Nervixxx: A Video Performance System with Neural Interfaces

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Abstract

Nervixxx introduces neural computing to overcome the limit of conventional performance systems[1] that uses tangible computing and physical computing. Specifically, we utilized the EEG (electroencephalogram) which is the most informative of the biosignals, and the EMG (electromyogram) which has a high controllability. Users manipulate the tangible objects that are the major function of this system. This intuitively enables to mix and apply visual effects as a motion graphics data. At the same time, users can control the playing speed and the parameter for each effect by wearing wireless EMG sensors on each of their arms. Also, users' brain waves can be used in real-time as a motion graphics data by wearing an EEG sensor. By introducing neural computing to tangible computing, it not only realizes the intuitive manipulation of applications but also increases the attractiveness of the actual performance. Moreover, the individuality of each user is reflected in the performer's ability to express him or herself.

1. Introduction

The interaction for neural computing is within the body. Let's take the phenomenon of thinking about something as an example. An interaction loop exists for the mind to think being the input and the variation of the brain wave being the output. Another example is the phenomenon of picking something up. In this phenomenon, the mind to pick something up is the input and the variation of the muscle potential together with the muscle is the output. Therefore, humans' nerve system forms a closed interaction loop.

When applying this kind of neural computing system to HCI, it is necessary to develop a method to match the characteristics of biosignals. For example, EEG, the root of conception, emotion and expression, has a lot of information but lacks of intentional control. GSR (Galvanic Skin Response) and EKG (Electrocardiogram) can be measured precisely, but is difficult to have an arbitrary control and doesn't have much real time change. On the other hand, EMG has an arbitrary control and can be controlled real time.

By contrast, the interaction for tangible computing is done with the tip of our bodies. For example, in Music Bottle, music starts to play directly out of the bottle by removing the lid from the bottle. [1]. In this case, the action of taking the lid off with the tip of the body, the hands, is the input and there is an interaction loop that outputs the sound. This phenomenon is essentially different from computing with graphical user interface (GUI) detached from the body, such as mouse and displays.

Though tangible computing has intuitive controllability of information, it is not suited for controlling complex process. For example, with Surface [2], even though it is possible to manipulate the file by hand directly and enlarge or reduce the size by multiple touches, users would not type documents for a long period of time with their hands and the screen. Tangible computing is consistently a simple control method which is suited for transmitting information directly. Therefore when conducting a complex process, designers should have a grasp of the essence of what the users will be experiencing and adopt the appropriate approach. The best user experience should be set out by matching many kinds of user interfaces and not by trying to realizing it with only tangible computing.

This paper proposes Nervixxx (Figure1) which is a video performance system that fuses tangible computing and neural computing. First, we realized mixing the motion graphics data and applying video effects by using tangible computing through the users' fingertips. This enables the direct control of the application. Also, we realized the control of parameters for the motion graphics data and visual effects, and also generating motion graphics data by using neural computing. Specifically, EMG is used for the former and EEG is used for the latter. The closed neural computing is expanded to the real space by fusing with tangible computing.

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[1] Performance stated here means the system to generate sound or video in real-time based on user's input action as performer.

Figure1. Appearance of playing Nervixxx. A user is selecting and moving a tangible object to change the motion graphics data.

Nervixx fuses tangible computing and neural computing to solve the problems that the conventional live performance systems had. In conventional live performance systems using tangible computing, an intuitive control was enabled due to its multifunctionality but it lead to complex manipulation which requires concentration. This decreased the attractiveness of the actual performance. Also, in systems using the physical computing , there was a flexibility for the users' actions so the attractiveness of the actual performance is high but it was difficult to control the motionless states and arbitrary control was impossible Nervixxx fuses tangible computing and neural computing so it provides users a new experience that could not be experienced with each system or the system that is a hybrid of those systems.

2. Related Research

Nervixxx introduces neural computing to solve the problems that the performances using tangible computing and physical computing have. In this chapter, 3 related works are stated; A system that controls movies and sounds by using tangible objects on a table top as a case of tangible computing, a system that senses the movement of the body and converting that into movies and sounds as a case of physical computing, and a system that uses a neural interface to control movies and sounds as a case of neural computing.

2.1.Performance systems with tangible computing

Systems using table tops to control movies and sounds have intuitive controllability and multifunctionality but lacks of appeal in the actual performance [3][4][5][6]. First, the intuitive control is realized by reflecting the movements of the tangible objects in the real space to the parameter on the application. Then, the multifunctionality is realized by measuring the ID, the 3D tilt, adjacent information and position of the tangible object. However, the more complex the manipulation gets on the tabletop, the more the users attention would be on the tangible objects on the table. Therefore the attractiveness of the actual performance is lacking.

