SUGISAKA MASANORI

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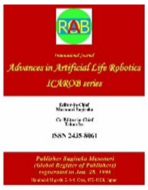

Research Article

Basic Study on Motion Control of CG Characters by Electroencephalography (EEG) analysis

Makoto Sakamoto[1], Kenji Sakoma[1], Takahiro Ishizu[1], Takahiro Shinoda[1], Amane Takei[1], Takao Ito[2]
[1]*Department of Computer Science and System Engineering, University of Miyazaki, Miyazaki-City, 889-2192, Japan*
[2]*Graduate School of Engineering, Hiroshima University, Higashi-Hiroshima, 739-8527, Japan*

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ABSTRACT

Virtual Reality (VR) technology is expected to develop in various fields such as medical, education, business and entertainment. In this study, we aim at more intuitive operation by focusing on troublesome mounting in VR. To achieve this goal, we propose manipulation method of CG character by electroencephalography (EEG) with relatively inexpensive equipment. In this paper, we ask five subjects to manipulate CG characters by EEG and evaluate this system by questionnaire.

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1. Introduction

Since 2016, the so-called the VR (Virtual Reality) first year, VR technology has made remarkable progress around the world. Every year, higher-level VR devices are released, and although the price is somewhat high, it has become easy to purchase for us. As a result, VR technology is expected to develop in various fields such as medical care, education, business, and entertainment.

However, there are five major problems that must be solved in the development of VR technology. The first one is the problem of troublesomeness of wearing, the second the problem of specifications, the third the social and market problem, the fourth the problem at the production site, and the last the health problem. Among these, I focused on the first problem of troublesomeness of wearing. When using VR devices, it is necessary to set up many cables and sensors. Also, there must be a certain space around the user when using it. This is for the consideration of the surroundings or the safety of the user extent when performing any operation in the VR world. For this reason, there arises a problem that it is necessary to select a place when using a VR device. Recently, integrated (stand-alone) models that do not require any cables are gradually appearing. The integral type solves the problem of cables. However, space problems around the user have not been solved [1].

Therefore, as a method for solving this problem, it is proposed to use an operation by electroencephalogram, that is, a method called BMI (Brain Machine Interface). BMI, also called BCI (Brain Computer Interface: Brain Computer Interface), is a study that measures brain waves with an instrument, extracts features from the brain waves, and causes the computer to react in some way according to the features. We think that space problems around the user may be solved by using this method [2], [3].

In this paper, we aim to manipulate virtual objects more intuitively by allowing a user to perform basic manipulations, such as creating virtual objects, deforming, moving and combining them.

We make it possible to realize the interaction of the user and the virtual objects by adopting the Leap Motion

Corresponding author's E-mail: sakamoto@cs.miyazaki-u.ac.jp, itotakao@hiroshima-u.ac.jp

Controller specialized for acquisition of three-dimensional (3D) coordinates of fingers and introducing flexible body virtual objects using Bullet Physics. We also perform a hidden surface removal to allow the user to recognize the context of the user's hand and the virtual objects.

2. System Component

In this study, it is necessary to measure brain waves. Therefore, the above equipment was used in this research.

Generally, the BMI research uses an international 10-20 electroencephalograph, but in this research, the equipment sold by Neurosky Inc. from the viewpoint of whether BMI can be realized inexpensively (see Fig. 1) was used.

2.1. Used equipment

1) Mind Wave Mobile.

Fig. 1: Mind Wave Mbile.

2.2. Development environment

The development environment for constructing this system is as shown in Table 1 below.

OS	Windows 10
Programming language	C#
Measuring equipment	Mind Wave Mobile
Software	Visual Studio 2017 Unity 2017.3.1f1

Table 1 : Development environment.

2.3. Library

1) libStreamSDK

Used to receive brainwave data from Mind Wave Mobile in Visual Studio 2017.

MathNet.Numerics

2) Accord

3) Accord.MachinerLearning

4) Accord.Math

5) Accord.Statistics

Used to process data received from Mind Wave Mobile in Visual Studio 2017.

