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Analysis of the Application of Spatial Audio in VR Tower Defense Game Rise of Majapahit in Improving Better Sound Localization Ability

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ABSTRACT

Virtual reality is a technology that is commonly used in games. To enhance its immersiveness, spatial audio plays a very important role as it can allow players to feel very important as it allows the player to feel the depth and direction of sounds in the game environment. The number of players who still find it difficult to localize the presence of enemies that are visually out of visual sight, making it a little difficult for them to complete the game. This research examines application of spatial audio in the VR game Tower Defense: Rise of Majapahit to improve sound localization capabilities. Using comparative quantitative methodology, this study tested respondents in physical and virtual environments, collecting data through t-tests. in physical and virtual environments, collecting data through independent t-test. Results showed a significant difference in ability to identify the direction of sound, easier virtually than physically, particularly sounds from behind, right, and left. This finding confirms the importance of spatial optimization of audio in VR games to create a more immersive gaming experience. VR games to create a more immersive and realistic gaming experience and realistic play experience. This research provides insights for further development of spatial audio technology, supporting the creation of immersive and satisfying virtual environments for the player.

KEYWORDS

Virtual Reality, Spatial Audio, Game, Majapahit, Unity

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INTRODUCTION

Virtual Reality (VR) is a commonly used technology in games to give players the experience of being inside the game world being played(Suardi, 2019). Spatial audio plays an important role in enhancing the immersive experience in VR players. This technology allows players to feel the depth and direction of sound within the game environment, increasing the player's level of immersiveness(Bosun, 2020; Meghanathan et al., 2021; Venema, 2021). One VR game that applies spatial audio is The Rise of Majapahit Kingdom, which presents an educational experience about the beginning of the Majapahit Kingdom. In the gameplay, players use arrows as the main weapon and hone strategies to defeat the enemy.

Spatial audio plays a crucial role in enhancing the immersive experience of players in the use of Virtual Reality (VR) technology. It not only creates a realistic sensation, but also assists players in navigating and localizing objects or enemies around them so that players no longer struggle to find enemies or targets that may escape their visual sight(Beig et al., 2019; Venema, 2021; Warp et al., 2022). Thus, spatial audio becomes a key element in creating a good VR experience and helps players to more effectively interact with their virtual environment(Buck et al., 2022).

Proper implementation of Spatial Audio technology is very important in The Rise of Majapahit Kingdom game that has participated in the KMIPN IV competition. This technology allows players to sense the direction of sound more accurately in locating enemy positionspotter(Cureton, 2023; Moraes et al., 2020; Potter et al., 2022). The use of Spatial Audio not only enhances immersiveness, but also supports the strategic aspects of the game. However, some players may experience difficulties due to a lack of familiarity or understanding of Spatial Audio. Therefore, understanding and adapting to this technology can provide a more satisfying and effective gaming experience. The purpose of this research is to analyze sound localization in game applications, especially focusing on identifying the direction of sounds that are difficult for players to know. This research will evaluate the difficulty of players in determining the origin of sounds that signal the presence of enemies or certain objects in the virtual environment. By measuring the player's response to sound localization, this research will provide insight into areas that require improvement.

RESEARCH METHOD

Analysis of Spatial Audio Application in VR Tower Defense Game: Rise of Majapahit in Improving Better Sound Localization Ability using a comparative quantitative research method adapted from Sugiyono's comparative quantitative research flow by taking experimental data conducted on respondents(Sugiyono, 2011). Seen in (Figure 1) the respondent will be physically tested then tested using the application and the respondent will guess the direction of the sound given. The results of the respondents' guesses will be collected and then data analysis will be carried out to retrieve the results with an independent t-test.

