



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

Graduation Project II

Real-time Tracking System for smart factories

Authors

Omar Dere

Ibrahem Arda

Supervisor

Dr.Hanal Abu Zanat

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Disclaimer

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Contents

Acknowledgements	1
Disclaimer	2
List of Figures	4
Abstract	7
Introduction	8
1.1 Background.....	8
1.2 Problem statement.....	8
1.3 Significance	8
1.4 Objectives and scope	8
1.5 Report Organization.....	9
Constraints and Earlier Coursework	10
2.1 Constraints	10
2.1.1 Inexperience	10
2.1.2 Lack of funds.....	10
2.1.3 Lack of Time	10
2.1.4 Lack of Mechanical knowledge	10
2.1.5 Some of the pieces were suddenly broken	10
2.1 Earlier coursework	11
2.1.4 Digital imaging process.....	11
Literature Review	12
3.1 A Quality Control Application on a Smart Factory Prototype Using Deep Learning Methods	12
3.2 RFID-enabled real-time production management system for Loncin motorcycle assembly line	12
3.3 RFID-enabled smart real-time manufacturing cost tracking system	12
3.4 How is our project better?	13
Methodology	14
4.1 Choosing the idea.....	14
4.2 Mechanical Part	14
4.2.1 Mechanical Design	14
4.2.2 Assembling	15
4.2.3 Parts.....	16
4.3 Controller Part.....	17
4.3.1 Arduino	17
4.3.2 Parts.....	18
4.3.3 Driving Motors.....	20
4.3.4 Additional features	22
Results & Problem Discussion	25
5.1 Drivers	25
5.2 Raspberry pi breakdown	25
5.3 Finding a Good conveyor.....	25
5.4 RFID readers.....	25
5.5 Final Results	25
Conclusion & Future Work	26
6.1 Summery	26
6.2 Improvements	26
6.3 Future Work	26
6.4 Outcome	26
Bibliography	27

List of Figures

Figure 1: camera stage in line	5
Figure 2: Hardware connection.....	5
Figure 3: production line	6
Figure 4: Mechanical Body	15
Figure 5: belt	16
Figure 6:stepper motor	16
Figure 7: mounting bracket	16
Figure 8: roller	16
Figure 9: convertor	17
Figure 10: power supply.....	17
Figure 11: Arduino mega.....	18
Figure 12: driver	18
Figure 13: shield stepper.....	18
Figure 14: convertor 12-5.....	18
Figure 15: IR sensor	19
Figure 16: ESP.....	19
Figure 17: RFID	19
Figure 18: Bread Board.....	19
Figure 19: wires male-male	20
Figure 20: wires female-male	20
Figure 21: RFID tags.....	20
Figure 22: web camera	20
Figure 23: Driver circuit.....	21
Figure 24: IR Sensor.....	22
Figure 25: RFID details.....	23
Figure 26: ESP connecting	23