2.4. Brainwave measurement

In this study, it is necessary to measure brain waves. In the general BMI research, the international 10-20 method is used, but in this research the brain wave measuring machine Mind Wave Mobile manufactured by Neurosky Inc., which is relatively inexpensive. because it is also that it is from the viewpoint of verifying whether BMI is possible even with a simple device. When receiving EEG data in Visual Studio 2017, I used a library called libStreamSDK.

In addition, when acquiring an electroencephalogram, the kind of electroencephalogram acquires a Row wave which is not processed at all. Then, extract features in Visual Studio 2017.

2.4.1. FFT (Fast Fourier Transform)

It is a kind of DFT (Discrete Fourier Transform), and is an algorithm designed to execute DFT fast on a computer. When using this analysis method, I used the library of MathNet.Numerics [5].

2.4.2. Continuous wavelet transform

It is possible to use a wavelet function as a basis function and leave temporal information that is lost in the Fourier transform. This is a method that attempts to represent the waveform of a given input by scaling, translating, and adding wavelet functions (see Equation 1).

$$WT(a,b) = \frac{1}{\sqrt{a}} \int f(t)\psi\left(\frac{t-b}{a}\right) \mathrm{dt} \qquad (1)$$

2.4.3. Discreate wavelet transform

The original signal is decomposed into the high frequency component and the low frequency component, and the decomposed low frequency component is also decomposed into the high frequency component and the low frequency component (see Equation 2)

$$d_k^{(j)} = 2^j \int_R f_{(t)} \overline{\psi(2^j t - k)}\, dt \quad (2)$$

2.4.4. EEG feature discrimination method

Generally, As EEG feature discrimination method, SVM (Support Vector Machine: support vector machine) generally used in EEG feature discrimination was used. SVM is one of pattern recognition models using supervised learning (see Equations 3, 4 and 5). SVM has high discrimination performance against unlearned data. In this study, Gaussian kernel was used as the kernel function. In addition, the library of MathNet.Numerics Accord, Accord. MachinerLearnin, Accord.Math, and Accord.Statistics was used to execute SVM [4].

$$y_{(x)} = \mathrm{sgn}\left\{\sum_{n=SV} w_n K(x_n, x) + b\right\} \quad (3)$$

$$= \begin{cases} 0 & x \in classA \\ 1 & x \in classB \end{cases} \quad (4)$$

$$K(x_1, x_2) = \exp(-\|x_1 - x_2\|^2 / 2\sigma^2) \quad (5)$$

2.4.5. Visual Studio 2017

Visual Studio 2017 processes brain wave data sent from Mind Wave Mobile and performs feature detection. At this time, the brain wave processing method used FFT. Thereafter, the processed electroencephalogram data is subjected to SVM, and the electroencephalogram is discriminated such that 0 is output when relaxing, and 1 is output when user tries to move (see Equation 4).

2.4.6. Unity 2017.3.1f1

We created CG characters and programs that change in response to the features of the brain waves (see Fig.2). It was processed in Visual Studio 2017, and it received the feature which was judged by SVM, and made it to respond according to the feature. In addition, this character uses the one promulgated free from Unity's Asset Store.

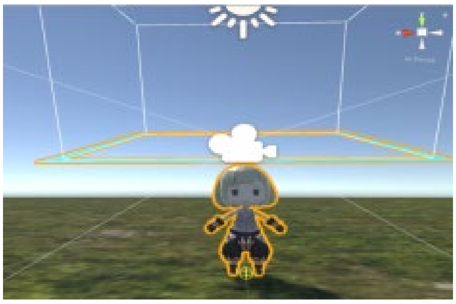

Fig. 2: The CG character which used in Unity.

3. Experimental method*

The subject sits in a chair and starts measuring after wearing Mind Wave Mobile on the head. The brain wave processing method uses FFT. During the experiment, subjects are asked to relax moderately or move their body, and so on, to evaluate how CG characters in Unity move. In this research, CG characters move only in two types, and they are stopped when relaxing and move forward when trying to move their bodies.

4. Evaluation experiment

In this experiment, five university students became subjects, and they conducted evaluation experiments and asked them to answer questionnaires. The contents of the evaluation were in the form of free-form descriptions of "good points", "bad points" and "others".

5. Evaluation results

As a result of conducting the questionnaire, it became as follows.

"Good things" were "Simply fun", "I was interested because I wanted to move the body, so I was interesting", "CG character was cute" and so on.

