An-Najah National University

Faculty of Engineering and Information Technology

Computer Engineering Department

Sorting Master

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Dedication

We want to express our heartfelt thanks and appreciation to our families, who have been an great source of encouragement and motivation for us during every step. Thanks for all the support, even if it was small. Finally, we would want to congratulate ourselves for our efforts and celebrate our successes.

Acknowledgement

We want to thank our families for their amazing assistance, which has been essential to our success, and to let them know how much we appreciate them. Our parents have been a source of inspiration and patience for us as they have proudly seen us grow and succeed.
Furthermore, we want to thank our supervisor, Dr. Amjad Abu Hassan, for his constant encouragement during the whole process. We also want to express our gratitude to Eng. Abdullah Al-Hinnawi for his invaluable advice and assistance during our engineering workshops. We appreciate the contributions made by all of the instructors in the department of computer engineering.
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Abstract

Certain industries face challenges in efficiently categorizing and organizing goods based on their country of manufacturing. Because it takes more time and effort, this frequently results in an increase in operational stress, which may lead to lower productivity and a lack of streamlined operation.
The "Sorting Master" proposed by our concept aims to solve this issue by providing a sorting machine. This device improves the classification procedure by offering a system for classifying goods according to their geographic location of manufacturing. The sorting machine decreases human error in the sorting process while also improving operational efficiency by automating this process.
Furthermore, Sorting Master addresses the challenges of categorizing goods by manufacturing country by providing an innovative and efficient solution.Automation increases productivity and lowers error rates. This technology has the power to transform whole industries, increasing overall productivity and streamlining operations.

0.1 Introduction

This report presents the design and implementation of a hardware Sorting machine called Sorting Master that works to sort goods according to their manufacturing country by reading their tag. The machine utilizes a micro controller called Arduino Mega 2560 along with various hardware components such as DC motor(Stepper motor), Servo motors IR sensor, Ultrasonic sensor, ESP32, LCD and RFID-RDM6300.
The project's objective is to demonstrate how these components are used and connected to the Arduino platform while creating an engaging and interactive experience.

0.1.1 Problem

The aim of the sorting machine project is to efficiently sort diverse objects according to their country of manufacture as indicated by the tag that the RFID-RDM6300 reads and records. The project attempts to improve and streamline the sorting process because traditional sorting involves a lot of time and effort.

0.1.2 Objectives

The objectives of the project are as follows:

- Develop a tag scanning-based automated sorting system that efficiently and accurately classifies goods according to the country of manufacture.

- Include a wireless control system using the ESP32 that enables users to remotely turn on and off the sorting device, offering simplicity and flexibility in use.

- Create a web page interface to show the device's state, including whether it is on or off and giving current information on the number of sorted packages using an IR sensor.

- Include an LCD display that displays each package's manufacturing country as it moves through the sorting process to provide immediate visibility.

0.1.3 Importance of the work

The development of a sorting master has several benefits:

- Quality: It aids in separating high-quality products from those of low-quality.

- Consumer Preference: Customers may favor goods from countries known for their reliability and high quality.

- Transparency and Accountability: Knowing the country of manufacture helps complies production meets international standards.

- Tracking Problems and Sustainability: It makes it possible to identify the product's manufacturing issues and determine where they originated. Additionally, it encourages sustainability by emphasizing goods from environmentally conscious countries.

0.1.4 Organization of the report

The report is organized as follows:

- Section 2 is about the constrains an earlier work of the project.

- Section 3 shows the literature review of studies and projects that are related to the same field.

- Section 4 shows the methodology employed in the design and implementation of the sorting machine.

- Section 5 provides a description in details about the hardware components used in the project.

- Section 6 explains the technical choices that were made during the designing and implementation processes.

- Section 7 talks about the things that were thought about while designing and the choices that were made.

- Section 8 describes possible future work to make the machine even better.

- Section 9 the report's conclusion, summarizes the project's accomplishments and offers advice to other students.

