KULLIYYAH OF ENGINEERING

DEPARTMENT OF MECHATRONICS

MCTE 3300

INTEGRATED DESIGN PROJECT

SEMESTER 2, 2022/2023

SECTION 2

GROUP 5

PROJECT:

MAP FOR THE BLINDS AND VISUALLY IMPAIRED

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TABLE OF CONTENT

1. CHAPTER 1: PROBLEM IDENTIFICATION

1.1. Introduction

"Globed for the Blind" is an innovative project aimed at empowering blind individuals by providing them with a unique means to understand and explore the location of the state in Malaysia. Understanding the size of the Earth and its geographical divisions can be difficult for people who are visually impaired. By utilizing technology and design concepts to produce an inclusive and accessible solution, this initiative aims to close that gap.

The objective of "Globed for the Blind" is to create a user-friendly and educational system that enables blind people to comprehend continents spatially. This project seeks to give a multimodal experience that enables blind people to explore, navigate, and visualize the layout of the state in Malaysia by combining tactile and interactive features.

This project has two modes which are mode A includes a Braille keypad with a push button, a xy-gantry for map movement, and automatic audio feedback. The Braille keypad allows easy navigation, while the xy-gantry lifts and moves the map for tactile exploration. The system provides informative audio feedback about the map's content. This technology enhances accessibility, independence, and understanding of maps for visually impaired individuals, promoting inclusivity and empowering them to navigate their surroundings with greater confidence.

The second mode is the assistive technology system, each state is equipped with a touch sensor. When a user touches the touch sensor, it triggers the system to turn on the audio feature. This modification ensures that the audio is activated and ready to provide information as soon as the user engages with the touch sensor. This added functionality enhances the user experience by streamlining the process of accessing audio instructions and information, allowing visually impaired individuals to quickly and easily engage with the system.

In the end, "Globed for the Blind" aims to empower blind people by giving them a tool that improves their knowledge of global geography. This research gives up new opportunities for learning, exploration, and cultural understanding by enabling blind people to understand the locations and characteristics of continents, enabling them to interact meaningfully and enriching with the global community.

1.2. Problem statement

1.2.1. Lack of accessible ways for blind people to comprehend the locations of state in Malaysia

1.2.2. Blind people struggle to have a thorough understanding of the world's geography, which restricts their educational options and exposure to different cultures.

1.2.3. The existing options (maps, written explanations) fall short of explaining the relationships between the continents and the spatial surroundings.

1.3. Proposed Solutions

Innovation of maps. Create a map that has a development in terms of mechanical, electrical, and control. This map will have a sensor, sound, and pop-up movement.

This is a reference video about this project: https://youtu.be/ZxWtpYeG-e8

1.4. Target user

SMK Pendidikan Khas Setapak (Setapak Blindness Special Education Secondary School), a school for the blind is the intended audience for our project, "Globed for the Blind." Due to their visual impairments, many children find it difficult to perceive and comprehend visual information. They only rely on several senses and ways of interacting in order to explore and understand their surroundings.

Blind students find it challenging to understand geography concepts in general and global geography in particular because traditional teaching materials mainly rely on visual aids. Without readily available and comprehensive resources, locating continents becomes a difficult endeavor. We are doing this project and we have tested it on several students. The teacher helped us by giving the students who are excellent in class and also students that are not doing well in class to test our project. Both students can use this map easily and know the state in Malaysia very well and can know the difference of every texture in every state in Malaysia.

They will have the chance to improve their geographic knowledge, cultivate cultural sensitivity, and develop a spatial grasp of the state of Malaysia. It can also make the students an active part in geography lectures and activities by adapting the solution to their unique needs and educational requirements.

Figure 1.4.1 This picture shows our members helping the students to use the map

Figure 1.4.2 This picture shows the students using the map independently

1.5. Survey

In this project, we have conducted an interview session with one of the teachers at SMKPK Setapak regarding the accessible map for Geography subjects for blind and visually impaired students. For the user's needs, the teacher suggested adding audio to the map to provide information to differentiate the continents. This is very helpful and interactive to instill the learning process in students as previously the learning method used is impractical and not informative. To add, emergency stop buttons also need to be put on the map for user safety in case the map is not functioning well. Moreover, as a way to differentiate the continents, every continent must have a different texture and it is advisable to have the cardinal direction on top of the map.

Furthermore, the size of the map should be moderate, convenient and easy to store. It is best if the map is moveable in order that the teachers will be able to move the map from the classes to the store room. On top of that, the material used to build the map has to be strong enough and not easily broken to support the mechanical parts of the map and the circuit so that it won't collapse. Other than that, for the maintenance, the components on the map ought to be easy to repair and troubleshoot.

We also have conducted a survey for the teachers as appeared in survey 1 in the appendix to assist us to develop the map for the blind and visually impaired students. The survey is separated with three sections, A, B and C including the teaching experience, learning experience and technology based map respectively. From the survey, the most important aspects for the learning aid kit come out with low cost, have several modes for instance, the quiz mode and self-learning mode and have a big size for a group of students.

1.6. Benchmarking

1.6.1. Clay Map

Clay map is a world map developed by one of the teachers at SMKPK Setapak. It is a very big map showing all the continents in the world. The maps were made from clay and plaster. For every continent, there are different textures. The maps are currently attached to the wall at schools and easily accessible by the students. However, due to the limitation, students can only touch the maps. Due to its big size, only tall students can access the higher continents.

Figure 1.6.1

1.6.2. Tactile globe

This is commonly used worldwide and developed by many societies or organizations. It is a globe that has been designed for people who are blind or visually impaired to be able to explore the world. Tactile globes have raised features that represent the different landforms on the globe such as mountains, oceans, and rivers. Also included raised text that labels continents and major cities.

Figure 1.6.2

1.6.3. Tactile textbook

This is a handmade textbook by teachers. It is common for blind school teachers to spend hours making this textbook for every subject especially geography, science, and history subject. The textbook contains raised content made from various items. For geography subject, there are maps in the textbook. However, during our visit, the teachers share that the maps in the textbook are too small for the students. The states and continents need to be separated. So most of them have difficulty to image the maps as a whole. They need bigger maps to be touched and explored.

Figure 1.6.3

1.7. Literature Review

1.7.1. Products Literature

- BlindSquare is a GPS navigation app for blind and visually impaired people. It uses audio cues to guide users to their destinations, and it also includes a tactile map feature that allows users to explore maps by touch. https://www.blindsquare.com/
- Tactile Maps are maps that are designed to be read by touch. They are typically made of thick paper or plastic, and they use raised symbols and textures to represent different features on the map. Tactile maps are available for a variety of locations, including cities, airports, and train stations.

  www.bloomberg.com

Figure 1.7.1

1.7.2. Technical Literature

- "Blind Friendly Maps" by J. Miele, M. C. Henshaw, and J. C. Goodrich (2015). This paper describes the development of a new method for creating tactile maps that are accessible to blind and visually impaired people. The method uses a combination of embossing and audio cues to create maps that can be read by touch.
- "Tactile Mapping: Helping the Blind Find Their Way" by TomTom (2018). This blog post discusses the use of tactile maps to help blind and visually impaired people navigate their surroundings. The post provides an overview of the different types of tactile maps that are available, and it discusses the benefits of using tactile maps for navigation.
- "A Patent for a Tactile Map for Blind People" (US Patent No. 7,791,547). This patent describes a method for creating tactile maps that are accessible to blind and visually impaired people. The method uses a combination of embossing and raised symbols to create maps that can be read by touch.

1.7.3. Patents Literature

- US Patent No. 7,791,547 (2010): This patent describes a method for creating tactile maps that are accessible to blind and visually impaired people. The method uses a combination of embossing and raised symbols to create maps that can be read by touch.
- US Patent No. 8,394,529 (2013): This patent describes a method for creating tactile maps that are interactive. The method uses a combination of embossing and audio cues to create maps that can be explored by touch and sound.
- US Patent No. 9,513,921 (2017): This patent describes a method for creating tactile maps that are personalized. The method uses a combination of embossing and audio cues to create maps that can be customized to the needs of the individual user.

2. CHAPTER 2: CONCEPTUAL DESIGN

2.1. Objectives

2.1.1. To design a mechatronics-based map to assist visually impaired students in learning maps, consisting of mechanical, electrical, and control systems.

2.1.2. To evaluate the effectiveness of the designed map using the technology acceptance model (perceived ease of use, perceived usefulness, attitudes, and actual behaviors).

2.2. Concept Design

After finding information related to map innovation and determining the problem statement, we decided to make an innovative map instead of a globe.

2.2.1. Proposed designs for the pop-up mechanisms

2.2.1.1. Electromagnet actuator

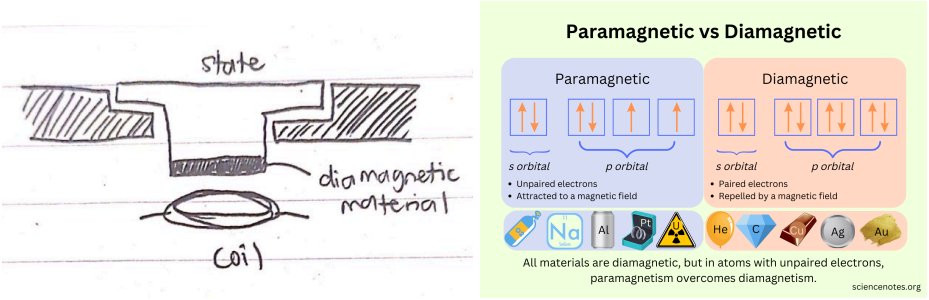


Figure 2.2.1

To run this actuator, current must flow into the coil and diamagnetic material shall be used so that when the magnetic flux exists, the material will repel from the coil and make the state move upward. When each state uses this kind of system, it may cause high power consumption and make the map get overheated. For safety, temperature sensors should be included in the system to give any feedback when the map is in high temperatures.

2.2.1.2. Bevel gear actuator

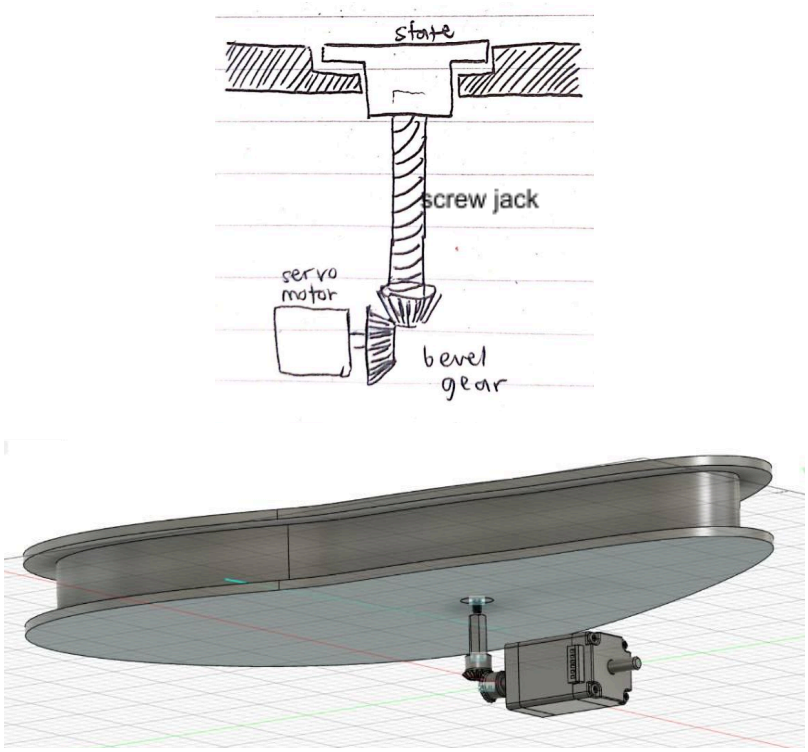


Figure 2.2.2

In this design, each state will have its own bevel gear connected with a screw jack. To make the state move up and down, a 5V servo motor will be used. It is quite plenty if all states have this set of actuators which may cause noise and the circuit system will be tangled. In the long run, the system also may cause the map to become overheated. To control this system, many limit switches may be used to control the actuation movement as well as the temperature sensor.

2.2.1.3. Pen-lock concept

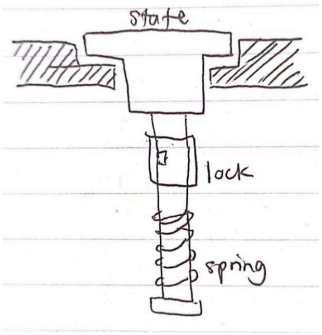


Figure 2.2.3

The pen-lock concept uses spring and lock. Users just have to push the state to make it pop up or pop down. To use this concept, we have to consider the spring constant value for each state. Some states may need high spring constant due to bigger size, therefore the spring specification may need to be varied.

2.2.1.4. MR fluid

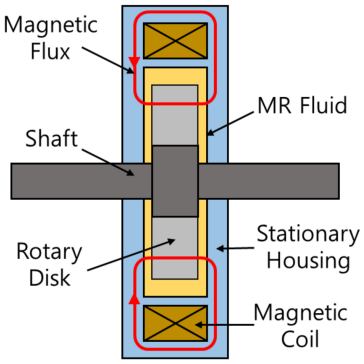


Figure 2.2.4

A magnetorheological (MR) fluid is a fluid that has good magnetic properties. MR fluid responds to the magnetic field and changes its properties when a magnetic field is presented. It is easy to control, fast response and has low power requirements. However, the cost was quite expensive about RM85.30 per 100g and the fluid is subjected to thickening after prolonged use.

2.2.1.5. Mini Linear Actuator

Figure 2.2.1.5

This is a mini linear actuator with a 50mm stroke length. The price is about RM111 including its motor driver. It needs 12V to power it up. It provides safe and clean motion control that is efficient and maintenance-free. It inputs only 0 or 1, so no limit switch is needed to cover its safety.

2.2.2. Proposed designs for the XY-gantry

2.2.2.1. Core XY-gantry

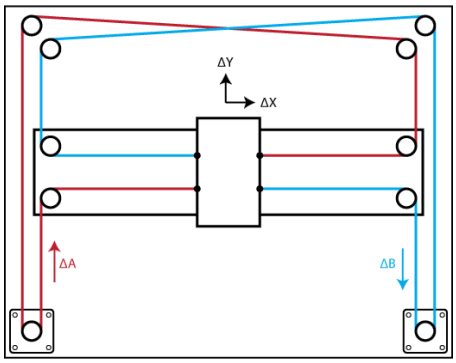


Figure 2.2.5.1

CoreXY printers can produce better results because the motor movement can provide more precise positioning and faster print speeds depending on the belt length and arrangement. The drawback of CoreXY printers is the design is more complicated and challenging construction.

2.2.2.2. Linear XY-gantry

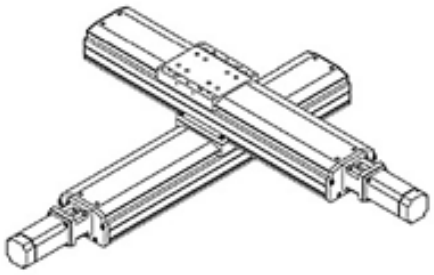


Figure 2.2.5.2

Linear xy-gantry run on two axes (XY). Therefore, when a linear actuator is embedded on top of xy-gantry, it will produce cartesian movement which can run on three axes (XYZ).

