International Journal of Engineering Trends and Technology
ISSN: 2231–5381 / https://doi.org/10.14445/22315381/IJETT-V71I6P214

Volume 71 Issue 6, 122-125, June 2023

Short Communication

A Study on Acoustic Approaches Applying a Simple Structural Modeling to Spatial Characteristics of Virtual Space

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Received: 23 April 2023 Revised: 12 June 2023 Accepted: 17 June 2023 Published: 25 June 2023

Abstract *- This study introduces an acoustic approach presented by structures in virtual space. It is a fact that it is generally assumed that the composition of virtual space is expressed as simple buildings and that the user stays there. It is very difficult to express this sense of realism with an unsophisticated visual structure. This lack of expression of realism should be provided with a sense of space or realism considering the acoustic characteristics and characteristics of buildings. In general, since it would be contradictory to place the premise that the users accessing the virtual space are arbitrarily present in the expression of such realism, the study of the expression of realism is represented by acoustic approaches through simple models. In this study, we study to reduce the sense of spatial heterogeneity that appears in non-face-to-face situations.*

Keywords *- Virtual space, Acoustic approach, Realism, Sense of space, Non-face-to-face.*

1. Introduction

Various acoustic studies so far have focused on understanding the characteristics of space. These research directions are the ones we use a lot to model the spread of acoustic properties in space. Recently, the development of acoustics is making appropriate models even in virtual spaces. The characteristics of various implementations of virtual space, such as the metaverse, are too monotonous and linear, so understanding simple structures is made only by considering acoustic characteristics. In implementing these acoustic spaces, it is true that there are many things that are difficult to express in real time because most of the user-oriented characteristics are intensively studied. Recently, in order to overcome these problems, various approaches have been proposed and implemented through evaluation. Most of the acoustic considerations can be divided into high sound quality or various expressions, and it is true that these classifications have been conducted through various studies. However, studies have been focused on reproducing acoustic parts considering real-time or spatial characteristics or representing characteristics in high sound quality for the diversity implemented so far [1][3][4]. Currently, studies are being conducted to improve satisfaction by reproducing the same sense of space that appears in real buildings and high-quality sounds to people in a special non-face-to-face environment. In order to understand the peculiarities of the metaverse space and get rid of the monotony and mechanical stuffiness that appear in virtual spaces, you will get very good satisfaction if you express and service the sense of space and grandeur that most people have felt in general buildings [10][12][13][14][15][16]. Various studies on implementation will be conducted. In order to overcome the monotony in the real space, the diversity of buildings exists, and these characteristics create various acoustic characteristics. In several European countries, it was possible to transmit sound to the public without amplifying sound by using the characteristics of resonance, and the designs of internal buildings were designed with appropriate consideration of these characteristics. The design was carried out by understanding the area where the sounds converge by equating the dome or the reflection angle to the space where specific sounds generated by resonance are concentrated [4][6][7][9]. The study was conducted based on the fact that these monotonous sounds could be applied when designing the current virtual spaces by changing them into various buildings.

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

In general, the characteristics of virtual space are to jointly perform actions or tasks while using simple structures to assume that they are in the same space. These are things that lead to sophisticated general social life in a world made of simple Lego blocks that lack realism. For this reason, it is possible to obtain an understanding or ask for opinions on the efficiency of works or common themes, but things about essential meetings or introductions in life are very less realistic. Since sophistication is very important in

meetings about new topics or topic discussions, changes are being made by adding structures or buildings. Even with these changes, the sense of reality is very low, so various studies are being conducted to supplement them. Currently, most of these studies are made by adding 3D structures or complexity using an approach to realism similar to existing buildings. However, it is true that the complexity of the configuration and the different arrangement of the users' buildings presents burdens and incurs high costs. These problems have a huge amount of data in the network or data because of the time required to create a virtual space and the amount of information to be exchanged. Here, the amount of data is regarded as a burden on users. Although various attempts have been made to overcome the existing methods, there has been no significant improvement yet. The recently applied method is making efforts to create virtual spaces by imitating existing buildings and using these virtual spaces as meeting places. The characteristics of these 3D structures are divided into open space and closed space, and open space reproduces the outdoors. The closed space is created by imitating the interior to express the outdoors or indoors. Here, place movement or conversion is made and used in consideration of visual characteristics.

For this reason, visual changes can be reproduced, but in terms of realism, there is not much difference from simple structures. As a task to overcome these limitations, various changes are being attempted. Here, various research directions mainly focus on structures, which are visual effects. This study attempts an acoustic approach to overcome the limitations of these visual structures.

