Computer controlled environment for people with spinal cord injury

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ABSTRACT: This paper describes computer controlled environment designed for a patient suffered by spinal cord injury. Considering physical ability of the user, two kinds of human interface devices are proposed. One human interface device is a head mount device on which an accerelation sensor to detect the head movement and a pressure sensor to detect the chewing action are attached.The other human device uses eye-ball movements as control signals. Eye-ball noivemens can be detected as EOG signal. Proposed interface devices were applied to other user with some disability. Another feature of the computer controlled environment is that most of the electric aapliances can be operated by the infrared signal. Due to employment of this infrared signals environment of the user could be free from cumbersome electric wires. In this environment the user is enjoying independent life.

1 Introduction

There is a great concern to help person with disability at their daily activities. In the engineering field one of these efforts to help these people is translated as development of dedicated devices. These devices use the residual body movement of the patient to operate external devices. One typical example is a patient suffered by spinal cord injury shown in Fig.1.

Fig.1 Patient with human interface device

He was injured at a falling accident in 2010. All his remaining physical acitivity is limited only above the the neck. He needs respilator to sustain his his breathing ability. A remarlkable problem to use a respilator is that the user is unable to utter voice. Also he needs switching his posture of his body by care-workers every two hours. Without this switching his posture of the patient's body the blood circulation might be stacked and will cause sereious damages to the patient. Even in such a physical condition, he can enjoy his life by the recent medical care support and also computer technology.

Because of his physical conditiuon, he lives most of his times on the bed. However, by using the computer devices he communicates with friends and family. Furthermore, by developing original interface devices he can use the electric apppliances.

In this paper a commuter controlled environment for the seriously disabled is explained. A feature of this system is that infrared red signal is used as a control signal. In addition, two kinds of human interface devics which enable the serious spinal cord injured to control the computer controlled environment. These interface devices are designed to detect the intentional slight movement of the jaw and eye-ball since the possible movements of the patient are limited.

2 Computer controlled environment

A computer controlled environment is shown in Fig.2 where the patient with spinal injury lies on the bed. The patient can operate electric appliances by using a human interface device designed for the patient. Controlable electric appliances are ceiling lights, air-conditioning system, emergency call, telephone, TV and so on. The TV monitor is mounted on the ceiling with an original adjustable mechanism. The posture and position of the TV monitor can be adjusted by the computer commands via infrared signal.

Fig.2 Computer controlled environment

In order to achieve effective computer controlled environment, a wireless infrared control system is introduced as shown in Fig.3. An infrared emitter sends modulated infrared signals according to the command signals obtained. The receiver receives the modulated infrared signals, decodes the commands and control six on/off status of the relay circuits inside the receiver. The emitter signal is designed to be compatible with commercialized infrared devices.