**Images of Module:
Camera stage and image-processing**

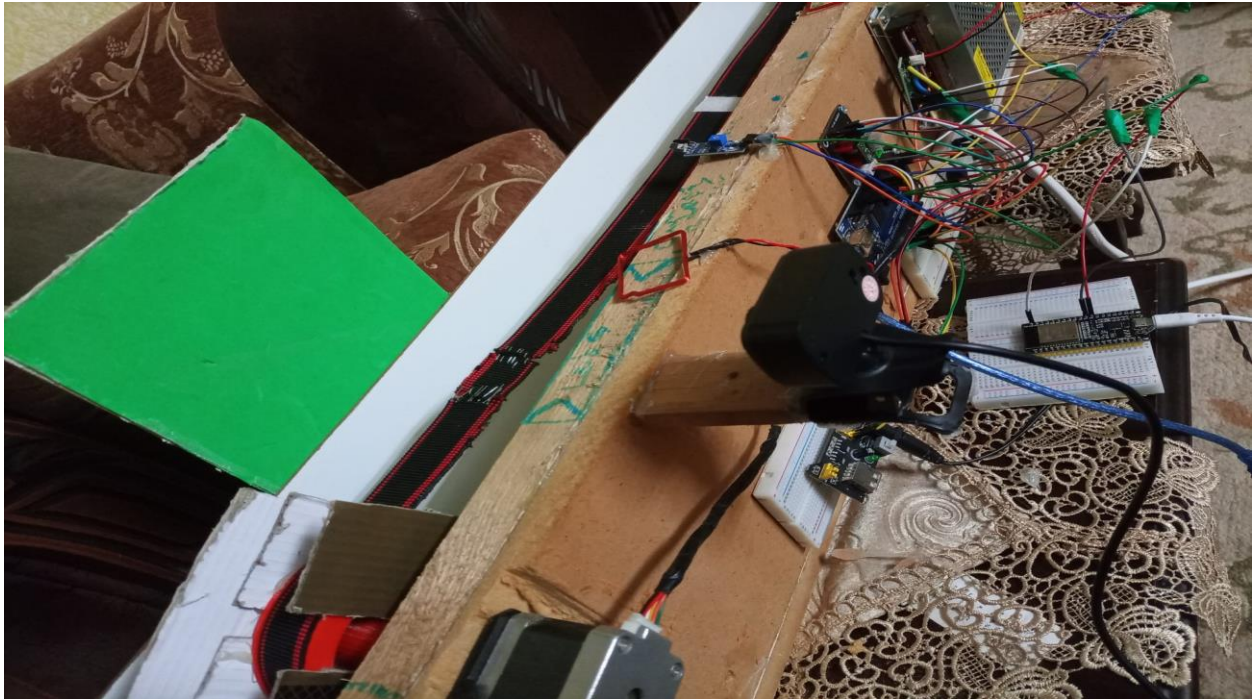


Figure 1: camera stage in line

Hardware connection:

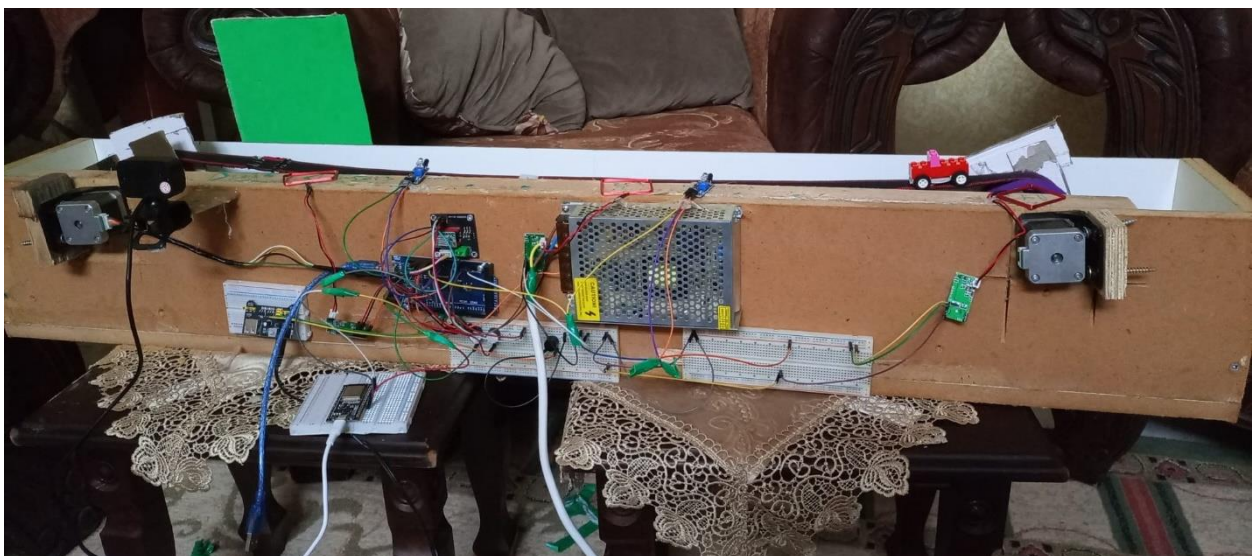


Figure 2: Hardware connection

Production line:

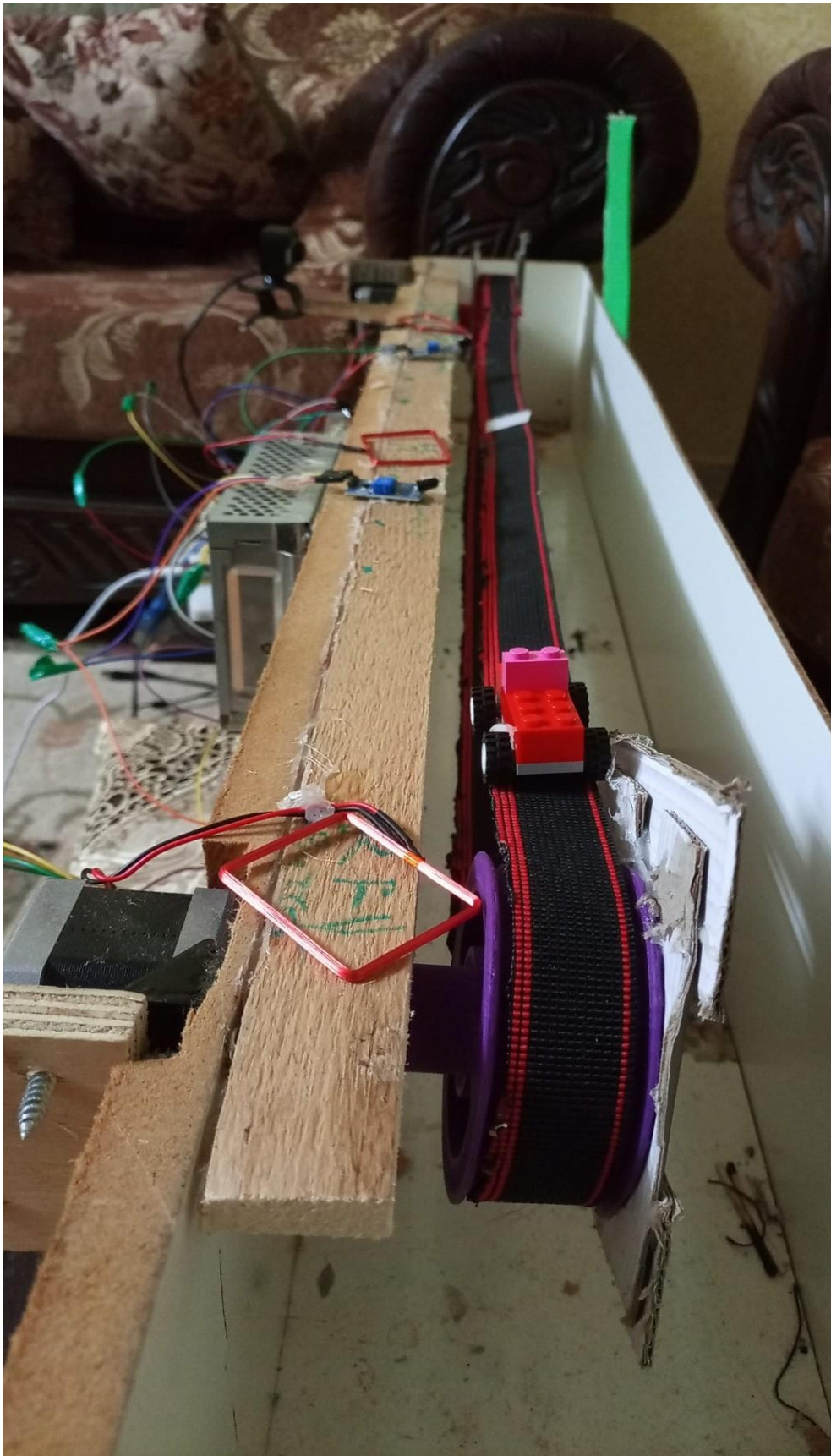


Figure 3: production line

Abstract

Industry real-time tracking applications can be used to collect and analyze data about manufacturing processes. Industrial engineers can convert it into information for increased productivity. More data means better decisions and fine-tuned production processes that make maximum use of resources. Continuous monitoring also ensures a better quality of production. The smart factory is at the heart of industry and describes a production environment that is self-organizing with the help of sensors and intelligently connected devices.

For this project we are going to design hardware-system to track what is happening within production process, provide the necessary information at the right time and in the proper format and control element when unplanned changes and details appear. And that functionalities are needed for essential part of intelligent manufacturing.

In this project, we will use one microcontrollers (Arduino), sensors, camera, motors and developing small software to monitor the output of hardware system.

Chapter 1

Introduction

1.1 Background

The presence of automated tracking system and image processing on the production line helps to increase accuracy in detecting defects in products that may not be noticed by the worker standing in front of the production line. The worker also needs to know more about the product in which defects were discovered and to stop production at a certain percentage.

1.2 Problem statement

Every employee whether he is worker or manager faces two main problems:

1. Predictive Maintenance: how to Improving the overall effectiveness of the equipment by predicting system failures and failures before they occur and continuously monitoring performance and deviations to optimize the scheduling of downtime.
2. Defect Detection: How to Improve Accuracy and Sensitivity of Fault Detection in Difficult, High Variation Environments.

1.3 Significance

The main goal of the project is to build a real-time tracking system to monitoring the product when it pass on the production line to helps to discover defects, and in the event of their recurrence, production is stopped and the production line is maintained, which leads to reducing waste and costs, ensuring quality and increasing productivity.