3. Proposed Methods

Right angles and curves can replace the features that appear in various buildings. If you model one of these features, the rest can be configured in a Lego-like form through addition. In particular, straight lines may be arranged in a line, but in the case of curves, they may be arranged according to distance. The method used in this study reconstructs the form obtained by creating a model and arranging it speculatively. In this case, various changes can be applied [10][12[[13][14][15][16]. First of all, before analyzing the characteristics of a model, modeling is performed on the premise that the characteristics of the structure to be made are composed of rectangles. The shape of a straight line should be defined in terms of reflectance and transmittance for acoustic considerations. Since the characteristic of reflectance affects the loss of direct sound when a sine wave is an input, in this study, 20% was treated as the loss rate, and the model was simplified. Straight models are used in many buildings because they are mainly used in pillars that play a role in creating space among building structures or supporting structures if acoustic characteristics are considered. This is the most important part considering this modeling because more than 70% of the buildings are used. In addition, when the space of the straight line is wide, it is far from the resonance, which gives a sense of space because the loss of sound and the amplification of sound are important. The method mainly used here considers the volume of sound by weighting it with *Ws* for the calculation of the case where the space is wide. The use of weights was determined by how wide or small the space was, and the negative pressure was adjusted by lowering the weight value as the number of rectangular pieces increased. These effects are one of the most important factors in architecture because they are inversely proportional to the sound volume rather than the sense of space.

When installing buildings in virtual space, most considerations give value only to what is visible, but this does not consider the structures' characteristics for buildings, so as an additional consideration, diversity is achieved by connecting linear modeling pieces and considered to have. When such a virtual space is created, fewer models will be used outdoors, and many pieces will be used inside, so this spatial area is designed to control the sound pressure. The important thing here is that circular buildings such as domes were designed and implemented by artificially inclining straight pieces. However, in this case, resonance can occur, so it is expressed as *Wr* as an effect that creates resonance. The method of designing the characteristics of the proposed metaverse space well is configured to implement the characteristics of the real space well by designing using *Ws* and *Wr* appropriately.

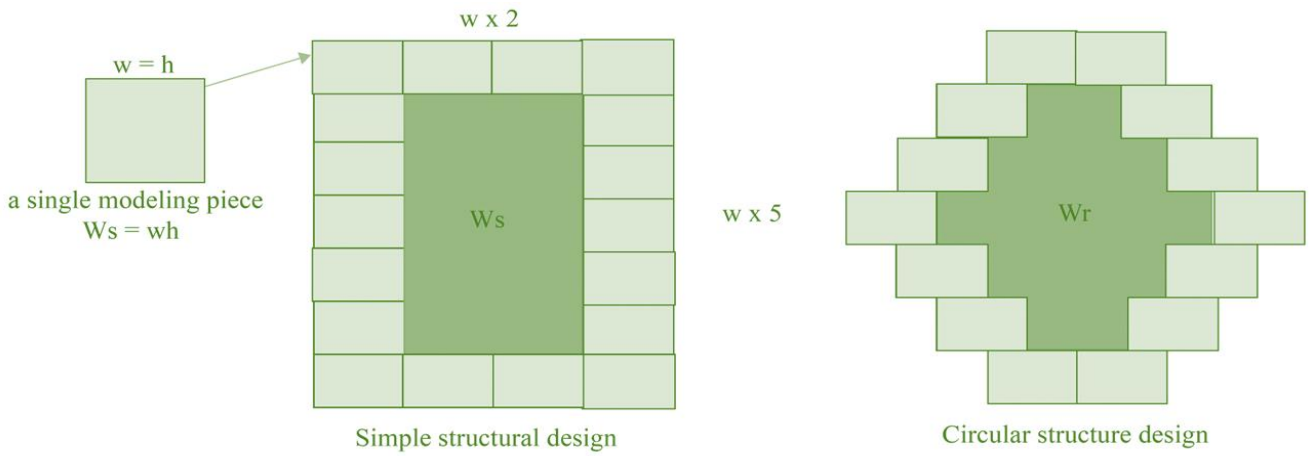

Fig. 1 Examples of virtual space design through acoustic considerations using a single modeling piece

