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VIRTUAL KOMPANG: MAPPING IN-AIR HAND GESTURES FOR MUSIC INTERACTION USING GESTURAL MUSICAL CONTROLLER

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ABSTRACT

The introduction of new gesture interfaces has been expanding the possibilities of creating new Digital Musical Instruments (DMI). However, the created interfaces are mainly focused on modern western musical instruments such as piano, drum and guitar. This paper presents a virtual musical instrument, namely Virtual Kompang, a traditional Malay percussion instrument. The interface design and its implementation are presented in this paper. The results of a guessability study are presented in the study to elicit end-user hand movement to map onto commands. The study demonstrated the existing of common hand gestures among the users on mapping with the selected commands. A consensus set of gestures is presented as the outcome of this study.

Keywords: Digital Music Instrument, Virtual Environment, Gestural Control, Leap Motion, Virtual Instrument

1. INTRODUCTION

The progressive advancement in computer technologies has been shifted the way humans interact with machine, e.g. from using only keys or buttons to convey commands and instructions, replacing it with direct hand gestures.

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The enhance in interaction technique has opened a wide range of possibilities in creating Digital Musical Instruments (DMI) by allowing users to perform music interaction using hand gesture input to produce sound output. Thus, it is essential to determine the strategies to map hand gestures to sounds. Nevertheless, current research works are primarily focused on modern western musical instruments, such as piano, drum, and guitar, with very few new interventions for traditional indigenous musical instrument. As the result, these traditional musical instruments will render extinct from practice. Hence, the efforts to preserve the traditional musical instruments are becoming more critical than ever.

This paper presents a prototype, namely *Virtual Kompang*, a new digital musical interface for *Kompang*. The *Kompang* is a traditional Malay percussion instrument that made from animal skin (mainly goat or cow skin) nailed to the wooden frame. The *Virtual Kompang* allows users to perform hand gestures in the mid-air to invoke commands and hit the visual representation of *Kompang* to produce sound, like playing the real instrument. The interaction of the application is controlled by the *Leap Motion*, a hand tracking controller which offers direct interaction with virtual object through recognition of hands and fingers motion in computer environment. With *Virtual Kompang*, user can have a more natural experience of playing *Kompang* with their bare hands within a virtual environment.

A major challenge in this application includes the expectations from users which may differ from the set of hand gestures developed by the application designers. Selection of gesture for interaction is essential because performing different gestures can create confusion. Hence, a *guessability* study is conducted in this study to elicit natural gestures end-users as follow: given a task to perform with the *Leap Motion* (e.g. pick and move the *visualize* kompang, open the menu). The result of the study can also eliminate the need for designers to arbitrarily create their own gestures.

In this study, the existing progress or research works in related to *Kompang* and hand tracking technologies is presented in Section 2. The Section 3 reviews other work and applications which have successfully used in hand tracking using *Leap Motion* controller. The design and implementation of the *Virtual Kompang* are briefly explained in Section 4 and Section 5, while the result of the *guessability* study will be discuss in Section 6. The paper ends with Section 7 which discusses the future plans and a conclusion.

2. THE KOMPANG

The *Kompang* is a traditional Malay musical instrument that is found in Malaysia. It is a membranophone instrument that makes sounds by beating the vibrating membrane with bare hand. The *Kompang* is a single-headed frame drum made with goat or cow skin, nailed to the wooden frame by metal nails as shown in Figure 1. The stretched animal skins act as the vibrating membrane.

Although the origin of *Kompang* in Malaysia is still disputed, major researchers believe that its' origin was from the Middle East and was brought to Malaysia through state of Johor and Melaka by traders in the thirteenth century [1]. It is commonly play for celebrating the bride and groom in wedding ceremony and use to announce the arrival of important guests.

Fig.1. Musical instrument *Kompang* with animal skin as membrane

To play a *Kompang*, a player hold the instrument upright with one hand, while hitting the membrane skin with the other bare hand. In general, the sound is produced by hitting a *Kompang* determined by its striking positions. Traditionally, there are two ways of striking a *Kompang* which are hitting on the edge (Figure 2a) or the center of the membrane (Figure 2b). Striking on any of these two locations will result in two different sounds, known as 'Bung' and 'Pak'.

