



جامعة الأمير محمد بن فهد
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Electrical Engineering

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Assessment 3:

Final Project Report

Automated Warehouse

**In partial fulfillment of the requirements for the
Degree of Bachelor of Science in Electrical Engineering**

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Abstract

As mass consumerism rises, the demand for products becomes more daunting to please, and doing what's humanly possible just isn't always satisfactory. From development facilities, to manufacturers, to simple retailers, managing item storage and flow becomes a crucial part of running a business. These days, where human error may produce faulty equipment or fail customer's trust, it is imperative to minimize; or better yet, eliminate any room for error. It's said that *a strong business is only as strong as its weakest link*, and the link of storage management can be the lifeblood of a manufacturing facility, or the product provider to the public.

Our prototype of an automated storage system would leave less room for errors and work more efficiently with respect to time and available storage space. When integrated into a supply chain system, it can send data regarding item availability and demand in real-time, allowing for more seamless business management with fewer hiccups. Our prototype will be aimed at smaller storage spaces with moderately light merchandise, thus it will mostly be made of aluminum sheets and padding where insulation is necessary. The prototype will be composed of a control terminal, a fetching/retrieving robot, and the actual storage shelves. The control terminal stores the different IDs of the slots as well as their locations and contents, while the robot will move items in and out of the storage slots on command.

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Introduction

1.1 Project Definition

Design an automation warehouse system (AWS), which is a robot that is responsible of picking up items and transporting them in their storage. This system is working with a battery of 12V. The robot can be controlled by card and Arduino and in order to make the Arduino works, there is a code that is going to be written in Arduino program. The basic elements of associate degree ASRS are:

- Storage and retrieval mechanisms.
- Storage racks and robot structure.
- Machine coded behavior.
- Wireless connection, internal database, and user interface.

1.2 Project Objectives

Our product has a lot of benefits in warehouses and we choose it because it is really helpful to store our items. The following information tell us why this product is so important to the industry:

1. **Ease** storage management.
2. **Increase** storage space efficiency.
3. **Minimize** storage errors/misplacements.

1.3 Project Specifications

1. Uses unique ID tags to identify storage slots.
2. Low power consumption.
3. Uses stationary and wireless control terminals.
4. Keeps track of in-storage items.

1.4 Product Architecture and Components

A monitor sends a signal to the ID reader to read an ID and that ID will be sent to the microcontroller. The microcontroller checks if there is a match. If there is a match, it will send distance variables to the other microcontroller through the Wi-Fi communication. The robot's microcontroller moves the base and the platform based on the distance values. Additional monitoring sensors are used to keep track of the items in storage.

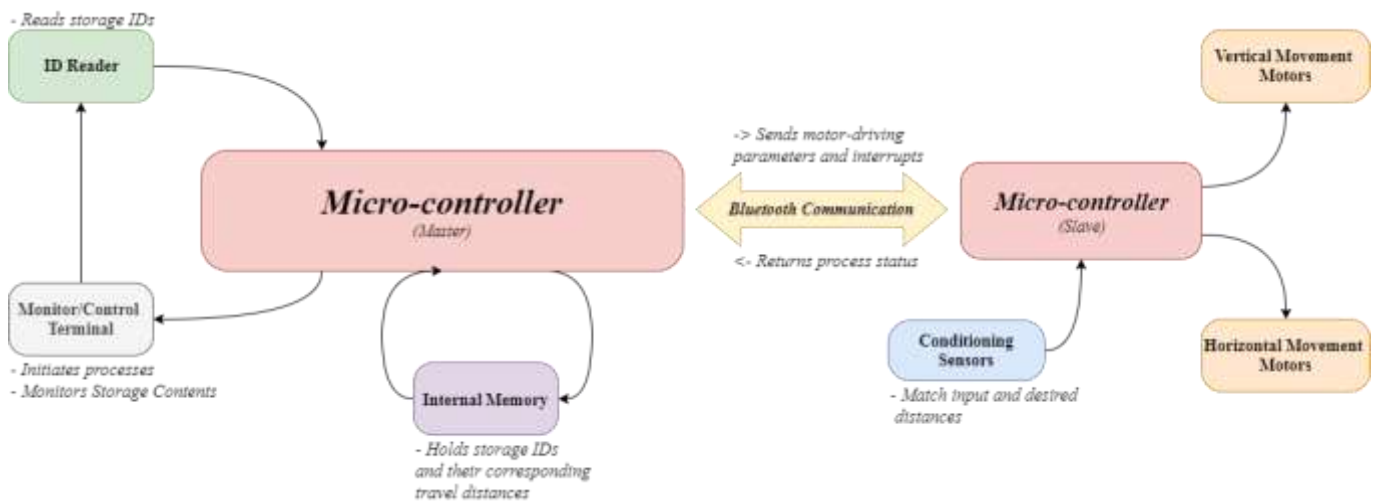


Figure 1: (product architecture).

Because not all of the individual components don't directly contribute to the overall project's behavioral architecture, here's a list of all the components used thus far:

- 12 V Battery
- 2 Circuit boards
- Various resistors and LEDs
- 2 Microprocessors (Arduino Mega and Uno)
- Arduino RFID reader module (MFRC522)
- 3 Arduino Bluetooth modules (HC-05)
- H-Bridge Arduino module (L298N)
- Wires (jumpers, battery, motors, etc.)
- Aluminum racks and shelves
- 3 DC stepper motors
- 3 Pairs of linear guide rails

- 2 Arduino Ultrasonic sensors (TBD)
- 8 Linear bearings

1.5 Applications

- In a typical warehouse or factory to Manage Buffer Storage
- It could be helpful to use this product in the library to read whatever the book you want rather than go and search for the book that you need.
- Using automated storage system in medical storage to bring medication from its storage.

