Analysis on User's Electroencephalography for Automatic Detection of 3D Syndrome

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Abstract

Various contents utilizing 3D holographic image have been developed and this led to the need of research on problems which are related to 3D syndrome. It is now more urgent to find the mechanism to sort out such problems as some people show such symptoms as fatigue, dizziness and vomiting after watching 3D contents. This research, in this light, has been conducted to suggest an indicator for detecting 3D syndrome by extracting and analyzing the changes in user's electroencephalogram of which result can be utilized for implementing the system which prevent and mitigate the syndromes which occur after watching 3D holography.

Keywords: 3D syndrome, coefficient correlation, brain wave, feature vector, detect

1. Introduction

The constant success of various contents utilizing 3D holography has resulted in 3D image-revolution which has become the priming for exploiting 3D-related products and market in new dimension. As a result, the 3D holography is being utilized and expanded to various contents [4-8]. The rapid development of 3D market, however, led to 3D syndrome which is one of the side effects of 3D technology. The syndrome, which is also called as 3D vision syndrome, includes eye-fatigue, headache, sight blurring, double image, dizziness and vomiting after watching 3D TV or video game [1, 2, 3, 9, 10]. As the development of 3D holography, which is being utilized in various field, has been focusing only on its profitability and spread of the technology, there has not be proper technical mechanism for sorting out the physical, psychological and physiological side effects. Therefore, this study has analyzed the characteristics of brain wave which occurs from 3D syndromes to suggest an indicator for detecting 3D syndrome according to each symptom and this is to sort out the 3D syndrome related symptoms so that the users can use 3D holographic contents comfortably. Further, the result of this will be utilized to suggest basic elements for eliminating the various side effects resulted from the 3D technology which has been utilized indiscreetly in various fields.

2. Related Works

Currently, the 3D technology is being utilized in various fields including TV, SW and contents but there has not been consideration on its side effects resulted from the products. There are some of ongoing studies on the 3D syndromes as the majority of users appeal eye fatigue and anxiety after watching 3D holographic image for a long time. Most of them, however, are focusing on the measurement of the level of eye fatigue rather than the danger of the eye fatigue and even there has not been standardized measurement yet [6, 7].

2.1. The Level of Eye Fatigue

The symptoms related to eye fatigue which occurs during and after watching 3D image include eye fatigue, tear, eye pressure, pain around eyes, inconvenient blinking, heated eye, difficulty in eye-focusing, blurred sight, hardened shoulders and headache. Further, the objective measurement for level of fatigue includes the subjective rating of controlling ability, sight, diameter of pupil, major synthesized frequency, eye moving speed, the level of eye fatigue and working ability [3, 4, 5, 10].

2.1. The Level of Eye Fatigue

The fundamental cause of eye fatigue is that the viewer of 3D stereoscopic image makes an image synthesizing different images reflected each eye. If the different image rids itself of the range in which the two images are synthesized, the viewer experiences a double image. As a result, convergence, diffusion and accommodation of eyes do not work properly hence eye fatigue occurs. Also, the eye fatigue is caused by the rapid changes in deepness of each scene. It has been reported that balances deepness between each scene makes the viewer more comfortable [8].

The infinite distant of focus point can cause eye fatigue. Stereoscopic image creates broader range of depth compared to the visual environment (the size of pupil) and focusing distant in real environment and this causes fatigue of eyes. If the difference become larger, the viewer perceive distinct image at the point on which he does not focus. In daily life, this image blurs hence the viewer does not perceive it. The unwatchable image which is blurred, according to the watching-section, becomes available to watch in stereoscopic image and the broadened difference causes eye fatigue [4].

3. Configuration of Experimental Environment

This experiment has been carried out to extract feature vector of the brain wave signal occurred by 3D syndrome by analyzing the changes in brain wave of viewers while they watch 3D stereoscopic image. To do so, the brain wave of participants has been classified into four categories for extractions and they are as follows: before and after watching 3D image, during watching the image, when the participant feels the 3D syndrome. Further the feature vector has been extracted from each part and this is to establish a standardized indication of changes in brain wave which is occurred by 3D syndrome.

