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ENHANCING ANGKLUNG PERFORMANCES USING A MIDI CONTROLLER

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ABSTRACT

Angklung is musical instrument originated from Indonesia, specifically West Java. It consists of bamboo tubes, connected to a bamboo frame. Sound is generated when the bamboo frame shakes, causing the bamboo tubes to oscillate. This musical instrument is played by an ensemble or individually. Music technology advancement has improved, allowing musicians to explore new possibilities for creating and performing music. One of the most important aspects of music technology is the existence of a communication protocol called the Musical Instrument Digital Interface, or MIDI in short. MIDI allows communication between electronic musical instruments as well as computers. The aim of this research is to create a prototype that allows users to control the angklung using a MIDI controller. The overall system requires a personal computer, a microcontroller, relay, and DC motor. The MIDI controller is used as an input, connected to a small-single board computer via a USB connection. The personal computer is used to proess incoming MIDI data. The microcontroller is used to receive input signal from the small-single board computer, in order to control DC motor according to its pitch. The result shows that the prototype is able to function properly, as the angklung will shake according to its input from the MIDI controller.

Keywords: *Angklung, MIDI, MIDI Controller*

1. INTRODUCTION

Angklung is an Indonesian musical instrument, specifically from an ethnic group in West Java called the Sundanese. It is made of bamboo tubes which are attached to a bamboo frame. The pitch produced varies, depending on the dimension of the bamboo tubes. This musical instrument is played by shaking its frame, causing the bamboo tubes to shake and produce sound. Angklung is played either in an ensemble (each individual holds one Angklung) or can be done individually by shaking the frame when the instrument is placed at a wooden stand [1].

Figure 1. Angklung Ensemble
Source: [2]

As time passes, there are several adjustments made to the instrument in order to adapt into contemporary music arrangements. Angklung was originally used as part of the Sundanese rice harvest ceremony. However, it is no longer used for the intended purpose. Therefore, Daeng Soetigna changed from the traditional pentatonic scale (*salendro*) to standard western diatonic scale in 1938. This is one of the contributing factors for the maintained popularity of the instrument in Indonesia [3]. In 2010, UNESCO awarded angklung as part of the Representative List of the Intangible Cultural Heritage of Humanity, which highlights its significance in Indonesian culture [4]. Nowadays, angklung is often played in traditional music performances and cultural events. Besides that, the musical instrument is also usually taught at schools.

Music technology has enabled users to explore new possibilities for creating and perfoming music. The existence of a communication protocol, named the Musical Instrument Digital Interface, that allow multiple musical intruments, as well as computers, to communicate with each other. This allows musicians to implement existing technologies, such as sequencers, sythesizers and digital audio workstation, in order to explore different ways to express themselves through music.

In recent years, there has been growing interest in robots, especially when it comes to exploring possibilities of using robots to interact with musical instruments as well as creating music with it. Robots can be designed and programmed to play various musical instruments, ranging from piano, guitar, drum, gamelan, and more. This journal article delves into the possibility of combining aspects of music technology and robotics into implementing MIDI controller as a method to control an angklung. It is going to open new methods in creating new ways of musical expression, which allows musicians to explore even further.

Musical Instrument Digital Interface

Musical Instrument Digital Interface, or MIDI, is a communication protocol that allows users to connect and control electronic musical instruments. It is a set of commands describing how the instrument is played. Therefore, it does not produce any audio signal. The primary use of MIDI is for audio production, stage lighting, robotics, and etc. Its main goals are universality and expandability. This means that every device that uses MIDI, has to act according to the data generated from other MIDI devices. If the device does not accept specific MIDI instructions, then it has to ignore the commands.

MIDI can be defined as a serial data protocol. This protocol grouped bits into bytes of 8 or 10 bits, depending on the message. MIDI bytes can be defined as status byte and data byte. Status byte shows specific instructions, such as NOTE_ON and NOTE_OFF, and documenting its designated channel. Meanwhile data byte shows its pitch (note number) and velocity. Velocity is defined as how hard the keys is strucked when the instrument is pressed. Meanwhile, delta-time represents the amount of time before the following event. If there are two events that occur at the same time, then the delta-time is considered as zero. These informations indicates how the notes are played specifically [5]

