GENDANG PAHANG AUGMENTATION AND TECHNOLOGICAL SYMBIOSIS

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Abstract: Gendang Pahang is one of the traditional musical instruments that are less popular and known since modern music is more appealing to the generation today. Nowadays, there are many musical instruments that have been augmented to make it more interesting in this modern world; however, most of them are western or contemporary musical instruments while there are only a few studies that focused on augmented traditional musical instruments. This paper describes the development of Robotic Gendang Pahang, a technological innovation of traditional musical instruments using the original instruments. The aim of this paper is to describe the construction of the actuator control system and the mechanism of the beater to automatically hit the drums and gong without interfering with the original features of the instruments. This is to help introduce the traditional musical instruments to the public along with the real sound coming from the instruments itself without using any recording audio and real players. This paper also describes the prototype development using the prototyping method with few steps which are requirement gathering and analysis, preliminary design, building the prototype, initial evaluation, refining prototype and implementation. The results are discussed in terms of the design and performance analysis based on musical instruments' robotic theory and future development.

Keywords: Augmented instrument, musical instrument, prototyping, robotic

1. Introduction

Gendang Pahang is one of the traditional musical instruments in Pahang made from local materials and consists of three type of instruments; Gendang Ibu, Gendang Anak and Gong. Gendang Ibu and Gendang Anak are membranophone instruments that emit sound from the beating on the skin surface either by hand or wooden material while Gong is an idiophone that produces sound by the vibration of the instrument (Razali, Mohd Yuszaidy, Mohd Yusoff & Ab Samad, 2017). Researchers of Gendang Pahang stated that in the past this instrument was widely played to accompany a performance as well as at weddings and palace customs (Muhamad, 2017).

Figure 1: Gendang Pahang consists of minimum three players (left) & the image of Gendang Ibu and Gendang Anak (right)

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This article presents the development of robotic Gendang Pahang as a new method of instrument innovation to be introduced as one of the traditional musical instruments to the public. Today, there are a lot of musical instruments that have been modified using technology either completely modified or without changing all features of the instrument to produce the same sound using several sensors that give the ability to control additional sound or music parameters or can be called augmented instrument as defined by Miranda and Wanderley (2006). Augmented instrument can also be called as hyper, hybrid, meta or extended instruments (Miranda et al., 2006) and according to Thibodeau (2011), augmented instrument is also defined as the connecting line of modern and traditional techniques.

A question when augmenting the instruments is how much the augmentation will modify the traditional techniques and features. According to Che Mat Jusoh (personal communication, October 13, 2020), innovating the traditional instrument using technology is one of good ways to attract public but is it not recommended to fully modify it as it is important to maintain the original features for the knowledge of future generation. One of the research goals is to introduce the traditional musical instrument using technology where they can experience listening the sound produced directly from the instrument without using any audio recording. This is because audio and video recording makes the music performance seems like artefact that ignores the preservation of producing tradition art (Kapur, 2007).

There are many kinds of augmented percussion instruments and this article reviews on it especially the membranophone and idiophone types of musical instruments because they are related to our research which is using drums and gong. The subsection of this article starts with an overview on related work which discusses on their augmentation work and comparing it with the beater or mallet system. This is followed by research methodology used to assist the augmentation development, implementation, conclusion and future development.

This study is expected to contribute to the relationship between traditional arts and new media technology as well as introducing one of the cultural heritage arts in Malaysia.

2. Overview Related Work

2.1 Robotic percussion

MahaDeviBot is a mechanical music instrument that helps to extend North Indian musical performance and helps to illustrate complex rhythmic cycles for novice players in a way that audio speaker cannot emulate (Kapur, 2007). The robotic musical instrument has 12 robotic hands for four drums, finger cymbals, a gong, several sets of bells and wood blocks that use solenoid-based system to produce various types and strengths of the beaters. The robotic hands use different types of solenoid-based drumming called *Kapur Fingers*, *Singer Hammer, Trimpin Hammer* and *Trimpin BellHop*.