2.2.Performance systems with physical computing

Systems that use image analysis to sense the physical movement of the body and convert that into sound or movies have a high attractiveness as an actual performance, but cannot arbitrary control it [7][8][9][10]. These systems use things such as web cameras and infrared cameras for the image analysis and analyze the users' movement, acceleration, quantity of the movement and the position information to parameterize it. In this case, users can get flexibility in their movement and express freely, resulting that the performance is attractive. However, it is difficult to control motionless states by the nature of image analysis. Also, it is impossible to finely control them as the control is based on actions.

Sensing the body movement by holding sensors and wearable sensors and then converting to movies and sounds have the same characteristics as the systems above. These systems give users the load to attach to the body the sensor which collects the analyzable information. Nonetheless, as long as the physical flexibility is not limited, this enables a more attractive performance. Also as stated above, it is difficult to analyze motionless states and is impossible to finely control.

2.3. Neural Interface and Performance systems

In all of the biosignals that can be obtained with a general neural interface, there are cases in human computer interaction(HCI) that applies the brain waves (EEG), heart rate (EKG), skin resistance (GSR) and muscle potential (EMG). EEG can be obtained by recording the electrical activity in the brain by placing the electrode on the head. EKG can be obtained by counting the number of heartbeats (the contraction) the heart makes in 1 minute. EMG can be obtained by recording the action potential of the muscle fiber when it is adrenalized. GSR can be obtained by measuring the electrical resistance of the skin when the respiratory glands are active due to a sympathetic stimulation.

The characteristics of each biosignal can be extracted (Table 1). It is important to select which biosignal to adopt based on the character of the application.

Table 1. Biosignals used in HCI and their characteristics

Name	Characteristics
EEG	Mainly analyzes the conception, emotion and the expression and is highly informative. Lacks accurate real time control.
EKG	Highly accurate and has a small margin of error when measured in different spots. Lacks controllability and is difficult to control real time.
EMG	Has accurate controllability and can be controlled real time. Able to control motionless states.
GSR	Highly accurate but differs when measured in different spots. Lacks controllability and is difficult to control real time.

There are many different research cases that apply biosignals to HCI. As a case of UI, Saponas used EMG to classify the position and the pressure when pushing with a finger, tapping with five fingers and holding something up [13]. Gilles Dubost suggests that the EMG is the best approach to the human body and designed a Bluetooth biologic sensor for interactive music [14]. IBVA detected delta rhythm, theta rhythm, alpha rhythm and beta rhythm for the muscle potential of the eyes by using 3 EEG sensors [15]. As a case of mobiles, Enrico Costanza designed and evaluated the Wireless EMG motionless gesture sensor based on the social context when using mobile devices [16][17]. Then as a case of game controllers, there is EmotivEPOC which uses 18 sensors to measure the EEG and detect the conception, emotion and expression to send wirelessly to the computer as a data [18]. Also ThinkGear detects the concentration and relaxing of the brain wave and the movement of the eyeball and blinking in a single sensor [19]. As a case of interactive games, there is a game that is designed like a biathlon which the skiing speed and the speed to adjust to the aim when shooting increases when the heart rate rises [20]. Finally, as a case of installations, Room of Desires changes the composition of the 750 video sequences according to the rate on the EEG and EKG sensors [21]. Lilith changes the virtual landscape according to the rate on the EEG, EKG and GSR sensors [22]. Censor Chair is a projected movie that shows a black bar as in a censorship when the rate of arousal and anxiety increases on the GSR sensor [23].

In the aspects of live performance system, there are some cases that used biosignals to map as a parameter for sounds and movies. Eduardo Miranda [24] used the Hjorth Analysis method in the BCMI-PIANO system and analyzed EEG into 3 waves, the activity, mobility and the complexity to create a sound using the parameters. Nagashima [25] realized 3 functions using the original sensor for EMG in BioCosmic Storm □, to make a 16ch band pass filter for white noises, to create a sine curve with 16 unique pitches and to FM composite 3+3 operators and 10 parameters. Baba [26] plays the drum sound assigned to a few of the audiences by detecting the contact by using the GSR. Robert Hamilton [27] built a system to display a recomposed version of the musical score written beforehand according to the measurement of the GSR obtained from the performers. These cases are focused mainly on the sound performance and there are no performance systems that focus on the visual effects like a VJ (Visual Jockey) in the previous researches.

