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Design of Angklung Music Scoring System Based on Remote Training

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ABSTRACT

Angklung is a traditional musical instrument from West Java, Indonesia. To play a song using this instrument can only be played in groups. The size of the musical instrument is quite large and prone to damage if carried anywhere, making it challenging to practice except in schools or music clubs. Since the pandemic, it has become increasingly difficult for students to practice angklung due to the limitations of face-to-face learning. This study aims to make it easier for students to practice and play angklung. The system is based on online multiplayer games so that students can learn and play angklung with more fun, and players can play anywhere. Players can use the mobile version of the angklung application as a substitute for the angklung instrument. Players can perform a duet with other players in playing the same song. The results of the player's performance will be displayed as scores and stored in the database. Besides that, a real-time feedback function is always displayed for each note played. To distinguish individual players and/or notes, we use vibration sensor technology installed in each mobile application or signal processing, and the system will recognise them properly. We propose a Short-time Fourier Transform (STFT) algorithm as a scoring system and realtime-feedback performance. We use class diagrams to describe the whole application system and describe the functionality of the system in detail. We collect some research related to angklung and technology. Currently, there is a little study that could answer all the problems of learning and training angklung. The results of this study in the form of a system design are the initial research stage and are used for the following research phase. In conclusion, the design of this study can solve the existing problems so that the system will make it easier for students to practice and play angklung.

1. Introduction

Indonesia has several traditional musical instruments, one of which is the angklung. Currently, angklung is not only played for performing arts but is introduced in schools starting from elementary school to university [1]. The uniqueness of the angklung instrument makes it a symbol of unity, struggle, and harmony [2], making this musical instrument very valuable for anyone who learns,

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plays, practices, and performs it, especially Indonesians. Playing this angklung musical instrument is simple since they need to shake it to make a sound.

However, when many people gather to play a song using this instrument, even normal people may have difficulties. Furthermore, deaf people who have hearing loss face more difficulties in such situations [3] since they cannot hear well [4]. Some of them cannot even hear anything, even though they are assisted with hearing aids, because deaf people have a different hearing classification from normal humans [5]. What happens when a deaf person plays a musical instrument? It may be possible if the instrument is easy to play with the help of technology.

In Indonesia, students have had difficulty learning and practising angklung due to the COVID-19 pandemic since the beginning of 2020. There is no distance learning system to practice angklung, even though practising angklung cannot be done alone. In 2020, a researcher introduced a unique application for deaf students called GEMBIRA (Mengenali Ragam Bunyi dan Bunyi/ Recognizing Variety of Sounds and Sounds). This application trains sound sensitivity for deaf students in 1st-grade elementary school [6]. Until 2022, this application is distributed nationally and can be downloaded free from the official website gtk.kemdikbud.go.id. On the other hand, the angklung application currently available on Google Playstore and Apple Store only introduces the sound of angklung based on the touched or shaken tone. Currently, few assistive technologies exist for deaf people, especially for playing music and the traditional angklung musical instrument.

Previous research is described in Table 1 in the “Current System” section below, shows some remaining problems, which are: no integrated system; no scoring systems; no realtime-feedback facilities; limited playing environments because they did not have a remote-training facility [7–9].

Assistive technologies should cover several things to solve these existing problems as follows

i. A scoring system with a function that can help improve Angklung's playing skills;
ii. A realtime-feedback facility with a function that can determine the player's ability in more detail;
iii. A remote-training function so the students can practice at home with playerbot and other players.

