Design and Implementation of Virtual Indonesian Musical Instrument (VIMi) Application Using Leap Motion Controller

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***Abstract*—Unity Leap Motion SDK is a tool which can be an alternative way to control input and interact with computer without touching. In this research, we use leap motion controller to develop an application to learn Indonesian traditional musical instrument such as: angklung, saron, kenong and kendang. This application is named VIMi (Virtual Indonesian Musical Instrument). Leap Motion Controller itself uses motion capture to help user interact with computer. We implemented VIMi using leap motion, laptop and speaker. Leap motion was used to capture the user's motion, laptop for the view of Indonesian traditional musical instrument, and speaker for the output sound. This research aims to develop an interactive learning media and introduce Indonesian traditional musical instrument.**

Keywords—leap motion, unity, virtual indonesia musical instrument.

I. Introduction

Indonesia has a thousand islands with its different culture, artistic history and character. This results many kind of Indonesian traditional music, such as gamelan, kecapi suling, jaipongan, tembang sunda, langgam jawa, etc. There are many kinds of Indonesian traditional musical instrument to perform those different forms of music. Since the introduction of modern music such as pop, rock, etc, the popularity of Indonesian traditional music has declined. But sometimes, on formal occasions and many traditional Indonesia ceremonies, those traditional musics are still commonly played. Because of that modern music, Indonesian people now days are more interested in playing those modern musical instrument than traditional musical instrument. This cause many courses opened to learn how to use those modern musical instruments. Not only many courses to learn how to use modern musical instrument, but also there are many shops or studios which sell many kinds of modern musical instrument such as guitar, violin, piano, etc.

Gamelan is one of Indonesia traditional ensemble music from Java and Bali. It is made of percussive instrument predominantly. The most common instruments used are metallophones which are played by mallets. Other instruments used in gamelan are kendang, xylophones, bamboo flutes (suling), and rebab. For most Indonesians, gamelan is an integral part of Indonesian culture. Now days, we can find gamelan played only on many traditional ceremonies such as traditional dance performance, puppet, or ketroprak. It is also difficult to find people who produce this traditional instrument. There are only some museums or studios which can produce these traditional instruments. And the production process itself also needs much time and many materials. This cause the traditional music instrument costs high and decrease the people interest.

This research aims to develop an interactive learning media using Leap Motion Controller. Besides, this research helps to introduce and conserve Indonesian traditional musical instrument. This research is also to explore the new technology especially in motion control for hand tracking.

Leap Motion Controller was introduced to public in 2010. Leap Motion Controller is computer hardware sensor device which support hand and finger motions as input, analogous to a mouse, but it requires no hand contact. Leap Motion Controller use technology of motion capture to process input. The usage of Leap Motion Controller is because this technology is possible to be implemented in this study case and it is cheaper than other technology. Leap Motion itself has small size, but it can capture more detail of motions such as the motion of finger. Before leap motion, there were other devices which have the same function such as: Microsoft Kinect. The different between Leap Motion and Microsoft Kinect are in their size, price, and their precision in capturing human motion. Leap Motion is smaller and cheaper than Microsoft kinect. In 2016, Leap Motion, Inc released new software designed for hand tracking in virtual reality.

Unity 3D and Leap Motion SDK is used to develop this application. Unity 3D can help to build 3D visualization of Indonesian traditional musical instrument and integrated with the Leap Motion SDK. The Leap Motion SDK can be used to control the user's input. The output of this application is sound which is based on the real sound of those traditional musical instruments. We named this developed application as VIMi (Virtual Indonesian Musical Instrument). VIMi is a desktop application. This application is implemented in C#. There are

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only four Indonesian traditional musical instruments which can be simulated in this version of application. They are: saron, kendang, kenong and angklung. This application is expected to be an interactive learning media of Indonesia traditional music and also can introduce and converse Indonesia traditional instruments.

This paper is organized as follows: the next section tells about proposed methodology. Section 3 defines implementation. Testing and Evaluation are in Section 4. Section 5 defines the conclusion and future work.