2.3. Pugh Chart

Design 1: Electromagnet actuator
Design 2: Bevel gear actuator
Design 3: Pen-lock concept
Design 4: MR-fluid
Design 5: Mini linear actuator

No	Selection criteria	Weightage	Reference Design	Design1	Design2	Design3	Design4	Design5
1	Easily operated by the blind and visually impaired	10	DATUM	+	+	+	_	+
2	Lightweight	7		_	_	+	+	+
3	High mobility	6		_	_	+	_	+
4	Less cost	5		_	_	+	_	_
5	Less production complexity	5		+	+	_	+	+
6	Easy to assembly	5		0	+	_	_	+
7	Easy for maintenance and troubleshooting	7		0	0	0	_	0
8	Safe	6		+	+	+	+	+
9	Sustainability	7		+	+	_	_	_
Total ‘+’				4	5	5	3	7
Total ‘-’				3	3	2	6	2
Weighted Score				10	15	17	-22	27

2.4. Engineering characteristic

No	Engineering Characteristic	Unit	Improvement Direction	Explanation
1	Jamming probability	%	↓	The product should be able to run smoothly
2	Energy to pop-up mechanism	N	↓	The energy required for pop-up mechanism should be less as it will decrease the cost
3	Material toughness	Kg	↑	Material used should be tough so that the product can sustain
4	Average time to pop up	Sec	↓	Average time to pop up must decrease to improve the product efficiency
5	Water resistant	Mpa	↑	The product should be water resistant to make it sustain
6	Weight	Mpa/m	↓	The lighter the product, the easier the product can be moved
7	Material rigidity	m	↑	The rigidity will make sure the product can last for a long time

2.5. House of Quality

		Engineering characteristics						
Improvement direction		↓	↓	↓	↓	↑	↑	↑
Units		%	N	kg	sec	MPa	Mpa/m	m
Customer requirements	Importance weight factor	jamming probability	Energy to pop up mechanism	weight	average time to popup	material rigidity	material toughness	water resistant
Mobility	4			9		3	1	1
10 years lifetime	2	9				3	9	9
Not jam	5	9	9		3	1		
water proof	5					1	3	9
Raw score (291)		63	45	36	15	28	37	67
Relative Weight %		21.64948454	15.46391753	12.37113402	5.154639175	9.621993127	12.71477663	23.02405498
Rank Order		2	3	5	7	6	4	1

3. CHAPTER 3: MODELING, PROTOTYPING & FABRICATION

3.1. Proof of Concept

This is the very first prototype that has been made in Engineering Design semester 1, 22/23. It is made to help us understand the basic concept of how the maps will work before proceeding with further design. We show the teachers this prototype during our visit to the school and also help them to understand and imagine the product.

In this prototype, the LED indicates the output such as the pop-up mechanism and audio. For the input, we try using Velostat as the pressure sensor. Velostat needs to be put together like a sandwich with copper tape. Then we decide to use a touch sensor instead because later we learn that Velostat uses analog values with a small range. The reading is also inconsistent which will lead to more errors and problems.

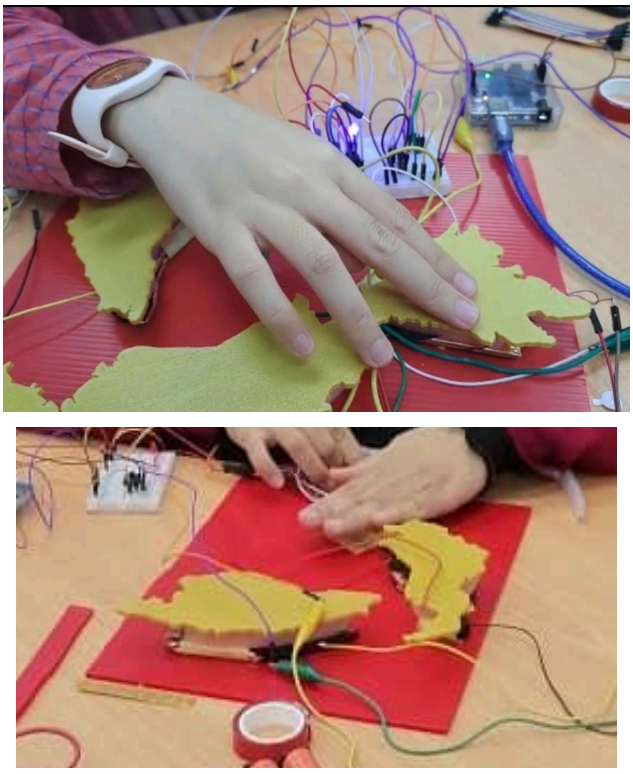
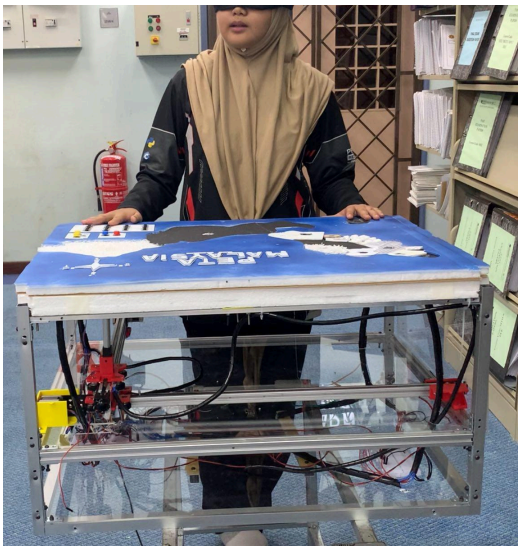


Figure 3.1

3.2. Mechanism Design



3.2.1. User Interface Design

This is the surface of the maps that function as the user interface. It consists of a push button, a touch sensor, a speaker with four cardinal directions, and textured maps.

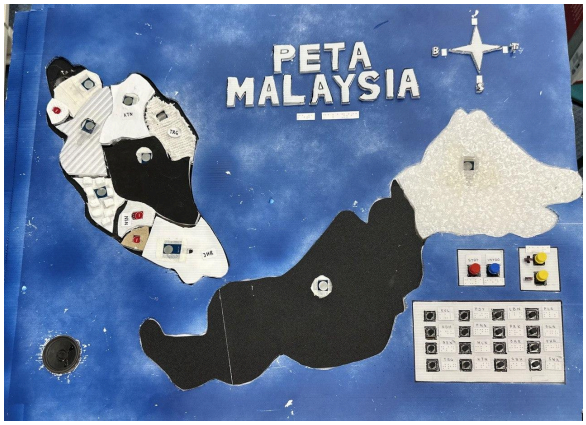


Figure 3.2.1

3.2.2. Pop-up mechanism

Pop-up mechanism consists of a linear actuator and the state. On top of the linear actuator, we attached a permanent magnet while every state, we put a spacer that functions to attach with the magnet when the actuator was at extruded state, as additional support. To avoid the state from going over their region, we designed each state to have its own blocker at the bottom. Therefore, the state only can move upward and downward inside its region.

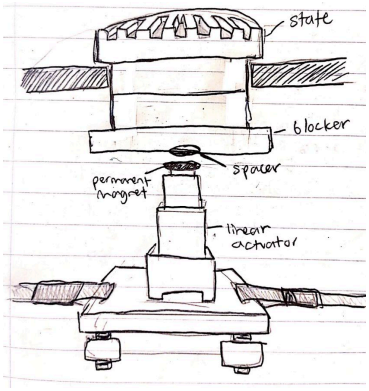
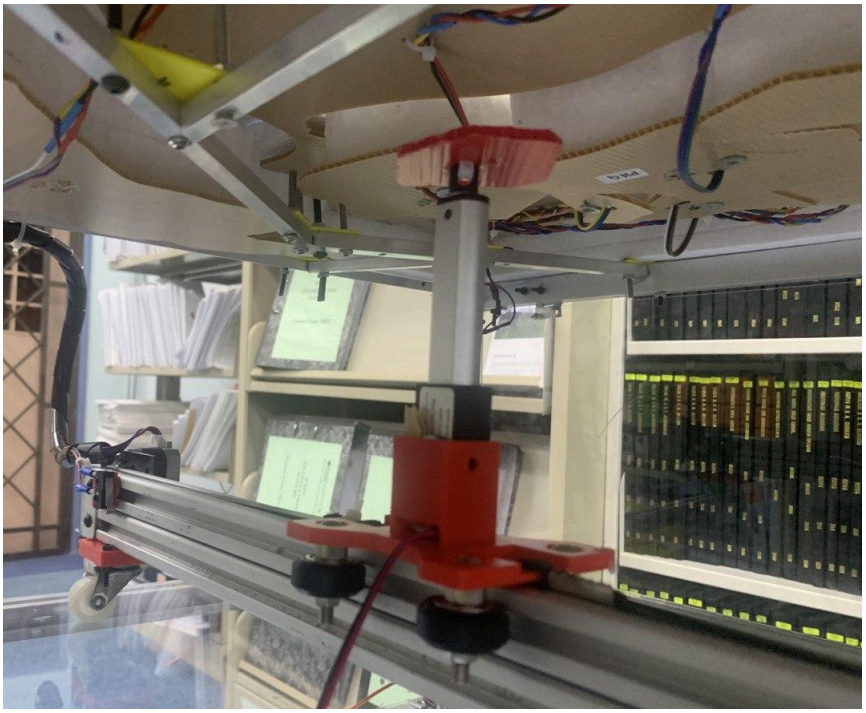


Figure 3.2.2

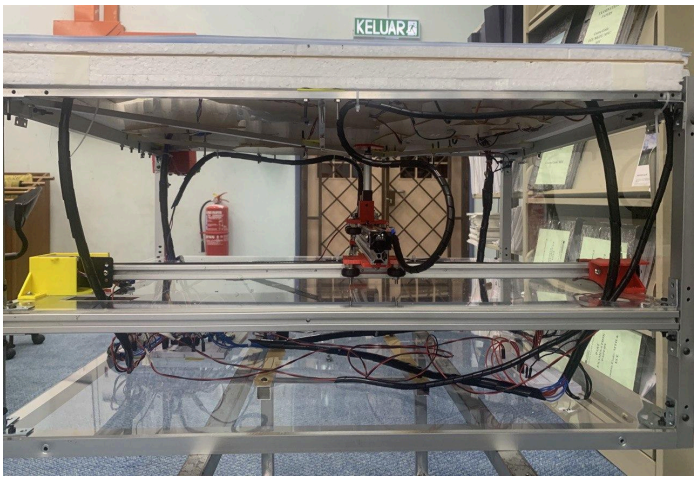


3.2.3. XY-Gantry

The XY-gantry is a type of mechanical system that is used to move a linear actuator around in two dimensions. The XY-gantry in this project uses two stepper motors to move the linear actuator in the X and Y directions. The stepper motors are controlled by the Arduino IDE using the accelstepper and multistepper libraries.

The accelstepper library provides a simple way to control stepper motors. It allows you to set the speed, acceleration, and deceleration of the stepper motors. The multistepper library allows you to control multiple stepper motors simultaneously.

In the IDE, the coordinates for each state of the XY-gantry have been assigned accordingly. The coordinates are the X and Y positions of the linear actuator. The push buttons will be the user input to move the XY-gantry to the desired position. The push buttons will send a signal to the Arduino IDE, which will then move the stepper motors to the desired position.



3.2.4. Audio

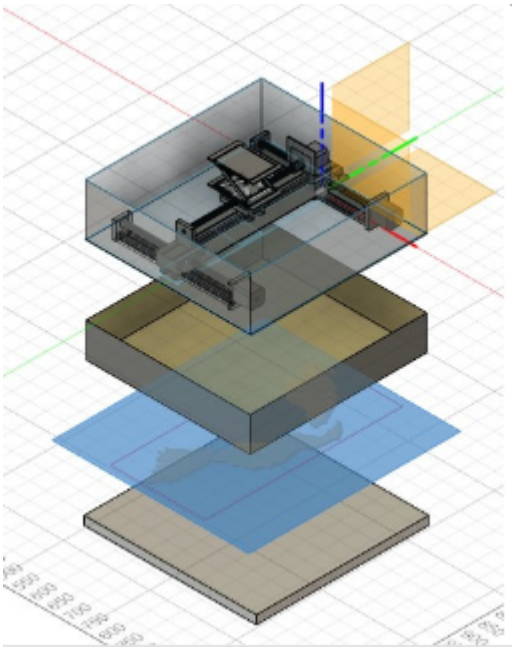
Audio will be one of the outputs of this project. The audio file will be generated from text-to-speech with a male voice. The audio file will explain about each state in Malaysia, including the location of the state, its main attractions, and any useful information for students. The main learning language at the school is Malay, so the audio file will be in the Malay language. We already got approval from the Geography teachers about the text content. The teachers have reviewed the text content of the audio file and have given their approval.

Below is the example text for Melaka state.

> *"Melaka terletak di Barat Semenanjung Malaysia diantara Johor dan Negeri Sembilan. Melaka ialah negeri keempat terkecil di Malaysia. Ibu negeri Melaka ialah Bandaraya Melaka. Melaka juga dikenali sebagai Bandaraya Bersejarah. Melaka telah diisytiharkan oleh UNESCO sebagai Bandar Warisan Dunia pada tahun 2008. "*

3.2.5. Base & circuit box

The base and body of the project are made from hollow aluminum and perspex. To ensure that students cannot touch any of the circuit components, each map below is covered with perspex. The second layer of the maps has some space for the circuit.



3.3. Components

3.3.1. Microcontroller

In this project, the microcontroller used is Arduino Mega 2560. Microcontroller is a small computer built on an integrated circuit that contains a processor core programable dedicated input/output peripheral and memory. Arduino is a single-board microcontroller designed to ensure accessibility in electronics-based projects. Arduino uses open-source programming and has many sources and references available. It comes in various form factors such as the Uno, Mega, Nano, Micro, and Leonardo. Arduino Mega is one of the frequently used Arduino because it has a good processor and many pinouts. It has 54 digital input/output pins (of which 15 can use as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

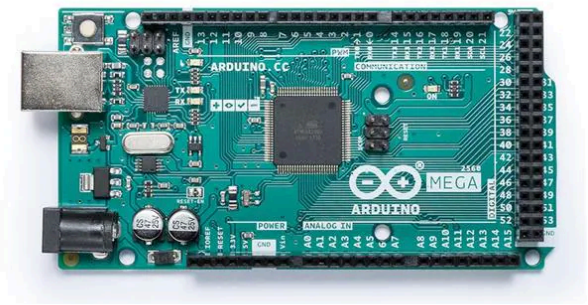


Figure 3.4.1

3.3.2. Capacitive touch sensor module (TTP223)

This touch sensor is a capacitive touch sensor module. The sensor driver is based on the driver IC TTP223. This touch sensor can function as an input button. The operating voltage of this sensor is from 2V to 5.5V with very low power consumption. It used the user body as part of the circuit. When you touch the sensor, the capacitance of the circuit is changed and detected. This detected change in capacitance results in the output changing states high or low. Touch has a pin which is the signal pin that is connected to the digital pin Arduino, ground, and a 5V VCC.

For this project, there are 12 touch sensors used that are connected to the 12 digital pin Arduino.

