Robotic Arm

Design and manufacture of automatic production line with robotic arm

Supervised By

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For a Bachelor's degree in Control and Automation Engineering Technologies

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Declaration

I hereby declare that the work presented in this Project has not been submitted for any other degree or professional qualification, and that it is the result of my own independent work.

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2021/11/14

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Abstract

In this project, we program a robotic arm with a conveyor belt, the robotic arm is designed by a 3D printer and the conveyor belt parts are made by a CNC machine. The principle of the robot arm is to classify objects by color and this is done based on the color sensor. The conveyor belt contains a color sensor with an IR sensor that is responsible for the movement of the belt, which in turn controls the speed and rotation of the conveyor belt servo. Both the arm and the conveyor belt were programmed by the Arduino card, later we talk about the software code that was applied. The goal of this project is to increase the speed of production inside factories, and such a robot can replace humans in hard and boring work.

Acknowledgements

We thank God who has been kind to us and facilitated our work, and praise be to God always and forever.

We thank everyone who contributed to the success of this project and had the credit and continuous attendance, starting with the head of the department, Dr. Ali Jaber, and the department's reporter Mr. Omran Ahmed as well as thanks to Dr. Hussein Tbena who was the reference for solving work obstacles.

We do not forget those who were encouraged and motivated, family and friends who trusted us. Thank you to the struggling father, loving mother and loyal friends .

Chapter 1: Introduction

The term robot comes from the Czech word robota, generally translated as "forced labour", this describes the majority of robots fairly well. Most robots in the world are designed for heavy, difficult to manufacture in work. They handle tasks that are difficulty, dangerous or boring to human beings. The most common robot is the robotic arm. This robotic arm is type of mechanical model arm, it is usually programmed, like of a human arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or linear displacement .

An industrial arm with six joints similar to a human arm it has equivalent of a shoulder, an elbow and a wrist. Typically, the shoulder is mounted on a stationary base structure rather than to a movable body. This type of robot has six degree of freedom, meaning it can pivot in six

different ways. A human arm by comparison have seven degrees of freedom .

Like as we have our arm whose job is to move your hand from place to place. Similarly job of robotic arm's is to move an object from one place to other that is what is a pick and place robotic arm. Industrial robots are designed to do exactly in an controlled environment, over and over again. For example, a robot might twist the caps of peanut butter jars coming down an assembly line. To each a robot how to do its job, the programmer guides the arm through the motions using a handheld controller. The robot stores the exact sequence of movements in its memory, and does it again and again every time a new unit comes down the assembly line .

Most industrial robots work in auto assembly lines putting cars together. Robots can do a lot of this work more.

efficiently than human beings because they are so precise, They always drill in the exactly the same place, and they always tighten bolts with the same amount of force, no matter how many hours, they've been working. Manufacturing of robots are very important in the computer industry. It takes precise hand to put together in tiny microstrip.

The robot or computerized machine is used to perform many difficult and arduous tasks, and it has become used instead of humans, as the robot has been used in the automobile industry as well as the manufacture of computers. The robot is also used in prosthetic medical devices that have a sense of touch, and there are robots that treat hazardous materials, and are used to remove Bombs, as well as used for mail delivery, fire prevention and other functions.

1.1 Robots are used in places where humans cannot stay and can afford them:

- Prosthetics and Medical Treatment Robots: Robotic technology and its senses can be tamed to produce prosthetic organs that have a sense of touch.
- Hazardous materials handling robots: They are used to remove bombs and treat dangerous materials.
- Service robots: for the purposes of guarding, controlling doors, mail delivery and fire prevention.

1.2 Robot industry laws

The manufacture of the robot, as well as the control of it, and the programming of the robot, require the use of some laws, called Asimov’s laws, which were established by Isaac Asimov, and these laws include the following:

- First Law: A robot must not cause any harm or any harm to a human being.
- Second Law: A robot must obey human orders, unless these commands conflict with the first law.
- Third Law: The robot must protect its existence, so that it does not conflict with the first and second laws.

1.3 Areas of use of the robot

Robots are used in many fields, including the following:

1. Industrial fields: The robot enters into many industries, including the automobile industry, where the robot carries the hot parts of automobile metals, which is considered a difficult and difficult task for the human being.
2. Medical fields: It is represented in the robot for performing surgeries that require long hours, as well as providing assistance to patients who need rehabilitation, as well as sterilizing operating rooms in hospitals, and providing food to patients, especially recently in cases of Covid 19.
3. Areas of domestic service: where the robot does all the household chores, such as cleaning the house, mowing the lawn and many other household chores.

1.4 Robot design science

The science of robot design is known as robotics, and it is considered one of the branches of engineering, especially those that rely on mechanical, computer science, and electrical engineering, with the aim of designing a robot. The great scientific development of robot construction, especially the complex ones, and programming was introduced into the robot’s automated systems, as well as the use of artificial intelligence and many modern devices were added, including sensors, which are used in the manufacture of artificial limbs for humans, as well as sensors for monitoring the effects that Occur in the environment, such as temperature, measurement of air pressure, movement, light, etc.

