An-Najah National University

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Hardware Graduation Project

TARNEEM

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Acknowledgment

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Disclaimer

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Abstract

Musical instruments play an important role in expressing our feelings, and there are many of these instruments, some of which have many fans but are difficult to transport, such as drums. It would be great if they were easily and flexibly available for transportation. Our project aims to provide a single place for most of the musical instruments used in performances, such as drums and guitars, while providing a teaching system designed to help beginner musicians master the notes well before the performance. It will be easy to switch between the normal playing mode and the teaching mode. This unified place is characterized by the ability to move and move in a direction determined by the musician, which facilitates the transportation and organization of the space.

The project is mainly composed of three parts:

1. Invisible drums. It is a 2-drum stick system used instead of the main drums.

2. Electronic Harp. A touchless interface where musicians can produce sounds by interrupting laser beams.

3. The Table. It provides moving various instruments and can be controlled to follow a specific path determined by the musician.

Chapter 1

Introduction

1.1 Statement of the problem

Traditional musical instruments, such as drums and guitars, are often large, cumbersome, and require constant maintenance, making them difficult and time-consuming to transport and set up for performances. This lack of portability limits musicians' flexibility, especially during live performances where quick transitions between instruments are necessary. Additionally, traditional harps can be harsh on the fingers over time, and traditional drum sets can be noisy, making them unsuitable for practice in shared spaces without disturbing others. Beginner musicians also face challenges in mastering these instruments and being able to practice effectively, as traditional learning systems are either complex or not interactive enough. A solution is needed that not only provides a compact and portable system for major musical instruments but also includes a robust learning mechanism for beginners and explains the playing steps in detail. This project addresses these issues by developing an invisible drumstick system, a laser-powered electronic harp, and a mobile platform that provides musical performance and educational features in a flexible and easy-to-move setup, allowing for quiet practice with headphones and reducing the physical strain associated with traditional harps.

1.2 Project Objectives

The main objective of this project is to build a moving system that contains the main instruments:

1. Develop an invisible drumstick system that enables musicians to play virtual drums using sensor technology, eliminating the need for physical drum sets while maintaining a realistic playing experience.

2. Design and implement an electronic laser harp, allowing musicians to produce musical notes by interacting with laser beams, providing a modern, touchless alternative to traditional harps.

3. Incorporate a learning system for the harp that assists beginner musicians in learning and mastering musical notes through an interactive, user-friendly interface, with the ability to switch between performance and learning modes seamlessly.

4. Incorporate a motorized, moving table system that can follow specific paths, enabling smooth movement in both directions during performances, thus facilitating repositioning

and enhanced stage flexibility.

1.3 Project Scope

This project can be used by many users, especially professional and amateur musicians, music educators, and event organizers. Additionally, because it includes a learning system, non-professional people can also enjoy it.

1.4 Project Importance

This project is important because it transforms the usability and portability of musical instruments by combining invisible drumsticks with an electronic laser harp and a moving platform. It offers enhanced flexibility for performances and easy transport. The learning system specifically for the laser harp aids beginners in mastering the instrument, making music easier and more interactive.

Chapter 2

Literature Review

The existence of a moving system that includes the necessary instruments in one place makes things better by supporting easier learning and reducing noise. Switching to an electronic drum kit might seem like a quieter solution since you can use headphones [1].

The laser harp consists of an array of beams organized in a fan arrangement. In analogy with the plucking of the strings of a harp, laser beams are intended to be blocked to produce sounds [2].

These technologies and research helped us develop this project, leading to the exploration of various sensors and motion detection technologies for better results.

Chapter 3

Methodology

3.1 Overview of the System

The system we have built to implement multiple instrument fr the musician and make the learning easy, less noise, this image show the final look of the design.

Figure 3.1: The system.

3.2 Hardware Components

3.2.1 Moving Part

Figure 3.2: The line for the car.

Figure 3.3: The car.

Window Motor

The window motor is a DC motor used with a coupler to allow the wheels to move in both directions—forward and backward. This motor can carry heavy weights. In our project, it carries the box, harp, drums, and a lot of wood.