3.1. Environmental Factors

This experiment is to analyze changes in brain wave which is to analyze the standardized indication of 3D syndrome caused by watching 3D stereoscopic image. The experiment, as the Figure 1 indicates, has been conducted in a 1person-sized experiment booth (about 320x180cm). During the experiment, external discouragements such as light and noise have been minimized to maximize the engagement of participants in watching the 3D image for the

best reliability of result. Further, the distant between 3D TV (42inch) and participants has been set at 160cm which in which 3D stereoscopic image can be outputted.
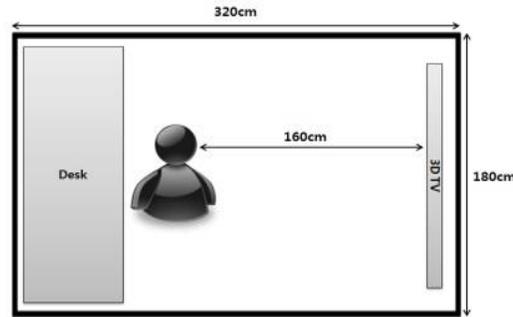

Figure 1. Experimental Environment

3.2. Methods

☑ Step 1

As a part of preparation for the experiment, brain wave measuring disc has been attached on "F7(ch1), F8(ch2), T3(ch3), T4(ch4), T5(ch5), T6(ch6), O1(ch7), O2(ch8)"of the participants head, 3D stereoscopic image has been prepared, noise has been minimized, headset and polarized 3D classes, which are for the participants to focus on the image, have been prepared according to 10-20 international electrode system. In this experiment F7 and F8 points of frontal lobe has been utilized regarding concentration and space-time perception, T3, T4, T5, T6 points of temporal lobe which is related to auditory perception and emotion have been utilized, O1 and O2 of occipital lobes, which are related to sight, have been utilized. The brain wave has been collected by using QEEG-8(LAXTHA Ltd. Co., Korea) which is a measuring equipment of brainwave with eight channels, input key-pad has been prepared to check the time in which the participants appeal 3D syndrome. To minimize the actions required for measuring brainwave, the participants have been educated to minimize their movement.

☑ Step 2

This stage is non-stimulation stage which is before watching 3D image that the brain wave of participants has been measured in stabilized state for five minutes before watching the image.

☑ Step 3

In this stage, the changes in brainwave before watching 3D stereoscopic image have been analyzed to extract the feature vector of brain wave when 3D syndrome occurs. The participants have watched 3D image for half an hour in stabilized state wearing polarized 3D stereoscopic glasses headset for concentration. When they feel such 3D syndrome symptoms as dizziness, eye fatigue or vomiting while watching the image, the subject has recorded the time in which he/she felt the symptom by using input keypad.

☑ Step 4

The next stage is stabilized stage after watching the 3D image. In this stage the participants have taken off glasses, headset and their brain wave have been measured for ten minutes in stabilized state as same as the stage 2. The purpose of this stage is to analyze the accurate

point in which 3D syndrome can occur and the extent such symptom occur after watching 3D image. In this stage, the participants who felt 3D syndrome symptom have recorded the time in which their symptom has occurred by using the input keypad.

4. Experimental Results

It has been attempted, during this experiment, to extract feature vector for automatic detections of 3D syndrome by analyzing changes in brain wave. In doing so, analysis on correlation of brainwave between frontal/occipital lobes and left/right brain has been carried out. In addition, for analysis on correlation between each channel, brain wave has been analyzed classifying them into alpha, beta, delta, theta and gamma waves, which are common classification of brainwave, and their indication have been established.

4.1. Analysis on Correlation between Channels of each Frequency Range in Frontal/Occipital Lobes

In this experiment, the brain wave signal of participants during non-stimulation stage (5 minutes), while watching the 3D contents (30 minutes) and stabilized stage (10 minutes) have been analyzed according to each channel of each frequency band to analyze correlation between brain wave of frontal/occipital lobes and the result is shown in Figure 2.

Figure 2. Coefficient Correlation and Change Rate of Frequency Band Channel of Frontal/Occipital Lobes

As the Figure 2 shows below, the correlation coefficient of each channel of alpha wave frequency band has been show the highest at ch4-ch-6 and ch3-5 respectively in descending order. In addition, the change in correlation coefficient between stimulation stage and watching stage has been appeared to be higher by 20% in every channel other than ch3-ch5 and ch4-ch6. Further, the correlation coefficient of each channel of beta wave band has been appeared to be highest in ch4-ch6 and ch3-ch5 respectively. Further, the correlation coefficient between non-stimulation and 3D watching stage has increased by more than 10% in every channel apart from ch1-ch7, ch3-ch5, ch3-ch7, ch4-ch5, ch4-ch6 and ch4-ch7. The correlation coefficient of each channel of delta wave has appeared to be the highest at ch4-ch6 and ch3-ch5 respectively. In addition, the correlation coefficient between non-stimulation and 3D watching stage has increased by more than 13% in every channel apart from ch3-ch5 and ch4-ch6.

