Control of Five Finger of Computer Graphics Hand Using Electromyographic Signal Measured with Multi-channeled Small Laplacian Electrodes

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Abstract. The authors propose a new simple method for controlling five fingers of computer graphics hand respectively using electromyograms signal. We manufactured five double-polar concentric ring electrodes, for measuring surface Laplacian electromyograms(Laplacian EMGs) from flexor muscle corresponding to each finger flexing action. Laplacian EMGs can detect the current flowing into the component that is proportional to the vertical surface current density. The experimental results shown the each manufactured electrode could measure the Laplacian EMG corresponding to each finger flexion without any interference and that the developed interface could control the CG hand in real time. These results infer that the proposed approach is promising as an EMG-based human-computer interface or human-machine interface. The next challenges to be addressed are to conduct the evaluation test for many subjects and to facilitate electrodes attachment.

Keywords: EMG, Human interface, Laplacian electrode.

1 Introduction

In recent years, devices using EMG such as EMG prosthetic hand has been developed to control the computer and human interface. And, the Laplacian electrode can detect signals along the axis into the origin perpendicular to the surface. A pilot measuring circuit and a dedicated interface circuit were also assembled by reference to previous our approach [1]-[2]. Therefore, multiple Laplacian electrodes is expected to be detected independently of each finger on each EMG. The purpose of this study are Laplacian multi-channel EMG signals detected using multiple electrodes, and development of device of control of five finger of CG hand using the EMG signal.

2 Theoretical Basis of Body Surface Laplacian

The use of the body surface Laplacian has been first proposed by Hjorth in electroencephalogram in 1975 [3] and by He and Cohen in electrocardiogram in 1992 [4], but not in EMG. Considering a local orthogonal coordinate system (*x, y, z*) with

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origin at a point on the body surface where the z axis is orthogonal to the body surface, the Laplacian EMG, L_S, is defined by applying a Laplacian operator to the body surface potential ϕ as follows:

$$L_S = -\nabla^2{}_{xy}\phi \equiv -\nabla_{xy} \cdot \nabla_{xy}\phi \equiv -\left(\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial x^2} \right) = -\left(\frac{1}{\sigma} \right) \frac{\partial J_z}{\partial z} \qquad (1)$$

Thus the Laplacian EMG signal is negatively proportional to the normal derivative of the normal component of the current density at the body. Therefore, Laplacian EMG is supposed to be sensitive to the firing of the measurement. Accordingly, the signal is potentially useful as an input for human interfaces, because it is less susceptible to the interferences caused by the activity of approximal muscles than the conventional EMG signal.

3 System Configuration

3.1 Laplacian Electrode

In this study, fabricated Laplacian electrode is bipolar concentric ring electrode. Bipolar concentric ring electrode can be realized by disk electrode and forming the electrodes on the outer ring of concentric circles. And taking the difference between the two electrodes can detect the vertical component proportional to the current flowing into the origin. Therefore, the Laplacian electrodes can be to measure potentials from a localized area smaller diameter. This fabricated electrode, the two electrodes area is 50mm^2, the distance between the electrodes is 1.0mm, diameter electrodes is 14mm.

3.2 Detection of EMG

Fig.1 shows the block diagram of the Laplacian EMG measurement circuit. This circuit is composed of high input impedance instrumentation amplifier, notch filter, high pass filter, low pass filter, inverting amplifier, additional type Driven-Right-Leg(D.R.L.)circuit. Laplacian electrode skin contact impedance is high because it is small, therefore inst.amp. with high input impedance first-stage IC was used. The circuit constants in the H.P.F. and L.P.F. were set to obtain a cutoff frequency of 10 and 1000Hz, respectively. Notch filters were used to reduce 50Hz interference. Amplification factor of 50,000 times the entire circuit. Additional type D.R.L. circuit was tried for S/N improvements by feedback signal to the Body-Earth, the signal adding the residual signal of five channels.

3.3 Signal Converter

Fig. 2 shows the block diagram of the signal converter circuit. This circuit is composed of H.P.F., Absolute value circuit, Integrating circuit, Inv.Amp., Comparator, Buffer, Relay circuit and USB Gamepad. The first stage is H.P.F. with a cutoff frequency of 53Hz, which cuts the low frequency component of EMG in order