Literature Review

2.1 Project background

Nowadays, as humans we might make errors, such as we might produce faulty equipment's, or making a mistake while creating a product and that will lead into losing the customer's trust. Our job as electrical engineering students is to avoid these kinds of mistakes by providing a good product that has no errors, so our product can be desirable and gain customer's trust. An automated storage system would leave less room for errors and it works properly with one condition providing more space. The robot can deliver items depends on the availability of a place.

2.2 Previous Work

We did research on previous projects similar to our project, we found two different projects that don't have as many features as ours. First project was only a system, which is capable of keeping track of item locations and quantities. Second project, it is a system that shows where each item has been stored and it leads you to every items place. Our project is going to provide many features such as having a robot that can transfer the items into and out of storage.

2.3 Comparative Study

Table 1: Comparative schedule of our project and previous projects

Projects	1	2	Our Project
Automatic coordination	√		√
Communication method	Wi-Fi and Dataspace	Wi-Fi	Bluetooth
Movement method	Railing	Forklifts	Railing
Storage monitoring	√	√	√
Monitoring method	Sensors/ Dataspace	Sensors/ Dataspace	Dataspace
Operation interruption		√	√

3. System Design

3.1 Design constrains

3.1.1 Design Constraints: Engineering Standards

In our project, we used 12V battery as standards. We used unique ID tags to determine where to put each item. In our automation warehouse, we are using DC rechargeable battery to reduce downtime by allowing the robot to recharge while idle.

3.1.2 Design Constraints: Environmental

Our environmental constraint was focusing on building an automation warehouse system that depends on our financial situation. Most of factories would take our project and apply it in reality with cheap employment. We need to make researches, and visit some factories to make a conversation with employees to gain some information for our project. Knowing the errors they are facing is our concern in order to avoid these mistakes and creating satisfactory automation warehouse system. The most important question is can they get benefits from our device in their factories? Then we can decide if our project is expensive or not based on the materials that we are using.

3.1.3 Design Constraints: Safety

It is a safe device where we can control the robot from a long distance, so there is no danger on human's lives from our device. Dealing with these kinds of devices in the field could harm the employment and objects may fall down if the material of the platform wasn't good enough to carry heavy objects and that's why we are choosing good materials to avoid these kinds of errors that could be harmful. If the project was harmful, we would lose customer's trust and our product wouldn't be desirable. Our country strives towards development of technology and progress that comes by choosing good quality and being accurate on every single thing in our project to get a successful one with good results.

3.2 Design Methodology

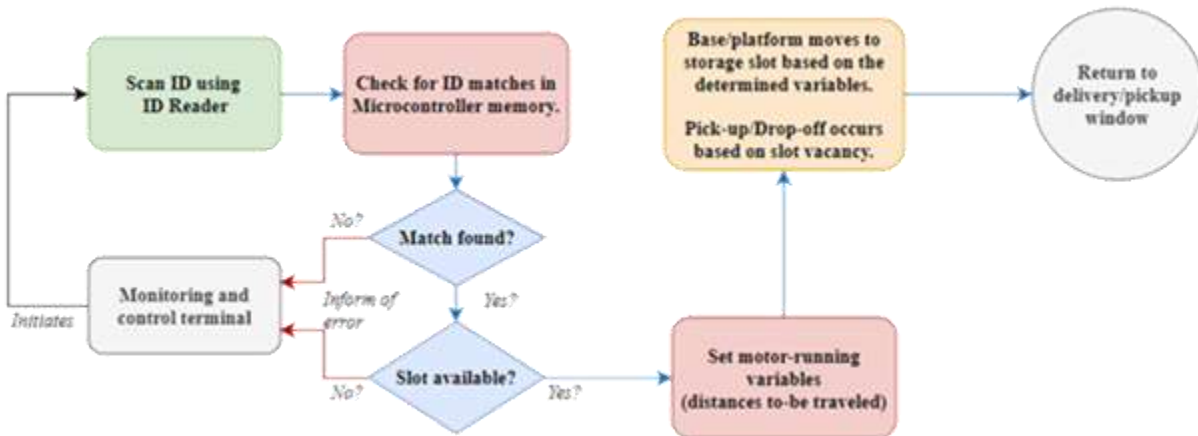


Figure 2: The Project Process Procedure

- **Basic mechanical model:**
Most of the non-electronic components will be made out of aluminum whenever possible due to its relatively lightweight and sheer force resistance. The robot will be fixed on an array of motor-aided rotating linear guide rails, and run in-between two sets of storage racks.
- **Body movement**
The robot-running Arduino board will instruct the motors to rotate the appropriate guide rails, with the aid of the linear bearings, to move the robot towards either end of the rail based on direction of rotation. The motor-running sensors fixed to the robot allow it to move set distances before stopping in order to store or fetch items based on the instructions given.
- **Processing and communication:**
The microprocessor connected to the user terminal, referred to as the master, processes RFIDs, stores them in its internal memory, matches IDs to actual locations in the storage, and takes instructions on further operations from the user.

Additionally, it communicates with the robot through a secure two-way Bluetooth communication.

3.3 Product Subsystems and Components

3.3.1 Product Subsystem1: Robot body and Movement

Body material:

In the first subsystem, we had three optional Body materials: aluminum, thin steel sheet, and hardened wood. Each body material has positive and negative aspects but we selected aluminum for the sheet, because it has least negative aspect and it has positive quality that we considered which are, easier to modify, average weight, and bends under pressure. In addition, we have chosen hardened wood for the base, which is going to be on the top of aluminum sheet. The reason why we chose wood for the base is because the wood is easier to customize, and it is cheaper than aluminum and steel. Steel sheet is the one we avoided because it needs insulation, and its weight is so heavy.