Source: https://front.bc.ca/events/the-mahadevibot-sessions-karmetik-collective/

Figure 2: MahaDeviBot

GanaPatiBot is a machine that is more advanced than MahaDeviBot after going to a few revisions by playing it at concerts as the beater is faster because each instrument is equipped with more solenoid beater that is comparable with the speed of real player. GanaPatiBot consists of three drums and other percussive noise-making devices where each drum is hit by two solenoids (Kapur, Darling, Wiley, Vallis, Hochenbaum, Murphy, Diakopoulos, Burgin & Yamin, 2010).

Source: https://www.karmetik.com/karmetik-robotics/ganapatibot/

Figure 3: GanaPatiBot

KarmetiK NotomotoN is a robotic drum used for performance and education with 18 solenoid beater. It has two different types of beater techniques which are TrimpTron and KalTron and it only uses two cables of power and the USB cable for communication (Kapur, Darling, Murphy, Hochenbaum, Diakopoulos & Trimpin, 2011). TrimpTron uses rotating solenoid that can give dynamic beater as it does not hit on one area only while KalTron uses linear pull solenoid that can only move linearly but capable of producing faster actuation. All the electronic and wiring components are hidden in the drum's body while the beaters are mounted to the circular structures around the drum's head. NotomotoN is used for learning system as the student can test the design of new beater and existing system on other objects.

Source: https://www.kaermetik.com/karmetik-robotics/notomoton/

Figure 4: The KarmetiK NotomotoN

Kinetix Xylophone is an interactive musical robotic that uses motorized mallet controlled using infra-red (IR) technology (Oh & Park, 2017). The technology is mounted with colourful metal tube act as xylophone where one infra-red sensor is assigned to each one of the tubes. The sensors will collect data from the hand waving gestures on each of it to move the mallet where the size of the whole set is suitable for kids and adults. The infra-red sensors detect distance of hand gestures and the data trigger the motor of the mallet to hit the metal tube.

Source: Oh & Park (2017)

Figure 5: Kinetic Xylophone

Angdroid by Putra and Wibowo (2019) is the combination of microcontroller, WiFi and Android to control one set of Angklung, a traditional musical instrument that needs multiple hands to play it and by augmenting it, it is easy to control the instrument. Each node of Angklung is connected to one servo motor to shake it as it is connected to Arduino and controlled using smart gadgets through WiFi.

Source: https://if.widyatama.ac.id/mahasiswa-prodi-informatika-universitas-widyatama-melestarikan-alat-musik-tradisional-angklung-dengan-inovasi-teknologi-angdroid/

Figure 6: AngDroid

2.2 Comparison of actuator system

Table 1: Actuator's System Comparison

Title / Author	Components	Actuator Description	Results
MahaDeviBot (Kapur, 2007)	Solenoids, drumstick, bracket, spring, microcontroller, resistor, transistor, diode	Four methods using push and pull type of linear solenoids	Different roll speed and dynamic response of actuators from four different methods
GanaPatiBot (Kapur et al., 2010)	Solenoids, drumstick, spring, bracket	Multiple solenoid-based system	Variety sound textures and the rolls speed increase
KarmetiK NotomotoN (Kapur et al., 2011)	12V DC power supply, solenoids, custom-developed daughterboard, microcontroller	Using pull-type linear solenoid and rotary solenoid	Rapid fire actuation and more dynamically expressive actuator
Kinetic Xylophone (Oh & Park, 2017)	RX-28 servo motors, microcontroller, infra-red sensor, MAX485 transceiver	Separated construction of each module for each xylophone plate where the distance signal detected triggers the servo motor to move the mallet	Dynamic rotational speed of motors depends on distance between sensor and hand
AngDroid (Putra & Wibowo, 2019)	Microcontroller, ESP8266 (WiFi), servo motors, Android SDK	Getting instruction from user to servo motors through the microcontroller where each servo motor controls one Angklung bamboo	Easy live instruction from user to real instruments through an application

2.2.1 MahaDeviBot

MahaDeviBot uses four methods for the actuators with different dynamic range (loudness level) and temporal range (speed level) which are named as Kapur Finger, Singer Hammer, Trimpin Hammer and Trimpin BellHop. Kapur Finger uses modified push-type solenoid to reduce more mechanical noise where it is hit directly on a surface with moderate high speed but limited dynamic range which could not strike very loud. Singer Hammer uses pull-type solenoid with steel rod and a ball. This method can move the rod faster than Kapur Finger with very soft and loud strikes. Trimpin Hammer and BellHop also use pull-type solenoid but different dynamic range and speed where Hammer can roll up to 18.18Hz but does not have enough power for dynamic capabilities while BellHop is the slowest with linear loudness response.

