بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

An-Najah National University
Faculty of Engineering and Information Technology
Computer Engineering Department

Hardware Graduation Project

Braille Printer

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Presented in partial fulfillment of the requirements for Bachelor degree in Computer Engineering.

Dedication

Dedication to loving memory of our grandmother, our loving parents, family, friends and for everyone who believed and loved us.

Acknowledgment

We extend our deepest gratitude and appreciation to the individuals who have played a significant role in our graduation project. Their guidance, support, and unwavering belief in our abilities have been invaluable throughout this journey.

We would like to **thank our supervisor Dr. Samer Arandi** a lot for his helpful, kind, patience and taking care of us, and for making everything simple. He was always inspiring and encouraging us to move.

We would also like to **thank all the teachers and teacher's assistant in the Department of Computer Engineering**, and we feel proud to be students in it, as this helps us to improve our educational level as well as improve our skills.

Disclaimer

This report was written by students at the Computer Engineering Department, Faculty of Engineering, An-Najah National University. It has not been altered or corrected, other than editorial corrections, as a result of assessment and it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of the students. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

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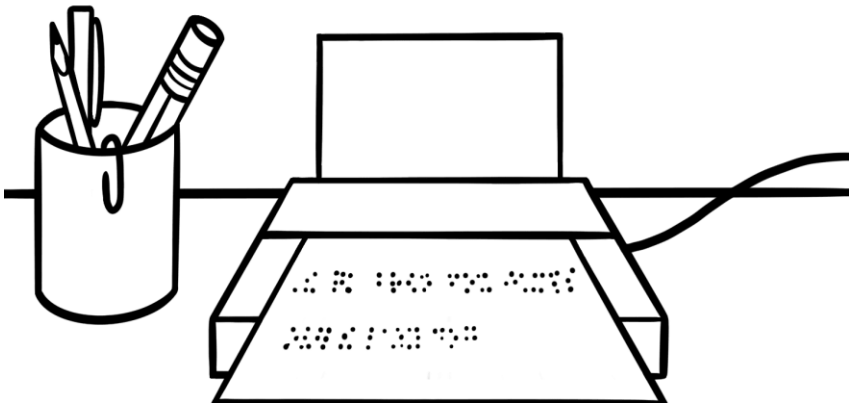
Abstract

People with visual disabilities suffer from the problem of unavailability of books and references in Braille, which restricts their access to them. Therefore, there is a need for printing Braille. However, they face several challenges, including the high cost of printers and their scarcity in the market.

A Braille printer provides a valuable means for visual disabilities people to access printed knowledge and materials by converting plain texts into Braille patterns. This significantly enhances the learning and personal development of individuals with visual impairments.

We implemented a Braille Printer that connected with web server to get the text. It also contains a paper feeder which will scroll paper from the paper container to the printing area. the paper feeder consists of a DC motor to scroll the paper. printing mechanism contains a solenoid to knock on the paper that is pinned at the XY coordinate, controlled using 2 stepper motors. After finish printing the feeding mechanism scrolling the paper from printing area to out of printer.



Chapter 1: Introduction

- **Statement of the problem**

People with visual disabilities they face several challenges when need to print text in Braille. One of the most significant challenges they face is the high cost of buying Braille printers, placing them beyond the reach of many who would benefit from their use.

Moreover, the scarcity of Braille printers in the market exacerbates this issue. While paper printers are widely available and accessible, Braille printers are relatively limited in supply. This scarcity is a result of several factors, including the specialized nature of Braille embossing technology, the smaller target market for such devices, and the technical complexities involved in their production.

As a consequence of these challenges, visually impaired individuals often encounter barriers in obtaining crucial printed materials in a format they can comprehend. Educational materials, books, work-related documents, and even everyday communication can all be inaccessible due to the high cost and scarcity of Braille printers. This not only hinders their educational and professional progress but also restricts their ability to fully engage in social and personal activities that involve written information.

In light of these obstacles, there is a pressing need for innovative solutions that address the cost-effectiveness and availability of Braille printers. By making these devices more affordable and accessible, individuals with visual disabilities can gain greater independence, educational opportunities, and inclusion in various aspects of society. Thus, a comprehensive exploration of these challenges and potential solutions is crucial in ensuring equitable access to information and promoting the overall well-being of visually impaired individuals.

Objective

The purpose of our work is to address the limitations and challenges visually impaired people face in the printing text in braille, and to provide them with a comprehensive solution through the Braille Printer system. The objectives of our work are as follow:

- **Develop a user-friendly system**: Our main goal is to create a user-friendly Braille Printer, complete with an LCD display and a buzzer to provide transparent feedback during the printing process. Additionally, we are designing a web application that is intuitive and user-friendly. This application will empower users to effortlessly input the text they desire to be printed in Braille.

- **Automating the Printing Process:** Our goal is to create a printer that is completely automated. This required placing the papers in the paper container, entering the text using a web application, and once the printing is complete, take the printed paper.

- **Enhancing Affordability and Accessibility of Braille Printing**: Currently, Braille printers available in the market not only take a significant amount of time to acquire but also come at a high cost ranging from $4000 to $7000. In contrast, our printer can be assembled rapidly, making it available on demand, and it is offered at a much lower cost, ranging from $300 to $400.

- **Precision and Quality**: The printer produces good-quality results that adhere to Braille language rules.

Scope of the work

- **Web Application using React JS:** Develop a Web application using React JS that allows users to connect to the Braille Printer via the ESP8266 D1 mini (WiFi module). The application should provide a user-friendly interface for enter text and sending it to the Printer.

- **WiFi Connectivity:** Implement the WiFi communication between the Web application and the Printer using the ESP8266 D1 mini. Establish a reliable connection to facilitate data transmission between the Web application and the Printer.

- **Developing a Text-to-Braille Conversion Algorithm:** Develop an algorithm that received the text from WiFi module then proceed to convert the text into a suitable representation that corresponds to Braille language rules.

- **Developing an Efficient Paper Feeder Mechanism:** Our focus is on creating a robust paper feeding system that operates seamlessly from the paper container to the printing area.

- **Developing a Printing mechanism:** build an XY coordinate to controlling the printing process and put solenoid on coordinate to knock the paper (for printing).

- **System Integration and Testing:** Integrate all the components and functionalities of the system, including the Web application, WiFi connectivity, paper feeders, XY coordinate, LCD and buzzer. Conduct thorough testing to ensure the system operates reliably and accurately.

Importance of the work

The Braille Printer holds significant importance for visually impaired people. Here are the key reasons why this work is essential:

- **Precision and Quality:** This printer yields good results, meticulously adhering to Braille language rules concerning the spacing between knocked points and characters.

- **Time and Effort Savings comparing with manual way:** Traditional manual way can be time-consuming and labor-intensive. The Braille Printer significantly reduces the time and effort required for printing paper and reduce the error while printing the papers.

- **Low cost:** Braille printers available in the market have a high cost ranging from $4000 to $7000. In contrast, our printer it is offered at a much lower cost, ranging from $300 to $400.

- **Availability:** Braille printers available in the market take a significant amount of time to acquire. In contrast, our printer can be assembled rapidly, making it available on demand.