(a) (b)

Fig.2. (a) Beating the edge of the *Kompang* skin and (b) Beating the centre of the *Kompang*

Previous works were primarily focused on replacing animal skins with various materials as the *Kompang* membrane [2], [3]. Traditionally, there is no formal class or institution set up purposely to teach *Kompang* in Malaysia as the training sessions are conduct by the experts orally. In addition, it becomes harder to get the *Kompang* as the number of experts *Kompang* maker decline with time. Therefore, this study attempts to imitate the physical characteristic of *Kompang* into digital musical interface, so that it is able to preserve in the form that is more easily accessed by the contemporary users.

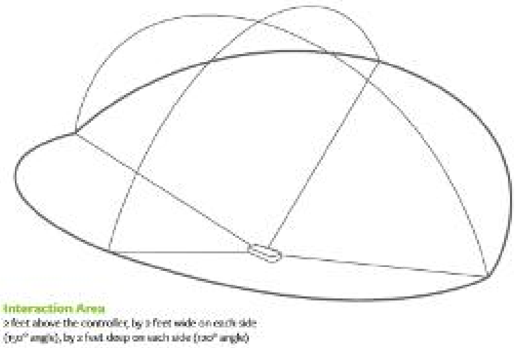
3. GESTURAL CONTROL OF DMI

In this section, past research works in topic related to gesture music instrument were reviewed. The implementation of gestural control on DMI has been developed over many years. In the past decades, many approaches to gestural-controlled DMI were based on the tracking of hand-held devices. Some of these hand-held devices were including baton [4], and drumsticks [5]. Later, data gloves or camera sensors were used to replace the necessity of using existing handheld devices. For instance, Mitchell et al. used gloves as gestural control mechanism for live music performance [6]. However, they were not able to implement all the gestures requested by the users such as the position of the hands with respect to the body. In [7], Nieto and Shasha used built-in-camera from smartphones or tablets to capture gestures, enabling user to play musical instrument in the air. In [8], another similar research work was done to emulate piano playing experience by using RGB-D camera to track finger tapping. This results in a system could accurately track each fingertip perform by the user.

The rapid development and availability of low cost technologies such as *Leap Motion* (Figure 3) has led to further developments in this area. Unlike *Nintendo Wii Remote* and *Microsoft Kinect*, which more focused on body and body member motion, *Leap Motion* provides a fine hand control which is promising for building new DMI. Nevertheless, the *Leap Motion* can only recognize gesture accurately within the view of field (Figure 4) [9]. Within limited workspace, interface with many virtual objects creates a problem in distinguishing the object the will accept the gesture.

Fig.3. The Leap Motion

In musical context, several efforts had made to evaluate the *Leap Motion's* utility as an interface for music interaction. For example, Han and Gold replicated the keyboard and drumpad into digital interface using *Leap Motion* [10]. Brown et al. combined both *Leap Motion* and wrist mount to perform better in gestural music interaction [11]. These studies indicated that the *Leap Motion* is a promising tool that providing expressive musical



experience, despite the absence of tactile and visual feedbacks.

Fig.4. Leap Motion field of view

4. OVERVIEW OF VIRTUAL KOMPANG

Virtual Kompang possesses with multimodal musical experience by providing user both audio and visual feedbacks. The visual form of the instrument is presented within a virtual environment as shown in Figure 4. The virtual instrument is enlarged when users beat the drum. This offers a visual feedback to user when striking hit is detected. User can also directly rotate and move the position of the *Kompang*. This approach enhances the playfulness significantly as user can play *Kompang* at the desired position.

The *Leap Motion* controller is implemented to capture hand gesture as input from user. As the input, the application only receives two types of information from the motion captured by the *Leap Motion*. Users' hand movement are captured and displayed as virtual hands on the screen. Sound is produced when user swing their hands towards the virtual instrument. The striking hit triggers the system to produce sound when the natural hand collides with the *instrument*. The striking position determines what sound to produce. For example, hitting the center of the virtual instrument will produce a '*pak*' sound and hitting to the edge of the virtual instrument will produce '*bung*' sound.