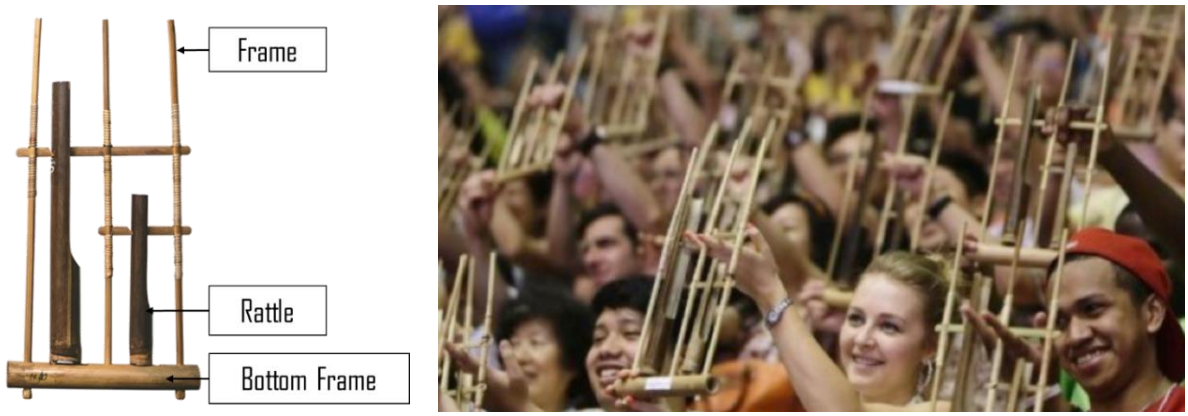
Therefore, this article proposes a new system design that can solve these problems. The proposed implementation allows the students to improve their skills with self and remote training facilities.

2. Related Works

2.1 Angklung

The angklung is a traditional musical instrument from Western Java (Jawa Barat), Indonesia. It comprises bamboo tubes with frames [10]. Angklung is a traditional musical instrument played by shaking [8]. One angklung only has one tone, so a full song must be played as a group (see Figure 1 part (b)). West Java angklung based on the basic tone is divided into two, namely: Sundanese Daminatilada angklung and Diatonic angklung. The first original angklung in Western Java is the Sundanese Daminatilada angklung because the tones in this type of angklung include "da, mi, na, ti, la, da," but the tone can only be understood by "Sundanese." Hence, the more popular one is Diatonic angklung. Diatonic angklung (some people call it angklung doremi) generally has a basic melodic tone: "do, re, mi, fa, so, la, si, do" [11]. Indonesians (besides Sundanese) and foreigners find Diatonic Angklung easier to understand. So if people say the word "angklung," it means "Dianotic angklung." Angklung has different shapes and sizes, but there are two important parts in an angklung, which are: 1) frame: The primary function is to hold the rattle tubes; 2) rattle: the primary function is to produce

a pitch frequency, but each rattle has each pitch frequency. In comparison, the function of the bottom frame is the foundation of the tubes and other frames [12]. Figure 1 shows the shape of the angklung with a label for each part of the angklung.



(a) (b) [14]

Fig. 1. Picture of (a) angklung [13] and (b) angklung performance from foreigners [14]

2.2 Angklung Characteristics

The angklung musical instrument has several characteristics, so there are advantages and disadvantages at the same time. The following are the characteristics of the angklung musical instrument

i. Sounding this instrument is relatively easy. The player only needs to shake it. This instrument is often used as a musical instrument introduced to local children, deaf people, and foreign tourists. Commonly, introductions are only made for the basic "doremi" note and not playing the whole song.
ii. One angklung only has one sound, so it takes many angklung to play a song.
iii. An angklung player is needed in a group to play a song. Even professional angklung players can only play 3-5 angklung at a time.
iv. Caring for this musical instrument is tricky, so it is usually only played in an art room (e.g., an art building or school). Players cannot bring angklung for self-practice at home.
v. An angklung player only needs to focus on his notes (e.g., do, mi, sol) because other players play other tones. This makes it both easy and difficult simultaneously because players need to adjust the play's rhythm with other players. Otherwise, the song being played will not be harmonious.

2.3 Problems by Deaf Students for Playing Angklung

Some special needs schools for deaf students in Indonesia (Indonesian: Sekolah Luar Biasa Bagian B/Tunarungu) teach angklung how to play the angklung musical instrument to their students. Generally, playing angklung for deaf students is not too focused on the performance of the music game but as a means of entertainment for deaf students to "play while learning." Deaf students cannot hear the music they play. In addition, teaching methods for children with special needs differ from those of normal children. Children with special needs are more easily stressed than normal children [15]. We design technology for children with special needs. It must be made simple, easy, and fun to use repeatedly [16].

2.4 Current System

Not many studies discuss angklung, especially related to the technology field. See Table 1 below to see the characteristics of several studies related to Angklung.