0.2 Constraints and earlier work

0.2.1 Constraints

-The rods for the belt:
To move the conveyor belt, we had to use two rods on each side of the belt which covered with rubber so it moves easily with less fiction and stickiness. We had a problem of getting this kind of rods because it was not available in stores. We managed to get one from a broken printer but it was too long so we had to cut it in half and cutting it was expensive because the lathe machine is not a common thing the Palestinian store because of the restrictions from the Israeli occupation.
-RFID-RDM6300:
For reading the tag we used this device that most of people don't use it so we had to do a lot of researches and work on it, and we wanted to use cards instead of tags but unfortunately it was not available in stores.Also we broke it once and when we wanted to get a new one we struggled to find it in stores.
-Time:
This project is done in the summer semester so the time of having enough knowledge to completing the project was too short specially that the workshop laboratory was opening at 9am to 3pm with two hours break in between so we had to put so much pressure on ourselves to complete it, and at the end we took it with us home to get more time.

0.2.2 Earlier Work

In computer Engineering department, we have learned many helpful classes that helped us to understand the basics and logics to make the project very well. Some of these project that was so important and essential for creating the project, like:

-Micro controllers' course and its laboratory: this course helped us to understand what are they and how to deal with them to make any project.

-Arduino Course: This one was an important course because it explained to us how to deal with the Arduino IDE and how to write codes with it.

These classes gave us the good and important skills to start a project and how to deal with the challenges that we faced in our Sorting Master Project.

0.3 Literature review

Object sorting is an expensive process that is necessary for many industrial applications. Designing a system that can recognize things and rearrange them when they satisfy specific requirements can have a significant effect. [1].

A multidisciplinary approach that includes mechanical engineering, electronics, software engineering, and data science is necessary for the development of sorting machines. The following are some of the major difficulties that engineers and designers may face during this process: Speed, accuracy, data collection and analysis, data processing and analysis, maintainability, sensing, throughput, and cost-effectiveness.

Sorting machines find applications in a variety of industries where effective item categorization and separation are crucial. The following industries commonly utilize sorting machines: Material sorting, food and agriculture, mining and minerals, ore sorting, medication sorting, component sorting, textiles, waste management, the plastics industry, plastic recycling, postal services, and grain sorting are just a few of the industries that benefit from sorting materials.

Sorting machines' flexibility and efficacy across a range of sectors significantly improve manufacturing procedures, reduce waste, and improve operational efficiency.

0.4 Methodology

0.4.1 Overview

First, we learned about each part individually. We wanted to know how they work and how to connect them to the Arduino, so we programmed each one with Arduino Then, we put all the parts together and set them up to work as one complete Project. The next part will show you more details about how we did this.

0.4.2 Components

0.4.2.1 Arduino Mega

The Arduino Mega is considered as a micro controller board which is based on the ATmega2560, which has a 54 digital pin as input and output pins, 14 of them can be used as PWM outputs. It also has 16 analog inputs with 4 hardware serial ports (UART), a 16MHz frequency of crystal oscillator and a USB connection that can be connected to computer and gives power to the Arduino device. [2]

Figure 1: Arduino Mega

0.4.2.2 Stepper Motor

The stepper motor is a type of DC motor, the difference between it and the other types of motors that its move step by step in both directions, and each step is a fixed angle. This property allows accurate controlling for positioning and rotating. We used one stepper motor that operates with +12V. [3]

Figure 2: Stepper Motor

0.4.2.3 Servo Motor-SG90

Servo Motor-SG90 is a tiny and lightweight server motor with high output power, its operating speed can reach 0.1s/60° with a +5 voltage and 2.5kg/cm.it can rotate 0°-180° in both directions, we used four servos of it to open and close the switches to sort the packets according to its suitable box. [4]

Figure 3: Servo Motor-SG90

0.4.2.4 RFID-RDM6300

RFID-RDM6300 or RDM6300 125KHz RFID is a card reader, it reads only tags and read/write cards, and it works at 125KHz frequency so it doesn't read the tags or cards from a long distance. We used the RFID to read the tag for each packet to decide which manufacturing country does it belong to. [5]