2.2.2 GanaPatiBot

GanaPatiBot as mentioned before is the upgraded version of MahaDeviBot striking system where they use multiple of solenoids on one drum that can give inhumanly fast roll speed and variety of sound textures.

2.2.3 KarmetiK NotomotoN

It uses custom daughterboard to convert 5V control voltage from AVR-based Arduino to 24V actuator signals and it has two types of actuator system which are KalTron and TrimpTron. KalTron uses linear motion of pull-type solenoid that changes to rotational motion which gives high speed drum rolls while TrimpTron uses rotary solenoid with dynamic strikes that can struck at different places on the drum surface.

2.2.4 Kinetic Xylophone

This augmented instrument uses servo motor to rotate the actuator with seven different velocity based on the distance between hand and infra-red sensor with separated construction for each xylophone plates. The instruction is programmed in microcontroller to communicate with the motors through transceiver and this circuit will be triggered after the infra-red sensor calculates the distance of performer's hand. Different distance will produce different rotational speed of the motors.

2.2.5 AngDroid

This instrument uses android application in a device where the user can control to move and play the Angklung using servo motors. Each servo motor is assigned to different node connected using wire. The application in the device will deliver instruction from user to servo motors through WiFi transmitter in Android, received by WiFi module connected to microcontroller and it will trigger the motors to move the Angklung. The researcher admits that this research still needs to be improved for the instrument to give better results.

2.2.6 Conclusion

There are two systems of actuator found which are using servo motor and solenoids that have two types of linear and rotary. In designing robotic Gendang Pahang, making comparison for actuator system is needed to select the best system as it will use a lot of automatic actuators for three instruments. Thus, the augmentation of Gendang Pahang has decided to use solenoid-based system for actuator as it is the most common type used in robotic musical instruments with low cost, simple system and produces the lowest mechanical noise so far. Meanwhile, servo motor generates high amount of the mechanical noise and less durable compared to the solenoid.