1.5 Android Advantages

The robot has many features, including the following:

- Offer low labor costs.
- provide more production.
- Use the equipment effectively.
- Provide good quality of services.
- Provide work in a shorter time, which saves effort, time and cost.
- Provide good investment returns.
- Possessing freedom of movement and the three dimensions of space. Improved quality of workplace.
- Offer improved flexibility.
- The ability of the robot to work in dangerous conditions, which may be difficult for a person to bear, such as: the manufacture of cars, the removal of bombs, and fire prevention.
- Flexibility and ease of programming.
- The robot is equipped with cutting tools and tweezers.
- The robot delivers an improved quality of production spaces and workplaces.

1.6 Disadvantages of Android

Despite the advantages of using the robot, there are some disadvantages, including the following:

- Still, the robot still can't catch a certain random part, as it uses a special vision system.
- The relentless entry of robots into the field of industries led to a great deal of dependence on it and to reduce the importance of the human role in some operations.

1.7 Basic robot movements

The main goal of using the robot is to complete work and tasks, for this there must be a hand at the end of the robot end in order to be able to complete the work easily and smoothly. It determines whether the robot is mobile or spatial.

Chapter 2: Literature review

Object Sorting Robotic Arm Based on Color Sensing

In this paper a project is proposed to separate the objects from a set according to their color. This can be usefulto categorise the objects which move on a conveyer belt. The proposed method of categorisation is based on color of the object. In this project the system categorise balls of three different colors. The detection of the particular color is done by a light intensity to frequency converter method. The robotic arm is controlled by a microcontroller based system which controls DC servo motors.

2.1 INTRODUCTION

Mainly the color sorters are used in agricultural machineries like rice sorter, beans sorter, peanut sorter etc. Color sorters are used in other industrial applications also like quartz sand sorter, plastic granule sorting of colored nuts and bolts etc. It reduces the human effort, labour and cost. It also increases the efficiency since the mechanised sorting is much faster the manual sorting.An ARM7 based microcontroller LPC2138, which is a 32 bit microcontroller with RISC architecture is programmed to control the robotic arm. The TCS3200 light intensity-to-frequency converter senses the color and produce a square wave with varying frequency depends on the color of the object to be picked up. Four DC servo motors are used in the construction of the robotic arm. The arm of the robot is constructed using aluminium brackets. Four types of brackets are designed for this purpose, two types for holding the servos and two types for length extension and interconnections. The ball picking gripper which is controlled by a servo is attached and the tip of the arm.

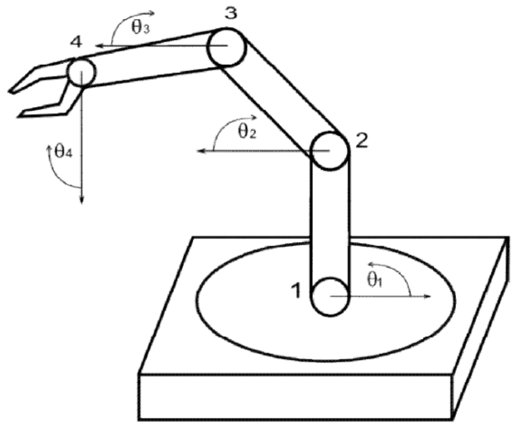


Fig. 1 Robotic Arm Structure.

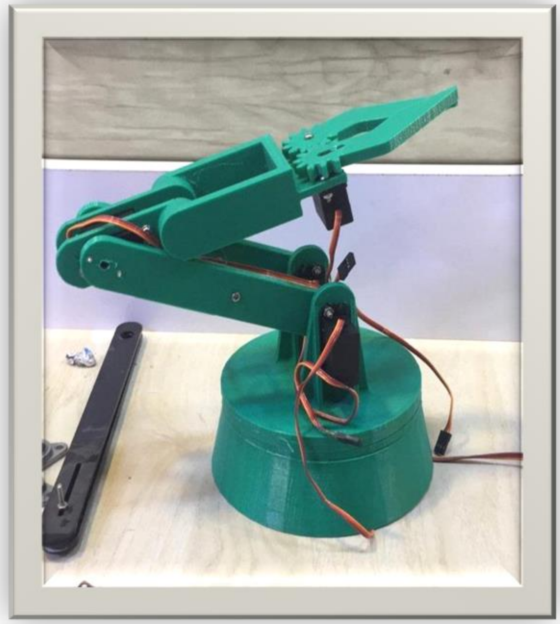
1. Servo Motor at Base — $\theta 1$– Degree of rotation of base and pole
2. Servo Motor at Shoulder — $\theta 2$ – Degree of rotation Shoulder
3. Servo Motor at Elbow — $\theta 3$ – Degree of rotation Elbow
4. Servo Motor at Wrist — $\theta 4$ – Degree of rotation of wrist (Gripper)