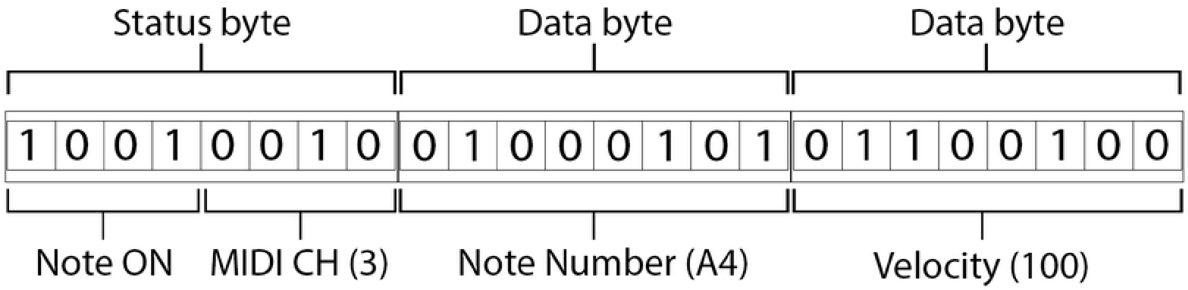


Figure 2. 25-Key MIDI Controller
Source: [6]

Besides status dan data byte, header chuck represents some information about the date in the file. It is usually shown at the beginning of the file. It shows the chuck type, length, format, ntrks and division. Format shows the overall organizations of the file. There are three types of MIDI: type 0, type 1 and type 2. The difference between these types are how the tracks are organized. Type 0 contains a single multi-channel track. Type 1 is when the file has one or more simultaneous tracks. Type 2 has independent single-track patterns. Meanwhile division indicates which time-code is used, between ticks per quarter-note or using the SMPTE format. This will affect how delta-time is measured.

The default tempo set by the protocol is 120 BPM or 500 000 microseconds per quarter note, with a time signature of 4/4. It is shown in the meta-even tof the file. This is relevant since delta-time is measured in ticks. Hence, it requires calculations in order to convert from ticks to seconds [7].

MIDI Controller

A MIDI controller is a device that sends MIDI messages to another MIDI-enabled devices. It ranges from samplers, synthesizers to computers. This allows musicians to control pitch, volume, dyanamic (how loud or soft a note is), timbre and more. MIDI controller can take various forms, ranging from percussion/drum pad MIDI controllers, faders to pedals. However, the most common form of this device is the keyboard-shaped MIDI controller, as shown at Figure 9. This device has become an important tool for musicians and music producers to explore music.

Figure 3. 25-Key MIDI Controller

2. RESEARCH METHOD

Planning

The planning stage is conducted in order to assess feasibility and scope of this project. Besides that, we will define the threats, contraints and integration of this project. Based on this information, we can decide on the objectives of the project.

There are several outlines that can be decided, based on the initial research at this stage. This research is conducted at the Mechatronics Laboratory at Universitas Tarumanagara. The objective of this research is to create a prototype that allows the angklung to be remotely controlled with a MIDI controller. This research also aims to allow receiving multiple input at the same time, hence allowing users to play both monophonic and polyphonic music.

A procedure is designed in order to conduct this study. This involves (1) planning, (2) analysis (3) development, and (4) testing. These methodologies will be discussed further into this chapter.

Analysis

A further study is conducted in order to observe existing prototype and determine its benefits and pain points. It is done by comparing two different literatures related to the project. The first literature is published by the Internatioanl Conference on Mechanical, Electronics, Computer, and Industrial Technology (MECnIT). The 18-note angklung is operated with an Android smartphone, via Bluetooth. The built-in application allows users to choose within the five selected songs, as well as controlling each of the angklung notes manually. The overall system uses a microcontroller, motor drivers, DC motor and 12V power supply [8].

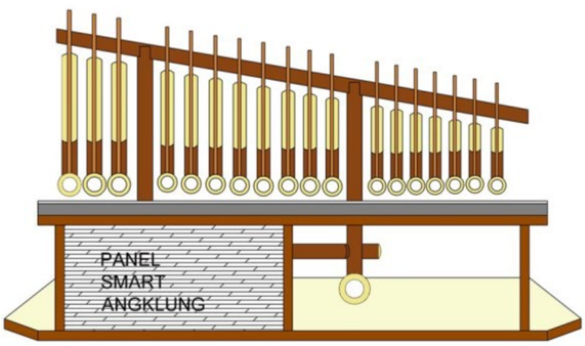


Figure 4. 25-Key MIDI Controller
Source: [8]

The second reference is based on a literature titled "Angklung Robot Control System Based on Microcontroller ". The authors designed an eight-note angklung robot, connected by a smartphone. The smartphone application allows users to play three songs and control each of the angklung notes. The microcontroller will receive MIDI messages from the smartphone via Bluetooth. It will process the messages and assign to switch a specific relay, in order to operate the motor [9].

Figure 5. 25-Key MIDI Controller
Source: [9]

Table 1. Comparison Table Between References and Planned Prototype

Comparison	***Literature 1***	***Literature 2***	***Prototype***
Microcontroller	Arduino Mega 2560	Arduino Uno	Personal Computer + Arduino Mega 2560
Input Method	Smartphone	Smartphone	MIDI Controller
Communication Protocol	Bluetooth	Bluetooth	Serial USB Connection
Actuator	DC Motor	DC Motor	DC Motor
Notes	18	8	25
Component	Motor Driver	Relay	Relay

Based on the survey conducted, main components can be decided in order to develop the prototype. A personal computer, a microcontroller (Arduino Mega 2560), a low-level trigger relay, and 25 DC motor are used to build the prototype. Figure 6 shows the general workflow of the overall system.

