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A robotic wheelchair for the disabled: design, command and control

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بسم الله الرحمن الرحيم
صلى
صلى



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To everyone who has taught me something, whether big or small, thank you.



Dedications :

I bow to God the almighty who has opened the doors of knowledge to me and helped me to cross it.

I dedicate this modest work:

To my father, a source of respect, as a testimony of my great gratitude for all the effort and the moral and material support that he has always given me.

To my dear and tender mother, source of affection, love, courage and inspiration who sacrificed so much to see me reach this day.

To my dearest brothers and my dearest sisters: Bilal, Mohamed, Younes, Faiza and her family, especially the princess, the most beautiful Aridj, Fatiha and her little family malek and the magnificent Djawad, and finally Nesrine and her marie Houssam, forget the sweet Ilyne.

To my soul and my beautiful twin: Titouma

To the whole Sebbache and Mennane family.

To my partner and my dear friend Lamis.

To all my intimates and close friends without exception,

and all my classmates from my class. Especially the comrade who was always by our side and helped us a lot to do this project: Nadir

and to all those whom I carry in my heart and I could not mention the name.

Nadjet



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To my dear and tender mother, source of affection, love, courage and inspiration who sacrificed so much to see me reach this day.

To my dearest brothers and my dearest sisters: Abdellah, sallah eddine, Imane, Asmaa, Djihad.

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To all my sweet cousins.

To the whole Chaouchi and Sebti family.

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Lamiss

الملخص:

يقوم هذا المشروع بتطوير نظام ذكي للكراسي المتحركة باستخدام منصة روبوت متنقلة مع لوحة Arduino. يتحكم المستخدم في الكرسي المتحرك عبر أوامر نظام تحديد المواقع العالمي ((GPSالتي تتم معالجتها بواسطة وحدة نظام تحديد المواقع العالمي (GPS)، حيث يتحكم في تحريك المحرك لتوجيه العجلات. بالإضافة إلى ذلك، يتميز النظام بالكشف التلقائي عن العوائق باستخدام أجهزة استشعار الموجات فوق الصوتية والأشعة تحت الحمراء. وقد أثبت المشروع نجاحا جزئيا مما يؤكد جدوى هذا النظام الذكي للكراسي المتحركة.

الكلمات المفتاحية: الكراسي المتحركة، الروبوتية، منصة روبوت متنقلة، اردوينو، نظام تحديد المواقع، أجهزة استشعار

Résumé :

Ce projet développe un système de fauteuil roulant intelligent utilisant une plate-forme robotique mobile avec une carte Arduino. L'utilisateur contrôle le fauteuil roulant via des commandes GPS traitées par un module GPS intégré, contrôlant le circuit intégré du pilote de moteur pour diriger les roues. De plus, le système dispose d'une détection automatique des obstacles à l'aide de capteurs ultrasoniques et infrarouges. Le projet a connu un succès partiel, confirmant la faisabilité de ce système de fauteuil roulant intelligent.

Mots clés : Robotique, Fauteuils roulants, Robotique mobile, Arduino, Capteurs, GPS.

Abstract:

This project develops an intelligent wheelchair system using a mobile robot platform with an Arduino board. User controls the wheelchair via GPS commands processed by an onboard GPS module, controlling the motor driver IC to steer the wheels. Additionally, the system features automatic obstacle detection using ultrasonic and IR sensors. The project demonstrated partial success, confirming the feasibility of this intelligent wheelchair system.

Keywords: Robotic, Wheelchairs, Mobile robot, Arduino, Sensors, GPS.

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General Introduction

General introduction:

Human limitations in performing various tasks drive the development of technologies to ease daily life. Robots are designed to overcome these limitations. This project focuses on an electric wheelchair based on a mobile robot.