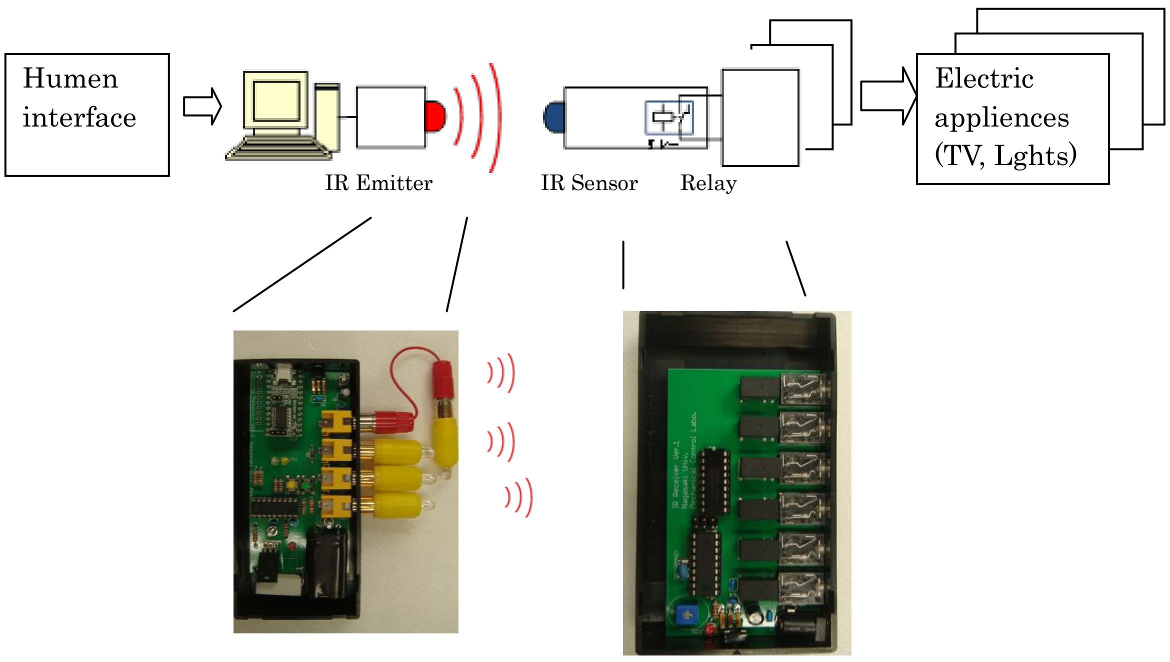

Fig.3 Infrared emitter and receiver

3 Interface devices for the disabled

3.1 Device to use chewing action as clicking signal

The human interface device introduced for the patient should be designed considering the physical ability of the patient and also the remaining physical ability of the user. An interface device shown in Fig.4 was developed. At the fore head a two-dimensional acceleration sensor is attached to detect the head movement of the patient. Only by moving the the head the patient can move the position of of the mouse cursor on the computer monitor. At the temporal muscle on one side of the head a pressure sensor is attached to detect the chewing action of the patient. Due to this pressure sensor the patient is able to make the clicking action of the computer mouse.

Fig.4 Computer interface device on the forehead

We focused on the temporal muscle on one side of the forehead. Based of our technique the capacitive pressure sensor is touched near the temple.

In Fig.5 output signal of the pressure sensor is shown where chewing signal can be recognized. It can be also recognized that effect of the talking action is negligible small.

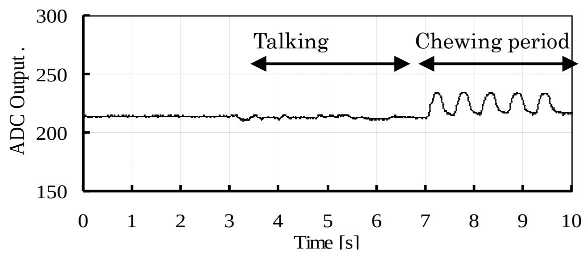

Fig.5 Chewing signal detected by capacitance sensor

3.2 Device to use eye-ball movement as clicking signal

The eye-ball movement is a significant signal that brings various intentions of the user. The eye-ball movement can be measured by detecting EOG(Electro-Oculogram) signals. The human eye is an electrical dipole, where the eye retina is negatively charged and the comea is positively charged. During eye movements the dipole position changes. If electrodes are placed on the skin area close to the eyes as shown in Fig.6, these movements can be measured as a change on the voltage(EOG).

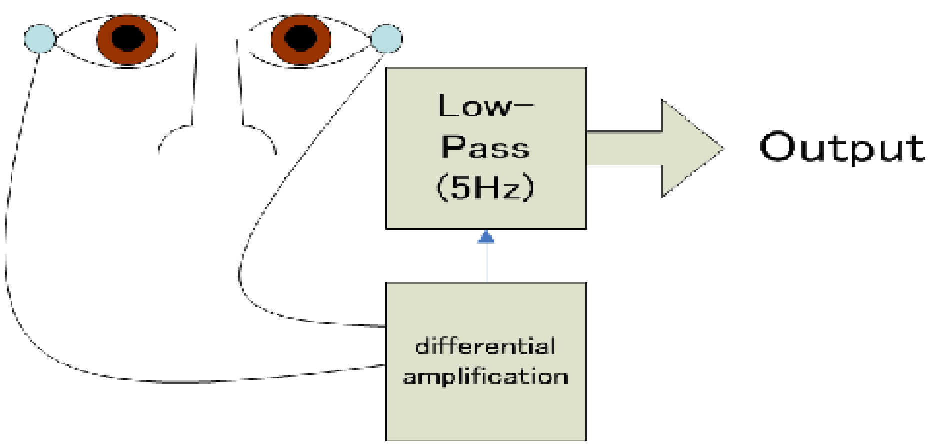

Fig.6 EOG signal obtained by differential aplifier

An experiment was conducted where target marks were placed on the wall in front of the user. The first mark was placed 15 degree rightward of the user, the second mark was 30 degree rightward, the third mark was 45 degree and the fourth mark was 60 degree rightward. The user was requested not to move his head. And he is requested to watch the target mark sequentially by moving his eye-ball. After wataching the target mark the user was requested to return his eye-ball to the initial position. EOG signals obtained through this experiment were shown in Fig.7. It can be recognized that EOG signal increseases corresponding to the number of the target mark. Suppose the electrodes are placed upper and lower skin erea of the eye, the vertical movement of the eye can be detected as shown Fig.8..

