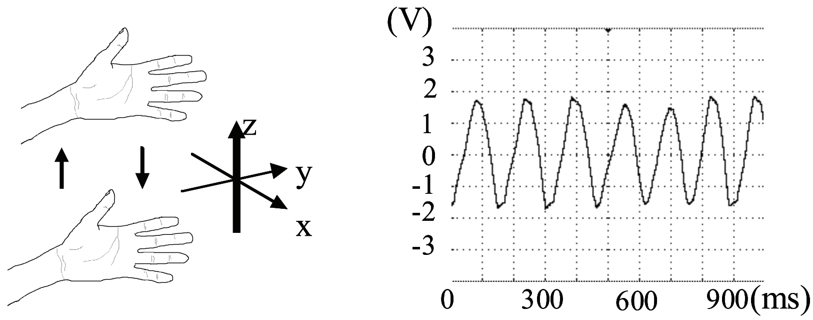
The frequency of the convulsion is extracted by the convulsion sensor, and the movement of daily life is detected too. Because the convulsion by the epileptic attack is assumed to be continuation for 30~60 seconds, it distinguishes from "Convulsion" when it is five seconds or more continuous and outputs threshold V_C or more to distinguish movement, and it distinguishes from "Normal" besides. Threshold V_C is decided by the experiment.

2.3. Distinction of Dangerous state

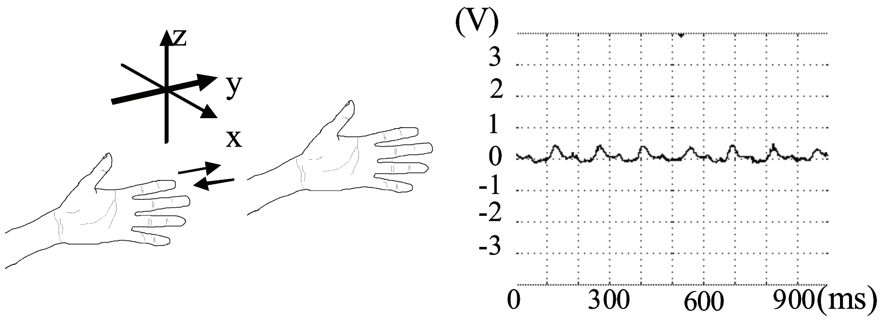
The “Dangerous state” is judged overall by the result of the distinction of the fall and the distinction of the convulsion. It distinguishes "Dangerous state" when both “Convulsion" and "Fall" is determined.



(a) Movement of hand, relation of x axis, and shape of waves.



(b) Movement of hand, relation of z axis, and shape of waves.



(c) Movement of hand, relation of y axis, and shape of waves.

Figure 6. Movement of hand and relation of axis and shape of waves.

3. Experiments

It experimented on the fall sensor, the convulsion sensor, and the dangerous state detection.

3.1. Experiment on fall sensor

3.1.1. Decision of threshold value V_F

The output of the acceleration sensor was measured when the fall sensor was inclined by 0°, 60, and 90° in z axis, and rotated in eight directions on x-y plane respectively. The output is 2.1V on 0°, 1.8V on 60°, and 1.5V on 90° which averages each eight directions result respectively,. Thus, the threshold was assumed to be 1.8V.

3.1.2. Fall distinction Experiment

The operation was confirmed using ten testees in three patterns which are fall, stood upright, and sat. And only the fall state was detected completely thus and the operation is confirmed working correctly.

3.2. Experiment on convulsion sensor

3.2.1. Threshold V_C decision

Ten testees shook the hand as little by little as possible quickly, and the output was measured for five seconds. Figure 7 shows the minimum value of each testee tremble output in five seconds. Because all of the output is lower than 0.28V, the threshold was assumed to be 0.20V.

3.2.2. Experiment on distinction of convulsion

Ten testees shook the hand for ten seconds as little by little as possible quickly after a geostationary state. And it experimented whether the movement of the hand was able to be detected repeating it three times. And only when you shake the hand was detected completely thus and it was confirmed to operate normally.

3.3. Experiment on dangerous state distinction

3.3.1. Experiment when it is not Dangerous state

Install the device to ten testees, and perform experiment five times for each. Then whether the mis-detection happens when geostationary and walking (3 km/h, 6 km/h, and 20 km/h) is confirmed. Moreover, repeat experiment ten times to check whether mis-detection happens under circumstance of acceleration, rapid acceleration, a deceleration, a sudden braking, a left turn, a right turn, and a usual running by the vehicle (car and bicycle).
Table 1 shows the result. There is no "Dangerous state" distinguished from all patterns, and the system is conformed to work correctly.

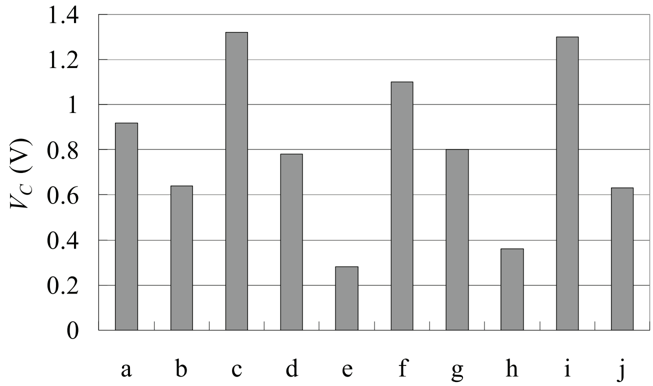


Figure 7. Output of convulsion sensor.

State		Detection rate[%] Fall	Convulsion	Dangerous state
Geostationary	Standing	0	0	0
	Sitting	0	0	0
	Falling	100	0	0
Walking	3km/h	0	0	0
	6km/h	0	0	0
	20km/h	0	70	0
Car	Usual running	0	0	0
	Right turn	0	0	0
	Left turn	0	0	0
	Acceleration	0	0	0
	Rapid acceleration	0	0	0
	Deceleration	0	0	0
	Sudden braking	0	0	0
Bycycle	Usual running	0	0	0
	Right turn	0	0	0
	Left turn	0	0	0
	Acceleration	0	0	0
	Rapid acceleration	0	0	0
	Deceleration	0	0	0
	Sudden braking	0	0	0

State	Detection rate[%] Fall	Convulsion	Dangerous state
Lying upon face	100	100	100
Turning up	100	100	100
Face to the right	100	100	100
Face to the left	100	100	100

3.3.2. Experiment when it is dangerous state

Ten testees were made to fall in four patterns: lay upon their face; turned up; face to the left and face to the right, then the shake hand. Experiments performed three times to check if the device works well.

Table 2 shows the result. Thus, all patterns were identified to “Dangerous state” as we expected, the detection is conformed to work well.

4. Conclusions

In this paper, a "Dangerous state" detection system for the epilepsy fit was proposed. It can be used at any time in daily life, and can detect the losing consciousness fit when convulsion suddenly occurred. It was shown that this system is able to detect the dangerous epileptic attack at any time in daily life. The device was constructed cheaply, and installed to a human body easily because of portable size.

As a future problem, an extended function should be added to detect the dangerous state without falling when person reclines against a wall. And also implementation of the communication function that can inform the surrounding people for a help is of importance.

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