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Intitulé

Design of a Multi-Purpose Robot for Risky Areas

Par la commission d'évaluation composée de* :

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Abbreviations

VR	Virtual Reality
RPI	Raspberry PI
MEMS	Micro-Electro Mechanical System
BT	Bluetooth
DC Motor	Direct Current Motor
PCB	Printed Circuit Board

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General Introduction

General Introduction

The world is full of life crises and natural disasters. In these recent years, all countries of the world incurred material and human losses due to the spread of diseases such as the Coronavirus and natural disasters such as the series of fires in Algeria.

We always find people who work in these dangerous conditions, risking their lives to die. In some developed countries, there is another way to deal with these crises and preserve people’s lives. For example, Japan has designed robots that are controlled by firefighters to fight fires. In some countries, instead of the doctor’s presence to diagnose the patient’s condition with the Coronavirus, a robot that has the advantage of transmitting live video and providing treatment if asked. And on the military side, robots are used to dismantle explosive bombs.

So we finally thought to develop a robot that has the functions of roughly the types of robots mentioned above, most of which share a compact robotic car with a robotic arm with a live video streaming feature. This robot can copy that instant action of the human being under various conditions and situations. So we decided to design a robot that will be driving itself according to the position of the user who stands in front of it. It does what the user desires to do. It makes a copy of all movements of the user standing in front of it. This kind of robot is called semi-autonomous or human-controlled robots. Some of the most commonly used control systems are voice recognition, tactile or touch controlled and motion controlled. A Gesture Controlled robot is a kind of robot which can be controlled by your hand gestures not by old buttons. You just need to wear a small transmitting device in your hand which included an acceleration meter. This will transmit an appropriate command to the robot so that it can do whatever we want. The transmitting device included an MPU6050 to capture accelerometer data and then it will transmit by an NRF Transmitter module. At the receiving end another NRF Receiver module receives the data. This data is then processed by a microcontroller and finally gets sent to our motor driver to control the motors. Now it’s time to split this task in different parts to make it easy and simple. As our project is already divided into two different parts that are the robot arm and the robot car. A special addition to this robot We made an Android app that can control the robot through Bluetooth So that the application sends commands and data to the Bluetooth unit hc-05 located in the receiving circuit part, which the microcontroller analyzes the data and executes the commands. With Live video transmission feature with VR box viewing experience made this project perfect. The applications of robotics mainly involve in bomb dismantling,, medical, construction, defense and also used as a fire fighting robot to help the people from fire accidents.

Chapter 1

General Idea of Robotics

Introduction

Robotics is a branch of engineering and science that includes electronics engineering, mechanical engineering, computer science, etc

In this chapter, we will talk about the relationship between electronics and robotics, we speak about robots in particular and their importance in industry, and we willdiscuss the types of robots.

1.2 Electronics in robotics

This robotics guide deals with the very basics of electronics required for developing robotics systems. Each section of the post deals with a different aspect of electronics.

1.2.1 Robotics Guide on Electronic Systems:

The electronics under the hood of any robot can be divided into a number of subcategories:

1. Power systems
2. Sensors
3. Actuators
4. Microcontrollers and processors
5. Useful software tools

Some of these subcategories are repetitive in the sense that they can also be grouped under domains other than electronics. For example, actuators can also be grouped under the mechanical domain. For such subcategories, we will look at the different properties under their respective domains.

1.2.2 Power Systems:

Just like humans, robots need energy to function. Humans survive on air, food, water, and Wi-Fi, and robots survive on electricity. So the No. 1 system in this robotics guide is the power system. Normally, robots have rechargeable batteries, which make them mobile and therefore more useful. It goes without saying that the larger the battery (the greater the capacity of the battery), the longer the robot can operate. But we can't have an infinitely large battery on a small robot! This is a tradeoff that power systems engineers try to balance. Ideally, the battery should be just large enough for the robot to be able to run for as long as you want it to in the worst-case scenario, but should be small enough that it can fit on the robot and does not add too much extra weight.

1.2.3 Sensors :

Batteries are important and fun to play with. But what good are batteries without the rest of the onboard electronics? Just like the human sensory system, which consists of the eyes, nose, ears, taste buds, and skin, robots have a sensory system too. It goes without saying that the system is not as developed as ours, but there have been some major advancement recently.

A typical robot's sensory system would consist of a number of analog and digital sensors, such as a camera for vision, microphones for perceiving sound, ultrasonic or IR sensors for perceiving distance (this is similar to echolocation in bats and whales), and flex/tactile sensors for perceiving physical feelings. You can check out some interesting sensors on SparkFun Electronics and Adafruit and their tutorials as well. Try ordering some sensors for yourself online from RoboRium or Amazon and play around with them to find out more
An actuator is a device that helps to induce motion in the robot. Actuators can be electronic, pneumatic, or hydraulic. For smaller robots, we generally use electronic actuators, as they are easier to deal with, widely available, and inexpensive. Here are some common electronic actuators:

This is a very broad classification of electronic actuators. They may have a number of subcategories, depending on various electronic and mechanical properties. The electronic attributes for an actuator are the voltage and the current it requires to function. The mechanical attributes of actuators such as speed and torque are dependent on the electronic attributes. For now, let's just think about an actuator as a black box that converts electrical energy to mechanical energy, i.e., outputs some kind of rotational/linear motion when some electrical energy is provided as input.

1.2.4 Microcontrollers and Processors :

One of the most important parts of a robot is the brain! Just like a human brain, the robot's brain is responsible for controlling all the robots actions. It consists of microcontrollers and microprocessors.

Microcontrollers are essentially small chips that are made up of hundreds of thousands of transistors. They have a set of programmable digital i/o pins called the GPIO (General Purpose

Input/Output) pins, some flash memory, some RAM, and a small processor core. A microcontroller is generally used for more repetitive tasks. They can be programmed to perform a certain set of functions, and they will carry out these functions one after the other repetitively. A good example of a microcontroller would be an ATmega, which can often be seen on the Arduino-compatible development boards. To learn more, visit their beginner-friendly Arduino tutorials.

Microprocessors, however, are slightly funkier in the sense that they don't have onboard memory. You need to interface a separate memory with them, which gives them more room inside; hence they have more processing power. A good example of a microprocessor would be a Raspberry Pi. They are also more expensive than microcontrollers. You can think of your computer's CPU as a microprocessor, which would require a separate hard disk and RAM for memory storage. Microprocessors are much more powerful than microcontrollers, and are generally used for advanced tasks such as image processing, artificial intelligence, mapping, and path planning. The most common programming language for working with a Raspberry Pi is Python. There are a number of quality classes offered for beginners by the University of Michigan on Coursera.

1.2.5 Useful Software Tools :

Fritzing: Free software that provides you with the tools to prototype circuits on a breadboard in software. It's great for beginners as well as pros. personally; I feel it's the easiest and best way to represent/document simple prototypes.

- Circuits.io : An online CAD tool for electronics engineers, designed by Autodesk. I haven't used it much yet, so no personal reviews, but I must say that I know a lot of people who use it on a regular basis.
- EagleCAD : Autodesk's CAD tool for hardcore electronics engineers. I have used it for creating a number of PCB designs, and it is a widely accepted tool in the professional community.
- OrCAD : This is a CAD tool for electronics engineers, developed by Cadence. It is taught in most universities and is popular in the industry as well. The design is simple to use. It can also be used with PSPICE, to simulate circuits.
- Circuit Wizard : An extremely intuitive and easy-to-use software for simulating circuits. However, it is not free software; you can only get the trial or student edition for free.

This robotics guide has been intended to allow beginners to easily get started on DIY robotics. Stay tuned to Maker Pro's robotics page for more.

1.3 ROBOTS:

A robot is a mechatronic device (combining mechanics, electronics and computers) designed to automatically accomplish tasks that imitate or reproduce, in a specific field, human actions. The design of these systems is the subject of a scientific discipline, a branch of automatism called robotics.

The term robot first appears in the (science fiction) play R. U. R. (Rossum's Universal Robots), written in 1920 by author Karel Čapek1. The word was created by his brother Josef from the Czech word "robota" which means "work, chore, and drudgery".

The first industrial robots appear, despite their high cost, at the beginning of the 1970s. They are intended to perform certain repetitive, trying or toxic tasks for a human operator: painting or welding of automobile bodies. Today, the evolution of electronics and computing makes it possible to develop robots that are more precise, faster or with better autonomy. Industrialists, soldiers and surgical specialists compete in inventiveness to develop assistant robots to help them perform delicate or dangerous tasks. At the same time, robots appear for domestic use : vacuum cleaners, lawn mowers, etc.

The use of the term “robot” has been overused to take on broader meanings: distributor automaton, electro-mechanical device in human or animal form, software serving as an adversary on gaming platforms, computer bot.

1.3.1 Robotics and their industrial role:

The increasing awareness about automation is the leading cause of adoption of robotics technology. With the emergence of IIoT (Industrial Internet of Things), the demand for robotic engineering and smart robots would surge considerably in the upcoming years. Intelligent robots are gaining more popularity for the fast, effective and efficient services they deliver Here are few apparent applications of robots.

1.3.2 Various applications of Robotic Services:

The emerging business model like RaaS (Robots-As-A-Service) is helping the organizations to operate in industries ranging from manufacturing to healthcare and complete larger tasks done in a shorter period virtually.

RaaS helps in reducing the costs incurred in the deployment of robots significantly.

1.3.3 The Gaining Traction of Co-bots or Collaborative Robots:

The co-bots work along with their human counterparts for increasing the efficiency and enhancing the overall productivity. The various Small and Medium Enterprises (SMEs) in the automotive sector, plastic and rubber industry, food and beverage industry leverage the benefits such as convenience in programming and integration and lower costs proffered by the collaborative robots.

1.3.4 AI Robots and the 3D Technology:

In recent years, artificial intelligence and 3D tech have become the mainstream of the robotics industry, and the trend will continue with new advancements and ideas. The 3D machine vision helps the robots to feed data to the AI tech which is then used by AI for translating the visual transformation obtained from the view. DIY (Do It Yourself) and Maker Movements around the globe have advanced the economies fostering the growth of 3D technology-enabled robotics fuelling the robotic engineering systems.

1.3.5 the robotic arm in the industry:

The industrial robotic arm’s influence in the production industry is spreading due to their efficiency, higher productivity, and cost savings. Many businesses with robotic arms can save on costs essentially in low-skilled human labor with reduced human error and waste. In addition, the robotic arms can increase productivity and efficiency with more extended operating periods of the same strength, accuracy, and repetitive, programmed actions.

So what are robotic arms? Robotic arms are mechanical arms that are generally programmable, having similar functions to a human arm. This machine can be a mechanism on its own or be part of a complex robot. Let’s discuss further the uses, benefits, and types of industrial robotic arms.

1.3.6 Industrial robots arms:

In keeping with the IFR (International Federation of Robotics), robotic arm is a robotic system designed for production that is programmable and automated to perform physical, production-related tasks without a human controller. This consists of three or more axles, making them capable of movement.

The general applications of an industrial robotic arm are welding, painting, assembly, pick and place, packaging, labeling, palletizing, product inspection, and testing. In addition, it can assist in material handling and administer interfaces. The robotic arm accomplishes its tasks with speed, high endurance, and precision. As a result, it is commonly found in the production industry.

1.3.7 The Essence of Robotic Arms:

There are a few reasons why robotic arms are being used in production facilities. First, industrial robotic arms are capable of mimicking human motion. With the ability to mimic human action, they are used and placed in areas that:

- need to reduce dangers towards humans,
- need more strength or accuracy than humans,
- a continuous operation is required,
- Roles assumed to be too dull to human workers.

Secondly, many robots can repeat actions and motions with precision while being operable 24 hours a day. This makes them a highly desired commodity in the production field. Lastly, the accuracy of robot arms is reliant on the correct calibration and maintenance of the machine. One example of an industry that depends on robotic arms is the light industry. The lighting sector has special interests in robotic arms due to SMT's (surface mount technology) and polar's pick and place, spot welding, and arc welding functions.

1.4 Different Types of Robotic Arms:

Many different robotic arm types are available on today's market. Each is designed with essential core abilities and functions that make each type particularly well-suited for distinct industrial environments. This section will explore some of the commonly deployed types of programmable robot arms used in the production sector.

Here are the four widely used robotic arms:

1.4.1 Cartesian Robotic Arms

Cartesian robot arms, named after the Cartesian coordinate system, are often known as rectilinear or gantry robot arms. The Cartesian coordinate system was developed by René Descartes in the 17th century to map geometric curves onto a graph using algebraic equations. In robotic arm terms, mechatronic Cartesian robots consist of three programmed articulating joints, using the X, Y, and Z coordinates. This is to specify linear movement in three dimensions along these three axes. In addition, the wrist joint often provides other rotational functionality.

Cartesian robot arms can be mounted vertically, horizontally, or overhead. Also, they are commonly used in machining parts or picking and placement along with conveyor belts.

1.4.2 Cylindrical Robotic Arms

In contrast to the Cartesian versions outlined above, cylindrical robot arms are ones whose axes form a cylindrical coordinate system. Essentially, their programmed movements occur within a cylinder-shaped space (up, down, and around).

These robot arms are commonly used for spot-welding, assembly operations, and machine tool handling, where robotic arm components, like rotary and prismatic joints, showcase a linear and rotational motion.

1.4.3 Spherical Robotic Arms

Similar to the cylindrical robotic arms, a spherical or polar robot arm functions within a spherical work envelope or potential locus of movement. This is carried out through a combined rotational joint, two rotary joints, and a linear joint.

The polar robotic arm is connected to its base through a twisting joint. The subsequent spherical workspace can perform similar roles as cylindrical robotic arms, such as handling machine tools, die casting, spot welding, and arc welding.

1.4.4 SCARA Robotic Arms

SCARA robotic arms are the most widely used assembly and pick-and-place applications. The acronym SCARA stands for Selective Compliance Articulated Robot Arm or Selective Compliance Assembly Robot Arm. This refers to their flexibility along some axes and ability to tolerate a limited degree of compliance while remaining rigid in others.

SCARA robotic arms are considered classic when thinking of a high-tech production line. Their certain compliance features make them ideal for these purposes. So for placement tasks and specific assembly, using these tools is highly advantageous. Moreover, they will not bind or damage any parts, even if you need to insert additional details into tight-fitting spaces.

