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Preliminary Test of Affective Virtual Reality Scenes with Head Mount Display for Emotion Elicitation Experiment

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Abstract: Emotion elicitation experiments are conducted to collect biological signals from a subject who is in a state of emotion. The recorded signals are used as training/test dataset for constructing an emotion recognition system by means of machine learning. In conventional emotion elicitation experiments, affective images or videos were provided for a subject to draw out an emotion from them. However, the authors have concerns about the effectiveness. To surely evoke a specific emotion from subjects, we have produced several Virtual Reality (VR) scenes and provided the subjects with the scenes through a Head Mount Display (HMD) in emotion elicitation experiments. Usability and effectiveness of the VR scenes with the HMD for emotion elicitation were experimentally verified. It was confirmed that experience of the VR scenes with the HMD was effective in evoking emotions, but we have to improve how subjects learn a way of playing VR scenes and provide measures against VR sickness at any cost. Moreover, Support Vector Machine classifiers as an emotion recognition system were constructed using the biological signals measured from the subjects in the emotion elicitation experiments.

Keywords: Emotion Recognition, Emotion Elicitation, Virtual Reality, Head Mount Display

1. INTRODUCTION

Emotion recognition systems with high accuracy can be used in many ways because it enriches interactions between computers and users. The systems would be absolutely necessary to develop robots that communicate with users and appropriately response to their requests [1, 2]. Mental therapy, such as counseling, music therapy, and self-help for mental disorders, also need the emotion recognition technology so that health care workers can accurately identify an emotional state of a patient for the treatments [3-5].

There are already a lot of preceding studies on emotion recognition system development. Some of the previous studies used user's speeches and expression to recognize their emotions. However, human beings can hide their facial expressions and/or intentionally change the tone of their voice with ease [6]. Since you can obtain the information only intermittently, the emotion recognition system based on speeches and facial expression are unavailable in a case that it must continuously yield recognition results. Besides reflecting their state of emotion, biological signals can be measured continuously. Therefore, this study aims to construct an emotion recognition system based on biological signals using machine learning technique.

While several preceding studies have developed emotion recognition systems with biological signals, there are few systems with practical accuracy [7]. One of the causes is that preparing a large quantity of high-quality training dataset is absolutely essential in order to achieve practical accuracy of emotion recognition with machine learning. Emotion elicitation experiments have been commonly conducted in a lot of studies on emotion recognition to collect training data for building an emotion recognition system [8, 9], however it is not always possible to arouse the emotion that an experimenter intended in the experiments. In addition, it is also difficult to prepare a large number of pictures and videos for emotion elicitation experiment. Although you can use a database of images for studying emotion, such as IAPS [10], the database includes violent and sexual images. For this reason, there is a possibility that those images would cause mental damages to subjects. Moreover, just watching images and videos might not be able to sufficiently induce emotional ups and downs in subjects because the stimulation only give them a scant sense of reality.

The authors propose eliciting an emotion of a subject by means of Virtual Reality (VR) scene experience through a Head Mount Display (HMD), which can provide a user with a high-quality sense of reality, presence, and immersion. This paper describes the VR scenes developed for use in emotion elicitation experiments, and then presents experimental results showing that a HMD is appropriate for emotion elicitation taking advantage of VR scene experience than a flat display. In addition, it indicates accuracy of the emotion recognition system constructed using biological signals of subjects who were playing the VR scenes.

2. VR SCENES FOR EMOTION ELICITATION

You need to prepare plenty of biological signals of subjects who are in a state of emotion, so that you can make an emotion recognition system using machine learning. The biological signals are used as training/test dataset for machine learning. As mentioned above, previous studies collected the dataset by means of emotion elicitation experiment. In the experiment, affective music, images, and videos were utilized to arouse an emotion in a subject, but we have concerns about the effectiveness.

VR can provide a user with simulated environments regardless of realistic or unrealistic. Moreover, VR scene experience through a HMD produces a high-quality sense of reality, presence, and immersion. Therefore, VR has a potential to effectively evoke users' emotions. The efficacy of VR as affective medium for anxiety and relaxation has been investigated especially about a circular interaction between presence and emotions [11]. Virtual reality exposure therapy (VRET) is an example that VR has been applied to mental treatment with its potential [12].

We have created five VR scenes for evoking "Happy", "Relaxed", "Depressed", "Distressed", and "Fear" using Unity [13], 3D game development environment. Subjects played each of the VR scenes in 60 seconds. VR scenes for practice and emotion evaluation were also produced. The subjects were asked to report the evoked emotion while watching the emotion evaluation VR scene.