The correlation coefficient of each channel of gamma wave has appeared to be highest at ch4-ch6 and ch3-ch5 respectively. Further, correlation coefficient between non-stimulation and 3D watching stage has increased by more than 3% on average. The correlation coefficient between each channel of theta wave ban has appeared to be in ch4-ch6 and ch3-ch5 respectively. Further, the correlation coefficient between non-stimulation and 3D watching stage has increased by more than 5% apart from ch3-ch5 and ch4-ch6 which showed low level of increasing.

According to the analyzed result, it has been found that measurement by utilizing correlation coefficient of channels apart from ch3-ch5 and ch4-ch6, the changes in correlation coefficient between non-stimulation/ 3D watching stage stabilization/3D watching stage are the feature vector which can be utilized for detection of 3D syndrome symptoms by utilizing correlation coefficient of brain wave in frontal/occipital lobes. Especially, speed of change in correlation coefficient between non-stimulation/watching and stabilization/watching stage have been appeared to be highest in alpha and delta waves compared to the others and it seems that this can be utilized for detecting 3D syndrome symptoms properly.

4.2. Analysis on Correlation Coefficient of Each Channel Frequency of Left/Right Brains

In this experiment, the correlation coefficient of each channel of each frequency band have been analyzed by analyzing the brain waves which have occurred during non-stimulation (5 minutes), 3D contents watching (30 minutes) and stabilization (1 0minutes) stage which have been collected from participants for analyzing correlation coefficient of brain wave of left/right brains and the results are indicated in Figure 3.