1.5 Conclusion:

In a nutshell, industrial robotic arms are positively impacting the manufacturing industry. The benefits are still growing with newer robotics coming out with unique specs. What's exciting is that we could be looking at a future where robotic arms labor is the norm in every production facility.

Chapter 2

Study and Conception of the robot

2.1 Introduction:

The aim of the project is to develop a robot that has approximately the functionality of the aforementioned types of robots, which most of them have in common of robotic car integrated with robotic arm with vision feature. For this purpose, we will build a system that acts as a channel between the human and the robot through physical change such as tilting of the hand as well as through an android application with Bluetooth instead of using joystick or physical controller with buttons.

In this chapter, we talk about our motivation for this project, then we explain how motion control for the robot car functions, the specifications of the robot and we explain the components used to make this happen and their configuration as well as the programs used.

2.2 Motivation for Project:

The world is full of life-threatening jobs. There was a time when humans merely gritted their teeth, accepted the risk and trusted that the training they received would protect them from harm. However, there is a growing trend of using robots to do the tasks that could harm humans. This year and the past years our country is going through a series of forest fires, so robots can make it nearly impossible for even the most experienced firefighters to put out the fire But with the help of remote-controlled firefighting robots equipped with cameras, the lives of those who sacrificed themselves to put out fires can be saved, another example are bomb disposal robots and Robots that Clean Up Nuclear Sites which are dangerous and harmful places so we can use robots which are controlled wirelessly and an intelligent vision system to see a lot of detail.

Figure2.1 : photos representing some useful robots

2.3 Methodology for Motion Control:

For the simplicity of analysis, the following Figure demonstrates the complete working mechanism and the features of the proposed robot car. Whereas, I/P and O/P represent the flow of the system as input and output. There are two modes of transmission and controlling of the robot car. The first one is the hand-gesture system. The hand accelerometer first senses the acceleration forces from the direction of the hand and sends them to the Arduino Nano that is attached to the hand. After receiving the data, Arduino converts it into different angles, between 0–360°, and sends it to the NRF receiver of the Arduino Uno that is attached to the robot car through the NRF sender, Instead of using two accelerometers, we create a way to control the robotic car and robot the arm with only one sensor, by using a push button to determine the type of part to be controlled, After receiving the data, the Arduino Uno of the robot will measure the received angles with the predefined set of angles and send a signal to the motor module to move the wheels of the robot car and robotic arm accordingly to the angles. It can be noticed that the range of angles are predefined for the wheel movement of the robot car to move forward, backward, brake, left and right and the same for arm with gripper , left and right rotation , up and down arm moving, forward and backward.

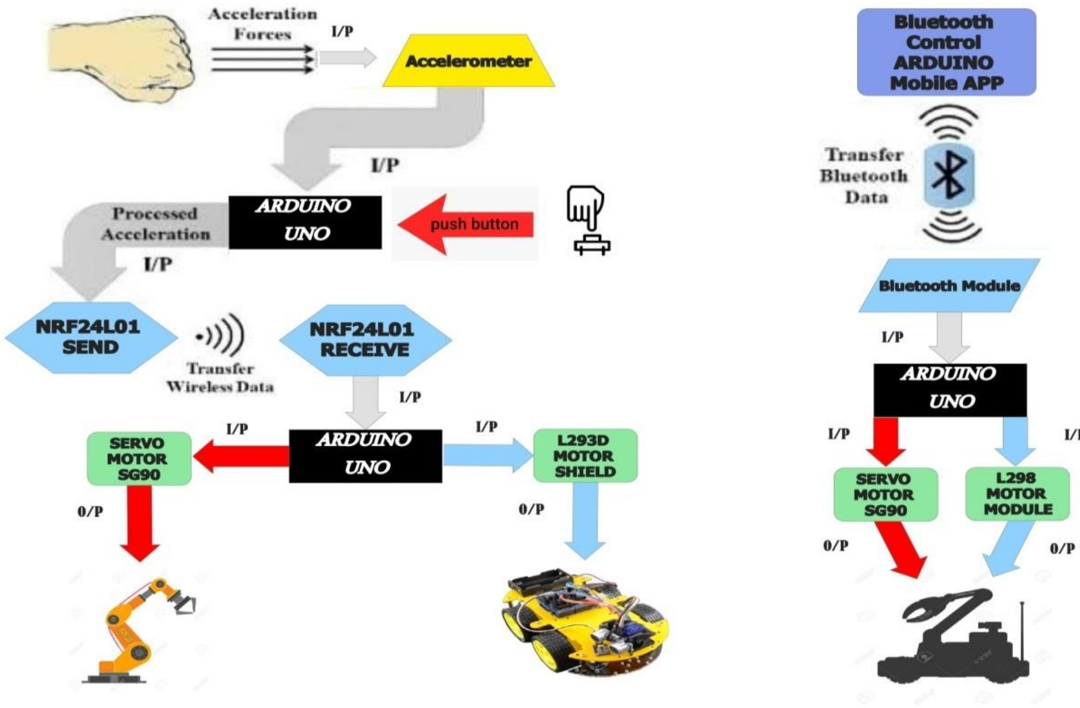


Figure2.2 : general diagram of the robot

The second mode is to control a robot car with an android mobile application, which is a built in android mobile application which we created it in MIT app inventor. In this system, when the user presses the corresponding touch button, a signal is transferred to the Arduino UNO that is attached to the car through the built-in mobile Bluetooth device. After receiving the following signal command, Arduino will check this signal with a predefined instruction that is programmed via coding and send the following signal to the motor module to move the wheels of the robot car accordingly to the received signal. And the same for the arm.

2.4 Specifications:

2.4.1 Electronic components:

Various electronic components are used for creating electronic circuits. Consequently, our proposed circuit diagrams also contain those components that are specified in **Table.**

Components	**Specifications**
Arduino UNO	28 pins; Operating voltage : 7–12 V
MPU6050	8 pins; Operating voltage 3.3 - 5v
NRF24l01 Sender/Receiver	
Bluetooth Module HC-05	6 pins; Operating voltage : 3.3–5 V; Transmission range : 100 m

2.4.1.1 MPU6050:

In recent years, some crafty engineers successfully made micro machined Gyroscopes. These MEMS (microelectromechanical system) gyroscopes have paved the way to a completely new set of innovative applications such as gesture recognition, enhanced gaming, augmented reality, panoramic photo capture, vehicle navigation, fitness monitoring and many more. No doubt the gyroscope and accelerometer are great in their own way. But when we combine them, we can get very accurate information about the orientation of an object. This is where the MPU6050 comes in.

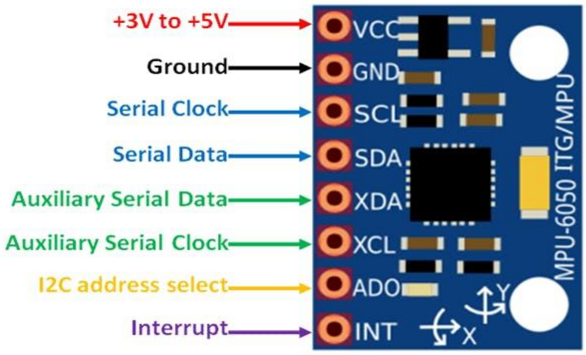


Figure 2.3 : MPU6050 Pinout

MPU6050 sensor module is a complete 6-axis Motion Tracking Device. It combines 3-axis Gyroscope, 3-axis Accelerometer and Digital Motion Processor all in a small package. Also, it has additional feature of on-chip Temperature sensor. It has I2C bus interface to communicate with the microcontrollers. The MPU6050 consists of Digital Motion Processor (DMP), which has property to solve complex calculations, and it consists of a 16-bit analog to digital converter hardware. Due to this feature, it captures three- dimension motion at the same time. This module has some famous features which are easily accessible, due to its easy availability it can be used with a famous microcontroller like Arduino. The following figure is the block diagram of MPU6050:

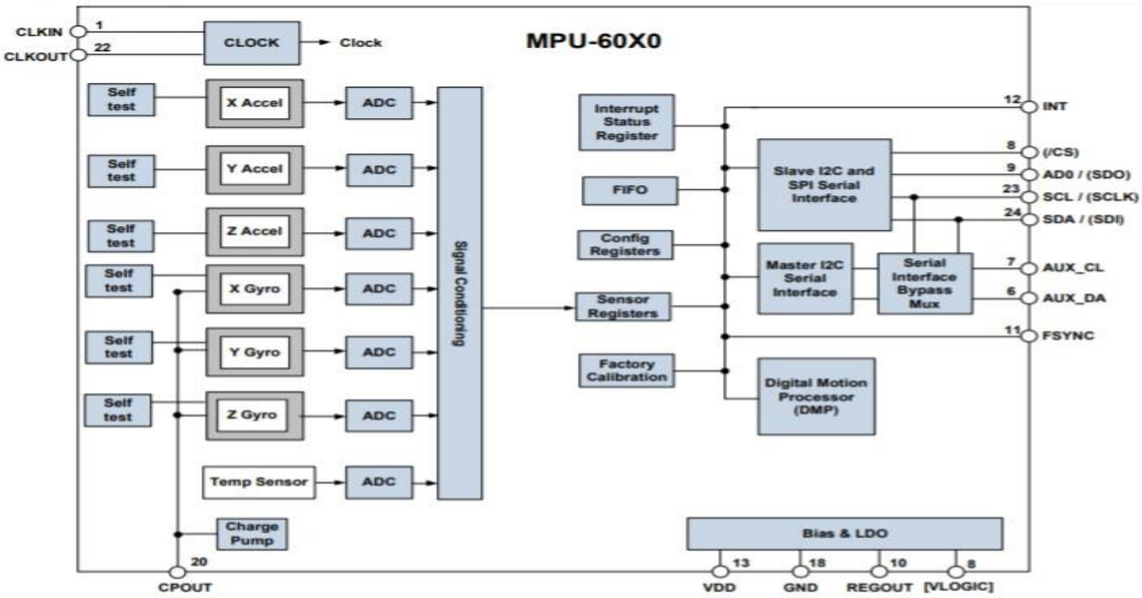


Figure 2.4: Block diagram of MPU6050

Before we use the MPU6050 in our Arduino project, "It would be nice to see how it really works especially the accelerometer with the whole project based on it."

How Does an Accelerometer Work?

An accelerometer works on the principle of the piezoelectric effect. Imagine a cuboidal box with a small ball inside it, like in the picture above. The walls of this box are made with piezoelectric crystals. Whenever you tilt the box, the ball is forced to move in the direction of the inclination due to gravity. The wall that the ball collides with creates tiny piezoelectric currents. There are three pairs of opposite walls in a cuboid. Each pair corresponds to an axis in 3D space: X, Y, and Z axes. Depending on the current produced from the piezoelectric walls, we can determine the direction of inclination and its magnitude. How MEMS Accelerometer Works?

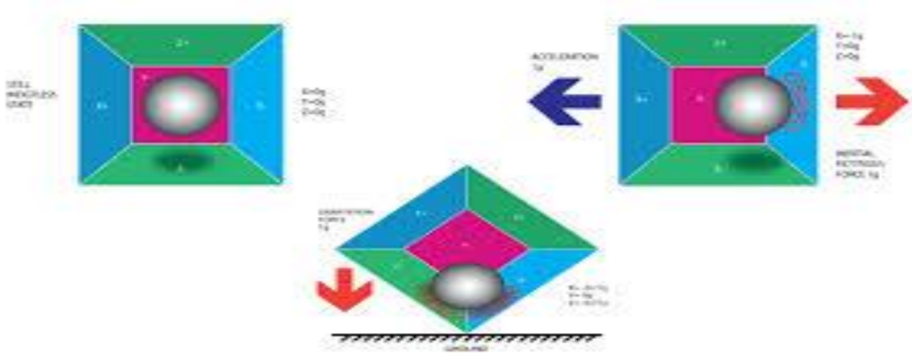


Figure2.5: principle of the piezoelectric effect

MEMS (Micro Electro Mechanical Systems) accelerometer consists of a micro-machined structure built on top of a silicon wafer

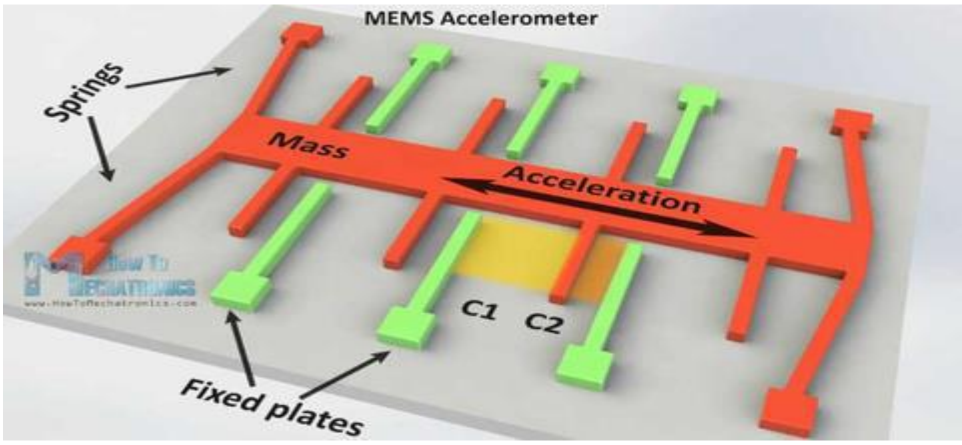


Figure2.6: MEMS accelerometer structure

This structure is suspended by polysilicon springs. It allows the structure to deflect at the time when the acceleration is applied on the particular axis. Due to deflection the capacitance between fixed plates and plates attached to the suspended structure is changed. This change in capacitance is proportional to the acceleration on that axis

2.4.1.2 NRF24L01:

NRF24L01 is basically a wireless trans-receiver, which is used to send the receive data by using radio waves. It is a single chip trans-receiver module. It uses SPI protocol for transmitting data. Its data transmission speed is up to 2Mbps. It is normally used in industrial devices and projects for data transmission. It is mostly used in computer, toys, remote control, games and other electronic devices.