Figure 4: RFID-RDM6300

0.4.2.5 Ultrasonic Sensor (HC-SR04)

The Ultrasonic sensor is an electric device that mismeasure the distance of the desired object by sending ultrasonic sound waves which are faster than the speed of audible sound, this sound will be reflected by the object and the ultrasonic will convert these waves into electrical signal. In our project we used this sensor to check if there is an object on the belt or not by calculating the distance, so when the distance is greater than zero then the belt will move until it reaches a certain distance and then will continue moving until the packet be sorted. [6]

Figure 5: Ultrasonic Sensor (HC-SR04)

0.4.2.6 H-Bridge Motor Driver (L298N)

This driver is typically used for controlling both, the motor's speed and its rotation direction. It's a powerful tiny motor driver with a heavy-duty Heat Absorber. It can give power to 5-35V motors with a maximum current equals 2A. In our project, we used this driver to control the stepper motor that moves the belt and to manage to control the motors movement using Arduino Mega. [7]

Figure 6: H-Bridge Motor Driver (L298N)

0.4.2.7 Jumper Wires

Jumper wires are simple wires that have jumper pins on each side at the end, they are easy to connect an remove the connection, they are usually used with breadboards and other prototypes tools. There are three types of it which are Male to Male, Female to Female and Male to Female. In our project we used them to connect the components with Arduino and to connect the Stepper Motor to the H-Bridge. [8]

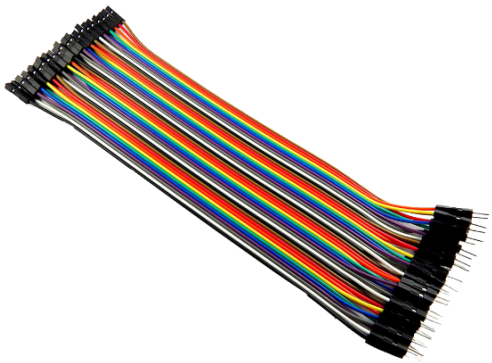

Figure 7: Jumper Wires

0.4.2.8 IR Sensor

IR sensor stands for infrared sensor which is an electronic device that detects objects by detecting the infrared radiation that's invisible to the human eyes because its wavelength is longer than the visible light. In our project we used it to count the total number of packets that is going to be sorted. [9]

Figure 8: IR Sensor

0.4.2.9 ESP32 WROOM 32

The ESP32-WROOM-32 is a potent, universal WiFi + Bluetooth® + Bluetooth LE MCU module that can handle a wide range of functions, including voice encoding, music streaming, and MP3 decoding, as well as low-power sensor networks. In our project we used this component to control the belt wirelessly with Bluetooth module and WiFi. [10]

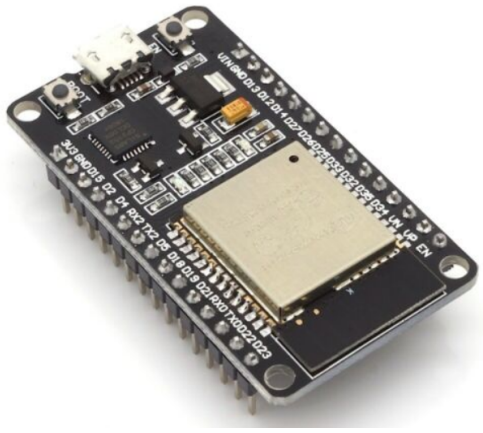

Figure 9: ESP32 WROOM 32

0.4.2.10 Power supply

Power supply is a hardware component that gives the power to other components. It converts the alternating current (AC) to steady low-voltage current (DC). The type of power supply we used in our project is the computer power supply which gives +5 and +12 voltages so we can operate the stepper motor and the other components. [11]

Figure 10: Power supply

0.4.2.11 LCD 2*16 Display

The term LCD stands for Liquid Crystal Display. It's a type of electronic displaying modules that is mainly made from multi-segment light-emitting diodes and seven segments. In our project we used the 16*2 LCD to show the country that manufactured the item. [12]

Figure 11: LCD 2*16 Display

0.4.2.12 Buzzer

Buzzer is an audio signaling device that converts the signal int voice in form of beep or alarm. In our project we used the buzzer to inform you that there is a packet passed by so each sound means that a new object is counted. [13]