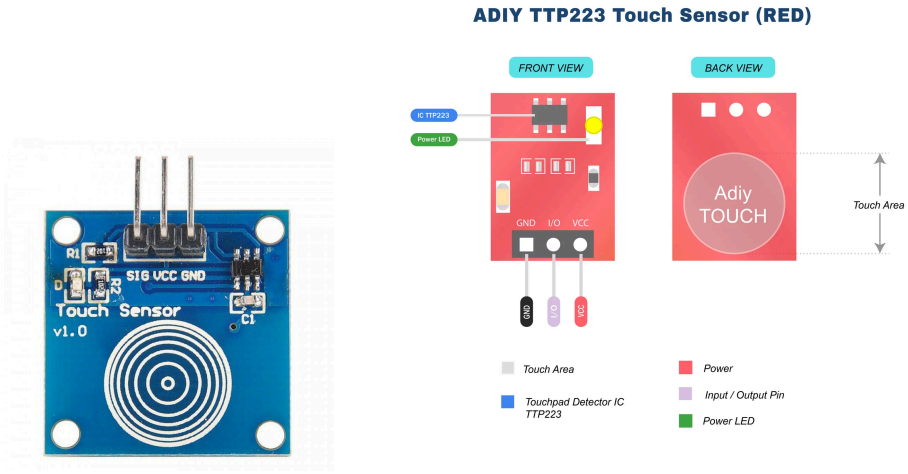


Figure 3.4.2.1

Figure 3.4.2.2

3.3.3. Push Button

The buttons used are 4-pin push buttons with 50mA current and 5V VCC. This push button requires a resistor connected to the ground for it to operate without interference. Another 2-pin will be connected to the VCC for power and signal.

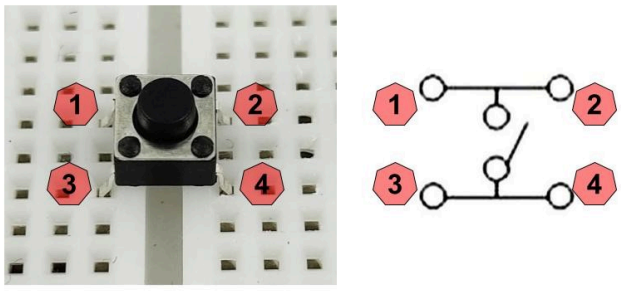


Figure 3.4.3.1

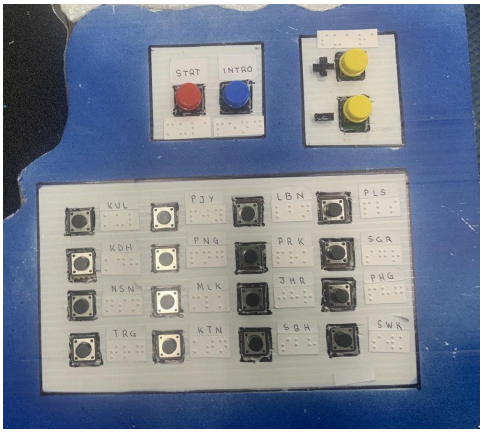


Figure 3.4.3.2

3.3.4. CNC Shield

CNC Shield can be attached together with Arduino so it will be connected directly. The shield consists of a red board with 4 motor driver board slots. The slot corresponds to the X-, Y-, Z- and 1 additional motor driver slot. In this project, only 2 motors were used for movement in the xy gantry which are the X-motor and Y-motor. CNC shield functioning in minimizing the circuit for XY gantry. Usually, a CNC shield is used with a universal G-code sender and GRBL firmware. However, for this project, the CNC shield is being used directly with Arduino IDE without other software or firmware.

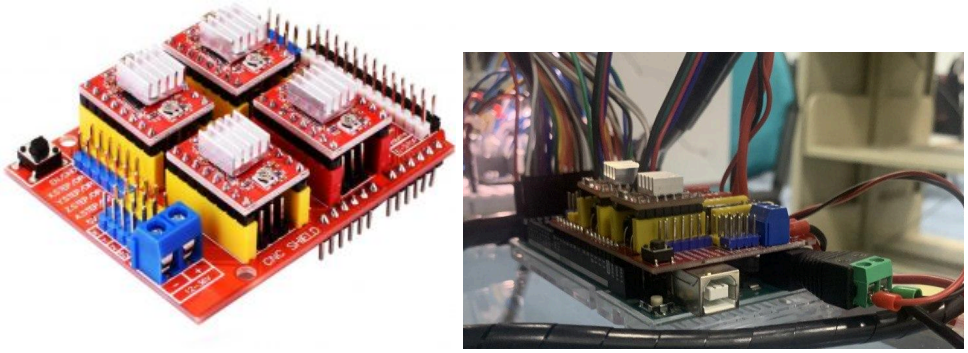


Figure 3.4.4.1

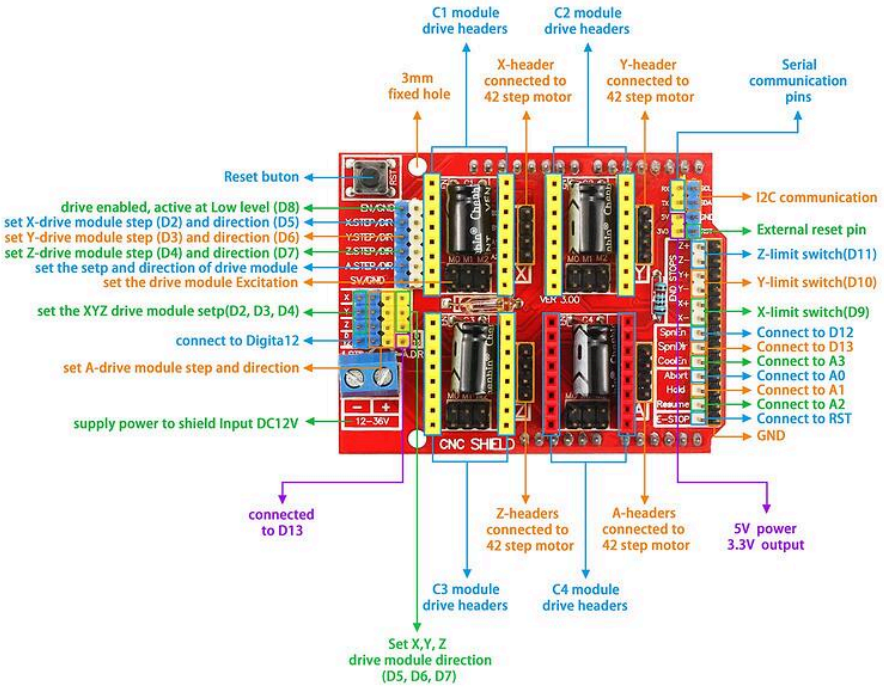


Figure 3.4.4.2

3.3.5. Motor driver stepper motor (A4988)

This is Allegros A4988 micro stepping bipolar stepper motor driver. It features adjustable current limiting, over-current and over-temperature protection, and five different microstep resolutions. For the voltage, it operates from 8V to 35V. Also, it can deliver up to approximately 1A per phase without a heat sink. In this project, the voltage supply to the motor is 12V from an AC adapter. 2 motor drivers are used for each motor in X and Y axes. These motors are directly attached to the CNC shield.

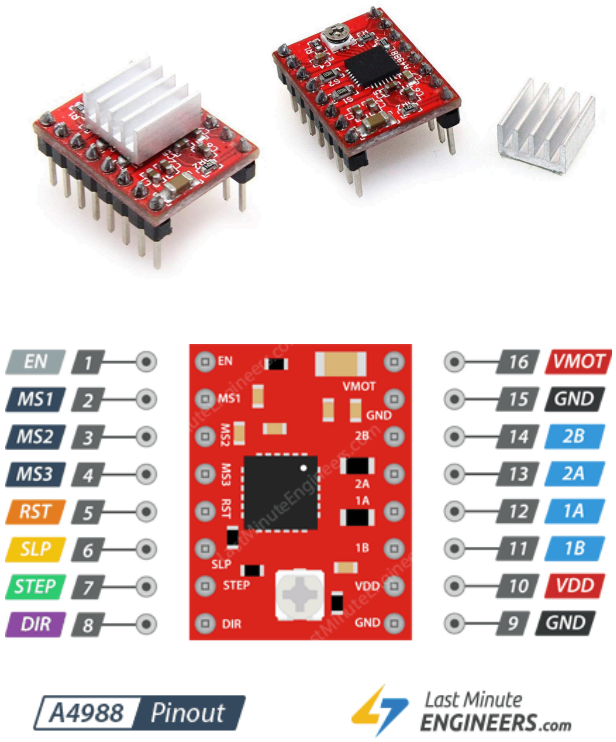


Figure 3.4.5

3.3.6. Stepper motor

There are many stepper motors that can be used for the XY-gantry. However, for this project stepper motor that was chosen is NEMA-17 42 x 34 mm with 1-meter cable XH2.54. It is because of the affordable price and the quality. This type of motor driver is usually used for the XY-gantry in the 3d printer. It has higher durability with higher performance and low power consumption. The step angle is 1.8 degrees with a rated speed of 1-1000 rpm and rated torque of 0.4 nm. The nominal voltage is 4.83V with a current rating of 1.5A.

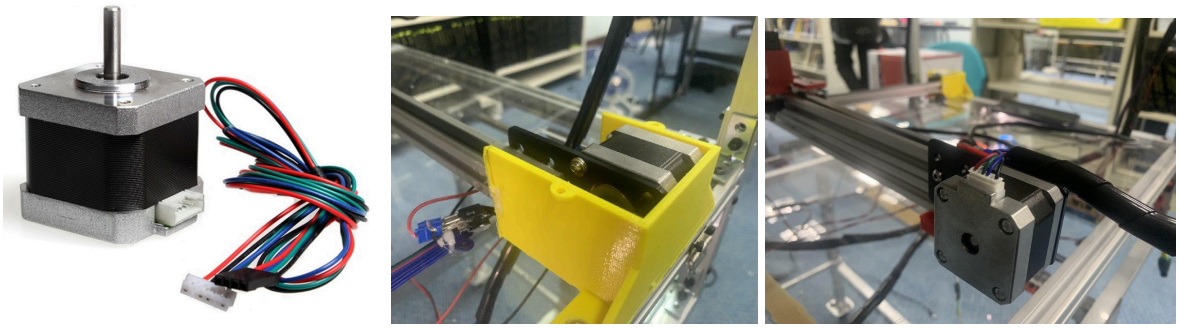


Figure 3.4.6

3.3.7. Motor driver linear actuator (L298N)

Motor driver L298N chip contains two standard H-bridges capable of driving a pair of DC motors. It supplies a range of 5V to 35V with 2A continuous current per channel.

There are 4 types of pins in this motor driver which are power pins, output pins, direction control pins, and speed control pins. Based on figure 3.4.7 below, power pins are number 1, 2, and 3 while output pins are number 8 and 9. Direction control pins are 5 and 6 and speed control pins are number 4 and 7. For pins that are connected to the Arduino, it must be used digital pins with PWM.

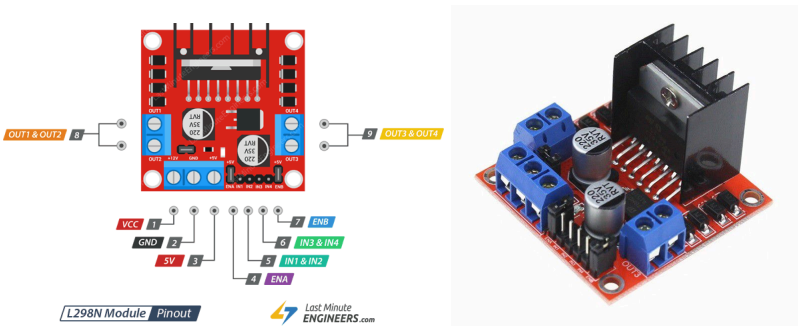


Figure 3.4.7

3.3.8. Linear actuator (LA-T8)

Linear actuator used in this project is the LA-T8 model. It uses 6V or 12V DC voltage input. This actuator is made from plastic and aluminum alloy. The retracted length for this actuator is 54.5 mm. The extends mechanism has a build limit switch makes this actuator very safe. When the linear actuator 100% fully extends, it touches the tail-limited switch and stops automatically.

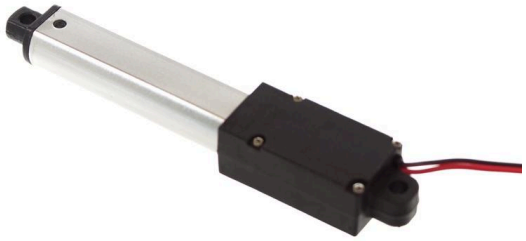


Figure 3.4.8

3.3.9. Speaker

Speaker module used in this project is 8 ohms of impedance. The ohms will affect the sound quality and loudness. Speakers with higher impedance ratings will get louder without producing distortion.

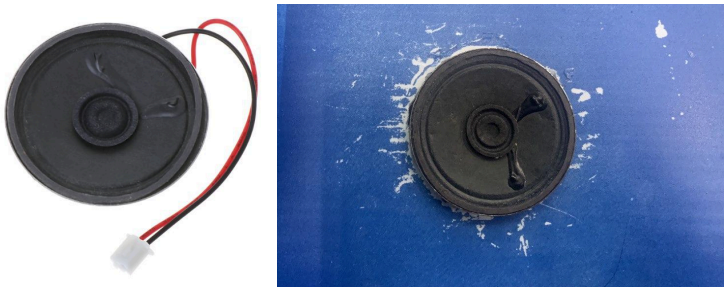


Figure 3.4.9.1

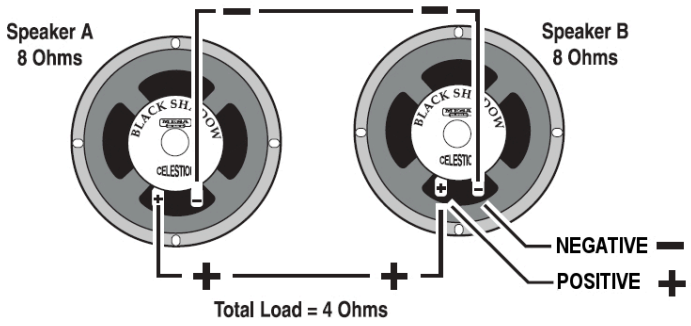


Figure 3.4.9.2

3.3.10. DFPlayer Mini MP3 Module

This MP3 module is a small and low-cost MP3 module with a simplified output directly to the speaker. This module can be used in combination with Arduino. It has a variety of control modes which are I/O control mode, serial mode, and AD button control mode. The audio data can be sorted by folding up to 100 folders and every folder can hold up to 155 songs. The volume can be adjustable from 0 to 30 levels.

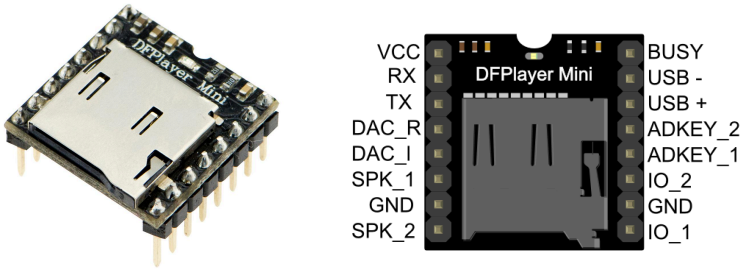


Figure 3.4.10

3.3.11. Power Adapter

Supply 12V Dc voltage to the motors and powered Arduino.

