International Journal of Advanced Culture Technology Vol.9 No.3 265-270 (2021)
DOI https://doi.org/10.17703/IJACT.2021.9.3.265

IJACT 21-9-34

Realistic Soap Bubble Appearance using Background Scene and Kelvin Temperature Matching

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Abstract

VR and AR contents provide a rich user experience [1]. Realistic content with human computer interaction and immersion provides an improved user experience, but there is a limit to producing all elements realistically. In this study, we propose a method to advance the rendering of immersive content using background color information [2]. First, the elements necessary for Kelvin temperature rendering are derived from the color and background as context elements, and the rendering effect has been realized in the soap bubble. For soap bubbles Kelvin temperature rendering, the average color of the background is extracted and the color with the highest similarity is applied by comparing the main color and Kelvin temperature.

Keywords: *Soap bubble, Context rendering, VR, AR*

1. INTRODUCTION

VR (Virtua Reality) and AR (Augmented Reality), the main fields of the 4th industrial revolution, provide a rich user experience (VRUX: Virtual Reality User Experience) [1-5]. With the advent of the new normal era, realistic content that expresses interaction and immersion is attracting attention. Immersive content gives users an enhanced user experience through observation and interaction [6]. However, immersive content has a limit in producing all elements as if they were real. In this study, we propose a rendering method that can further improve immersive content by using background context. The authors reported on a soap bubble to which physics-based rendering technology had been applied in a previous study [7]. This study uses the interaction of physics-based soap bubble rendering, tools and hand gestures to solve the limitations of skilled technicians, materials, and tools required in soap bubble arts. Therefore, as a context element of soap bubble arts, we propose Kelvin temperature rendering that reflects various colors and various background colors. In this way, we want to contribute to immersive content by enhancing visual expression while expressing what the user chooses and imagines.

2. THE COLOR OF SOAP BUBBLES

In soap bubbles to which physics based rendering technology is applied, the configured environment and conditions such as light sources, backgrounds, and objects are projected onto the surface. In addition, reflection, refraction, and distortion occur on the surface in real time due to physical properties. However, soap bubbles for soap bubble arts are intentionally mixed with pigments to give various visual pleasures, as shown in Figure 1.