- **Enhancing Customer Satisfaction:** This initiative seeks to elevate customer satisfaction by introducing cost-effective Braille printers into the market. By offering affordable alternatives, individuals with visual disabilities can access good quality Braille printing solutions that not only meet their needs but also align with their budget constraints.

▪ Organization of the report

The report is structured in a logical and systematic manner to effectively present the information related to the project. The organization of the report is as follows:

- **Introduction:** This section provides an overview of the project, highlighting the problem statement, objectives, and the importance of the work. It sets the context for the rest of the report.

- **Theoretical Background and Previous Work:** In Chapter 2, It presents a comprehensive review of existing research, studies, and relevant literature related to Braille Printers, automation techniques, and similar projects. This section helps establish the project's context and highlights any gaps in the existing knowledge.

- **Methodology:** Chapter 3 explains the materials and methods used throughout the project. It provides a detailed description of the experimental setup, the Web application development process, and the design and implementation of the Braille Printer. The chapter outlines the steps taken to achieve the project objectives.

- **Results and Analysis:** Chapter 4 presents the results obtained from the project. It includes the outcomes of the Printing process using the Braille Printer, as well as any relevant data or measurements. The results are analyzed and interpreted to draw meaningful conclusions.

- **Discussion:** Chapter 5 focuses on the discussion of the results. It provides a comprehensive analysis of the findings, highlighting the features, benefits, and limitations of the Braille Printer. The chapter also addresses any challenges faced during the project and offers recommendations for future improvements.

- **Conclusion and Recommendation:** chapter6 concludes report by summarizing the key findings, reiterating the significance of the work, and highlighting its potential impact. It may also include a reflection on the overall project experience and suggestions for further research.

- **References:** A list of all the references cited throughout the report is provided in the References section, following the conclusion.

- **Appendices:** GitHup links of microcontroller code and web application code.

Chapter 2: Theoretical Background and Previous Work

Braille printing technology has undergone significant advancements over the years, with the primary objective of facilitating access to written content for individuals who are blind or visually impaired. The development of Braille printers has played a pivotal role in achieving this goal.

Initially, Braille was printed manually by using a Braille stylus to emboss dots onto paper. However, this method was inefficient and time-consuming.

The transition from manual embossing to mechanical embossing devices marked a crucial advancement in Braille printing technology. Mechanical embossers utilized punch and die mechanisms to emboss Braille characters onto paper. While these devices offered improved efficiency, they were still relatively large, expensive, and limited in terms of print speed.

The integration of digital technology into Braille printing revolutionized the field. Electronic Braille printers emerged, leveraging computer-generated content to emboss Braille characters onto paper. These printers enabled the conversion of digital text into Braille format, making it possible to produce a wide range of materials, from books to educational materials.

On the other hand, this improvement required to complex design for the printer and high cost. in our design we aim to build printer with low cost and simple design.

Chapter 3: Methodology

- **How It Works?**

  At first you need to turn on the printer by press on power button then the WiFi module start connecting to the WiFi then connect to the server and print status on LCD then reset XY coordinate to the start position.

  Now we can enter text that you want to print it to the Web application then press on print button if there is a previous req that send to the server will appear message and we can re press on print button after loader disappear after that the text is sent to the server then the WiFi module listen to the server if they have a new text to print it or not if there, then WiFi module send text to the Arduino serially then Arduino send received to then WiFi module serially then the WiFi module update status on server to be in progress then Arduino will start to printing process.

  To start of the printing process should there is a papers on paper container if the paper container not contain papers then the buzzer beeping and print “No papers” on LCD. If there is a paper in paper container then the paper feeder scrolls one paper to the first roller then the roller scrolls the paper to the printing area then take char by char from string that contain text then convert it to the representation in Braille then start knocking on the paper by the solenoid and move to the next until paper is full or finish printing then the roller 2 scroll the paper to the out of printing area, if paper is full, then after move paper to out of printing area return to take new paper and repeat process and continue until finish text. After finish printing the buzzer beeping and print “finish printing” on the LCD and update status on Server to Finished then show pop up on the Web application that indicate to finish printing.

- **The Mechanism of conversion text to braille**

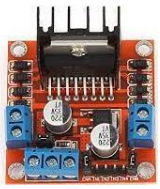
When text received in the Arduino store it on string then when start printing take char by char and get the corresponding representation on braille language by using this mechanism :

```
bool SymbolMatrices[numSymbol][numRows][numCols]=/*store the
representation of all char */
{
  // Matrix for 'a'
  {
    {true, false},
    {false, false},
    {false, false}
  },
  // Matrix for 'b'
  {
    {true, false},
    {true, false},
    {false, false}
  },/*and so on to all char*/}
 int getSymbolIndex(char c)// take char and return corresponding index
{
  if(c >= 'a' && c<='z')
  {
    return c-'a';
  }
  else if(c >= 'A' && c <= 'Z')
  {
    return c-'A';
  }
  else if(c == '.')return 26;
  else if(c==',')return 27;
  else if(c=='?')return 28;
  else if(c=='!')return 29;
  else if(c=="'")return 30;
  else if(c=='-')return 31;
  else if(c=='#')return 31;
  else if(c==' ')return 33;//capital → index 34 | number → index 35
  else if(c>='0' && c<='9')
  {
    return 36 + (c-'0');
  }
  else return 33;//any other char return ' '}
```

- # Components

Table 1: Hardware components

Hardware Component	Image	Number of times Used	Purpose
Arduino Mega		**1**	Main controller board for overall system functionality.
ESP8266 D1 mimi		**1**	Used for WiFi communication between the Braille Printer and the Web application application.
Optical sensor TCRT 5000		**3**	Used to detect if there is a paper or not.
Stepper Motors Nema 17		**2**	Control to the XY coordinates.
A4988 Stepper Motor Driver Carrier		**2**	Drives the stepper motor responsible for precise movement in the system

Hardware Component	Image	Number of times Used	Purpose
DC motor		**3**	Controlling of paper feeder and rollers
H-bridge L298N		**2**	Drives the DC motor responsible for precise movement in the system
Servo Motor MG966R		**1**	To prevent the paper scrolling when put it in paper container.
5V 2-Channels Relay Module Active High/Low		**1**	To controlling to the solenoid and buzzer.
Inverter IC		**1**	To Invert the logic of EN in driver of stepper motors.
DC 12V 2.1Kg 10mm Stroke Push Pull Type Solenoid		**1**	To knocking on the paper.

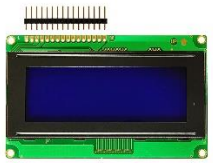
Hardware Component	Image	Number of times Used	Purpose
12V 16mm Metal Push Button Switch		**1**	Serves as an on/off switch for the entire system, allowing easy control of the system's power.
12V 12A Power Supply		**1**	Supplies the required power to the system, ensuring proper functioning of the components.
LM2596 Adjustable Step Down Buck Converter		**2**	Provides a regulated 5V output to power several components in the system. Generates a stable 6.7V supply voltage to power the Arduino board and ensure its operation.
LCD 20*4		**1**	To show the status of printing process
12v Buzzer		**1**	To indicate to the status of the printing process.
Limit switch		**2**	To reset XY coordinate to the start point.