3. Design Concept

Nervixxx adopts two design concepts. One concept is about the combination of different neural interfaces. The other concept is about the combination between tangible interface and neural interface. We aim to solve some problems which the existing live performance systems have.

First, a number of neural interfaces with different characteristics are combined to match the purpose of the application. Nervixxx realizes the parameter control of the motion graphic data and visual effect data and also the motion graphic generation by neural computing. In concrete terms, EMG attached to both arms for the former and EEG for the latter is used. EMG is appropriate for accurate parameter control as it is able to arbitrary control real time. On the other hand, EEG is appropriate for motion graphics as the information is from the conception, emotion and expression, there is a variety of patterns based on the individual.

Secondly, the complexity of functions can be made possible by matching neural interface with tangible interface which is suited for intuitive control. Nervixxx realizes mixing of motion graphic data and applying visual effects with the users' fingertips using tangible computing. This makes it possible to control applications intuitively. In this case, the focus for the high function such as the parameter control should not be on the tangible object, so it is dispersed by measuring with the neural interface. This enables to maintain the capability of the complex processing and attract the actual performance. Therefore, flexibility seen in physical computing is maintained and also has an arbitrary control.

4. System

4.1. System

There are 4 layers to the Nervixxx system flow, Real world, Sensing, Data and Feedback (Figure2). First, in the Real world layer, there are tangible objects for users to control the motion graphics data and visual effects, arms to control the parameter and brain waves as motion graphics. Then, in the Sensing layer, tangible objects are analyzed by using image analysis. At the same time, the muscle potential of the arm and brain waves are analyzed. Next, in the Data layer, as a result of image processing, the type (motion graphic data/ visual effect) of tangible objects, ID and location information is stored as a parameter data. Lastly, in the Feedback layer, the 4 feedbacks are presented. One feedback shows an animation based on the location of the tangible object on the table top by sorting from the type and the location information of the tangible object. Second feedback changes the playing speed based on the variation of EMG when played by the tangible

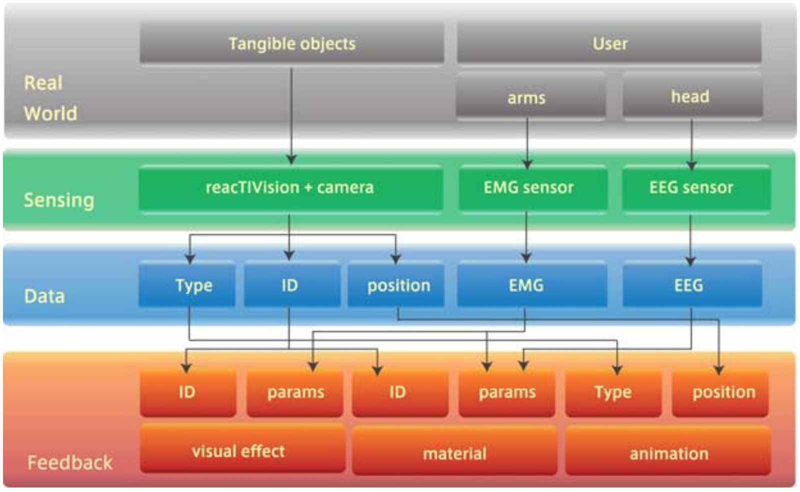


Figure 2. The system flow

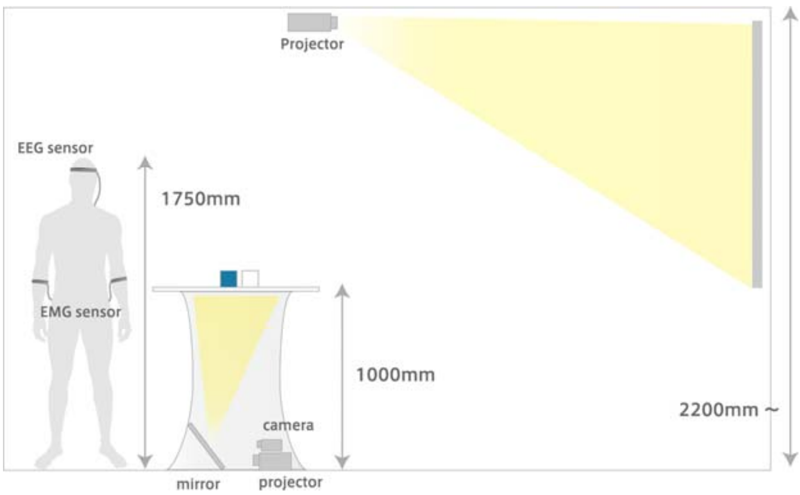


Figure 3. The hardware deployment

object's ID and motion graphic data. Third feedback applies visual effects on the motion graphic data sorted by the ID of the tangible object and changes each parameter based on the variation of EMG. The hardware deployment is shown in Figure3.