A significant number of disabled individuals (1 in 200) struggle with or cannot use a standard electric wheelchair. To enhance autonomy, researchers have been working for several decades on improving manual control and integrating additional control systems. Despite advancements, "intelligent" electric wheelchairs have not fully met expectations: current market offerings are limited to basic features like line following and obstacle detection, which are not widely accessible.

This dissertation addresses the challenge of proposing a driving assistance feature to advance the technological transfer of more complex autonomous mobility functions. The solution involves designing a wheelchair that uses an Arduino board and an ultrasonic sensor for obstacle avoidance, and developing a sophisticated GPS-based control system for electric wheelchairs.

The first chapter provides general information about wheelchairs and mobile robots. The second chapter describes the materials used in this work. The third chapter covers the electrical and mechanical design of the wheelchair, detailing the project phases. The final section offers a general conclusion and future prospects.

Chapter I: Wheelchair for people with Disabilities

I.1. Introduction:

The wheelchair is one of the most commonly used devices for individuals with disabilities, primarily facilitating movement for those unable or struggling to use their legs due to various conditions. Over the decades, numerous advancements have been made to enhance the functionality and ease of use of wheelchairs, leading to the development of smarter devices based on mobile robot technology and the latest innovations.

This chapter aims to provide a comprehensive overview of wheelchairs, highlighting its general features and the characteristics of various types. Additionally, it will discuss the mobile robot, which forms the foundation of this project.

I.2. Historical of Wheelchairs:

The history of the wheelchair spans centuries, evolving from rudimentary designs to sophisticated, motorized devices tailored to various needs. The journey of the wheelchair from the early 20th century to the present day reflects significant advancements in mobility aid technology and societal attitudes towards accessibility.

In the early 20th century, the design of wheelchairs underwent notable advancements. Spoked wheels, akin to those used on bicycles, were introduced around 1900, enhancing maneuverability and comfort. However, manual propulsion remained the norm until further innovations emerged.

In 1916, the landscape of mobility aids changed with the introduction of the first motorized wheelchair in London. Despite early attempts at motorization, widespread commercial production did not materialize until later years.

A significant breakthrough occurred in 1932 with the invention of the folding, tabular steel wheelchair by engineer Harry Jennings. This design, crafted for his paraplegic friend Herbert Everest, revolutionized wheelchair accessibility. The establishment of Everest & Jennings marked the beginning of a dominant presence in the
wheelchair market, offering modern conveniences in mobility.

The post-World War II era saw a surge in the production and accessibility of motorized wheelchairs. George Klein and his team's invention of the first power wheelchair (PW) in Canada addressed the mobility needs of quadriplegic individuals injured during the war. By 1956, Everest & Jennings, alongside

the American wheelchair company, commenced mass production of motorized wheelchairs, significantly expanding accessibility and independence for users.

The latter half of the 20th century witnessed continuous research and development in wheelchair technology, paving the way for intelligence wheelchairs (IWs). IWs integrate advanced sensors, algorithms, and navigation systems to enhance user autonomy and safety.

Indoor navigation systems emerged as a focal point of research, leveraging state-of- the-art methods to maneuver wheelchairs in confined spaces. However, navigating outdoor environments posed significant challenges due to their dynamic and unstructured nature.

Recent decades have seen a proliferation of diverse intelligence wheelchair systems, categorized into indoor and outdoor variants. Researchers deploy various sensors and algorithms to tackle the complexities of outdoor navigation, striving to create safer, more reliable, and cost-effective solutions.