"The bad point" were "It took time for the CG character to actually reflect the reaction after trying to relax / move the body," "Mind Wave Mobile is coming off," "Mind Wave Mobile was tightening my head and hurts me", "It moves even though it is relaxing. / The character freezes while trying to move the body." and so on.

"Other" were that "is it not compatible with other movements?" and "is there no other CG character?", etc.

*

6. Consideration

From the evaluation results, it was found from the “good points” that the control of CG characters by EEG which measured by inexpensively equipment, which is the purpose of this research, can achieve certain results with regard to only two simple patterns of forward and backward.

However, from the "bad point", it was found that the method of detecting the characteristic of the electroencephalogram and the discrimination method were still incomplete. We also found that there was a problem with the installation of Mind Wave Mobile. This is considered to be a problem that the size cannot be changed or cannot be selected. From the above "bad points", it was found that this research needs further improvement.

According to the opinion of "other", it was found that the operability and key CG characters in this research require diversity.

7. Conclusion

In this research, we focused on the "trouble of wearing" which is a problem in the development of VR technology. Above all, we focused on the problem of spatiality around the user, and researched that it could be solved by the following method. We have proposed a method in a field generally called BMI : the electroencephalogram data is measured using an electroencephalograph, the electroencephalogram data is received by Visual Studio 2017, the electroencephalogram data is appropriately processed, and then the electroencephalogram features are discriminated by SVM, and the discriminant values sent to Unity 2017.3.1f1 and operates CG characters in Unity according to the determined value. In addition, although an electroencephalogram measurement machine conventionally uses the international 10-20 method, in this research, Mind Wave Mobile manufactured by NeuroSky was used because it verifies that it could be substituted by an inexpensive device. The result of the evaluation experiment shows that although the manipulation of CG character by electroencephalogram which is the purpose of this research can achieve a certain result, its accuracy is bad and there is much room for improvement. Future issues will include brain wave feature detection, improvement of brain wave feature discrimination accuracy, improvement of troublesomeness when wearing Mind Wave Mobile, and diversity of motion of CG characters.

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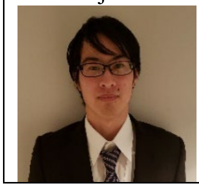
Authors Introduction

Dr. Makoto Sakamoto

He received the Ph.D. degree in computer science and systems engineering from Yamaguchi University. He is presently an associate professor in the Faculty of Engineering, University of Miyazaki. He is a theoretical computer scientist, and his current main research interests are automata theory, languages and computation. He is also interested in digital geometry, digital image processing, computer vision, computer graphics, virtual reality, augmented reality, entertainment computing, complex systems and so on.

Mr. Kenji Sakoma



He is a master student at Department of Computer Science and System Engineering, University of Miyazaki. His current research interests are computer graphics and image processing.

Mr. Takahiro Ishizu

He is a master student at Department of Computer Science and System Engineering, University of Miyazaki. His current research interests are computer graphics and image processing.

Mr. Takahiro Shinoda

He is a master student at Department of Computer Science and System Engineering, University of Miyazaki. His current research interests are computer graphics and image processing.

Prof. Amane Takei

He is working as Associate Professor for Department of Electrical and systems Engineering, University of Miyazaki, Japan. His research interest includes high performance computing for computational electromagnetism, iterative methods for the solution of sparse linear systems, domain decomposition methods for large-scale problems. Prof. Takei is a member of IEEE, an expert advisor of The Institute of Electronics, Information and Communication Engineers (IEICE), a delegate of the Kyushu branch of Institute of Electrical Engineers of Japan (IEEJ), a director of Japan Society for Simulation Technology (JSST).

Dr. Takao Ito

He is Professor of Management of Technology (MOT) in Graduate School of Engineering at Hiroshima University. He is serving concurrently as Professor of Harbin Institute of Technology (Weihai) China. He has published numerous papers in refereed journals and proceedings, particularly in the area of management science, and computer science. He has published more than eight academic books including a book on Network Organizations and Information (Japanese Edition). His current research interests include automata theory, artificial intelligence, systems control, quantitative analysis of inter-firm relationships using graph theory, and engineering approach of organizational structures using complex systems theory.