1.4 Objectives and scope

This application does not support the maintenance of production lines and does not make predictions using artificial intelligence. The goal of this application is to tracking the product from stage1 to stage2 then to end line and discover defects in the products and inform the system to take the necessary actions.

1.5 Report Organization

- **Second chapter:** In this chapter, we covered the important subjects we learned previously, as well as the external courses and the primary constraints and obstacles we encounter while working on the project.
- **Third chapter:** in this chapter we talk about the related project to our project.
- **Fourth chapter (Methodology):** We talked about the mentality through which we built the application, in addition to the features that we offer and the technology's used.
- **Fifth and final chapter:** we talked about the results, as well as the lessons we learned from working on the project and future developments.

Chapter 2

Constraints and Earlier Coursework

2.1 Constraints

2.1.1 Inexperience

We created many modest demos and tests to ensure that the notion we are going for is feasible. However, all of these testing required time that we could have spent on other things.

Even after all of the testing, research, and time invested, we still made certain judgments that are considered safe risks since we couldn't test specific components and couldn't afford for the overall project to fail.

2.1.2 Lack of funds

Some options required additional money to create, making the project more expensive and unaffordable, especially at our budget.

2.1.3 Lack of Time

In every operation, time is of the utmost importance. Researching, communicating, testing, designing, analyzing the needs, planning, and wasting time due to inexperience all cost time, which, no matter how trivial, rapidly adds up.

2.1.4 Lack of Mechanical knowledge

The project involves many mechanical aspects that we only partially understood, but even after all of our study, an experienced mechanical engineer was required to answer some problems and arrange the execution effectively.

Considerable 3D printed pieces(reels) required some balance and mechanical understanding to repair; thus, the concepts and original drawings were brought to the engineer students for modification.

2.1.5 Some of the pieces were suddenly broken

While we were preparing to finish the project, suddenly the Raspberry Pi broke down and did not work anymore, and we did not have time to buy a new one, so we had to buy an esp and connect the Arduino to the computer wirelessly and write the image processing code on the computer instead of the Raspberry Pi

2.1 Earlier coursework

2.2.1 Microcontrollers and pic lab

These classes covered the fundamentals of the Arduino, including as basic serial communication and controlling steppers.

2.2.2 Networks and Wireless

We used the ESP and serial module to connect the Arduino with the raspberry pi wirelessly.

2.2.3 Critical Thinking and Research Skills

This course has provided me how to conduct research and write a report, and it's one of the few non-technical courses that is also lifetime.

2.1.4 Digital imaging process

In this project we used image processing to detect defects in products, all techniques used in our code, we learned it in this course

Chapter 3

Literature Review

Our project aims to track the products and discover defects in it. That come out of the production line to make it easier for employees to work. However, it is not the first project that was Created to achieve the same purpose, there are some other different projects that are Already live. Some of these projects are presented below:

3.1 A Quality Control Application on a Smart Factory Prototype Using Deep Learning Methods

In this work, the implementation of visual quality control automation using a camera placed above the assembly line in an intelligent worker model is proposed. The product is detected in an image obtained from an assembly line and then rated as “good” or “unacceptable” using deep learning methods [1]

Advantages

Using a camera placed above the assembly line and informing the worker of any defect in the product as soon as it is produced, which leads to improving the quality of production.

Disadvantages

Using deep learning requires time and a large processor. The same goal can be achieved using image processing.

3.2 RFID-enabled real-time production management system for Loncin motorcycle assembly line

The article introduces the RFID-enabled real-time PMS system on the Loncin motorcycle assembly line, which has addressed the current problems and met the requirements for effective production management [2].

3.3 RFID-enabled smart real-time manufacturing cost tracking system

This paper proposes an innovative real-time manufacturing cost tracking system (RT-MCT) which integrates the concepts of lean manufacturing and RFID [3].

3.4 How is our project better?

Our project was built with what other projects offer and what they don't offer in mind. Our project was designed to contain most of the important features offered by other applications, as we combined the idea of detecting defects in the product by image processing with the idea of time tracking of the product at all stages of manufacturing. Finally, we did our best to eliminate any issues featured with other projects.

Chapter 4

Methodology

This section contains detailed information about the techniques and methods we used to develop the project.

4.1 Choosing the idea

When we start our software project in the past semester we have worked with Industrial Engineering department, our project was to handle the management of the manufacturing process by developing Software application (Web and mobile), and we done an image processing application that detect defects of products by calculating the area and the color of it.