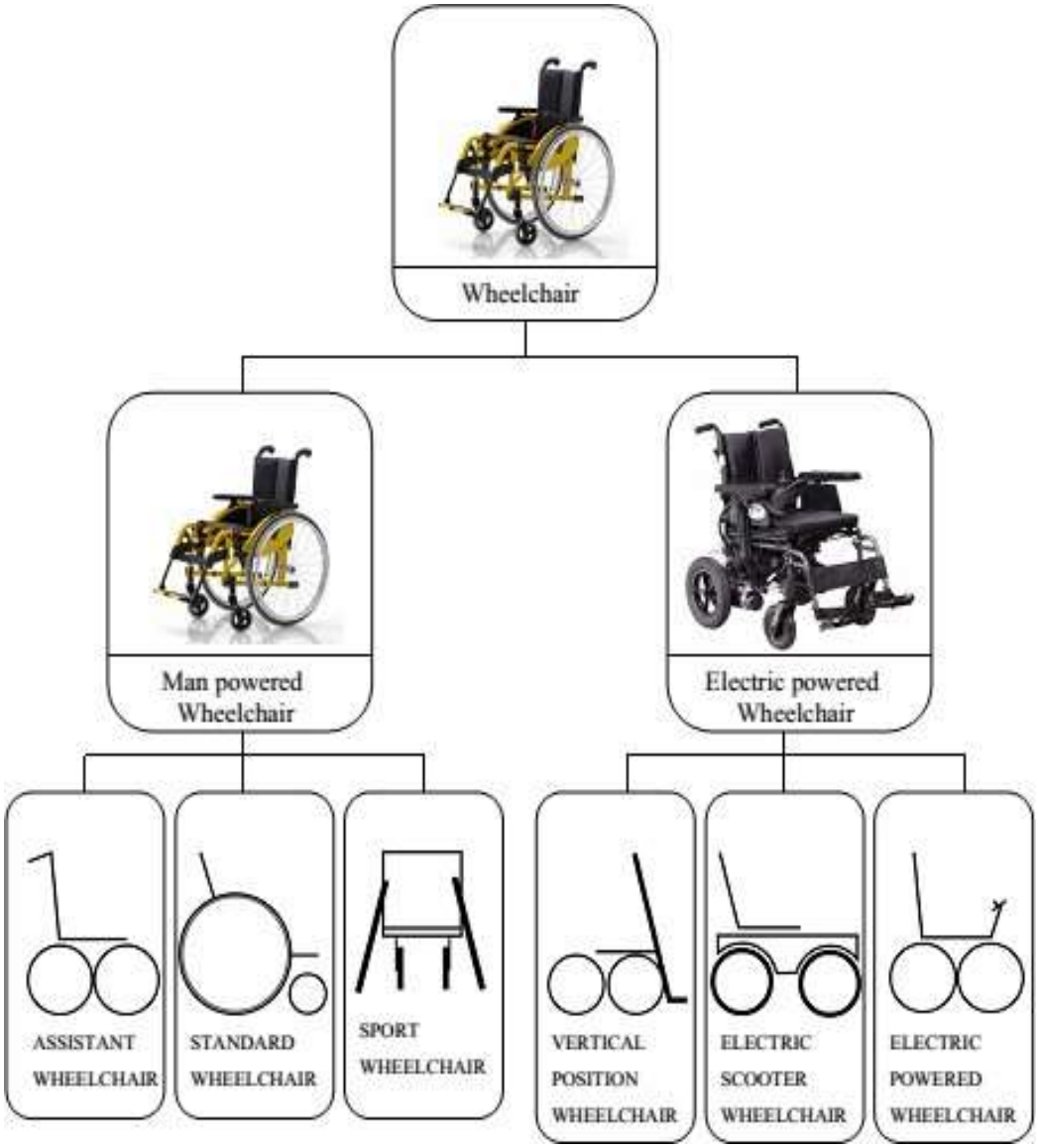
In conclusion, the historical trajectory of wheelchairs from the early 20th century to the present day underscores a narrative of innovation, inclusivity, and empowerment. From humble beginnings to cutting-edge technology, the evolution of wheelchairs reflects society's commitment to enhancing mobility and accessibility for all. [1]

I.3. Classification of wheelchairs:

One of the most effective ways to categorize wheelchairs is based on their power source, resulting in two distinct categories: manually powered wheelchairs and electric- powered wheelchairs (Figure I.1).