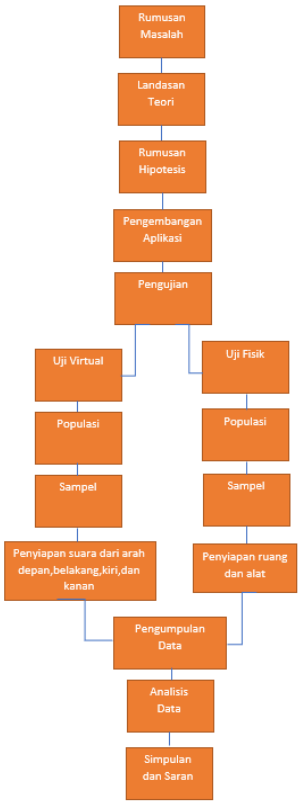

Figure 1. Quantitative Comparative Research Flow

SPATIAL AUDIO

Spatial audio is an audio technology that allows users to hear sounds from different directions and distances in 3D space, thus creating a realistic audio experience(Lakka et al., 2020). This technology is used in various applications, including VR games, to enhance user immersion and interactivity within the VR environment. It works by creating a realistic sound field that matches the visual scene. This allows players to hear sounds from different directions and distances in 3D space, so they can sense the direction of the sound more accurately in locating the position of enemies or objects around them(Bhide et al., 2019; Bosun, 2020). In addition, spatial audio also provides spatial clues and information that help players to identify the origin of the sound and direct their attention in the right direction, allowing them to navigate and localize objects or enemies around them more accurately (Beig et al., 2019; Venema, 2021; Warp et al., 2022).

RESPONDENTS' PROFILE

In Roscoe's research, the ideal sample size for a study is between 30 and 500 respondents(Roscoe, 1975) so that respondents in the Analysis of Spatial Audio Application in VR Tower Defense Games: Rise of Majapahit in Improving Better Voice Localization Capability numbered 30 from the age range of 18-25 years. All respondents

who participated in this study have at least played games and have a good level of hearing. The data used in this study is voluntary and is not used for anything other than this research.

MEASUREMENTS

The independent t-test is a statistical method used to compare the means of two different types of data. This test is conducted to determine whether the difference between the means of the two types of data taken is statistically significant. There are several tests that must be done before conducting this independent t-test such as normality test and reliability test. The method applied to perform the normality test in this study is the Shapiro-Wilk test. This test was chosen because it can evaluate the distribution of a small amount of random data. Based on two journal seminars conducted by Shapiro, Wilk, and Chen in 1968, the amount of data used in the simulation amounted to approximately 50. Therefore, testing with this method is highly recommended for data that is less than 50 (N < 50). The significance level used in this study is 0.05, so if the significance value of the data obtained is greater than 0.05 (sig, > 0.05), then the data is normally distributed.(Suardi, 2019).

$$W = \frac{(\Sigma \alpha_i x_{(i)})^2}{\Sigma (x_i - \bar{x})^2} \text{.....(1)}$$

Description:

W : the value of the Shapiro-Wilk test statistic

α_i : coefficient that depends on the number and size of samples

$x_{(i)}$: the order of data sorted from smallest to largest

x_i : actual data value

$\bar{x}$: the average of the data

Data that has been normally distributed will be tested again for reliability using the Cronbach's Alpha reliability test.

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum \sigma_t^2}{\sigma_t^2}\right) \text{.....(2)}$$

Description:

σt_2 : Total variance

$\sum_{\sigma b}2$: Total Variance of items

r_{11} : Instrument reliability coefficient

Furthermore, the data that has passed the Shapiro-Wilk normality test stage and the Cronbach's Alpha reliability test will be tested with an independent t-test to obtain the significance results.

$$t_{hitung} = \frac{X1 - X2}{\sqrt{\frac{(n1-1)s_{1^2} + (n2-1)s_{1^2}}{n1+n2-2}\left(\frac{1}{n1} + \frac{1}{n2}\right)}} \quad .....(3)$$

Description:
X1: Mean value of the first sample group
X2: Mean value of the second sample group
n1: Size of the first sample group
n2: Size of the second sample group
S1: Standard deviation of the first sample group
S2: Standard deviation of the second sample group

AUDIO SOURCE

Audio Source is a tool that allows playback of Audio Clips in a scene. These Audio Clips can be played to an audio listener or through an audio mixer. Audio source can play various types of Audio Clip and can be configured to play as 2D, 3D, or a mix of both by using the SpatialBlend property.

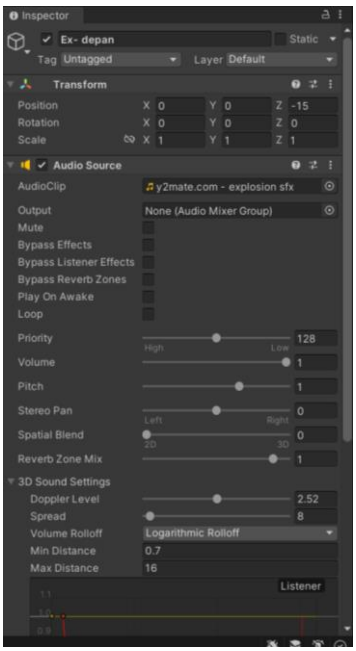

Figure 2. Audio Source Group

In making the Spatial Tester application, the parts used are Stereo Pan, Spatial Blend, 3D Sound Setting, Min Distance, and Max Distance as shown in (Figure 2)(Unity, n.d.).