Figure 12: Buzzer

0.4.2.13 10K Ohm Resistor

To establish a voltage divider circuit between the Arduino and the esp32, we utilized two resistors, each 10k ohm, as shown in the picture below. [14]

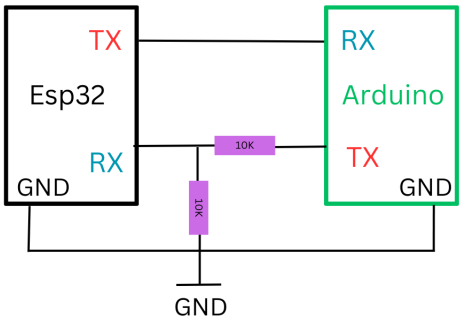

Figure 13: Voltage Divider

0.4.3 Technical choices

0.4.3.1 Web page

The languages HTML, CSS, and JavaScript were used to build the website because they offer a user-friendly interface for creating web pages. In order to create our unique web page, we carefully considered the factors that are most crucial to the sorting process, we displayed the status of the belt "moving or not", as well as the number of boxes of goods, and finally the country of manufacture of the last sorted box.

In general, the website is made to keep track of changes at each stage and watch the sorting process. We picked WiFi to show this information since it has a wide coverage range, and because we were aware of the potential risks, we refused to allow control activities through it.

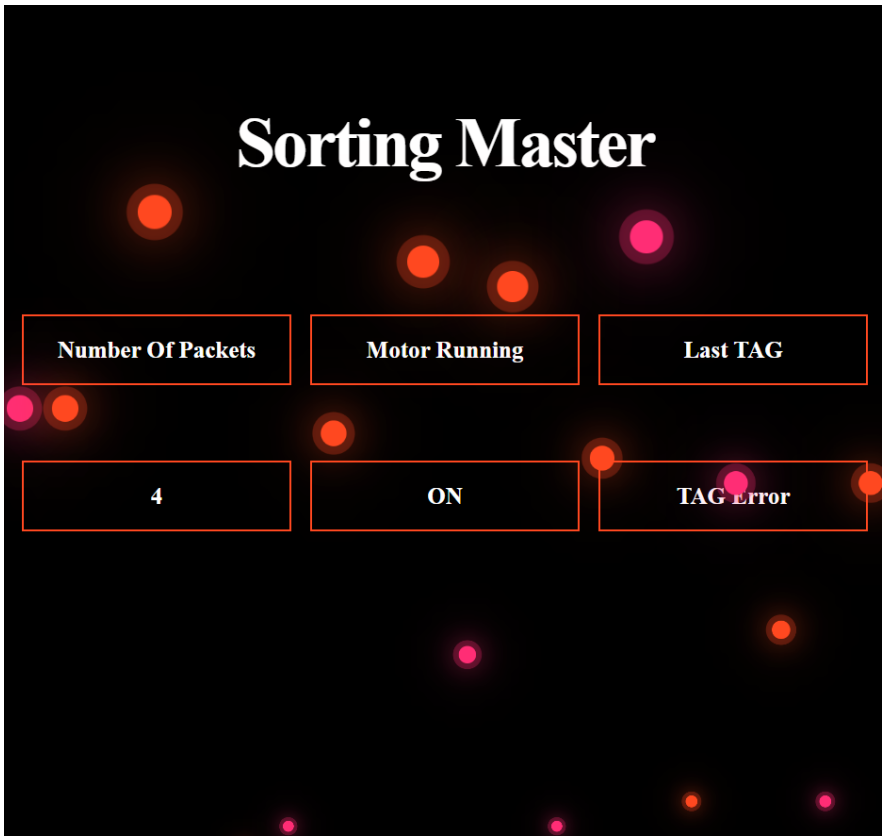

Figure 14: web page

0.4.3.2 Bluetooth Terminal

We have developed a set of commands for system control and monitoring, as well as for checking the system's status, using the Serial Bluetooth Terminal application. As soon as you pair your Bluetooth device with the esp 32, the system will inform you to the last factory in which the product was made. You can also transmit commands to check out or control the device, and these commands are as follows: Enable - This command will make the engine able to run. Disable – This command will stop the engine from functioning. Status - To determine whether the belt is functioning or not. To determine how many boxes the system has sorted, use packets.