Table 2: Mechanical components

Mechanical Component	Image	Number of times Used	Purpose
MGN12 12mm Linear Guide Rail 40cm		**1**	Y coordinate
MGN12 12mm Linear Guide Rail 30cm		**1**	X coordinate
MGN12C Steel Slide Block Carriage Unit		**2**	To move on X and Y coordinate
GT2 Timing Pulley 20 Teeth Bore 6.35mm		**2**	To put it in the head of the stepper motor to move system
GT2 16 Teeth Idler Pulley Bore 3mm		**2**	To put it in the corresponding side of each of stepper motors.

Mechanical Component	Image	Number of times Used	Purpose
1meter Rubber GT2-6mm Open Timing Belt ,6mm Width		**2**	To move MGN (XY movement)
Braille pen		**1**	To put it on the head of solenoid
Paper feeder		**1**	Scroll the paper from paper container to the roller 1
Paper roller 1		**1**	Scroll the paper to the printing area
Paper roller 2		**1**	Scroll the paper to the out of printing area

Design

Body of machine

1. We first took apart an old printer to see how the paper feeding mechanism inside the printer worked and from this printer we get a DC motors, paper feeder and rollers.

Figure 1: Dismantled an old printer

2. We began by envisioning the printer's structure based on the old printer, and then proceeded to construct the framework using wood. The structure design indicated the need to select the correct angle for the flat surface responsible for paper feeding.

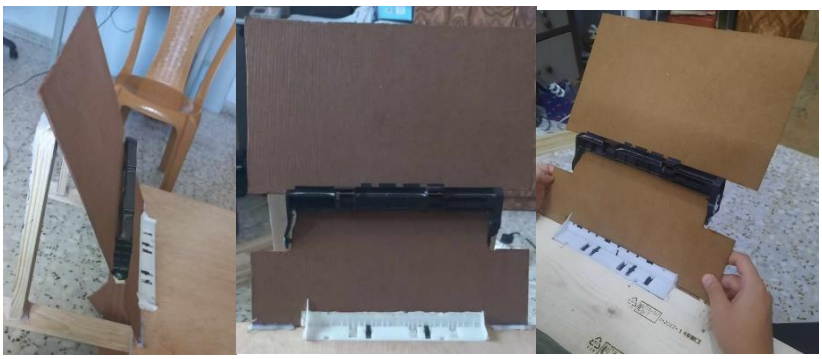


Figure 2: Paper feeder in paper container

3. building the XY coordinate.

