Verification of CG character operation by brain wave discrimination

Kenji Sakoma, Kodai Miyamoto, Taketo Kamasaka, Makoto Sakamoto*, and Amane Takei
Faculty of Engineering, University of Miyazaki,
Miyazaki-City, Miyazaki, Japan

Tsutomu Ito
National Institute of Technology, Ube College
Ube-City, Yamaguchi, Japan

Takao Ito
Graduate School of Engineering, Hiroshima University
Higashi-Hiroshima, Hiroshima, Japan

E-mail: hm16011@student.miyazaki-u.ac.jp, hm15037@student.miyazaki-u.ac.jp, hm16043@student.miyazaki-u.ac.jp, fruits2000jp@yahoo.co.jp
**Corresponding Author*

Abstract

Recently VR technology is expected to develop in various fields. In this research, we verified whether the VR space can be operated just by thinking in the head by using a device that is cheaper than the device used in the existing research. We used the fast Fourier transform and the support vector machine as the methods of EEG analysis. In the future, we will try to improve it further by changing the method of EEG analysis and other conditions.

Keywords: EEG, BMI, FFT, SVM, VR

1. Introduction

Since 2016, which was called the "first year of VR (Virtual Reality)", VR technology has been researched and developed all over the world and has made remarkable progress. Various companies have begun to develop and sell VR equipment, and although it is a little expensive, even ordinary people can easily purchase it. VR technology has become widespread, as PCs and other devices that can use VR devices have become affordable even for individuals. As a result, VR technology is expected to develop in various fields such as medical care, education, business, and entertainment. However, there are some major challenges in the development of VR technology.

We paid attention to the troublesomeness of wearing in this. When using VR equipment, it is often necessary to set up cables and sensors in advance. Also, when using a VR device, it is necessary to have a certain amount of space around the user. This is to ensure the safety of the surroundings and the user himself / herself because the controller is always used when operating / moving in the world inside VR. Therefore, there is a problem that the place where the VR device can be used is limited. It tends to be more expensive than models that require cables, but recently, integrated (standalone) models that do not require cables have also been released. Therefore, the problem of setting up the cable or the like can be solved. However, the spatial problem when using VR equipment has not been solved.

Therefore, in order to try to solve the spatial problem, the operation by brain waves --- BMI (Brain-Machine Interface) is used. Since the frequency band of human brain waves, such as "α wave" and "β wave", fluctuates depending on the activity state, the purpose is to use them for controlling CG characters and robots by reading them with a device and discriminating them. It is a study. I think that it may be possible to solve the spatial problem when using VR equipment by using this method[1-4].

2. Research Method

2.1. *VR*

VR (Virtual reality) is a technology and system that creates an environment that is not the actual thing or the real thing but has the same essence as a function by stimulating the senses including the five senses of the user. Translated as "artificial reality" or "virtual reality" in Japanese. In the olden days, novels, paintings, plays, television, etc. also had more or less VR functions.

Several problems have been identified with VR technology, and these are problems that must be resolved for future development.

1. Troublesome installation problem
2. Spec problem
3. Social and market issues
4. Problems at the production site
5. Health issues

The above-mentioned "installation troublesome problem" includes a safe space problem that must be ensured in order to use the VR product that occurs when the VR product is used. This problem means that you can't play anywhere when using a VR product.

This study focused on this problem.

2.2. *Used equipment*

- Mind Wave Mobile

Fig. 1. Mind Wave Mobile.

Equipment sold by NeuroSky (see Figure 1). In this study, we will use this device to measure brain waves.

2.3. *Development environment*

OS	Windows 10
Programming language	C#
Measuring equipment	Mind Wave Mobile
Software	Visual Studio 2019 Unity 2019.2.18f

Table 1 . Development environment.

2.4. *Library*

- libStreamSDK

  Used to receive brainwave data from Mind Wave Mobile in Visual Studio 2019.
- MathNet.Numerics
- Accord
- Accord.MachinerLearning
- Accord.Math
- Accord.Statistics

  Used to process data received from Mind Wave Mobile in Visual Studio 2019.

2.5. *Brainwave measurement*

Use NeuroSky's Mind Wave Mobile[6] brain wave sensor to measure brain waves. In addition, in order to receive brain wave data in Visual Studio 2019, we used a library called libStreamSDK included in the development tool provided by NeuroSky.

2.6. *EEG processing method*

2.6.1. FFT (Fast Fourier Transform)

It is a type of DFT (Discrete Fourier Transform) and is an algorithm devised so that DFT can be executed at high speed on a computer (see Equation 1). When using this analysis method, the MathNet.Numerics library was used[7].