Table 1
Research related to Angklung and technology

No	Research title	Characteristics
1	Using Pazia Angklung application in understanding song scores [9]	Using the android application; touch to play and make a sound; the user is a normal student; no integrated system, no scoring system.
2	Redesigning and Implementing Traditional Musical Instruments in Integrated Technology Classroom [8]	Using the android application; the system is integrated with a PC, speaker, Makey Makey, and a set west-java angklung; one system is only for one user; the user is an elementary student; no integrated system, no scoring system.
3	The Impact of Implementation of Angklung Learning Application for SLB Part B Deaf using Multimedia-Based Coloring Method on User Satisfaction [7]	Using desktop and android applications; the user is deaf students; the systems are not integrated; no scoring system.
4	Smart Band Technology: A Music-Based Activity for the Thai Elderly [10]	Using Thai angklung; vibration sensor attached on hand-glove and angklung instruments; wired connection to the system; the user is Thai-elderly; no scoring system.

2.5 Problems with Current System

Based on the information in Table 1 above, we can conclude some problems and provide some solutions for each problem. See Table 2 for detail for each solution from problem finding.

Table 2
Problems finding with solution

No	Problems Finding	Solution
1	There is no feedback, integrated system and scoring	Make an integrated system including the scoring system and realtime-feedback function. The students can know their performance (what strengths and weaknesses point), so they know which part they need to improve.
2	Even though it uses a vibration sensor (Table 1, no. 4), it's not integrated with any system. In addition, the connection uses a cable.	Using the vibration sensor technology with a wireless connection is difficult to play if the wire cable is attached to our hands and music instruments.
3	No system can help players develop playing skills. a) Unable to do self-training. b) Couldn't solve the problem of synchronisation between players (remote training).	Build an angklung application that includes two main modes, which are: a) self-training: players can practice alone at home to hone their solo playing skills. This is possible because the system has a playerbot function, which acts as an angklung player other than the player. b) remote training: players can train with other players to improve synchronisation skills. This is possible because all players are connected to the system online.

Based on Table 2 above, this study will develop a new Angklung training application that addresses these problems. This study describes the design of class diagrams in detail, as shown in section 3.1 below.

3. Design System

3.1 Class Diagram

Class diagrams clearly describe each object's structure, attributes, classes, relationships, and methods [17]. They also describe whole application systems. Class diagram design in this study is needed to solve the problems in Table 2 above. The global system design for scoring angklung music performance can be seen in Figure 2 below.