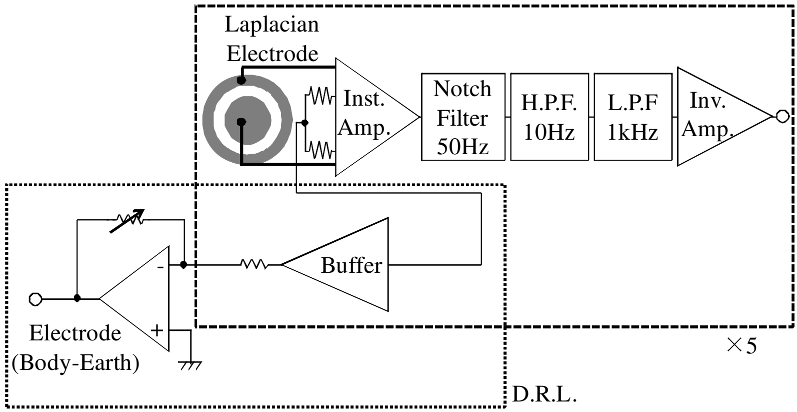

Fig. 1. A block diagram of the Laplacian EMG measurement circuit/

to reduce baseline variation. In the second stage, full-wave rectified signal to the Absolute value circuit In the third stage, the time constant of 0.1s to smooth at the integration circuit. Then, the comparator input signal is amplified 10 times. A pulse outputs that exceeds the threshold of the comparator. The comparator has hysteresis to prevent chattering. Shorts the gamepad button and send to PC when the input signal of high the at relay circuit.

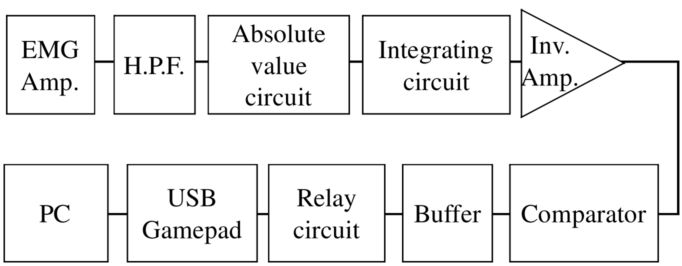

Fig. 2. Block diagram of the signal converter circuit

4 Evaluation of Developed System

Three male volunteer aged 22 were instructed to sit down on a chair. Laplacian electrode was fixed by surgical tape and rubber bands to each subject's right forearm. Arrangement of electrodes was fixed to the best part out of the fingers being in EMG at pilot experiment. We control for EMG than CG hand when flexion of the five finger.

In addition, similar experiments were performed with disposable electrodes fabricated same diameter attached to the same site. And it is compared the discrimination probability. In addition, the discrimination probability if we could control without interfering with the other fingers, finger obtained at 5 × 20 sets of 100 trials. Show the discrimination probability of disposable electrodes in Table 1, discrimination probability of Laplacian electrodes in Table 2.

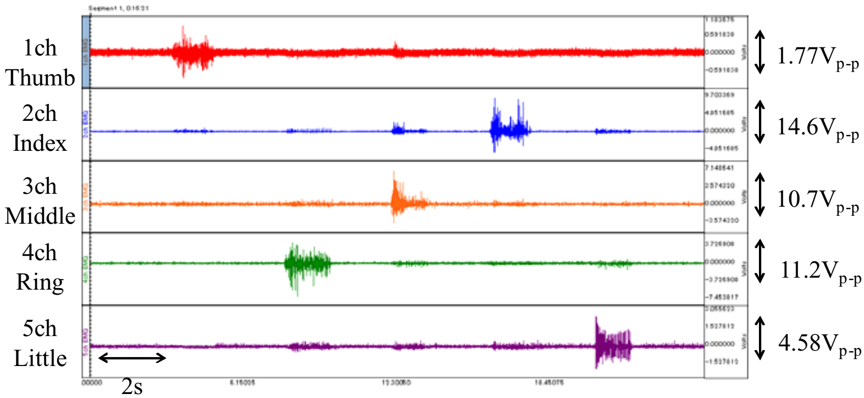

Fig. 3. Recordings of Lalacian EMG during individual finger flexions

Table 1. Discrimination Probability of disposable electrodes

	1ch Thumb	2ch Index	3ch Middle	4ch Ring	5ch Little	Total
Subject A	0%	0%	0%	55%	0%	11%
Subject B	65%	15%	10%	5%	50%	29%
Subject C	35%	0%	90%	5%	95%	45%

Table 2. Discrimination Probability of Laplacian electrodes

	1ch Thumb	2ch Index	3ch Middle	4ch Ring	5ch Little	Total
Subject A	95%	75%	65%	100%	100%	87%
Subject B	100%	85%	95%	80%	90%	90%
Subject C	100%	85%	70%	95%	100%	90%

5 Conclusion

The result is a high probability Laplacian EMG without interfering with other finger flexion can be measured in response to each finger, five fingers can be controlled in real time showed that CG hand.

The next challenges to be addressed are to conduct the evaluation test for many subjects and to facilitate electrodes attachment. In addition, on-off only control to the

CG, and it is expected to be high discrimination probability is obtained by performing signal processing such as pattern recognition.

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