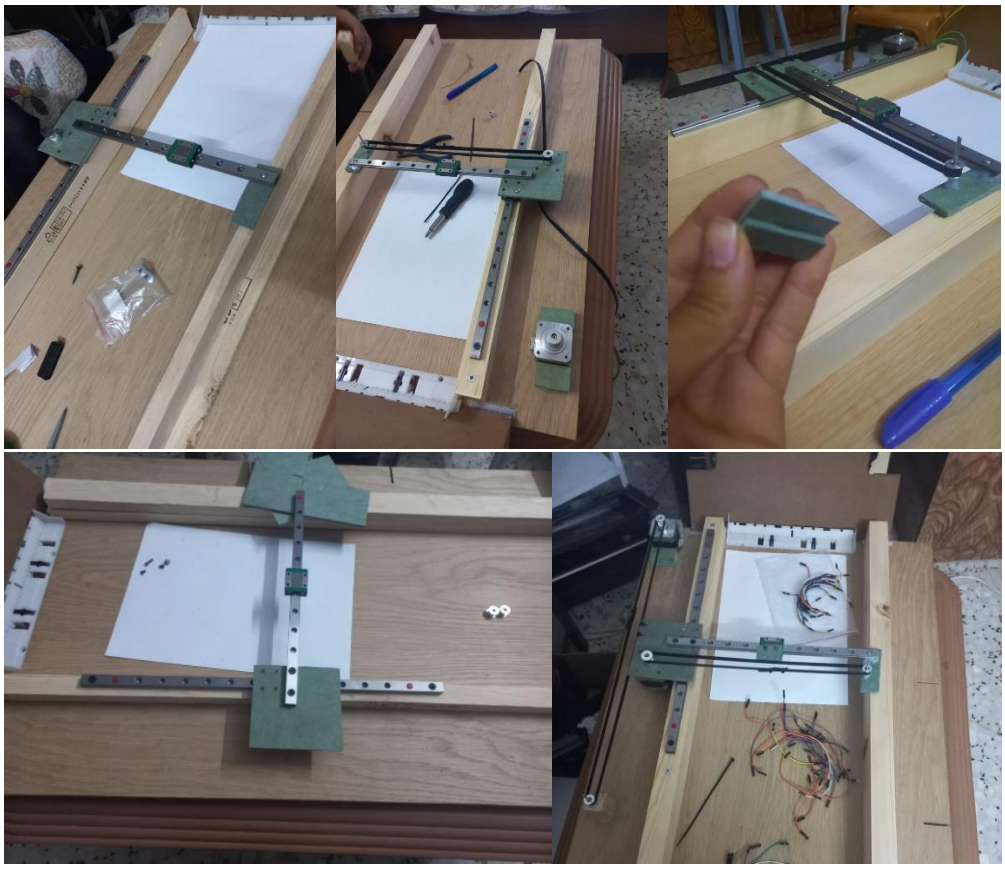


Figure 3: Build XY coordinate

4. We attached the paper rollers at the start and at the end of printing area.

Figure 4: Attached the paper roller

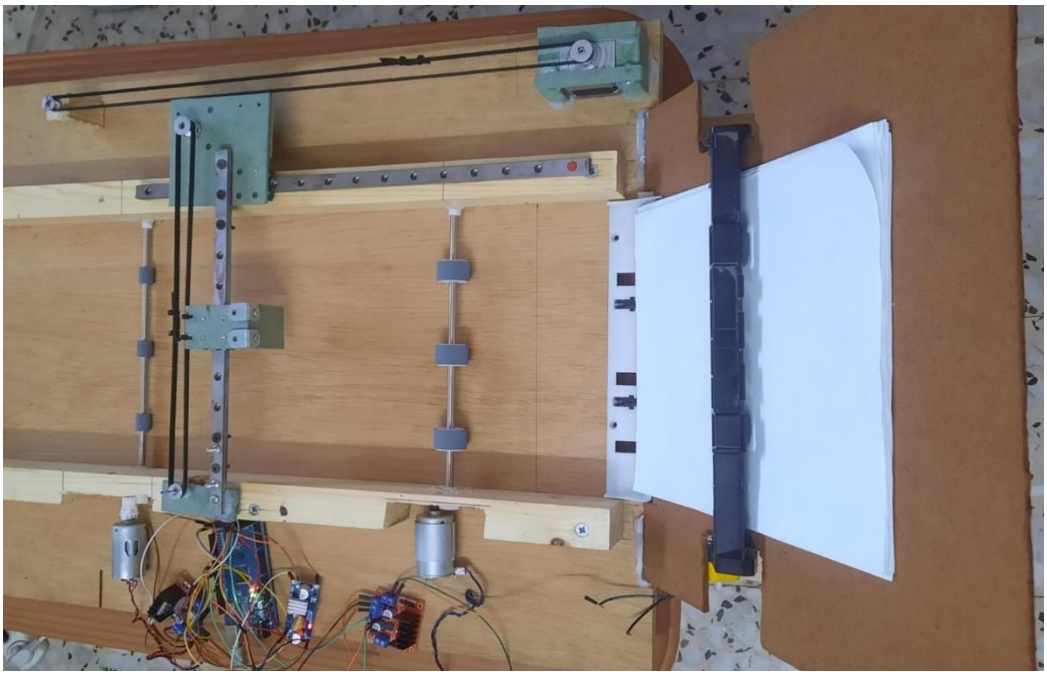


Figure 5: Attached feeder, paper rollers and XY coordinate

5. Move to the production stage:
   The previous design was a prototype due to its lack of stability and imprecise dimensions. As a result, we reconstructed the original design with the help of a carpenter to achieve a stable and precise outcome. We also encountered a problem when attempting to emboss paper directly placed on wood. The impact wasn't visible on the paper due to the solid surface of the wood. As a solution, we experimented with a corkboard; however, this proved to be ineffective. Consequently, we transitioned to using a foam board as the printing surface, which demonstrated efficiency. As a result, we incorporated this solution into the final design.