Horizontal Movement:

In this semester, we come up with a new idea for the robot's movement. Our first subsystem is the horizontal movement. The base robot is going to move horizontally over aluminum sheet. The horizontal movement is going to be controlled via motor and the motor is rotating a screw, the screw and the motor is attached together by shaft coupler. The screw is drilled in the middle of the base robot from the sides to control the movement horizontally. The motor we have chosen is a stepper motor due to its usage for high torque. Horizontally, the base robot takes one minute to reach the last location and half minute to fetch an item, then it takes one minute to go back where it initiates

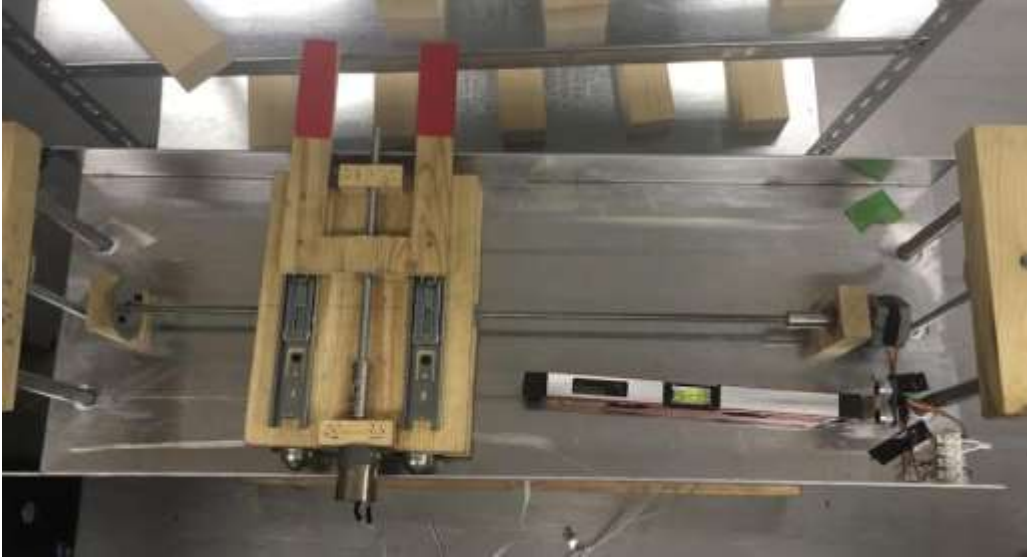


Figure 3: Product Subsystem1: Horizontal movement.

3.3.2 Product Subsystem2: vertical movement and wireless communication

Vertical movement:

For the vertical movement, we choose linear guide rails. We bought a sheet of wood to stick four linear rails: two of them are on the right side and the others on the left side. We designed two bases with three holes from downside to upside. The base has three holes: one on the left and in the middle and on the right. All of them are drilled from downside to upside. The right and the left hand side holes have linear bearings that makes linear guide rails move upward and downward easily. The hole in the middle is used for the screw that is attached with the motor to control the movement. We made a sheet out of wood for keeping the system fixed on it. The wood sheet has three holes: on the right hand side, and on the left hand side. These holes are drilled to place the linear guide rails and the stepper motor. These stuff are designed to make the horizontal movement easy. We check if everything that has been designed fits together or not. In order to make everything works, we had to measure the radius of the linear rails, so we can drill a hole on the wood sheet with the same radius of the linear rails, as well as, we get the measurements of the stepper motor to make a place for them. After designing every part of our prototype, we went to our lab at prince Mohammad bin Fahd University and

attached each part we designed together, and that requires a lot of mechanical work. We have storage with two shelves that are facing the mechanical prototype that we designed. We faced some obstacles about the design and the measurements but all of these took us a while to be solved. Vertically, the base robot takes one minute and a half to go down and half minute to fetch an item, then it takes one minute and a half to go back where it initiates.

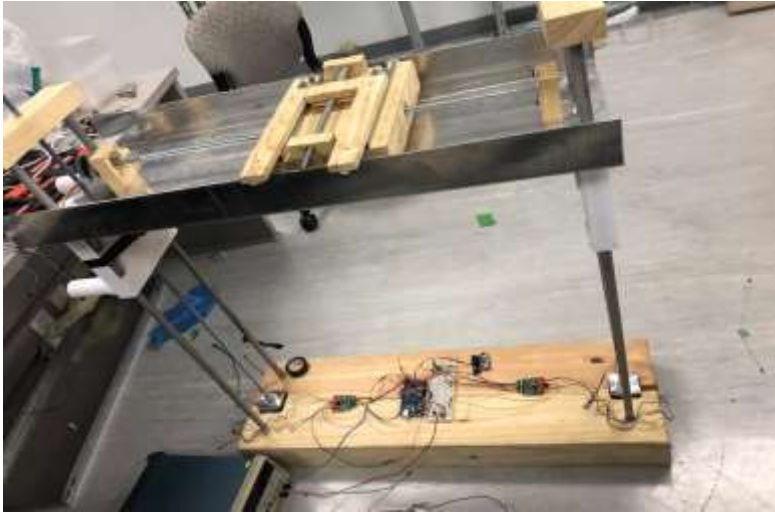


Figure 4: Vertical Movement



Figure 5: The Storage

Wireless communication:

By having two separate microprocessors controlling the system that we have as you can see *Figure 6*, there had to be some connection between them; either wired or wireless. We opted to go for wireless communication to give ourselves more freedom with the robot's movement. After researching WiFi, radio, and Bluetooth modules for our Arduinos, we settled on Bluetooth communication as we only needed to send simple commands across a short range at a low power consumption. To do this, we paired two HC-05 Bluetooth modules, and used their serial communication to send data back and forth a few bytes at a time. These data packets may

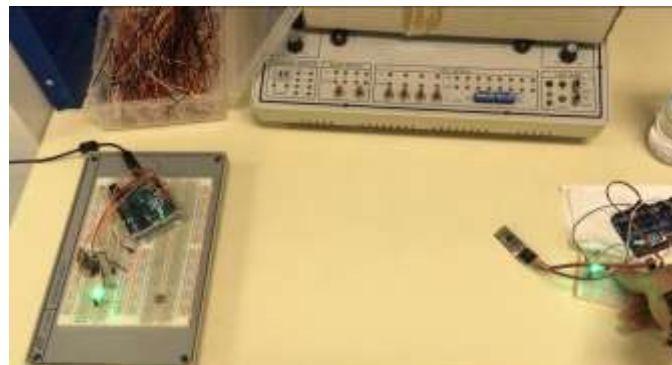


Figure 6: Wireless Communication

include the distance needed for the robot to travel, interrupt commands, status updates in case of a failure, and so on.