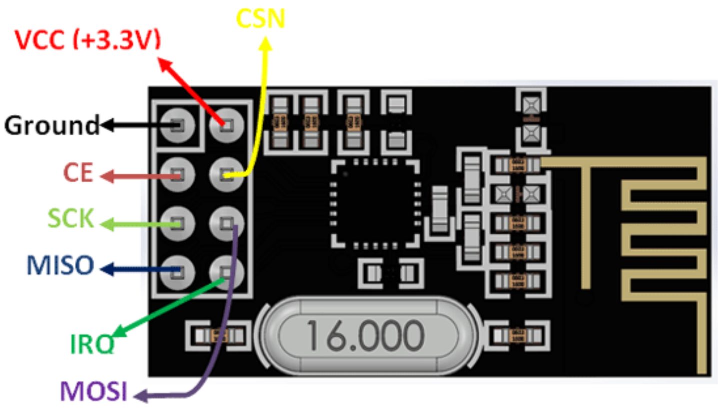


Figure2.7: MEMS accelerometer structure

NRF24L01 is a single chip radio transceiver for the worldwide 2.4 - 2.5 GHz ISM band. The transceiver consists of a fully integrated frequency synthesizer, a power amplifier, a crystal oscillator, a demodulator, modulator and Enhanced ShockBurst™protocol engine. Output power, frequency channels, and protocol setup are easily programmable through a SPI interface. Current consumption is very low, only 9.0mA at an output power of -6dBm and 12.3mA in RX mode. Built-in Power Down and Standby modes makes power saving easily realizable.

a Block diagram

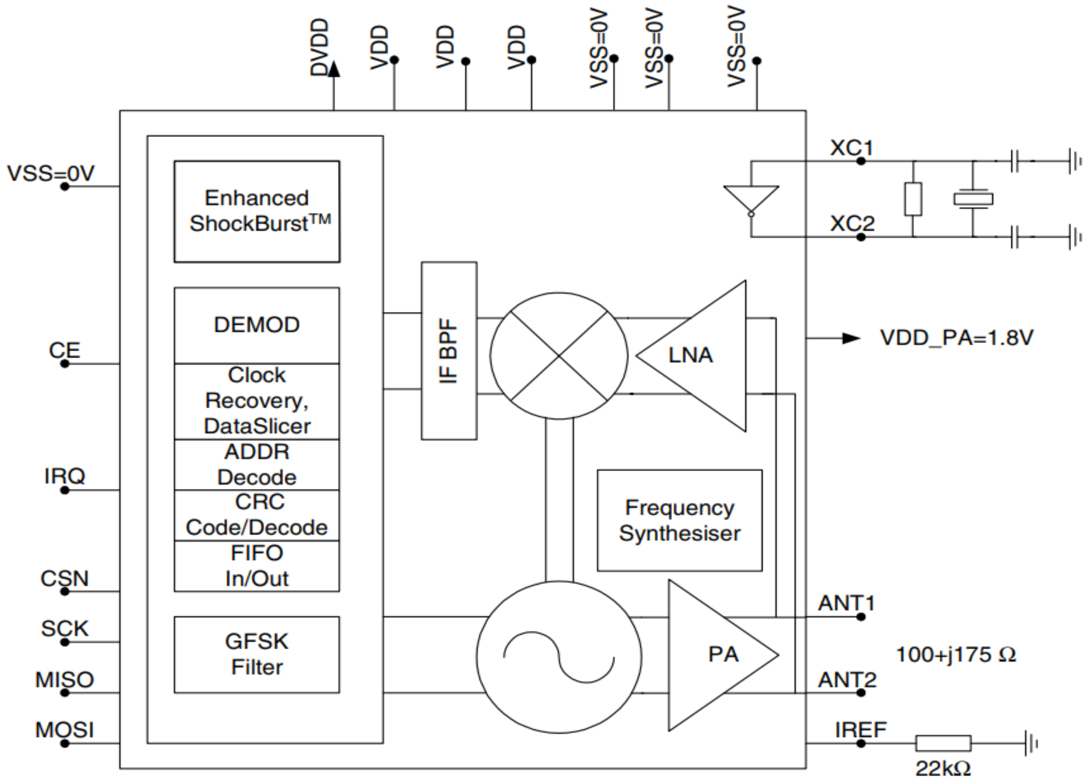


Figure2.8 : Block diagram of NRF24L01

b How nRF24L01+ transceiver module works?

b.1 RF Channel Frequency:

The nRF24L01+ transceiver module transmits and receives data on a certain frequency called Channel. Also in order for two or more transceiver modules to communicate with each other, they need to be on the same channel. This channel could be any frequency in the 2.4 GHz ISM band or to be more precise, it could be between 2.400 to 2.525 GHz (2400 to 2525 MHz).

Each channel occupies a bandwidth of less than 1MHz. This gives us 125 possible channels with 1MHz spacing. So, the module can use 125 different channels which give a possibility to have a network of 125 independently working modems in one place.

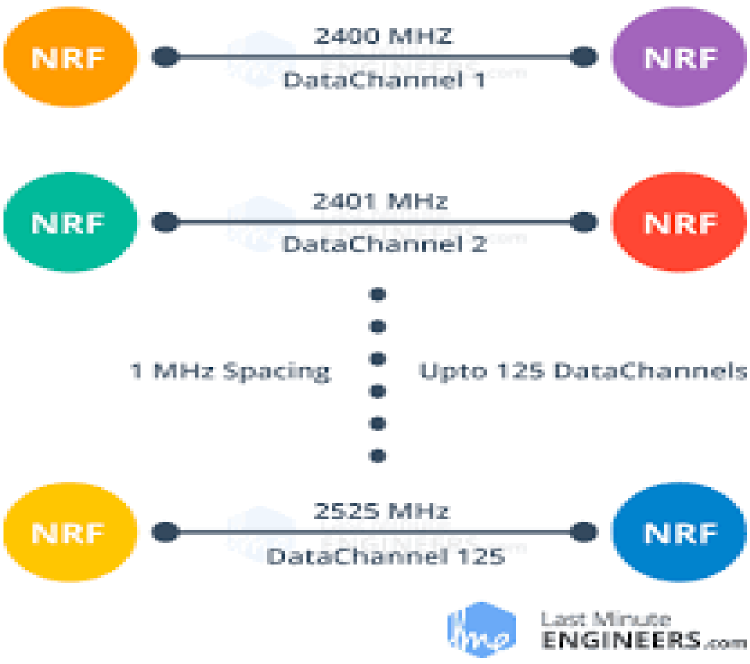


Figure2.9: NRF24L01 channel frequency for communication

RF channel frequency of your selected channel is set according to the following formula: $Freq_{(Selected)} = 2400 + CH_{(Selected)}$

For example, if you select 108 as your channel for data transmission, the RF channel frequency of your channel would be 2508MHz (2400 + 108)

b.2 Enhanced ShockBurst Protocol:

The nRF24L01+ transceiver module uses a packet structure known as Enhanced ShockBurst. This simple packet structure is broken down into 5 different fields, which is illustrated below.

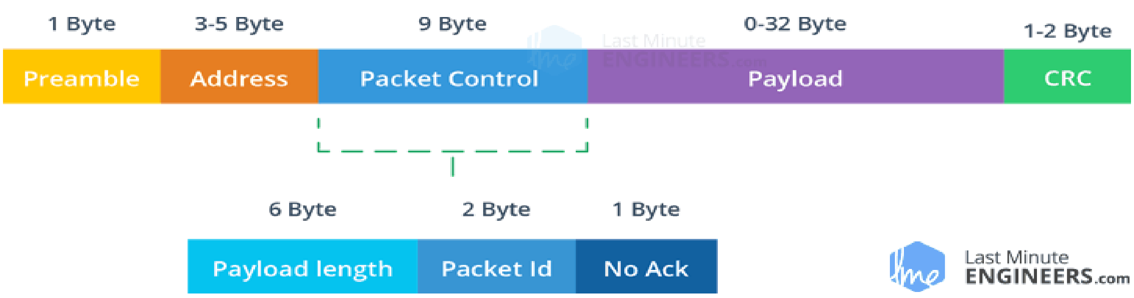


Figure 2.10: Representation of the packet structure in NRF24L01

The original ShockBurst structure consisted only of Preamble, Address, Payload and the Cyclic Redundancy Check (CRC) fields. Enhanced ShockBurst brought about greater functionality for more enhanced communications using a newly introduced Packet Control Field (PCF).

This new structure is great for a number of reasons. Firstly, it allows for variable length payloads with a payload length specifier, meaning payloads can vary from 1 to 32 bytes.

Secondly, it provides each sent packet with a packet ID, which allows the receiving device to determine whether a message is new or whether it has been retransmitted (and thus can be ignored).

Finally, and most importantly, each message can request an acknowledgement to be sent when it is received by another device.

c nRF24L01+ Automatic Packet Handling:

c.1 Transaction with acknowledgement and interrupt:

The transmitter starts a communication by sending a data packet to the receiver. Once the whole packet is transmitted, it waits (around 130 µs) for the acknowledgement packet (ACK packet) to receive. When the receiver receives the packet, it sends ACK packet to the transmitter. On receiving the ACK packet the transmitter asserts interrupt (IRQ) signal to indicate the new data is available.

c.2 Transaction with data packet lost:

This is where a retransmission is needed due to loss of the packet transmitted. After the packet is transmitted, the transmitter waits for the ACK packet to receive. If the transmitter doesn't get it within Auto-Retransmit-Delay (ARD) time, the packet is retransmitted. When the retransmitted packet is received by the receiver, the ACK packet is transmitted which in turn generates interrupt at the transmitter.

c.3 Transaction with acknowledgement lost:

This is where a retransmission is needed due to loss of the ACK packet. Here even if the receiver receives the packet in the first attempt, due to the loss of ACK packet, transmitter thinks the receiver has not got the packet at all.

This whole packet handling is done automatically by the nRF24L01+ chip without involvement of the microcontroller.

2.4.1.3 Microcontroller Arduino:

The Arduino Uno is a microcontroller board based on the ATmega328.It has 14 Digital Input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, and a reset button. It contains everything needed to support the microcontroller. To get started connect it with USB cable or with an AC-DC adapter or a battery. The microcontroller on the board is programmed using Arduino programming language using Arduino IDE. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators.

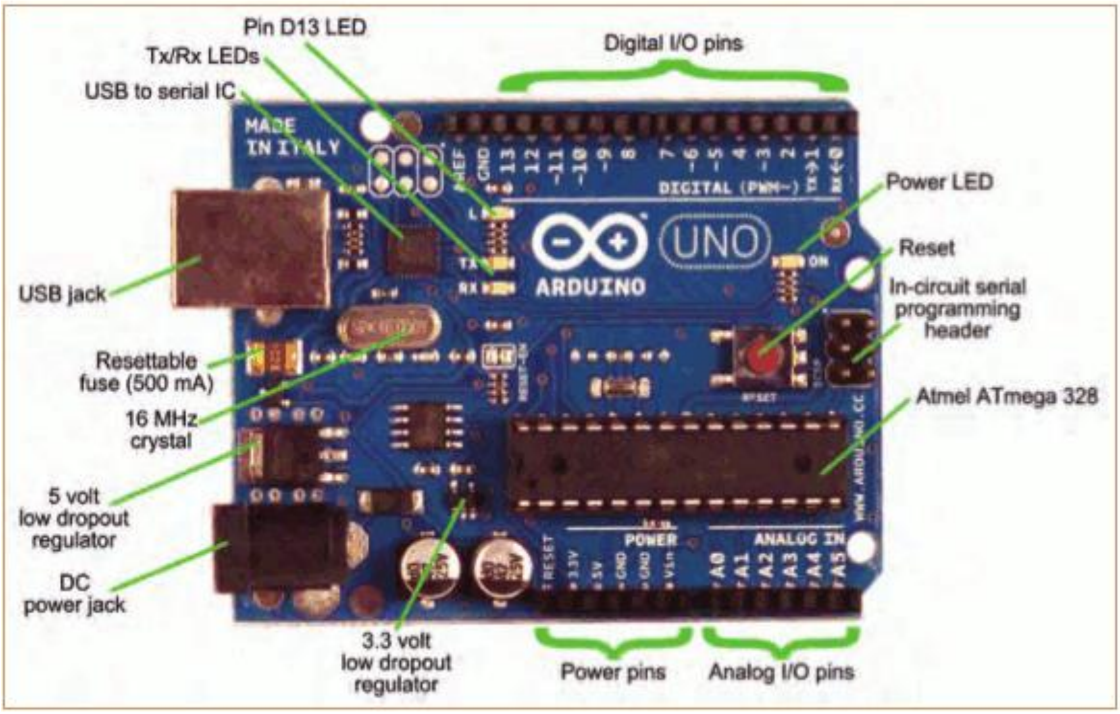


Figure2.11: Arduino pinout

2.4.1.4 L293D:

The L293D is a 16-pin Motor Driver IC which can control a set of two DC motors simultaneously in any direction. The L293D is designed to provide bidirectional drive currents of up to 600 mA (per channel) at voltages from 4.5 V to 36 V (at pin 8!).

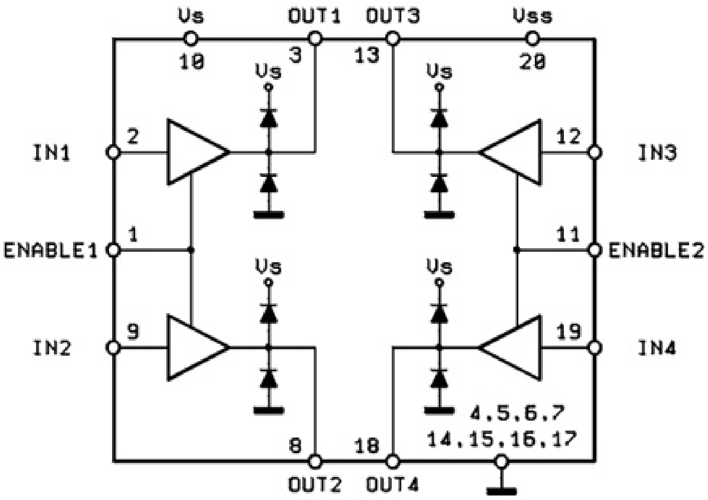


Figure2.12: L293D internal circuit

2.4.1.5 Hall Effect sensor:

Hall Effect Sensor is the solid state device which switches to active state when it is introduced in magnetic field. The output voltage of Hall Effect sensor is dependent on magnetic field around it. When the magnetic field across the semiconductor slab changes the magnetic flux density also changes due to which the output voltage of Hall Effect sensor varies.

Figure2.13: Hall Effect sensor pinout

The Hall Effect sensor works on the principle of Hall Effect. According to Hall Effect when a semiconductor slab is placed in magnetic field provided that magnetic field lines are perpendicular to the axis of semiconductor specimen and current is allowed to pass along the axis of semiconductor specimen then the charges carriers of the semiconductor device experiences magnetic force.