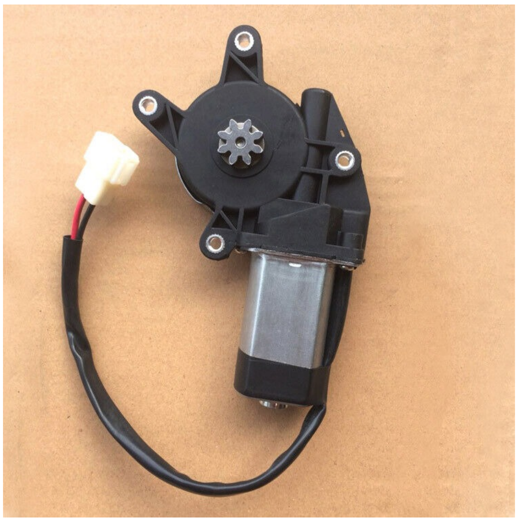


Figure 3.4: Window Motor used for movement.

Relay

We used a two-channel relay connected to the motor for controlling the movement and directions. Initially, we used active high for both relays, but one had a broken pin, so we replaced it with an active low relay. Thus, they work together but in different pin modes.

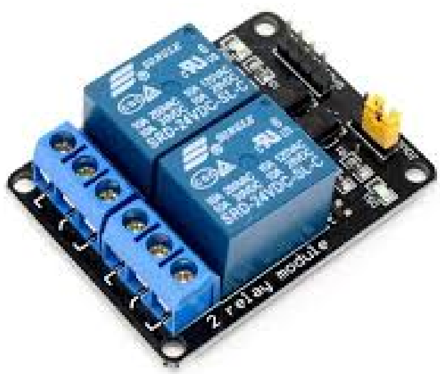


Figure 3.5: Two-channel Relay for controlling the motor.

Ultrasonic Sensors

We use three ultrasonic sensors for moving forward and backward and one for control. A small wooden wall is placed at the end of the line, and the ultrasonic sensors detect it to stop the car. If we want to move it again, we use the control ultrasonic sensor.

Figure 3.6: Ultrasonic sensors used for motion control.

4-Channel Relay

We used a 4-channel relay to control the light lines. Each channel was used for specific lights, and they were connected to the same final cable for power. This part was risky and required caution.

Figure 3.7: 4-Channel Relay for controlling lights.

Lights

We used multiple 220V light lines for the car, controlled by the relay, by connecting them to the channels with the common pin and the normally open pin.

Figure 3.8: 220V Lights controlled by relay.

ESP32

We used an ESP32 as a WiFi access point to connect our application with the Arduino in the car. This allows us to control the car, including moving it forward or backward and controlling the lights and two steams (which will be discussed next).

Figure 3.9: ESP32 used as WiFi access point for control.

Arduino UNO

In this part of the project, we used the Arduino Uno as the microcontroller to handle the movement of the car and to connect with the ESP32 so the user can control the car's forward and backward movements easily.

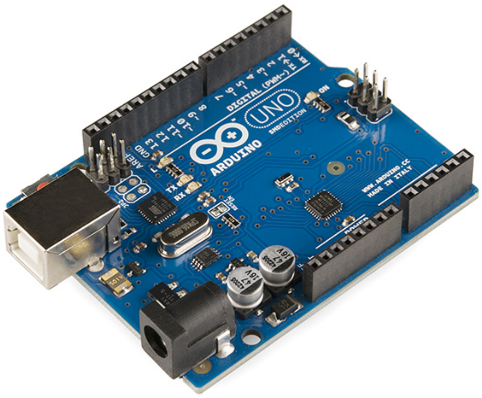


Figure 3.10: Arduino UNO for controlling car movements.

3.2.2 Laser Harp

Figure 3.11: Laser harp in the final project.

Figure 3.12: Laser harp with steam.

LDR Module

The LDR module is used to detect the laser cutting by specifying the threshold value. These values are calculated by the amount of light on the sensor. The initial state is receiving the laser, and when the beam is cut, the threshold value increases, allowing detection.

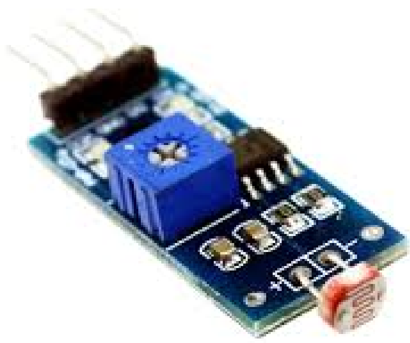


Figure 3.13: LDR Module for detecting laser cuts.