Manuscript received: June 3, 2021 / revised: August 24, 2021 / accepted: August 28, 2021
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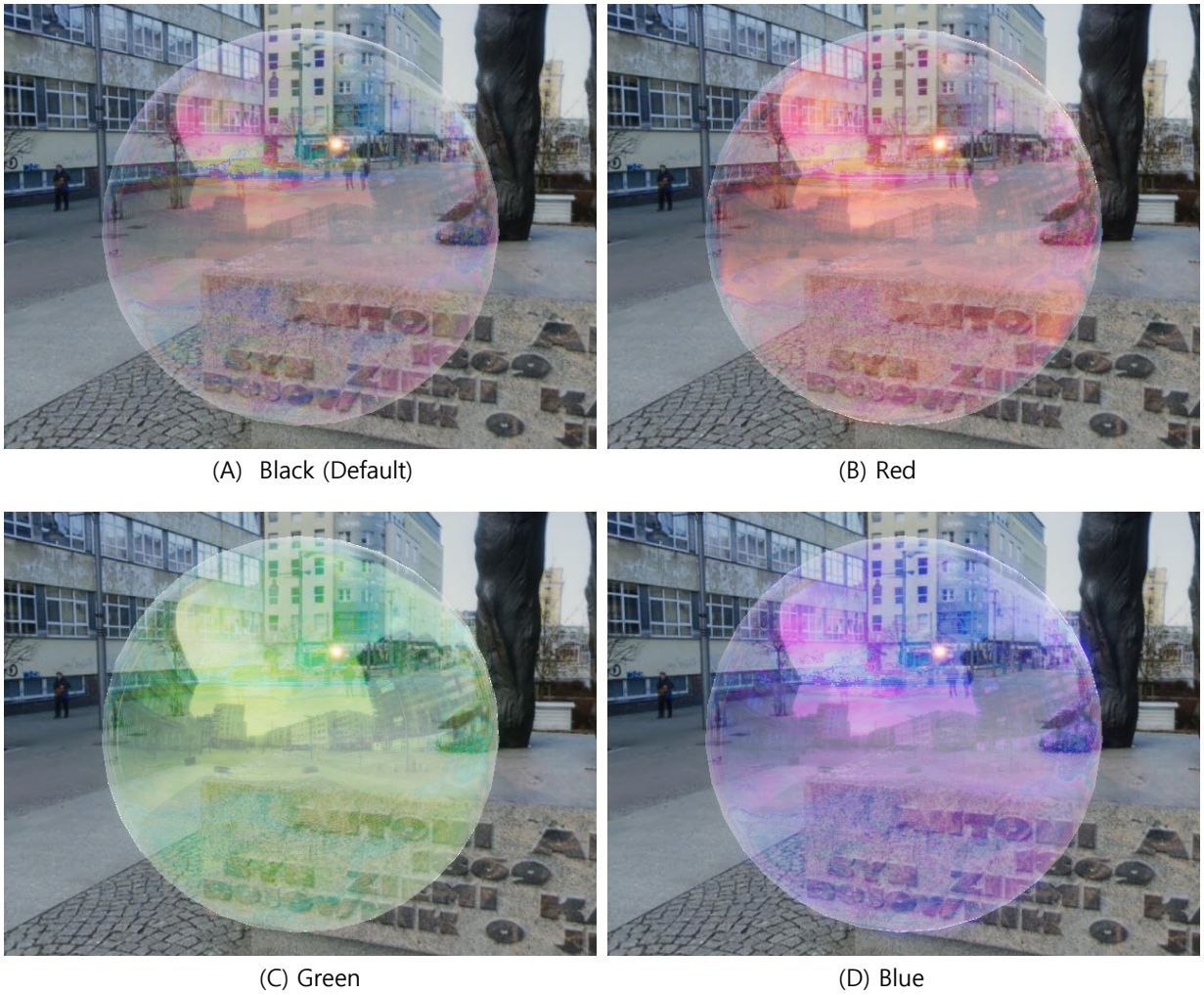
Accordingly, colorful soap bubbles were realized by mixing RGB values with the colors of existing soap bubbles. The soap bubbles implemented with Unity Shader Graph are expressed in color by iridescent by the interference of base color and light. By blending HDR Color here, the user can control the professional RGB value. The control method is Leap Motion and NUI (Natural User Interface) interaction, and the color selected by the user is reflected in real time by referring to the parameter address value of the HDR Color node of the Shader Graph [8]. Soap bubbles, which can be expressed in various colors, stimulate the user's emotions as well as the content elements of soap bubble arts.



(A) Black (Default) (B) Red

(C) Green (D) Blue

Figure 1. Rendering of Soap Bubbles with Color Change

3. MATCHING THE COLOR

A study on human emotions and cognitive responses depend on the lighting environment and chromaticity. The spectral characteristics of sunlight, the daily light rhythm, and seasonal changes in light cause various physiological responses of all animals and plants [9-10]. Accordingly, changes were made to HDRI Sky. Weather and changes were expressed as bright days (Figure 2, (A)), cloudy days (Figure 2, (B)), and cold days (Figure 2, (C)). , (D)), pink sky (Figure 2, (E)), and sunset sky (Figure 2, (F)). Depending on the background change, the soap bubbles adapt to the environment and the color of the surface becomes clear or transparent. We use Leap Motion as control interface, which is a NUI (Natural User Interface) interaction. The background selected by the user is reflected in real time by referring to the HDRI Volume. This changed background

deconstructs the concept of physical time and space in a world dominated by connections and provides users with a variety of experiences.