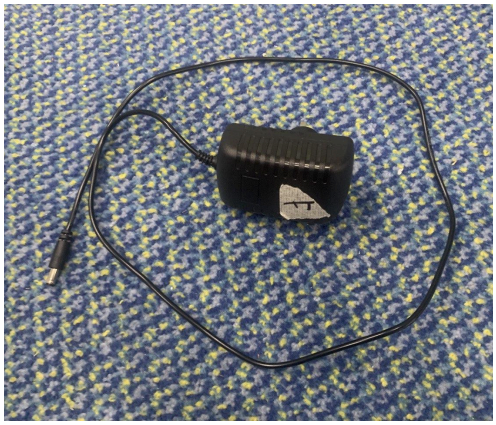


Figure 3.4.11

3.3.12. Micro limit Switch

Limit switch is an electromechanical device that is operated by a physical force applied. Once the lever is in contact with the limit points, the switch opens the circuit and stops the motor. In this project, there are 4 limit switches attached to the XY-gantry. Each axis will have 2 limit switches. The type of limit switch that has been used is the lever limit switch.

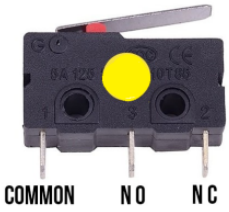


Figure 3.4.12

3.3.13. 16-Channel Analog Multiplexer

Due to not enough input pins, we decided to use a multiplexer for the input from the push button.

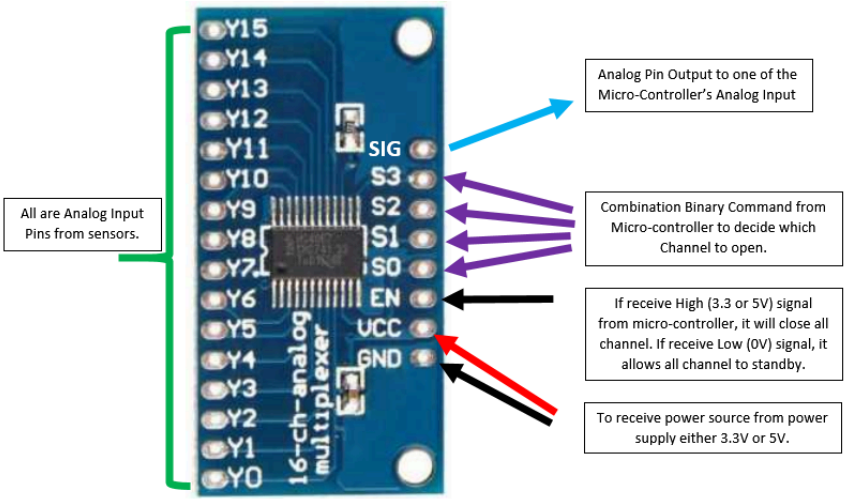


Figure 3.4.13

3.4. Materials

Choosing the materials used in our project is very important because our target users are students. Their well-being and safety are the priority while using our product. At the same time, environment and sustainability need to be taken into consideration too.

3.4.1. Aluminum Hollow

Two size aluminum hollows used in this project which are 1cm x 1 cm and 1.9 cm x 1.9cm. Aluminium hollow has been chosen to be used the most in our project because it is light but still strong enough. It is also easy to cut and handle while resilient and ductile at low temperatures. Aluminium can also be recycled as non-toxicity materials.

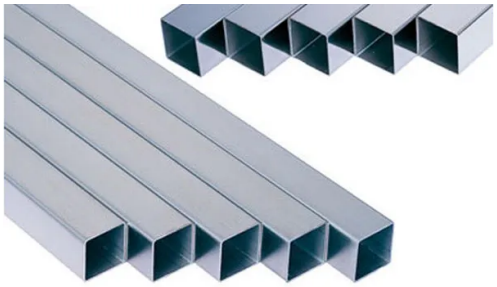


Figure 3.5.1

3.4.2. Aluminium Profile

Besides aluminum hollow, a few aluminum profiles were also used in the project. It is because, for the XY-gantry parts it need more strength and durability. Aluminium hollow is extremely strong so it is very suitable to be used as an XY-gantry body. It is also widely used in the 3D printer.

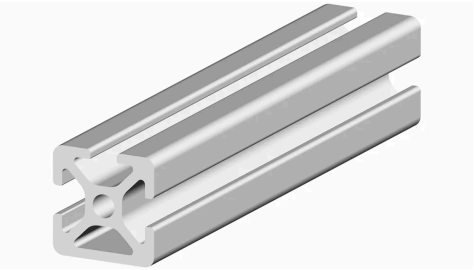


Figure 3.5.2

3.4.3. Screws, washers, and nuts

Screws and nuts are used to assemble the base and to put together the aluminum. Various types of screws with different sizes are used but the most used are button-head socket cap screws. The washer is used to tighten up the screw.

Figure 3.5.3

3.4.4. L-bracket

Used to put aluminum and perspex together.

Figure 3.5.4

3.4.5. Perspex

Perspex is a type of acrylic that is often used in engineering projects because of its strength, clarity, and versatility. It is a transparent thermoplastic that is made from polymethyl methacrylate (PMMA). Perspex is often used because it is more lightweight, shatter-resistant, and weather-resistant. Also, it is cost-effective, easy to work with, and recyclable materials. In this project, perspex is used as a cover and base for the whole body.

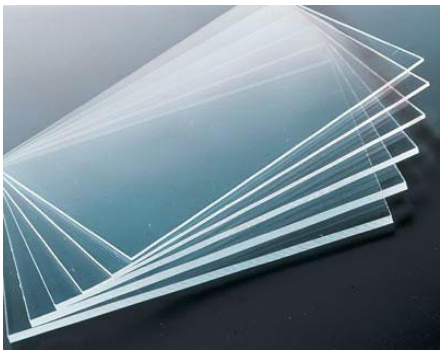


Figure 3.5.5

3.4.6. Styrofoam & Strawboard

Styrofoam is a type of polystyrene foam that is often used for packaging and insulation. It is lightweight, strong, and water-resistant, making it a good choice for these applications. Styrofoam is also recyclable, which means that it can be reused or converted into new products, reducing the amount of waste that goes to landfills.

Strawboard is a type of cardboard that is made from recycled paper and straw. It is strong, lightweight, and water-resistant, making it a good choice for packaging and other applications. Strawboard is also biodegradable, meaning that it will break down naturally in the environment, reducing the amount of waste that goes to landfills.

In terms of their environmental impact, these two materials are considered to be more environmentally friendly than some other materials that are commonly used. In this project, these two are used together at the top of the product as user interfaced. Styrofoam and strawboard are layered together like a sandwich.

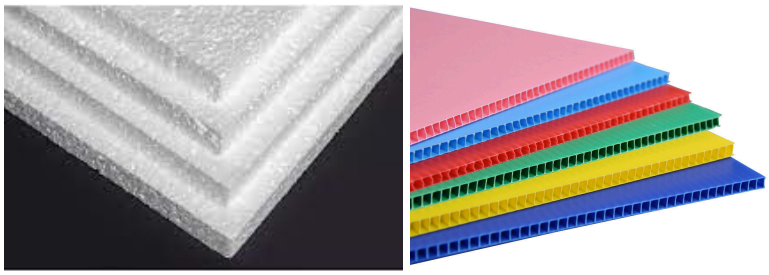


Figure 3.5.6

3.4.7. 3D printer filament

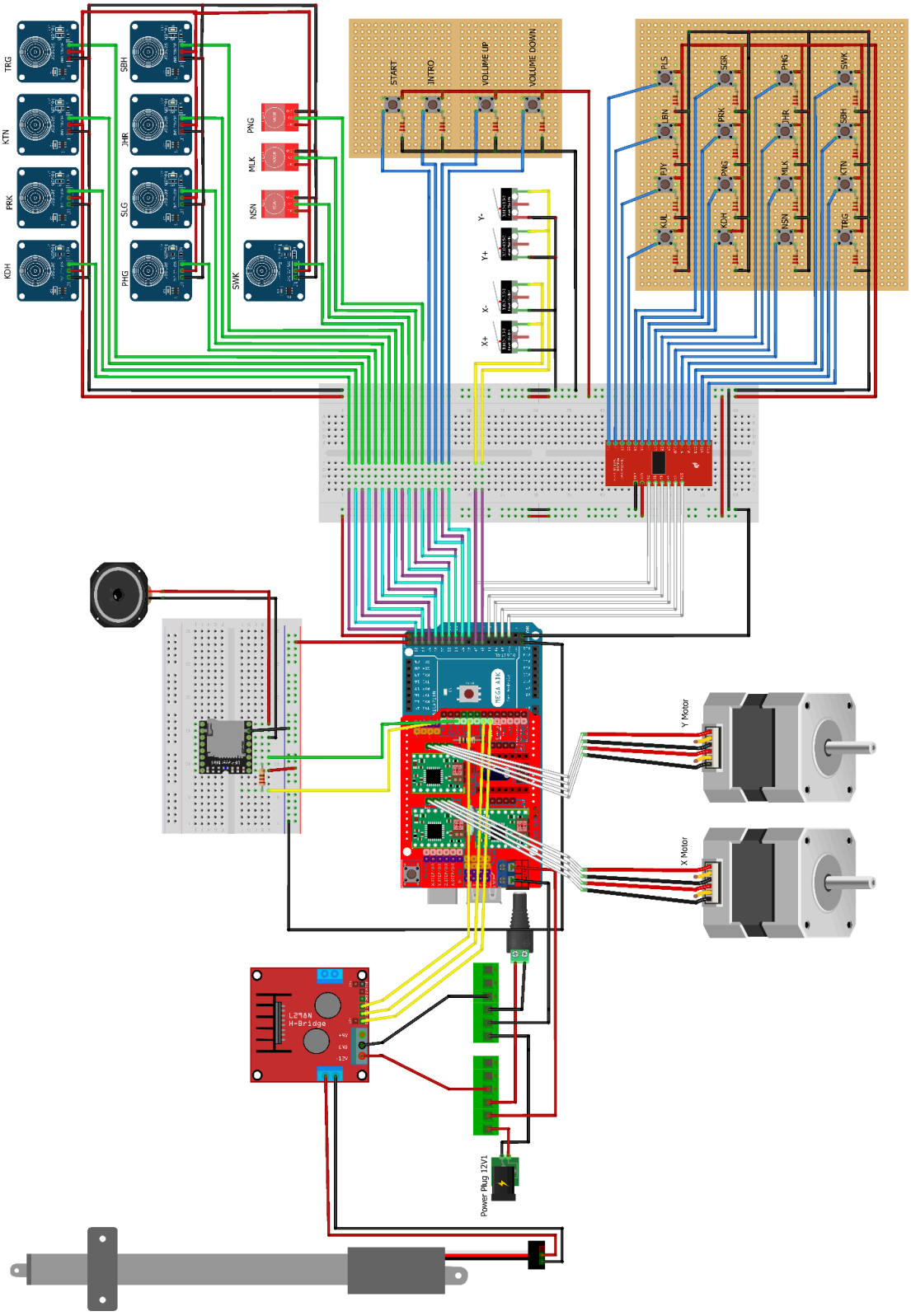
Some parts of the project are being 3D printed. There are 2 types of filament used which are PLA+ (Polylactic acid) and PETG. These filaments are used according to its property suitable for the application

PLA+ is used in most of the parts but only in parts that do not have high temperatures. PLA is a thermoplastic made from cornstarch or sugarcane. It is a biodegradable and non-toxic material that is easy to print. It has a smooth finish and is relatively strong. However, PLA is not heat resistant and can warp if it is exposed to high temperatures.

PETG is used on the parts that are possible to have high temperature and friction. PETG also is a thermoplastic but made from polyethylene terephthalate glycol. It is a strong and durable material that is resistant to heat, chemicals, and moisture. Even though PETG has a slightly rough finish, there are more resistant to warping than PLA prints.

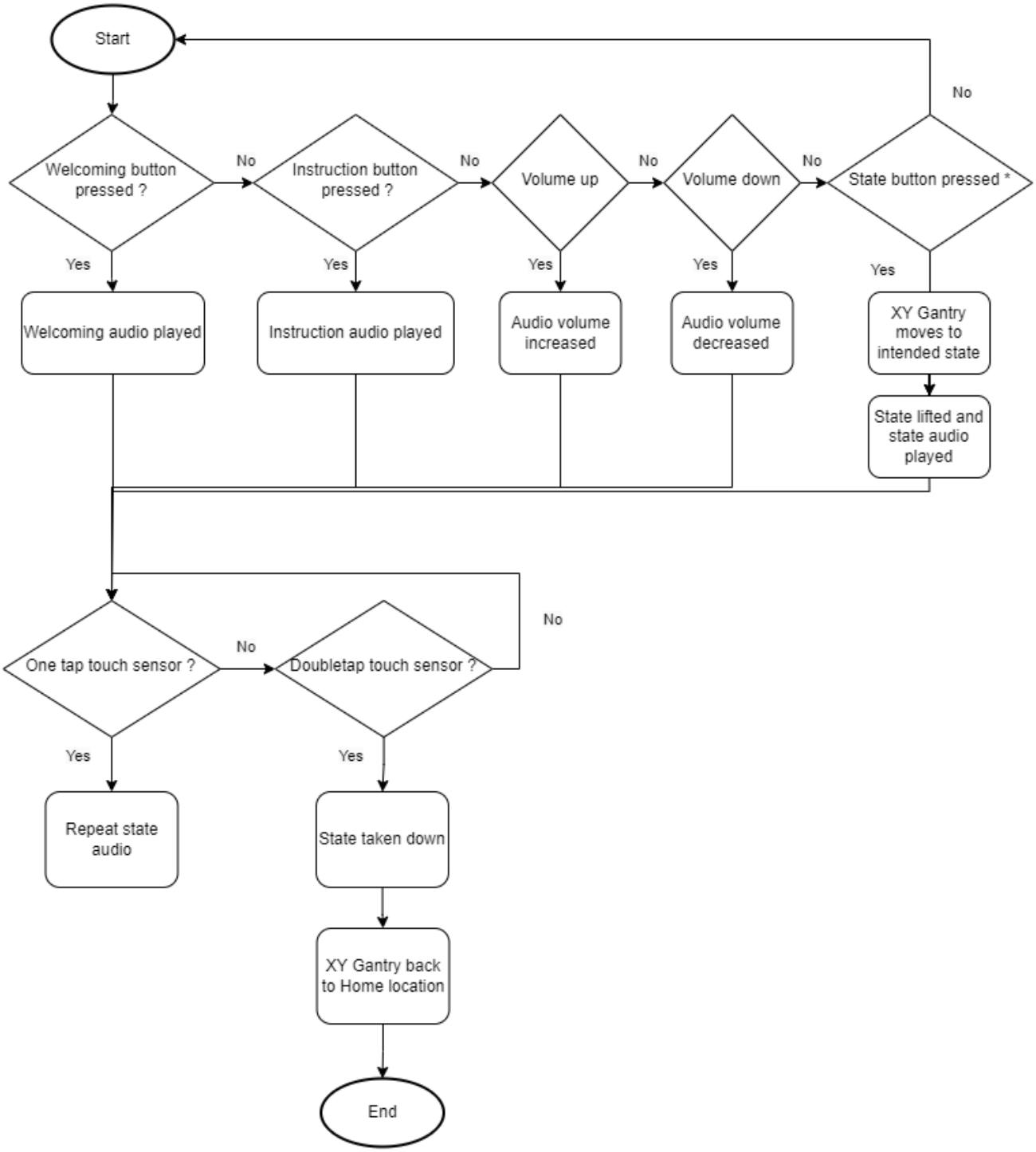
To differentiate between these two is the color. In the project, the red parts are from PLA+ while the yellow parts are from PETG.