3. Methodology

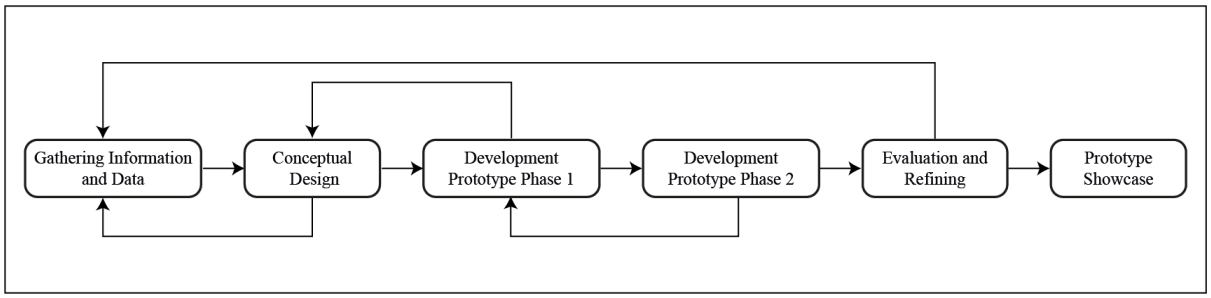

Figure 7: Prototyping Methodology

This augmented musical instrument uses prototyping methodology modified from the previous study of Virtual Gamelan (Ahmad Faris, 2012) and other studies of Asia's traditional musical instruments as the project tends to change in the development phase. In initial phase, the processes involved are collecting data from experts, analysing information of traditional instruments, understanding how Gendang Pahang works and studying the past related research regarding the technology used in this research. Primary data collection through interviews is documented using video and audio recordings which are transcribed into text. Meanwhile, the collection of secondary data of the instruments and the use of technology are done by studying previous studies such as journals, articles, thesis, books and seminar papers to get better results in augmenting the traditional musical instruments. All of the information and data are compiled and transferred into initial design of the project such as framework, flowchart and rough sketch of the actuator system and the prototype. After that, early phase of building prototype is done by focusing on the actuator system to make it function well enough before getting feedback from the expertise. When the actuator system is ready, the next phase of building prototype is continued which is the process of mounting the actuator system onto the musical instruments body and programming it to play automatically. After the prototype is ready, this augmented instrument will first collect feedbacks from experts to evaluate and refine it to the lowest potential risks. The last phase after everything getting smooth is to showcase it either in virtual mode because of the pandemic issue or both through virtual and exhibiting in collaboration with museum or gallery to get feedback from public in order to achieve the objective of this research. The feedback is collected using questionnaire given through the website to the museum's visitors either in physical paper or online form. The data obtained are analysed using SPSS (Statistical Package for the Social Science) software.

4. Implementation

The augmentation of Gendang Pahang with attachment of electronic element on the musical instrument is a kind of technological symbiosis where it is programmed based on basic playing of Gendang Pahang as taught by a real player. According to Brangier and Hammes-Adele (2011), technological symbiosis is a relationship between human and technology to simplify, assist or satisfy them in certain activity and it exists when humans programme part of them to technology and the technology itself acts as the agent of symbiosis.

This augmented Gendang Pahang is intended for the instrument to play automatically to introduce the traditional musical instrument to the public. The implementation of this project is in the progress of first phase building prototype which focuses on building actuator system for the instruments. The goal is to test solenoid-based system works in variety powers and speeds because to play Gendang Pahang, many types of struck speed and loudness need to be used to produce one song.

4.1 Hardware design

Gendang Pahang consists of three instruments which are gong and two drums with two flat surfaces. The gong only uses one beater to strike one area while the drum needs to use a lot of actuators

based on real human playing. The large skin surface for drum has two different types of struck which uses hand palm and a beater, while the smaller one uses hand palm and the drum's body is also used as an area to strike. Usually the beater's strike on the drum uses a variety of speed with high power or loudness while hand palm uses a variety of power and speed.