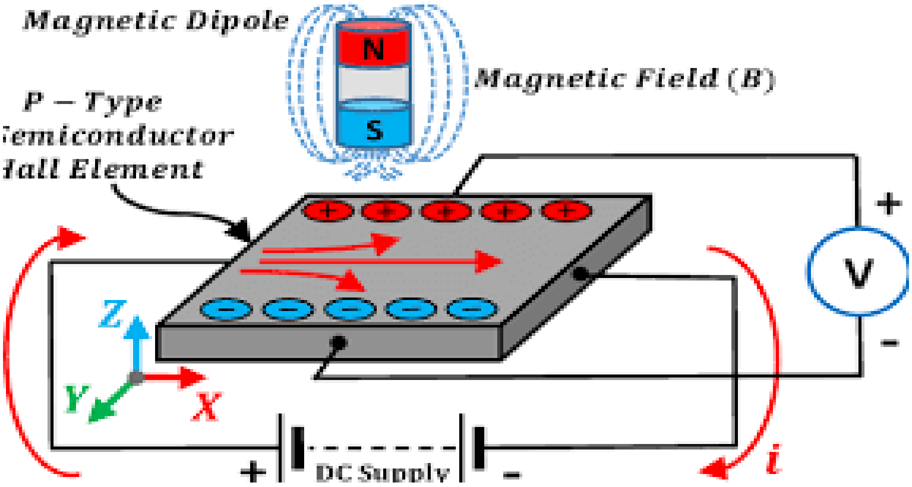


Figure: 2.14: Working principle of a Hall Effect sensor

2.4.1.5 Bluetooth module HC-05:

The HC-05 is a Bluetooth SPP (Serial Port Protocol) module that is designed for direct wireless serial connection setup and can be used in a Slave or Master configuration, giving it an outstanding solution for wireless transmission. This serial port Bluetooth module is entirely adequate Bluetooth V2.0 + EDR (Enhanced Data Rate) 3 Mbps Modulation with complete 2.4 GHz radio transceiver and baseband. It has a total number of six pins; an ENABLE pin to toggle between the Data Mode and AT command mode, a VCC pin for providing voltage, a Ground pin for grounding, a TX-Transmitter for transmitting serial data, a RX-Receiver for receiving the serial data, and a State pin (to check if Bluetooth is working correctly or paired/unpaired). Its input voltage is 3.3–5 V and can transmit up to 90 m.

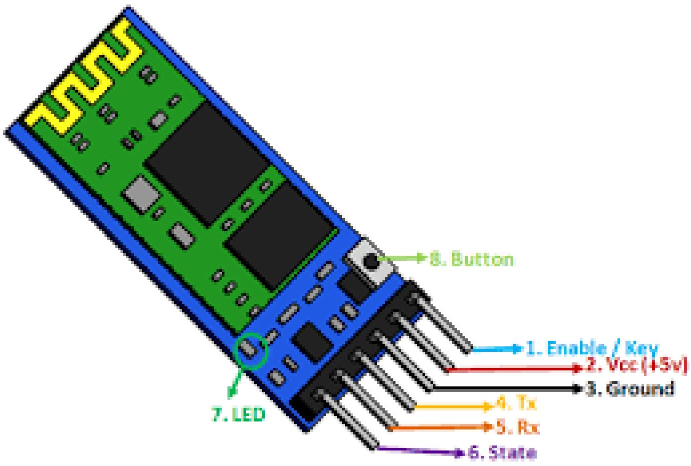


Figure2.15: Bluetooth module HC-05 Pinout

2.4.1.6 SG90 Servo Motor:

The SG90 Servo Motor is an actuator that produces a rotary motion approximately from 0° to 180°. There is an obstacle Mounted on the gears so that the servo arm rotates only 180°.
Inside the SG90 Servo Motor there is a small DC motor, A plastic gears to increase the torque, A potentiometer to give us the Current position of the output shaft, And a control circuit in the bottom. There are 3 wires coming out from the Servo, The Red wire is for powering the device with 5v, The Brown wire is the GND The Yellow wire is for controlling the servo position (signal wire) You can for example use servo motor to control nicely the direction of an RC car or boat, to make a robotic arm, A spider robot

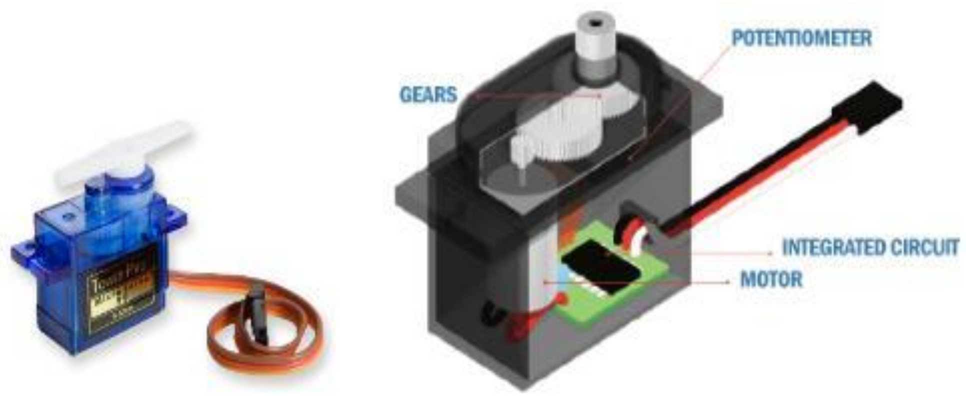


Figure2.16: Servo Motor Layout.

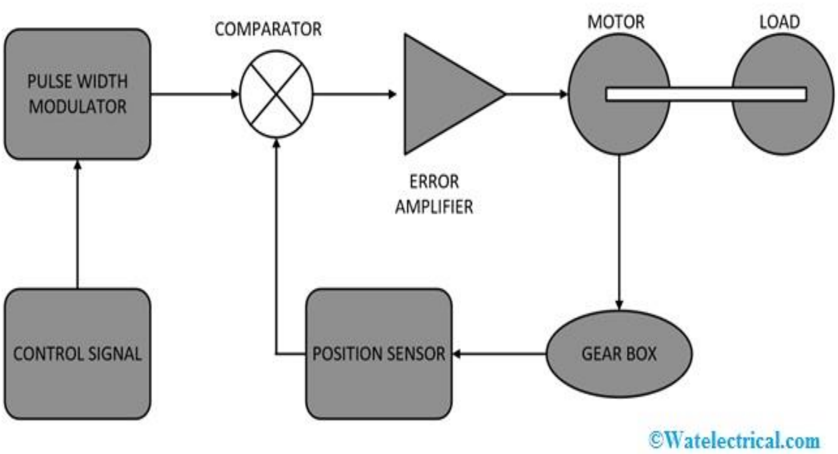


Figure 2.17: Servo motor Block diagram.

2.4.1.7 TT dc motor:

A DC motor is defined as a class of electrical motors that convert direct current electrical energy into mechanical energy.

From the above definition, we can conclude that any electric motor that is operated using direct current or DC is called a DC motor. We will understand the DC motor construction and how a DC motor converts the supplied DC electrical energy into mechanical energy in the next few sections.

Figure2.18: a picture of a TT DC Motor

2.4.2 Programs and tools used:

Before starting the description of our system, we will begin to present the design and simulation software used to carry out our project.

2.4.2.1 Proteus:

Proteus is used to simulate, design and drawing of electronic circuits. It was invented by the Labcenter electronics.

By using proteus you can make two-dimensional circuits designs as well.

The use of this engineering software, you can construct and simulate different electrical and electronic circuits on your personal computers or laptops.

2.4.2.2 ConceptDraw Diagram:

Concept Draw PRO is a full-featured diagramming platform that lets you display, communicate, and dynamically present.

You can create flow charts, schematics, and other diagrams with ConceptDraw PRO diagramming tools. You can connect two objects and ConceptDraw PRO automatically routes the path between them. Smart connectors allow you to rearrange your diagrams without losing your connections. The Clone Tool lets you quickly add multiples of the same objects. Hyperlinks let you connect your document to external documents, folder, web pages, email addresses, and more. The Rapid draw tool allows you to quickly and easily create professional flowcharts, block diagrams, org charts, and other diagrams

2.4.2.3 Fritzing:

Fritzing is a great open source tool for anyone to teach, share, and prototype their electronic projects! It allows you to design a schematic, and thus a part, which can then be added to very professional-looking wiring diagrams. You can even design your own PCBs and have them fabricated from the files you design

2.4.2.4 IronCAD 4D:

IRONCAD is a software product for 3D and 2D CAD (computer-aided-design) design focused mainly on the mechanical design market that runs on Microsoft Windows.

IRONCAD primary focus is on 3D CAD design using solid modeling technology. IRONCAD uses both Parasolid and ACIS modeling kernels to provide computational methods for solving geometric calculations such as calculating blends and shells. Users create designs in 3D using a drag and drop design methodology by dragging and dropping shapes and components from 3D catalogs to build parts and assemblies. They then use those designs to communicate with other users in the design process using both 3D models and 2D drawings. The drawings remain associative to the 3D model so as the model is updated the drawings reflect the changes. IRONCAD also employs the use of direct face editing and allows the combination of features and direct face edits within the same part.

2.4.2.5 Ultimaker Cura Slicer:

Cura is an open source slicing application for 3D printers, UltimakerCura works by slicing the user’s model file into layers and generating a printer-specific g-code. Once finished, the g-code can be sent to the printer for the manufacture of the physical object.

The open source software, compatible with most desktop 3D printers, can work with files in the most common 3D formats such as STL, OBJ, X3D, 3MF as well as image file formats such as BMP, GIF, JPG, and PNG

2.4.2.5 MIT app inventor:

App inventor lets you develop applications for android phones using a web browser and either a connected phone or emulator. The app inventor servers store your work and help you keep track of your projects.

You build apps by working with the app inventor designer, where you select the components for your app and the app inventor blocks editor, where you assemble program blocks that specify how the components should behave. You assemble programs visually, fitting pieces together like pieces of a puzzle.

Your app appears on the phone step by step as you add pieces to it, so you can test your work as you build. When you’re done, you can package your app and produce a stand-alone application to install.

2.5 Conclusion:

In this chapter, we have reviewed the control diagram of the robot as well as the principle of operation. We used different methods to control the robot instead of the traditional methods like touch button or joystick. We also studied the theoretical part of the various electronic components. This will allow us to approach the practical part of our project in the next chapter.

Chapter 3

Simulation and Practical Realization

3.1 Introduction:

After having a look at the general idea of the robot, the main reason for developing it, the theoretical background and the hardware required for the project. It is now the time to deal with the implementation of this project and have a look on the design methodology with implementation results of each part of this project. Finally, we discuss the final result of this project and the future work we aspire to achieve.

3.2 Designing Methodology:

3.2.1 Circuit Diagram and Explanation:

To understand the working of this **Arduino gesture control car**, let us divide this project into two parts. The **first part is the transmitter part (remote)** in which the MPU6050 Accelerometer sensor continuously sends signals to the receiver (Robot) through Arduino and NRF transmitter.

The **second part is the Receiver part (Robot car and arm)** in which the nRF receiver module receives the transmitted data and sends it to Arduino, which further processes them and move the robot accordingly.

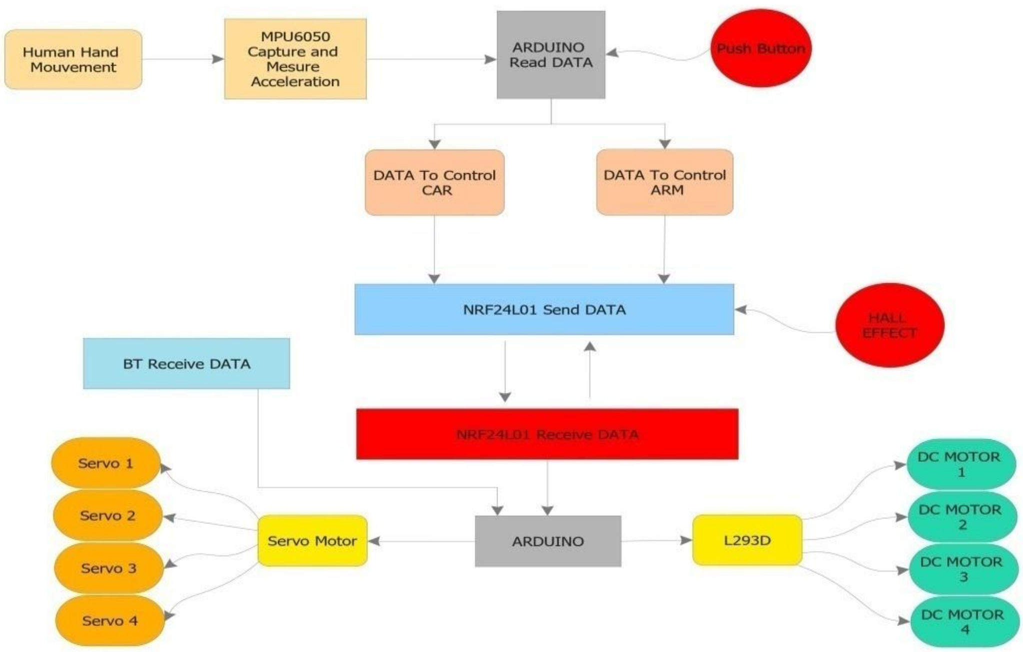


Figure 3.1: Arduino Gesture control diagram

The MPU6050 Accelerometer sensor reads the X Y Z coordinates and sends the coordinates to the Arduino. To control by mpu6050, we can only use X and Y coordinates. Arduino then checks the values of coordinates and according to the state of the push button; Arduino sends data of one of the parts of the robot (car or arm) to the nRF Transmitter. The transmitted data is received by the nRF Receiver. The receiver sends the data to the receiver side's Arduino. In case the push button is not pressed the Arduino passes the data to the Motor Driver IC and the motor driver turns the motors in the required direction, now if the push-button is pressed so in this case the Arduino passes the data directly to servo motors.

According to the motive, the primary idea of this project is to produce an innovation for the robot that will allow it to be controlled by hand-gestures as well as an Android mobile application In this scenario, the robot will move with the built-in Android application which contains touch button control (arrow and simple buttons), after establishing the connection to the Android mobile application with Arduino through the Bluetooth module, whenever the user presses any of the touch buttons in the application, the corresponding signal is sent to the Arduino Uno. After receiving the signal, Arduino will check this with predefined instruction for moving the car and arm then send the command to the motors to move the robot in the corresponding direction.