3.5. Circuit diagram



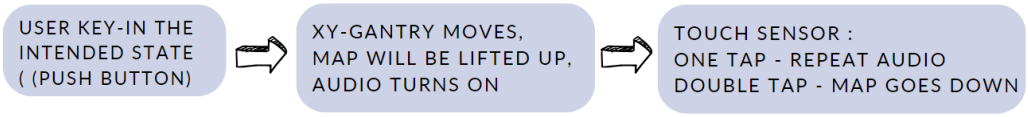
3.6. Control

3.6.1. Flowchart



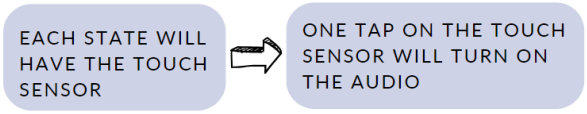
3.6.2. Modes

3.6.2.1. Mode A



Firstly, there will be 14 state push buttons, 1 push button for welcoming the user and 1 push button for the first-time user guide. When the user pushes one of the 14 state push buttons, the data will be sent to the microcontroller which is an Arduino Mega 2560. Then, the XY-gantry will move to the intended state and the linear actuator will be extended to lift up the state. The state explanation audio will be played automatically. Each state will have a one-touch sensor on top of it. Hence, if it is tapped once, the state explanation audio will be repeated. If it is double-tapped, the linear actuator will be retracted and the state will go down.

3.6.2.2. Mode B



As has been mentioned above, each state will have a touch sensor on top of it. For this mode, the user can directly tap the touch sensor without pressing the push button.

3.6.3. Coding

Refer to Appendix C

3.7. Calculations

3.7.1. Lifting force

State mass = 0.1kg Time to lift up = 3s Linear actuator extension = 0.015m

Velocity = Distance/ Time = 0.015m/3s = 0.005m/s

Acceleration = Velocity/ Time = (0.005m/s)/3s = 0.00167 m/s^2

F = ma = (0.1kg) (0.00167 m/s^2) = 0.00017 kN = <u>0.17 N</u>

3.7.2. XY - Gantry speed

Velocity = ((x2 - x1)^2 + (y2 - y1)^2)^0.5 / (t2 - t1)

3.8. Software & Firmware

- Arduino IDE
- Autodesk Fusion 360
- GRBL
- Universal G-code sender
- Fritzing
- Prusa Slicer

3.9. Bill of Material

No.	Items	Price (RM)	Quantity
1	3d print filament	-	
2	Allen key (Hex)	6.20	1
3	Allen key (Hex)	6.20	1
4	Allen key (Hex)	6.20	1
5	Aluminium Hollow 0.6x0.8	18.00	1
6	Aluminium Hollow 2x2	18.00	1
7	Aluminium Profile	-	
8	AWG loose	40.90	/49
9	Belt 2meter	40.00	/2

10	Belt clip	5.00	/2
11	Belt holder	58.00	/2
12	Bread board	13.00	/2
13	Button - ss-5	3.50	1
14	Button - v-km-12	3.00	1
15	Button smg5502	2.50	1
16	Cable lug	15.00	/50
17	CNC shield	15.00	1
18	Development board	175.20	/8
19	Donut board	5.90	/3
20	Drill bit	7.90	
21	Emergency push button	18.00	1
23	Fuse	5.00	/5
24	Fuse holder	5.00	/5
25	Hammer nut	6.00	
26	Hot glue gun	-	
27	Hot glue gun filler	-	
28	Iron pulley	12.00	/2
29	Jumper female-female	1.50	1
30	Jumper male-female	1.60	1
31	Jumper male-male	2.10	1
32	Jumper mini	0.97	1
33	L bracket	10.70	/5
34	Limit switch	4.80	/4
35	Male breadboard jumper	4.40	1
36	Masking tape	5.00	1
37	Measuring tape	2.80	1
38	Measuring tape	2.80	1
39	Mix jumper	12.00	/2
40	Motor driver - linear actuator	-	1
42	Mounting board	11.00	1
43	Mounting bracket	30.00	1
44	Mounting bracket	30.00	1

45	MP3 module	16.00	1
46	Perspect	-	4
47	Pin header	2.40	/4
48	PV 1x40	6.00	/4
49	PVT pin	40.00	/200
50	Sand paper	4.00	/4
51	Screws	77.05	/311
52	Shrinkable but connectors	3.00	/10
53	Silicon cable	12.00	/2
54	Speaker	3.00	1
55	Spray paint	6.50	1
56	Stand off - 10 mm f-f	2.20	/4
57	Stand off - 12 mm f-f	2.60	/4
58	Stepper driver - A4988	6.50	/2
59	Stepper motor Nema 17	30.00	1
60	Stepper motor Nema 17	30.00	1
61	Straw board	11.00	
62	Styrofoam	10.00	4
63	Styrofoam cutter	7.00	1
64	T-nut	4.20	/6
65	Tact switch	8.50	/17
66	Terminal block	3.20	1
67	Thermostat sensor	7.30	1
68	Timing belt clip	2.00	/2
69	Touch sensor_1	45.00	/15
70	Touch sensor_2	12.00	/5
71	Transportation1	66.00	/3(bfs)
72	Transportation2	34.00	/2(fs)
73	UHU glue	7.00	
74	V wheel 3d printer	35.00	/10
75	Washer	3.20	/120
76	White glue	3.60	
77	Wire 22 awg black		3 m

78	Wire 22 awg blue		3 m
79	Wire 22 awg red		3 m
80	Wire 22 awg white		3 m
81	Wire 26 awg blue		3 m
	Hex nut	4.50	/150
82	Linear actuator	-	1
83	Wrapping band	28.00	/2
85	Touch pad	14.00	5
TOTAL		1145.00	

3.10. Safety, Environmental, Social Impact, and Sustainability for the Product

3.10.1. Safety

3.10.1.1. Emergency button:

This button can be used to cut off the circuit in the event of an electrical hazard. For example, if something happens, the emergency button can be used to stop the flow of electricity and prevent further injury.

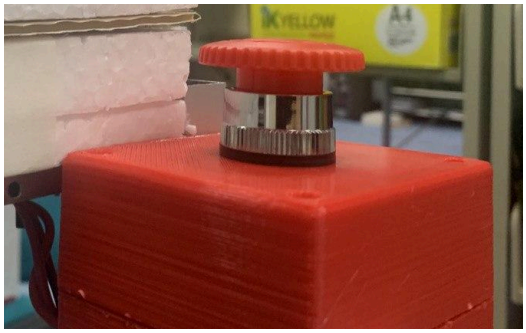


Figure 3.11.1.1

3.10.1.2. Limit switch:

A limit switch will be installed at the end of each axis. This would prevent the gantry from moving past the end of the track which could potentially damage the gantry. Thus, installing a limit switch will prevent accidents. In the case of the gantry losing control, the limit switches will stop the gantry from moving and prevent further damage. There are 2 limit switches installed at each axis. The total number of the limit switch is 4.

3.10.1.3. Homing condition:

The linear actuator in the XY-gantry homing needs to satisfy the following condition:

1. Linear actuator cannot be in an extended condition. The actuator must be fully retracted. It means any maps in pop-up condition must first retract before the actuator can go home.
2. Homing will occur after 3 minutes of idle time.

3.10.1.4. Power indicator:

This feature will let the user know the power is being turned on. When the indicator lamp lights up it tells that current is being supplied into the circuit.

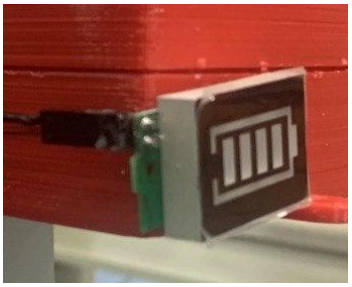


Figure 3.11.1.4

3.10.2. Environment

3.10.2.1. Does not produce any gasses or material

This product is environmentally friendly as it does not produce any gasses or material that can harm the environment. This is because we have chosen sustainable materials for any physical components of the project, such as tactile maps or interactive devices. We also prioritize materials that are eco-friendly, recyclable, and have a low environmental impact. Additionally, encourage responsible manufacturing practices and consider the lifecycle of the project's physical components.

3.10.2.2. Give accessibility and inclusivity to blind people about the environment

The project encourages environmental awareness and involvement among a traditionally marginalized community by giving blind people an accessible and inclusive way to learn about geography The project creates a sense of environmental responsibility and gives blind people the tools they need to make a difference by educating them about environmental issues, conservation efforts, and sustainable practices.

3.10.2.3. Reduced material waste

3D printing filament uses an additive manufacturing process, which means that material is added layer by layer to create an object. This approach significantly reduces material waste compared to traditional subtractive manufacturing methods where excess material is removed. With 3D printing, we only use the amount of filament necessary to create the object, minimizing waste generation.

3.10.3. Sustainability

The product's durability over 7 to 10 years was chosen since it shows a long-term perspective on usage and functionality. We exhibit a dedication to offering a dependable and long-lasting solution for blind people by taking into account this chronology. Using standardized parts rather than custom parts ensures that the product is built with components readily available in the market. This approach simplifies maintenance and repair processes. In the event that certain parts need replacement, they can be easily sourced from various suppliers or vendors who offer standardized components. This reduces dependency on specific suppliers and ensures the availability of spare parts throughout the product's lifespan.

This user manual supports teachers in maintaining and troubleshooting the "Globed for the Blind" project. It provides step-by-step instructions for regular maintenance, common troubleshooting scenarios, and contact information for further assistance. Teachers will learn how to clean components, check connections, perform software updates, and address power, connectivity, display, and audio issues. The manual emphasizes the importance of ongoing training, documentation, and professional development. By following these guidelines, teachers can ensure optimal functionality and longevity of the project, enhancing the learning experience for blind students.

By documenting the project's development, methodologies, and impact, transparency is ensured, and valuable insights are made accessible. This documentation allows others to learn from the project's successes and challenges, enabling further innovation and improvement in the field of accessible geographic education. By fostering a culture of knowledge sharing, the project contributes to collective learning and empowers others to build upon its foundations, ultimately benefiting blind individuals worldwide.

3.10.4. Social Impact

3.10.4.1. Bridging the gap between visually impaired students and normal students

Students who are blind or visually handicapped can use tactile maps, interactive tools, and audio feedback through the "Globed for the Blind" solution to learn about the locations of the continents. This encourages equal engagement and participation among students, building teamwork and understanding. The project encourages inclusivity, empathy, and a more inclusive educational environment where visually impaired students can fully participate alongside their sighted colleagues by removing barriers and fostering shared learning experiences.

3.10.4.2. Improve the learning environment.

The project increases students' interest and satisfaction by giving them a practical way to comprehend where continents are located. They may actively participate in discussions and activities in class thanks to the interactive aspect of the maps, which boosts their general learning satisfaction. By fostering an inclusive environment where they can thrive and take pleasure in their academic path alongside their peers, this program enables visually impaired pupils.

3.10.4.3. Improve students' understanding.

The initiative helps these students to investigate and comprehend the locations of continents by utilizing tactile maps, interactive tools, and aural feedback. Their spatial awareness and memory are improved by the project's hands-on and interactive elements. The project closes the accessibility gap to allow visually impaired students to participate completely in geography lectures, improving their knowledge, interest, and confidence in the subject.

3.10.4.4. Lighten the load of the teachers.

During our visit to the schools, we identify that teachers spend a lot of time every day preparing teaching aids for the student. Our research shows that teachers take a very long time to prepare teaching aids for blind and visually impaired students. This will lighten their workload, creating a more efficient and fulfilling teaching experience.

3.11. Prototype Testing

On 20th June 2023, we visited SMKPK Setapak for the third time. This time, we brought the prototype to the school for students to test and use. Seven students tested the product, and most of them were satisfied with it. However, due to some unexpected issues, the XY-gantry could not be moved to the school. As a result, we asked the students to play with the texture and touch sensor. The students were very happy with the audio, as they had never used an audio-supported tactile map before. The large size of the maps made them even more satisfying.

Furthermore, we also received positive feedback from the teachers, even though the XY-gantry could not move. However, they suggested using a stronger material for the maps rather than use the styrofoam and strawboard. This is because the students are most likely to play with the maps, and styrofoam and strawboard can break easily. Overall, the teachers were satisfied with the design of the map because it has a strong base to support the XY-gantry and circuit but not the material used for the map.

For the survey can refer to Appendix B below.

Figure 3.11

3.12. Constraints, limitations and challenges

3.12.1. Time constraint

Our circuit arrangement was quite a coir. Actually, we have planned to do PCB for our circuit. However, because we are late to finalize the circuit, at about week 11, so, we don't have enough time to order the PCB from China, which will take about 1 to 2 months. Then the efficient methods that can we use just use donut boards, solders, and jumpers.

3.12.2. Size

The big different sizes of small states like Perlis, Melaka, and Pulau Pinang compared to Sawarak has led us to face difficulties to bring up the small states using the linear actuator. These small states are possible to lift up if we resize again the map dimension and maybe we also have to adjust some other parts. But of cost, this may affect the total expenses also increase.

3.12.3. Machinery

Our original idea is to use strong material as the map surface which will be used perspect as the border and use 3d print as the state part. We already design the states with their specific texture for the sensory, but we did not have a suitable cutter to cut the perspex following the shape of each state, and quite costly. As the other alternative which is cheaper and easy to do, we just used styrofoam and strawboard as the map surface.

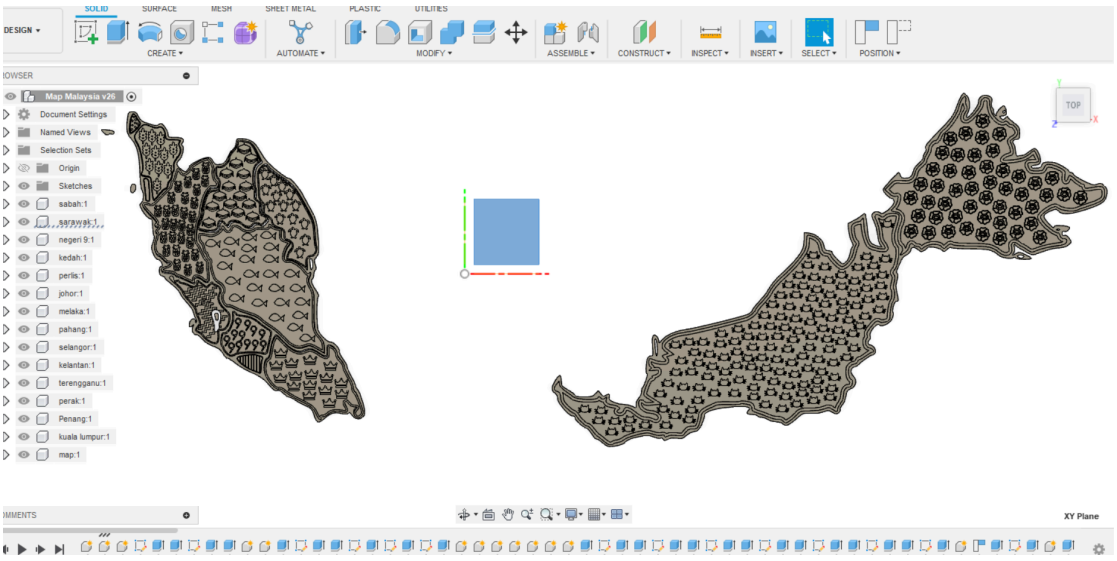


Figure 3.12.3

3.12.4. Accessibility Compliance

Compliance with accessibility standards and guidelines are essential to meet the needs of visually impaired individuals in the "Globed for the Blind" project. Adhering to accessibility regulations imposes constraints on design, development, and user experience. The project must prioritize inclusive design, compatibility with assistive technologies, usability testing with visually impaired users, and accessible content. Meeting regulatory compliance to ensure equal access and a seamless user experience for individuals with visual impairments. By embracing these constraints, the project creates an accessible and inclusive environment for visually impaired individuals to engage with geography education effectively.