After the good experience that we have earned by the other department, we decided to continue this relation and resume what we did and make it like a real example.

At first we have met the industrial team members and their instructor to came with an good idea, after a long discussion the idea came that we want to produce a Hardware system called Real time tracking, this system is responsible for tracking the product from the early begging of the production line, store the timing from the begging of the stages until end and store that data to make a good analysis on it, like calculating the average time for each product to be produced, the efficiency of the production process, etc..., to make this project acceptable for our department we also have to implement a simulation for the the production line and adding image process feature that we have implemented before in our software project.

4.2 Mechanical Part

The mechanical component of the project is responsible for moving the product on the production line, and this necessitates the presence of motors, belts, etc. This requires taking the following steps:

4.2.1 Mechanical Design

In the first step, we worked on designing the external model of the device and installing the motor and we needed some 3D-printed bodies to help support the model.

4.2.2 Assembling

It is the part that demands the use of bolts and drill bits to put the components together, and it must be done correctly for the project to function properly.





Figure 4: Mechanical Body

After we put everything in its place, as shown in the above figure, we began to work on the motor to ensure proper movement and so that there would be no mechanical problems that could disrupt us in the future, such as balance and weight distribution evenly so as not to cause vibrations that would sabotage the project.

The above image it's in starter work, after that we replaced the belt because it was heavy, and we used a lighter one, and we put an extra motor, but after that we did not use it

4.2.3 Parts

Item Name	Item Image	Quantity
belt	 <p data-bbox="756 568 893 600"><i>Figure 5: belt</i></p>	2m length
Stepper Motor	 <p data-bbox="708 965 943 996"><i>Figure 6:stepper motor</i></p>	2
mounting bracket	 <p data-bbox="687 1397 963 1429"><i>Figure 7: mounting bracket</i></p>	2
3d printer rollers	 <p data-bbox="751 1733 900 1765"><i>Figure 8: roller</i></p>	2

Item Name	Item Image	Quantity
Convertor to 12v	 <p data-bbox="730 472 919 499"><i>Figure 9: convertor</i></p>	1
power supply 10A	 <p data-bbox="707 925 943 952"><i>Figure 10: power supply</i></p>	1

4.3 Controller Part

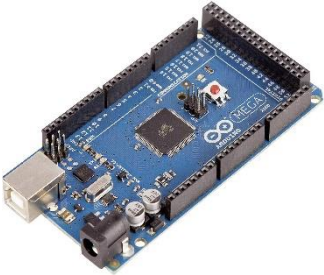
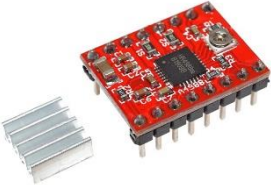


The controller part is responsible for directing and operating the mechanical part, controlling the process time tracking system and it is made up of Arduino mega:




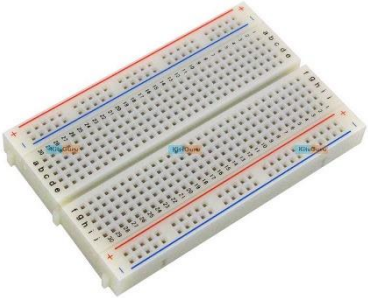
4.3.1 Arduino


We have used the Arduino to control the process of running the motor and to write the code needed to build the project. Also used it to connect with ESP serially to store data and link it with react app.

These are the electronic parts that we needed to run the electronic part of the project:

4.3.2 Parts

Item Name	Item Image	Quantity
Arduino mega 2560	 <p data-bbox="703 600 948 629"><i>Figure 11: Arduino mega</i></p>	1
driver A4988	 <p data-bbox="743 987 906 1016"><i>Figure 12: driver</i></p>	1
shield stepper driver 42ch	 <p data-bbox="703 1375 948 1404"><i>Figure 13: shield stepper</i></p>	1
convertor (12v-5v)	 <p data-bbox="703 1742 948 1771"><i>Figure 14: convertor 12-5</i></p>	1

<p>IR sensor</p>	 <p><i>Figure 15: IR sensor</i></p>	<p>2</p>
<p>ESP32</p>	 <p><i>Figure 16: ESP</i></p>	<p>1</p>
<p>RFID RDM6300</p>	 <p><i>Figure 17: RFID</i></p>	<p>3</p>
<p>Bread board</p>	 <p><i>Figure 18: Bread Board</i></p>	<p>5</p>

<p>Wires (male-male)</p>	 <p><i>Figure 19: wires male-male</i></p>	
<p>Wires (female-male)</p>	 <p><i>Figure 20: wires female-male</i></p>	
<p>RFID tags</p>	 <p><i>Figure 21: RFID tags</i></p>	<p>3</p>
<p>Web-camera</p>	 <p><i>Figure 22: web camera</i></p>	<p>1</p>

4.3.3 Driving Motors

To control the motor, we must use a driver [4], and for that we used a 4988 driver. To make it easier for us to control with high accuracy, and to protect the motor.