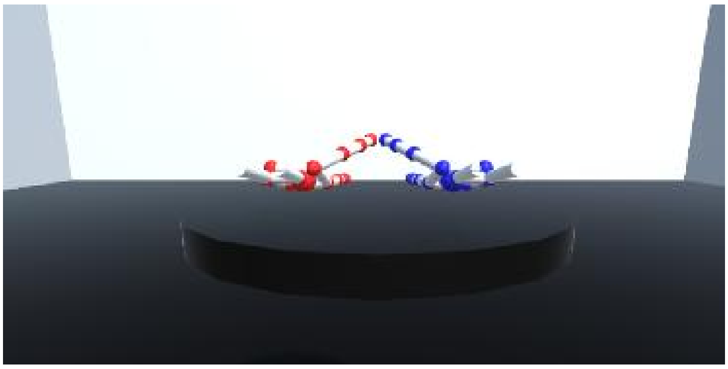


Fig.4. The user interface of *Virtual Kompang*

The *Virtual Kompang* provides two distinctive modes for these two different uses, which are the *moving mode* and *playing mode*. The *moving mode* enable user to twist, and resize the instrument. In this case, user can reposition the virtual instrument, rotate the shape and change its size according to their like. Meanwhile, the idea of *playing mode* is intentionally designed to be simple, so that users can focus on interacting with the instruments. When users are in *playing mode*, the sound is produced when their bare hands touch on the virtual instrument.

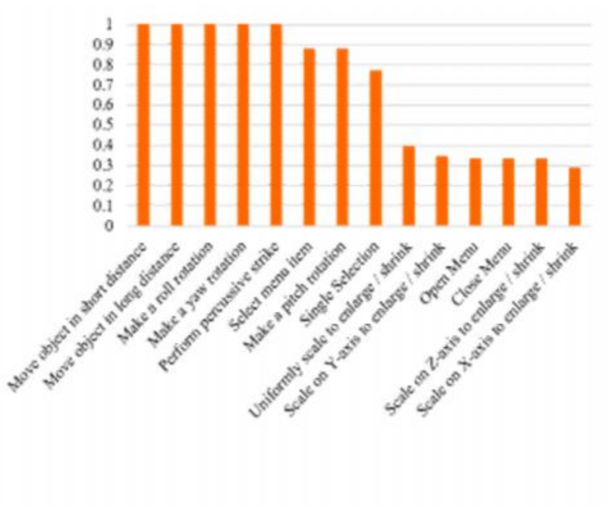
The mode switching buttons are shown on the menu interface which held on user's left arm. Three buttons were presented on the menu, whereby the top button is referring to the *moving mode*, while the second button is referring to the *playing mode*. User can switch to other modes by tapping on the relative button with the bare fingers. The buttons are presented as button with an icon is placed at the center, tells users which mode they are in. A summary of the tasks to perform within Virtual Kompang are as shown in Figure 5 (a).

5. MAPPING HAND GESTURES AS INPUT DEVICE

The study followed approach in [12] by conducting a *guessability* test to form a user-defined set of hand gestures to invoke commands and music interaction when playing the *Virtual Kompang*. For example, the proper gesture to implement to make menu fades into view. The study was conducted with 15 respondents: 7 males and 8 females who experienced in using hand tracking controller such as Leap Motion and Microsoft Kinect. Respondents were asked to design preferred hand gesture in performing given tasks, as shown in Figure 5 (a). 14 tasks were presented to the respondents during the study. Respondents used the think-aloud protocol [13] and supplied subjective ratings for each gesture in terms of ease of use and goodness.

The data collected during the study included a set of hand gestures designed by the respondents, subjective ratings of the set of hand gestures and the agreement scores for each task. As the outcome of the study, a total of 195 gestures were generated and the identical gestures were grouped into 60 group. The gestures that gained plurality among the suggestions will be selected as part of the consensus set. To evaluate the degree of consensus among the respondents, the study adopted similar approach which done by Wobbrock [14] by calculating the agreement score for each task, with the idea of the higher the agreement score is, the greater the degree of consensus among the respondents. The study result showed that there are 8 gestures gained good agreement score for the given tasks.

