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Analysis of superposition characteristics in gamelan sounds using the spectra plus and audacity applications

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ABSTRACT

This research aims to analyze the characteristics of superposition waves in the musical instrument known as "saron" in the gamelan ensemble. In this study, three types of gamelan sarons were used as research instruments: "saron demung," "saron barung," and "saron panerus" or "peking." The sounds produced by these musical instruments were recorded, mixed, and analyzed using Audacity software and Spectra Plus Sound Card Edition. The analysis results conducted with Audacity and Spectra Plus Sound Card Edition revealed the presence of superposition waves that either reinforced each other when they had the same phase and frequency or weakened each other when they had different phases and frequencies. Therefore, this study concludes that audio mixing that falls under constructive or reinforcing superposition of waves is the combination of "saron demung" with "saron demung." On the other hand, audio mixing that falls under the destructive superposition of waves includes the varieties of "saron barung" with "peking," "saron barung 1" with "demung," "saron barung 2" with "peking," and "saron barung 2" with "demung."

Keywords: Amplitude, characteristics, superposition, wave.

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INTRODUCTION

The island of Java is home to many traditional musical instruments, one of which is the gamelan. Gamelan instruments are thought to have been known in Java since 404 AD, and today, Javanese gamelan is used as a musical performance with Sinden as the one who sings a song (Dinas Pariwisata dan Kebudayaan DKI Jakarta, 2019). The gamelan is used for various significant events and serves as an accompaniment, whether in dance performances or rituals (Trisnowati, 2017). The gamelan consists of instruments that produce distinct sounds, with each instrument generating different frequencies depending on the octave produced. Gamelan is personally created with the makers' feelings and experiences in mind. Although the human ear can discriminate between high and low tones, it cannot identify the specific tone being heard (Mitrayana & Cytasari, 2015). Each gamelan, depending on the materials used and the thickness produced, has its unique sound characteristics. As a result, the instruments' strength and frequency vary (Pramudya et al., 2018). The sound of the gamelan varies due to the human intuition-based crafting process (Widayanti & Pramudya, 2017). Each ensemble has distinct characteristic features, making the gamelan genuinely unique. Most gamelan instruments are played by striking (Yuda & Azis, 2019).

Javanese gamelan is a musical instrument comprising the rebab, celemung, gong, and bamboo flute. The components of the gamelan are made from wood, bamboo, and metal (Iswara, 2018). Based on their function, gamelan is divided into four types or sections: 1) Rhythmic players, which include the large gong, gong suwukan, kempul, kenong, kethuk, engkuk, and kempyang. 2) Main melody carriers, whose instruments consist of saron (barung, demung, slenthem), and bonang penembung. 3) Melody embellishers include saron penerus (peking), saron bonang, saron gender, and saron gambang. 4) Rhythm embellishers, who have instruments like the large kendang, ketipung, and Batangan (Alkausar & Setiawan, 2021).

Saron is one of the gamelan musical instruments played by hitting with a wooden hammer that produces sound through the vibration of metal blades (SANJAYA, 2022). Saron is a general term for a six-pronged or six-branched gamelan instrument made of copper or brass that rests on a wooden frame and serves as a resonator (Maula & Setiawan, 2018). The gamelan instruments are divided into three types: saron barung, demung, and panerus (peking). Saron demung produces notes in the middle octave, while barung is medium-sized and produces high-octave notes. Lastly, saron panerus or peking has the highest octave but is the smallest in size among the saron instruments.

The most fundamental branch of science is physics. Understanding physics is the first step towards understanding science (Anggraeni et al., 2019). It is possible to speculate that theoretical and experimental methods will improve in these directions, revealing the unexpected (Wittkop et al., 2023). Physics is the science that studies natural objects, phenomena, events, and interactions in nature. These phenomena are usually perceived through our senses, such as light, optics, acoustic noise, heat, and sound waves, which can also be felt through touch (Nova et al., 2020). Waves are oscillations of energy that propagate through a medium or without a medium (Halliday, 2004). Vibration itself is a back-and-forth motion about an equilibrium or a balanced state. When waves propagate, energy is transferred from one place to another (King, 2009). The motion of waves can be seen as the transfer of energy and momentum from one point to another without the transfer of matter (Tipler, 1998: 471). Waves themselves come in two types: transverse waves and longitudinal waves. The difference between the two types of waves lies in their direction of propagation and the nature of their vibrations. Transverse waves have perpendicular wave propagation, while longitudinal waves have parallel wave propagation (Widodo et al., 2022). An example of a longitudinal wave is sound waves, while transverse waves can be seen in water ripples. Mechanical waves are energy that propagates mechanical waves in a medium without any movement in the medium. In contrast, electromagnetic waves are electromagnetic waves that do not require a medium to propagate (Sahyar et al., 2020). Radio waves, which have a frequency of, are one example of electromagnetic waves whose lowest frequency is 10^2Hz to 10^8 Hz (Herliana, 2023)

Every sound has waves to propagate and be heard by humans. Sound waves belong to the category of longitudinal mechanical waves, which means that sound waves can propagate through any medium (solid and liquid) with parallel wave propagation resulting from the vibration of a source (Widodo & Endarko, 2018). Sound waves are produced when an object vibrates due to the influence of another thing with the same frequency, a phenomenon known as sound resonance. These waves travel in a spherical wavefront that propagates in a uniform medium with a constant speed (Kua et al., 2021). The amplification of instrument sounds is caused by sound resonance when air molecules vibrate in sync with the sound source at the same frequency (Fitriyani & Andryani, 2023). Each sound source will have a unique sonic signature. These distinguishing characteristics can be observed depending on the frequency and intensity parameters of the sound source (Azalia et al., 2022).