We also used a special shield in that driver to facilitate the process of connecting with the motor and giving it sufficient voltage and to ensure high accuracy.

In order for us to connect the motor with the two-entry coil in the shield driver, where there are four entrances in the shield, especially to the coil, which are (1A,1B,2B,2A) which (1A,1B) mean the first coil, and (2B,2A) the second coil. [4]

To determine the coil, through the wires coming out of the motor, we wrapped each two wires together, and then we twist the motor by hand. If we feel it is difficult to move the motor, these two wires represent a first coil and so on.

Also the shield has 2 input for power supply (12v), input for (step), input for (direction), input for enable, and input for (Vcc,Gnd)-(5v).

Below is a picture of the linking process:

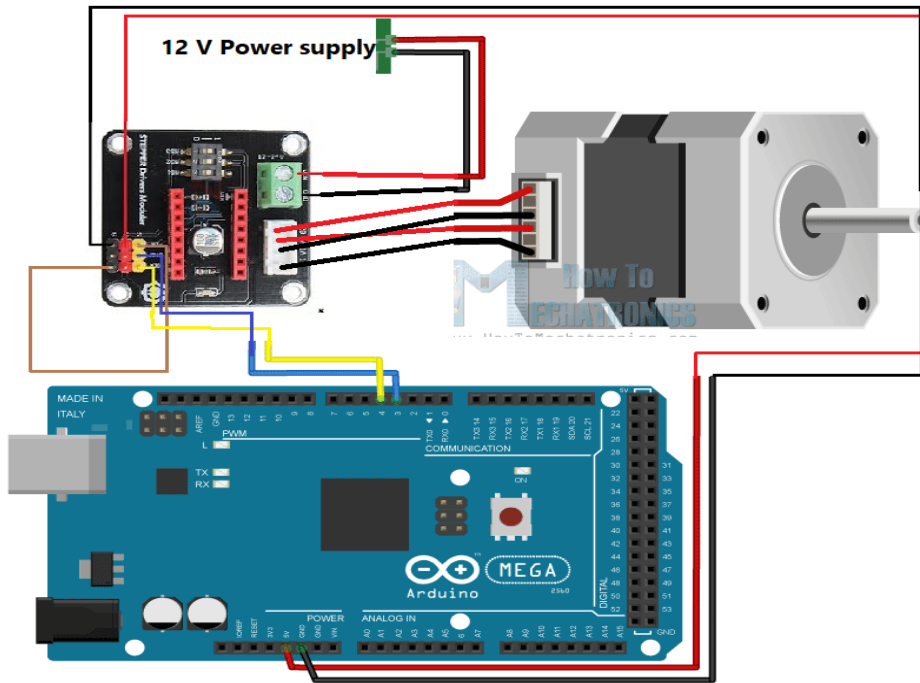


Figure 23: Driver circuit

Moving Stepper motor:

After the connect wire process. Through the code, we used step and directional pin to move motor on half-step mode and control it using another sensors like IR and RFID and data from ESP. and control speed by this result

4.3.4 Additional features

4.3.4.1 IR sensor:

We want to put a sensor on the belt and if the product passes in front of the sensor. The sensor send signal to motor to stopped and then the RFID start read the tag.

