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A Study on the Improvement of Sound Quality by Compensatory Variables through Improved Openness in Virtual Space

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Abstract *— In human-computer interaction (HCI), research on interacting with a computer using voice is continuously being studied. This is currently being applied in virtual reality space. In response to this trend, various studies are being conducted to improve the acoustic spatial feeling felt in a virtual space. This sense of reality can be improved by improving the sense of space. In this paper, improving the acoustic spatial feeling was processed by continuously changing the sound effect by separating the open space and the closed space in the virtual space area. It isn't easy to apply all diversifying environments in a virtual space, and it is a general method to apply without considering space by continuously generating a certain sound effect. It is to apply sound effects that can be applied to various spaces by applying them to sound signals in such a diversified virtual space or complex space. Most of the studies focused on studying spatial sound effects that can apply diversity as a variable in general, where the features of virtual space are not well established. In this study, although it is a prior study to support advanced sound effects that change according to computer space and users in the field of HCI research, it is to study the applicability by changing the application to the variable space. Introduction Apply the usual method. Through such research, we have studied a method that can add more realistic feeling in virtual or complex spaces.*

Keywords *— Human-computer interaction, acoustic spatial feeling, spatial sound effects, virtual or complex spaces*

I. INTRODUCTION

The realism of virtual spaces applied in various ways has been studied with intensive interest in most images. Although this method is very important in its extremely realistic role, acoustic effects have not been studied. In virtual reality, a lot of research is being conducted to make use of the sense of space and realism. The realism in the video is limited to the resolution and image effect. Research is being conducted from this point of view on what is currently being studied. Research is currently being conducted by maximizing the sense of realism and increasing the frame that appears in the eye by using complex effects in virtual space. On the contrary, the acoustic effect is composed of only the characteristics that come through the ears, or the space is virtual, but the sound is transmitted only through the speakers. Here, since the speaker is transmitted without considering the virtual space's characteristics at all, the image and the sound are separately implemented and used. This part shows a limitation in maximizing the sense of realism despite a lot of research in virtual reality research. Here, this study made various attempts to overcome this problem. In this study, a comparative analysis was also performed using the conventional method and the proposed method for the acoustic effects used to enhance realism. The generally used sound effect method uses the recorded sound or uses it in a virtual space by using a repetitive effect. These existing methods are boring and monotonous, making it difficult to apply various virtual spaces' characteristics. Failure to consider the characteristics of virtual space means that it is not effective in maximizing realism because it uses a separate video and audio method. In particular, applying the change for each frame of the image in the existing method is to propose using the method of applying the complexity of the image.

In this study, the first sound intensity is applied to the virtual space's sound effect by obtaining the degree of change of the image. The second method is used by applying several patterns according to the sound effect. Chapter 2 examines the characteristics and problems of the existing method. Chapter 3 explains the proposed method's application to sound effects, and Chapter 4 confirms the experiment and results and concludes in Chapter 5.

II. EXISTING METHODS

Research to increase the degree of immersion according to images in virtual spaces is continuously studied. Most of the studies to increase the realism or resolution of images are ongoing. In particular, the resolution is more important because it is viewed close to the eye using an immersive device, and there is an effect that the frame is too small to reduce the realism of the immersion. In general, sound effects or audio are not applied as such, and most of them repeat the sound effects of a certain pattern continuously, making you feel bored and frustrated. This method interferes with the continuation of the sense of immersion because it uses the least data and is repeatedly used. Various methods have been studied to overcome this part.

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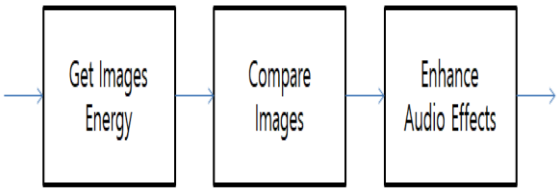


Figure 1. Method for existing sound effects

As shown in the figure, the general method applies the basic sound effect, so it is monotonous and not diverse and cannot affect various images. Suppose the characteristics of sound pressure are diversified by analyzing the characteristics of the image of the input terminal, and an acoustic pattern according to the gradient is used in the image. In that case, it can be applied more effectively. Since the image energy input unit is for analyzing the image's characteristics, the energy for each frame is investigated and processed. This is similar to the energy measurement method used in the acoustic analysis. The energy obtained in this way compares the degree of change for each neighboring frame, which evaluates the amount of change for each frame. Afterward, the sound pressure is added to the acoustic change, or the additional pattern is changed according to the image change.

III. PROPOSED METHOD

The proposed method was divided into two and processed. In the existing method, immersion is improved by changing the sound pressure side's characteristics and the boring pattern according to the degree of change of the image. To distinguish these characteristics, consider the negative pressure aspect. The characteristic of sound pressure is that where there is no change in the image, the level of sound pressure can vary depending on the disease, so if the image change is high, the sound pressure level is increased. If the image change is small, the sound pressure is smoothly output. Since these effects are applied by measuring the gradient of the image, the gradient's measurement method is more important. Of course, since an accurate measurement method is not required, the frame comparison method was used in this study. Each frame's image was obtained as the difference signal, and the energy gradient was also obtained.

$$En(u) = \sum_{n=1}^{k} (image(n) - image(n-1))^2 \quad (1)$$

Where u is the frame number and n is the pixel in a frame.