Sound waves can be reflected and even combined with other sound waves. When one wave combines with another, it is called the superposition of waves. In this instance, the two tones can either strengthen or altogether cancel each other out as they superimpose (Aygün et al., 2019). Also, when two or more waves overlap to create a wave of greater or lower amplitude, this is called interference (Jaafar et al., 2019). One of the principles of physics with the deepest roots is the superposition of waves (Castañeda, 2017).

The superposition of waves can be understood as combining or adding two or more waves. The total wave coming in and the reflected wave that forms vibrations or free waves are also included in the superposition of waves (Chen et al., 2017). The wave superposition approach based on singular-value decomposition gave physical insight (Wu & Xiang. 2018). Waves combined in the superposition of waves can be either destructive or constructive. Destructive waves mean that the waves weaken each other, whereas constructive waves are waves that reinforce each other (Tsutsumi et al., 2020). Constructive waves have the same phase, while destructive waves have different phases.

Each type of wave has its characteristics, and wave characteristics vary depending on the type of wave. This research paper aims to analyze the characteristics of superposition waves in the saron musical instrument of the gamelan. This analysis is aided by Spectra Plus Sound Card Edition software to observe the frequency, waveform, and amplitude generated.

RESEARCH METHODS

The research method employed in this journal is an experiment conducted at the Karawitan Laboratory of the Faculty of Language and Arts, Universitas Negeri Yogyakarta. Several tools and materials were utilized in this experiment, including three types of gamelan sarons (Saron demung, saron barung, and saron panerus or peking), a Samsung Galaxy A51 smartphone for sound recording, a laptop, Audacity software, and Spectra Plus Sound Card Edition software. The experiment involved playing the gamelan saron musical instruments with the notes of the song "Ibu Kita Kartini" on all the types of sarons used. In the experiment, each gamelan saron musical instrument was played by a single performer to ensure consistency in tempo and playing style. Subsequently, the sound produced by the gamelan instruments was recorded. The sound recordings were input into a laptop and analyzed. After removing noise, two audio tracks were combined or mixed into one using Audacity software to generate superposition waves. Audacity is a free sound processing software used in this experiment to record and analyze sound signals in waveform format (Astuti, 2016). Following this, an analysis was conducted using Spectra Plus Sound Card software to determine the frequency and amplitude of the sound produced by the gamelan.

RESULTS AND DISCUSSION

Analysis Results of the Gamelan Demung

Figure 1. Spectra plus sound card software analysis of the saron demung wave.

Figure 2. Spectra plus sound card software analysis of the saron demung gamelan with the same audio file.

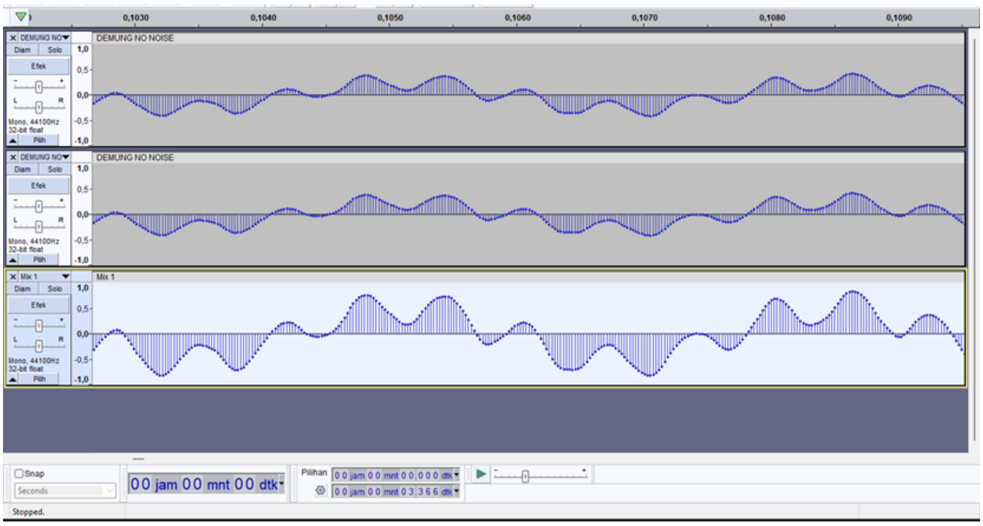

Figure 3. Audacity software analysis of the superposition of gamelan saron demung waves with the same audio file.