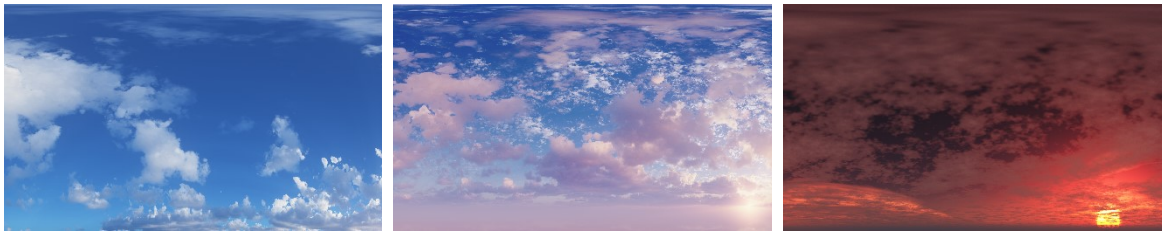
(A) Bright day (B) Cloudy day (C) Cold day

(D) Blue Sky (E) Pink Sky (F) Sunset Sky

Figure 2. Rendering of Bubbles with Different Background

4. SOAP BUBBLES KELVIN TEMPERATURE RENDERING

The light source plays the biggest role in changing the background. When the light source is strong, it becomes a bright day, and when the light source is obscured by clouds, it becomes a cloudy day. In addition, with the passage of time, it may become a blue sky, a pink sky, or a sunset sky. At this time, the colors of the light source projected on the soap bubbles are all different. Accordingly, we propose a Kelvin temperature rendering of a light source projected on soap bubbles. In this study, ten average colors were extracted using the K-Mean Clustering algorithm by cutting out the top part of the Skybox, which is the part where the light source has the greatest influence [11]. Next, the main color among the 10 average colors was compared with the most similar Kelvin temperature color. The background used for comparison is shown in Figure 3, and each background is 4K, some images in the upper left corner.

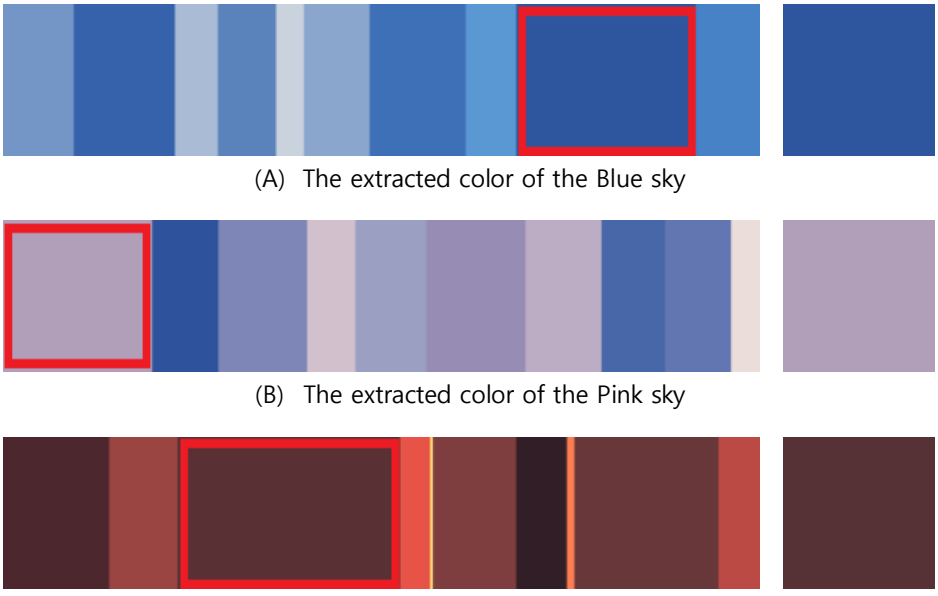


(A) Blue Sky (B) Pink Sky (C) Sunset Sky

Figure 3. Rendering of Bubbles with Different Background

The average color of the blue sky in Figure 3, (A) is Figure 4, (A), and the RGB values are RGB (45, 86, 158). Next, the average color of the pink sky in Figure 3, (B) is Figure 4, (B), and the RGB values are RGB

(177, 158, 185). Finally, the average color of the sunset sky in Figure 3, (C) is Figure 4, (C), and the RGB value is RGB (86, 49, 53).