3.2.2 Transmitter Circuit:

The following figure shows the circuit design for hand gestures, which sends data to control one of the parts of the robot. Here we notice that there is are another component we didn't talk about it before so the hall effect sensor, is only used to control the arm gripper when the magnet is near this sensor it gives an analog value and Arduino changes it to the rotation angle value for the servo motor and the red led is turn on automatically whenever the sensor detects.

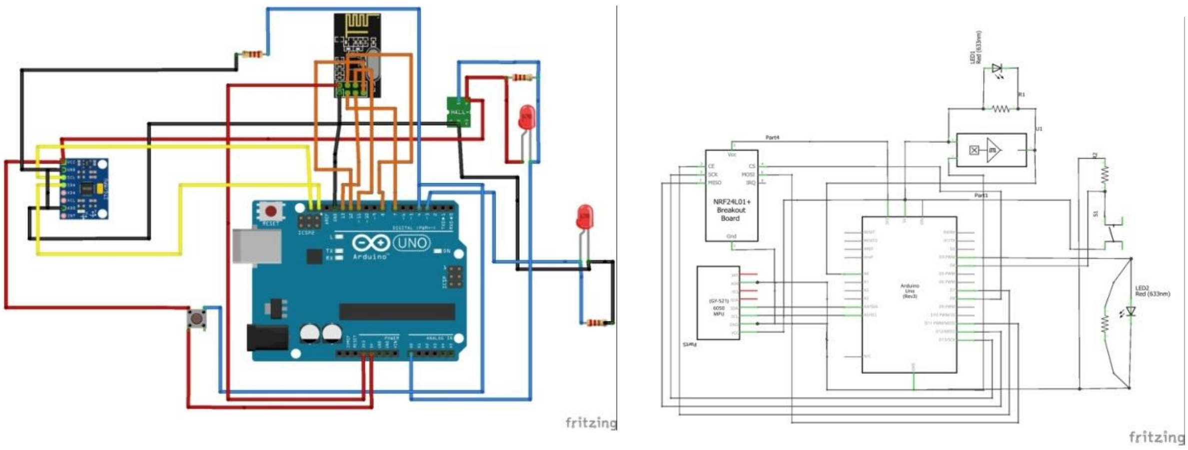


Figure3.2: design for Transmitter circuit

3.2.3 Receiver Circuit:

This Figure shows the receiver circuit design, which controls the robotic car and arm using hand movement and a phone app

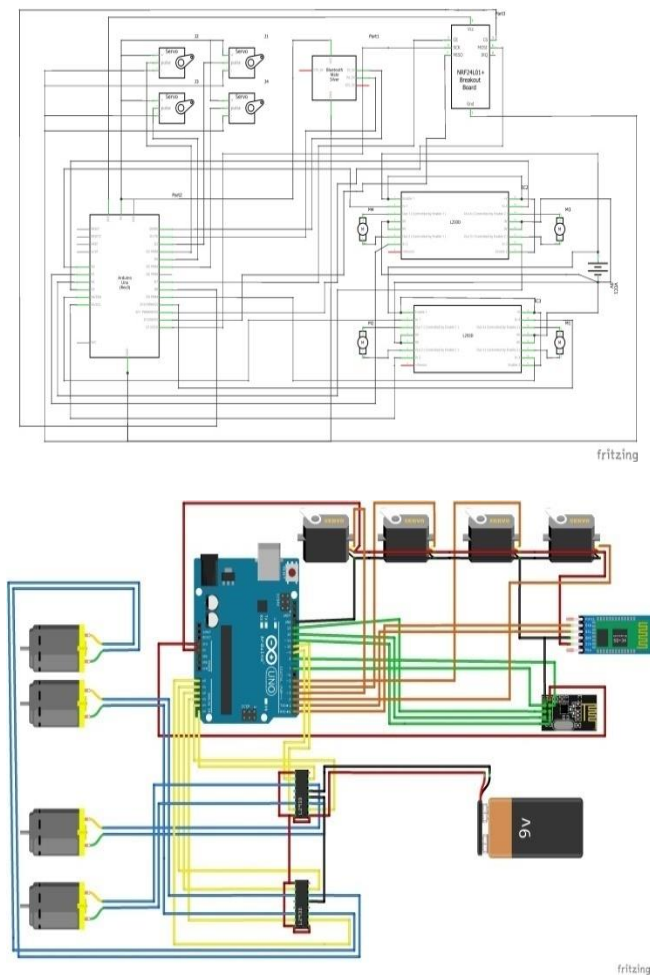


Figure3.3: design for receiver circuit

3.3 Pin configuration:

HALL EFFECT SENSOR	Arduino Uno (S)
VCC	5V
GND	GND
OUTPUT	PIN A0

L293D (1)	Arduino Uno (R)
IN1	A0
IN2	A1
IN3	A2
IN4	A3

nRF24L01	Arduino Uno S/R
VCC	3.3V
GND	GND
CE	Pin 7
CSN	Pin 8
SCK	Pin 13
MOSI	11
MISO	12

L293D (2)	Arduino Uno (R)
IN1	A4
IN2	A5
IN3	9
IN4	10

- 05-HC Bluetooth Module	Arduino Uno (R)
VCC	5V
GND	GND
TX	RX
RX	TX

MPU6050	Arduino Uno (S)
VCC	5V
GND	GND
SCL	Pin A5
SDA	Pin A4
INT	GND

3.4 Flowchart program

In this type of control (hand gesture), the fluidity of movements can a robot do is depend on how much coordinates there are and how the hand position can do as I mentioned before we can only use x and y Coordinates of mpu6050 and this is fine to control the car but for the arm, we need another 2 coordinates because it works with 4 servo motors so we added hall effect sensor to make controlling the gripper easier and we divided the X coordinate interval in two parts to allow us to control in 2 servos motor and the Y coordinate controls the last servo.

There are a lot of solutions like adding a flex sensor... But we try to make this robot with less cost and more effective

This figure shows the sender circuit and the logic used to make it function as intended

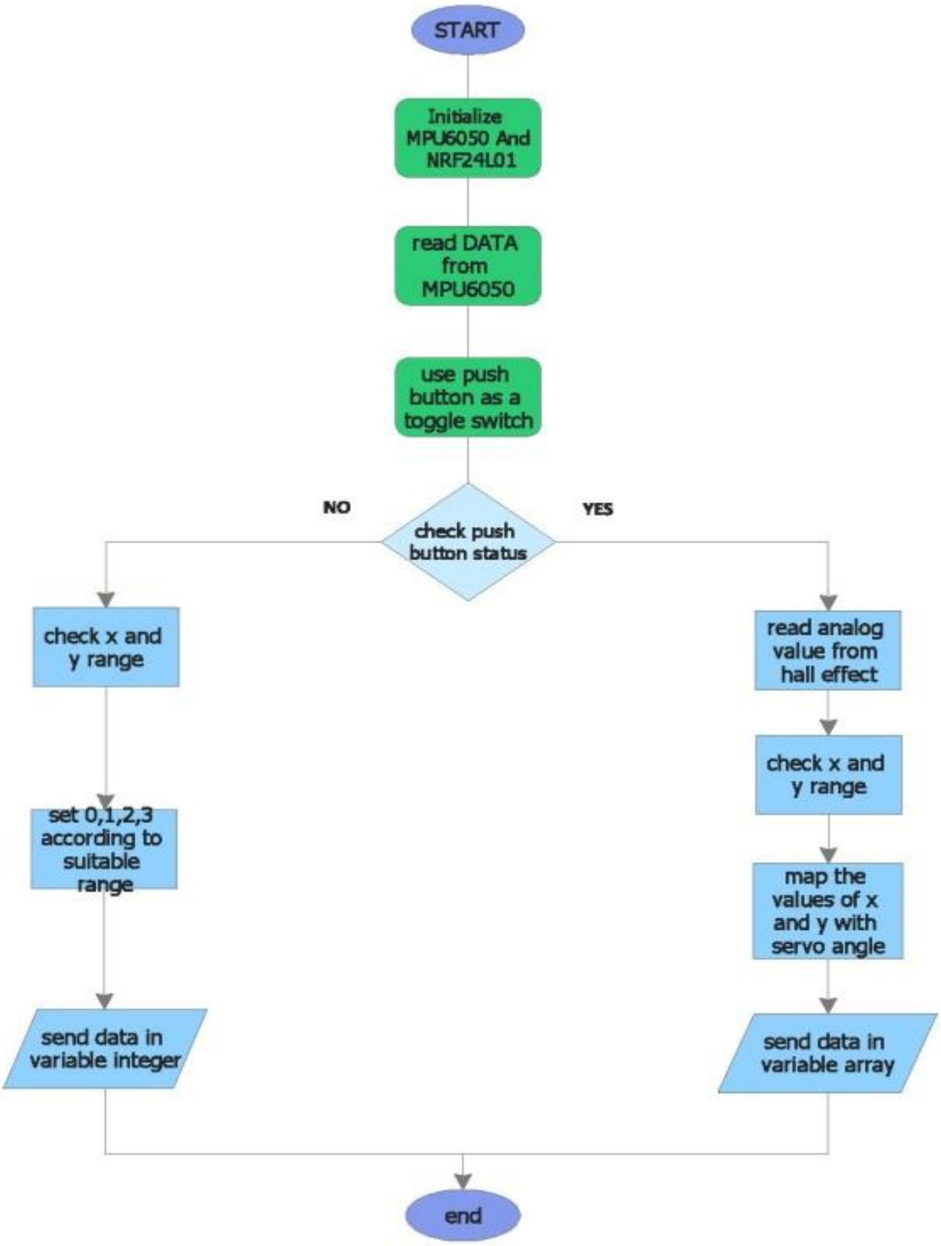


Figure3.4: Flowchart for transmitter circuit

After we sent our data, it will be received by the NRF module which in turn will send the data to the Arduino, the microcontroller will check the state of the push button variable. If it is not pressed, the arduino will give commands based on the data received from the transmission circuit to the DC Motors on the robotic car and if it is pressed, then the arduino will give commands to the Servo motor on the robotic arm.

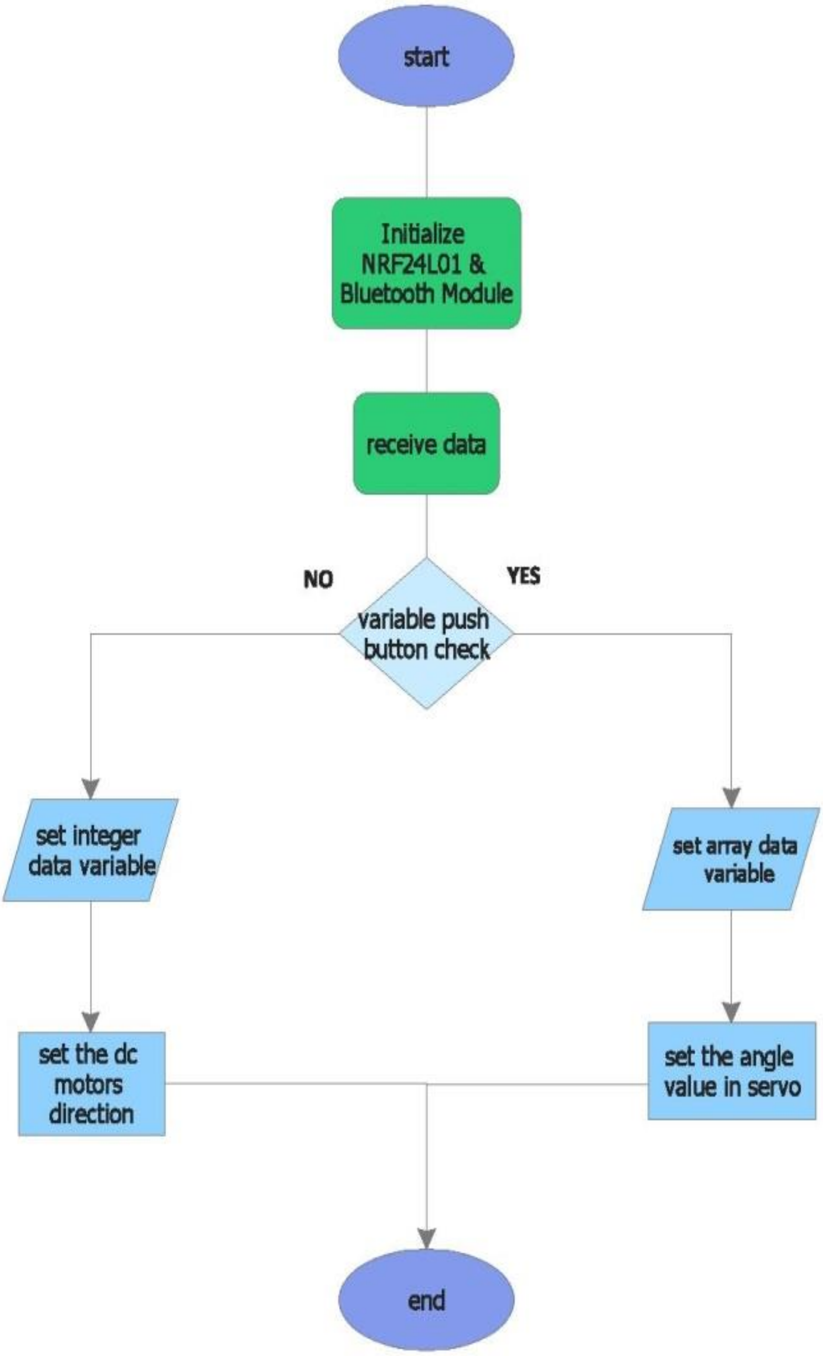


Figure3.5: Flowchart for receiver circuit

For the second method of controlling the robot, we used an android application which sends data to the Bluetooth module in the receiver circuit which is then processed by the arduino and gives commands to the robotic arm and car, this following figure explains the process with which the robot is controlled by the mobile application.