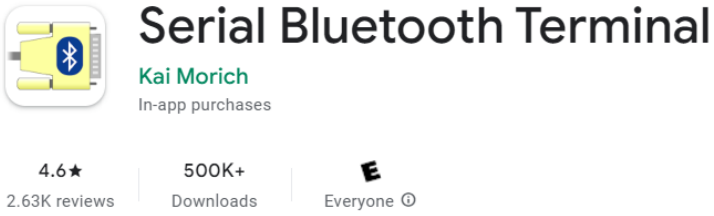

Figure 15: serial Bluetooth app

0.4.4 Process of work

In the initial stages of creating the project, we determined the requirements and needs for the project like the components and the material of the frame. the first thing we started to build is the frame, we draw a sketch for the final design and we chose the best material for it to be a strong and light-weight design so it can handle the wight of the objects and the components that will be sticked to the frame, and easy to carry with us to home and the workshop laboratory, so the chosen material is Steel instead of Wood. The second thing we stated to think about is the belt, we searched for a suitable structure for the belt so the object wont slip over the belt and can be hold very well. To move the belt, we chose the stepper motor because we want to move the belt step by step and stop it exactly at the wanted distance that's measured by the Ultrasonic sensor.
When we finished the external design, we started to use the Arduino Mega and using its simulator application which is the Arduino IDE to connect all the other components to work together as a full project by writing the compatible code for each one and using the right connection with the right pins for each component.
Also, we used the ESP32 module to control the Stepper motor and monitor the number of packets wirelessly using Bluetooth, it turns the stepper on and off by sending the commands "on" and "off "using Serial Bluetooth Terminal Application, and the number of packets will be counted using IR sensor that checks every packet that's going to be sorted. By each count a buzzer will turn on to inform you that a packet passed by, the number of packets with the status of the motor will be shown in a web page using the WiFi module of the ESP32.
Now let's talk about the stop stations that we wanted the packet to stop in them, the first one which is the point that all the packets will stop in it, the reading tag point, which is the point where RFID-RDM6300 (the tag reader) is located. The second station depends on what manufacturing country does the packet belongs to, this will be determined by the RFID tag and it will decide which servo motor from the 4 servo motors that will be moved from 0 degree to 90 degree to open the switch that belongs to that manufacturing country and push the packet to its suitable box of sorting. If the box doesn't belong to any of these countries, then the belt will keep moving until the packet fall into its "Unknown Box".