Figure 6. Block Diagram

Development

The development stage is the most important step to ensure that the project is properly conducted. It involes translating the block diagram shown at figure 6 into an actual prototype. This includes building the electrical and mechanical system, as well as coding.

The electrical components consist of 25 DC motor, one 16-channel relay, one 8-channel relay, and one single channel relay, Arduino Mega 2560, a power supply and a personal computer. The personal computer connectes to the microcontroller through a USB connection, which then connects the relay, DC motor and power supply. The schematic for one of the motors with a single channel relay is shown at Figure 7.

Figure 7. Schematic with a Single Channel Relay

The MIDI controller is connected to a personal computer through a USB connection. A custom code is developed in order to parse and process incoming MIDI messages into a readable string. The string then is sent to a microcontroller via serial communication, which then used to assign a specific command. If the message states NOTE_ON (when the keys are pressed), then it will switch the relay OFF, hence turning the assigned DC motor on. The same algorithm also applies when the keys are lifted off, which states NOTE_OFF and turning off the assigned DC motor. The flowchart is shown at Figure 9.

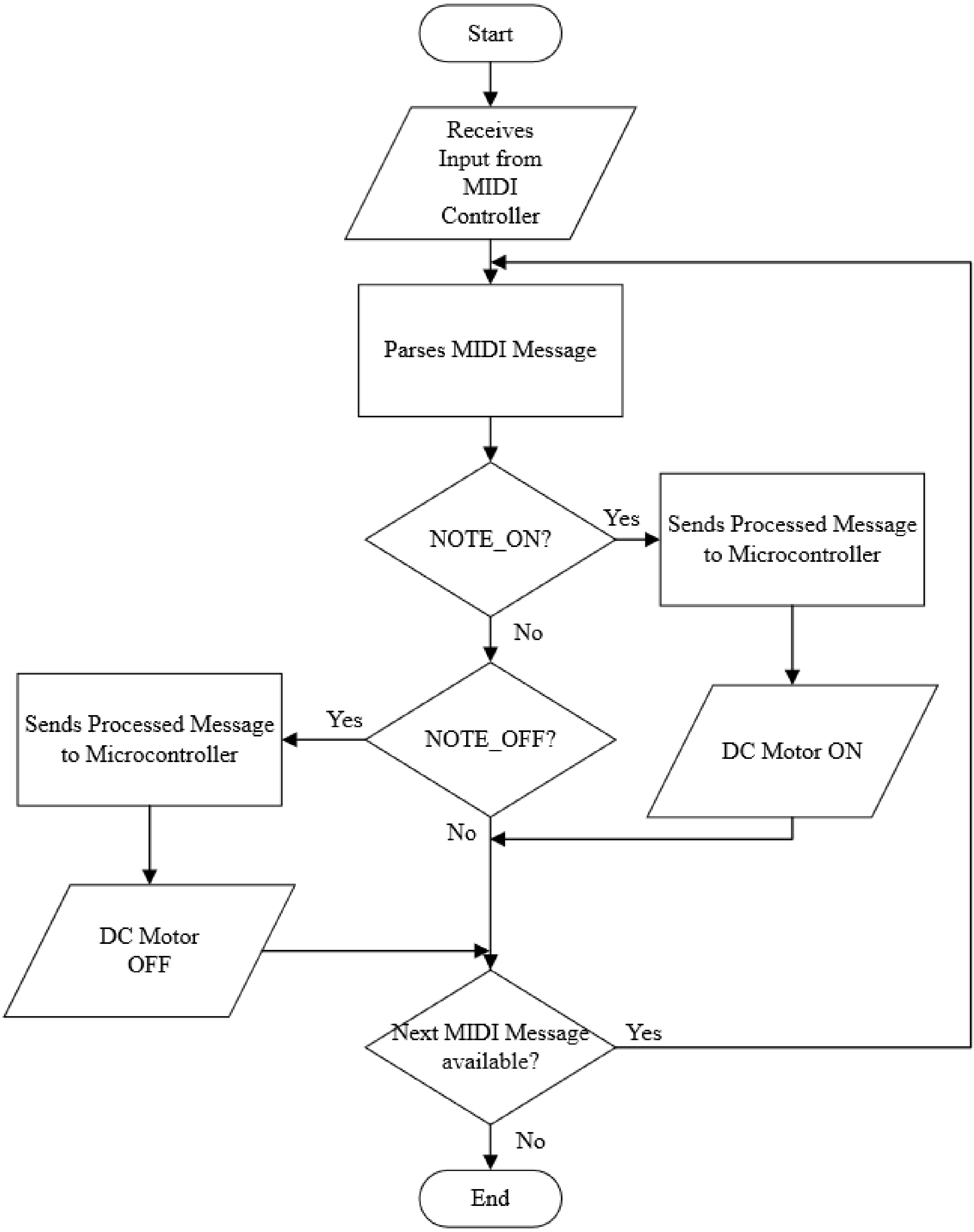


Figure 8. Flowchart of the Overall System

Testing

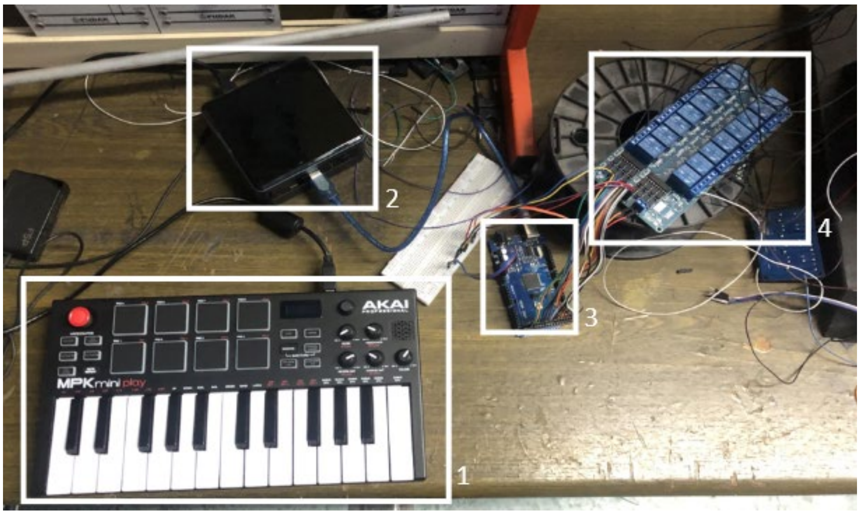
This stage is started after the prototype is built, to ensure it functions properly and meets the necessary requirements.

The testing stage is conducted in order to observe the change in current exerted by the motor. It is done by pressing the MIDI controller keys for 10 seconds and record the observed current. These steps are repeated for each change in voltage, ranging from 3-7 volts with a 0.5 volts interval. Theses ranges are selected based on the voltage specified at the data sheet.

3. RESULTS AND DISCUSSIONS

The mechanical parts are defined as the components that connects the angklung with the motor. The location of the DC motor is on top of the angklung stand. It is placed x cm from the designated pivot and 11.6 cm above the instrument. It is designed through a Computer Aided Design (CAD) and printed with a 3D printer. Some sections of the mechanical parts are shown at Figure 9 and for the electrical system at Figure 10.