Figure 6: Start working to the final design

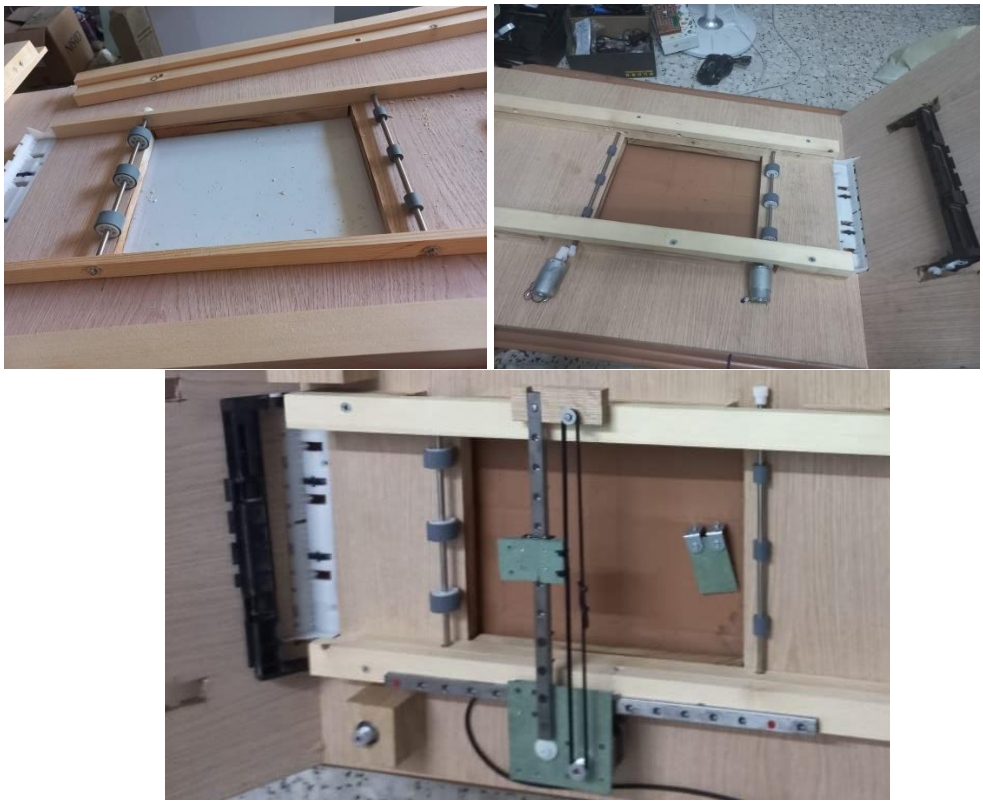


Figure 7: Assemble of the final design

- **Component circuits**

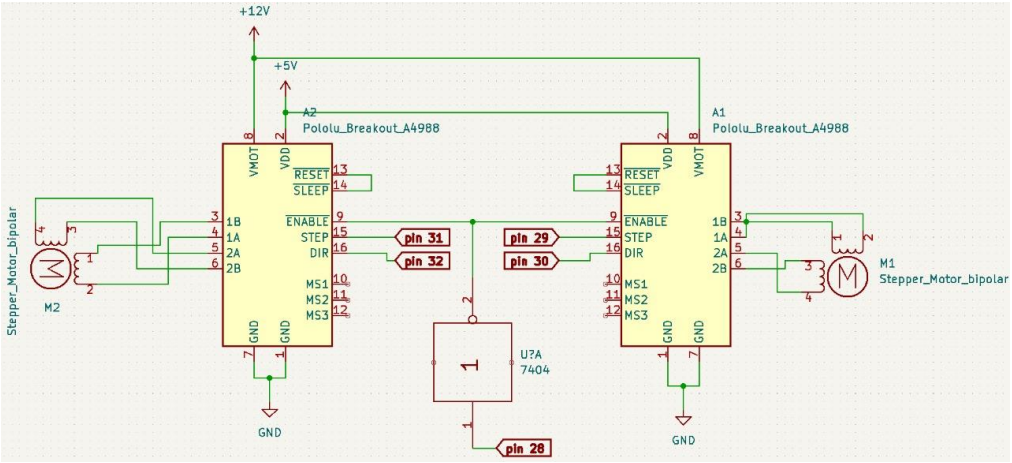


Figure 8: Stepper motors connection

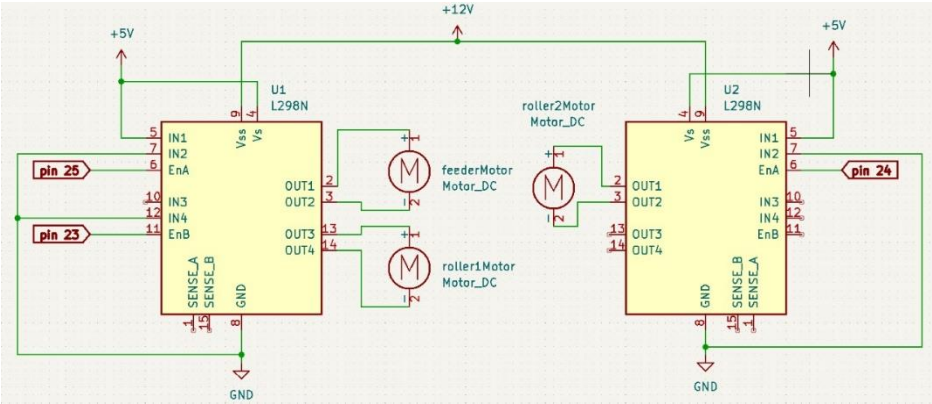


Figure 9: DC motors connection

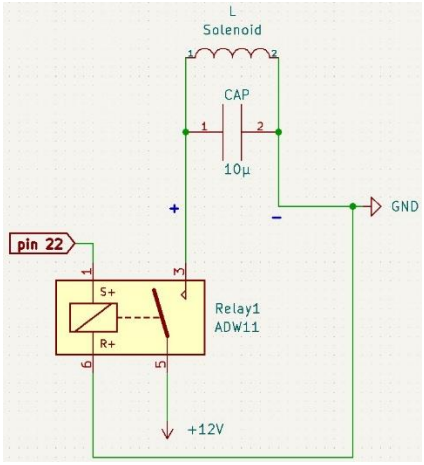


Figure 10: Solenoid connection

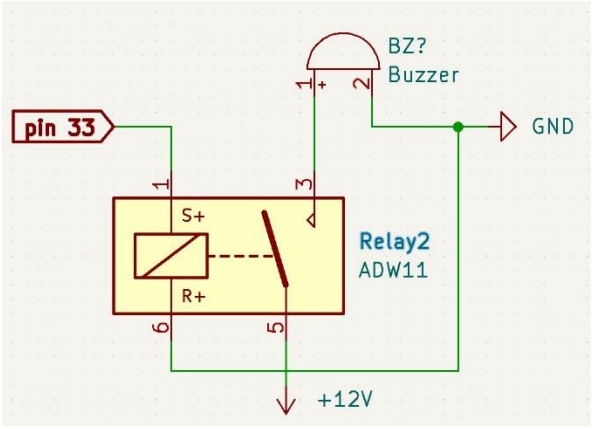


Figure 11: Buzzer connection

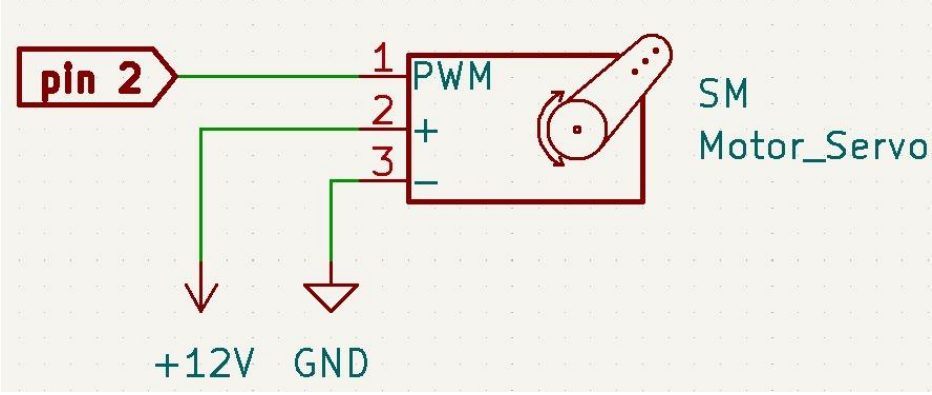


Figure 12: Servo motor connection

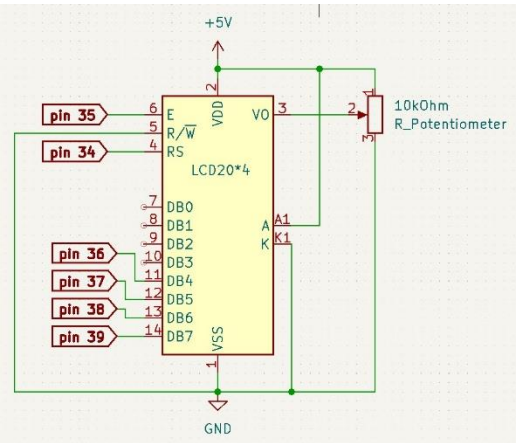


Figure 13: LCD connection

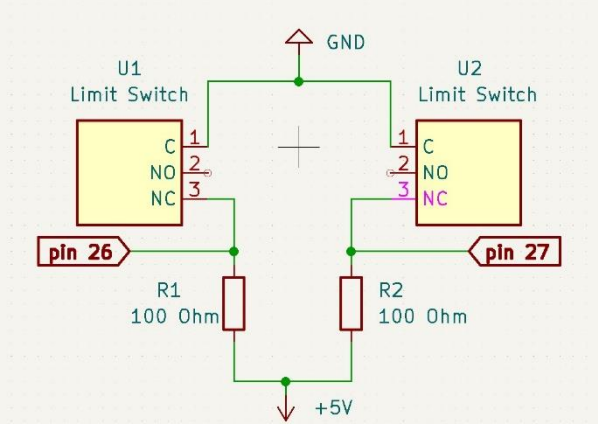


Figure 14: Limit switches connection

