An Analysis on the Degree of 3D Sense Following Distance and Location through 3D Depth Level Change

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Abstract

As 3D movies are becoming increasingly popular due to the advancement of the imaging technology these days, development of contents that use 3D images is taking place actively in diverse fields besides the 3D film industry. As a result, 3D contents industry including the 3D TV, S/W, 3D game and others are growing in general. Accordingly, users too are demanding the 3D contents that enable them to experience optimal 3D feeling instead of simple 3D images. Currently, the degree of the 3D feel in case of the contents that we watch these days is affected significantly by the 3D Depth value. In fact, there are researches under way to improve the sense of 3D feel by using 3D Depth value [5, 6]. However, it is necessary to factor in the user's distance and location as well along with the 3D Depth value of the image in order to feel 3D effectively when watching 3D image.

Accordingly, this research paper presents the index for 3D Depth level analysis that enable users to feel the 3D most effectively and to be immersed deeply into the image according to user's location and distance through the Depth level change of the 3D images.

Keywords: *Depth level, Image control system, three-dimensional effect start*

1. Introduction

After the film, "Avatar," the 3D films are being distributed widely. As such, 3D contents industry is becoming vitalized worldwide. 3D contents market is growing every day including various areas such as 3D TV, S/W, 3D game and so forth. Diverse technical researches and development efforts are underway in the areas of filming, editing, reenactment, major and standardization. Despite these technical advancements, however, users complain of the discomfort and fatigue [2, 3, 4] depending on the individuals' characteristics when using the 3D contents. This is because 3D imaging technology increases the fatigue of the eyes [7, 8] since binocular vision is used [1] and increases the amount of signal processed by the brain. This problem is not easy to resolve since it is necessary to factor in the eyes' biological movement and cognitive processing by the brain at the same time. Another problem is that the users must maintain specific distance and location when using 3D contents in order to feel the 3D effect effectively. In general, users do not know that location well. Accordingly, this research paper configured an environment that minimizes the fatigue of the eyes and that enables users to experience the 3D feel in the most effective manner. As such, 3D Depth analysis and experiment were executed to analyze the 3D as it is felt by users and for the 3D feel adjustment.

2. Principle behind 3D Images [9]

Human beings feel 3D because of their brains' cognitive function using 2D images. There are diverse data interpretation methods and elements regarding depth, and there is a difference by people. Among them, the depth cognitive principle of the images using binocular vision is used most often.

2.1 Depth Recognition due to Binocular Eyes

The human eyes are located right next to each other in a horizontal direction with a distance of 65mm. Each of the eyes accept retinal images from other locations. These images that are different from each other are recognized by the brain, which in turn leads users to recognize depth. In other words, one point in the space is placed at the different locations of the retina of the left and right side. Thus, the brain unifies the images into one image when it comes to the difference of the binocular eyes. User feels depth while recognizing the sense of perspective and sense of reality into one image during this process.

2.2 Perspective Adjustment and Convergence

When human beings observe an object, the eyes play two roles; perspective adjustment and convergence. Perspective adjustment refers to the function that adjusts the distance of the focus as the thickness of each eye's lens changes while convergence refers to the movement in which eyeball rotates so that the two eyes can observe an object. In order to observe object accurately, perspective adjustment that perceives the images at the retina's center part and convergence function take place without knowingly. If the difference of the binocular eyes mentioned before is retina's image cognitive signal, perspective adjustment and convergence can be considered body signal resulting from the movement of diverse muscles that surround the eyes.

3. 3D Analysis on the Degree of 3D Feel following User's Distance and Location through 3D Depth Level Change

3.1 Environmental Factors

Figure 1. View of the Users Wearing Anaglyph Eyeglasses Prior to Conducting the Experiment

This research paper conducted a research to analyze the 3D Depth level, distance and location of the images that enable group viewers to feel the optimized 3D when they are viewing 3D images. Towards this end, an experiment was conducted, targeting large number of people at a university's lecture hall. To increase the level of immersion when watching the images, external factors (light, noise etc.) were minimized. Moreover, to increase level of reliability of the experiment, distance for the location of each when it comes to the lecture hall and the subjects was measured. Fig 1 shows the users wearing Anaglyph goggles to view the 3D images before the analysis and experiment on the 3D feel following distance and location through 3D Depth level change were conducted.

3.2 Methods

□ Stage 1

Each of the subjects were handed Anaglyph goggles and data sheet where they could list down the 3D feel. Then, they were asked to enter into the premise and preparation was made to view 3D images.

□ Stage 2

The subjects were shown images of then 0 3D Depth level for one minute. After the viewing, subjects were asked to record on the data sheet whether they experienced 3D effect or not.

□ Stage 3

The subjects were to rest for one minute before carrying out the experiment of the next stage in order to minimize eye fatigue.

□ Stage 4

Stages 2 and 3 were carried out in the same way. When the first experiment was completed, users were asked to view 3D image of 0.05 greater 3D Depth level for one minute. Then, they were asked to rest for one minute. This was repeated until the 3D Depth became level 1. In addition, the entire experiment was repeated while the subjects' location was re-shuffled in order to analyze the 3D feel following the subjects' distance and location.