In the given equation, the energy is obtained by comparing the pixels per frame with the previous frame. The energy obtained in this way is the faster the change, the higher the energy and the smaller the change. Here, the negative pressure was applied by aging.

Second, five patterns were classified in the image gradient. To distinguish between the image's speed and the characteristics of the image, it is necessary to analyze the change characteristics of more than 5 seconds, which classified the characteristics of the image into fast, slightly faster, normal, slightly slow, and slow. The necessary patterns are constantly changing. This pattern is to generate a sound effect by designating the pattern if the change of the image lasts more than 5 seconds, considering the sound's characteristics. The degree of change of the pattern was considered to be applied and used in various ways rather than continuously using various patterns by allowing the user to choose.

Lastly, to give more realistic sound pressure change and pattern change, the method of use was applied with real sound. This is a more effective method because the general boredom in the virtual space must be applied in the real environment. For the sense of space, an additional sense of space was created by using acoustic reverberation.

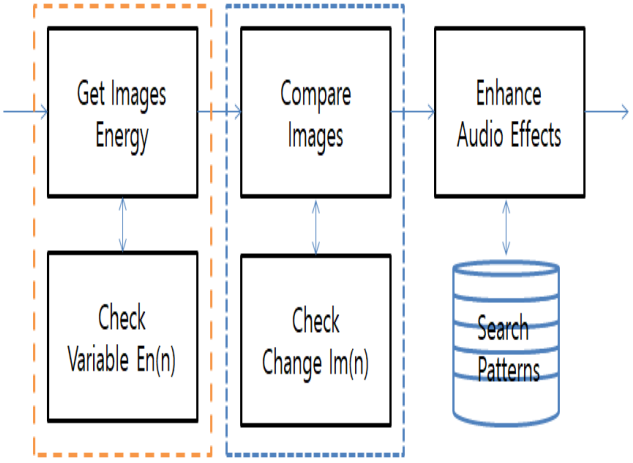


Figure 2. Block diagram of the proposed algorithm

IV. CONCLUSION

To simulate the proposed method, 16-bit data was used with 48kHz sampling using a personal computer and an input/output AD/DA converter capable of sound simulation as an interface. For the performance evaluation of the treatment results, the virtual reality environment preferred by those in their 20s, 30s, and 40s was used. The algorithm processing process was used to measure the sense of realism while generating sound effects with the proposed method in the spatial section appearing in the virtual reality environment. The overall balance between the background sound for the sound effect and the live signal was used as a one-to-one mixing method to increase concentration. The standard of oxygen saturation or heart rate was used to evaluate the emotion in virtual space as much as possible.

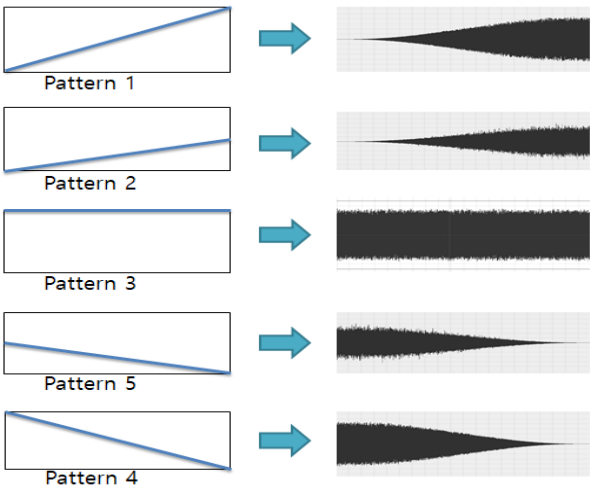
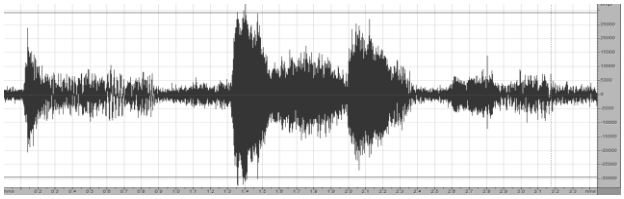
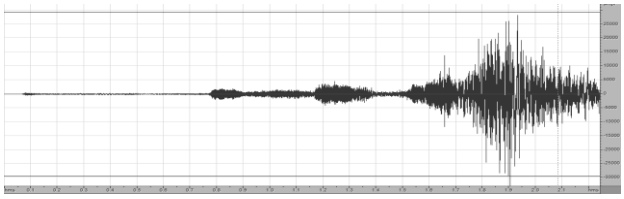


Figure 3. Characteristics of the proposed pattern



a. Sound effect of the conventional method



b. The sound effect of the proposed method

Figure 4. Acoustic effects of the existing and proposed methods

In this paper, as part of the HCI study, a study was conducted to improve the sound effect to improve the virtual space's realism. First, we used a method of comparing the flow of images through sound pressure change and processing them, and secondly, we used sound effect sounds suitable for images by patterning the energy required for sound. It helped to improve the realism of the virtual space by variously changing the existing monotony effect. The algorithm for giving realism in the commonly used background sound was applied using patterning. It was suitable to apply to various images by simultaneously changing the acoustic effect and boredom of the existing background sound effect. This study is a case applied to maximize the sound effect that appears in virtual reality. In the future, it will be important research to make it applicable to various systems in various research fields and to be used for smartphones, communication equipment, and control equipment.

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