3.3.3 Product Subsystem3: Fetching Mechanism

Our way that we have chosen for collecting the item is forklift. The base is made out of wood and there is a piece of wood in U shape is stuck on the top of it as shown in *Figure 7*. The U shape can move forward to carry the item and go backward. There is a slider drawer under the U shape, which is making the movement easy for the U shape, as well as, it is a support to carry heavy weights. We can control the U shape using a motor and the one that controls the movement is the screw, which is drilled in middle of the u shape and it is attached to the motor through shaft coupler



Figure 7: Base Robot

3.3.4 Product Subsystem4: Refinements

Once we had the mechanical model and all the motors and mechanisms in place, it was time to get everything to work together cohesively. This included the following:

- Refining the vertical, horizontal, and fetching mechanisms to move in specific sequences based on each possible storage slot and whether the system was executing a fetch or store operation.

This involved making use of multiple trial and error iterations based on different sensor inputs (ultrasonic, IR, line-following, etc.) and several coding techniques (if-else statements, interrupt commands, void loops).

- Providing a cohesive and simple user “interface” that can be accessed through a serial monitor using the Arduino IDE desktop app, or any other Bluetooth-based serial monitor on mobile devices.

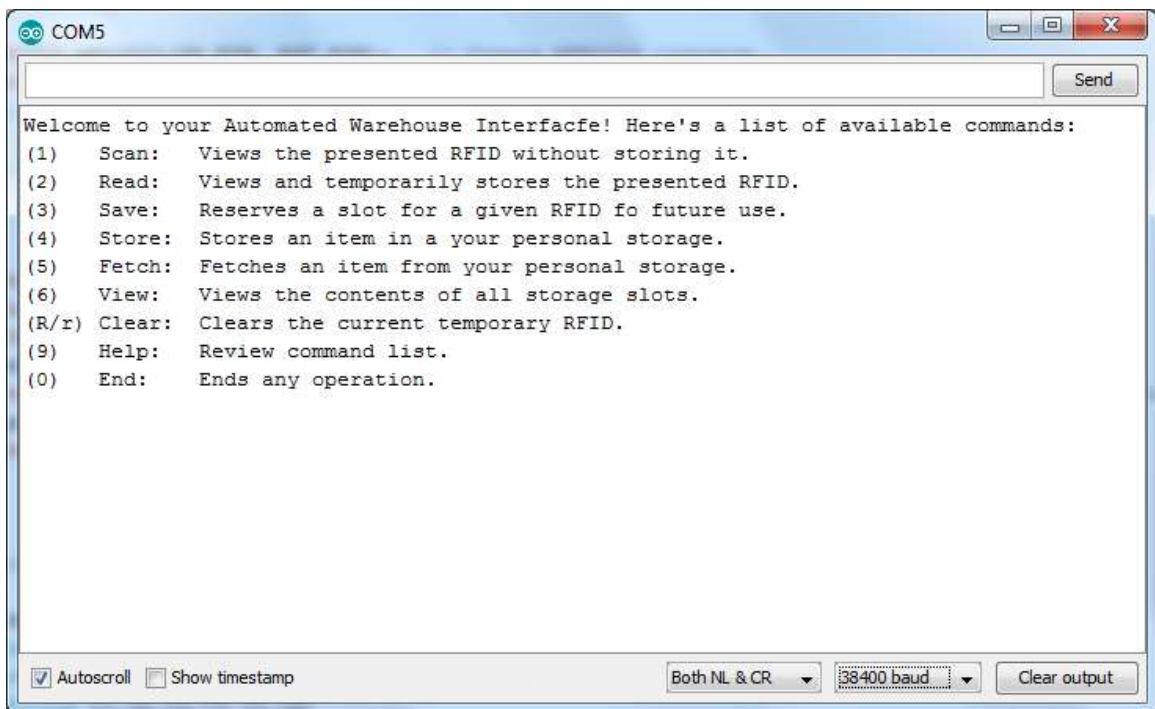


Figure 8: Automated Warehouse Interface

This makeshift interface provides the user with a short guide text to each input they have access to, and they only need to input the number or case-specific letter and follow the instructions.

- As a result of using some heavy-duty stepper motors, the current draw during normal operation is quite high for our goal of low power consumption. To reduce the effect of this problem as much as possible, we made use of some special motor drivers that allow us to shut the current altogether.

Of course, balancing this to increase power efficiency comes at a compromise to motor wind-up time, for which we reached a middle ground through further testing.

3.4 Implementation

- First of all, we were thinking about building robot that is capable of moving horizontally and vertically, so we searched on the Internet about the materials. We considered three of them, which are, aluminum, thin steel sheet, and hardened wood. The chosen ones are, hardened wood, and aluminum. We avoided the last choice, which is thin steel sheet because it needs insulation, and its weight is heavy.
- We selected each component based on the idea that we are given from one of the engineers who is working in Saudi Electricity Company, which is building an automated warehouse that moves through a card, as well as, having more room space.
- We implemented our design by starting with circuit that has ID reader and it is connected to the Arduino. The motors of the robot are connected to a breadboard. We wrote a code for four cards, each card has specific location to go to. The robot goes to the location based on the reading of RFID, because each card is set to a specific location.
- We checked the operation in front of the Instructor and everything was working properly. We set the card to let the robot go to a specific location to fetch the item, then it goes back where it initiates. We wrote a code that when we use one of the cards the robot go to the first shelve to fetch an item from a specific place then goes

back where it initiates. We set another card to go to fetch an item from the second shelf from a specific location. To summarize our project go to a specific location depending on the order of the cards.