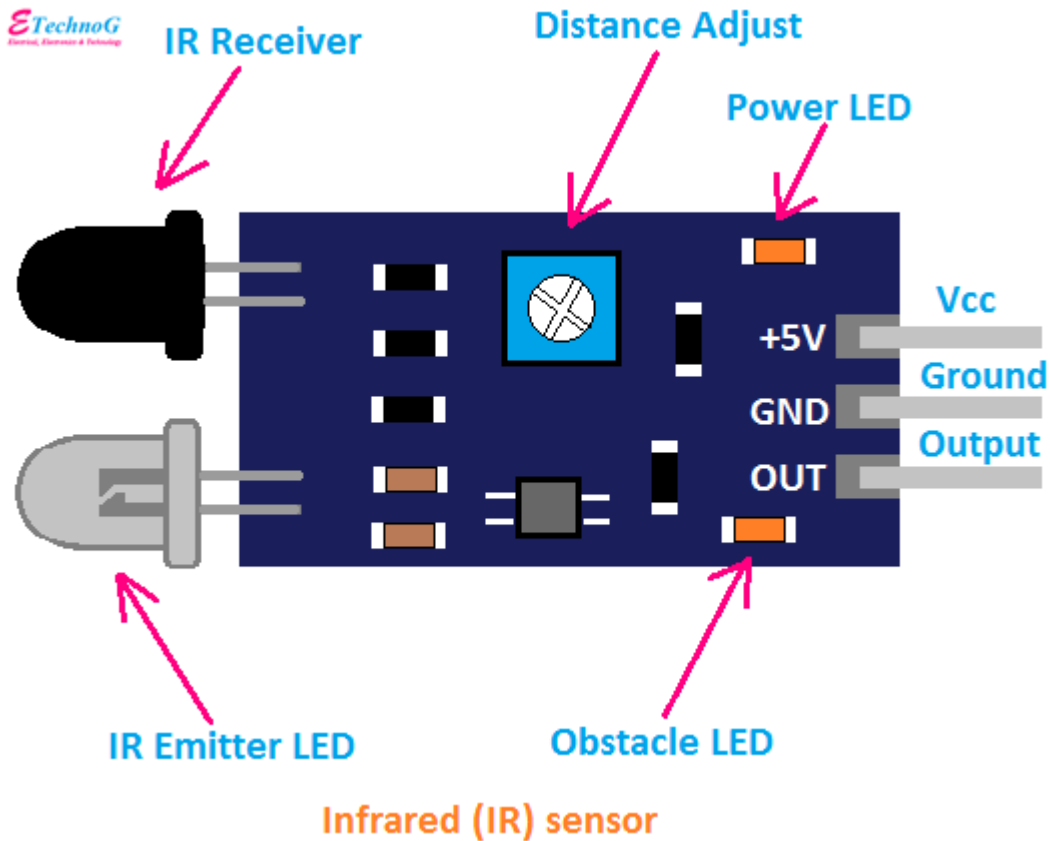


Figure 24: IR Sensor

We connect the GND and VCC from the convertor to take 5 V fixed, and output to Arduino, We read the output and if it equal 0 then it means the product passes in front of the sensor