Laser

Initially, we wanted to use a visible laser module, but it was unavailable and expensive. Instead, we used two steam machines, as seen in the photos, to make the laser visible in the air.

Figure 3.14: Laser module and steam to make the laser visible.

DC Motor

The first steam machine is controlled by a DC motor to rotate and align the steam directly on the laser, making it visible in the air with a red color.

Figure 3.15: DC motor controlling steam machine.

Steam Machine

We used an electrical steam machine (220V) connected to a relay. The steam serves two purposes: making the laser visible in the air and adding a dramatic visual effect. The steam machine operates with water above it to create the steam.

Figure 3.16: Steam machine for laser visibility and visual effect.

DFPlayer with Speakers

We used a DFPlayer with an SD card to store sounds for each laser and provide system sounds that help users understand what is happening. When one of the lasers is cut, it commands the DFPlayer to play the corresponding sound.

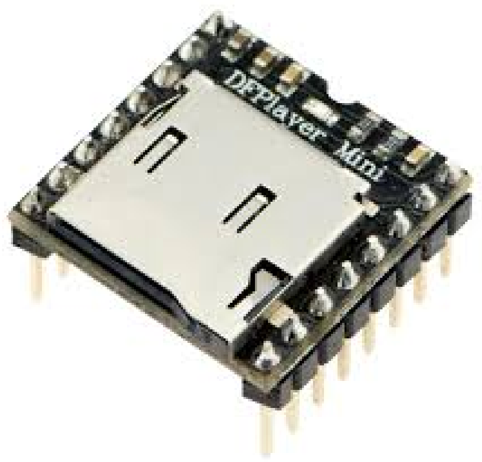


Figure 3.17: DFPlayer and speaker for sound playback.

RFID with Cards and Buzzer

We used an RFID module to allow specific users to enter the learning system mode and start cutting the beams in a specific sequence. Each user has a unique card to enter the system.

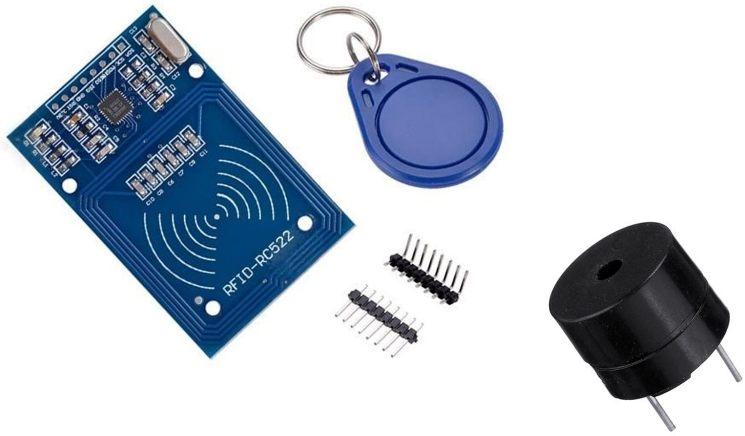


Figure 3.18: RFID module with cards and buzzer for user identification.

Keypad

If the user does not have a card, they can still access the system by entering the password assigned to them using the keypad.

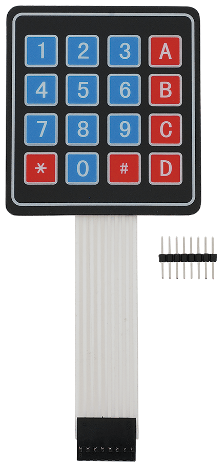


Figure 3.19: Keypad for password entry.

LCD with I2C Module

The LCD is used to display commands to help the user understand the system. The I2C module simplifies wiring and reduces the number of pins needed, allowing the use of the same Arduino Mega for multiple purposes.