- Stereo Pan: Sets the position in the stereo plane of the 2D sound.
- Spatial Blend: Sets how much influence the 3D engine has on the audio source.
- 3D Sound Settings: Settings that are applied proportionally to the Spatial Blend parameters.
- Min Distance: Within the MinDistance, the sound will remain as loud as possible. Increasing the MinDistance of the sound is used to make the sound 'louder' in the 3d world, and decreasing to make it 'quieter' in the 3d world.

- Max Distance: The distance at which the sound stops damping. Beyond this point, the volume will remain at the Maximum Distance unit from the listener and will no longer weaken.

THE PROCEDURE

There are several procedures that must be carried out when collecting physical and virtual data so that the research can run well. Here is the list of procedures:

1. Physical
   There are several procedures for voice localization research to physical test respondents:
   - Creating and distributing voice guessing answer sheets
   - Selecting respondents who have physical and mental health criteria
   - Informing the place and date to the respondents to do the test.
   - The respondent will wear a blindfold and be checked so that the respondent can only hear and cannot see at all.
   - Briefing the respondent about the physical test that will be carried out.
   - Respondents will be asked to guess the origin of the sound of table knocking.
   - Recapitulate the answer sheet that has been filled in beforehand
   - Analysis of test results that will be a reference for improving the Tower Defense Rise of Majapahit game provides reasons why it should fix and improve existing factors that are considered unsatisfactory.
   - Provide conclusions and suggestions after conducting the tests that have been carried out. Conclusions are obtained from the results of data analysis.
2. Virtual
   There are several procedures for sound localization research to the Spatial Tester application tester:
   - Creating and distributing voice guessing answer sheets
   - Selecting respondents who have the criteria to have played games and at least know the difference in sound direction.
   - Informing the place and date to the respondents to do the test.
   - Respondents will use the VR device and check that the device is installed and working properly.
   - Briefing the respondents about how the application works and the flow of the research.
   - Participants will try to use the Spatial Tester application after which the respondent will fill in the answer sheet about the direction of the sound produced.
   - Recapitulate the participant's answer data
   - Analysis of test results that will be a reference for improving the Tower Defense Rise of Majapahit game provides reasons why it should fix and improve existing factors that are considered unsatisfactory.
   - Provide conclusions and suggestions after conducting the tests that have been carried out. Conclusions are obtained from the results of data analysis.

TOOLS

The tools used as material for this research are Spatial Tester applications that can only be played using virtual reality tools. It can be seen from (Figure 3) that players who will be tested using the application will be faced with 4 buttons on a table and there is a writing "There will be 4 sounds from your side, please guess the source of this sound". The four buttons if pressed will play an explosion sound from different directions and these buttons are sorted from left to right.

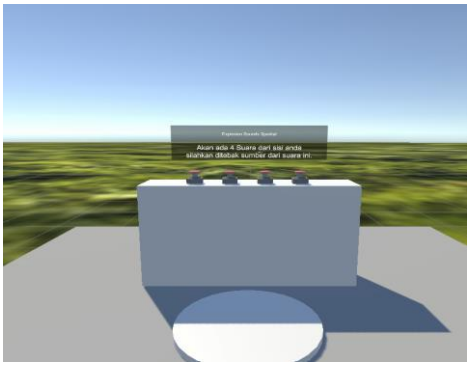

Figure 3. Spatial Tester Application View

MATERIALS

The sound used in this research has a frequency of 0-5 KHz, both the sound in physical testing and virtual testing.

RESULT AND DISCUSSION

DATA COLLECTION INSTRUMENT

Data collection from physical testing uses room 11.4 Tower A and data collection from virtual testing uses computers and VR equipment located in the Techno lab at Batam State Polytechnic. The devices used for experiments have the specifications presented in (Table 1).