I.4. Electric powered wheelchair:

Electric-powered wheelchairs are designed for individuals who are unable to maneuver a manual wheelchair on their own. These chairs offer increased independence, particularly when it comes to outdoor activities and leaving the home. Here are different types of electric wheelchairs [2]



1Figure I.1: classification of wheelchairs

- **Indoor Wheelchair:**

These are folding wheelchairs that are less bulky compared to outdoor models. However, folding them can be challenging and tiring for a caregiver. They typically have a range of 10 to 16 km and adjustable speeds from 0 to 6 km/h. These chairs can easily fit in a car trunk.



2Figure I.2: Indoor Wheelchair

- **Outdoor Wheelchair:**

Non-folding wheelchairs that are larger in size. They have a range of 16 to 45 km and adjustable speeds from 0 to 10 km/h. Due to their size, they require specialized transportation methods as they cannot fit in a car trunk. The larger wheels allow for crossing thresholds and small obstacles.



3Figure I.3: Outdoor wheelchair

- **Standing Wheelchair:**

These chairs enable users to transition from a seated to a standing position. This not only provides a better view of the environment but also enhances social integration. These chairs are equipped with knee supports and a trunk strap for added safety.



4Figure I.4: standing wheelchair

- **Height-adjustable Wheelchair:**

These chairs allow users to adjust their seating position, providing a higher vantage point. Similar to standing chairs, they can improve environmental understanding and social integration. Some electric wheelchairs combine verticalization and variable height in the seated position.



5Figure I.5: Height-adjustable wheelchair

- **Robotic wheelchairs:**

Robotic wheelchairs offer several advantages over traditional manual or electric wheelchairs. They enhance mobility with advanced technology, allowing users to navigate complex environments independently. With sensors for obstacle detection and sophisticated control systems, they provide greater safety and precise, intuitive operation health benefits include posture support pressure relief,

and improved circulation. Electric powered wheelchairs offer a range of options to suit different needs and environments, allowing individuals with mobility challenges to regain independence and participate in various activities. Figure 1.6 show an example of this type of wheelchairs.



6Figure I.6: an example of robotic wheelchair

I.5. Mobile robot

A mobile robot is a system that combines mechanics, electronics, and computer science, allowing it to physically interact with its environment to achieve a specific objective or mission. A mobile robot is a robot capable of locomotion. Mobile robotics is typically considered a subfield of robotics and information engineering. Unlike stationary robots, mobile robots can move freely in their environment. Mobile robots can be autonomous (AMR - autonomous mobile robot), navigating uncontrolled environments without external guidance, or rely on guidance devices to follow predetermined paths in controlled spaces (AGV - autonomous guided vehicle). In contrast, industrial robots are usually fixed in place, consisting of a multi-linked manipulator and end effector. [3]

I.5.1. Automated Guided Vehicles (AGVs):

Automated Guided Vehicles (AGVs) are robots that rely on guidance devices to follow predetermined paths in controlled environments. AGVs are ideal for companies needing reliable and cost-effective material transport solutions along fixed routes within such environments. They excel in performing repetitive tasks in settings with minimal environmental changes, making them perfect for businesses with stable processes and infrastructure. AGVs enhance efficiency and reduce labor costs, offering a dependable solution for streamlined operations.[4]



7:Figure I.7:Automated Guided Vehicles(AGVs)

I.5.2. Autonomous mobile robot (AMRs) :

Autonomous Mobile Robots (AMRs) are cutting-edge machines that navigate independently within their environment. Utilizing sophisticated onboard sensors such as cameras, and depth sensors, AMRs create dynamic maps and employ artificial intelligence algorithms for real-time decision-making. This advanced technology enables AMRs to move freely and adaptively through complex and changing environments without relying on predefined pathways or external guidance systems. [4]



8: Figure I.8: Autonomous Mobile Robots(AMRs)

I.5.3. Components of a mobile robot:

A mobile robot typically consists of a controller (microprocessor, embedded microcontroller, or PC), control software (assembly or high-level languages), sensors (dead reckoning, tactile, proximity, ranging, collision avoidance, position location, etc.), and actuators.