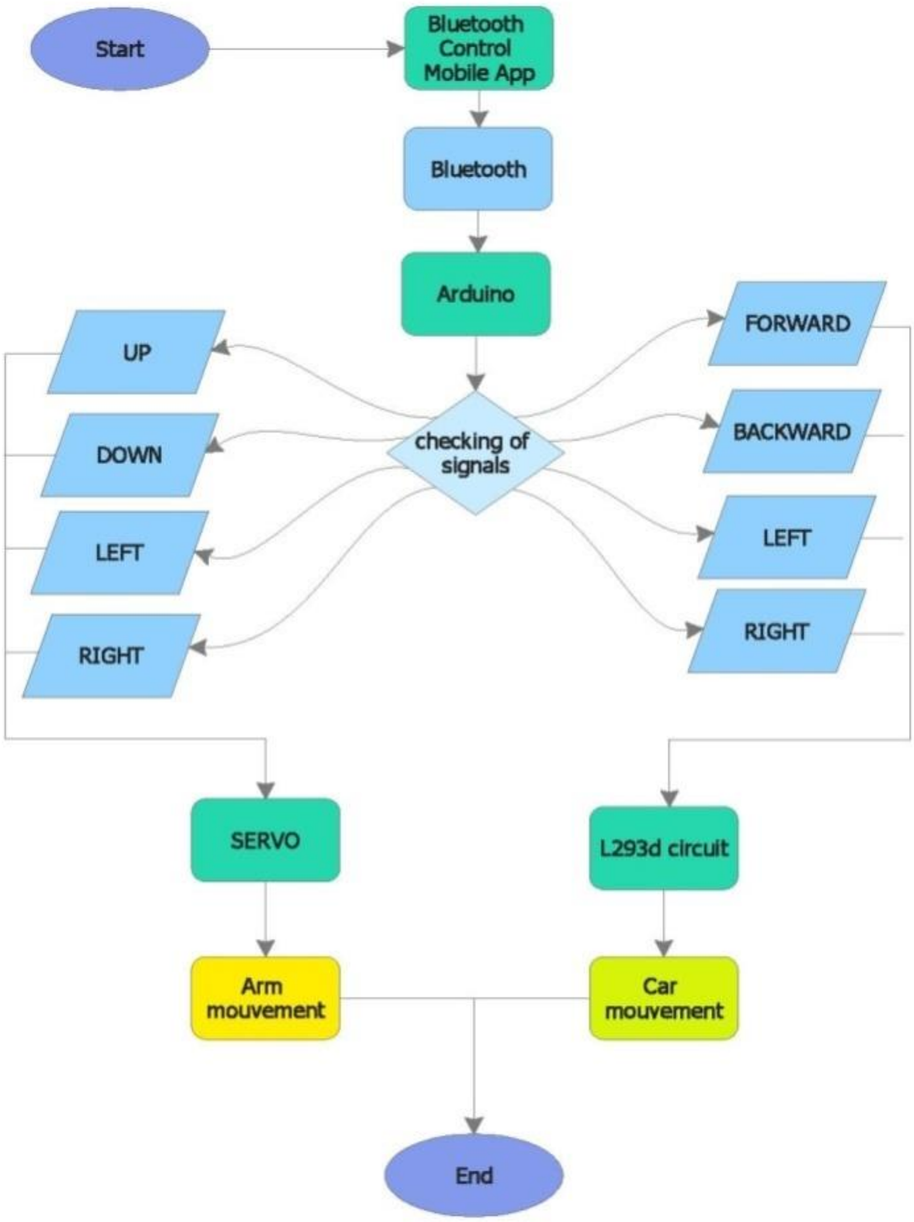


Figure3.6: Flowchart for Android app control

3.5 Result diagrams:

After we uploaded the program that recognizes certain hand gestures to the arduino, we realized a robot that's able to move in the same direction as your hand.

Finally Result diagrams should be like the following figures

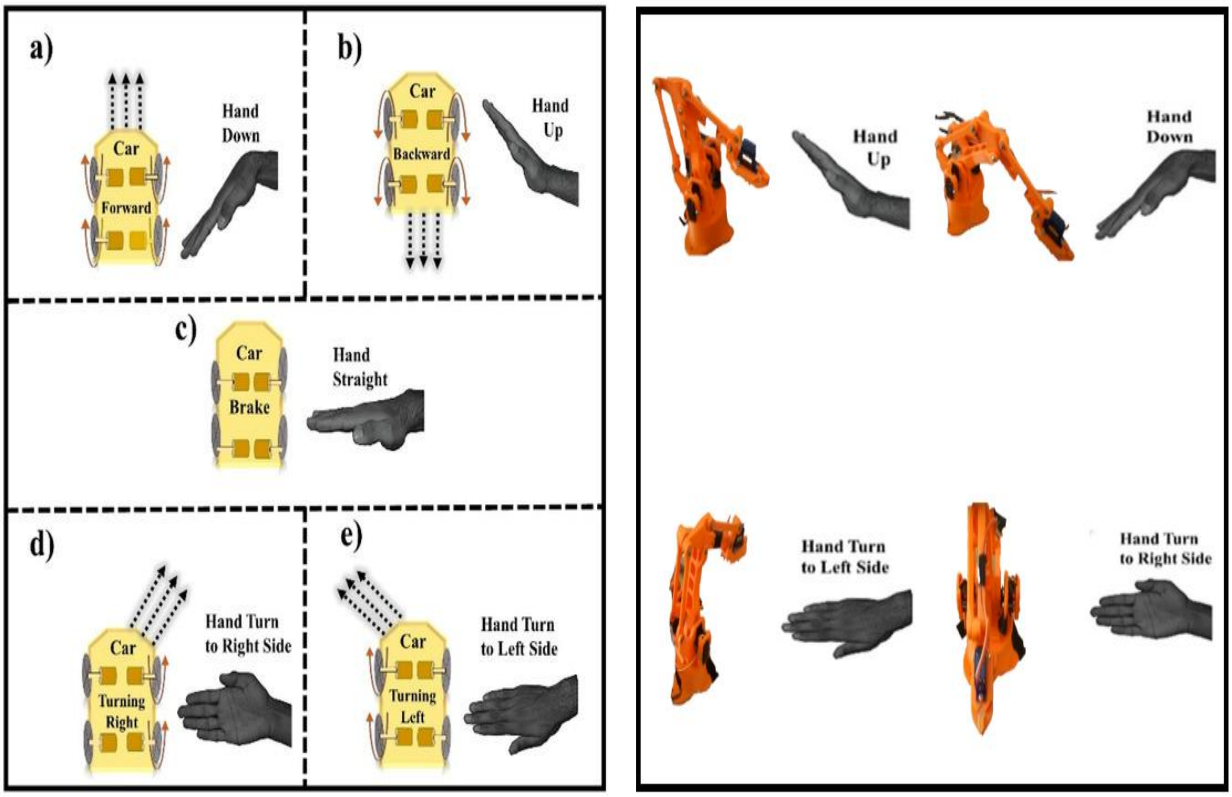


Figure3.7: Gesture control commands for the robotic arm

3.6 Circuit implementation

3.6.1 Circuit issues:

At first we used the Proteus program to design and print the circuit, but unfortunately there are not enough libraries, so in place of components we just replace them with female pin header as we see in this figure

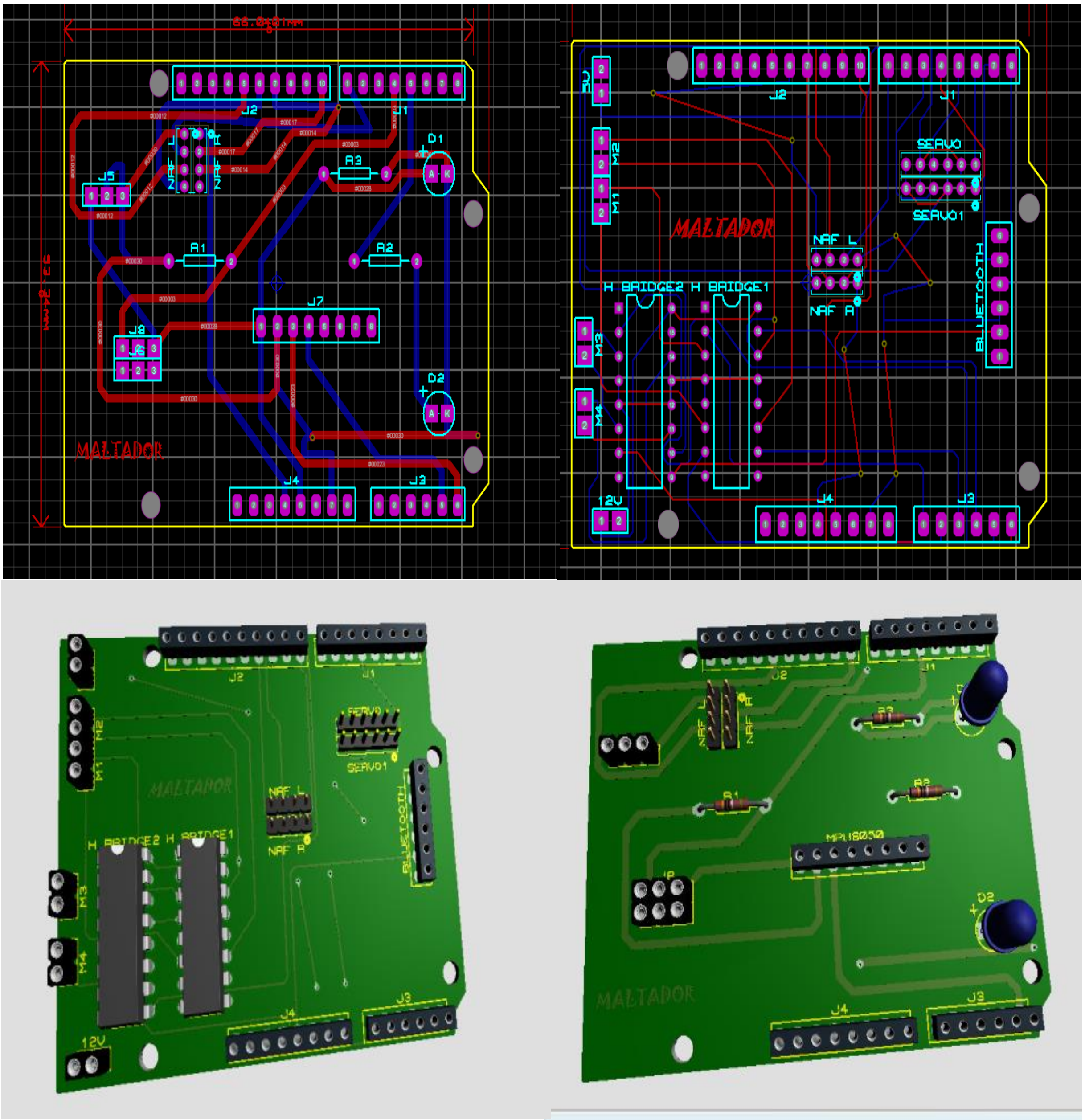


Figure 3.8: Circuit design for sender and receiver Shield

Unfortunately, these circuits need a professional machine to print them, and this is because with the experience of printing the transmitter circuit, we faced a problem in soldering components and short circuits, but that's okay.

We used a dotted PCB board, and the result was as follows

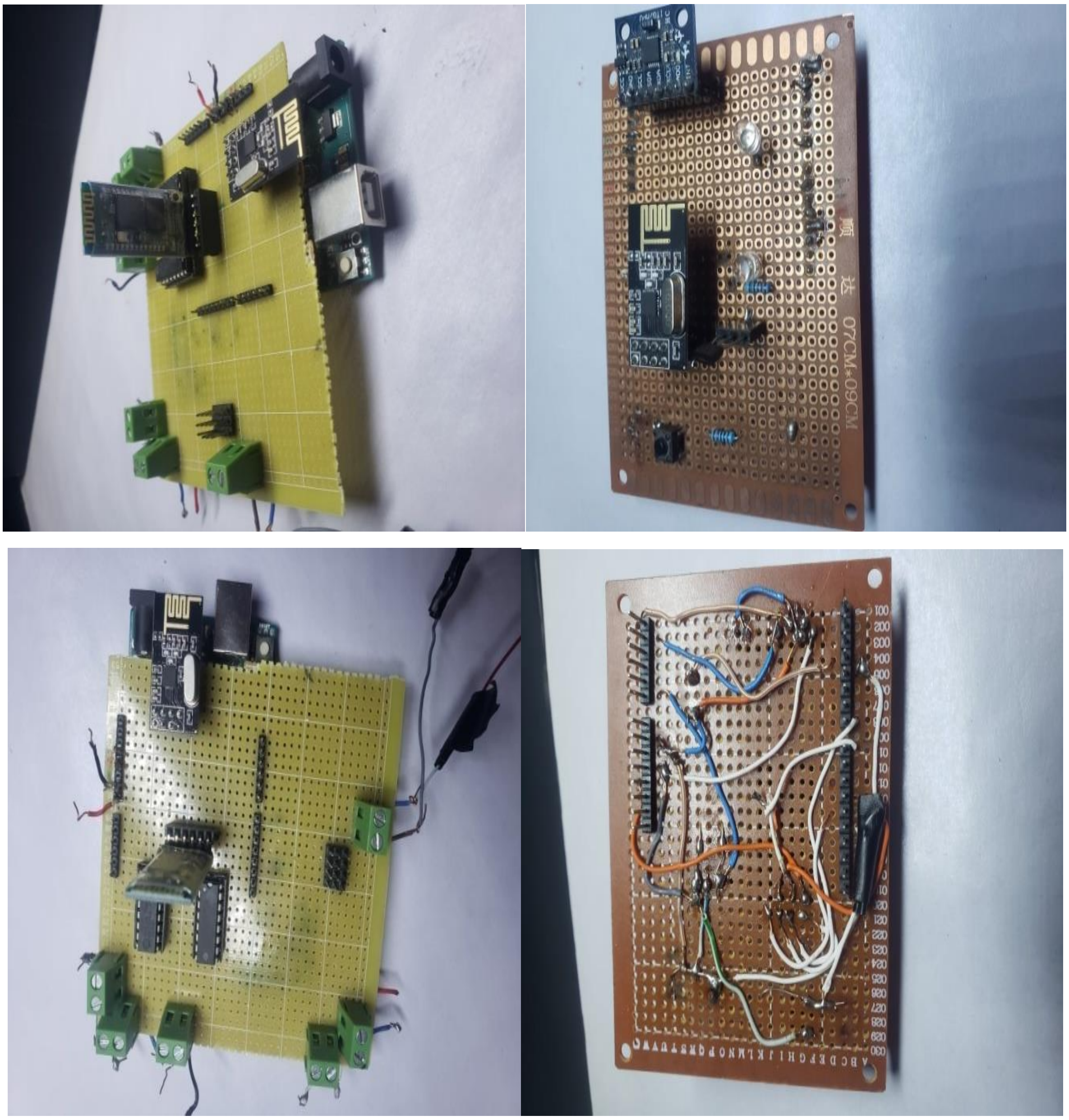
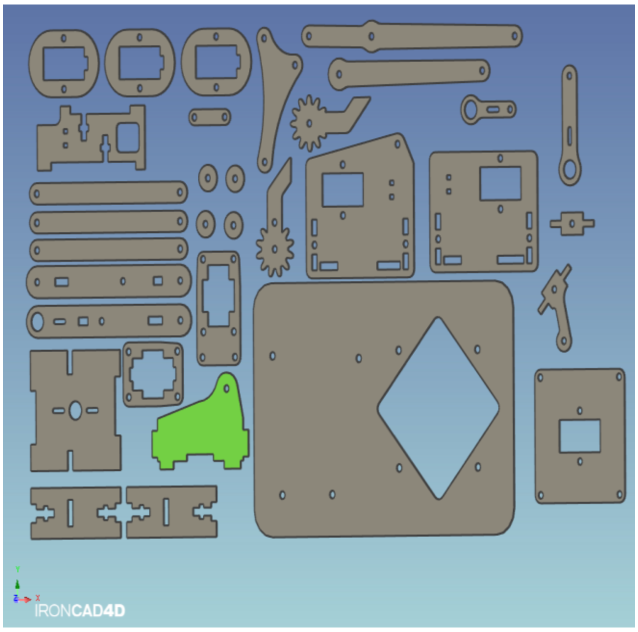