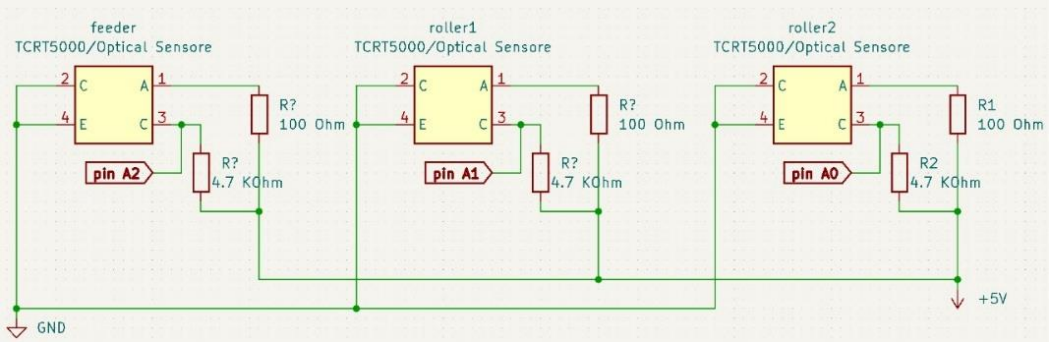


Figure 15: Optical sensor connection

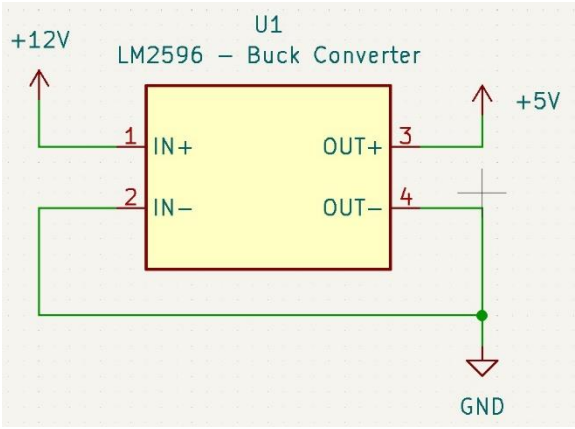


Figure 16: Buck converter connection

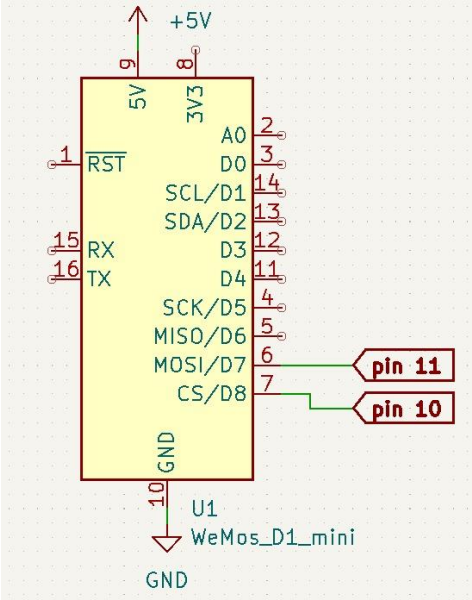


Figure 17: ESP8266 D1 Mini connection

- **The Final result of the model**

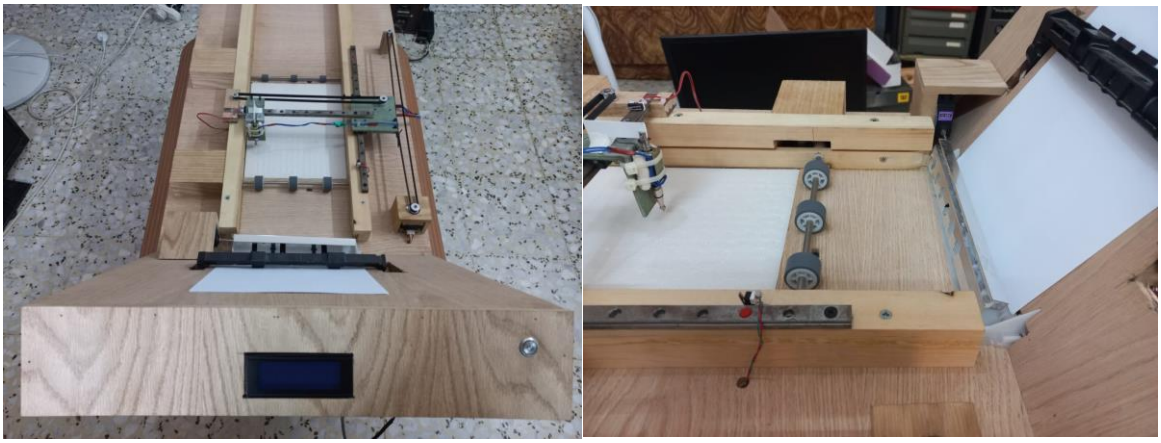


Figure 18: Top and side view of the model

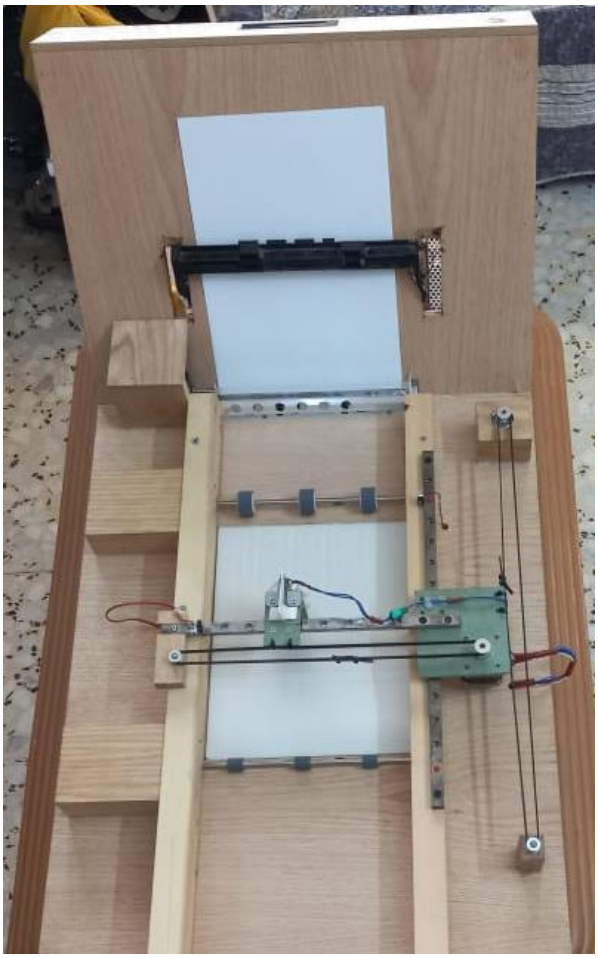


Figure 19: Complete model

- **Build Web application using React JS**

We developed a full responsive Web application using React JS with a user-friendly interface. This Web app served as a control interface for the system, allowing users to register at the application and enter text to print it.