Based on this pronciplae, a human interface device can be developed.

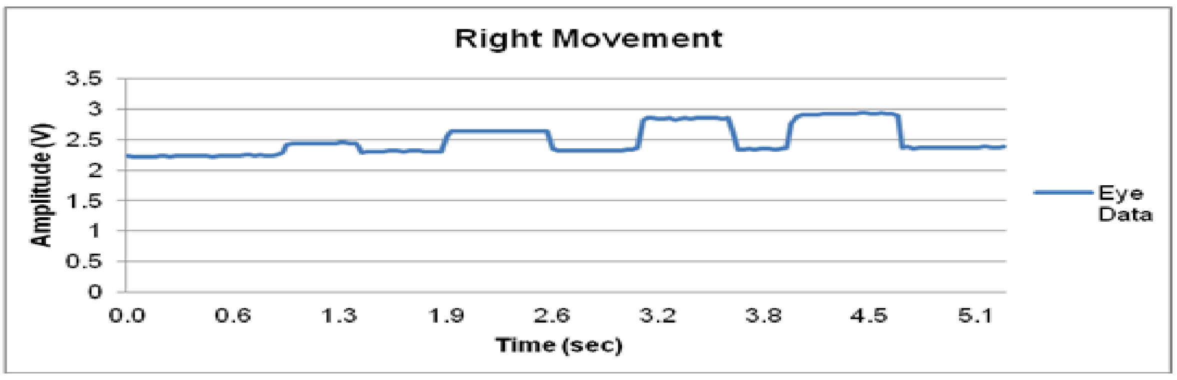

Fig.7　EOG signals during the wataching experiment

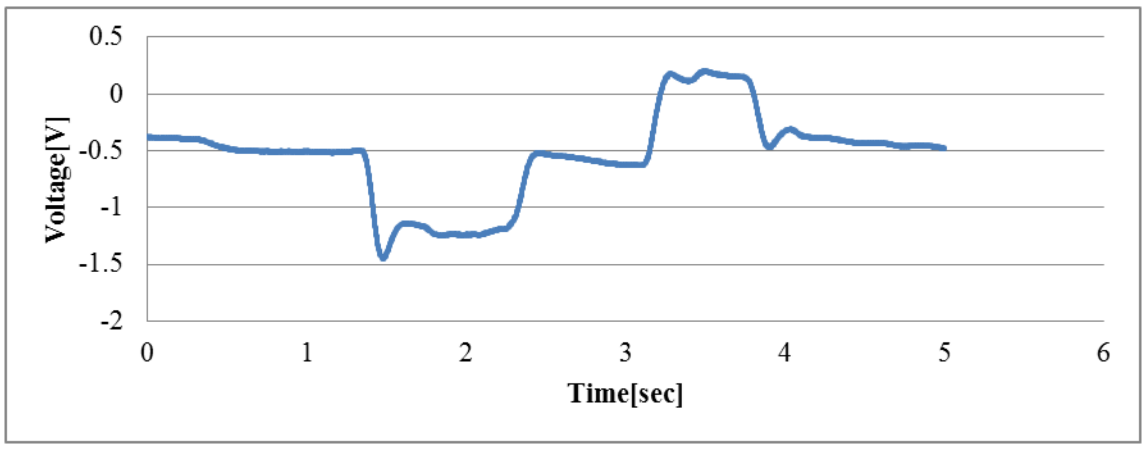

Fig.8　EOG signals obtained through vertical movement of the eye-ball

4　Conclusions

The purpose of this paper is to develop computer cotrolled environment for a patient with serious spinal cord injury.　Since the patient's physical ability is limited only above his neck, the two kinds of human interface devices are developed by using the one-chip computer. One human interface device is a head mount device on which an accerelation sensor to detect the head movement and a pressure sensor to detect the chewing action are attached.The other human device uses eye-ball movements as control signals. Eye-ball noivemens can be detected as EOG signal. Proposed interface devices were applied to other user with some disability. Fig.9 shows a ALS patient operating a computer and TV using EOG signal. Fig.10 shows a user operating a power assist glove.by head mount type interface device. While his glasping function is disabled, he can glasp the target objects using proposed interface device.　. .

Fig.9　User with interface to use EOG

Fig.10　User with head mount type device

References

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