2.2 RESULTS AND DISCUSSION

This paper presents the design, development and construction of a robotic arm, which can pick and sort objects of different color. The mechanical structure of the robot was assembled using aluminium brackets which helped to reduce the weight without losing the mechanical strength. The aim of the project was to have a fully functional robotic arm which sorts different colored balls and the target is achieved successfully. In the final run of the project red, yellow and green balls were successfully sorted. The color sensor IC TCS3200show almost stable response in various sunlight conditions. The system is working with open loop. A better resolution can be achieved if closed loop control is incorporated. The system responses are a little bit slower than expected. It can be improved by using a more advanced color sensor and microcontroller. User interfaces also can be provided as a modification which will enable the on demand reconfiguration of the movement in a better way.

Chapter 3: The project

3.1 Design and manufacture of automatic production line with robotic arm:



A robotic arm, sometimes referred to as an industrial robot, is often described as a 'mechanical' arm. It is a device that operates in a similar way to a human arm, with a number of joints that either move along an axis or can rotate in certain directions. In fact, some robotic arms are anthropomorphic and try and imitate the exact movements of human arms. They are, in most cases programmable and used to perform specific tasks, most commonly for manufacturing, fabrication, and industrial applications. They can be small devices that perform intricate, detailed tasks, small enough to be held in one hand; or so big that their reach is large enough to construct entire buildings.

Robotic arms were originally designed to assist in mass production factories, most famously in the manufacturing of cars. They were also implemented to mitigate the risk of injury for workers, and to undertake monotonous tasks, so as to free workers to concentrate on the more complex elements of production. These early robotic arms were mostly employed to undertake simple, repetitive welding tasks. As technologies develop, in particular robotic vision and sensor technology, the role of robotic arms is changing. And in this research, we will talk about a production line robot.

Robot production line, today we present to you this type of robot, which depends on its work on separating things by color, depending on the color sensor. This work is coordinated by the Arduino.

3.2 What is Arduino?

Arduino is an electronic development board consisting of an open source electronic circuit with a microcontroller on a single board that is programmed by a computer and is designed to make the process of using interactive electronics in multidisciplinary projects easier. Arduino is mainly used in the design of interactive electronic projects or projects that It aims to build different environmental sensors (such as temperature, wind, pressure, etc.) and the Arduino can be connected to different programs on the personal computer. Arduino programming depends on the open source programming language Processing, and the programming codes of the Arduino language are similar to the C++ programming language and it is considered one of the easiest programming languages used in writing microcontroller programs.

3.3 Why Arduino?

In fact, there are a lot of electronic micro-controllers available in the market such as Parallax, Basic Stamp, Netmedia's BX-24 Phidgets and Raspberry Pi, all of which have powerful capabilities and have the ability to control various electronic parts and software, of course, with a varying advantage. But what distinguishes the Arduino is a set of things that make the difference between it and others, the most important of which are:

- **Simplicity:** The Arduino is designed to fit the needs of everyone, professionals, professors, students and interactive electronics enthusiasts.

- **Price**: The Arduino board is less expensive compared to other boards of the same type, as the most expensive Arduino does not exceed $50.
- **Self-Assembly**: You can download the Arduino datasheet for free from the official website, buy the parts and install it yourself!
- **Multi-platform**: The Arduino program has the ability to run on windows, Mac OS, Linux and most other electronic controllers only work on Windows only.
- **Simple and easy programming environment**: The Programming Environment is designed to be easy for beginners, stable and powerful for professionals.
- **Open Source Software**: It is written in C++ and is available to everyone to download, and programmers can modify it according to their needs.
- **Open Source Hardware**: Arduinos are made primarily from ATMEGA8 and ATMEGA168 microcontrollers and the schematics are published under a Creative Commons license, allowing Electronic Circuits designers to design their own circuits.

ATmega328P	the controller
5V	work stress
7-12V	Recommended tension
6-20V	Terminal voltage
14 (of which 6 provide PWM output)	Digital outputs (0 or 5 volts)
6	PWM Digital I/O Pins
6	Analog Input Pins
20 mA	The working current of the pole is 5 volts
50 mA	The working current of the pole is 3.3 V

32 KB (ATmega328P) of which 0.5 KB used by bootloader	flash memory
2 KB (ATmega328P)	SRAM memory
1 KB (ATmega328P)	EEPROM memory

16 MHz	Processor speed
68.6 mm	height
53.4 mm	Width
25 g	Mass

Table (1) Know the contents of the Arduino

3.4 What is a Color sensor?

A color sensor is a type of "photoelectric sensor" which emits light from a transmitter, and then detects the light reflected back from the detection object with a receiver.