4. System Testing and Progress Analysis

4.1 Subsystem Testing

Location

Our objective is to work as teamwork, so we found out that the best place to work in was at Prince Mohammad bin Fahd University in the project room. We brought all the components to the university then we tested each component. Every component was working properly, so we started to work on creating our robot.

4.2 Progress Analysis

Completed work:

From previous semester we were working on a body that moves through the rail and that work has been done. This semester, we are working on a different idea which two storages that are facing each other symmetrically. We have done the whole storage. We finished written the code for wireless communication and it is already done to test the model once we get it done. The mechanical module has been done, as well as, the coding for ID reader and how we can control the movement. We completed the whole requirements for the project. The project meets the objectives, which focuses on how to make the ID reader reads each card and giving orders to the system which location should the robot head to.

Remaining work:

Our design of automated warehouse is done, so we have no remaining work. We are now focusing on testing to check there is any error and to make sure that is everything is working properly.

5. Project Management

5.1 Project Plan

ACTIVITY	PLAN	PLAN	Assigned	ACTUAL	ACTUAL	PERCENT	Actual (beyond plan)		% Complete (beyond plan)												
	START	DURATION	To	START	DURATION	COMPLETE	Periods (Weeks 1-15)														
							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cont: Design subsystem 2 (Warehouse movement rail and vertical platform)	2	5	ALL	2	6	100%															
Designing rail setup overhaul	2	1	ALL	2	1	100%															
Ordering new components **	3	1	YA,MA	3	2	100%															
Building new rail and racks setup	4	3	YA,MA,ME	6	3	100%															
Wiring and coding new movement functions	5	3	MA,ME,NY	6		100%															
Establishing wireless communication between master and slave microcontrollers	6	1	ME,MA,NY	3	1	100%															
Prepare midterm Presentation	7	1	ALL	7	1	100%															
Design subsystem 3 (Fetching and Storing Tech)	8	4	ALL	8	6	100%															
Consult advisor regarding fetching and storing mechanism design	8	4	MA,NY	8	7	100%															
Ordering mechanism components	8	1	YA,MA	11	4	100%															
Building and wiring mechanism	9	2	ALL	13	2	100%															
Coding fetch and store protocols	8	2	ME,NY,YA	14	2	100%															
Testing operation	10	2	ME,NY,YA	13	3	100%															
Design subsystem 4 (System Refinements)	11	5	ALL	13	3	100%															
Refining vertical and horizontal movement	11	5	YA,MA,NY	13	3	100%															
Refining fetch and store protocols	11	5	ME,YA,MA	13	3	100%															
Refine user "interface"	11	5	ME,NY	13	3	100%															
Prepapre final report	12	2	ALL	15	3	100%															
Prepapre final presentation	12	2	ALL	13	3	100%															
Prepare project demo	13	3	ALL	15	1	100%															
Submit Rpt/PPT/Brochure	14	2	ALL	15	1	100%															

5.2 Contribution of Team Members

Table 2: Contribution of Team Members

Task	Mohannad	Mustafa	Nour	Yousif
Search & Acquire Components	30%	10%	20%	40%
Design & Implementation	15%	35%	15%	35%
Research and Problem-Solving	25%	25%	35%	15%
Physical Construction	25%	15%	25%	35%
Circuitry and Power Management	25%	25%	20%	30%
Coding and Testing	10%	40%	10%	40%
Write Reports & Presentations	25%	25%	40%	10%

While we all pitched in wherever we could, our plan of action was to primarily let our members handle the areas they're most proficient in. Mustafa was mainly responsible for coding, behavior testing, presentation design and some circuit building when required. Yousif was mainly responsible for mechanical design and implementation, component assembly, seeking out component sources in the market, and power management. Nour was mainly responsible for research, information acquisition, writing reports, and hosting most group meetings outside of PMU. Mohannad, being the leader, was responsible for keeping group cohesion, keeping track of deadlines, fetching necessary components, and -due to his overall good skills in most disciplines involved in the project- assisting the other group members under pressure.

5.3 Project Execution Monitoring

In this section we are covering the various lists of activities:

- Meetings with Advisors

We had a discussion with instructor couple of time. First of all, in the first meeting we talked about testing several of operations about the base movement and the lifting such as motor gears and color following tags. After the final presentation, we were given some feedback about what we presented such as some quality of life improvements like battery monitoring and more accurate movement using speed encoding.

- Team meetings

We met a couple of times. Our objective was to develop our project and achieve our target within a specific time. In order to make a special product with more features we used to meet regularly and each one of our group members used to come up with a new idea and that will help our project to make it more desirable. Last two meetings, we were under pressure because we started working on building our system, so we missed the meetings.

- We tested motors, motor speeds, RFID sensors.

5.4 Challenges and Decision Making

- Problems with team members not cooperating/meeting.

In the beginning of planning to do the project we faced a lot of busy members because of some courses that they have been taken and the conflict of the free time for each member so we have just the weekends to work together

- Problems or delays in procuring required parts/components/tools.

For the delay, we faced a couple of delays refer to some parts that have to be designed in a specific form and shape. Also, the availability of some components for subsystem 2 forced us to order some of the stuff online

, Which made us wait for a couple of days to have the components delivered to us. Furthermore, we have to write a code on Arduino program that matches our operation system, so if we faced some errors in the code, we edit it.

- Problems with equipment or components not working or malfunctioning.

In the implementation the instruments that we buy were all working but when we started to work on our circuit, one of the components burned out which was heat sink so we had to replace it with DC battery. Other than that everything was working properly.

- Started to redesign the whole system in assessment III course.

Our previous work was about aluminum vehicle moving on the ground in front of storage. We avoided our previous semester work because of the stability and the vehicle wouldn't be able to lift heavy weights. Otherwise, the items would fall down. Throughout the semester, we spend a lot of money on the design, but most of our money were wasted because it wasn't the proper design that would meet our goals. We wasted over 1700 SAR because of misunderstanding the mechanical module that we are required to do. We redesigned the whole prototype by making a system that is capable of moving vertically and horizontally using linear guide rails and screws attached with stepper motor

- Come up with proper idea cost use a lot of time.