Figure3.9: Realization of sender and receiver shield

The main Feature of this design is that it is designed to be installed directly into the Arduino board (as a shield)

3.7 3D Design:

For making the robot arm itself, we decided to go with 3d printing because it's cheaper and lighter than something like a robot arm made of metal, so we designed each part separately in IronCAD 4D like shown in this figure



Then we assembled it to look at the final model of the arm and it came out as we envisioned

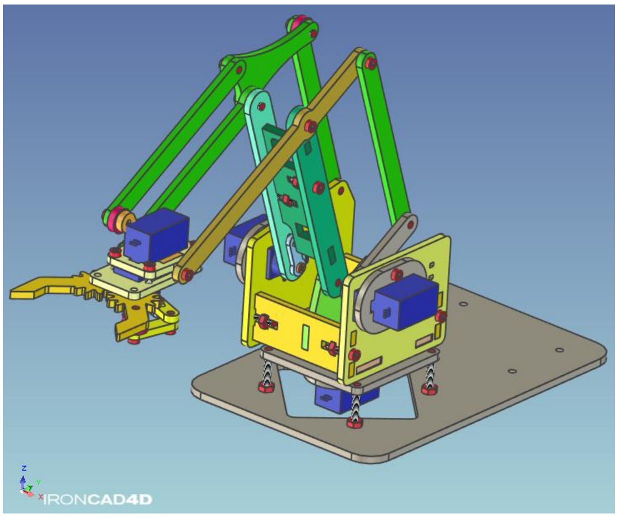


Figure3.10: 3D module of robot arm in IronCAD

The next step we took was taking the 3d parts into a slicer program in order to print it out and we managed to send them the model to a 3d printing workshop to save time and effort. The result was satisfactory and the printed parts looked exactly like shown in this figure

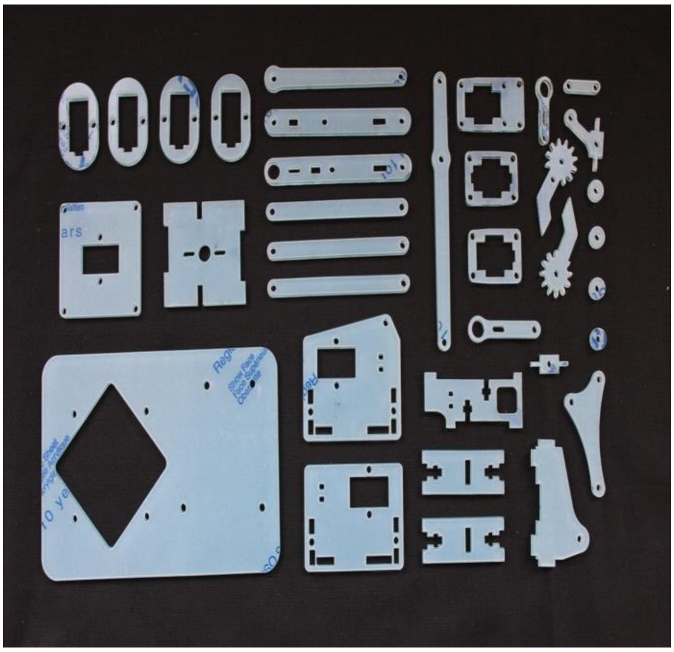


Figure3.11:3D printed parts of the robot arm

Finally after we attach the pieces together we get this:

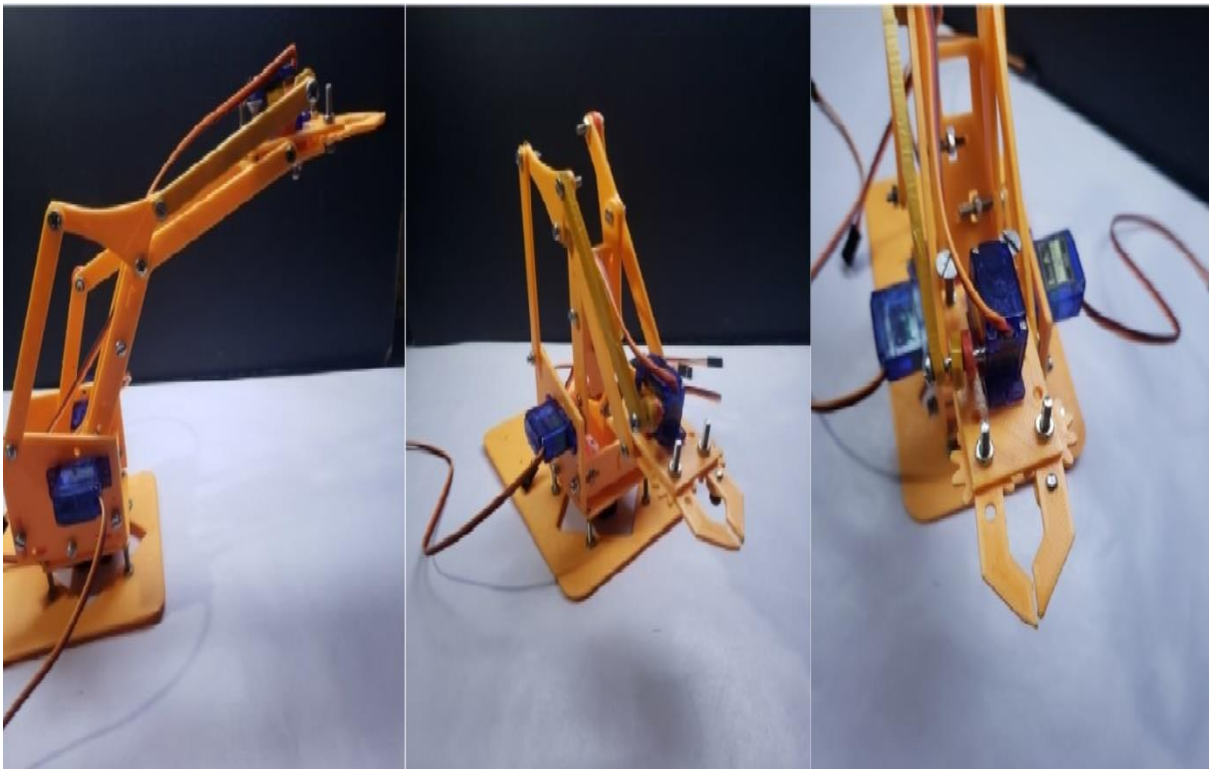


Figure3.12: Realization of the robot arm

For the robotic car we built it using a wooden box with a lid on top to allow for all the electronics to be hidden as follows in this figure:

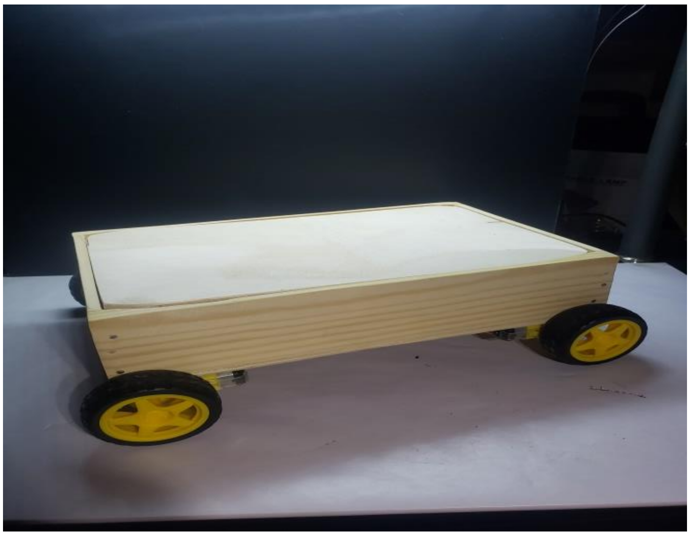


Figure3.13: Realization of robot car

3.8 App design:

The proposed robot system controlled via the mobile application to build this app we will use MIT app inventor which contains two parts, designer and block editor.

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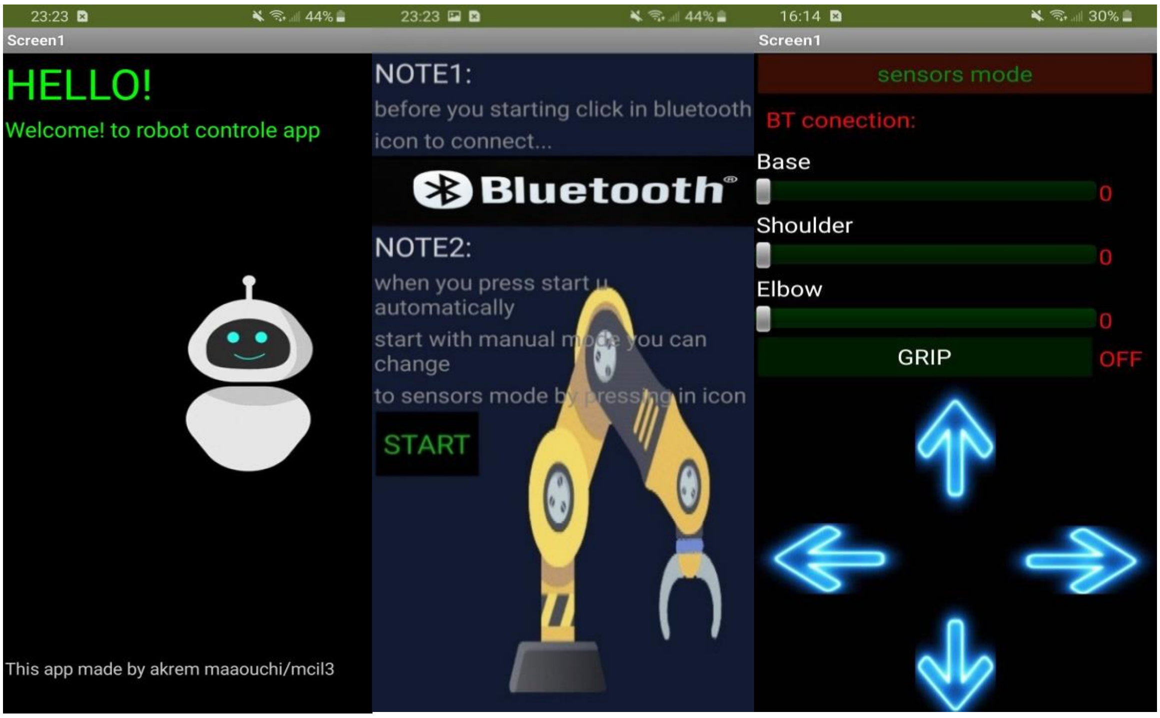

Figure3.14: Android app for controlling the robot arm and car

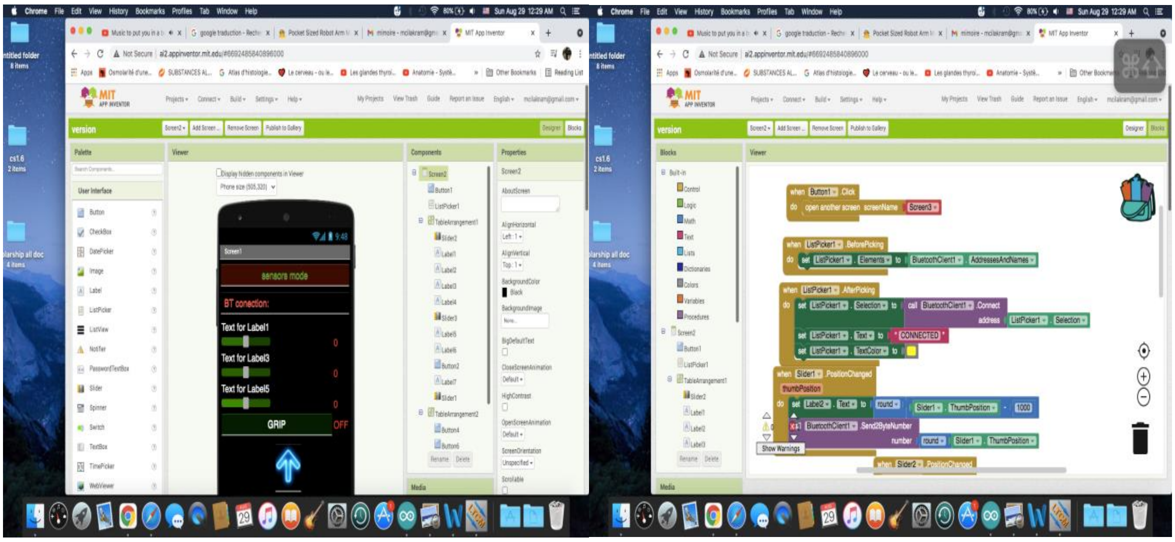

Figure 3.15: MIT app inventor interface and program

3.9 VR vision:

In this section, we discovered a couple of methods to make it possible to get live footage of the camera mounted on the robot anywhere we want, one of them is using an FPV camera or designing a system with RPI and camera module to send 360° view to a mobile phone which we put it in VR box.

