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Original Article

A Study on Sound Quality Improvement using Differences in Acoustic Characteristics of Two Different Spaces in Metaverse

Seong-Geon Bae

School of ICT Convergence Engineering, Kangnam University, Youngin-si, Gyunggy, Korea

Corresponding Author : sgbae@kangnam.ac.kr

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Abstract *- This study is to understand the shortcomings of the metaverse space and apply realism to implement it. Embodying spatial realism in various ways has been using methods that have been studied by focusing on the funeral of familiar encounters. The purpose of this study is to understand these acoustic elements because the understanding of the ambient sound in this problem was not considered. This study applied and used acoustic ambient sound as a method to maximize this realism and maintain realism by considering the user's environmental part. In addition, in this sense of realism, the weight of the surrounding noise is applied, and the signal-to-noise values of the users are applied. An efficient acoustic adaptation approach is applied to the weight between users as the signal-to-noise ratio. These acoustic considerations can be applied in a variety of ways.*

Keywords *- Improved metaverse, Spatial sound, Signal-to-noise ratio, and Sound quality.*

1. Introduction

Recently, the field of research on virtual space has been increasing. This is an effect that non-face-to-face activities are increasing due to the influence of Corona, and daily life is increasing through non-face-to-face rather than face-to-face. Non-face-to-face activities create a variety of lifestyles. This is because there are more metaverse activities in virtual space or activities in different spaces due to this influence. In particular, it is expected that there will be much variety in the future because there are more activities that can be obtained in the metaverse space.

For this reason, recent research directions have become very important in increasing space utilization in non-face-to-face. Users' appropriate understanding of activities in different spaces, conversations, and activities are very important factors in understanding the two spaces. It is expected that many studies will be conducted to understand this space in the future. This study was conducted as one of these studies and can be applied in various spaces. This study begins under the condition that the characteristics of visual space can be intuitively understood. Under these conditions, we can see that people are interested in the acoustic difference, and we used these points for the two spaces. In particular, it can be seen that the acoustic characteristics are very important, as the emotions felt in different spaces appear prominently in the difference of sounds. People recognize and accept various knowledge through sound. These characteristics are, of course, important in the virtual space as well. Acoustic characteristics that humans perceive are mostly used as frequencies that humans can hear and recognize. Here, only listening to and speaking of these things is processed. Characteristics within a frequency band of up to 4 kHz deliver voice signals well and can be processed in various ways. Due to this characteristic, the existing method uses a lot of processing methods limited to voice.

Moreover, if the video transmission stops in the two spaces, there is also a disadvantage that the sound does not come out. Here, changing the audio frequency band to the acoustic frequency band and processing it as data separate from the video is important. This study was designed so that it can be applied in real-time regardless of the video because this study used a method that appropriately combines and uses the acoustic frequencies felt in different spaces[1,2,4,5,7].

In this study, Chapter 2 introduces the existing methods and characteristics, and Chapter 3 introduces the proposed method and its characteristics. Finally, the research results and future plans are introduced in the conclusion.

2. Existing Method

Understanding spatial characteristics used in virtual space is a very important issue these days. We used conditions as the environment in which users use spatial characteristics. This is because the number of users is assumed to be 2 or more. This is because the use of metaverse or virtual space, which is popular nowadays, is only used for visual encounters or simple voice delivery. If this quick process is used, it is difficult to use the

characteristics of the space used non-face-to-face as in face-to-face. Here, the existing method has difficulty in immersion because it processes using the 4kH band of the voice or uses the background sound. In a non-face-to-face space, immersion is very important. In order to fully have this sense of immersion, we performed various tests. In this case, when the voice signal is used in the 4 kHz band, and the background sound is used, it is perceived as an unnatural environment. These problems are caused simply by the background noise. It has been shown to create problems with cognitive blockages and immersion enhancement in space. Here, we remove the background sound, and even when using the existing method, only too simple voices are delivered to the virtual space, which can also cause immersion problems. Various methods can be considered for the utilization of virtual space that makes the most of the strengths and weaknesses of the metaverse. Virtual spaces replace various activities necessary for meetings, meetings, and offline face-to-face meetings that are active in the non-face-to-face era. Here, realism is maximized by diversifying and constructing the spatial characteristics that make use of the existing characteristics. These characteristics are intended to replace the inconvenience of non-face-to-face contact with existing familiar places. These points play a role in providing convenience to users and giving a sense of intimacy to the space by reproducing a familiar space. Disadvantages include a sense of heterogeneity and time-consuming adaptation to the environment because it does not consider the characteristics of familiar ambient sounds between people. This phenomenon can cause discomfort like a classical sound with a mechanical sound. Inconveniences such as these mechanical sounds are the limits of the metaverse, and various studies are desperately needed to develop further. There has been no concrete discussion of things to solve this existing method. To study these problems, it can be efficient to approach them by solving sound quality problems away from spatial implementation. Existing methods solve only visual effects by simply implementing spatial designs [5,7,8,9,11,12,14,15,16].