II. Literature

A. *Gamelan*

The word of gamelan comes from the low Javanese word 'gamel', which may refer to a type of mallet. Gamelan itself is some traditional musical instruments played in Indonesian traditional ceremony. Some of traditional instruments included in gamelan are Saron, Bonang, Gender, Gong, Kedang, Kethuk, Slenthem, Peking, Suling, Siter, Slentho, Rebab, Tabuh, Kempul, Kemanak, Kempyan, Celempung, and Kenong [7]. Different instruments have different sound. Many of gamelan instruments are created from bamboo, metal, and wood [8]. Figure 1 shows the Gamelan musical instruments.

Fig. 1. The Gamelan Musical Instruments

Gamelan has different kind of lilt for every Indonesian's region. In Java, gamelan is played with slow tempo. In Bali and Lombok, gamelan is played fast with beautiful synchronization of sound. And in Sunda, gamelan is played with slow lilting and it dominate with suling (bamboo flutes). Different culture of each regions cause gamelan has its own musical characteristic. In this research, we use two main traditional instruments in gamelan which is described as follows.

- Saron

  Saron is one of gamelan instruments which have seven bronze bars placed on top of resonating fame. Saron provides the core melody (balungan) in the gamelan orchestra. Saron can be struck with a mallet made from wood which is looked like hammer. The earliest known of saron is in a relief at Borobudur which is from 9th century. Saron can be described in Figure 2.

Fig. 2. Indonesian Traditional Musical Instrument: Saron

- Kenong

  Kenong are also one of gamelan instruments. Kenong is technically a kind of gong. But it is placed on its side and it is roughly as tall as its wide. Kenong is similar to bonang, kempyang, and ketuk. Kenong is generally larger than any of those instruments. Kenong has unique timbre. It is usually played with similar padded sticks to the bonang. A set of kenong can be described in Figure 3.

Fig. 3. Indonesian Traditional Musical Instrument: Kenong

- Kendang

  Kendang or in malay also known as gendang, is a drum which has two headed and used by people from Maritime Southeast Asia. Kendang is one of the primary instruments used in gamelan. One of oldest image of kendang can be found in ancient templates in Indonesia, they are Borobudur and Prambanan temple. Good kendang is made from the wood of jackfruit, coconut or cempedak. Kendang has cylinder shaped, and each two headed of kendang is made from animal hide.

Fig. 4. Indonesian Traditional Musical Instrument: Kendang

- Angklung

  Angklung is multi tone instrument. And it is known from Sunda and it has become identity of Sundanese. Angklung is made of two or four bamboo tubes attached to a bamboo fame. Dictionary of the Sunda Language created by Jonathan Rigg in 1862 tells that angklung is traditional musical instrument made from bamboo tubes, attached to one bamboo frame, and it can produce sound by shaking. The base of the frame is held in one hand, whilst the other hand shakes the instrument. The visualization of angklung can be shown in Figure 5.

Fig. 5. Indonesian Traditional Musical Instrument: Angklung

B. *Leap Motion Controller*

Leap motion controller is a device developed by Leap Motion, Inc. This device was developed by David Holz in 2008. Leap motion was used to control input without touch the computer device. Leap motion is computer hardware sensor device which supports hand and finger motions as input, analogous to a mouse, but it requires no hand contact. The first Leap Motion was introduced to public in 2010 [3]. Leap motion also known as new technology in motion capture which can capture human body motion.

Fig. 6. The Evolution of Leap Motion Controller [4]

Leap Motion Controller is a simple hardware. The main parts of Leap Motion Capture are on two cameras and three infrared LEDs. These track infrared light with a wavelength of 850 nanometers, which is outside the visible light spectrum. The wide angle lenses cause this device can has a large interaction space of eight cubic feet. The Leap Motion Controller's viewing was limited to roughly 60 cm above the device. Figure 6 shows the evolution of Leap Motion Controller. Figure 7 describes the wide angle of Leap Motion Controller. And Figure 8 shows it viewing area.