4. CHAPTER 4: MARKETING AND BUSINESS MODEL

4.1. Product Scale Up

Marketing is the act of introducing a company's products or services to a target market. In our case, we selected some target audiences and took resource management into account in order to increase profit, minimize loss, and deliver a high-quality product. We must be informed of the market competition to increase our chances of success with product marketing. In order to make sure this project can be scaled up and to promote this project we have to follow these criteria:

Targeting: By Considering factors such as age, education level, geographic location, interests, and challenges faced by blind individuals in understanding state in Malaysia locations. This persona will serve as a reference point for identifying the target market. Customers who are in the target market are those who lack of accessible ways for blind people to comprehend the locations of the state in Malaysia

Scale-up: To scale up this project, we can find a partnership or funding to support the scaling-up process. Explore funding opportunities from grants, foundations, corporate sponsorships, or government initiatives. Demonstrate the project's impact, potential for growth, and positive outcomes to attract financial support for scaling up and sustaining the project.

For the successful expansion and ongoing support of the "Globed for the Blind" initiative, it is essential to establish strategic alliances and acquire long-term funding via grants, foundations, and corporate sponsorships. More and more can be improvised day by day on this project.

4.2. Break-Even Analysis

To determine the point at which a company's or project's total revenue matches its total costs and produces neither a profit nor a loss, a financial tool known as a break-even analysis is used. It helps determine the lowest level of revenue required to cover all fixed and variable costs. The break-even point is the level of output or revenue at which a business becomes profitable.

Numerous factors, such as contribution margin, the selling price per unit, variable costs, and fixed costs are included in a break-even analysis. Examples of fixed costs are rent, salaries, and utilities. These expenses are made regardless of the amount of output or sales. On the other hand, variable costs, such as raw materials

and direct labor costs, change depending on the level of production or sales. The difference between the selling price per unit and the variable cost per unit is what is referred to as the contribution margin. The price at which a good or service is sold is known as the selling price per unit.

Divide the fixed costs by the contribution margin per unit to get the break-even threshold. Through this computation, the number of units or the amount of sales income needed to cover fixed expenses and start making a profit is determined. After the break-even point, every extra unit sold raises profits.

Break-even analysis can provide information about a company's or project's ability to make a profit. It assists in choosing sales objectives, pricing strategies, and cost-management strategies. By figuring out the break-even point, businesses may make educated decisions about their amount of production, pricing, cost management, and overall financial planning. It serves as a baseline for measuring profitability and financial performance and is a crucial tool for establishing a venture's feasibility and sustainability. As a result, the values needed to calculate break-even point are listed below:

Variable cost (per unit)	RM 1145.00
Fixed cost (per unit)	RM 1065.00
Selling price (per unit)	RM 1500.00

$$break\ even\ point\ = \frac{fixed\ cost}{selling\ price - variable\ cost}$$

$$break\ even\ point\ = \frac{1065.00}{1500.00 - 1145.00}$$

$$= 3$$

As a result, in order to recoup the investment, a minimum of 3 units must be sold.

UNITS	FIXED COST	VARIABLE COST	TOTAL COST	SELLING PRICE	PROFIT
0	1065	0	1065	0	-1065
1	1065	1145	2210	1500	-710
2	1065	2290	3355	3000	-355
3	1065	3435	4500	4500	0
4	1065	4580	5645	6000	355
5	1065	5725	6790	7500	710
6	1065	6870	7935	9000	1065
7	1065	8015	9080	10500	1420
8	1065	9160	10225	12000	1775

THIS GRAPH SHOWS THAT WHEN WE HAVE SOLD 3 UNITS WE CAN HAVE A PROFIT AFTER THAT FOR PROJECT

5. CHAPTER 5: CONCLUSION

In this IDP project, we have worked to innovate a new form of map to help blind and low-vision learners to study the map more easily and delightfully. We implement many sensing textiles, and audio aid as well as provide a feedback system so that the user can interact with the map. As a result, they have exposure to the development of technology and can learn the map with minimal guidance. Clear instructions in the form of audio are also provided to help users understand how to use the map properly. The variety of modes also helps users to learn the map according to their needs. Not forgetting the safety implementation in this map is also provided. So, this map is highly recommended to be used by blind and visually impaired people like our targeted users, Setapak Blindness Special Education Secondary School (SMPK). Hopefully, this kind of effort can narrow the gap between normal-sighted people with visually impaired people in receiving a formal education and lead to an independent life.

We also experienced a series of challenges in deciding and evaluating the best mechanical system, planning the user flow, and designing the circuit and control system. We admit more study is needed to understand successful techniques to support the unique needs of blind and low-vision students learning maps.

In Islamic reflection, as engineers, we are known as creators and inventors. However, in this project, we are only able to make a map for one country, Malaysia. Even that, we felt very difficult to do. Humans need to be grateful for being given a little of the nature of God the Creator to create and use reason. But human creations are nothing compared to His creations which are so perfect and detailed. All precision could not happen without the Greatest Planner and Creator. As Allah’s creatures, we should always be grateful for the blessings and witness the existence of God using all the sensing that is lent by Him, namely sight, touch, hearing, smell, taste, and feeling using the heart.

6. APPENDIX

6.1. Appendix A: Gantt Chart

6.1.1. Engineering Design (Semester 1, 22/23)

o	Gantt Chart	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Research on problem statement														
2	Literature Survey														
3	Project selection and propose title														
4	Site visit to SMKPK Setapak														
5	Brainstorming ● Electrical system ● Mechanical system ● Control system														
6	Project structure discussion														
7	Component identification														
8	Presentation														
9	ED Report														

6.1.2. Integrated design project (Semester 2, 22/23)

No	Gantt Chart	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Purchasing components															
2	Gather and assembly components															
3	Build prototype															
4	Testing and evaluation															
5	1st Evaluation															
6	Product test with customer															
7	Improvisation of prototype															
8	2nd Evaluation															
9	Presentation															
10	IDP Report															

6.2. Appendix B: Survey

6.2.1. Survey 1

MAP FOR THE BLINDS
Product Design Survey

Dear teachers,
We are third year students from Kulliyyah of Engineering IIUM. Hereby, we seek your kind cooperation to help us fill up this survey. The survey will be useful for us to develop an assistive device to help your students in learning maps.

1-Strongly disagree 2-Disagree 3-Don't know 4-Agree 5-Strongly agree

Please tick '/' the number from 1 to 5 that most accurately reflects your answer.

SECTION A : Teaching Experience		**1**	**2**	**3**	**4**	**5**
1)	I think the current map eases the teaching session.				✓	
2)	I think the current map is easy to fabricate.					✓
3)	I think the current map technology is user friendly.				✓	
4)	*I think the current map is very convenient.*					✓
5)	I think the current map helps to meet the syllabus.	✗				✓
6)	I think the current map need a huge amount of money to set up		✓			
7)	I think the current map need a lot of time to set up		✓			
8)	I think the current map need a lot of manpower to set up		✓			
SECTION B : Learning Experience		**1**	**2**	**3**	**4**	**5**
1)	I believe the students can use the current map independently				✓	
2)	I believe the students understand the syllabus better using current map technology				✓	
3)	*I believe the students look forward to learning more about maps using current map*		✓			
4)	I believe the students enjoy learning using the current map		✓			
5)	*I believe the students take a short time to master the current map*				✓	
6)	I believe the students easy to visualise the current map		✗		✓	
7)	I believe the students can memorise the location using *the current map*		✗		✓	
8)	I believe the students learnt a lot using the current map					✓

MAP FOR THE BLINDS
Product Design Survey

What do you think if we use more technology-based features on the map which will have several modes such as teaching mode and self-learning mode with applying the tactile features, control features, audio and several sensors with safety systems included as a new teaching aid?

SECTION C : Technology Based Map		1	2	3	4	5
1)	I believe the map must have good mobility				✓	
2)	I believe the map must have a bigger size than the textbook provided					✓
3)	I believe the map might be easy for the student to use					✓
4)	I believe the map can operate in a long time				✓	
5)	I believe the students will be able to learn more quickly and easily					✓
6)	I believe the students will enjoy, understand and be interested to learn more using the map					✓
7)	I believe the students will be able to learn properly					✓
8)	I believe the students can learn independently with minimal guidance from teachers					✓

Based on the elements listed below, tick 3 the most important aspects for the learning aid kit.

- ☑ Low cost
- ☐ Great mobility
- ☑ Have multiple functions (eg : quiz mode, self-learning mode)
- ☐ Bigger size than a textbook.
- ☑ Have a big size for a group of students to use.

Suggestion :

_____

_____

_____

_____

Thank you for participating in our survey.

Voluntary Demographic Information : Age : 58 Gender : Male Year of teaching : 26

6.2.2. Survey 2

MAP FOR THE BLINDS
Product Design Survey

Dear teachers,
We are third year students from Kulliyyah of Engineering IIUM. Hereby, we seek your kind cooperation to help us fill up this survey. This survey aims to evaluate the effectiveness of developed maps in the teaching and learning process for Geography and History subjects..

1-Strongly disagree 2-Disagree 3-Medium 4-Agree 5-Strongly agree

Please tick '/' the number from 1 to 5 that reflects your answer.

SECTION A : Teaching Experience		**1**	**2**	**3**	**4**	**5**
1)	I believe the interactive map project would be supportive for blind students' learning.					✓
2)	I would like to adopt the interactive map project in my teaching.					✓
3)	I trust the interactive map project aligns with the curriculum objectives for blind students.					✓
4)	I would say that the interface of the interactive map are user-friendly.					✓
5)	I plan to continue using the interactive map project in my teaching in the future.					✓
SECTION B : Learning Experience		**1**	**2**	**3**	**4**	**5**
1)	I would say that the sufficiency of the instructions and guidance provided for using the interactive map project are enough.				✓	
2)	I believe the interactive map project would enhance my learning experience.					✓
3)	I think i can navigate and interact with the interactive of this map project					✓
4)	I like to use the interactive map project for my learning activities.					✓
5)	I would say that the simplicity and user-friendliness of the interactive map project are very good.					✓

MAP FOR THE BLINDS
Product Design Survey

SECTION C : Technology Based Map		1	2	3	4	5
1)	I believe the map might be easy for the student to use				✓	
2)	I trust the map can operate in a long time				✓	
3)	I believe the students will be able to learn more quickly and easily					✓
4)	I believe the students will enjoy, understand and be interested to learn more using the map					✓
5)	I believe the students will be able to learn properly					✓
6)	I believe the students can learn independently with minimal guidance from teachers					✓

Suggestion to improve our project :

- Using strong base for map.

Thank you for participating in our survey.

Voluntary Demographic Information : Age : 38 Gender : F Year of teaching : 15

MAP FOR THE BLINDS
Product Design Survey

Dear teachers,

We are third year students from Kulliyyah of Engineering IIUM. Hereby, we seek your kind cooperation to help us fill up this survey. This survey aims to evaluate the effectiveness of developed maps in the teaching and learning process for Geography and History subjects..

1-Strongly disagree 2-Disagree 3-Medium 4-Agree 5-Strongly agree

Please tick '/' the number from 1 to 5 that reflects your answer.

SECTION A : Teaching Experience		**1**	**2**	**3**	**4**	**5**
1)	I believe the interactive map project would be supportive for blind students' learning.					✓
2)	I would like to adopt the interactive map project in my teaching.					✓
3)	I trust the interactive map project aligns with the curriculum objectives for blind students.					✓
4)	I would say that the interface of the interactive map are user-friendly.					✓
5)	I plan to continue using the interactive map project in my teaching in the future.					✓
SECTION B : Learning Experience		**1**	**2**	**3**	**4**	**5**
1)	I would say that the sufficiency of the instructions and guidance provided for using the interactive map project are enough.				✓	
2)	I believe the interactive map project would enhance my learning experience.					✓
3)	I think i can navigate and interact with the interactive of this map project					✓
4)	I like to use the interactive map project for my learning activities.					✓
5)	I would say that the simplicity and user-friendliness of the interactive map project are very good.					✓

MAP FOR THE BLINDS

Product Design Survey

SECTION C : Technology Based Map		1	2	3	4	5
1)	I believe the map might be easy for the student to use					✓
2)	I trust the map can operate in a long time		✓			
3)	I believe the students will be able to learn more quickly and easily					✓
4)	I believe the students will enjoy, understand and be interested to learn more using the map					✓
5)	I believe the students will be able to learn properly					✓
6)	I believe the students can learn independently with minimal guidance from teachers					✓

Suggestion to improve our project :

Tapak peta perlu menggunakan material yg lebih kuat.

Thank you for participating in our survey.