Table 1. Computer and VR Device Specifications

Computer.	Virtual Reality.
KAT-VR Intel Core I5 9400F CPU @ 2.90Ghz (6 CPUs) RAM 8GB DDR4 Windows 10 Pro 64bit RTX 2060 6GB GDDR6	HTC Vive Pro 2 2448x2448 Pixels per eye 120Hz Refresh Rate 120-degree horizontal POV Hi-Res certified headphones Intergrated dual microphones Bluetooth & USB-C connectivity Steam VR Tracking 2.0

NORMALITY TEST

The method used in this normality test is Shapiro-Wilk. This method was chosen because the amount of sample data obtained is not more than 50. Using a significance level of 5%, we will make a decision based on the p value (significant value) which is smaller than the specified significance level (Santoso, 2014). The basis for decision making in the Shapiro-Wilk normality test is as follows:

1. If the Shapiro-Wilk normality test value> 0.05 then the data is normally distributed

2. Meanwhile, if the value of the Shapiro-Wilk normality test <0.05 then the data is not normally distributed

Table 2. Normality Test Results

Sound Direction	Physical	Virtual
Front	.052	.107
Behind	.187	.064
Left	.712	.135
Right	.173	.068

As seen in (Table 2) of the physical test data, because the significance values of front (0.052), back (0.187), left (0.712), right (0.173) are higher than the significance level (0.05). Therefore, we can accept that the physical test data is normally distributed. For the virtual test data, since the significance values of front (0.107), back (0.064), left (0.135), right (0.068) are also higher than the significance level (0.05). In this case, we can accept that the virtual test data is also normally distributed.

RELIABILITY TEST

This test is carried out with the aim of evaluating the level of confidence in the data that has been collected. The method used in this test is Alpha Chronbach. In his book Wiratna Sujarweni, it is explained that physical and virtual data reliability tests can be carried out serially (V. Wiratna Sujarweni, 2014). The following are guidelines for making reliability test decisions using the Alpha Chronbach method:

1.If the Cronbach's Alpha value> 0.60 then the data is considered reliable or consistent.

2.Meanwhile, if the Cronbach's Alpha value is <0.60, the data is not considered reliable or consistent.

Table 3. Reliability Test Results from Various Voice Directions

Voice Direction	Chronbach's Alpha Value
Front	.608
Behind	.614
Left	.604
Right	.620

In (Table 3), it is known that the front, back, left, right, and total sound direction data for both physical and virtual groups have Cronbach's Alpha values above 0.60. Therefore, according to the decision-making guidelines above, we can conclude that both types of questionnaire data for physical and virtual front direction data variables are reliable or consistent.

INDEPENDENT SAMPLE T-TEST

Guidelines for decision making in the Independent Sample T-test test based on the significance value (Sig.) of the SPSS output results, are as follows:

1. If the value of Sig. (2-tailed) <0.05, then H0 is rejected and Ha is accepted.

2. If the value of Sig. (2-tailed) > 0.05, then H0 is accepted and Ha is rejected (V. Wiratna Sujarweni, 2014).

The independent t test hypothesis in the Analysis of Spatial Audio Application in VR Tower Defense Rise of Majapahit Game in Improving Better Sound Localization Ability is as follows:

1. Null Hypothesis (H0): There is no average difference between virtual and physical test results, which means that the direction of the sound source heard is more difficult or equally difficult to identify virtually than physically.

2. Alternative Hypothesis (Ha): There is an average difference between the virtual and physical test results which means that the direction of the heard sound source is easier to identify virtually than physically.

Table 4. Independent T-test Results

Independen T-test	**t-test for Equality of Means**							
Posisi	Sig.(2-tailed)		Mean Diffrence		Std. Error Diffrence		95% Confidence ... Lower	
	Equal variances assumed	Equal variances not assumed	Equal variances assumed	Equal variances not assumed	Equal variances assumed	Equal variances not assumed	Equal variances assumed	Equal variances not assumed
Depan	.569	.569	-2.7333	-2.7333	4.7752	4.7752	-12.2920	-12.3025
Belakang	.027	.027	-6.6667	-6.6667	2.9298	2.9298	-12.5312	-12.5439
Kiri	.001	.001	-9.9333	-9.9333	2.9425	2.9425	-15.8235	-15.8290
Kanan	.008	.008	-10.2333	-10.2333	3.7200	3.7200	-17.6797	-17.7018

Based on the results of the independent t-test in (Table 4), the Sig. (2-tailed) for the forward sound direction (0.569). This value is higher than 0.05, which means that the alternative hypothesis (Ha) is rejected and the null hypothesis (H0) is accepted. Hence, it can be decided that the virtual identification of the front voice direction has the same level of difficulty or is more difficult than the physical identification.

However, for the back, right, and left voice directions, the significance value is less than 0.05 so that the alternative hypothesis (Ha) is accepted and the null hypothesis (H0) is rejected. Thus, it can be concluded that the identification of the back, left, and total voice directions is easier to do virtually compared to physical identification.