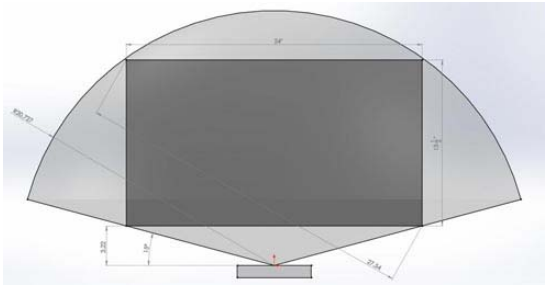

Fig. 7. The Wide Angle of Leap Motion Controller [4]

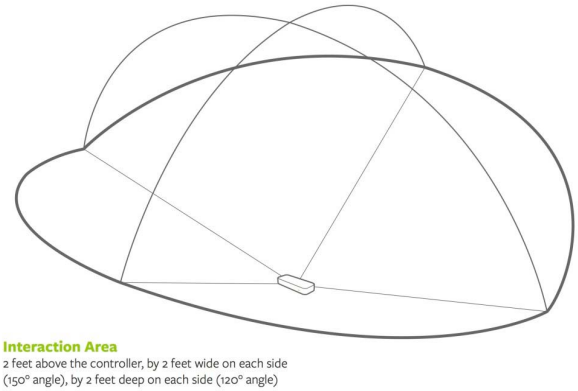

Fig. 8. The Leap Motion Controller Viewing Area [4]

C. *Leap Motion SDK*

Leap Motion SDK is library which contains system requirement from developed application using Leap Motion Controller. There are some functions which can be used in this SDK, such as: function to model human fingers. Leap Motion SDK was developed to make easier developer in develop application. Developer can download the SDK free and it provides in different programming languages, i.e. Javascript, Unity/ C#, C++, Java, Python, and Objective-C. This SDK also support in different operating system, i.e. Windows, OSx, and Linux [5].

In this research, the application developed using Unity 3D. Unity 3D is game engine which is developed by Unity Technologies. Unity can build a multiplatform application which can run in Windows Phone, Android, iOS, Windows 8, OSX, Blackberry 10, Playstation 3 and 4, XBOX, etc. The visualization of game built in Unity 3D can be 2D or 3D visualization. There are many partners of Unity. They are: Microsoft, Sony, Qualcomm, Blackberry, Samsung and Nintendo [6]. Unity has two kinds of products. They are: Unity Pro and Unity Free. Only Unity Pro which require payment for its registration. Unity Pro also has different features from Unity Free.

The Leap Motion SDK is implemented in Unity using C# programming language. Unity support Leap Motion and provide an easy way to develop this kind of application. There are a wide variety of Unity assets designed for drag and drop simplicity, rigged hands, demo scenes, and resources for VR.

III. Design and Implementation

A. *Usecase Specification*

The use case specification of this application can be described in Figure 9. User can choose what kind of Indonesian traditional musical instrument which wants to be played. After choose the instrument, user also can run the simulation. In the simulation process, user can play traditional musical instrument.

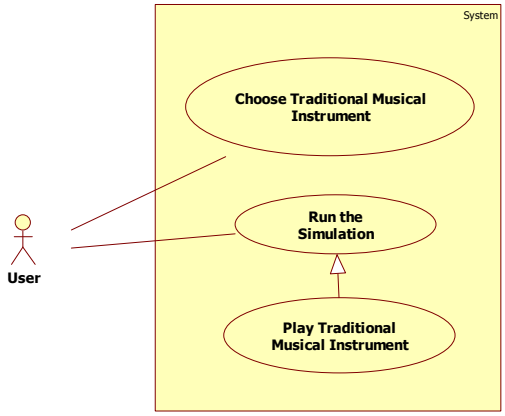

Fig. 9. The Use Case Specification

B. *Architectural System*

The design of architectural system can be shown as follows.

Fig. 10. Architectural System

There are Leap Motion Controller device, Laptop or computer PC, and speaker (if it is needed). Leap Motion Controller is used to capture motion. Laptop is used for visualization and control the process in producing sound based on input. And speaker can be used only if it is needed.

C. *Design of Strike Detection Process*

VIMi provides user's hand to strike the virtual traditional musical instrument. The process of strike detection in VIMi can be explained in Figure 11. The detected object will be processed by it position. If the touch distance of object more than 0, the system will set the status 'not hit' and process the data into pointer. This means the user doesn't strike the instrument. But if the touch distance of object less than 0, the system will set the status 'hit' and also process the data into pointer which means the user strikes the instrument. If this condition happened, system will produce sound based on coordinate of the instrument struck.