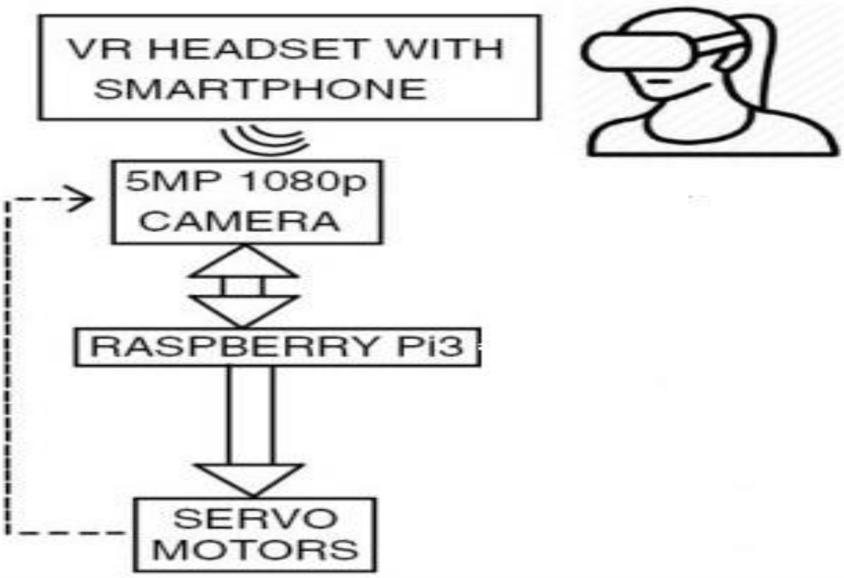

Figure3.16: Block diagram of VR vision using RPI

But since those methods cost a lot of time and money to make we went with an alternative method that is both cheaper and easier to realize.

We replaced the Raspberry PI and Camera module combo with a mobile phone camera and by using the deep diver app we can get a VR which we can send to another phone that's on the VR box via using an app called TeamViewer that lets you share your screen to any compatible device.

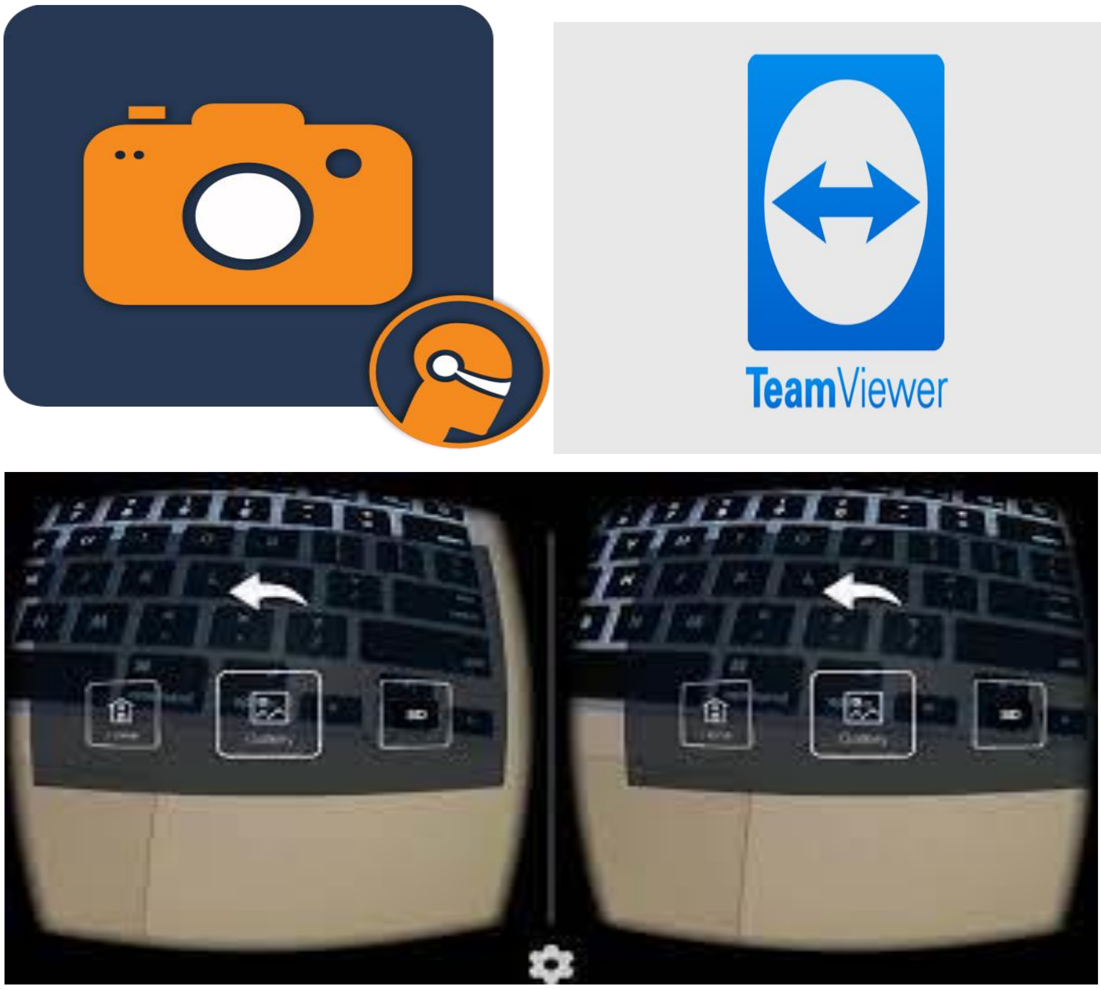

Figure3.17: VR view inside the deep diver app

3.10 Final result:

After implementing the whole project including its hardware and software parts, by testing the performance of our robot .We got an acceptable result with some issues, also we are planning for more adjustment that's going to make our project much better. The advantage of our project is that it can be used in many fields such as the military(for defusing bombs) or discovering unknown dark places where humans can't reach and as the situation of coronavirus it will be able to reduce human interaction by acting as mediator. And all of this can be done by adding some advanced parts.

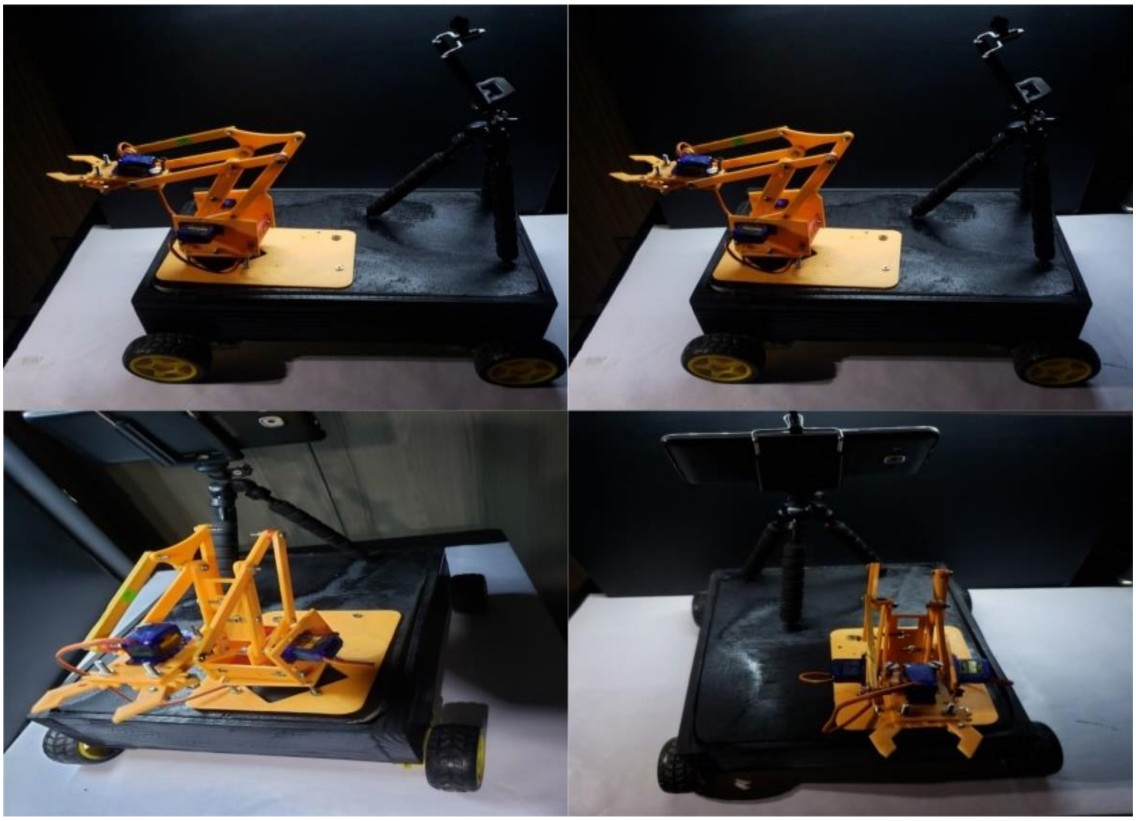

Figure3.18: Final result of the robot

3.11 Issues:

The inability to share data in real time due to hardware limitations in the first type of control made it difficult to control the arm at first due to unfamiliarity with angles.

Due to the lack of means for a consistent feeding of the robot, We assembled two batteries of the type Condor, which cannot output an 8v power source, and an acceptable current for the work of the robot so because of this it puts us in The problem of the battery to power the servo motors, so that if the battery is fully charged, it affects the movement of the motors quickly and powerfully, and if it is used for a long time, it may be damaged, or if the battery has less charge, the motors start to vibrate and lose the exact rotation accuracy. But we found a solution for this, we added the voltage rating, and the result of moving the motors became acceptable.

Sometimes an error occurs in data transmission due to the noise of the power source and another potential source of noise for an RF circuit is the outside environment, especially if you have neighboring networks set on the same channel or interference from other electronics. To prevent these signals from causing issues, we switched to the highest 25 channels to nRF24L01 module and capacitor in power pins. Reason for this is that Wi-Fi uses most of the lower channels.

3.12 Future work:

The system is still a prototype and can be developed and improved. In our future plan we also can improve different features extraction algorithms to easily control the arm. And add 3d view with the RPI system where we can artificial intelligence and open cv methods, we also plan to make our robot work automatically to do pre-determined functions, our project should work for a large portion of time without being affected by interferences or running out of power, so a bigger battery should be added for a longer use.

3.13 Conclusion:

In this chapter we have dealt with the implementation of our project as well as the design methodology and the development of the system which consists of the hardware design and software design, also we have dealt with two methods to control the robot. After that we take a look on the overall results, issues and problems we have faced, we arrived to the fact that we can add more adjustments and features to this project.

General Conclusion

General Conclusion:

The purpose of project is to control a robot that contains a robotic arm integrated with a robotic car using accelerometer sensors. The sensors are intended to replace the remote control that is generally used to run the robot. It will allow us to control the forward, backward, left and right movements of the car, while using the same accelerometer sensor to control the movements of the arm based on the hand movements. By using the above mentioned components the hardware was setup, thus resulting in the formation of a robot. In order to implement the experiment an android phone was used, whose camera acted as the input device for capturing the video. The final movement of the robot can be concluded as follows: At the beginning the robot was in a stop mode. As the hand moved from bottom to top, the robot moved in the forward direction. As the hand moved from top to bottom, the robot moved in the backward direction. As the hand was shown as an acute angle towards the left, the robot moved towards the left direction. As the hand was shown as an acute angle towards the right, the robot moved towards the right direction. As the hand is kept stationary with respect to the environment, the robot was in the stop mode, and the same thing applies to the Arm attached to it. From the experiment, about 80% of the implementation worked accordingly, the remaining was due to background interference which is a negative marking to the implementation. Hand Gesture Controlled Robot System gives a more natural way of controlling devices. The command for the robot to navigate in specific direction in the environment is based on technique of hand gestures provided by the user. Without using any external hardware support for gesture input unlike specified existing systems, the user can control a robot from his software station

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ABSTRACT:

This project presents a robot consists of a car holding a robotic arm with live video streaming that can be watched in VR box.

The goal is to control the car with hand gestures; the control system is based on Arduino (UNO), MPU6050 Accelerator and radio-frequency (RF) transmitter. Furthermore, an android application is proposed to send the commands to the car wirelessly via means of Bluetooth. To achieve a good tracking, the car construction is based on the differentiation mechanism which allows the car to rotate on its own axis. Hall Effect sensor is also introduced in order to control the gripper of the arm.
The project is so flexible and easy to manipulate according to the desired function.

Résumé

Ce projet présente un robot composé d'une voiture tenant un bras robotique avec un streaming vidéo en direct qui peut être regardé dans une boîte VR.

Le but est de contrôler la voiture avec des gestes de la main ; le système de contrôle est basé sur Arduino (UNO), l'accélérateur MPU6050 et l'émetteur radiofréquence (RF). De plus, une application android est proposée pour envoyer les commandes à la voiture sans fil via Bluetooth. Pour obtenir un bon suivi, la construction de la voiture est basée sur le mécanisme de différenciation qui permet à la voiture de tourner sur son propre axe. Un capteur à effet Hall est également introduit afin de contrôler la pince du bras.

Le projet est ainsi flexible et facile à manipuler selon la fonction souhaitée.

ملخص:

يقدم هذا المشروع روبوتًا يتكون من سيارة تحمل ذراعًا آليًا مع بث فيديو مباشر يمكن مشاهدته في صندوق ***VR***.

الهدف هو التحكم في السيارة بحركات اليد؛ يعتمد نظام التحكم على ***Arduino (UNO)*** و ***MPU6050 Accelerator*** وجهاز إرسال التردد اللاسلكي ***(RF).*** علاوة على ذلك، يُقترح تطبيق ***android*** لإرسال الأوامر إلى السيارة لاسلكيًا عبر ***Bluetooth***لتحقيق تتبع جيد ، يعتمد بناء السيارة على آلية التمايز التي تسمح للسيارة بالدوران على محورها الخاص. تم إدخال مستشعر ***Hall Effect*** أيضًا للتحكم في قابض الذراع.

المشروع مرن للغاية ويسهل التعامل معه وفقًا للوظيفة المطلوبة