CONCLUSION

Based on the results of research conducted related to the application of spatial audio in the VR Tower Defense Rise of Majapahit game, it can be concluded that there is a significant difference in the player's ability to identify the direction of sound in the virtual environment compared to the physical environment. Players show better ability in identifying sounds from the back, left, and right directions virtually than physically. For frontal sound directions, visual information is needed to help players identify the source of the sound, such as smoke or light for frontal sound sources because players tend to look in other directions to find the source of the sound. Further research is needed to confirm whether the results observed here can be generalized to other test conditions..

REFERENCES

Beig, M., Kapralos, B., Collins, K., & Mirza-Babaei, P. (2019). An Introduction to Spatial Sound Rendering in Virtual Environments and Games. *The Computer Games Journal*, *8*(3–4), 199–214. https://doi.org/10.1007/s40869-019-00086-0

Bhide, S., Goins, E., & Geigel, J. (2019). Experimental analysis of spatial sound for storytelling in virtual reality. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *11869 LNCS*, 3–7. https://doi.org/10.1007/978-3-030-33894-7_1

Bosun, X. (2020). Spatial Sound-History, Principle, Progress and Challenge. In *Chinese Journal of Electronics* (Vol. 29, Issue 3, pp. 397–416). Chinese Institute of Electronics. https://doi.org/10.1049/cje.2020.02.016

Buck, L., Vargas, M. F., & McDonnell, R. (2022). The Effect of Spatial Audio on the Virtual Representation of Personal Space. *2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, 354–356. https://doi.org/10.1109/VRW55335.2022.00079

Cureton, D. (2023, February 28). *What is Spatial Audio? An Immersive Experience - XR Today*. https://www.xrtoday.com/mixed-reality/what-is-spatial-audio-an-immersive-experience/

Lakka, E., Brutzman, D., Puk, R., & Malamos, A. G. (2020). Extending X3D Realism with Audio Graphs, Acoustic Properties and 3D Spatial Sound. *The 25th International Conference on 3D Web Technology*, 1–9. https://doi.org/10.1145/3424616.3424709

Meghanathan, R. N., Ruediger-Flore, P., Hekele, F., Spilski, J., Ebert, A., & Lachmann, T. (2021). Spatial sound in a 3D virtual environment: All bark and no bite? *Big Data and Cognitive Computing*, *5*(4). https://doi.org/10.3390/bdcc5040079

Moraes, A. N., Flynn, R., Hines, A., & Murray, N. (2020). Evaluating the User in a Sound Localisation Task in a Virtual Reality Application. *2020 Twelfth International*

Conference on Quality of Multimedia Experience (QoMEX), 1–6. https://doi.org/10.1109/QoMEX48832.2020.9123136

Potter, T., Cvetković, Z., & De Sena, E. (2022). On the Relative Importance of Visual and Spatial Audio Rendering on VR Immersion. *Frontiers in Signal Processing*, *2*. https://doi.org/10.3389/frsip.2022.904866

Roscoe, J. T. (1975). *Fundamental research statistics for the behavioral sciences (Second ed.)*.

Santoso, S. (2014). *Statistik parametrik: Konsep dan aplikasi dengan SPSS* (Revisi). Elex Media Komputindo.

Suardi. (2019). *PENGARUH KEPUASAN KERJA TERHADAP KINERJA PEGAWAI PADA PT BANK MANDIRI, Tbk KANTOR CABANG PONTIANAK*. http://jurnal.shantibhuana.ac.id/jurnal/index.php/bee

Sugiyono. (2011). *Metode penelitian kuantitatif, kualitatif dan kombinasi (mixed methods)* (2nd ed.). Alfabeta.

Unity. (n.d.). *Unity - Manual: Audio Source*. Retrieved March 18, 2024, from https://docs.unity3d.com/Manual/class-AudioSource.html

V. Wiratna Sujarweni. (2014). *SPSS untuk Penelitian* (Florent, Ed.). Pustaka Baru Press.

Venema, A. (2021, July 22). *Spatial Audio Techniques for Enterprise VR Applications*. https://www.liveswitch.io/blog/archive/-spatial-audio-vr-guide

Warp, R., Zhu, M., Kiprijanovska, I., Wiesler, J., Stafford, S., & Mavridou, I. (2022). Validating the effects of immersion and spatial audio using novel continuous biometric sensor measures for Virtual Reality. *2022 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, 262–265. https://doi.org/10.1109/ISMAR-Adjunct57072.2022.00058