The previous ideas that we had cost us more time, which made us rush in the last three weeks of the semester, because we had the proper idea in the last month of the semester. We faced many obstacles during the semester; these obstacles included hardware misfires, component shipping delays, incompatible software, etc.

5.5 Project Bill of Materials and Budget

Table 3: Project Costs

Item	Quantity	Unit Cost (SAR)	Subtotal
Frame	Total	500	500
Robot Body	Total	150	150
Control Unit (Arduino)	2	80	160
Rails + Bearings	Total	300	300
RFID Reader	1	40	40
Bluetooth HC05	3	40	120
DC Battery	1	45	45
Stepper Motors	2+1	175+110	460
Motor Drivers +Sensors	4+2	65+40	340
			Total: 2,115 SAR

6. Project Analysis

6.1 Life-long Learning

In this section we acquired new knowledge that is helpful in our project while we were working in our project with each other

- New hardware devices such as Arduino, Bluetooth, and ID reader.
- A new software tool that we used in our project is Arduino IDE program. We learned how to write a code that gives command to the robot to move with certain time. Our project is focusing on coding because every movement requires a specific code.

- Project management skills, we planned that every one of the team members has to put a hand on everything, such as, the plans for the project, buying the equipment, writing the codes, and making reports and presentations. Our objective as teamwork is to get all the work done before the deadline, so we can check if there is any error that has to be fixed and submit it on time.
- Time management skills, we managed that each one of the group members has to do what he is required to do before the deadline otherwise our work wouldn't be done by the deadline that we are given from the instructor.

Each tool of the above is acquired from a certain place such as, Arduino bought from a store that is called Mawjat because this store has some of the project requirements. We used Arduino software in university as long as we want to write a code, we go to university in order to write it. Project management and time management are old skills that we have; we acquired them from previous courses.

6.2 Impact of Engineering Solutions

Automation warehouse has a large impact on our society. It improves warehouses, has a lot of benefits in the field, such as, make accuracy of orders, safe material handling processes, reduced product damage, and throughput and the productivity of labor. Intelligent machines and software offer a futuristic approach to handle increased warehouse density, volume, and the demand for outsourced logistics providers. Our project can help people with large warehouses and it is desirable to place each item where it belongs.

6.3 Contemporary Issues Addressed

These days, where human error may produce faulty equipment or fail customer's trust, it is imperative to minimize; or better yet, eliminate any room for error.

A strong business is only as strong as its weakest link, and the link of storage

management can be the lifeblood of a manufacturing facility, or the product provider to the public.

We as electrical engineering students, we had a conversation with someone who works in Saudi electricity company in order get information for the errors that they are facing. These errors could make a lot troubles such as, losing customers trust and an automation warehouse with less room space.

Our project is focusing on these errors in order to provide a product with less error, so we are designing an automation warehouse with room that has more space for overshooting, as well as, providing a robot that has the ability to lift stuff without any damage.

7. Conclusions and Future Recommendations

7.1 Conclusions

In conclusion, the storage system we have developed will be more time efficient and will decrease the possibility of any errors in storing products. Even though automatic storing systems have been done before, our way of integrating the RIFD card allows the user to easily inform the robot of the items needed to be collected. One of many obstacles we faced was allowing the base to move vertically which we had many designs to test. None of them worked unless one. We fixed that problem by using two bases that move upward and downward through linear guide rails and controlling the movement using screw that is attached to a stepper motor. Another small issue was finding the materials needed to create an appropriate railway for the robot to take, but our solution was providing aluminum sheet to let the robot to move horizontally. Working on this project allowed us to have a deeper look on the different methods of designing and creating robotic machines. Finally, we learned more about the needs of organizing a storage and the

mechanical movement, which will lead into problem solving within a small duration of time in the future in the workplace.

7.2 Future Recommendations

In future we are planning on controlling the speed through Arduino program, as well as, our project battery is going to be rechargeable. We have plan in future to create a vehicle with a battery on the top of it, as well as charger station. We program the vehicle to move to a station where the charger is set to charge the battery when it is dead.

8. References

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3. Development of an Automated Storage and Retrieval System in Dynamic Industrial Environment <https://www.researchgate.net/publication/307173277>
4. Students Automate warehouse <https://www.zhaw.ch/en/about-us/news/news-releases/news-detail/news-single/students-automate-warehouse/>
5. Electric machinery textbook (Electric Machinery and Transformers 3ed).

Appendix A: Progress Reports

ACTIVITY	PLAN	PLAN	Assigned	ACTUAL	ACTUAL	PERCENT	Actual (beyond plan)															% Complete (beyond plan)														
	START	DURATION	To	START	DURATION	COMPLETE	Periods (Weeks 1-15)															Periods (Weeks 1-15)														
Cont: Design subsystem 2 (Warehouse movement rail and vertical platform)	2	5	ALL	2		30%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Designing rail setup overhaul	2	1	ALL	2	1	100%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Ordering new components **	3	1	YA,MA	3	2	60%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Building new rail and racks setup	4	3	YA,MA,ME			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Wiring and coding new movement functions	5	3	MA,ME,NY			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Establishing wireless communication between master and slave microcontrollers	6	1	ME,NY	3	1	100%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Prepare midterm Presentation	7	1	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Design subsystem 3 (Fetching and Storing Tech)	8	4	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Consult advisor regarding fetching and storing mechanism design	8	4	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Ordering mechanism components	8	1	YA,MA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Building and wiring mechanism	9	2	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Coding fetch and store protocols	8	2	ME,NY,YA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Testing operation	10	2	ME,YA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
						0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Design subsystem 4 (System Refinements)	11	5	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Refining vertical and horizontal movement	11	5	ME,YA,MA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Refining fetch and store protocols	11	5	ME,YA,MA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Refine user "interface"	11	5	ME,NY			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
TBD							[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
TBD							[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Prepapre final report	12	2	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Prepapre final presentation	12	2	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Prepare project demo	13	3	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Submit Rpt/PPT/Brochure	14	2	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														