4.2. Sensing

The ID and the location information of the tangible objects on the table top are obtained from reacTIVision Framework [4]. reacTIVision is a open source platform that has fiducial markers to analyze the image and enables to get an ID and location information for each image. In Nervixxx, the fiducial marker is attached to the bottom of the tangible object which is shot with a camera from the inside of the table so the ID and the location information can be obtained. If there is no object on the table, it indicates a value parameter of null and if there is an object on the table, it indicated the ID (00-) and the X-Y coordinates (x,y).

By using the EMG sensor attached to the users' arms, the variation of the muscle potential can be obtained. EMG sensors can obtain AC signals generated by muscle contraction in 1-200Hz bandwidth. The obtained value is sent to the computer through Bluetooth. After the value is received, it is formed according to the variation (min.0.0- max. 1.0) set at 200msec each in the software. Then it is assigned as a parameter to control the speed of the motion graphic data or an arbitrary parameter for each visual effect.

By using the EEG sensor worn on the users' heads, users' brain waves can be obtained. EEG sensors can obtain AC signals generated by the brain activity in 1-200 Hz bandwidth. The obtained value here is also sent to the computer through Bluetooth. After the value is received, it is passed on as a wave data to the brain wave motion graphic data generating parameter on the software.

4.3. Feedback

4.3.1. Motion Graphics Data. When users place the tangible object (material object) assigned with motion graphic data on the table top, the arbitrary motion graphics data can be loaded. At present, there are 11 – 20 IDs assigned for motion graphics data. Also, an icon in the motion graphic motif is printed on the top of the object. The motion graphic data can be mixed by placing 2 material objects on the table top at the same time.

In Nervixxx, in order to have an easier recognition of material objects treating motion graphics data and effect objects treating the visual effect data, a wavelike animation is projected on the table top. When an object is recognized, a wavelike animation based on the obtained X-Y coordinates is projected below the object. The main color for motion graphics data is green and for visual effect data is light blue, so this makes it easier for users to recognize the effect (Figure 4).

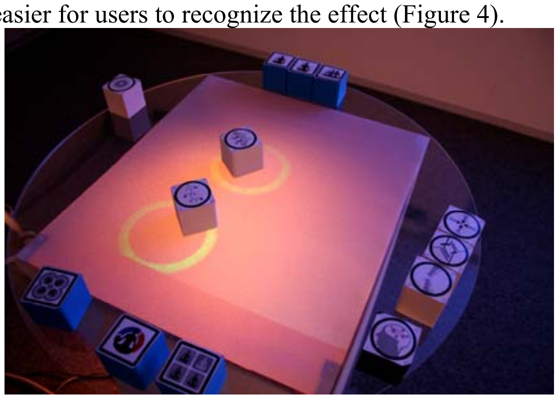


Figure4. Tangible Objects on the table top. When user places material objects, the green circle animation appears under the object.

Users can then control the playing speed of the motion graphics data by the variation of the value on the EMG sensor attached to one of their arms. The more the user moves the user's arm, the more EMG in the arms changes. It also changes even if the user just put some muscle without any movement. The value sent by wireless EMG sensors is converted into a value of 0.0 – 1.0 on the software. According to this value, the playing speed changes within 0.0 to 3.0.

Also, users can use their individual brain wave data as a motion graphics data in their performance by using the EEG sensor. Therefore, users wear a brain wave motion graphics data object (brain object) which has ID00 and a wireless EEG sensor on their foreheads. The value obtained from the wireless EEG sensor is processed as a wavelike data in time sequence. It is then loaded as a brain wave motion graphics data after it is combined with the scaling and feedback effects (Figure 5).