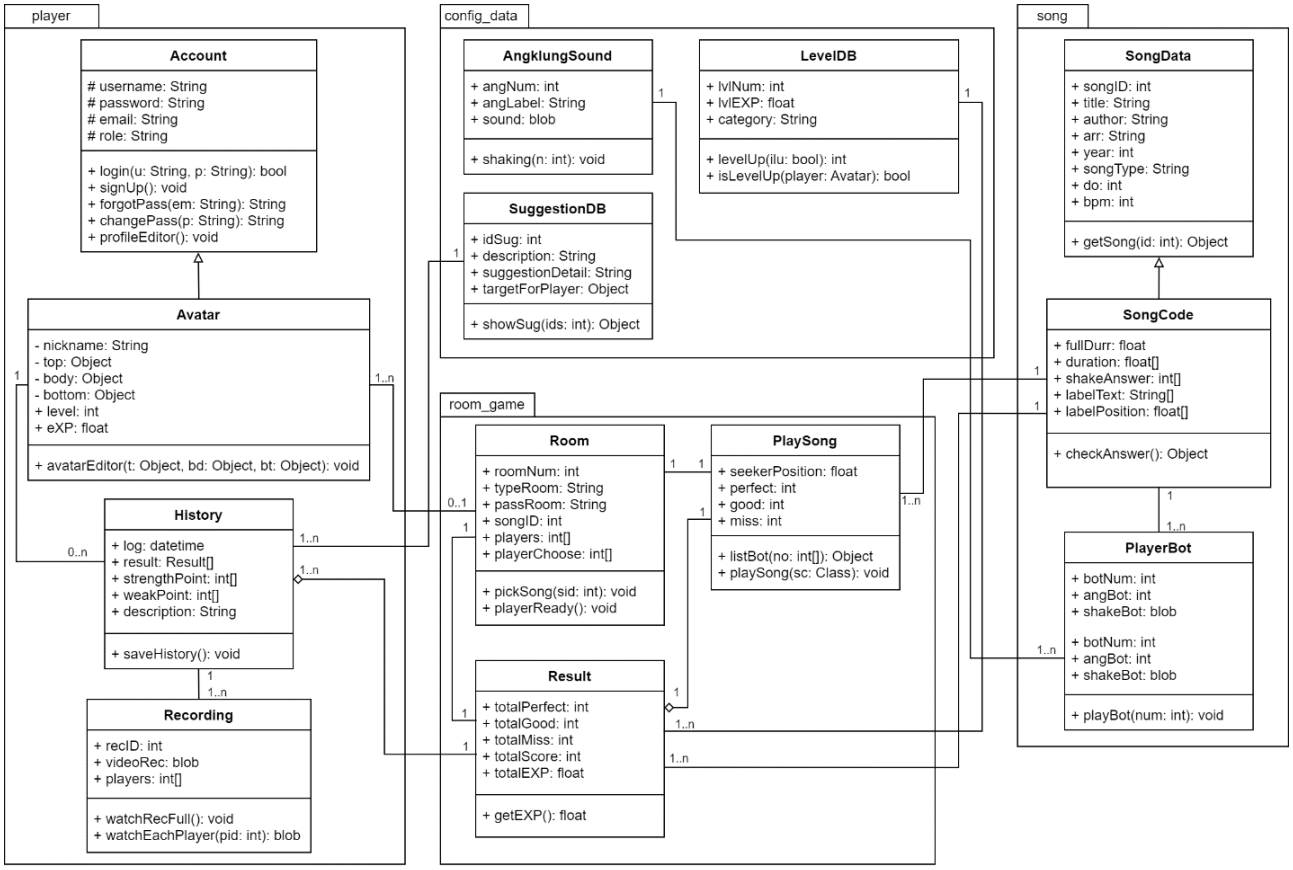


Fig. 2. Design of class diagram scoring Angklung performance

The main functions in the class diagram application design for scoring angklung performance will be explained based on the package placement, including

i. Player: All information about the player contains a player account, avatar, performance history, and performance recording. All player performances will be saved and can be watched by his/herself or other players. The goal is to find out the individual strengths and weaknesses of the players. This package is required to solve problems 3-b, especially 3-a from Table 2.
ii. Config_Data: contains a dataset of angklung sounds, levels, and suggestions. The level dataset is used to decide whether the player has succeeded in increasing the level of angklung performance. At the same time, the suggestion dataset describes what players should do to cover their weaknesses to improve the game's performance. This package is required to solve problem 1 from Table 2.
iii. Song: saves a complete dataset of songs the player will choose to play. The system designed has a playerbot facility, namely the tones that are not selected by the player,

then played by the playerbot. With this facility, players can play solo or in groups. This package is required to solve problem 1 from Table 2.

iv. Room_Game: Players can create a room game that can be played with other players or playerbot. Players can see real-time feedback based on the score obtained per note, divided into perfect, good, and miss. This package is required to solve problems 3-a, especially 3-b from Table 2.

The system is designed as a multiplayer online gaming music performance system for normal and deaf people. However, the currently designed system first uses a song arrangement dataset for deaf students.

3.2 Short-time Fourier Transform (STFT) Algorithm

STFT Algorithm can be used for real-time performance scoring experience. The two central cores are 1) music detection, 2) smart scoring, and realtime-feedback can be solved using the STFT algorithm [18]. Before explaining the use of STFT in this study, please see Figure 3 below to understand the network design for the angklung music scoring system.