A color sensor can detect the received light intensity for red, blue and green respectively, making it possible to determine the color of the target object.

3.5 Work principle: There are two types of color sensors. One illuminates the object with broad wavelength light and differentiates the three types of colors in the receiver. The other type illuminates the object with the three types of light (red, blue, and green) independently.

In both scenarios, the received light intensity of red, blue and green are detected, and the ratio of light received is calculated.

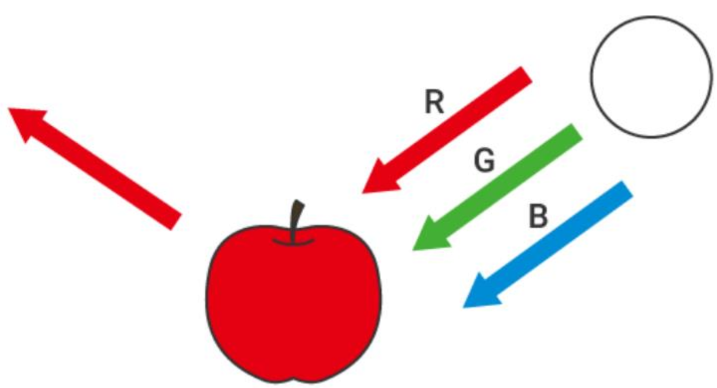


Fig.1

If light containing the red, blue, and green wavelengths is shown on a red object, only red light will be reflected.

- The white circle in the diagram represents a white light source.

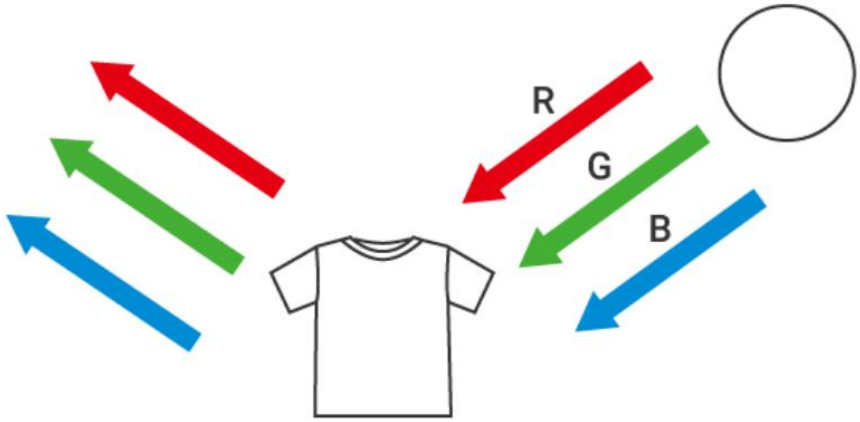


Fig.2

For a white object, all three colors of red, blue, and green are reflected.

- The white circle in the diagram represents a white light source.

The ratio of the red, green, and blue reflections vary according to the color of the object.

Object color	Reflected light		
	Red	Green	Blue
Red	√		
Yellow	√	√	
Green		√	
Blue			√
White	√	√	√
Black			

Table (2) How to read colors in a color sensor

By calculating the ratio of the intensity of the red, green, and blue light received, it is possible to distinguish differences in the color or appearance of the object.

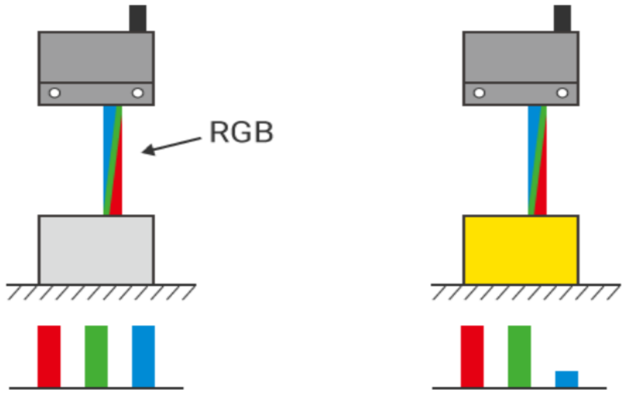


Figure (3)

Differences can be detected

Left: Received light ratio 1:1:1

Right: Received light ratio 4:4:1

3.6 What is IR Sensor : Circuit & Its Working:

IR technology is used in a wide range of wireless applications which includes remote controls and sensing. The infrared part in the electromagnetic spectrum can be separated into three main regions: near IR, mid-IR & far IR. The wavelengths of these three regions vary based on the application. For the near IR region, the wavelength ranges from 700 nm- 1400 nm, the wavelength of the mid-IR region ranges from 1400 nm – 3000 nm & finally for the far IR region, the wavelength ranges from 3000 nm – 1 mm.