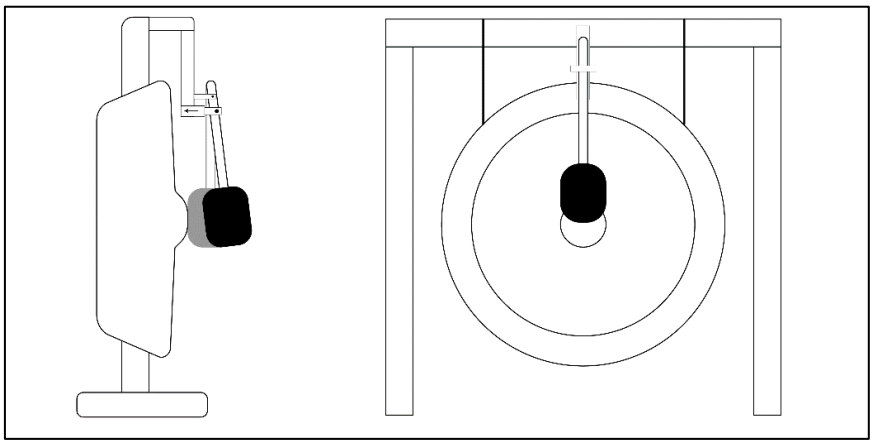

Figure 8: Illustration of gong beater

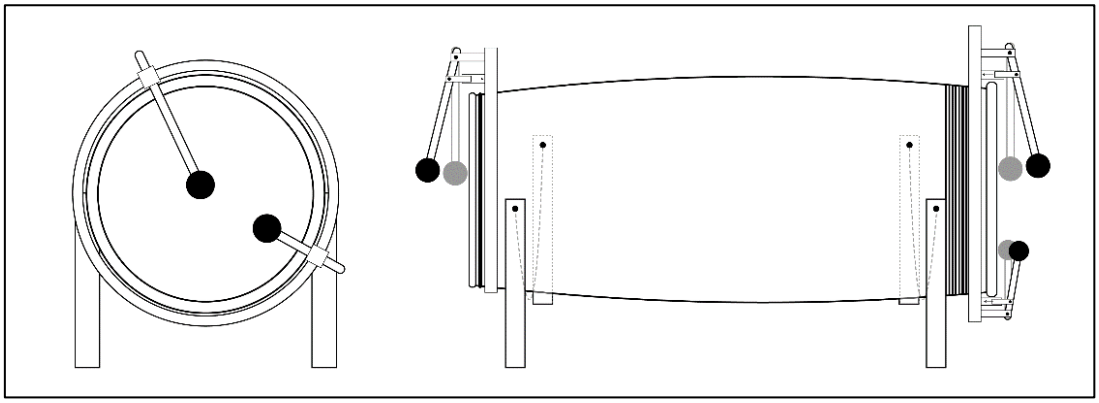

Figure 9: Illustration of drum beater

Based on the existing actuator system, the gong uses linear solenoid to move the beater in a linear motion. The drum consists of three areas and two skin surfaces with different sizes that uses linear solenoid but since the project is using prototyping method, the motion of the actuator can be changed as it is still in progress. The small and body area of the drum only uses one solenoid each but it can be increased more than that to achieve a higher speed while the largest area needs a minimum of two solenoids since two different types of beaters are used as illustrated in Figure 7 and 8. For early phase prototype, each instrument uses 12V DC power supply with one Arduino Uno.

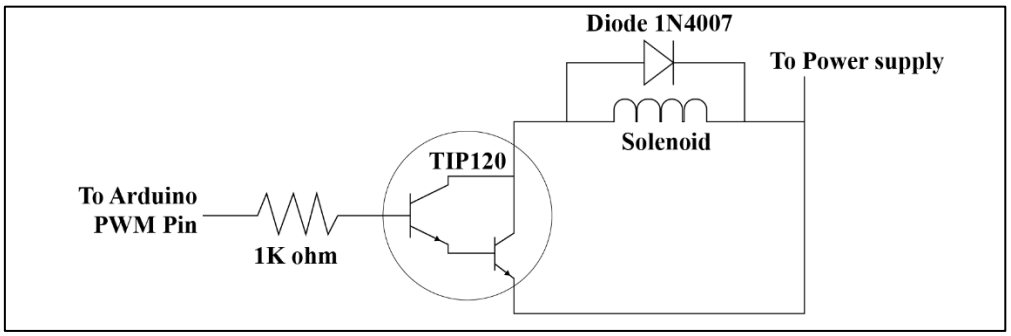

Figure 10: Circuit diagram for using a solenoid

4.2 Software

The computational function for instruction is programmed in Arduino software as the main controller for the beaters strikes. The programme will allow the interaction between user and technology to start the beater to play automatically. As the project is still in progress, the function can be programmed more than just playing a song. Each microcontroller will be programmed to connect and communicate with each other to play a song as all the Gendang Pahang's instruments itself depends on each other to play it.