I.5.4. Characteristics of mobile robots:

- Perceptive ability through sensors to gather environmental information.
- Adaptability to changes in the operating space or environment.
- Independent navigation, planning, and action capabilities.
- Task-oriented software/programming.

I.5.5. Types of mobile robots:

- **Wheeled robots:**

Wheeled robots, the most common type, utilize a straightforward locomotion mechanism, making them widely used across various environments. They operate in landscaped sites, industrial areas, and indoors, with some even designed for outdoor explorations, including space missions. However, most wheeled robots have non- holonomic constraints that limit their instantaneous movements, complicating trajectory planning and control. [5]



9:Figure I.9: wheeled robots

- **Tracked robots:**

Tracked robots are designed for navigating uneven terrain where traditional wheeled robots struggle. They utilize caterpillar tracks that enhance grip on the ground and enable traversal of larger obstacles. However, tracked robots have non-holonomic constraints, meaning their movement is limited to specific directions and requires careful path planning. Despite this, their superior mobility in challenging environments makes them valuable in various applications, from military to agricultural. [5]



10: Figure I.10: tracked robots

- **Walking robots:**

Walking robots, ideal for navigating highly uncertain terrains with significant elevation changes like stairs or rugged landscapes, utilize legs for support, overcoming the limitations of wheeled or tracked counterparts. However, their complex design and control mechanisms typically result in slower progress compared to other robotic technologies. [5]



11:Figure I.11: walking robots

- **Crawling robots:**

Crawling robots utilize reptation, a locomotion method inspired by animal movement, for navigating tunnel-like environments. These robots consist of modular units with various mobility features. Three main types exist: scolopendra, with an inextensible, articulated structure; earthworm, featuring three joints for orthogonal rotations and translation; and peristaltic, which displaces modules relative to neighbors for movement. [5]



12: Figure I.12: crawling robots

I.6. Conclusion:

Robotic wheelchairs represent one of the most significant areas of robotics that require further development to assist individuals with disabilities and enhance their comfort and autonomy. These advanced devices have become increasingly important in our lives and are poised to play a crucial role in the future. As machines continue to transform human experiences, this chapter has provided definitions and insights into the design and functionality of both wheelchairs and mobile robots.

Chapter II: Component Description for the Wheelchair Robot

II.1. Introduction:

The present project consists of the study and development of a robotic wheelchair based on a mobile robot with obstacle avoidance capabilities and GPS control. This autonomous vehicle is designed to navigate safely and independently without human intervention. In this chapter, we will focus on the electronic components and equipment necessary for the implementation and design of our project, discussing the selection of these components based on their characteristics.

II.2. ARDUINO board:

The ARDUINO Uno serves as the brain of our wheelchair robot. It is an open-source microcontroller board. The Arduino board is widely used in both educational settings and professional projects due to its user-friendly nature and extensive community support. [6]

II.2.1. Types of ARDUINO board:

The Italian company Smart Projects provides the original modules for each version of Arduino. The American company Spark Fun Electronics manufactures some Arduino-brand boards. To date, there are versions of Arduino-type boards. [6]

The most commonly used board is showed in figure II.1.