(A) The extracted color of the Blue sky

(B) The extracted color of the Pink sky

(C) The extracted color of the Sunset sky

Figure 4. Ten Average Color Values from K-mean clustering and Extracted Colors

In order to compare the main colors and Kelvin temperature, as shown in Table 1, Kelvin temperature was divided into 1,500K ~ 15,000K and divided into ten segments. In addition, the RGB values of each stage were extracted and compared with the main colors extracted in Figure 4. The comparison method used the Euclidean distance similarity as in Equation 1, and the color and similarity that are close to each other are high. The comparison results are shown in Table 2. The blue sky was similar to 15,000K and the pink sky was similar to 9,600K. Finally, the sunset sky was most similar to 1,500K.

Reflecting the results of Table 2, Kelvin temperature was applied as shown in Figure 5. There is no significant difference between the blue sky ((A) in Figure 5) and the pink sky ((B) in Figure 5) because the color is close to white due to the high Kelvin temperature. On the other hand, the sunset sky ((C) in Figure 5) has a color close to red due to the low Kelvin temperature, so it is very different from the general white light source and blends with the background.

Table 1. Ten Segments Kelvin temperature and RGB

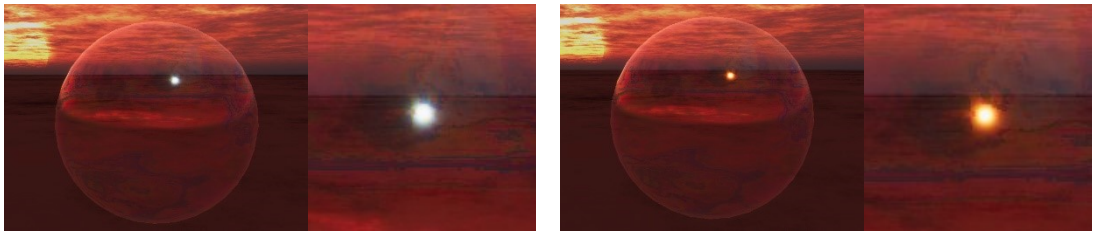
K	1,500K	2,850K	4,200K	5,550K	6,900K	8,250K	9,600K	10,950K	12,300K	15,000K
R	255	255	255	255	246	218	205	196	190	181
G	108	172	211	238	244	228	220	215	211	205
B	0	99	175	224	255	255	255	255	255	255

Table 2. Similarity of Euclidean Distance

K	1,500K	2,850 K	4,200 K	5,550 K	6,900 K	8,250 K	9,600 K	10,950 K	12,300 K	15,000K
Blue Sky	263.7	234.4	244.9	266.2	253.5	234.8	221.1	214.6	205.1	185.4
Pink Sky	206.9	169.1	225.1	254.7	158.3	93.9	72.6	76.1	80.2	342.8
Sunset Sky	186.6	214.1	263.9	312.7	210.2	294.9	283.6	279.1	272.3	212.2

(A) Normal white light source (Left), 12,300K Kelvin temperature light source in blue sky (Right)

(B) Normal white light source (Left), 9,600K Kelvin temperature light source in pink sky (Right)



(C) Normal white light source (Left), 1,500K Kelvin temperature light source in sunset sky (Right)