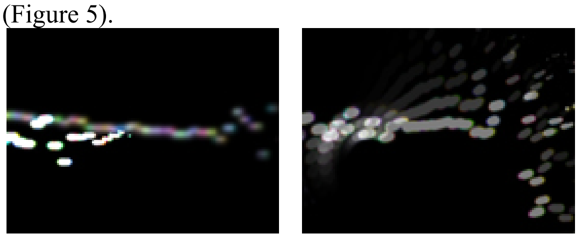
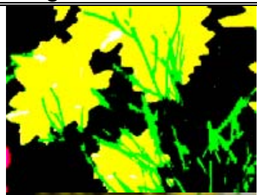


Figure5. Left : Wave data taken from EEG data Right : Default image processed from the wave data when brain object is put on the table.

Table 2. ID, Effect name, general description and image of the effect object

ID	Effect Name	General Description	Image
31	Glow	Applies a glowing effect by changing the contrast (1.0-5.0) and the brightness (1.0-5.0) based on the variation of EMG.	
32	Offshoot	Controls ratio of the movement (0-320px) of 4 separate layers based on the variation of muscle potential.	
33	Division	Divides the frame (2-5) based on the variation of muscle potential.	
34	RGB	Able to control a random RGB level(0-255) based on the variation of muscle potential. RGB is set randomly.	
35	Kaleido	Applies a kaleidoscope effect by changing the number of rotations (1.0-3.0) and scale (1.0-0.3) based on the variation of muscle potential.	
36	Feedback	Controls the residual ratio (0-1.0) and the time (0-1000msec) of the previous frame based on the electric potential.	

4.3.2. Visual Effects Data. Users can load arbitrary visual effect data by placing the tangible objects (effect objects) on the table, like the material object. At present, there are 31-36 IDs assigned for visual effect data. Also, an icon in the visual graphics motif is printed on the top of the object. Unlike the material object, multilayer visual effects can be applied by placing multiple visual effect objects on the table top at the same time for one material object.

Users can then control the parameter of each effect by the variation of the value on the EMG sensor attached to the other one of their arms. The value sent by wireless EMG sensors is converted into a value of 0.0 – 1.0 on the software. According to this value, the parameters change relatively (Table 2).

5. Evaluation & Future Development

We had a user who has experience playing as a visual jockey perform Nervixxx for 30 minutes to evaluate the system as a video performance system and asked his opinion. The hearing categories are 4 categories: 1. Attractiveness of the actual performance, 2. Arbitrary control by EMG, 3. Intuitive manipulation by tangible objects, 4. Complex process by combination of simple functions. After explaining each category, we had him comment freely. The pros and cons of each category are summerized (Table3).

Table3 : The result of the interview

1. Attractiveness of the actual performance.	
To use the EMG sensors increases the attractiveness of performance itself.	The appearance of the EEG sensor is not good.
2. Arbitrary control by EMG.	
It is easier to control than user interfaces on desktop computing.	I guess that to use the controller by EMG for a long time makes the user tired.
3. Intuitive manipulation by tangible objects.	
The mixing function with the tangible objects is understandable. Switching each data can be done smoothly.	There are some areas where the system cannot recognize the position of the objects. Why doesn't this system have another function regarding the positions of the objects? It is better to visualize the relationship between the material objects and visual effect objects.
4. Complex process by combination of simple functions.	
Each object having a wide variety of parameters controlled means the user can achieve a wide variety of expression.	It is difficult to recognize the variation of EEG. The function to import material data freely is desirable.

We will improve these cons for future developments. From the result of the experts, two points are listed as immediate improvements. First, one point is the way to utilize EEG as one of the motion graphics data. In the present system, it is only used as an electric signal and as data for wave lines. It is preferred to be used as advanced information for conception, emotion and expression. It makes the performance differences more recognizable between the users. Secondly, the other point concerns the problem of the object analysis. The present version has several areas where the system cannot recognize the objects on the tabletop from the relationship in the body between the camera and the projector. This problem arises because the image analysis based on the camera catches the light from the projector. We will solve this problem by delaying the each frame between shooting by the camera and projection from the projector.

6. Conclusion

In this paper, we describe a system using neural computing to solve the problems that the conventional tangible computing and physical computing performance systems had. First, EMG data was assigned and controlled to arbitrary control each parameter for the motion graphics data and visual effects. Secondly, EEG data was used as a motion graphics data to directly link the performer's individuality as an expression. And lastly, to realize a complex process, neural interface was matched with tangible interface that has a high controllability. As a result, we were able to set up a system that has the advantages for each approach which did not appear together in conventional systems, for example, improvement of the attractiveness of the actual performance, arbitrary control, intuitive manipulation and complex process. In the future, we improve the processing of EEG and the recognition of the objects.

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