The near IR region is used on fiber optic & IR sensors, the mid-IR region is used for heat sensing and the far IR region is used in thermal imaging. The range of frequency for IR is maximum as compared to microwave and minimum than visible light. This article discusses an overview of the IR sensor and its working.

3.7 What is IR Sensor?

The IR sensor or infrared sensor is one kind of electronic component, used to detect specific characteristics in its surroundings through emitting or detecting IR radiation. These sensors can also be used to detect or measure the heat of a target and its motion. In many electronic devices, the IR sensor circuit is a very essential module. This kind of sensor is similar to human’s visionary senses to detect obstacles.

The sensor which simply measures IR radiation instead of emitting is called PIR or passive infrared. Generally in the IR spectrum, the radiation of all the targets radiation and some kind of thermal radiation are not visible to the eyes but can be sensed through IR sensors.

In this sensor, an IR LED is used as an emitter whereas the photodiode is used as a detector. Once an infrared light drops on the photodiode, the output voltage & resistance will be changed in proportion to the received IR light magnitude.

3.8 IR Sensor Working Principle:

An infrared sensor includes two parts namely the emitter & the receiver (transmitter & receiver), so this is jointly called an optocoupler or a photo-coupler. Here, IR LED is used as an emitter whereas the IR photodiode is used as a receiver.

The photodiode used in this is very sensitive to the infrared light generated through an infrared LED. The resistance of photodiode & output voltage can be changed in proportion to the infrared light obtained. This is the fundamental IR sensor working principle.

The type of incident that occurred is the direct otherwise indirect type where indirect type, the arrangement of an infrared LED can be done ahead of a photodiode without obstacle. In indirect type, both the diodes are arranged side by side through a solid object ahead of the sensor. The generated light from the infrared LED strikes the solid surface & returns back toward the photodiode.

IR sensors use three basic Physics laws like Planck’s Radiation, Stephan Boltzmann & Wein’s Displacement.

- Planck’s Radiation Law defines that the temperature of any object is not equivalent to Zero
- Stephan Boltzmann Law defines that the whole energy which is generated at all wavelengths through a black body is associated with the total temperature.
- Wein’s Displacement Law defines that the temperature of different objects emits spectra that are maximum at various wavelengths and inversely proportional with temperature.

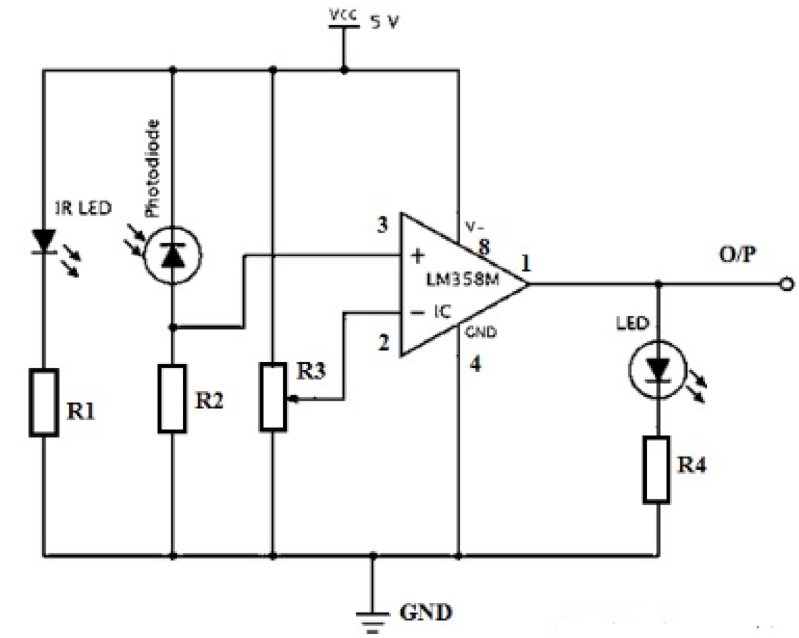


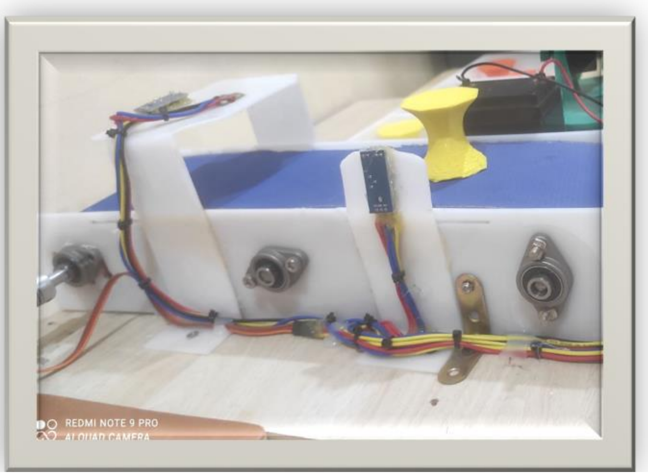
Fig.4 IR Sensor Circuit Diagram

After identifying these parts, we will now talk about the main components of the project, which are:

1. **Conveyor Belt**
2. **Robot Arm**
3. **Rating Boxes**
4. **Belt Box**

3.9 Conveyor Belt:

The belt is an important part of the production line robot. As things can be moved through it. The belt consists of several parts:



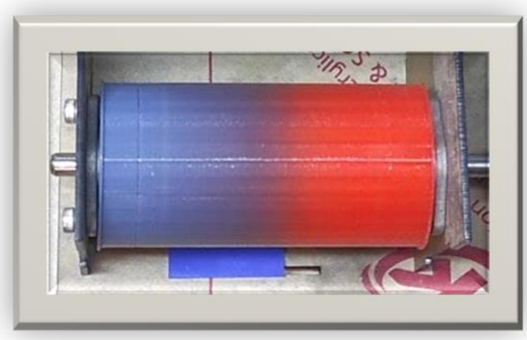
- **Motor**
- **Wheels**

- **IR Sensor**
- **Color sensor**

3.9.1 Motor:

The movement of the belt depends on the movement and speed of the servo that is connected to one of the wheels. The speed and direction of rotation of the servo can also be controlled through the Arduino.

3.9.2 Wheels:

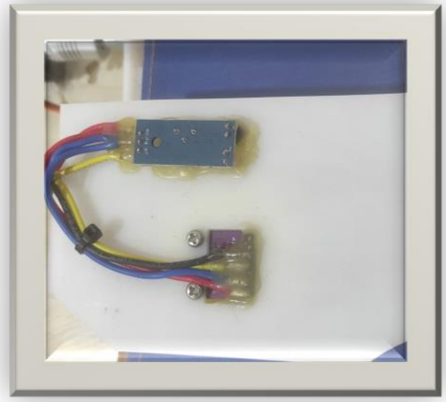


The wheels have an important role in rotating the belt. There are three wheels in the conveyor belt design, one connected to the servo, the second rotating freely, and the third located in the middle to reduce bending in the center of the belt.

3.9.3 IR Sensor:

The action of (IR Sensor) has been previously explained. In the conveyor belt, there is an important role (IR Sensor) as it senses the objects that are placed on the belt in order for the arm to classify them.

3.9.4 Color sensor:



The work of the color sensor was previously explained. The basis of the production line arm is to classify objects by color. This is done through the color sensor that is placed at the beginning of the belt, where it determines the color of the objects that pass through it.

3.10 Robot Arm:

The arm consists of the base with several servo-connected links. Through the servo, the arm is moved in certain directions and the work of the servo is coordinated by the Arduino. The arm can hold objects by the clamp, which has double servo. The base can rotate at an angle of 180 and the rest of the joints rotate at an angle of 90.

3.11 Rating Boxes:

The place where things are placed that are categorized by color. And installed in a place accessible to the arm.

3.12 Belt Box:

It is installed at the end of the conveyor belt, in which items that are not classified are placed.

3.13 Project work summary:

1. The arm classifies objects by color using a color sensor.
2. The objects that pass through the conveyor belt are controlled using IR sensor.
3. The coordination between the arm and the conveyor belt is done by the Arduino card.
4. There is a specific location for each color, the arm moves things to their specified location.
5. Items that are not classified go directly to the end of the conveyor belt.

Chapter 4: Problems and solutions

4.1 Introduction

It is normal to encounter problems when designing and implementing a particular project, which creates a challenge for you to find appropriate solutions.

And now we will mention the problems that we encountered in the design and implementation of the project.

1. **arm design:**
   - In designing the arm, we faced the problem of distributing the load on all parts of the arm so that no load would occur on one of the servos, which would cause it to malfunction. The solution was to design an arm containing two servomotors in the first leg.
   - There is also the problem of the clamp at the end of the arm, where it must be relatively large in order to facilitate the grip of things.
2. **conveyor belt design:**
   - In the design of the conveyor belt, there were some problems that hindered the work of the project as the belt was low in the middle area and this problem was solved by placing a third wheel in the middle.
   - Another problem is the soft surface that causes things to slip on it, and the solution was to put a kind of rough surface.

Chapter 5: Programming

5.1 Introduction

Programming is simply: it is a set of commands that you give to the computer, so that the latter can execute them! These commands are written "strangely" in English!

Programming appears everywhere, and through it you can control the machines, from a robot looking after a patient to another looking for water on Mars! Or making fun games (such as Angry Birds, Minecraft…), or developing your own website, such as the site of Muslim researchers. Behind every programmed website, what you see on the screen is this aesthetic, so that you can read articles and simply browse photos.

As we mentioned earlier, the project was programmed using an Arduino card, and now we will explain the most important thing in the code.