Figure 9. DC Motor on Angklung



Note:
1. MIDI Controller
2. Personal Computer
3. Arduino Mega 2560
4. Relay

Figure 10. Electrical System of the Prototype

Table 2 shows the relationship between the voltage and current drawn by the motor in several conditions, no load (single and multiple motors) and with load (i.e., the musical instrument). The selected note is C4, due to its relative position in the scale of the instrument. The general pattern of the experiment is the higher the voltage, the higher the current. Between the all the tested conditions, when a single motor is in full load, then it takes more current to move the motor (range: 0.41A, across 4V). It requires more inerta and torque to move the load, increasing the stall current, hence requiring more current than when the motor has no load. It is also observed that operating two (multiple) motors simultaneously requires more current than a single motor. The multiple motors' starting current at 3V is 0.09A higher than the single motor. However, the range between the highest and lowest current for both single and multiple motor shows similar value, with 0.11A for single motor and 0.12 for multiple motors).

Table 2. Voltage vs Current Table

Input Voltage (V)	***Current (A)***		
	Single Motor (No Load)	***Single Motor (With Load)***	***Multiple Motors (No Load)***
3.0	0.08	0.08	0.17
3.5	0.08	0.11	0.20
4.0	0.08	0.14	0.22
4.5	0.08	0.21	0.22
5.0	0.09	0.30	0.23
5.5	0.11	0.34	0.24
6.0	0.11	0.40	0.26
6.5	0.11	0.45	0.27
7.0	0.19	0.49	0.29

4. CONCLUSIONS AND SUGGESTIONS

Based on the results shown at the previous chapter, it shows that the prototype is able to operate when the keys in the MIDI controller are pressed one at a time and multiple notes at the same time. It uses the most current when the motor is in full load and when multiple motors are running.

However, there are several suggestions that can be taken into account in order to improve this research:

1. Implementing more than two types of DC motors for the entire prototype in order to accommodate different masses of the instrument.
2. Placing the motors further away from the pivot, hence requiring less torque to move the same force.

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