4.3.4.2 RFID:

We used the RFID to read tag then we send tag information to database by ESP

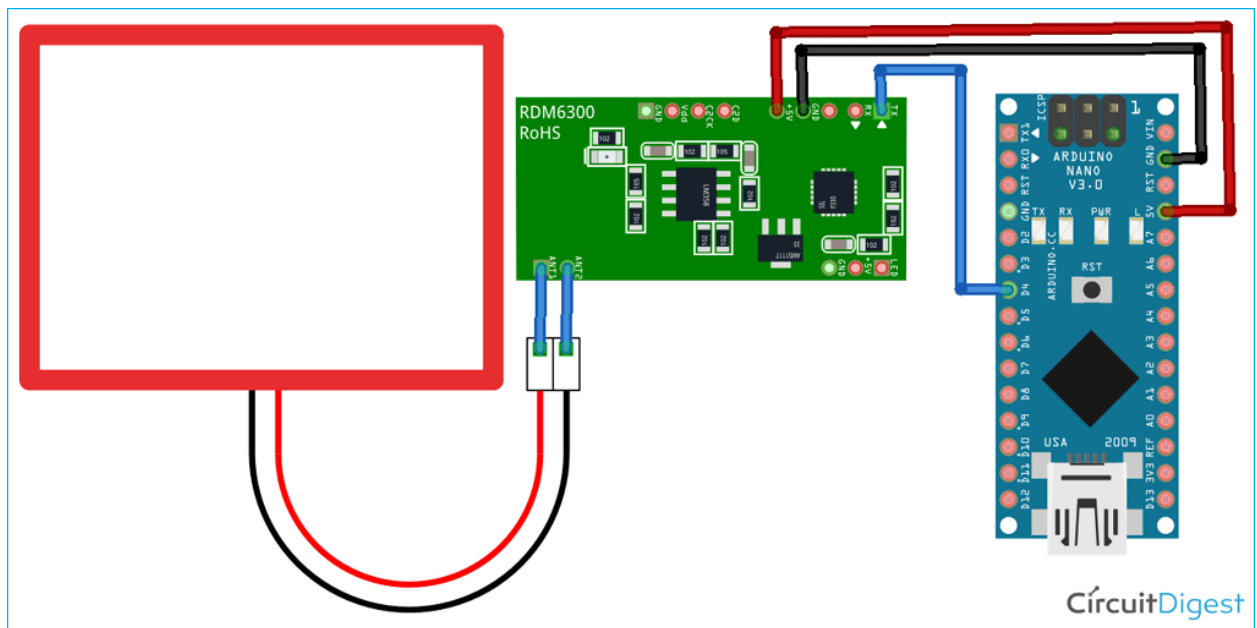


Figure 25: RFID details

We connect the GND and VCC from the convertor to take 5 V fixed, and RX to TX from Arduino, We have three RFID because this we need three serial and Arduino mega has three Additional serial.

4.3.4.3 ESP:

We used ESP to connect Arduino serially with pc to store data in database and display data in react app and control of motor speed

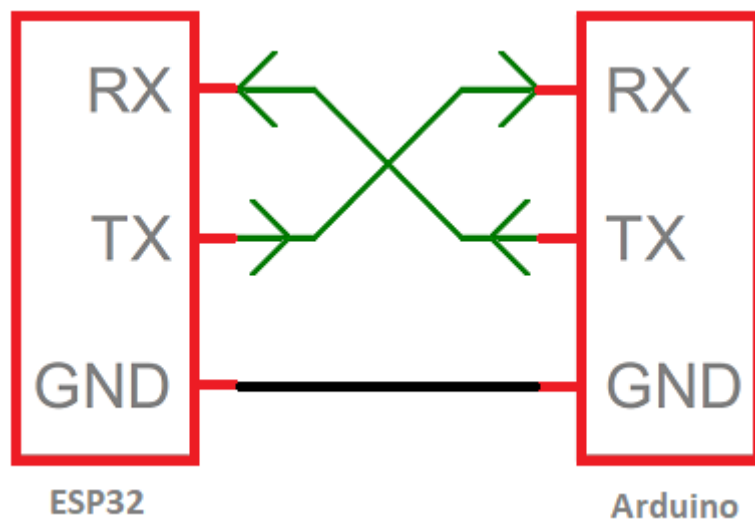


Figure 26: ESP connecting

To establish serial communication between Arduino and ESP32, we can cross-connect TX and RX pins of Arduino with ESP32. There should be common ground. So, we will connect Arduino GND pin with ESP32 GND pin.

4.3.4.4 Camera:

We used camera and image processing python code to detect defect on final stage and send result to Arduino code by ESP32.

Chapter 5

Results & Problem Discussion

5.1 Drivers

There are many problems that we encountered in building the project, including the problem of drivers, and the problem was that if you touch the drivers with your finger and they are connected to electricity, the drivers are immediately burned, and this problem we faced a lot in the beginning and took us a long time to discover it.

5.2 Raspberry pi breakdown

This was the biggest problem that we have faced, we were using Raspberry pi to store the data and to make the image processing for our system, unfortunately it breakdown, but we didn't found another one so to handle this problem we used Arduino esp32 micro controller and connected it serially with the Arduino mega, so it can send requests, we implemented a spring Boot server application that handle the request from esp32 and save our data and process it.

5.3 Finding a Good conveyer

At first we got a heavy conveyer and does not have any roller that suits it, we designed a roller and print it 3dly, but that didn't work also, the motor can't move it, after that we replace it by a piece of fabric.

5.4 RFID readers

It was hard to find them in a good market that doesn't take advantage of students, after we got them they are not working very well.

5.5 Final Results

The end result is a fantastic project that works well in the majority of the scenarios we tested and meets all of our objectives.

Chapter 6

Conclusion & Future Work

6.1 Summery

We can say that we done a good job not our best duo to a lot of problems that we have faced, our project is working 80 percent maybe, we have learned a lot about hardware and using multiple programming languages (Arduino(C++), Java Spring boot, React, python), multiple micro controllers (Arduino(Mega & esp32),raspberry pi 3) and how to connect them serially, how to make hardware system integrate with software system to make a complete and efficient solution.

6.2 Improvements

We can improve our system by getting new Raspberry pi 4 micro controller, make the production line longer and more stable by adding a good material conveyer, adding deep learning by collecting a good data for the product and make the write analysis.

6.3 Future Work

As for future work, we can implement our functionality on a real time production line, so we don't have to worry about the mechanical part as you know it's not our field, now we have the idea looking forward to make it real and applicable.

6.4 Outcome

We have enjoyed the process of developing this system, and we hope that we have the chance to make it real.

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