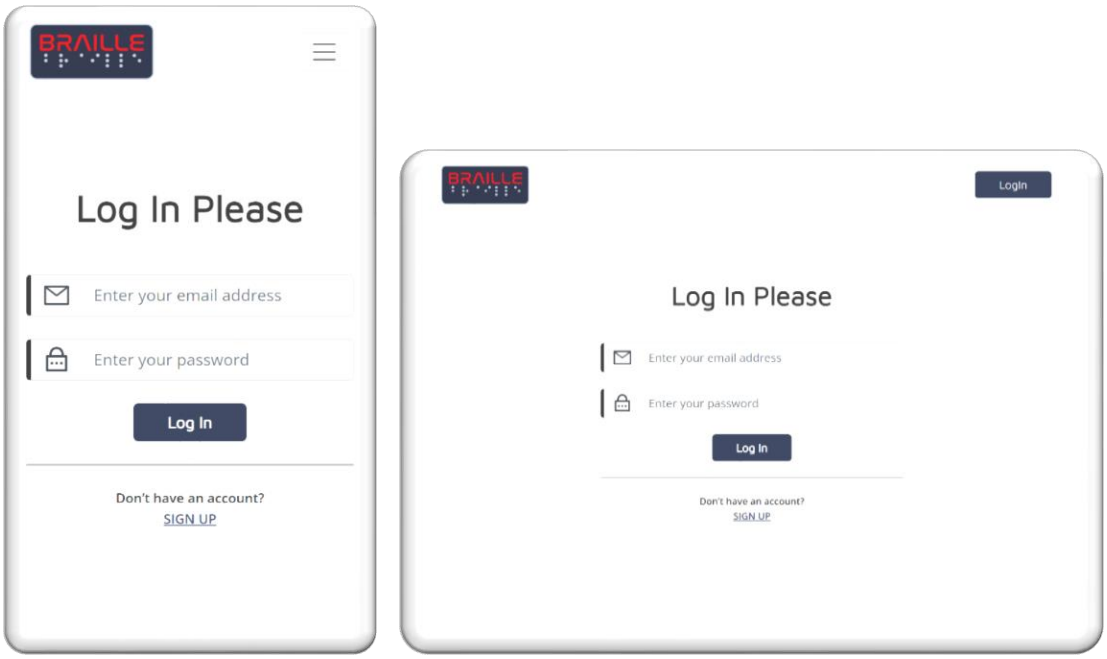


Figure 20: Log In page

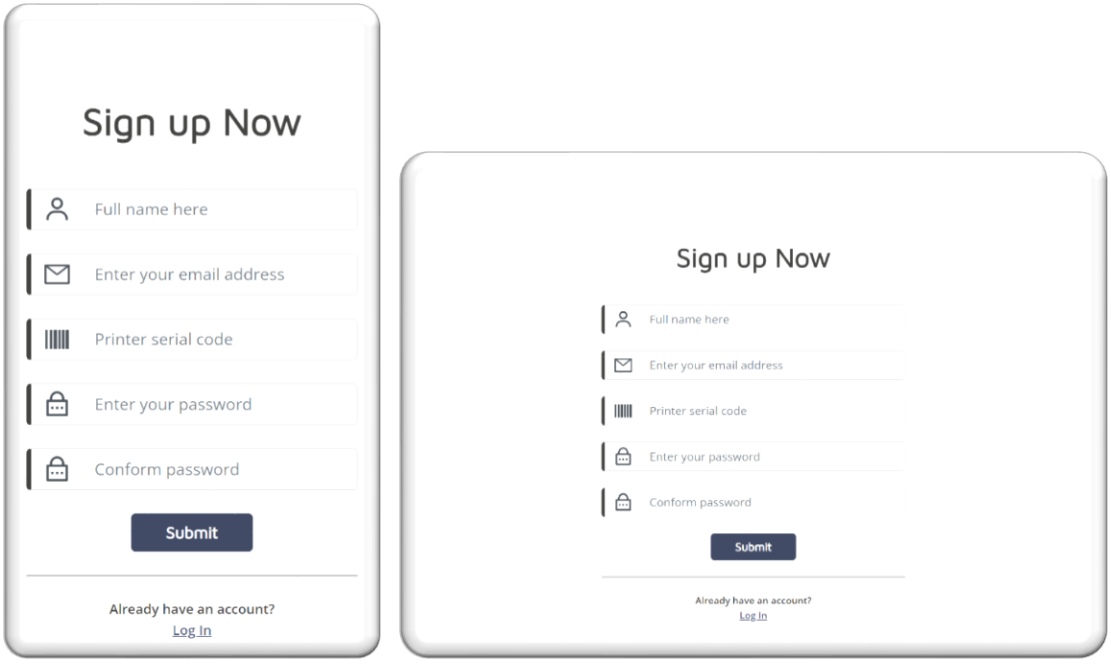


Figure 21: Sign Up page

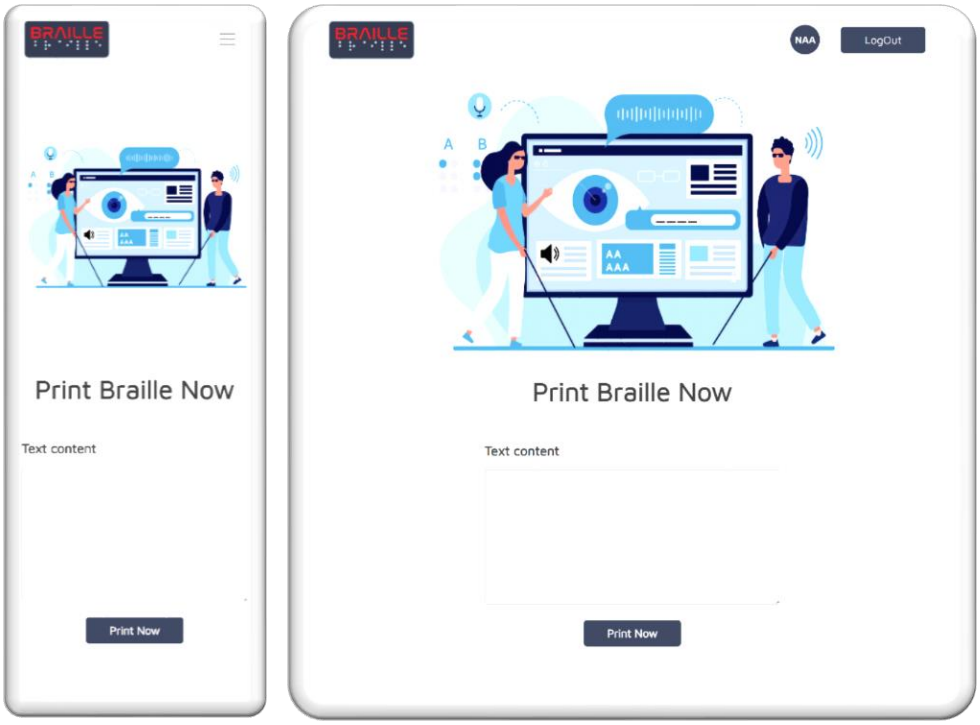


Figure 22: Printing page

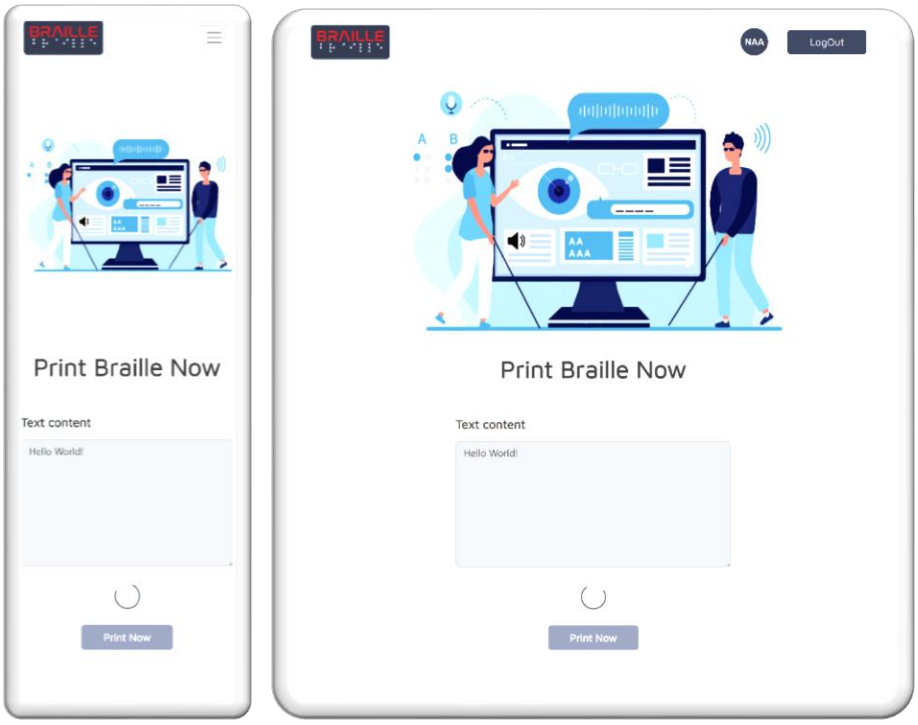


Figure 23: Start printing

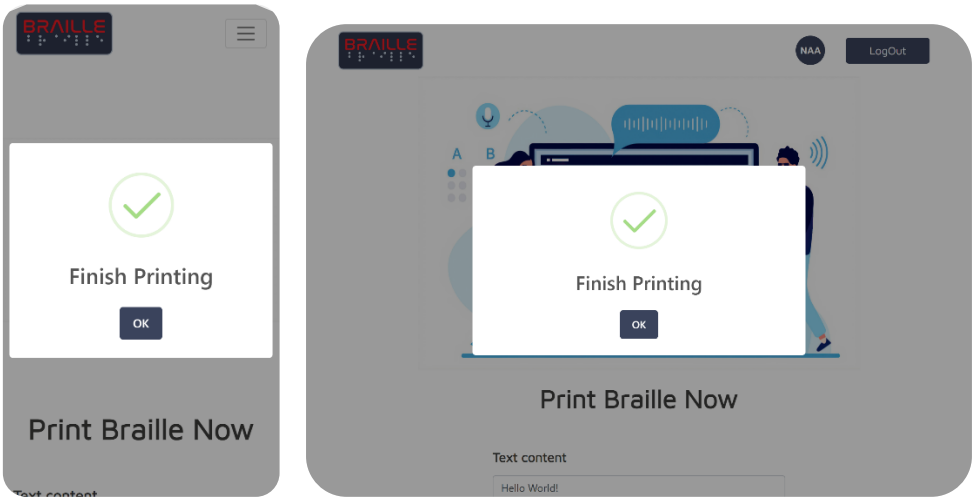


Figure 24: Finish printing

- **We use Firebase as a server and we connect the web application with it.**

- **ESP8266 model connection (WiFi):**

We connected an ESP8266 into the Arduino. The module was connected serially with the Arduino Mega by USART. This setup allowed us to establish a WiFi communication between the Arduino and a Web Server using the ESP8266.

- ## Challenges Through design

In our journey of designing the Braille printer, we encountered several challenges and successfully addressed them through diligent research and the implementation of best solutions.

1- **Unintended stepper motor rotation when powered system:** The default value of the enable pin in the stepper driver is active low. When we program the microcontroller, the enable pin is low, causing the stepper motor to turn on. This results in unintentional movement.
We solved this problem by inverting the logic of the enable pin of the stepper motor driver by using inverter IC 7404 that connecting with enable pin.

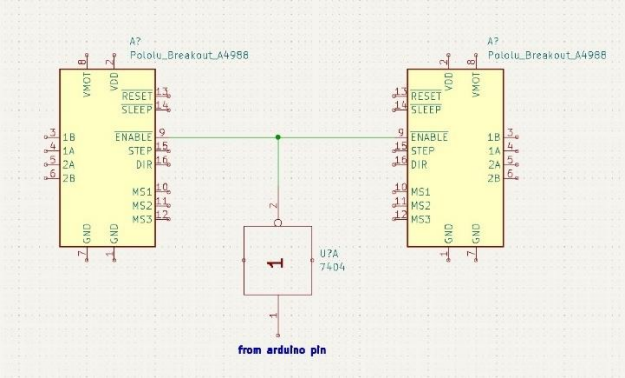


Figure 25: Connect driver with inverter

2- **Disrupting LCD character display:** The problem began to arise when the solenoid started knocked on the paper for text printing. Subsequently, the characters on the LCD became disrupted. After conducting a search, we determined that the solenoid was generating noise that affected the LCD data. To solve this problem, we added capacitor that has value 10µf that connected in parallel with the solenoid. This capacitor effectively eliminated the noise and resolved the problem.

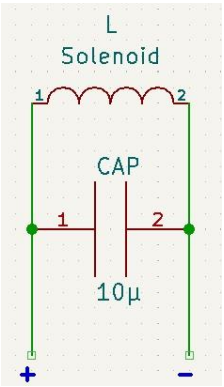


Figure 26: Connect capacitor with solenoid

- ## Standards and specifications

  - **The Brille language:** is a tactile writing system that enables individuals with visual impairments to read and write through touch. It consists of raised dots arranged in a grid, with different combinations of dots representing letters, numbers, punctuation, and even whole words. The Braille language has its own standard that governs its usage and ensures consistency in communication for people who are blind or visually impaired.

  - **WiFi technology for communication**: employed as the standard protocol for communication between the Web application using Server and the printer.

- ## Constraints and design limitations

  - **Build the suitable design:** The process involves working with woods that are inherently tough to manipulate, especially in achieving the precise and intricate shape demanded by the desired design.

  - **Handling paper:** handle paper with very small thickness presents a set of intricate challenges that revolve around the paper's delicate nature and its interactions with various mechanical systems. The difficulties mainly stem from the fact that the paper's thinness makes it less substantial and more susceptible to a range of mechanical and environmental factors.

  - **Rare mechanical components:** Some mechanical components suitable for the project were difficult to find in markets such as GT2 and MGN.

  - **Printing accuracy:** the solenoid it has a shiver while XY coordinate move and while solenoid knocking.

  - **Head of solenoid:** find the suitable head that knock the paper in correct dimension.

  - **Surface of printing area:** to be able to knocking the paper and the knock appear on the paper clearly should have mushy surface while the current surface is solid wood.