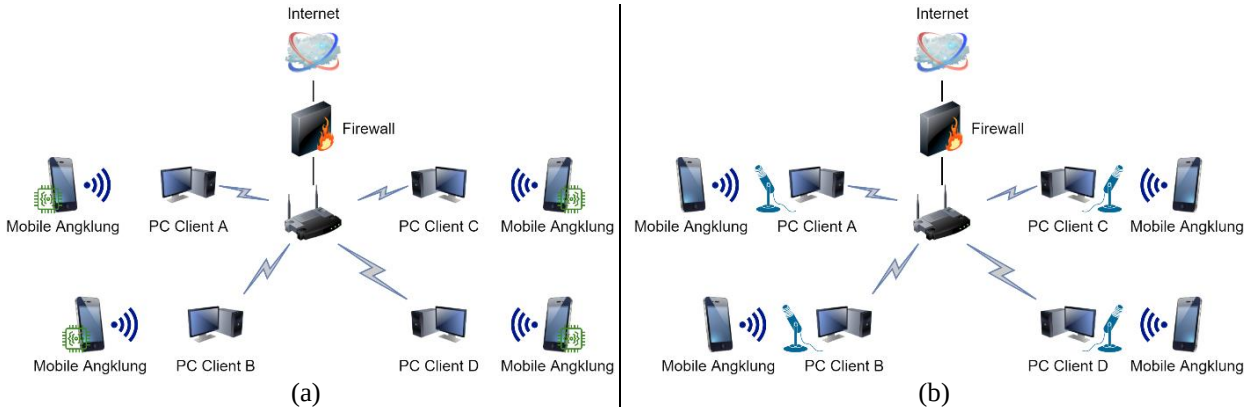


Fig. 3. Network Design for Angklung Music Scoring System

Each player must first log in to an account and then at least have a PC/laptop computer with the application's desktop version. The player also requires a mobile device with the application's Android version. After that, computer PC and mobile devices must be connected to the same network and be paired and synchronized first. The difference between Figure 3 is that Figure 3(a) is designed for a system that uses a vibration sensor, while Figure 3(b) is for a system that uses signal processing. The system's version (a or b) still uses STFT as the main algorithm, especially in the scoring system function. The following is an explanation of the two main functions of using the STFT algorithm

i. Music detection: The system can read music notes from "SongCode" (text base) and interpret them into visual and animation. Each node that will be displayed also displays a different colour. The purpose is to make it easier for players to read these nodes so that this system allows it to be used by beginners or even deaf students. The general description can be seen in Figure 4 part (a).

ii. Smart scoring and real time-feedback: The system can read the input from the player by shaking his angklung mobile device. The assessment will be divided into 3 grades: 1) perfect: timing, and duration of shake accordingly; 2) good: timing or duration of shaking one of them

is appropriate; 3) and miss: timing and duration of shake do not match. Each grade has a different score. The system will accumulate these scores and show the final score of the player's performance. The general description resembles the "Taiko no Tatsujin" game [24]. The difference is that the game uses "Japanese Drums" as a musical instrument and no remote (collaborative) training function. This game is suitable for self-training only. Figure 4 part (b) shows an example of the real-time feedback music scoring function.

(a) (b)

Fig. 4. Example of (a) music performance display and (b) realtime-feedback system

Based on Table 2 solution no 3 and the Design System in this section, the game modes and difficulty levels for further research are divided into two, which is

i. Solo playing: player mode can do self-training with playerbot. The difficulty level of the research in this section is not as complicated as remote training. This mode only requires an algorithm from the playerbot as a partner to play with the player. This mode can also be played without connecting to online multiplayer.
ii. Group playing: player mode can do remote training with other players. The difficulty level of the research in this section is very complicated. This mode only works if they use a server computer that can be accessed globally. Apart from the slightly different playerbot algorithm, we also have to have the latency of the internet network. This particular mode will be explained in several studies.

3.3 Vibration Sensor Vs Signal Processing Comparison

Based on Figure 3, we can see that the two versions have different designs. Version (a) uses a vibration sensor installed on a mobile device. On the other hand, version (b) uses a microphone as the input medium. See Table 3 to understand the difference between those two in more detail.