4. Experimental Results

4.1 Analysis on the Timing when the Users Start to Feel the 3D Effect

Table 1 shows the results of the analysis that shows when the users start to feel the 3D effect following the distance and location. The figures shown on Table 1 (for example, 0.3) presents the level with which the images that are to be shown to the right and left eyes are separated by considering binocular vision. In case of 0, the two images are overlapped completely. In case of 1, it is shown that the two images are separated completely. According to the research results shown on Table 1, 3D Depth Level where users start to feel the 3D effect decreases when the distance between the subjects and screen is smaller as in the case of the Row 1 and 2. Moreover, it is possible to see that the 3D Depth level is lower when it comes to the time when the users start to feel the 3D effect when the subjects are mostly placed at the center of the screen. In terms of location, 3D Depth level in which users start to feel the 3D effect is lower at the Column 4, 5 and 8. On average, the subjects start to feel the 3D feel at the 3D Depth level of 0.28 level.

Table 1. Analysis on the Timing when the Users Start to Feel the 3D Effect following Distance and Location

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Average	Total average	Rank	Proportion
Row 1				0.2	0.05	0.2	0.45	x	0.6	0.3	0.2	2	9/10
					0.15	0.15	0.1	0		0.1			
Row 2		0.45		0.3	0.25			0.25		0.31	0.18	1	5/6
				x	0.05					0.05			
Row 3			0.3	0.05		0.25		0.05	x	0.16	0.25	4	5/7
				x				0.35		0.35			
Row 4	0.65	0.25		0.15	0.1		0.3	0.25	0.15	0.26	0.29	5	10/12
		0.15		x	0.5		0.3	x		0.31			
Row 5				0.05	0.1	x		0.45	x	0.2	0.2	2	4/9
					0.2	x		x		0.2			
Row 6	0.8	x	0.15	0.05			0.25	0.15	0.25	0.27	0.48	6	7/10
		0.8	x				0.6		x	0.7			
Row 7	1	x	0.45	0.2		0.05	0.05	0.25		0.33	0.61	7	6/12
		x	x			x	0.9	x		0.9			
1st average	0.81	0.35	0.3	0.14	0.12	0.16	0.25	0.23	0.33				
2nd average	x	0.47	x	x	0.22	0.15	0.47	0.17	x				
Total average	0.81	0.41	0.3	0.14	0.17	0.15	0.36	0.2	0.33				
Rank	9	8	5	1	3	2	7	4	6				
Proportion	3/3	4/7	3/5	7/10	8/8	4/7	8/8	8/12	3/6				

4.2 Analysis of the Time when User Stops to Feel the 3D

Table 2. Analysis of the Time when User Stops to Feel the 3D following Distance and Location

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Average	Total average	Rank	Proportion
Row 1				0.9	0.4	0.3	x	0.45	1	0.61	0.61	3	9/10
					0.55	0.65	0.6	0.7		0.62			
Row 2		x		0.6	0.5			x		0.55	0.61	2	4/6
				0.55	0.8					0.67			
Row 3			0.75	0.9		0.4		0.8	1	0.77	0.72	5	7/7
				0.9				0.45		0.67			
Row 4	0.65	0.55		0.4	0.2		0.45	0.9	0.7	0.55	0.5	1	10/12
		0.45		0.6	x		x	0.35		0.46			
Row 5	0.8			0.6	x	0.9		x	1	0.82	0.86	7	6/9
					x	0.8		1		0.9			
Row 6		0.9	0.45	0.45			0.35	0.7	1	0.64	0.7	4	8/10
		x	1				x		0.55	0.775			
Row 7	1	x	0.7	0.8		0.75	0.35	0.8		0.73	0.81	6	9/12
		0.8	1			x	0.9	0.9		0.9			
1st average	0.81	0.72	0.63	0.66	0.36	0.58	0.38	0.73	0.94				
2nd average	x	0.62	1	0.68	0.67	0.72	0.75	0.68	0.55				
Total average	0.81	0.67	0.81	0.67	0.52	0.65	0.56	0.7	0.74				
Rank	9	5	8	4	1	3	2	6	7				
Proportion	3/3	4/7	5/5	10/10	5/8	6/7	5/8	10/12	6/6				

Table 2 shows the analysis carried out to study the timing when the users stop to feel the 3D effect following the subjects' distance and location. The figures shown on Table 2 (for example, 0.3) presents the level with which the images that are to be shown to the right and left eyes are separated by considering binocular vision. In case of 0, the two images are overlapped completely. In case of 1, it is shown that the two images are separated completely. According to the research results shown on Table 2, 3D feel is felt continually even when the 3D Depth level of the two images is high as the users move from the center of the screen to the center of the left and right side. However, in case of the center seat, it is possible to see that the images are felt as two separate images rather than as one 3D image as the 3D Depth level of the two images increases. As for the distribution of the location in accordance to the experiment conducted by this research on group subjects, 3D Depth level of the images that lead to the end of the 3D feel in the order of Row 1, 3 and 8 was recorded high. Meanwhile, analysis following distance manifested low in this order, Column 4, 2 and 1 when it comes to the 3D Depth level of the images that stop the 3D feel.

5. Conclusion

To conduct a study on the 3D Depth level following distance and location in order to minimize fatigue to the eyes and to enable the users to feel the 3D effect in an effective manner, this research conducted an experiment targeting 33 subjects. The subjects' location was re-shuffled by factoring in the fact that the subjects may perceive 3D differently due to personal characteristics. The experiment was conducted twice as such. According to the experiment results, it is possible to see that the difference in the timing for the start and end of the 3D feel is significantly affected by the level of sloping of the seat to the right or left and by the center of the screen than the distance between the subjects and the screen. Meanwhile, difference in the level of 3D feel following the difference in the pre and post distance was minimal. Moreover, it is possible to see that the figure that is lower than 0.68 level on average is the most effective when the distance and location are considered for the group viewers.

Acknowledgements

This work was supported by Small & Medium Business Administration grant funded by the Korea government (SMBA) (No. SM121322).

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