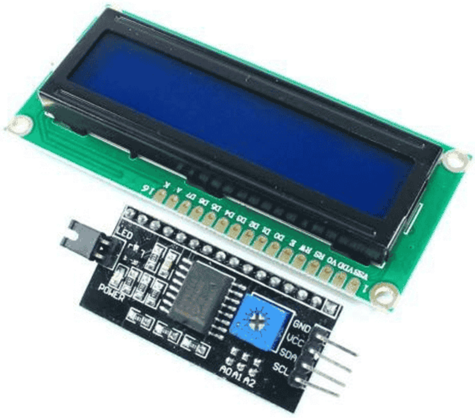


Figure 3.20: LCD with I2C module for displaying commands.

220V LEDs

Green and red LEDs are used as feedback for the user. The green LED turns on when the user cuts the correct beam in the sequence, and the red LED turns on if they cut the wrong one. This helps the user understand the learning system.

Figure 3.21: 220V LEDs used as feedback indicators.

4-Digit 7-Segment Display

We used a 4-digit 7-segment display to calculate the time the user spends in the learning system. It starts from the beginning of the sequence until the last one is completed, tracking the user's speed and improvement.

Figure 3.22: 4-digit 7-segment display for timing.

Ultrasonic Sensor

An ultrasonic sensor is used to switch between sounds of high and low frequencies by measuring the distance between the user's hand and the control sensor. This adds another level of control to the instrument.

Figure 3.23: Ultrasonic sensor for sound frequency control.

White LEDs

A rectangle of white LEDs is connected to the LDR to visually indicate that the LDR has correctly detected the laser cut.

Figure 3.24: White LEDs for LDR detection feedback.

Arduino Mega

In order to handle all these components, we used the Arduino Mega. It was the best choice because it includes many pins for serial communication and has more than one RX and TX, but we still used almost all the pins available.

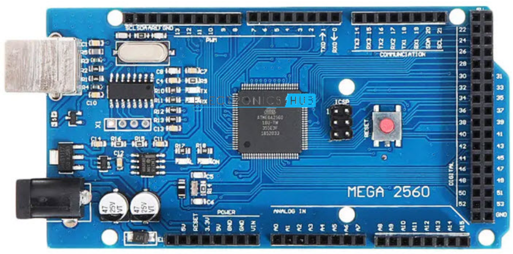


Figure 3.25: Arduino Mega used to handle multiple components.

3.2.3 Invisible Drums

Figure 3.26: Invisible drums stand.

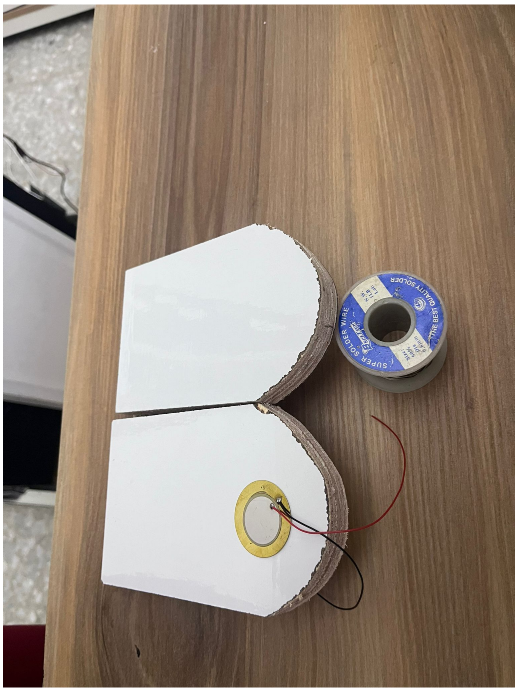
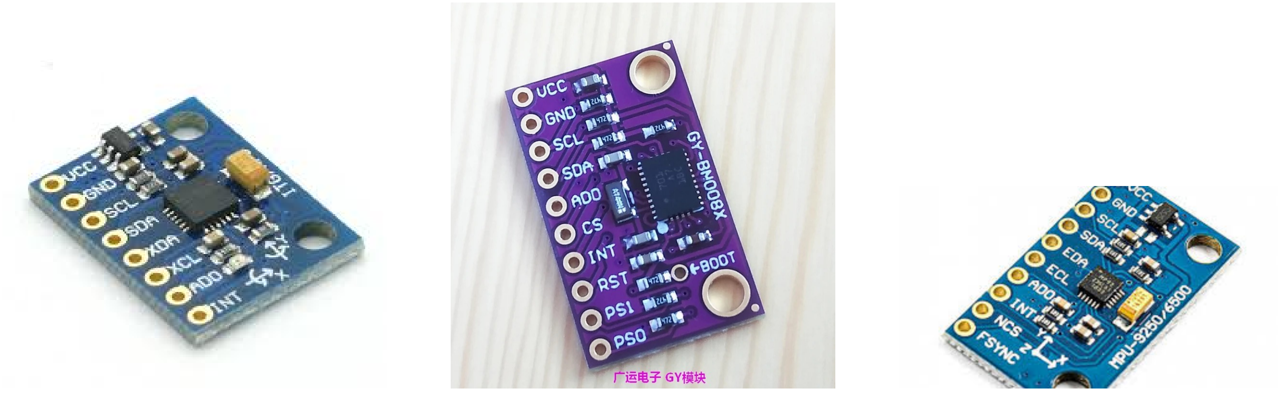