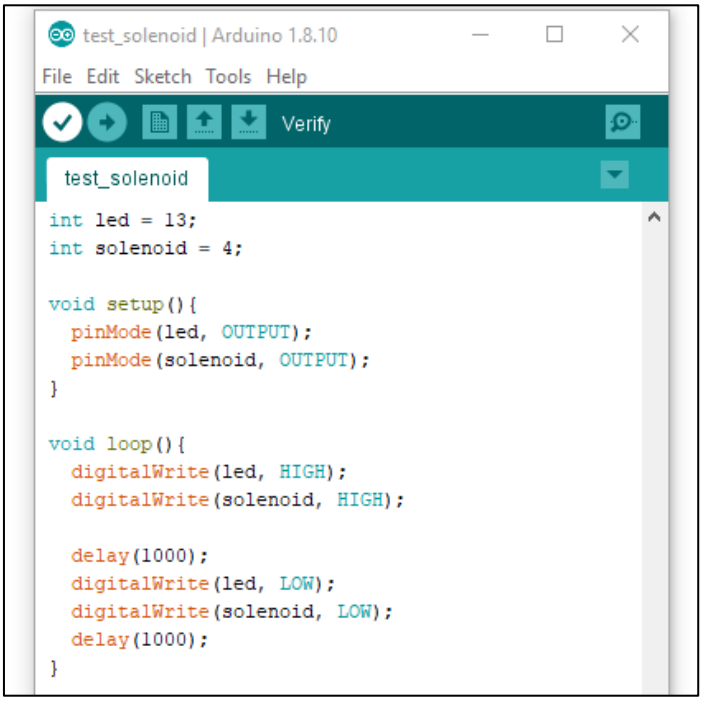

Figure 11: Basic coding for controlling one solenoid using Arduino. The led pin to detect if the code is functioning

5. Discussion and Future Development

As the project is still in a progressing phase, the author has faced many challenges and obstacles starting from the time allocated for collecting all the electronic elements as it is hard to find the area where this phase is being developed due to the pandemic restrictions of crossing to other places. The development part of electronic is not easy to understand as the author is not an expert in that field and using prototyping methodology is the best way to develop this prototype.

The prototype development in this paper is still in progress in order to make the actuator functions very well and diversifies the speed and power of the actuators. The development prototype is based on a musical instrument's robotic theory from Thibodeau (2011) which consists of four factors; thus, augmentation would not change the traditional instrument completely.

Intrusiveness is the level of physical modification which should be carefully avoided since there is the risk of potentially damaging the real instruments since in this project, physical modification will be made to mount the actuator system on the body of the drums.

Next is obtrusiveness which is the extent to which augmentation will affect the performance of the instruments. In this case, the mounted actuator on the drums should be done without affecting the sound that will be produced from the instruments.

The restrictiveness of the movement around performance environment should be noted such as the distance between the instrument and the floor where it should be restricted to avoid affecting the sound produced while the distance between each instrument should avoid any form of mechanical collision that can affect the performance.

Finally, it depends on the robustness of the augmentation which is the life span. This factor depends on the quality and fineness of the prototype development in taking good care of it which includes the use of electronical components, the actuator mounted on the instruments and environment surrounding the instruments. Based on these factors, they can help guide the process of augmentation so that the traditional musical instruments will be introduced in physical appearance that are still recognizable as one of cultural heritage arts.

The need for the technological innovation in traditional musical instruments is necessary which can connect the past with future, create opportunity to show them in international level and for education purpose. From past studies, the use of technology on real physical Asia's traditional musical instruments is limited. Some studies showed the use of virtual application to introduce the musical instruments (Kurniawanto, Sulistijono & Kusuma, 2011; Permana, Tolle, Utaminingrum & Dermawi; Simeon, 2015; Tan & Lim, 2018; Wiguna, 2019) which gave effect on the tradition values. According to Kapur (2007), the recording of audio and video in those applications might make the instruments become an artifact that ignores the preservation and learning system that have traditional ways to produce such an art.

Robotic Gendang Pahang is developed by applying technology to the real physical musical instruments in the concept of installation art or exhibition and the sound produced is original from the instrument itself without using any audio recording.

6. Conclusion

Most of the cultural heritage art displayed in museum or gallery by introducing it to the public is just a static object that provides a one-way visual experience for the visitors (Candlin, 2008). Either accompanied by written information or recorded video and audio, this study could give a contribution to the transition of the concept of the cultural heritage arts exhibition in Malaysia by giving it more interactive experience. Although those existing concepts provide information, if it is difficult to understand and access, it will make the visitors just pass the exhibition without engaging on the displayed object (Templeton, 2011). The technological symbiosis on the traditional musical instruments can help to introduce it to the public as we live in this modern world with the use of technology in daily life. Based on the past studies of Asia's traditional musical instruments, it is found that this field is still less studied and published as appropriate reference which might affect its value with lots of western musical instrument that is more popular nowadays. Thus, it is important for researchers, especially in Malaysia, to contribute by studying the technological innovations of our traditional musical instruments so that future generation would know and understand our own cultural heritage.

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