5.2 Software Used

5.2.1 Arduino UNO : Arduino is an open-source hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices. Its hardware products are licensed under a CC BY-SA license, while software is licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially from the official website or through authorized distributors.

5.2.2 Code

```
int col=0;
//------------------
#include <VarSpeedServo.h>
VarSpeedServo myservo_clamp;
 VarSpeedServo myservo_m;
  VarSpeedServo myservo_2b1;
   VarSpeedServo myservo_2b2;
    VarSpeedServo myservo_belt;
     VarSpeedServo myservo_b;
//------------------------------------------------------------------
// Libraries einbinden
#include "Wire.h"
#include "Adafruit_TCS34725.h"
Adafruit_TCS34725 tcs = Adafruit_TCS34725(TCS34725_INTEGRATIONTIME_50MS, TCS34725_GAIN_1X);
//==========================================================================================
void setup() {
 Serial.begin(9600);
 if (tcs.begin()) {
 Serial.println("Sensor gefunden");
 } else {
 Serial.println("TCS34725 nicht gefunden ... Ablauf gestoppt!");
 while (1); // Halt!
 }
 myservo_clamp.attach(3);
  myservo_m.attach(5);
   myservo_2b1.attach(6);
    myservo_belt.attach(9);
     myservo_2b2.attach(10);
      myservo_b.attach(11);
 pinMode(2,INPUT_PULLUP);//ir col
 pinMode(7,INPUT_PULLUP);//ir stop
 delay(1000);
}
//==========================================
void loop() {
myservo_belt.write(180);
int ir=digitalRead(2);
int ir1=digitalRead(7);
if(ir==0){
  myservo_belt.write(180);
  delay(500);
  myservo_belt.write(90);
  uint16_t clearcol, red, green, blue;
  float average, r, g, b;
  delay(100); // Farbmessung dauert c. 50ms
  tcs.getRawData(&red, &green, &blue, &clearcol);
  average = (red+green+blue)/3;
  r = red/average;
  g = green/average;
  b = blue/average;
// Serial.print("\tClear:"); Serial.print(clearcol);
// Serial.print("\tRed:"); Serial.print(r);
```

```
// Serial.print("\tGreen:"); Serial.print(g);
// Serial.print("\tBlue:"); Serial.print(b);
 if ((r > 1.4) && (g < 0.9) && (b < 0.9)) {
 Serial.println("\tRED"); col=1;}

 else if ((r < 0.8) && (g < 1.2) && (b > 1.2)) {
 Serial.println("\tBLUE");col=3;}
 else if ((r > 1.15) && (g > 1.15) && (b < 0.7)) {
 Serial.println("\tYELLOW");col=4;}
 else {Serial.println("\tNot Coler");col=0;}
 // myservo.write(nonePos);
}
 delay(100);
if(ir1==0 && col==4){
  myservo_belt.write(90);
  colY();
}
if(ir1==0 && col==3){
  myservo_belt.write(90);
  colB();
}
if(ir1==0 && col==1){
  myservo_belt.write(90);
  colR();
}
}
void colY() {
 //----------------------------------------1
  //----------------------------------------1
   myservo_b.write(165,30);
   myservo_2b2.write(75,30);
   myservo_2b1.write(75,30);
   myservo_m.write(65,30);
   myservo_clamp.write(110,30);
   delay(3000);
   myservo_m.write(25,30);
   delay(1000);
   myservo_clamp.write(0,30);
   delay(2000);
   myservo_m.write(55,30);
   delay(1000);
 //-----------------------------------------11
 myservo_b.write(100,30);
   myservo_2b2.write(90,30);
   myservo_2b1.write(90,30);
   myservo_m.write(55,30);
   myservo_clamp.write(0,30);
   delay(1000);
   myservo_m.write(20,30);
   delay(1000);
   myservo_clamp.write(0,30);
   delay(1000);
   myservo_clamp.write(45,30);
   delay(1000);
```

```
  myservo_m.write(55,30);
 delay(1000);
 col=0;
}
void colB() {
 //-----------------------------------------1
  myservo_b.write(165,30);
  myservo_2b2.write(75,30);
  myservo_2b1.write(75,30);
  myservo_m.write(65,30);
  myservo_clamp.write(110,30);
  delay(3000);
  myservo_m.write(25,30);
  delay(1000);
  myservo_clamp.write(0,30);
  delay(2000);
  myservo_m.write(55,30);
  delay(1000);
 //-----------------------------------------11
 myservo_b.write(60,30);
  myservo_2b2.write(90,30);
  myservo_2b1.write(90,30);
  myservo_m.write(55,30);
  myservo_clamp.write(0,30);
  delay(1000);
  myservo_m.write(20,30);
  delay(1000);
  myservo_clamp.write(0,30);
  delay(1000);
  myservo_clamp.write(45,30);
  delay(1000);
  myservo_m.write(55,30);
 delay(1000);
 col=0;
}
void colR() {
 //-----------------------------------------1
  //-----------------------------------------1
  myservo_b.write(165,30);
  myservo_2b2.write(75,30);
  myservo_2b1.write(75,30);
  myservo_m.write(65,30);
  myservo_clamp.write(110,30);
  delay(3000);
  myservo_m.write(25,30);
  delay(1000);
  myservo_clamp.write(0,30);
  delay(2000);
  myservo_m.write(55,30);
  delay(1000);
 //-----------------------------------------11
 myservo_b.write(35,30);
  myservo_2b2.write(90,30);
  myservo_2b1.write(90,30);
```

```
  myservo_m.write(55,30);
  myservo_clamp.write(0,30);
  delay(2000);
  myservo_m.write(20,30);
  delay(1000);
  myservo_clamp.write(0,30);
  delay(1000);
  myservo_clamp.write(45,30);
  delay(1000);
  myservo_m.write(55,30);
 delay(1000);
 col=0; }
```