3. Proposed Methods

In this study, various environmental sounds were used. This method utilizes the various ambient sounds that metaverse users have. This study considered three users. As shown in Figure 2, these cases were adapted to the environment by classifying the surrounding environment into three categories.

Here, weighted values can be classified into three categories. The weighted values used herein were applied according to the frequency of voice use of users. All weighted values used here were multiplied by ambient noise. The weighted values are thus multiplied and used again as a full ambient sound. The total weighted ambient sound is used for voice transmission through redistribution back to each user.

First of all, the voices used by each user in the picture are used when it is necessary to use them in conversation or space. Moreover, when these sounds do not exist, the background sound is sent or treated as silence, so it is a structure in which the sound is emitted in a monotonous tone. Finally, it is a structure that is delivered to users and listened to by users. As shown in the figure, acoustic improvement is used by mixing the method of using the existing voice and the method of properly using the background. This causes problems such as immersion in space and lack of concentration when there are many users. This phenomenon will likely cause more serious problems with boredom and concentration because simple voices are used when there are many users. The voice signal used here uses 4 kHz bands. High-quality voice signals are very helpful in understanding virtual space, but when using low-band 4kH bands, it is possible to perceive sound. However, important background sounds for boredom or immersion are missing. Here, when several users overlap, there is a case where we need to set the order and have a conversation. Important characteristics that appear in the existing methods are cognitive problems, and various misrecognition problems may occur when there are many users. This study focused on solving these problems and additionally minimizing the stuffiness felt in non-face-to-face. As shown in Figure 1, the voice signal considers the voice band using the 4kHz bandwidth. In addition, a single ambient sound is received by directly sending the ambient sound that the user has. A method of combining these two notes and delivering them to each user was used here. These methods are being developed after being used in early research. Users receive and understand the surroundings and voices conveyed in their own ambient sounds, which may cause maladaptation problems because they are active in the metaverse space.

These methods are called weighted sound quality improvement methods. This study uses this as a key approach and considers realistic acoustics for ambient sounds.

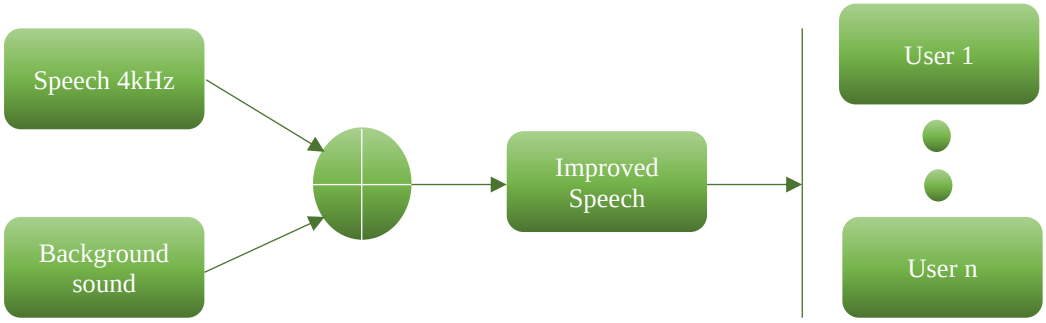

Fig. 1 Example of improvement with the existing method for sound improvement in virtual space