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i\frac{2\pi}{N}} \quad (1)$$

2.6.2. EEG feature discrimination method

For EEG characterization, SVM (Support Vector Machine), which is generally used for EEG characterization, was used. SVM is one of the pattern recognition models that uses supervised learning (see

Equation 2). SVM has high discrimination performance for untrained data. In this study, a Gaussian kernel (see Equation 3, 4) was used as the kernel function. In addition, 5 libraries of MathNet.Numerics, Accord, Accord.MachinerLearning, Accord.Math, and Accord.Statistics were used to use SVM[5].

$$y_{(x)} = \mathrm{sgn}\left\{\sum_{n=SV} w_n K(x_n, x) + b\right\} \quad (2)$$

$$= \begin{cases} 0 & x \in classA \\ 1 & x \in classB \end{cases} \quad (3)$$

$$K(x_1, x_2) = \exp(-\|x_1 - x_2\|^2 / 2\sigma^2) \quad (4)$$

2.6.3. Visual Studio 2019

Visual Studio 2019 processes the brain wave data read by Mind Wave Mobile and performs feature detection. At this time, FFT is used to detect the feature amount of the electroencephalogram data. Then, using SVM, the processed brain wave data is discriminated so that 0 is output when the brain wave is relaxed and 1 is output when the brain wave is conscious of moving.

2.6.4. Unity 2019.2.18f

We created CG characters and programs that act according to the characteristics of the read brain waves. The brain wave data was processed by Visual Studio 2019, the result of discrimination by SVM was received, and the CG character was created to act according to the discrimination result. The CG character uses Unity-Chan !, which is provided free of charge in Unity's Asset Store (see Fig. 2) .

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

3. Experimental Method

Have the subject sit in a chair, wear Mind Wave Mobile on his head, and then start measuring brain waves. During the experiment, the subjects are made aware of relaxing and moving, and evaluate how the CG character in Unity moves accordingly. In this study, there are only two types of CG character movements: stop when you are relaxed and keep moving forward while you are thinking of moving your body.

4. Evaluation Experiment

In this experiment, three university students will be the subjects. An evaluation experiment was conducted and a questionnaire was conducted. The evaluation contents were "good points", "bad points", and "others" in a free description format.

5. Evaluation Result

The results of the questionnaire are as follows. In "Good points", "It is fresh and interesting to move just by thinking" was mentioned.

"Bad points" are "I was worried because there was a little time from thinking until the operation was reflected in the CG character", "Mind Wave Mobile is uncomfortable to wear", "The action that the CG character is thinking There were times when it did the opposite of what it was. "

"Others" included "Can I do anything other than move forward?" "Can I use running properly when walking?"

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

6. Consideration

From the "good points" of the evaluation results, it was found that the control of the CG character by brain waves, which is the purpose of this study, can obtain a certain result in distinguishing only two patterns of forward and stop.

From the "bad points", it was found that there was a problem with the accuracy and speed of EEG discrimination, and it was found that it was necessary to improve the EEG feature detection method and discrimination method, and to improve the performance of the processing device. It was also found that there was a problem with the installation of Mind Wave Mobile, but it is thought that the problem with this is that the size of the product used this time cannot be adjusted. From the above "bad points", it was found that there are points that should be further improved in this study.

From the opinion of "Other", it was found that actions other than advancing and stopping are necessary in this research.

7. Conclusion

In this research, we tried to solve the space problem around the user, among the "troublesomeness of wearing" which has become an issue in the development of VR technology. The brain wave data was measured by Mind Wave Mobile, the brain wave data from Mind Wave Mobile was received and processed by Visual Studio 2019, and the characteristics of the brain wave data processed by SVM were determined. We sent the discrimination result to Unity and verified the method in the field called BMI, which manipulates the characters in Unity based on the discrimination result.

From the results of the evaluation experiment, it was found that although the operation of the CG character by brain waves can obtain certain results, the accuracy is not sufficient and there are many points to be improved. Future tasks include improving the accuracy of brain wave feature detection and brain wave feature discrimination, increasing character movements by discriminating the ratio of brain wave frequency bands, and improving the uncomfortable wearing of Mind Wave Mobile. It is thought that there is, and we plan to work on it in the future.

If this research progresses, it is expected that it will play a major role in the medical field. By using this technology for people with physical disabilities who are physically handicapped or who are using artificial limbs, it will be possible to operate the body only with brain waves, which will be much more convenient than it is now. In addition, the field of e-sports is currently developing in the world, and VR technology is attracting attention in that field as well, so it is expected that if this research progresses, it will be able to play an active role in the field of e-sports.

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