ACTIVITY	PLAN	PLAN	Assigned	ACTUAL	ACTUAL	PERCENT	Actual (beyond plan)															% Complete (beyond plan)														
	START	DURATION	To	START	DURATION	COMPLETE	Periods (Weeks 1-15)															Periods (Weeks 1-15)														
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Designing rail setup overhaul	2	1	ALL	2	1	100%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Ordering new components **	3	1	YA,MA	3	2	100%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Building new rail and racks setup	4	3	YA,MA,ME	6		60%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Wiring and coding new movement functions	5	3	MA,ME,NY			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Establishing wireless communication between master and slave microcontrollers	6	1	ME,MA,NY	3	1	100%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Prepare midterm Presentation	7	1	ALL	7		60%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Design subsystem 3 (Fetching and Storing Tech)	8	4	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Consult advisor regarding fetching and storing mechanism design	8	4	MA,NY			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Ordering mechanism components	8	1	YA,MA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Building and wiring mechanism	9	2	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Coding fetch and store protocols	8	2	ME,NY,YA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Testing operation	10	2	ME,NY,YA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Design subsystem 4 (System Refinements)	11	5	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Refining vertical and horizontal movement	11	5	YA,MA,NY			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Refining fetch and store protocols	11	5	ME,YA,MA			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Refine user "interface"	11	5	ME,NY			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Prepapre final report	12	2	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Prepapre final presentation	12	2	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Prepare project demo	13	3	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														
Submit Rpt/PPT/Brochure	14	2	ALL			0%	[Gantt chart bars for weeks 1-15]															[Gantt chart bars for weeks 1-15]														

ACTIVITY	PLAN	PLAN	Assigned To	ACTUAL	ACTUAL	PERCENT COMPLETE	Actual (beyond plan)		Periods (Weeks 1-15)							% Complete (beyond plan)				
	START	DURATION		START	DURATION		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cont: Design subsystem 2 (Warehouse movement rail and vertical platform)	2	5	ALL	2	6	70%														
Designing rail setup overhaul	2	1	ALL	2	1	100%														
Ordering new components **	3	1	YA,MA	3	2	100%														
Building new rail and racks setup	4	3	YA,MA,ME	6	3	100%														
Wiring and coding new movement functions	5	3	MA,ME,NY	6		40%														
Establishing wireless communication between master and slave microcontrollers	6	1	ME,MA,NY	3	1	100%														
Prepare midterm Presentation	7	1	ALL	7	1	100%														
Design subsystem 3 (Fetching and Storing Tech)	8	4	ALL	7		0%														
Consult advisor regarding fetching and storing mechanism design	8	4	MA,NY	7		60%														
Ordering mechanism components	8	1	YA,MA	7		60%														
Building and wiring mechanism	9	2	ALL			0%														
Coding fetch and store protocols	8	2	ME,NY,YA			0%														
Testing operation	10	2	ME,NY,YA			0%														
Design subsystem 4 (System Refinements)	11	5	ALL			0%														
Refining vertical and horizontal movement	11	5	YA,MA,NY			0%														
Refining fetch and store protocols	11	5	ME,YA,MA			0%														
Refine user "interface"	11	5	ME,NY			0%														
Prep final report	12	2	ALL			0%														
Prep final presentation	12	2	ALL			0%														
Prepare project demo	13	3	ALL			0%														
Submit Rpt/PPT/Brochure	14	2	ALL			0%														

ACTIVITY	PLAN	PLAN	Assigned To	ACTUAL	ACTUAL	PERCENT COMPLETE	Actual (beyond plan) % Complete (beyond plan)														
	START	DURATION		START	DURATION		Periods (Weeks 1-15)														
							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cont: Design subsystem 2 (Warehouse movement rail and vertical platform)	2	5	ALL	2	6	70%															
Designing rail setup overhaul	2	1	ALL	2	1	100%															
Ordering new components **	3	1	YA,MA	3	2	100%															
Building new rail and racks setup	4	3	YA,MA,ME	6	3	100%															
Wiring and coding new movement functions	5	3	MA,ME,NY	6		50%															
Establishing wireless communication between master and slave microcontrollers	6	1	ME,MA,NY	3	1	100%															
Prepare midterm Presentation	7	1	ALL	7	1	100%															
Design subsystem 3 (Fetching and Storing Tech)	8	4	ALL	7		20%															
Consult advisor regarding fetching and storing mechanism design	8	4	MA,NY	7		60%															
Ordering mechanism components	8	1	YA,MA	7		60%															
Building and wiring mechanism	9	2	ALL			40%															
Coding fetch and store protocols	8	2	ME,NY,YA			30%															
Testing operation	10	2	ME,NY,YA			15%															
Design subsystem 4 (System Refinements)	11	5	ALL			0%															
Refining vertical and horizontal movement	11	5	YA,MA,NY			0%															
Refining fetch and store protocols	11	5	ME,YA,MA			0%															
Refine user "interface"	11	5	ME,NY			0%															
Prepapre final report	12	2	ALL			0%															
Prepapre final presentation	12	2	ALL			0%															
Prepare project demo	13	3	ALL			0%															
Submit Rpt/PPT/Brochure	14	2	ALL			0%															