After looking at the code, it becomes clear to us that we need a group of offices to add to the Arduino in order for it to work, and now we will talk about these offices.

5.2.3 Arduino libraries:

1- #include <VarSpeedServo.h> : The build in Servo library is good and very simple to use. However, there's more we can do with the hardware than it allows us. For example, how fast should the motor move from one position to the next? What about the ability to define a set of movements for the motor to perform, and then send them with a single instruction?

To achieve functionality like that, we need to use an external library. I am going to show you how to use the VarSpeedServo library, written by Korman and updated by Philip van Allen. Thank you to both for their work and contribution!

What distinguishes this library is its ability to control the speed of the servo and this makes the movement of the arm very stable and smooth.

2- #include "Adafruit_TCS34725.h": The RGB TCS3472 Color Sensor Module is one of the best modules with which you can see different and stunning colors. This module is the best color sensor on the market that has RGB and Clear light sensing elements.

This module has an IR filter that filters the IR spectrum, resulting in a larger color spectrum that can be viewed with high accuracy. The range of this module is 3800000:1. Therefore it is suitable for use behind dark glass.

3- #include "Wire.h": This library allows you to communicate with I2C/TWI devices. On the Arduino boards with the R3 layout (1.0 pinout), the SDA (data line) and SCL (clock line) are on the pin headers close to the AREF pin. The Arduino Due has two I2C/TWI interfaces SDA1 and SCL1 are near to the AREF pin and the additional one is on pins 20 and 21. As a reference the table below shows where TWI pins are located on various Arduino boards.

Board	I2C/TWI pins
UNO, Ethernet	A4 (SDA), A5 (SCL)
Mega2560	20 (SDA), 21 (SCL)
Leonardo	20 (SDA), 21 (SCL), SDA1, SCL1

Table (3)

Note: There are both 7 and 8-bit versions of I2C addresses. 7 bits identify the device, and the eighth bit determines if it's being written to or read from. The Wire library uses 7 bit addresses throughout. If you have a datasheet or sample code that uses 8-bit address, you'll want to drop the low bit (i.e. shift the value one bit to the right), yielding an address between 0 and 127. However the addresses from 0 to 7 are not used because are reserved so the first address that can be used is 8. Please note that a pull-up resistor is needed when connecting SDA/SCL pins. Please refer to the examples for more information. MEGA 2560 board has pull-up resistors on pins 20 and 21 onboard.

After we know the importance of these libraries, we will now talk about the mechanism of the code's work.

1. We define the number of servos and know each one of them, for example the base servo or the clamp servo.

2. It is important to know all the sensors that are connected to the arm and the conveyor belt, such as the color sensor and the IR sensor.

3. The working mechanism of the color sensor is by setting a ratio of the basic colors, which are red, green and blue. Through these ratios, the color readable by the color sensor appears.

4. After determining the color, we now specify a location for each color by rotating the servo at a certain angle, provided that there is no conflict between one servo movement and another.

5. One of the important things that must be considered is the movement of the conveyor belt servo with the movement of the arm. The time of movement of the conveyor belt servo must be adjusted so that the arm has enough time to move and this is done by relying on the IR sensor.

Chapter 6: Conclusion

The goal of the project was to design and program a robotic arm capable of categorizing things according to their color. The project proved the success of this idea, as the results were accurate in reading colors by the color sensor, and the movement of the arm was very good in locating the things that were programmed according to color. Also, the robotic arm has been programmed on the Arduino card, where its programming can be changed for any other purpose.

The project proved that it is possible to use such an arm in factories that need speed and accuracy in production.

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BOOKS

1- Arduino Development Cookbook
2- Designs and Prototypes of Mobile Robots
3- Robotic Welding, Intelligence and Automation
4- Make: Making Simple Robots
5- ROBOTICS Designing the Mechanisms for Automated Machinery