Table 3
Vibration Sensor Vs Signal Processing Comparison

Vibration Sensor	Signal Processing
Advantages: i) Pairing vibration sensors are more accessible to configure than using a microphone. ii) It is easier for developers to develop systems/applications. iii) Requires additional cost to purchase sensors. iv) The sensor must be small because the large sensor makes the mobile device difficult to play. In addition, small sensors are more expensive than large sensors.	Advantages: i) Doesn't require expensive costs to buy tools. ii) If there is no external microphone, the player can use the built-in microphone (already installed on the PC/Laptop computer) iii) The built-in microphone usually has poor sound sensitivity, resulting in inaccurate scoring. iv) Implementing a signal processing algorithm into the system is much more complicated than just using a vibration sensor.

4. Discussion

Based on the findings described in Table 1, no research has discussed the practice and learning of angklung for self-training (solo) and group training (close-range and long-distance training). However, learning and practising musical instruments with the help of technology has been proven to improve the playing ability of players [19]. In addition, playing music remotely can provide a more enjoyable and easy-to-understand playing experience [20].

If this follow-up research takes place, the limitations of this research are as follows

i. Assuming that the mobile system is a substitute for an alternative angklung musical instrument. This is necessary so that the system is integrated and can run wirelessly.
ii. Using the Windows OS (for the desktop version) and Android OS (for the mobile version). This is because the planned implementation of the system will begin in Indonesia. This is in accordance with Indonesia's average operating system user (see Figure 5).
iii. The implementation plan using the vibration sensor or signal processing version (see Table 3) will be described in detail in further research.

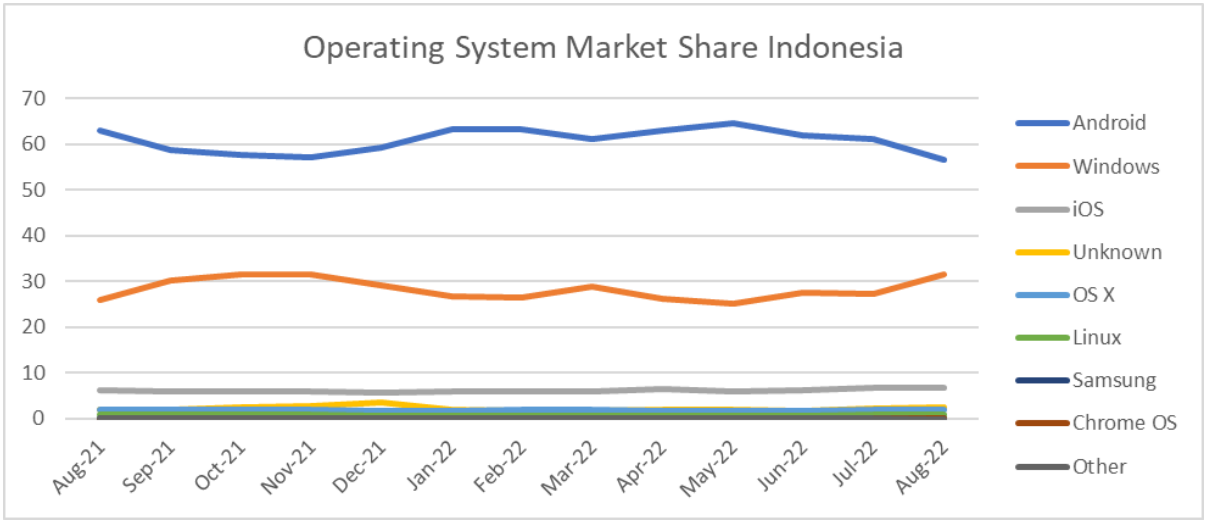


Fig. 5. Operating system market share Indonesia (August 2021-August 2022) [21]

4. Conclusions

This study aims to make it easier for students to practice and play angklung. Based on the problem analysis, we mention the design system section above. We conclude that the class diagram design depicted in Figure 2 can solve the existing problems summarised in Table 2. It can also manage both versions using a vibration sensor or signal processing version. It is not specifically for the STFT algorithm only. Other researchers using other algorithms can apply this design. The use of interactive games has been proven to aid students in the learning process both at school and at home [22]. Additionally, technology-based learning is also utilized to achieve similar benefits [23]. In the future, we will develop the system, starting with self-training, implement the self-training mode for users and confirm the results. And then, we will continue developing the remote-training system and validating its effectiveness. Furthermore, we will implement the system to combine training modes for deaf and normal students.

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