alpha wave	ch1 - ch2	ch1 - ch4	ch1 - ch6	ch1 - ch8	ch3 - ch2	ch3 - ch4	ch3 - ch6	ch3 - ch8	ch5 - ch2	ch5 - ch4	ch5 - ch6	ch5 - ch8	ch7 - ch2	ch7 - ch4	ch7 - ch6	ch7 - ch8	average
Non-Stimulation	0.59	0.41	0.35	0.37	0.45	0.4	0.36	0.39	0.38	0.39	0.45	0.49	0.43	0.47	0.54	0.57	0.44
Non-Stimulation – Percentage Change while Watching	-31.13%	-33.65%	-42.04%	-36.86%	-36.09%	-25.46%	-29.05%	-29.44%	-38.30%	-23.44%	-21.68%	-25.18%	-26.71%	-21.55%	-20.88%	-21.58%	-28.39%
watching	0.4	0.27	0.2	0.23	0.28	0.3	0.26	0.27	0.23	0.3	0.35	0.36	0.31	0.37	0.42	0.45	0.31
Stabilizing while Watching – Percentage Change while Watching, Stabilization	-27.22%	-32.76%	-39.67%	-32.99%	-33.97%	-28.88%	-31.75%	-30.98%	-30.40%	-21.39%	-19.26%	-20.54%	-19.30%	-16.30%	-13.95%	-17.39%	-25.41%
Stabilization	0.56	0.4	0.34	0.35	0.43	0.42	0.38	0.39	0.34	0.38	0.43	0.46	0.39	0.44	0.49	0.54	0.42
beta wave	ch1 - ch2	ch1 - ch4	ch1 - ch6	ch1 - ch8	ch3 - ch2	ch3 - ch4	ch3 - ch6	ch3 - ch8	ch5 - ch2	ch5 - ch4	ch5 - ch6	ch5 - ch8	ch7 - ch2	ch7 - ch4	ch7 - ch6	ch7 - ch8	average
Non-Stimulation	0.61	0.41	0.29	0.32	0.46	0.39	0.32	0.34	0.34	0.35	0.34	0.42	0.43	0.41	0.46	0.47	0.4
Non-Stimulation – Percentage Change while Watching	-10.86%	-8.50%	-16.75%	-21.50%	-12.80%	-6.76%	-10.52%	-15.82%	-18.94%	-5.00%	-8.76%	-11.69%	-11.87%	-6.98%	-11.31%	-14.46%	-11.80%
watching	0.55	0.37	0.25	0.25	0.4	0.36	0.29	0.29	0.28	0.33	0.38	0.38	0.37	0.38	0.41	0.4	0.36
Stabilizing while Watching – Percentage Change while Watching, Stabilization	-1.72%	-3.65%	-6.89%	-5.45%	-4.51%	-5.03%	-8.95%	-10.08%	-3.16%	5.10%	4.95%	-1.38%	1.89%	-6.89%	-2.38%	-9.42%	-3.13%
Stabilization	0.56	0.39	0.26	0.26	0.42	0.38	0.32	0.32	0.29	0.31	0.37	0.39	0.36	0.39	0.42	0.44	0.37
delta wave	ch1 - ch2	ch1 - ch4	ch1 - ch6	ch1 - ch8	ch3 - ch2	ch3 - ch4	ch3 - ch6	ch3 - ch8	ch5 - ch2	ch5 - ch4	ch5 - ch6	ch5 - ch8	ch7 - ch2	ch7 - ch4	ch7 - ch6	ch7 - ch8	average
Non-Stimulation	0.59	0.45	0.37	0.35	0.5	0.49	0.44	0.4	0.41	0.47	0.54	0.51	0.44	0.46	0.51	0.48	0.46
Non-Stimulation – Percentage Change while Watching	-11.56%	-12.74%	-25.28%	-30.99%	-16.85%	-12.63%	-19.30%	-23.82%	-22.94%	-15.24%	-13.72%	-16.33%	-19.87%	-17.42%	-18.76%	-22.41%	-18.18%
watching	0.52	0.39	0.27	0.24	0.41	0.43	0.35	0.3	0.32	0.4	0.47	0.42	0.35	0.38	0.41	0.37	0.38
Stabilizing while Watching – Percentage Change while Watching, Stabilization	-5.72%	-11.18%	-20.23%	-22.24%	-11.40%	-10.78%	-15.97%	-19.64%	-15.25%	-11.46%	-6.63%	-9.41%	-11.82%	-13.02%	-13.33%	-23.73%	-13.37%
Stabilization	0.56	0.44	0.34	0.31	0.47	0.48	0.42	0.38	0.37	0.45	0.5	0.47	0.4	0.44	0.47	0.48	0.44
gamma wave	ch1 - ch2	ch1 - ch4	ch1 - ch6	ch1 - ch8	ch3 - ch2	ch3 - ch4	ch3 - ch6	ch3 - ch8	ch5 - ch2	ch5 - ch4	ch5 - ch6	ch5 - ch8	ch7 - ch2	ch7 - ch4	ch7 - ch6	ch7 - ch8	average
Non-Stimulation	0.6	0.42	0.36	0.35	0.46	0.41	0.38	0.38	0.39	0.4	0.52	0.5	0.41	0.43	0.49	0.48	0.44
Non-Stimulation – Percentage Change while Watching	-6.02%	-6.23%	-6.24%	-7.93%	-5.73%	-0.71%	1.59%	-5.04%	-6.64%	-1.43%	-6.93%	-9.06%	-9.01%	-8.90%	-10.01%	-7.28%	-6.11%
watching	0.56	0.39	0.34	0.33	0.43	0.41	0.39	0.36	0.36	0.4	0.48	0.45	0.37	0.39	0.44	0.44	0.41
Stabilizing while Watching – Percentage Change while Watching, Stabilization	-0.50%	-4.95%	-4.68%	-0.67%	-2.13%	-6.36%	-5.13%	-3.30%	5.13%	-0.14%	-2.77%	-6.04%	1.69%	-2.70%	-2.89%	-10.52%	-3.08%
Stabilization	0.57	0.41	0.35	0.33	0.44	0.44	0.41	0.37	0.34	0.4	0.49	0.48	0.37	0.4	0.45	0.49	0.42
theta wave	ch1 - ch2	ch1 - ch4	ch1 - ch6	ch1 - ch8	ch3 - ch2	ch3 - ch4	ch3 - ch6	ch3 - ch8	ch5 - ch2	ch5 - ch4	ch5 - ch6	ch5 - ch8	ch7 - ch2	ch7 - ch4	ch7 - ch6	ch7 - ch8	average
Non-Stimulation	0.57	0.38	0.27	0.32	0.4	0.36	0.29	0.32	0.3	0.33	0.39	0.43	0.38	0.38	0.44	0.48	0.38
Non-Stimulation – Percentage Change while Watching	-9.62%	-12.74%	-15.23%	-13.72%	-10.98%	-9.87%	-9.21%	-10.76%	-11.51%	-5.94%	-8.26%	-10.77%	-5.25%	-5.88%	-11.69%	-12.98%	-10.22%
watching	0.52	0.33	0.23	0.28	0.36	0.33	0.26	0.28	0.27	0.31	0.36	0.38	0.36	0.36	0.39	0.42	0.34
Stabilizing while Watching – Percentage Change while Watching, Stabilization	-1.72%	-9.98%	-10.49%	-2.43%	-6.16%	-6.05%	-9.73%	-7.55%	-0.21%	3.08%	2.87%	-1.51%	5.65%	-2.60%	-3.49%	-6.57%	-3.47%
Stabilization	0.53	0.37	0.25	0.28	0.38	0.35	0.29	0.3	0.27	0.35	0.39	0.34	0.37	0.41	0.45		0.35