0.5 Design

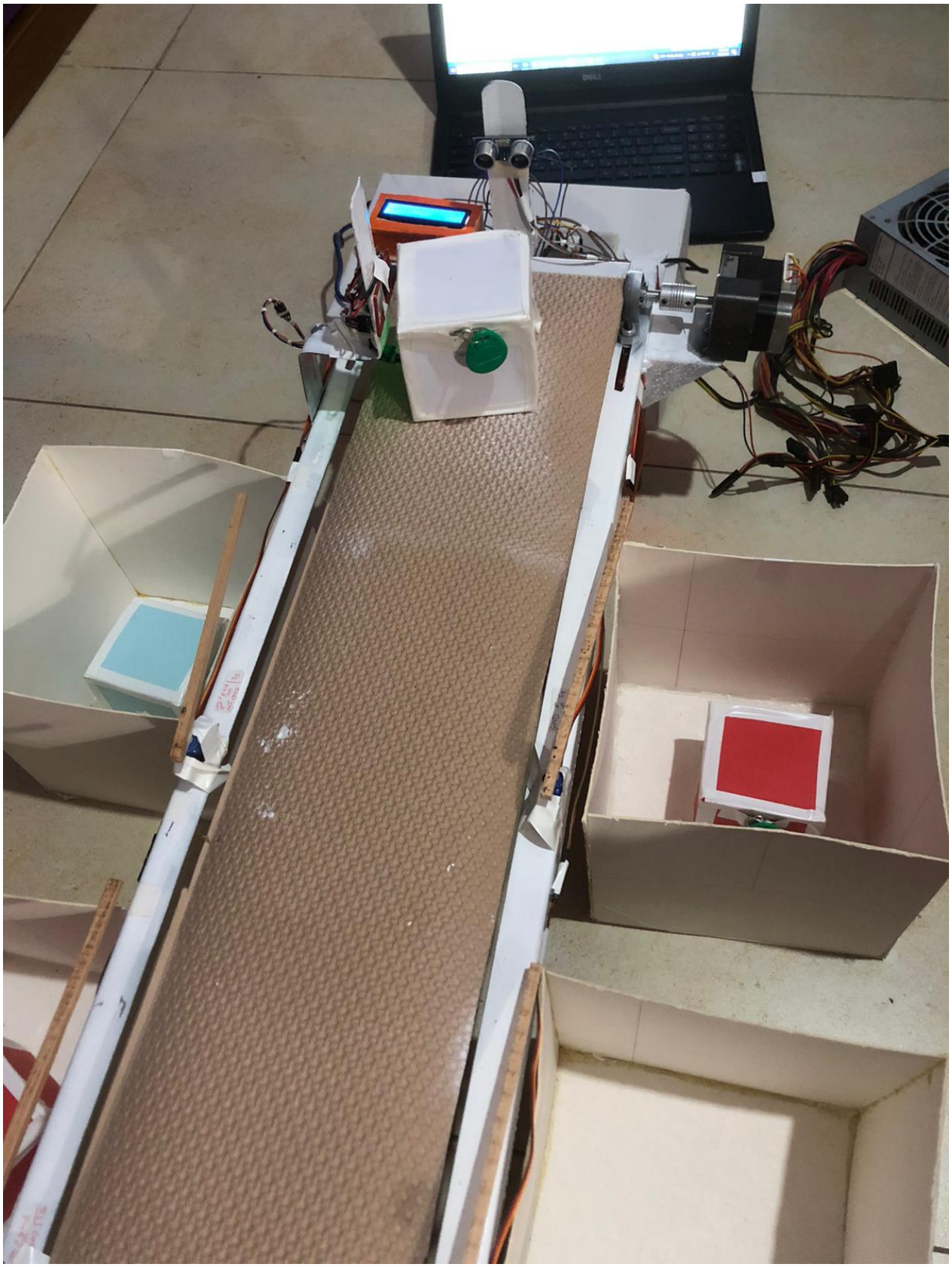

Figure 16: Sorting Machine Design 1

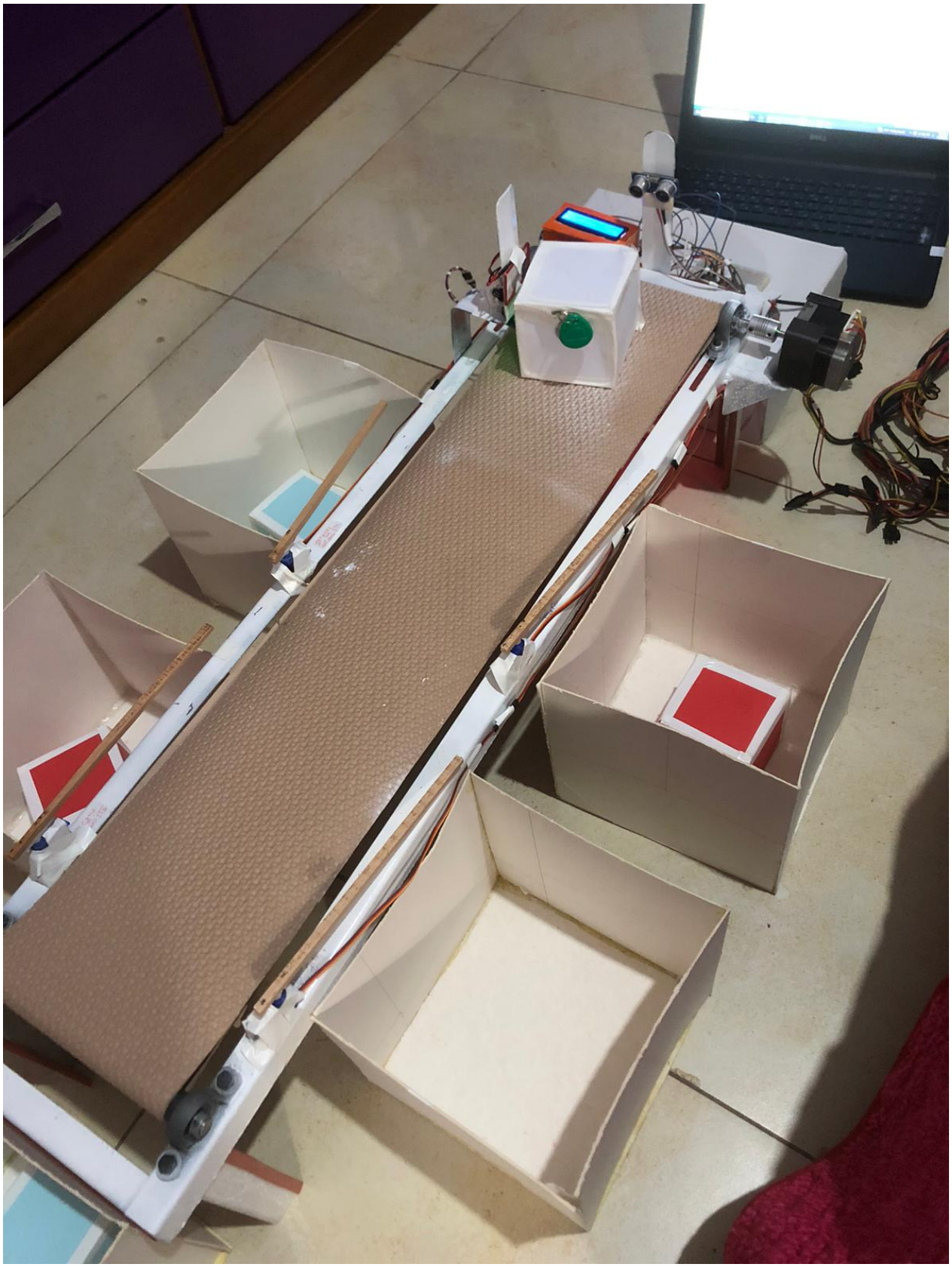

Figure 17: Sorting Machine Design 2

Figure 18: Sorting Machine Design 3

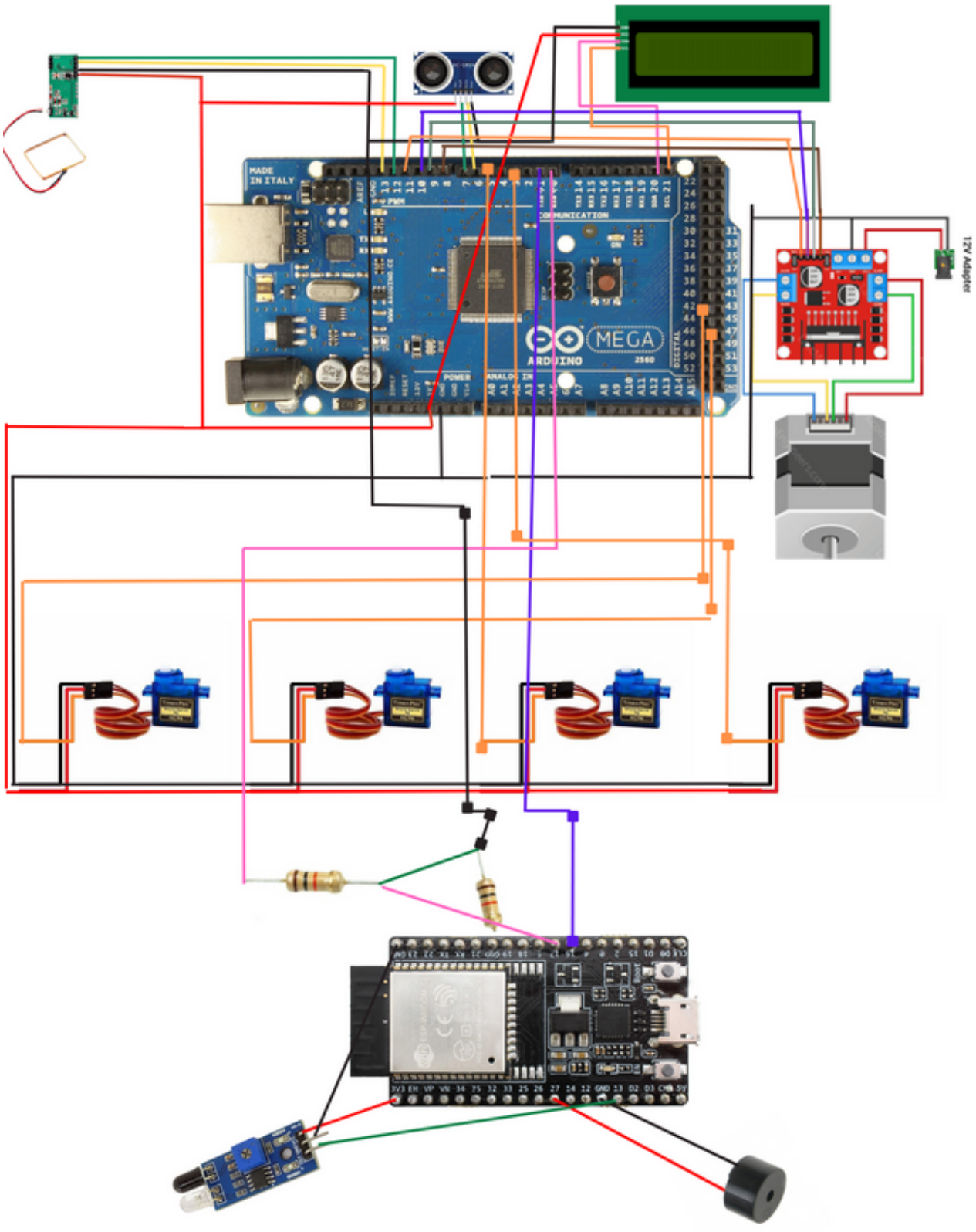

Figure 19: Interfacing Arduino with Components

0.6 Future Work

- Camera-based barcode recognition system:
Using a camera-based barcode recognition system can have several of benefits over using standard barcodes. The idea replaces barcode digits with images using image recognition technology, enhancing accuracy and increasing productivity. The system can identify boxes of goods with great accuracy by analyzing visual images from the camera using the most recent image recognition algorithms.
- Robot Arm for Sorting process:
Building a robot arm for sorting could be a significant improvement over traditional switches. To improve sorting accuracy, the robot arm can be integrated with the sorting device. We may overcome obstacles like limiting the number of various suppliers in the sorting process from 5 as in our project to a greater amount by integrating the arm with the sorting machine.