Fig. 1 shows a VR scene for drawing out "Happy" emotion from a subject. The subject take a crane and fly between floating islands in the simulated environment. After a lapse of 30 seconds, the VR scene gets dark and then fireworks explode in the night sky.

Fig. 2 is a VR scene for "Relaxed" where a subject walk around freely in the simulated village with calm atmosphere.

The VR scene shown in Fig. 3 is for evoking "Depressed" emotion. When you pass through a particular point in the dark basement of the VR scene, zombies get up all at once and turn to you.

Fig. 4 is a virtual barren desert for "Distressed" emotion, where an aged person is burying a coffin in the desert. You will hear his sob when you get close to him.

Fig. 5 was created with the intention of inducing "Fear" emotion. You are inside of a ruined church at the beginning and start to wander about in the cemetery. After a certain time, a ghost suddenly appears in front of you.

Fig. 1 VR scene for eliciting “Happy” emotion

Fig. 2 VR scene for eliciting “Relaxed” emotion

Fig. 3 VR scene for eliciting “Depressed” emotion

Fig. 4 VR scene for eliciting “Distressed” emotion

Fig. 5 VR scene for eliciting “Fear” emotion

In this study, subjects watched these VR scenes through a HMD or a flat display. Oculus Rift DK2 was used as the HMD, the flat display was 23-inch Iiyama ProLite X2377HDS, and Xbox 360 controller was a device for move operation in the VR scenes.

3. EMOTION ELICITATION EXPERIMENTS WITH VR SCENES

The authors conducted experiments to verify that the VR scenes are effective to elicit a state of emotion from a person. 10 male college students of 21-year-old participated in the experiments as subjects. We made the subjects separated into two groups. 5 subjects experienced the VR scenes with the HMD, while the other 5 subjects watched them on the flat display. 4 sensors were put on the subject to record their biological signals, heartbeat, electrical skin conductance, skin temperature, and breathing rate.

Fig. 6 is a procedure of the experiment. We carefully explained the procedure to the subjects at the beginning, and then received signed consent forms.

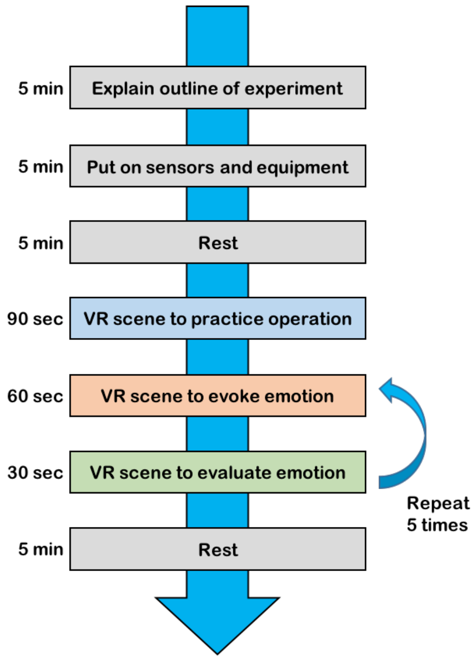


Fig. 6 Experimental procedure

We checked usability of the HMD and flat display for the VR scenes in terms of the 5 evaluation items stated below, which were made by reference to ISO9241-11. After finishing the experiment, the subjects evaluated the evaluation items about usability in five stages.

1. **Effectiveness**: aroused an emotion by the VR scene experience
2. **Efficiency**: could evaluate your own emotion after the VR scene experience
3. **Satisfaction**: did not feel any stress and anxiety while experience the VR scenes
4. **Environmental setting**: the experimental environment was arranged neatly and everything was ready
5. **Learnability**: could readily learn how to watch and play the VR scenes

Fig. 7 and Fig. 8 are usability evaluation results by the subjects watched on the flat display and the ones wore the HMD, respectively. Focusing on the averaged point, "Effectiveness", "Efficiency", and "Environmental setting" were evaluated higher by the subjects used the HMD. Using the HMD caused the higher scores of "Effectiveness" and "Efficiency" probably because the device provided the subjects with a higher sense of reality and immersion, and evoked their stronger emotions. In regard to "Learnability", the subjects watching through the flat display gave higher points than those with the HMD. The likely cause is that almost all subjects were inexperienced in wearing a HMD. Hence it is necessary to devise a VR scene where a subject can practice in using a HMD. 3 subjects with the HMD had complained of VR sickness, and gave "Satisfaction" quite low points.