Figure 3. Coefficient Correlation and Change Rate of Frequency Band Channel of Left/Right Brains

As the Figure 3 shows below, alpha wave band coefficient for each channel correlation has appeared to be the highest at ch1-ch2 and ch7-ch-8 respectively. Further, the correlation coefficient between non-stimulation and 3D watching stage has increased by more than 28%. The beta wave correlation coefficient for each channel has appeared to be the highest in ch1-ch2 and ch7-ch8 respectively. In addition, the correlation coefficient between non-stimulation and 3D watching stage has increased by more than 11% on average. The delta wave correlation coefficient for each channel has appeared to be the highest in ch1-ch2 and ch5-ch6 respectively. In addition, the correlation coefficient between non-stimulation and 3D watching stage has increased by more than 18%. The gamma wave correlation coefficient for each channel has appeared to be the highest in ch1-ch2 and ch5-ch6 respectively. In addition, the correlation coefficient between non-stimulation and 3D watching stage has increased by more than 5% apart from ch3-4, ch3-ch6 and ch5-ch4. The theta wave correlation coefficient for each channel has appeared to be the highest in ch1-ch2 and ch7-ch8 respectively. In addition, the correlation coefficient between non-stimulation and 3D watching stage has increased by more than 8% apart from ch5-ch4, ch7-ch2 and ch7-ch4.

According to the analyzed result, it has been found that correlation between each channel apart from ch1-ch2, changes in correlation coefficient between watching and non-stimulation stage and correlation coefficient between watching and stabilization stage are the feature vector which can be utilized for detecting 3D syndrome by utilizing brain wave signal of left/right brains. Especially, changes in correlation coefficient of watching and non-

stimulation as appeared to be higher in alpha and delta waves compared to the other bands as those of the frontal/occipital lobes has shown and it seems that this can be utilized for detecting 3D syndromes properly.

5. Conclusion and Further Studies

As earlier mentioned, this research has been carried out to extract feature vector of brain wave of 3D syndrome occurs by analyzing experiment participant's brain wave when they watch 3D stereoscopic image. The result of analysis, as the Table 3 indicates, on the correlation coefficient of frontal/occipital and left/right channel showed that the correlation coefficient of ① front/occipital lobes' channel and ② left/right brain channels have increased in alpha and delta wave more than the other wave bands and it seems that they can be inter-utilized for detecting 3D syndrome with higher reliability.

	Coefficient Correlation between Each Frequency Band Channel of Frontal/Occipital Lobes					Coefficient Correlation between Each Frequency Band Channel of Left/Right Brains				
	alpha	beta	delta	gamma	theta	alpha	beta	delta	gamma	theta
Non-Stimulation	0.43	0.39	0.46	0.42	0.38	0.44	0.4	0.46	0.44	0.38
Non-Stimulation - Percentage Change while Watching	-23.35%	-10.08%	-17.38%	-3.42%	-7.52%	-28.39%	-11.80%	-18.18%	-6.11%	-10.22%
watching	0.33	0.35	0.38	0.4	0.35	0.31	0.36	0.38	0.41	0.34
Stabilizing while Watching - Percentage Change while Watching, Stabilization	-21.48%	-2.17%	-13.28%	-0.87%	-2.43%	-25.41%	-3.13%	-13.37%	-3.08%	-3.47%
Stabilization	0.41	0.36	0.44	0.41	0.36	0.42	0.37	0.44	0.42	0.35

Figure 4. Coefficient Correlation between Each Frequency Band Channel of Frontal/Occipital Lobes and Left/Right Brains

The increasing rate of correlation coefficient of each channel of alpha and delta waves, according to the result of this research, indicates the implication of the change rates of 3D watching/ stabilization stage and 3D watch/non-stimulation stage in the abstract. Finally, it seems that there needs to be further research on accurate threshold of increasing rate of 3D syndrome symptoms at the time in which such symptom occurs.

Acknowledgements

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