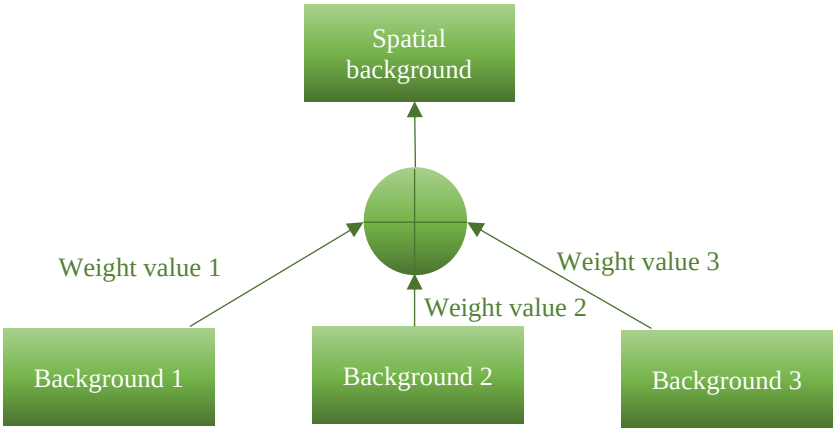

Fig. 2 Realistic acoustic consideration using a weighted approach to ambient sound

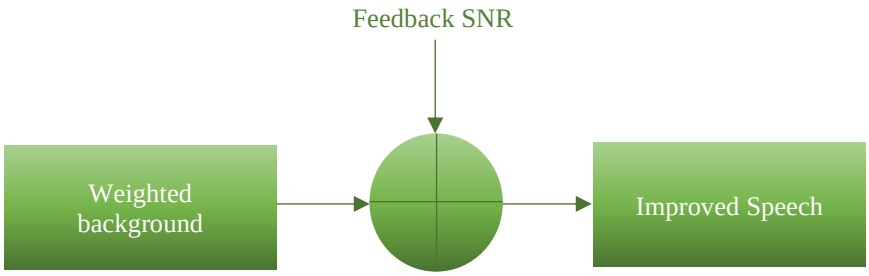

Fig. 3 Method of applying feedback based on using frequency to weighted ambient sounds

$$(W_{value}1 \text{ X } B_{Sound}1 + W_{value}2 \text{ X } B_{Sound}2 + W_{value}3 \text{ X } B_{Sound}3) \text{ X SNR} \quad (1)$$

Sound quality improvement by applying a sense of realism, which is generally used, has been used as an approach by considering only users' voices. The purpose of this study is to give a sense of realism in a virtual space such as the metaverse. Such realism is possible with various approaches, but we will use a weighted approach with feedback in this study. In order to maximize realism, the relative strength of the signal to the ambient noise was applied, and the ambient sound was added to the user with the high frequency of use. This method allows other users to focus on what users have a high frequency and to increase adaptability.

In Figure 3, the user's sound quality improvement and realism can be further emphasized by applying the feedback according to the frequency of the weighted ambient sound. In the figure, this feedback SNR focuses on providing realism through the comparison method of ambient sound according to sound quality. These approaches used in this study were first implemented to help increase concentration by using ambient sounds and users adapting, and second by using ambient sounds of various users and environmental sounds encountered by users.

Here, various approaches can come out, and since this synthesizes and uses a general weighted approach and feedback, it helps a lot to eliminate users' sound quality deterioration for ambient sound or silence in virtual space. These methods serve to compensate for the disadvantages of virtual space.

4. Conclusion

Recently, we have been conducting various research on spatial changes in the metaverse environment in general. These various approaches are constantly being studied and developed in various studies on space implementation. These approaches only consider visual impacts. These studies did not consider visual effects but used an acoustic approach.

Considering users' environmental sound quality, we studied them to adapt immediately. These legal methods were actively implemented in spatial research of the metaverse by considering sound quality together. In order to diversify these features, various acoustic approaches of users were applied. Acoustic considerations vary in various ways, but a method of weighting the user's ambient sounds was applied to the weights considering feedback and signal band ambient noise ratio. These features further helped with the sense of realism most needed in the metaverse environment. This feedback approach using ambient noise and ambient noise versus signal ratio was applied using a method to emphasize important speech sounds in relative ambient sounds. This approach is used in this study and is in line with recent research into how we adapt to our environment. In the future, this study will allow research on the sound quality of the metaverse to apply the realism and realism of the advanced metaverse more realistically.

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