Figure 3.27: Piezo stand.

The Sensor

This part of the project has been a long journey. At first, we spent a lot of time searching for the BNO055 sensor, but it was unavailable, and we could not find it. As a workaround, we decided to use the MPU6050, which is cheaper, to detect the rotation of my hand when using the drumsticks. However, the movements it captured were inconsistent and unclear, leading to inaccurate drum sounds. Determined to improve the performance, we resumed our search for the BNO sensor and eventually found the BNO085. This sensor accurately detected the acceleration of my hand in a specific space and worked well. Unfortunately, two days later, it was damaged, and finding another one was even more challenging than the first time. Eventually, we obtained an MPU9250, which was as expensive as the BNO but worked effectively.

The primary goal of the sensor is to be highly accurate in detecting the musician's hand movements to produce authentic and precise drum sounds.



(a) MPU6050 sensor (b) BNO085 sensor (c) MPU9250 sensor

Figure 3.28: Sensors used during the project for the invisible drums

SD Card

For the drums part, at first, we tried a Python code, and it worked well. However, the aim of the invisible drums is ease of use and eliminating the weight. Thus, we saved the needed sounds of the drums in the SD card and connected it with the circuit.

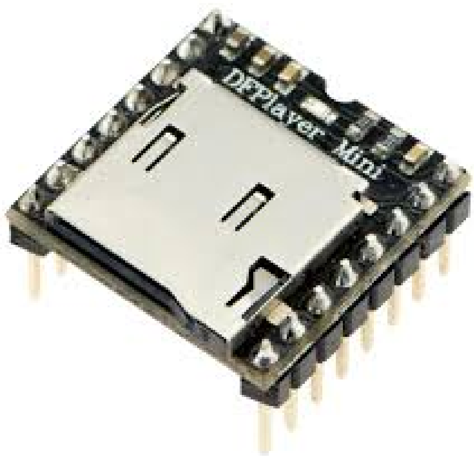


Figure 3.29: SD card used for storing drum sounds

Piezoelectricity

The Piezoelectricity is an component that convert the energy from the mechanical domain to the electrical domain and vice versa. it have a threshold value when we exceed this value they detect this change and allow us to make actions, in our case we use the piezo then when the musician kick it with his foot the sound will turn on.

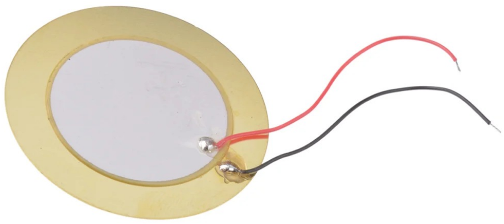


Figure 3.30: Piezoelectricity used for the foot in the invisible drums

Arduino Nano

The purpose of using the Arduino Nano in the invisible drums part is its compact size, as shown in the first image of our drumstick design. We needed a small microcontroller that could fit in the specific place and require fewer wires. Additionally, our circuit is small and does not need many pins, so the Arduino Nano was a good choice and performed the required functions.