Voluntary Demographic Information : Age : 39 Gender : female Year of teaching : 12

6.3. Appendix C: Coding

```
#include "Arduino.h"
#include "SoftwareSerial.h"
#include "DFRobotDFPlayerMini.h"
#include "Mux.h"
#include <AccelStepper.h>
#include <MultiStepper.h>

#define MotorX_StepPin 2
#define MotorX_DirPin  5
#define MotorY_StepPin 3
#define MotorY_DirPin  6

void MODE_A();
void MODE_B();

//Instance of AccelStepper for each motor
AccelStepper stepperX (AccelStepper::DRIVER, MotorX_StepPin, MotorX_DirPin);
AccelStepper stepperY (AccelStepper::DRIVER, MotorY_StepPin, MotorY_DirPin);

const byte enablePin = 8; //enable pin [cnc shield]
long positions[2]; //array for the desired positions
int i = 0;
unsigned long previousMillis = 0;
unsigned long currentMillis  = 0;

//Initial coordinate
//
int positionX []       = {          0,
                            0,       0,       0,       0,
                           97,       0,     350,     920,
                         1050,       0,    1300,     780,
                          330,     250,     810,    1550   };

int positionY []       = {          0,
                            0,       0,       0,       0,
                         2700,       0,    2600,    2580,
                         2200,       0,    1900,    2100,
                         1960,    2320,       0,    1030   };

String continent_name [] = {       "Home",
                              "Kl",  "Putrajaya",  "Labuan",  "Perlis",
                          "Kedah", "Pulau Pinang",  "Perak",  "Selangor",
                  "Negeri Sembilan",    "Melaka",  "Johor",  "Pahang",
                     "Terengganu",   "Kelantan",  "Sabah",  "Sarawak"  };
```

```
//Instance of MultiSteppers
MultiStepper steppers;

//limitswitch
const byte stopLimitPin = 50;
const byte homeLimitPin = 52;
//limit switch state
int stopLimitState = 0;
int homeLimitState = 0;

//MUltiplexer
using namespace admux;
Mux mux(Pin(22, INPUT, PinType::Digital), Pinset(30, 28, 26, 24));


//MP3 Player
SoftwareSerial mySoftwareSerial(10, 11); //RX, TX
DFRobotDFPlayerMini myDFPlayer;
void printDetail(uint8_t type, int value);

// int button_volumeUP = ;
// int button_volumeDOWN = ;

//TRACK
//myDFPlayer.playFolder(folder,track); 1 negeri 2 explain 3 others
  // myDFPlayer.playFolder(1, 0001);  // track_Kl
 const int track_Kl        = 1;
 const int track_Putrajaya  = 2;
 const int track_Labuan     = 3;
 const int track_Perlis     = 4;
 const int track_Kedah      = 5;
 const int track_Penang     = 6;
 const int track_Perak      = 7;
 const int track_Selangor   = 8;
 const int track_N9         = 9;
 const int track_Melaka     = 10;
 const int track_Johor      = 11;
 const int track_Pahang     = 12;
 const int track_Terengganu = 13;
 const int track_Kelantan   = 14;
 const int track_Sabah      = 15;
 const int track_Sarawak    = 16;
 // explaination
 const int track_Kl_E        = 17;
 const int track_Putrajaya_E  = 18;
```

```
const int track_Labuan_E     = 19;
const int track_Perlis_E     = 20;
const int track_Kedah_E      = 21;
const int track_Penang_E     = 22;
const int track_Perak_E      = 23;
const int track_Selangor_E   = 24;
const int track_N9_E         = 25;
const int track_Melaka_E     = 26;
const int track_Johor_E      = 27;
const int track_Pahang_E     = 28;
const int track_Terengganu_E = 29;
const int track_Kelantan_E   = 30;
const int track_Sabah_E      = 31;
const int track_Sarawak_E    = 32;

const int track_start = 34;
const int track_intro = 33;

//Push Button
 const int PB_Kl         = 8;
 const int PB_Putrajaya  = 0;
 const int PB_Labuan     = 15;
 const int PB_Perlis     = 7;
 const int PB_Kedah      = 9;
 const int PB_Penang     = 1;
 const int PB_Perak      = 14;
 const int PB_Selangor   = 6;
 const int PB_N9         = 10;
 const int PB_Melaka     = 2;
 const int PB_Johor      = 13;
 const int PB_Pahang     = 5;
 const int PB_Terengganu = 11;
 const int PB_Kelantan   = 3;
 const int PB_Sabah      = 12;
 const int PB_Sarawak    = 4;

 const int PB_Start      = 47;
 const int PB_Intro      = 49;
 const int PB_Up         = 51;
 const int PB_Down       =  53;

//Push Button State
 int PBstate_Kl         = 0;
 int PBstate_Putrajaya  = 0;
 int PBstate_Labuan     = 0;
 int PBstate_Perlis     = 0;
```

```
  int PBstate_Kedah      = 0;
  int PBstate_Penang     = 0;
  int PBstate_Perak      = 0;
  int PBstate_Selangor   = 0;
  int PBstate_N9         = 0;
  int PBstate_Melaka     = 0;
  int PBstate_Johor      = 0;
  int PBstate_Pahang     = 0;
  int PBstate_Terengganu = 0;
  int PBstate_Kelantan   = 0;
  int PBstate_Sabah      = 0;
  int PBstate_Sarawak    = 0;
  int PBstate_Start      = 0;
  int PBstate_Intro      = 0;
  int PBstate_Up         = 0;
  int PBstate_Down       = 0;

//Touch Sensor
  const int TS_Kedah     = 25;
  const int TS_Penang    = 27;
  const int TS_Perak     = 29;
  const int TS_Selangor  = 31;

  const int TS_N9        = 33;
  const int TS_Melaka    = 35;
  const int TS_Johor     = 37;
  const int TS_Pahang    = 39;

  const int TS_Terengganu = 41;
  const int TS_Kelantan  = 23;
  const int TS_Sabah     = 43;
  const int TS_Sarawak   = 45;


//Touch Sensor state
  int tap_Kedah      = 0;
  int tap_Penang     = 0;
  int tap_Perak      = 0;
  int tap_Selangor   = 0;
  int tap_N9         = 0;
  int tap_Melaka     = 0;
  int tap_Johor      = 0;
  int tap_Pahang     = 0;
  int tap_Terengganu = 0;
  int tap_Kelantan   = 0;
  int tap_Sabah      = 0;
```

```
  int tap_Sarawak     = 0;

//Touch Sensor DoubleTap
  unsigned long TimeStart = 0;
  unsigned long TimeLimit = 0;
  int clicks = 0;
  int pos = 0;

//Linear Actuator
  const int ENA_PIN = 9;
  const int IN1_PIN = 13;
  const int IN2_PIN = 12;
//state
  int state_IN1_PIN = 0;
  int state_IN2_PIN = 0;

 int vol = 20;

//XY-gantry

void setup() {
  //Serial Monitor
  Serial.begin(115200);
  //STEPPER MOTOR
    pinMode(enablePin, OUTPUT);
    digitalWrite(enablePin, LOW);
    //Configuration for each stepper
    stepperX.setMaxSpeed(1000);
    stepperY.setMaxSpeed(1000);
    //MultiStepper manage
    steppers.addStepper(stepperX);
    steppers.addStepper(stepperY);
    //numSteps = sizeof(positionX) / sizeof(positionX[0]);

  //limit switch setup
   pinMode(stopLimitPin, INPUT_PULLUP);
   pinMode(homeLimitPin, INPUT_PULLUP);


  // MP3 checking
  mySoftwareSerial.begin(9600);
  Serial.println();
  Serial.println(F("DFRobot DFPlayer Mini Demo"));
  Serial.println(F("Initializing DFPlayer ... (May take 3~5 seconds)"));

  if (!myDFPlayer.begin(mySoftwareSerial)) {  //Use softwareSerial to communicate with mp3.
```

```
    Serial.println(F("Unable to begin:"));
    Serial.println(F("1.Please recheck the connection!"));
    Serial.println(F("2.Please insert the SD card!"));
    while(true);
  }
  Serial.println(F("DFPlayer Mini online."));

  myDFPlayer.volume(10);  //Set volume value. From 0 to 30
  //myDFPlayer.play(track_start); //start
  //myDFPlayer.play(34);

  //PUSH BUTTON
  pinMode(PB_Start, INPUT_PULLUP);
  pinMode(PB_Intro, INPUT_PULLUP);


  //TOUCH SENSOR
  pinMode(TS_Kedah,      INPUT);
  pinMode(TS_Penang,     INPUT);
  pinMode(TS_Perak,      INPUT);
  pinMode(TS_Selangor,   INPUT);
  pinMode(TS_N9,         INPUT);
  pinMode(TS_Melaka,     INPUT);
  pinMode(TS_Johor,      INPUT);
  pinMode(TS_Pahang,     INPUT);
  pinMode(TS_Terengganu, INPUT);
  pinMode(TS_Kelantan,   INPUT);
  pinMode(TS_Sabah,      INPUT);
  pinMode(TS_Sarawak,    INPUT);

  //LINEAR ACTUATOR
  pinMode(ENA_PIN, OUTPUT);
  pinMode(IN1_PIN, OUTPUT);
  pinMode(IN2_PIN, OUTPUT);

  digitalWrite(ENA_PIN, HIGH);
}

void loop() {
  //Serial Monitor
  //Serial.print(PBstate_Sabah);
  //Serial.println(PBstate_Sarawak);

  //PUSH BUTTON STATE
  PBstate_Kl        = mux.read(PB_Kl);
  PBstate_Putrajaya  = mux.read(PB_Putrajaya);
```

```
 PBstate_Labuan     = mux.read(PB_Labuan);
 PBstate_Perlis     = mux.read(PB_Perlis);
 PBstate_Kedah      = mux.read(PB_Kedah);
 PBstate_Penang     = mux.read(PB_Penang);
 PBstate_Perak      = mux.read(PB_Perak);
 PBstate_Selangor   = mux.read(PB_Selangor);
 PBstate_N9         = mux.read(PB_N9);
 PBstate_Melaka     = mux.read(PB_Melaka);
 PBstate_Johor      = mux.read(PB_Johor);
 PBstate_Pahang     = mux.read(PB_Pahang);
 PBstate_Terengganu = mux.read(PB_Terengganu);
 PBstate_Kelantan   = mux.read(PB_Kelantan);
 PBstate_Sabah      = mux.read(PB_Sabah);
 PBstate_Sarawak    = mux.read(PB_Sarawak);

 PBstate_Start   = digitalRead(PB_Start);
 PBstate_Intro   = digitalRead(PB_Intro);

 //TOUCH SENSOR STATE
   tap_Kedah      = 0;
 tap_Penang     = digitalRead(TS_Penang);
 // tap_Penang     = 0;
 tap_Perak      = digitalRead(TS_Perak);
 // tap_Perak      = 0;
 tap_Selangor   = digitalRead(TS_Selangor);
 // tap_Selangor   = 0;
 //tap_N9         = digitalRead(TS_N9);
 tap_N9         = 0 ;
 //tap_Melaka     = digitalRead(TS_Melaka);
 tap_Melaka     = 0 ;
 tap_Johor      = digitalRead(TS_Johor);
 tap_Pahang     = digitalRead(TS_Pahang);
 //tap_Terengganu = digitalRead(TS_Terengganu);
 //tap_Kelantan   = digitalRead(TS_Kelantan);
 // tap_Johor      = 0;
 // tap_Pahang     = 0;
tap_Terengganu = 0;
 tap_Kelantan   = 0;
 tap_Sabah      = digitalRead(TS_Sabah);
 tap_Sarawak    = digitalRead(TS_Sarawak);

 //limit switch
 // xLimitState = digitalRead(xLimitPin);
 //yLimitState = digitalRead(yLimitPin);

 // linear actuator state
```

```
  state_IN1_PIN = digitalRead(IN1_PIN);
  state_IN2_PIN = digitalRead(IN2_PIN);

    while (digitalRead(stopLimitPin) == 0){
      //Serial.println("stop limit switch pressed");
    }

    if (PBstate_Start == HIGH) {
       myDFPlayer.play(34);
    }

    if (PBstate_Intro == HIGH) {
       myDFPlayer.play(33);
    }
    //HOME
    if ((PBstate_Start == HIGH && state_IN1_PIN == LOW && state_IN2_PIN == HIGH)|| (PBstate_Kl ==
LOW &&  PBstate_Putrajaya == LOW &&  PBstate_Labuan == LOW
       &&  PBstate_Perlis == LOW &&  PBstate_Kedah == LOW &&  PBstate_Penang == LOW &&
PBstate_Perak == LOW && PBstate_Selangor == LOW &&  PBstate_N9 == LOW
       &&  PBstate_Melaka == LOW &&  PBstate_Johor == LOW &&  PBstate_Pahang== LOW &&
PBstate_Terengganu == LOW && PBstate_Kelantan == LOW
       && PBstate_Sabah == LOW && PBstate_Sarawak == LOW && state_IN1_PIN == LOW &&
state_IN2_PIN == HIGH &&
       tap_Kedah == LOW && tap_Penang == LOW && tap_Perak == LOW && tap_Selangor == LOW
&& tap_N9 == LOW && tap_Melaka == LOW
     && tap_Johor == LOW && tap_Pahang== LOW && tap_Terengganu == LOW && tap_Sabah ==
LOW && tap_Sarawak == LOW) ){
      currentMillis = millis();
    if (currentMillis - previousMillis >= 10000) {
      previousMillis = currentMillis;
        Serial.println("HOME");
        if (steppers.run() == 0){
           positions[0] = positionX[0];
           positions[1] = positionY[0];
           steppers.moveTo(positions);
        }
        while (steppers.run()){
        }
    }
  }

  //MODE A: Push Button will move xy-gantry
    MODE_A ();
  //MODE B : ONE TAP AUDIO ON
    MODE_B ();
// int volumeLevel;
```

```
  //VOLUME CONTROL
  if (digitalRead(PB_Up) == HIGH){
    myDFPlayer.volumeUp();
    // myDFPlayer.volume(volumeLevel);
    // vol++;
    // Serial.println(vol);
    Serial.print("volume Up   ");
    Serial.println(myDFPlayer.readVolume());
  }

  if (digitalRead(PB_Down) == HIGH){
    myDFPlayer.volumeDown();
    // Serial.println("volume Down");
    // vol--;
    // Serial.println(vol);
    Serial.print("volume Down  ");
    Serial.println(myDFPlayer.readVolume());
  }
  //MP3 Player Error and status
  if (myDFPlayer.available()) {
    printDetail(myDFPlayer.readType(), myDFPlayer.read()); //Print the detail message from DFPlayer to
handle different errors and states.
  }
}

void MODE_A(){

  //PUSH Button Kl
  if (PBstate_Kl == HIGH){
    //State name
    myDFPlayer.play(track_Kl);

    //xy gantry
    i = 1;
    Serial.println("Button " + continent_name[i] + " is pushed" );
    if (steppers.run() == 0){
      positions[0] = positionX[i];
      positions[1] = positionY[i];
      steppers.moveTo(positions);
    }
    while (steppers.run()){
    }

    //linear actuator
       // digitalWrite(IN1_PIN, HIGH);
       // digitalWrite(IN2_PIN, LOW);
```

```
      // delay(4000);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
      myDFPlayer.play(track_Kl_E);
      delay(500);

      currentMillis = millis();
      previousMillis = currentMillis;
}

//PUSH Button Putrajaya
if (PBstate_Putrajaya == HIGH){
  //State name
  myDFPlayer.play(track_Putrajaya);
  //xy gantry
  i = 2;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
      // digitalWrite(IN1_PIN, HIGH);
      // digitalWrite(IN2_PIN, LOW);
      // delay(4000);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
       myDFPlayer.play(track_Putrajaya_E);
      delay(500);

       currentMillis = millis();
      previousMillis = currentMillis;
}

//PUSH Button Labuan
if (PBstate_Labuan == HIGH){
  //State name
  myDFPlayer.play(track_Labuan);

  //xy gantry
  i = 3;
  Serial.println("Button " + continent_name[i] + " is pushed" );
```

```
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
      // digitalWrite(IN1_PIN, HIGH);
      // digitalWrite(IN2_PIN, LOW);
      // delay(4000);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
      myDFPlayer.play(track_Labuan_E);
      delay(500);

       currentMillis = millis();
      previousMillis = currentMillis;
}

//PUSH Button Perlis
if (PBstate_Perlis == HIGH){
  //State name
  myDFPlayer.play(track_Perlis);

  //xy gantry
  i = 4;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
      // digitalWrite(IN1_PIN, HIGH);
      // digitalWrite(IN2_PIN, LOW);
      // delay(4000);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
      myDFPlayer.play(track_Perlis_E);
      delay(500);
```

```
      currentMillis = millis();
     previousMillis = currentMillis;
}

//PUSH Button Kedah
if (PBstate_Kedah == HIGH){
  //State name
  myDFPlayer.play(track_Kedah);

  //xy gantry
  i = 5;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
     digitalWrite(IN1_PIN, HIGH);
     digitalWrite(IN2_PIN, LOW);
     delay(4000);
     //MP3 play
      Serial.println("Playing " + continent_name[i]);
     myDFPlayer.play(track_Kedah_E);
     delay(500);

      currentMillis = millis();
     previousMillis = currentMillis;
}

//PUSH Button Penang
if (PBstate_Penang == HIGH){
  //State name
 myDFPlayer.play(track_Penang);

  //xy gantry
  i = 6;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
```

```
  while (steppers.run()){
  }

  //linear actuator
     // digitalWrite(IN1_PIN, HIGH);
     // digitalWrite(IN2_PIN, LOW);
     // delay(4000);
     //MP3 play
      Serial.println("Playing " + continent_name[i]);
     myDFPlayer.play(track_Penang_E);
     delay(500);

      currentMillis = millis();
     previousMillis = currentMillis;
}

//PUSH Button Perak
if (PBstate_Perak == HIGH){
  //State name
  myDFPlayer.play(track_Perak);

  //xy gantry