D. *Implementation*

This application was built in Apple Macbook Pro Retina Laptop 13.3 inch with specification: Processor Intel® Core i5 CPU @2.4 GHZ, RAM 4.00 GB, Leap Motion Controller, Intel Iris Graphics, and Speaker Stereo. Unity Version 4.5.5 fl, Mac OS Yosemith 64 bit, Inkscape Version 0.48, and LibreOffice Draw Drawing version 4.3.2.2 were used in building this application.

The detection of leap motion is based on the position of hand. The coordinate position of hand will be saved and checked in every motion. To detect the strike process, Leap Motion use Touch Distance which measure the depth of hand horizontally. Then the sound as output is detected based on object struck. There is class of object such as: angklung.cs etc which represent the virtual traditional musical instrument. Each strike detected, will be checked the name of object struck. Then the class of object struck will be executed to produce the sound. The area of hand motion is based on the Leap Motion device used. In this research, the area of hand motion is limited to roughly 60 cm above the device. And it was explained in the previous section.

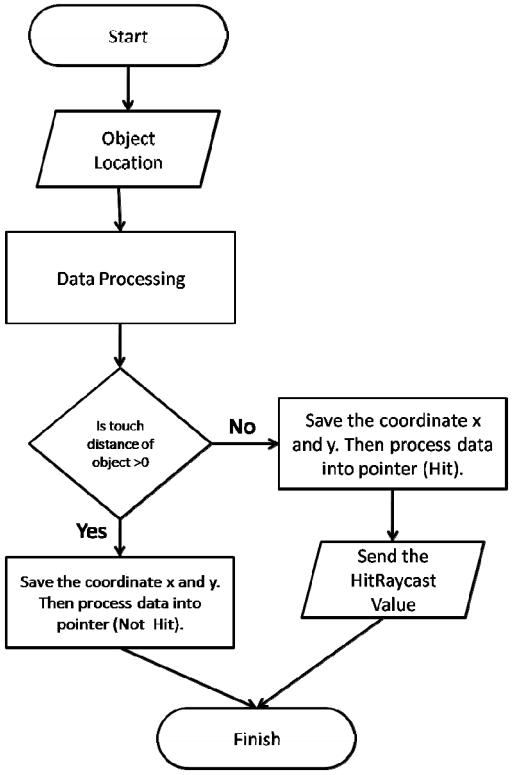

Fig. 11. Design of Strike Detection Process

IV. Testing and Evaluation

In this section will discuss about testing and evaluation of developed application. Test case was generated based on requirement specification. We define some test scenarios. The first scenario is object motion detection captured by Leap Motion Controller. This scenario categorized test case into four, i.e. move hand to the right side, move hand to the left side, move hand to the top and down. The result of this test scenario can be shown in Figure 12, 13, 14, and 15.

Then, the second scenario is to detect the object position. This test scenario has the same test cases with the first scenario. Hand move to a random position of screen. And the position is checked whether it is the same position or not which was read by system. Figure 16 shows this test scenario.

Hand move into random position of instrumental object. And system can show that, the position of moving hand is in area of the object (angklung).

Fig. 12. Object Motion Detection (Moving to The Right Side)

Fig. 13. Object Motion Detection (Moving to The Down Side)

Fig. 14. Object Motion Detection (Moving to The Left Side)

Fig. 15. Object Motion Detection (Moving to The Top)

The next test is to detect the instrument struck. This test result is described in Figure 17 and 18. This testing is checked by the output sound. The output sound should be matched with the defined instrument's sound.