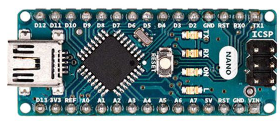


Figure 3.31: Arduino Nano used for the compact design of the invisible drums

3.2.4 Application

We built a mobile application using the App Inventor and downloaded it on an Android device. The application connects to the ESP32, which is configured as an access point. The Android device connects to this access point, allowing the user to control the system and send commands to the Arduino.

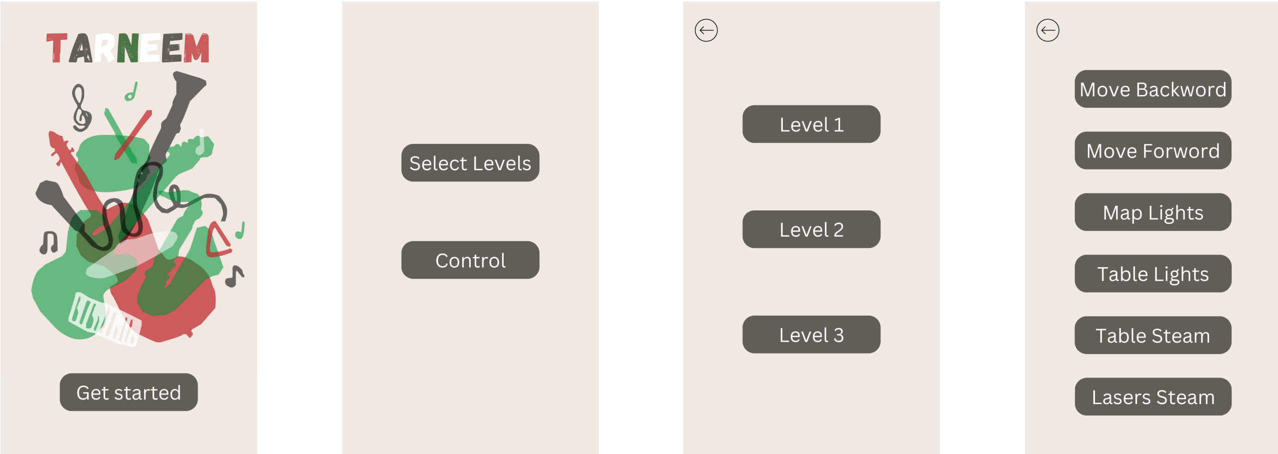


Figure 3.32: GUI of our mobile application.

3.2.5 Design

We designed the model ourselves using AutoCAD software and printed it using a CNC machine. These images explain the design:

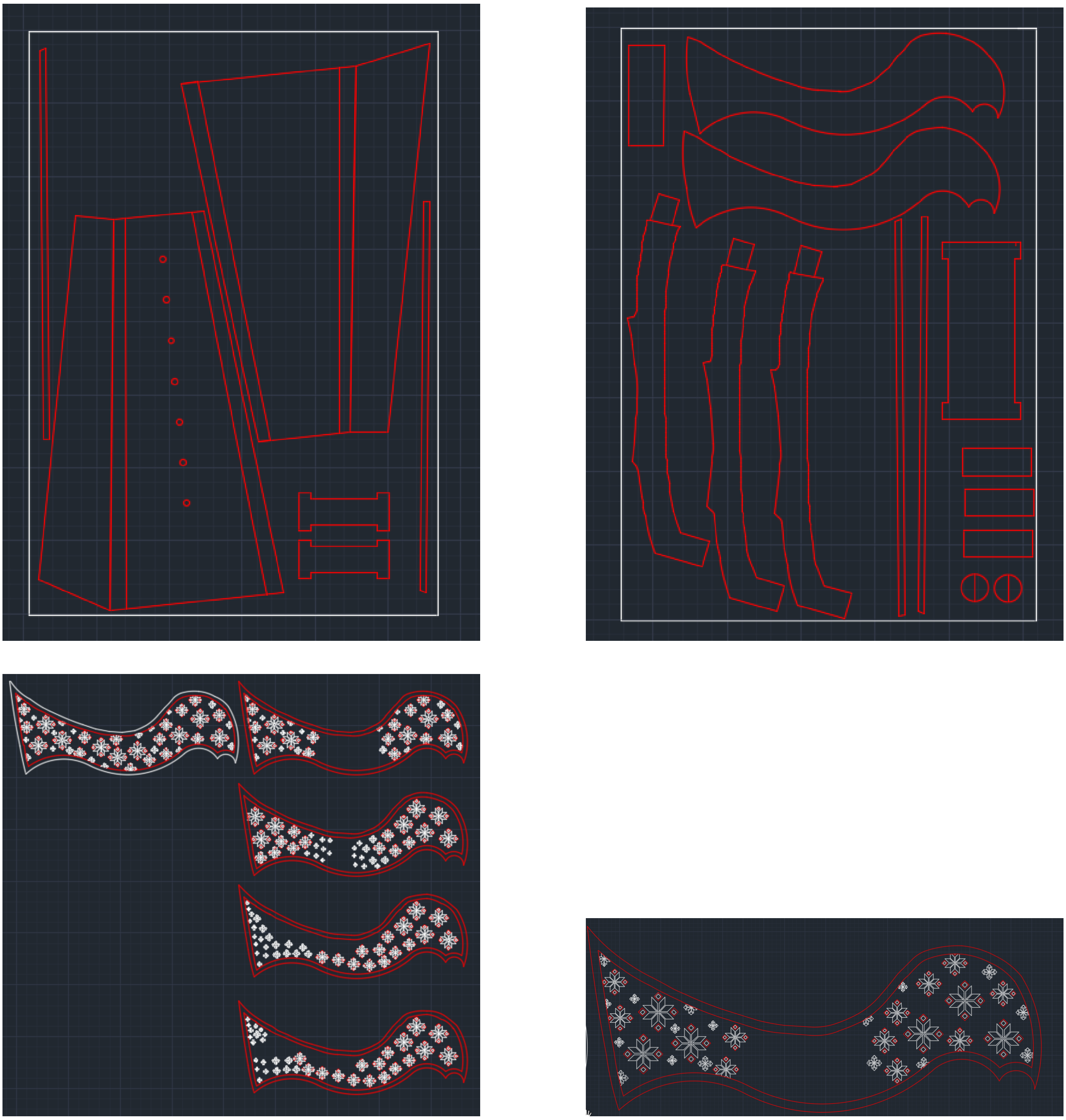


Figure 3.33: Design of the model using AutoCAD and CNC machine.

Chapter 4

Problems and Challenges

Like every hardware project, we faced several challenges and problems during the development process:

1. It took a long time to get used to the Arduino Uno + WiFi board and understand how its modes and modules work.
2. We had to fix the delay issue with the SD card.
3. Dealing with 220V in some cases was very risky and caused a few injuries.
4. Finding the right sensor for the invisible drums took considerable time.
5. We had to solve a noise problem with the speaker.
6. Ensuring that the car moved correctly along the railway was challenging.

Chapter 5

Results and Discussion

At the end of this project, despite all of the previous challenges, we successfully achieved our goal of designing the system. We tackled the work step by step, first learning about each component and principle individually and then integrating them into a complete system. By starting with learning about programmable boards, motors, the MPU sensor, ESP32, and other elements, we believe we have built a flexible, user-friendly system that simplifies the learning process for users. Ultimately, we are proud to have created a system that is both functional and intuitive, making it easier to interact with complex musical instruments.

Chapter 6

Conclusion and Future Work

While working on this project, we gained experience working with new components and learned a great deal of interesting concepts. Key takeaways include:

1. Understanding new programmable boards and analyzing datasheets to comprehend how they work.
2. Learning about motors and relays and how to control them.
3. Acquiring knowledge of wireless networks and ESP32 modules.
4. Gaining experience with acceleration sensors, understanding how they work, and differentiating between acceleration and rotation.
5. Working with sound frequencies and SD card modes for sound storage and playback.

Future Work: The primary goal for future work is to add more instruments to the table and allow musicians to switch between them easily. Additionally, improving the movement system by tailoring the movement line for large stages and enabling the car to move in all directions, getting closer to the musician, will be important future work.

References

[1] Hafthor Árni Hermannsson, *The Invisible Drum Set Project*, Reykjavik University, April 2024.

[2] G. Ferenc and J. Popović-Božović, "An Infinite Beam Laser Harp with External MIDI I/O Functionality," *22nd Telecommunications Forum (TELFOR)*, IEEE, pp. 877-880, 2014.