0.7 Conclusion and recommendation

0.7.1 Conclusion

In conclusion we managed to make different electronic components to work and interactive together by software programming with suitable mechanical design to create the Sorting Master machine.
We also succeeded to get the benefits of the capabilities of the Stepper Motor, servo motors, ultrasonic sensor, IR sensor, L298N driver, LCD display, RFID-RDM6300, Buzzer and ESP32 WROOM 32 module. So, at the end of the project, all the objectives were reached and done effectively.
In addition, we had the chance to create a wireless connection using the ESP32 in Both modules, Bluetooth and WiFi so we can give the user the updates coming about the Sorting Master Machine, about the motor states, number of packets and which country does it belong to, all of these will be shown on the Serial Bluetooth Terminal Application on the mobile phone.
Also the user can control the stepper motor by sending commands from the Serial Bluetooth Terminal application.

0.7.2 Recommendation

We did the project on summer semester which means the lack of time we had to finish the project, specially that we didn't get a lot of knowledge about the components and how they work, so we recommend to other students to get enough knowledge about the components they are trying or thinking to deal with, at least how they function.
The design of the project took a lot of time and there were some details that took more time to recreate and fix it, so we recommend to other students to put every detail in their mind so they don't waste any time by remembering a detail that will take time later.
We also advise students to put a plan for each step they are trying to do and if one of the steps failed don't lose hope and continue do something else. The most important thing is the consistency and the regularly work.

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