Fig. 7 Usability evaluation by subjects used display

Fig. 8 Usability evaluation by subjects used HMD

It was confirmed from these results that experience of the VR scenes with the HMD was effective in eliciting emotions. However, we have to improve how subjects learn a way of playing VR scenes, and provide measures against VR sickness at any cost.

In addition, we investigated the biological signals recorded from the subjects watching the VR scenes on the flat display and the ones used the HMD. Table 1 describes biological signal change from baseline that we intended to come about in a subject playing the VR scenes. The averaged changes found in each of the groups are shown in Table 2 and Table 3, in which the values that indicated not only desired but also stronger change are colored in red. These results show that using the HMD led the subjects' biological signals to be more appropriately provoked than watching on the flat display.

Table 1 Intended change of biological signals from baseline

	Happy	Relaxed	Depressed	Distressed	Fear
Heartbeat	higher	lower	lower	higher	higher
Skin conductance	lower	lower	lower	lower	lower
Skin temperature	higher	higher	lower	lower	lower
Breathing rate	higher	lower	lower	higher	higher

Table 2 Averaged change of biological signals (display)

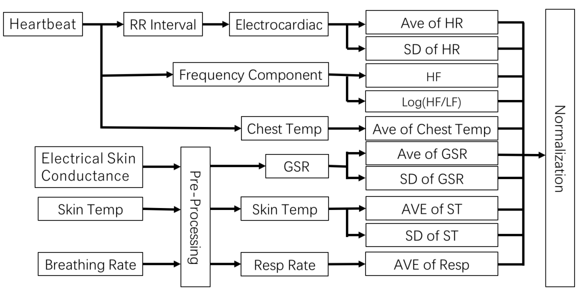
	Happy	Relaxed	Depressed	Distressed	Fear
Heartbeat	2.791	1.563	2.125	1.873	3.648
Skin conductance	-8.690	-16.66	-24.42	-36.71	-47.15
Skin temperature	-1.067	-1.008	-1.218	-1.230	-1.388
Breathing rate	0.236	0.046	0.168	0.075	-1.389

Table 3 Averaged change of biological signals (HMD)

	Happy	Relaxed	Depressed	Distressed	Fear
Heartbeat	1.976	1.115	5.974	3.222	4.662
Skin conductance	-28.06	-20.40	-79.21	-67.00	-121.6
Skin temperature	0.296	0.851	1.034	1.189	1.073
Breathing rate	-1.696	-0.938	-2.452	-2.060	-1.881

4. EMOTION RECOGNITION WITH SVM

The authors adopted Support Vector Machine (SVM) with Radial Basis Function (RBF) kernel to construct emotion recognition systems with the biological signals collected in the emotion elicitation experiments with the VR scenes. As shown in Fig. 9, feature vectors as training/test datasets were extracted from the biological signals recorded from the subjects. Only 150 samples for each subject were obtained in the emotion elicitation experiments. LIBSVM [14] was employed for making the SVM emotion recognition systems. The RBF kernel parameter and a cost parameter were adjusted in the range of -2^{-2} to 2^{2} and 2^{-5} to 2^{5}, respectively, using grid search on the basis of the samples. The performance of the emotion recognition systems was evaluated using leave-one-out cross-validation.



Ave: Average, SD: Standard Deviation, HR: Heart Rate, GSR: Galvanic Skin Response, HF: High Frequency, LF: Low Frequency, Temp: Temperature, ST: Skin Temperature, Resp: Respiration

Fig. 9 Feature extraction from biological signals

Table 4 shows the results of emotion recognition with the SVM. The results said that there was no significant difference between using the devices, display and HMD. The shortage of the samples used to make the SVM apparently caused the dissatisfied recognition results.

Table 4 Emotion recognition rate

Device	Display	HMD
Ave.	80.67	81.33
SD	4.897	5.417

5. CONCLUSION

This paper proposed the emotion elicitation method with VR through HMD for surely evoking a specific emotion from a subject. When it comes to biological signals reflecting an evoked emotion in a subejct, they were appropriately activated or deactivated by means of watching the affective VR scenes through the HMD. With respect to the emotion recognition rate of the SVM, however, notable enhancement was not achieved probably because of not enough data for machine learning. We will improve the affective VR scenes and introduce measures against VR sickness in order to conduct emotion elicitation experiments again to collect more effective samples for constructing an emotion recognition system with high accuracy.

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