Based on the data obtained from the analysis using Spectra Plus and Audacity software, it was found that the combined waveform of the Saron Demung with the same audio, with a frequency of 441 Hz and an amplitude of 59.96 m, resulted in a superposition waveform with higher amplitude compared to the original waveform. The original audio had a frequency of 441.32 and an amplitude of 54.09 m. This is because mixing two waves with the same frequency and phase will result in a waveform with an amplitude twice as large as the original waveform. Since the frequency of the combined wave is inherited from the original wave, the period of the combined wave will also be the same as the original wave. This theory can be supported by Figure 3. The resulting combined waveform has an amplitude twice or more than 2π times larger. The frequency and phase produced are almost the same. Therefore, based on the obtained analysis results, the superposition of the Gamelan Saron Demung wave with another Saron Demung falls under the characteristic of constructive superposition waves or mutual reinforcement.

Analysis Results of the 1st Gamelan Barung with Gamelan Peking

Figure 4. Spectra plus software analysis of 1st gamelan barung audio.

Figure 5. Spectra plus software analysis of gamelan peking audio.

Figure 6. Spectra plus software analysis of the superposition of 1st gamelan barung and gamelan peking audio waves.

In Figure 6, they combined the audio of the 1st Gamelan Barung with peking, which shows that the generated amplitude is lower than that of one of the original waves. The frequency of the combined audio is 705.212 Hz, and the resulting amplitude is 51.30. Meanwhile, the 1st Gamelan Barung and Peking audio frequencies are 882.861 Hz and 699.829 Hz, with amplitudes of 44.43 m and 51.87 m, respectively. This is because the frequencies and phases of the two audio signals are different, so when combined, they result in an amplitude that falls between the amplitudes of the original waves. Different frequencies will cause the period of the superposition wave to be different from the original wave. The more significant the difference in the frequencies and phases of the audio, the lower the difference in amplitude produced by the superposition wave. The analysis results indicate that the superposition of the 1st Gamelan Barung and Peking waves falls under the category of destructive superposition waves or mutual weakening.

Analysis Results of 1st Gamelan Barung and Gamelan Demung

Figure 7. Spectra plus software analysis of the superposition of 1st gamelan barung with gamelan demung audio waves.

In Figure 7, when compared to Figure 1 and Figure 4, it can be observed that the generated amplitude is smaller than that of the original waves. The frequencies of the original 1st Gamelan Barung and Gamelan Demung waves are 882.861 Hz and 441.431 Hz, respectively, with amplitudes of 44.43 m and 54.09 m. Both waves produce a superposition wave with a frequency of 441.431 Hz and an amplitude of 54.01 m. With the frequencies and phases generated by both audio signals having a significant difference, the decrease in amplitude in the resulting superposition wave will be more significant than for audio signals with less disparity in frequency and phase. Therefore, the result is a destructive or weakening superposition wave.

Analysis Results of 2nd Gamelan Barung and Gamelan Peking

Figure 8. Spectra plus software analysis of 2nd gamelan barung audio.

Figure 9. Spectra plus software analysis of the superposition of 2nd gamelan barung and gamelan peking audio waves.

Based on the comparison between Figure 9, Figure 5, and Figure 8, it can be observed that the generated amplitude is smaller than that of one of the original waves. The frequencies of the original 2nd Gamelan Barung and Gamelan Peking waves are 1405.042 Hz and 699.8829 Hz, respectively, with original amplitudes of 22.68 m and 51.87 m. These two original waves produce a superposition wave with a frequency of 699.829 Hz and an amplitude of 41.08 m. Due to the significant difference in frequencies and phases generated, this superposition wave can be categorized as a destructive or weakening superposition wave.

Analysis Results of 2nd Gamelan Barung and Gamelan Demung

Figure 10. Spectra plus software analysis of the superposition of 2nd gamelan barung and gamelan demung audio waves.

Based on the comparison between Figure 10, Figure 8, and Figure 1, it can be observed that the generated amplitude is smaller than that of one of the original waves. The frequencies of the original 2nd Gamelan Barung and Gamelan Demung waves are 1405.042 Hz and 441.431 Hz, respectively, with original amplitudes of 22.60 m and 54.09 m. These two original waves produce a superposition wave with a frequency of 1405.042 Hz and an amplitude of 32.94 m. Due to the significant difference in frequencies and phases generated, this superposition wave can be categorized as a destructive or weakening superposition wave.

CONCLUSION

Based on the research conducted, the conclusions can be drawn: audio mixing falling under constructive superposition of waves or reinforcement occurs when combining Saron Demung with Saron Demung. On the other hand, audio mixing falling under destructive superposition of waves happens when combining 1st Gamelan Barung audio with Peking, 1st Barung with Demung, 2nd Barung with Peking, and 2nd Barung with Demung. This research provides a deeper understanding of the characteristics of superposition waves in the Javanese gamelan instrument known as saron. This understanding can be valuable in enhancing and developing traditional Javanese music.

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