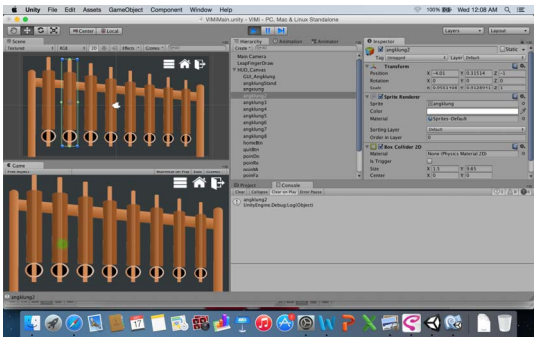

Fig. 16. Object Motion Position Detection

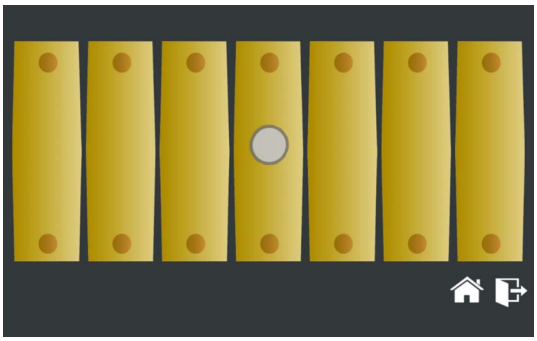

Fig. 17. The Strike of Instrumental Test (Not Hit The Instrument)

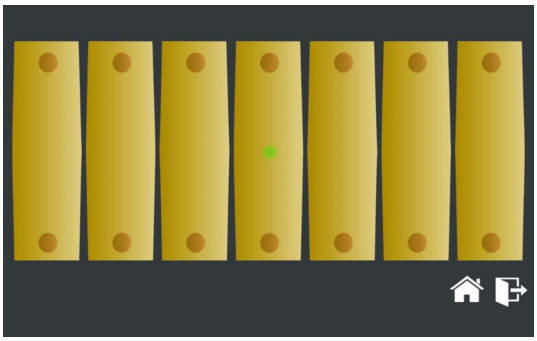

Fig. 18. The Strike of Instrumental Test (Hit The Instrument)

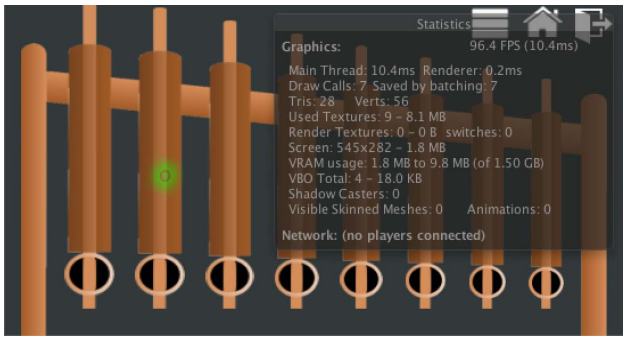

Fig. 19. The Application Frame Rate

The fourth test scenario is to prove that frame rate of developed application is 25 fps. This test is done by application debugging and check the debugging status from the running application. The result shows that this application has 96.4 fps of frame rate. The result of this testing can be shown in Figure 19.

The application interface and user's experience was measured by survey. The rate interval which was use in this survey is 1-5. The survey results that the average rate of application interface is 3.6. Average rate of user's experience is 3.4. Average rate for 3D visualization of musical instrument is 3.8. And the average rate of output sound produced by each musical instrument is 4.4.

The last test scenario is to check the reliability of VIMi in producing traditional music. We used Suwe Ora Jamu song to be played. And it results similar sound with the real one.

v. Conclusion and Future Work

Based on testing result, we can conclude that:

- This exploration technology can run well in both MAC OS and Windows. The requirement specifications can be implemented using Leap Motion Controller. The object motion detection, the frame rate, and the strike simulation process of each virtual instrument can be implemented well. It can respond the input correctly.
- Based on result of user experience survey, VIMi can be an alternative way to learn Indonesia traditional musical instrument. The feature and the 3D visualization can describe the virtual of Indonesia traditional musical instruments. The feature to show Indonesia traditional songs also help user to learn more about Indonesia traditional songs. And it also can help to introduce and conserve the Indonesia traditional music.

For the further work, another research is needed to improve the 3D visualization of traditional musical instrument. This will help more real visualization of VIMi. Besides, other Indonesian traditional instrument is required to be implemented using this Leap Motion Controller. To improve this application, we suggest to use stereo speaker and graphics card which can visualize this application more real.

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