  i = 7;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
     digitalWrite(IN1_PIN, HIGH);
     digitalWrite(IN2_PIN, LOW);
     delay(4000);
     //MP3 play
      Serial.println("Playing " + continent_name[i]);
     myDFPlayer.play(track_Perak_E);
     delay(500);

      currentMillis = millis();
     previousMillis = currentMillis;
}

//PUSH Button Selangor
```

```
  if (PBstate_Selangor == HIGH){
    //State name
    myDFPlayer.play(track_Selangor);

    //xy gantry
    i = 8;
    Serial.println("Button " + continent_name[i] + " is pushed" );
    if (steppers.run() == 0){
      positions[0] = positionX[i];
      positions[1] = positionY[i];
      steppers.moveTo(positions);
    }
    while (steppers.run()){
    }

    //linear actuator
        digitalWrite(IN1_PIN, HIGH);
        digitalWrite(IN2_PIN, LOW);
        delay(4000);
        //MP3 play
         Serial.println("Playing " + continent_name[i]);
        myDFPlayer.play(track_Selangor_E);
        delay(500);

         currentMillis = millis();
        previousMillis = currentMillis;
  }

//PUSH Button N9
  if (PBstate_N9 == HIGH){
    //State name
    myDFPlayer.play(track_N9);

    //xy gantry
    i = 9;
    Serial.println("Button " + continent_name[i] + " is pushed" );
    if (steppers.run() == 0){
      positions[0] = positionX[i];
      positions[1] = positionY[i];
      steppers.moveTo(positions);
    }
    while (steppers.run()){
    }

    //linear actuator
        // digitalWrite(IN1_PIN, HIGH);
```

```
      // digitalWrite(IN2_PIN, LOW);
      // delay(4000);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
      myDFPlayer.play(track_N9_E);
      delay(500);

       currentMillis = millis();
      previousMillis = currentMillis;
}

//PUSH Button Melaka
if (PBstate_Melaka == HIGH){
  //State name
  myDFPlayer.play(track_Melaka);

  //xy gantry
  i = 10;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
      // digitalWrite(IN1_PIN, HIGH);
      // digitalWrite(IN2_PIN, LOW);
      // delay(4000);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
      myDFPlayer.play(track_Melaka_E);
      delay(500);

       currentMillis = millis();
      previousMillis = currentMillis;
}

//PUSH Button Johor
if (PBstate_Johor == HIGH){
  //State name
  myDFPlayer.play(track_Johor);

  //xy gantry
```

```
  i = 11;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
      digitalWrite(IN1_PIN, HIGH);
      digitalWrite(IN2_PIN, LOW);
      delay(4000);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
      myDFPlayer.play(track_Johor_E);
      delay(500);

       currentMillis = millis();
      previousMillis = currentMillis;
}

//PUSH Button Pahang
if (PBstate_Pahang == HIGH){
      //State name
  myDFPlayer.play(track_Pahang);

  //xy gantry
  i = 12;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
      digitalWrite(IN1_PIN, HIGH);
      digitalWrite(IN2_PIN, LOW);
      delay(4000);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
      myDFPlayer.play(track_Pahang_E);
```

```
      delay(500);

       currentMillis = millis();
      previousMillis = currentMillis;
}

//PUSH Button Terengganu
if (PBstate_Terengganu == HIGH){
  //State name
  myDFPlayer.play(track_Terengganu);

  //xy gantry
  i = 13;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
      digitalWrite(IN1_PIN, HIGH);
      digitalWrite(IN2_PIN, LOW);
      delay(400);
      //MP3 play
       Serial.println("Playing " + continent_name[i]);
      myDFPlayer.play(track_Terengganu_E);
      delay(500);

       currentMillis = millis();
      previousMillis = currentMillis;
}

//PUSH Button Kelantan
if (PBstate_Kelantan == HIGH){
      //State name
  myDFPlayer.play(track_Kelantan);

  //xy gantry
  i = 14;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
```

```
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
     digitalWrite(IN1_PIN, HIGH);
     digitalWrite(IN2_PIN, LOW);
     delay(4000);
     //MP3 play
      Serial.println("Playing " + continent_name[i]);
     myDFPlayer.play(track_Kelantan_E);
     delay(500);

      currentMillis = millis();
     previousMillis = currentMillis;
}

//PUSH Button Sabah
if (PBstate_Sabah == HIGH){
     //State name
  myDFPlayer.play(track_Sabah);

  //xy gantry
  i = 15;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
     digitalWrite(IN1_PIN, HIGH);
     digitalWrite(IN2_PIN, LOW);
     //delay(4000);
     //MP3 play
      Serial.println("Playing " + continent_name[i]);
     myDFPlayer.play(track_Sabah_E);
     delay(500);

      currentMillis = millis();
     previousMillis = currentMillis;
}
```

```
//PUSH Button Sarawak
if (PBstate_Sarawak == HIGH){
    //State name
  myDFPlayer.play(track_Sarawak);

  //xy gantry
  i = 16;
  Serial.println("Button " + continent_name[i] + " is pushed" );
  if (steppers.run() == 0){
    positions[0] = positionX[i];
    positions[1] = positionY[i];
    steppers.moveTo(positions);
  }
  while (steppers.run()){
  }

  //linear actuator
     digitalWrite(IN1_PIN, HIGH);
     digitalWrite(IN2_PIN, LOW);
     delay(400);
     //MP3 play
      Serial.println("Playing " + continent_name[i]);
     myDFPlayer.play(track_Sarawak_E);
     delay(500);

      currentMillis = millis();
     previousMillis = currentMillis;

    //   currentMillis = millis();
    // previousMillis = currentMillis;
 }

//PUT DOWN ACTUATOR : Double Tap
 if ( tap_Kedah == HIGH || tap_Penang == HIGH || tap_Perak == HIGH || tap_Selangor == HIGH || tap_N9
== HIGH || tap_Melaka == HIGH
    || tap_Johor == HIGH || tap_Pahang== HIGH || tap_Terengganu == HIGH || tap_Sabah == HIGH ||
tap_Sarawak == HIGH){

  delay(200);

  if (clicks == 0){
    TimeStart = millis();
    TimeLimit = TimeStart + 225;
    clicks =1;
  }
```

```
  else if (clicks == 1 && millis() < TimeLimit){
    Serial.println("Double tap");
    myDFPlayer.stop();
    digitalWrite(IN1_PIN, LOW);
    digitalWrite(IN2_PIN, HIGH);

    currentMillis = millis();
    previousMillis = currentMillis;

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
  }
 }

 // if (xLimitState == LOW){
 //     if (steppers.run() == 0){
 //         positions[0] = positionX[0];
 //         positions[1] = positionY[0];
 //         steppers.moveTo(positions);
 //       }
 //       while (steppers.run()){
 //      }

 // }

}

void MODE_B(){
   // if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
   //     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
   //     && tap_Sabah == LOW && tap_Sarawak == LOW){

   //   Serial.println("Button Pressed Once TS_Kl");

   //   //MP3 play
   //   myDFPlayer.play(track_Kl);
   //   delay (500);
   //   myDFPlayer.play(track_Kl_E);
   //   delay(500);

   //   TimeStart = 0;
   //   TimeLimit = 0;
```

```
   //   clicks = 0;
   // }

   // if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit  &&  tap_Kedah == LOW &&
tap_Penang == LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
   //     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang == LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
   //     && tap_Sabah == LOW && tap_Sarawak == LOW){

   //   Serial.println("Button Pressed Once TS_Putrajaya");

   //   //MP3 play
   //   myDFPlayer.play(track_Putrajaya);
   //   delay (500);
   //   myDFPlayer.play(track_Putrajaya_E);
   //   delay(500);

   //   TimeStart = 0;
   //   TimeLimit = 0;
   //   clicks = 0;
   // }

   // if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
   //     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
   //     && tap_Sabah == LOW && tap_Sarawak == LOW){

   //   Serial.println("Button Pressed Once TS_Labuan");

   //   //MP3 play
   //   myDFPlayer.play(track_Labuan);
   //   delay (500);
   //   myDFPlayer.play(track_Labuan_E);
   //   delay(500);

   //   TimeStart = 0;
   //   TimeLimit = 0;
   //   clicks = 0;
   // }

   // if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit  &&  tap_Kedah == LOW &&
tap_Penang == LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
   //     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
   //     && tap_Sabah == LOW && tap_Sarawak == LOW){
```

```
  //   Serial.println("Button Pressed Once TS_Perlis");

  //   //MP3 play
  //   myDFPlayer.play(track_Perlis);
  //   delay (500);
  //   myDFPlayer.play(track_Perlis_E);
  //   delay(500);

  //   TimeStart = 0;
  //   TimeLimit = 0;
  //   clicks = 0;
  // }

   if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit && tap_Kedah == HIGH && tap_Penang
== LOW && tap_Perak == LOW && tap_Selangor == LOW && tap_N9 == LOW
   &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu ==
LOW && tap_Kelantan == LOW && tap_Sabah == LOW && tap_Sarawak == LOW){

     Serial.println("Button Pressed Once TS_Kedah");

     //MP3 play
     myDFPlayer.play(track_Kedah);
     // delay (500);
     // myDFPlayer.play(track_Kedah_E);
     delay(500);

     TimeStart = 0;
     TimeLimit = 0;
     clicks = 0;
   }

   if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== HIGH &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
       &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
       && tap_Sabah == LOW && tap_Sarawak == LOW){

     Serial.println("Button Pressed Once TS_Penang");

     //MP3 play
     myDFPlayer.play(track_Penang);
     // delay (500);
     // myDFPlayer.play(track_Penang_E);
     delay (500);
```

```
    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
   }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == HIGH && tap_Selangor == LOW &&  tap_N9 == LOW
     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
     && tap_Sabah == LOW && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_Perak");

    //MP3 play
     myDFPlayer.play(track_Perak);
    // delay (500);
    // myDFPlayer.play(track_Perak_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
   }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == HIGH &&  tap_N9 == LOW
     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
     && tap_Sabah == LOW && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_Selangor");

    //MP3 play
    myDFPlayer.play(track_Selangor);
    // delay (500);
    // myDFPlayer.play(track_Selangor_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
   }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == HIGH
     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
```

```
== LOW && tap_Kelantan == LOW
      && tap_Sabah == LOW && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_N9");

    //MP3 play
    myDFPlayer.play(track_N9);
    // delay (500);
    // myDFPlayer.play(track_N9_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
   }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
      &&  tap_Melaka == HIGH &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
      && tap_Sabah == LOW && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_Melaka");

    //MP3 play
    myDFPlayer.play(track_Melaka);
    // delay (500);
    // myDFPlayer.play(track_Melaka_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
   }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit && tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
      &&  tap_Melaka == LOW &&  tap_Johor == HIGH &&  tap_Pahang == LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
      && tap_Sabah == LOW && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_Johor");

    //MP3 play
    myDFPlayer.play(track_Johor);
    // delay (500);
```

```
    // myDFPlayer.play(track_Johor_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
   }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang == HIGH &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
     && tap_Sabah == LOW && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_Pahang");

    //MP3 play
   myDFPlayer.play(track_Pahang);
    // delay (500);
    // myDFPlayer.play(track_Pahang_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
   }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== HIGH && tap_Kelantan == LOW
     && tap_Sabah == LOW && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_Terengganu");

    //MP3 play
    myDFPlayer.play(track_Terengganu);
    // delay (500);
    // myDFPlayer.play(track_Terengganu_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
   }
```

```
  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == HIGH
     && tap_Sabah == LOW && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_Kelantan");

    //MP3 play
     myDFPlayer.play(track_Kelantan);
    // delay (500);
    // myDFPlayer.play(track_Kelantan_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
  }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit && tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
     && tap_Sabah == HIGH && tap_Sarawak == LOW){

    Serial.println("Button Pressed Once TS_Sabah");

    //MP3 play
    myDFPlayer.play(track_Sabah);

    //myDFPlayer.play(track_Sabah_E);
    delay(500);

    TimeStart = 0;
    TimeLimit = 0;
    clicks = 0;
  }

  if (clicks == 1 && TimeLimit!= 0 && millis() > TimeLimit &&  tap_Kedah == LOW &&  tap_Penang
== LOW &&  tap_Perak == LOW && tap_Selangor == LOW &&  tap_N9 == LOW
     &&  tap_Melaka == LOW &&  tap_Johor == LOW &&  tap_Pahang== LOW &&  tap_Terengganu
== LOW && tap_Kelantan == LOW
     && tap_Sabah == LOW && tap_Sarawak == HIGH){

    Serial.println("Button Pressed Once TS_Sarawak");
```

```
      //MP3 play
      myDFPlayer.play(track_Sarawak);
      //delay (500);
      //myDFPlayer.play(track_Sarawak_E);
      delay(500);

      TimeStart = 0;
      TimeLimit = 0;
      clicks = 0;
    }
}

void printDetail(uint8_t type, int value){
  switch (type) {
    case TimeOut:
      Serial.println(F("Time Out!"));
      break;
    case WrongStack:
      Serial.println(F("Stack Wrong!"));
      break;
    case DFPlayerCardInserted:
      Serial.println(F("Card Inserted!"));
      break;
    case DFPlayerCardRemoved:
      Serial.println(F("Card Removed!"));
      break;
    case DFPlayerCardOnline:
      Serial.println(F("Card Online!"));
      break;
    case DFPlayerPlayFinished:
      Serial.print(F("Number:"));
      Serial.print(value);
      Serial.println(F(" Play Finished!"));
      break;
    case DFPlayerError:
      Serial.print(F("DFPlayerError:"));
      switch (value) {
        case Busy:
          Serial.println(F("Card not found"));
          break;
        case Sleeping:
          Serial.println(F("Sleeping"));
          break;
        case SerialWrongStack:
          Serial.println(F("Get Wrong Stack"));
          break;
```

```
      case CheckSumNotMatch:
        Serial.println(F("Check Sum Not Match"));
        break;
      case FileIndexOut:
        Serial.println(F("File Index Out of Bound"));
        break;
      case FileMismatch:
        Serial.println(F("Cannot Find File"));
        break;
      case Advertise:
        Serial.println(F("In Advertise"));
        break;
      default:
        break;
    }
    break;
  default:
    break;
 }
}
```