Chapter 4: Result and Analysis

Our Braille printer produces printed Braille papers of good quality that adhere to the rules of the Braille language, ensuring correct distances between dots within each character and between characters. It's important to note that achieving absolute distance accuracy between dots can be challenging due to various factors. For instance, the solenoid's precision may not be optimal and on the other hand, handling the paper presents difficulties due to its extremely small thickness and sensitivity to external factors. Despite these challenges, the overall output results are good.

Chapter 5: Discussion

Individuals with visual impairments encounter numerous hurdles when seeking to print text in Braille. Among these challenges, a prominent one is the considerable expense associated with purchasing Braille printers, rendering them inaccessible to a substantial portion of the population that could greatly benefit from their utility. Furthermore, the availability of Braille printers presents an additional obstacle.

We've developed an affordable Braille printer that's easily accessible whenever required. This printer is made up of readily available basic parts found in the market. This creative solution enables people with visual impairments to conveniently obtain the resources they need.

Chapter 6: Conclusions and Recommendation

We have constructed a Braille printer with a low cost that is readily available when needed. This printer is composed of simple components that are readily available on the market. This innovative solution allows individuals with visual impairments to easily access to the resources.

After studying the project during the design stage, we chose the most efficient approach to its implementation. Our goal was to achieve high performance based on the hardware components and project design, while also ensuring cost-effectiveness and high availability.

We gained valuable insights into effectively working with hardware components by thoroughly studying datasheets and component documentation. This comprehensive approach allowed us to understand the intricate details of each component's functionality and integration. In addition to mastering the technical aspects, we honed our skills in designing a system that ensures stability and reliability.

By delving into the datasheets, we were able to get information about pin configurations, electrical characteristics, and communication protocols.

Furthermore, our journey involved not only understanding individual components but also orchestrating their harmonious collaboration. By thoughtfully addressing these aspects, we were able to create a system that remains good and dependable under varying conditions.

Future Works :

1- Make the Web application accept formats such as .pdf, .docx, …etc.
2- Make the printer accept different sizes of papers such as A5, A3.
3- Add the scanner that scan the text from papers then send it to printer to print in in Braille.

References

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- **FirebaseESP8266**. Available: https://github.com/mobizt/Firebase-ESP8266 .
- **React JS Documentation**. Available: https://react.dev/ .
- **Firebase Documentation**. Available : https://firebase.google.com/docs .

Appendices

- **Arduino Mega code :** https://github.com/Momen-Odeh/Braille-Printer-GP2/tree/main/GP2 **.**

- **ESP8266 D1 mini code :** https://github.com/Momen-Odeh/Braille-Printer-GP2/tree/main/WIFI_ESP86266 .

- **Web application code :** https://github.com/Momen-Odeh/Braille-Printer-Web-Page .