Category	Task Name
Act on Selection	Single Selection
Navigation	Open Menu
	Close Menu
	Select menu item
Transform	Move object in short distance
	Move object in long distance
	Make a roll rotation
	Make a yaw rotation
	Make a pitch rotation
	Scale on Z-axis to enlarge / shrink
	Scale on X-axis to enlarge / shrink
	Uniformly scale to enlarge / shrink
	Scale on Y-axis to enlarge / shrink
Musical Activity	Perform percussive strike



(a) (b)

Fig.5. (a) The list of tasks presented to respondents (b) Agreement for each task sorted in descending order.

There were 14 tasks but a total of 15 gestures were selected. The greater number of gestures per task was because users were allowed to map multiple hand gestures to a single task. From these 15 gestures, 2 of them were assigned to the same task (*Scale on X-axis to enlarge / shrink*) as both of these gestures gained the plurality of four votes suggested by the users. As part of the outcome of this study, two sets of hand gesture were presented. The first set is those gestures in the consensus set, which are those that were specified by majority of respondents for each task. The second set includes all other gestures that are not part of the consensus set. The complete consensus of set is displayed in Figure 6.

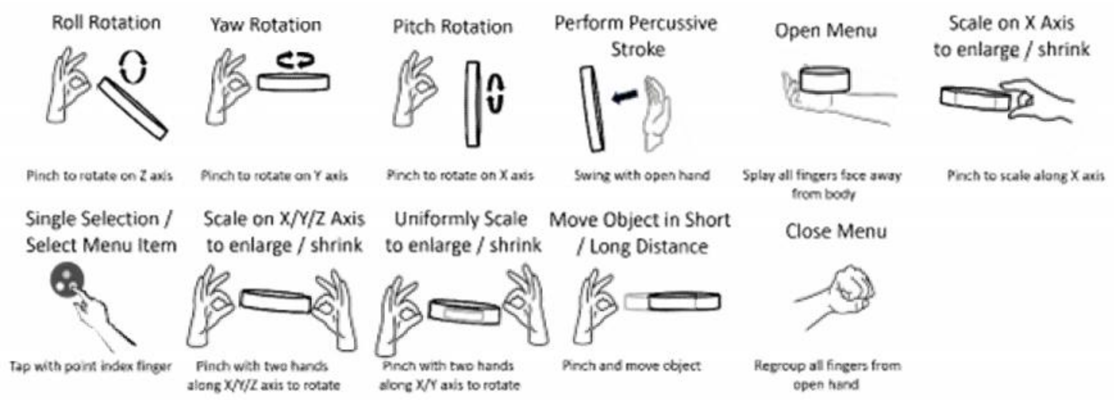


Fig.6. The consensus set designed by users.

By comparing the subjective ratings for both gesture sets, it was found that the subjective ratings on consensus set in terms of goodness was higher rated than those gesture that are not in the consensus set, with average scores of 6.13 and 6.10 respectively. Meanwhile, the subjective ratings on consensus set in terms of ease to use was also higher than the gestures that are not part of the consensus set with average scores of 6.15 and 6.08 respectively. This indicated that users preferred the consensus set than those who were not in the consensus set in terms of both goodness and ease to use.

6. FUTURE PLANS

Future improvements on the *Virtual Kompang* are planned in further understanding the acceleration profile of each striking hit on the instrument. In order to replicate the similar musical experience as playing a real instrument, the *Virtual Kompang* must not only detect each striking hit, but the output sound must be produced concurrently with its relative impact. For instance, if the user swings quickly, a louder the sound is produced, mimicking the behavior of a real drum. Study will be extended in exploring the expressive control of a percussive gesture. The current prototype still plays recorded or pre-computed sounds when striking hit has triggered. Hence, the sound samples should be compute in real time with physical modeling. Further enhancement in graphical interface is expected as the system is currently a low-fidelity prototype. The instrument in current system will be replaced with its' actual model. This will provide a more realistic and expressive output sound because it is based on the real response of a drum.

7. CONCLUSION

The paper presented *Virtual Kompang*, a virtual instrument that used gestural control mechanism for control. The background of the *Kompang* ensembles is highlighted. All ideas of interaction resented in this paper have been implemented. The result of the guessability study for music interaction is presented. The *guessability* study indicated that 15 gestures were designed by users for the selected tasks. A consensus set of gestures were presented as the final outcome of this study.

8. ACKNOWLEDGEMENTS

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