ACTIVITY	PLAN	PLAN	Assigned To	ACTUAL	ACTUAL	PERCENT COMPLETE	Actual (beyond plan) % Complete (beyond plan)														
	START	DURATION		START	DURATION		Periods (Weeks 1-15)														
							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cont: Design subsystem 2 (Warehouse movement rail and vertical platform)	2	5	ALL	2	6	100%															
Designing rail setup overhaul	2	1	ALL	2	1	100%															
Ordering new components **	3	1	YA,MA	3	2	100%															
Building new rail and racks setup	4	3	YA,MA,ME	6	3	100%															
Wiring and coding new movement functions	5	3	MA,ME,NY	6		100%															
Establishing wireless communication between master and slave microcontrollers	6	1	ME,MA,NY	3	1	100%															
Prepare midterm Presentation	7	1	ALL	7	1	100%															
Design subsystem 3 (Fetching and Storing Tech)	8	4	ALL	8	6	100%															
Consult advisor regarding fetching and storing mechanism design	8	4	MA,NY	8	7	100%															
Ordering mechanism components	8	1	YA,MA	11	4	100%															
Building and wiring mechanism	9	2	ALL	13	2	100%															
Coding fetch and store protocols	8	2	ME,NY,YA	14	2	100%															
Testing operation	10	2	ME,NY,YA	13	3	100%															
Design subsystem 4 (System Refinements)	11	5	ALL	13	3	100%															
Refining vertical and horizontal movement	11	5	YA,MA,NY	13	3	100%															
Refining fetch and store protocols	11	5	ME,YA,MA	13	3	100%															
Refine user "interface"	11	5	ME,NY	13	3	100%															
Prepapre final report	12	2	ALL	13	3	90%															
Prepapre final presentation	12	2	ALL	13	3	100%															
Prepare project demo	13	3	ALL	15	1	90%															
Submit Rpt/PPT/Brochure	14	2	ALL	15	1	80%															

ACTIVITY	PLAN	PLAN	Assigned	ACTUAL	ACTUAL	PERCENT	Actual (beyond plan)		% Complete (beyond plan)												
	START	DURATION	To	START	DURATION	COMPLETE	Periods (Weeks 1-15)														
							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cont: Design subsystem 2 (Warehouse movement rail and vertical platform)	2	5	ALL	2	6	100%															
Designing rail setup overhaul	2	1	ALL	2	1	100%															
Ordering new components **	3	1	YA,MA	3	2	100%															
Building new rail and racks setup	4	3	YA,MA,ME	6	3	100%															
Wiring and coding new movement functions	5	3	MA,ME,NY	6		100%															
Establishing wireless communication between master and slave microcontrollers	6	1	ME,MA,NY	3	1	100%															
Prepare midterm Presentation	7	1	ALL	7	1	100%															
Design subsystem 3 (Fetching and Storing Tech)	8	4	ALL	8	6	100%															
Consult advisor regarding fetching and storing mechanism design	8	4	MA,NY	8	7	100%															
Ordering mechanism components	8	1	YA,MA	11	4	100%															
Building and wiring mechanism	9	2	ALL	13	2	100%															
Coding fetch and store protocols	8	2	ME,NY,YA	14	2	100%															
Testing operation	10	2	ME,NY,YA	13	3	100%															
Design subsystem 4 (System Refinements)	11	5	ALL	13	3	100%															
Refining vertical and horizontal movement	11	5	YA,MA,NY	13	3	100%															
Refining fetch and store protocols	11	5	ME,YA,MA	13	3	100%															
Refine user "interface"	11	5	ME,NY	13	3	100%															
Prepapre final report	12	2	ALL	15	3	100%															
Prepapre final presentation	12	2	ALL	13	3	100%															
Prepare project demo	13	3	ALL	15	1	100%															
Submit Rpt/PPT/Brochure	14	2	ALL	15	1	100%															

Appendix B: Bill of Materials

Item	Quantity	Unit Cost (SAR)	Subtotal
Frame	Total	500	500
Robot Body	Total	150	150
Control Unit (Arduino)	2	80	160
Rails + Bearings	Total	300	300
RFID Reader	1	40	40
Bluetooth HC05	3	40	120
DC Battery	1	45	45
Stepper Motors	2+1	175+110	460
Motor Drivers +Sensors	4+2	65+40	340
Total:			2,115 SAR

Appendix C: Datasheets

- Frame
- Robot Body
- Control Unit (Arduino)
- Rails + Bearings
- RFID Reader
- Bluetooth (HC05)
- DC Battery (12V)
- Stepper Motors (NEMA 23, NEMA 17)
- 20A Motor Driver + Sensors (Ultrasonic, IR line following)

Appendix D: Program Codes



Mastertooth_Latest.in

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Code 1: The master microcontroller:

- Includes monitor connection and RFID scanner
- Requires the EEPROM and RFID MFRC522 libraries to operate



Stepperdrive.ino

Code 2: The motor driver:

- Runs all motors involved in the project
- Includes custom-made libraries by the group

The codes:



Master.txt



Slave.txt

Appendix E: Operation Manual

Upon turning on the power supply, both microcontrollers will turn on, causing the motors to return the robot to its starting position if it wasn't already there, and the master microcontroller to provide a list of possible commands as follows:

- (1) Scan: Reads the presented RFID and shows the user the hex code within it.
- (2) Read: Reads the presented RFID, shows the user its hex code, and saves it in a temporary slot for further saving and processing.
- (3) Save: Saves the ID in the temporary slot to the internal memory, and links it with a specific storage slot based on the user's choosing.
- (4) Store: Reads the presented RFID and looks for a match in the internal memory. If a match is found and the corresponding slot is free, the system will store the item presented in that slot. Otherwise it will ask the user to empty that storage space first.
- (5) Fetch: Reads the presented RFID and looks for a match in the internal memory. If a match is found and the corresponding slot is full, the system will store the item presented in that slot. Otherwise it will prompt the user that the storage space is empty.
- (6) View: Shows the RFIDs attached to all storage slots, and their status of availability. Where (1) is full and (0) is vacant.
- (R or r) Clear: Clears the ID saved in the temporary slot. Can be used to clear one of the storage slots of it linked RFID.
- (9) Help: Shows this list of available commands.
- (0) Terminate: Ends any ongoing (local) operation.