Figure 5. Rendering of Bubbles with Different Background

5. CONCLUSION & DISCUSSION

In this study, color, background, and Kelvin temperature rendering were proposed as context elements for the advancement of realistic content expression. For soap bubbles Kelvin temperature rendering, the average color of the background was extracted, the main color and Kelvin temperature were compared, and the color with the highest Euclidean similarity was applied. It provides users with an enhanced experience with interactivity and immersion in VR. First, until now, realistic VR contents including bubble arts have focused on expressing realistic space. The light source is the most important factor in realistic representation. Although many researchers have conducted to synthesize the environment in taking into consideration the light source, on the contrary, there are few studies to represent the light source according to the environment. The light source synthesis presented in this study is a new guideline for the advancement of realistic contents. Secondly, soap bubbles are greatly affected by the surrounding environment and reflected light. In particular, in bubble arts, stage equipment and lighting seem to create a virtual space. VR is free from physical constraints such as time and cost to create a virtual space. The color and background context proposed in this study contributes to the production of potential contents by directing the virtual space. Future research will try to supplement some factors. Colorful colors can be expressed as true colors by specifying RGB values between 0 and 255, respectively. However, it is very difficult to specify a value between 0 and 255 due to the nature of Leap Motion. Therefore, you need to implement additional buttons that refer to new buttons or different colors. Next is the Kelvin temperature that changes in real time depending on the background. This is because it takes a long time to extract the average color and apply it compared to the Kelvin temperature depending on the size or capacity of the background image. It is necessary to analyze the development of hardware elements or new algorithms. Complementing this and providing better VR experience to users will not only contribute to

immersive content, but also VR content will become a key icon in the new normal era.

REFERENCES

[1] J.H. Park, Y.B. Lee, "Simulation Training for Inactive Nurses with 360 VR content," *International Journal of Internet, Broadcasting and Communication(IJIBC)*, Vol. 13, No. 1, pp. 116-122, Feb 2021. https://doi.org/10.7236/IJIBC.2021.13.1.116

[2] J.W. Han, "Effects of Implementation and Application of Realistic Digital Contents," *International Journal of Advanced Smart Convergence(IJASC),* Vol. 8, No. 1, pp. 147-152, March 2019. https://doi.org/10.7236/IJASC.2019.8.1.147

[3] S. Han, S.W. Yoo, S.A. Chin, "Physics-based height map optimization conveying real-measured flow speed for virtual soap bubble rendering," *International Journal of Advanced Culture Technology(IJACT)*, Vol. 8, No. 3, pp. 284-290, Sep 2020. https://doi.org/10.17703/IJACT.2020.8.3.284

[4] J.K. Kim, J.K. Kim, "Discourse on ICT Virtual Reality Media: Focusing on Immersible Space and Communication Theories," *The Journal of the Convergence on Culture Technology(JCCT)*, Vol. 7, No. 2, pp. 333-338, May 2021. https://doi.org/10.17703/JCCT.2021.7.2.333

[5] I.S. Kim, C.S. Jeong, K.D. Jung, "AR Tourism Service Framework Using YOLOv3 Object Detection," *The Journal of The Institute of Internet, Broadcasting and Communication(IIBC)*, Vol. 21, No. 1, pp. 195-200, Feb 2021. https://doi.org/10.7236/JIIBC.2021.21.1.195

[6] Y.S. Shim, "Technology Trends of Realistic Contents and Application to Educational Contents," *The Journal of the Convergence on Culture Technology(JCCT)*, Vol. 5, No. 4, pp. 315-320, Nov 2019. https://doi.org/10.17703/JCCT.2019.5.4.315

[7] S.W. Yoo, C.H. Lee, S.A. Chin, "Physically Based Soap Bubble Synthesis for VR," Applied Sciences, Vol. 11 No. 7 pp. 3090, March 2021. https://doi.org/10.3390/app11073090

[8] M.G. Kim, J.W. Heo, K.S. Jeong, J.M. Kim, "Tangible 3D Contents Production Pipeline based on Virtual Reality using Leap Motion and Arduino," in Proc. Proceeding of HCI Korea 2017, pp. 509-512, Feb 2017.

[9] H.J. Suk, G.M. Kim. "The influence of chromacity of LED lighting on time perception," *Science of Emotion and Sensibility*, Vol. 13, No. 1, pp. 69-78, March 2010.

[10] S.Y. Kwon, J.H. Lim, "Multi-objective context-adaptive natural lighting system," *Energy and Buildings*, Vol. 144, No. 1, pp. 61-73, June 2017, https://doi.org/10.1016/j.enbuild.2017.03.045

[11] J. MacQueen, "Some Methods for classification and Analysis of Multivariate Observations," in Proc. Proceedings of 5th Berkeley Symposium on Mathematical Statistics and Probability, pp. 281-297, 1967.