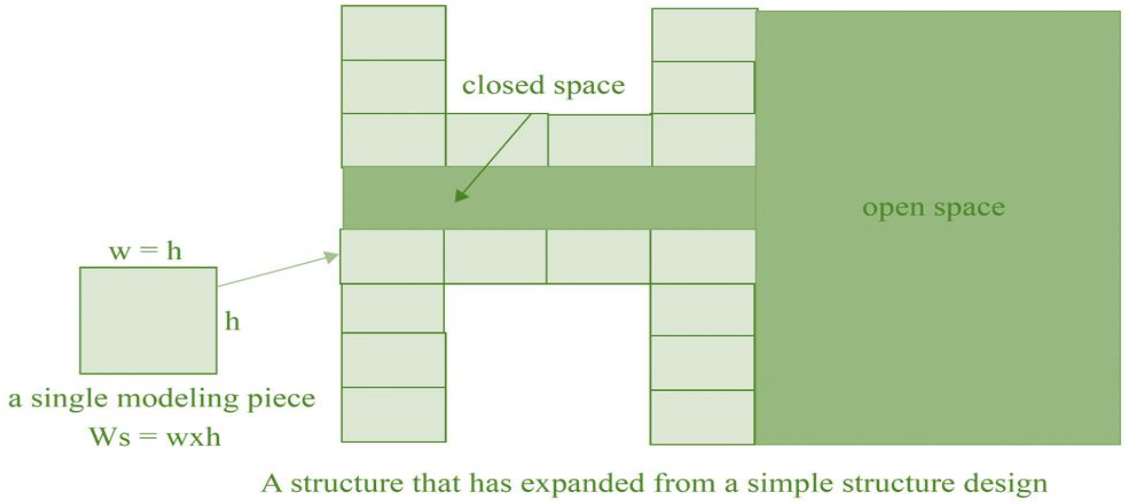

Fig. 2 An example of the arrangement of simple models for open and closed spaces

$$Ea = Ws / N + (Wr \times Rp) \quad (1)$$

where N = numbers of a simple model, Ws = w x h and Wr = Ws x Hz

The use of resonant sound in virtual space is to give effect to specific internal sounds. These considerations were used to emphasize the resonance of the sound or the characteristics of the interior, giving the effect of the buildings. As in the equation, the area of a structure was calculated in a single model, or the resonance sound was added for a circular structure, and acoustic characteristics were considered and used.

When tested by simple addition, we obtained various features, and some users needed to adapt to the sense of space. Acoustic characteristics in virtual space vary according to the number and structure of buildings. First of all, a single model was used to simplify these considerations. This single model only considers straight and curved structures, depending on the number and shapes used. This is to make it easy to apply when providing sound pressure in an acoustic feature. This is because if this simplicity is expanded to various components in the future, excellent realistic sound can be created. A variety of configurations can be considered, from visually simple structures to complex 3D structures. It is believed that these features can be made diverse as an extension to the single structure Ws. A good representation of spatial sounds given in virtual space can be made by detecting and expressing the areas of spatial structures, whether straight or curved. In this study, it was designed to show various acoustic characteristics by modeling various structures, excluding perspective, by expressing them with straight lines and curves. The most common structure is simple, but the structure that suddenly disappears from a simple structure is realized by expressing it as if water is flowing by giving a resonance characteristic, a phenomenon in which sounds appear and then become smaller. As shown in Figure 2, acoustic effects were used by finding the areas of spaces using a model, which is a simple structure, and finding openings and closings for those areas. These structures are divided into simple ones and complex ones, and depending on how many models are used, they maximize the sense of space by adding the size of the acoustic sound pressure or the resonance compared to the area.

4. Conclusion

This study proposes considering the acoustic conditions of the virtual space similar to the buildings in the real space. Since the characteristics of virtual space are intended to give people a sense of reality by designing only what is visible, the sense of reality is diminished due to dry and stuffy structural problems. This study modeled this part as a simple structure such as Lego, divided it into outdoor and indoor areas, and designed it to use it appropriate. It was possible to apply it in a variety of ways. These features use virtual space visual and acoustic expressions such as the metaverse. They can double the realism of users by adding auditory expressions with acoustic effects rather than visual immersion effects. The simple modeling used in this study was designed to be appropriately used in any structure by adding direct and resonant sounds to the number of pieces and the composition of various buildings. From simple structures to complex structures, the number of models used indoors and outdoors and the acoustic characteristics of structures using open and closed were made to be represented. In this study, we were able to achieve excellent results by reproducing effective acoustic production.

This study can be used in more virtual spaces such as the metaverse if additional elaborate models are developed, and additional studies on the arrangement and composition of the models are made. In the future, we will develop more advanced models so that they can be applied to complex buildings or structures, and we will present them through continuous research.

Acknowledgement

This research was supported by Kangnam University Research Grants (2021).

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