13Figure II.1: Arduino boards

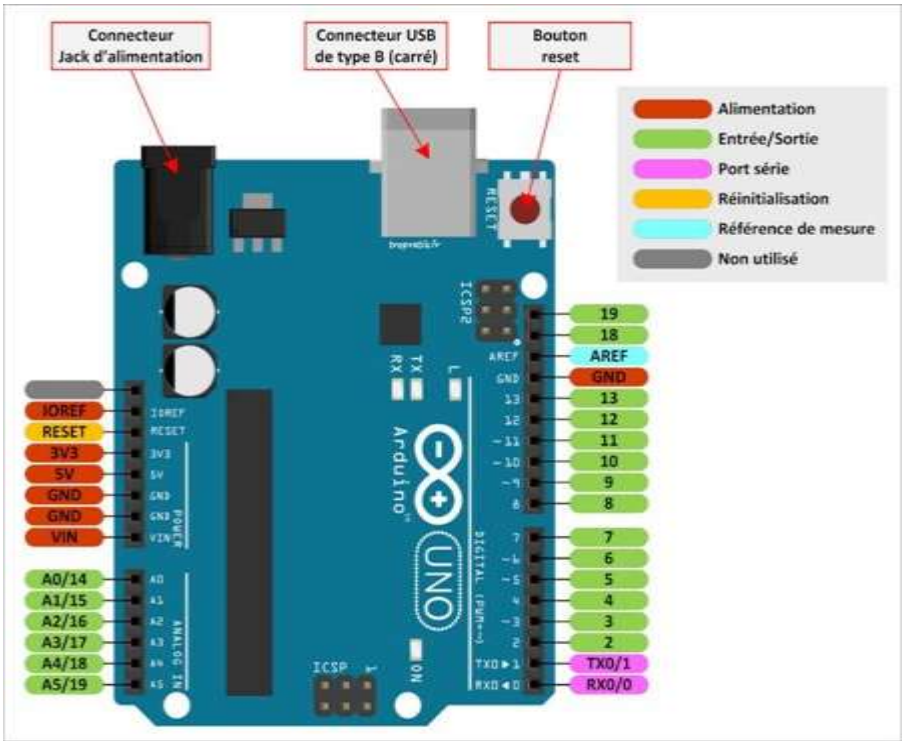
II.2.2. ARDUINO UNO board:

- **Function:**

The Arduino Uno serves as the brain of our wheelchair robot. It is an open-source microcontroller board based on the Microchip ATmega328P microcontroller. The Arduino Uno is widely used in both educational settings and professional projects due to its user-friendly nature and extensive community support.

- **Features:**

The Arduino Uno board is based on an ATmega328 microcontroller and is equipped with the following features (See Figure II.2 and Table II.1).

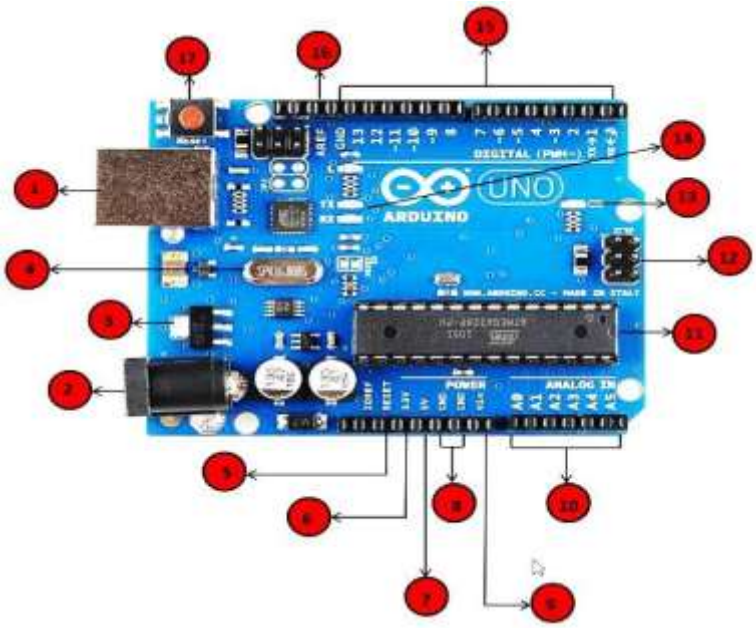


14Figure II.2: Arduino Uno boards

Table II.1: features of Arduino Uno board [7]

Microcontroller	Atmega 328
Operating Voltage	5v
Power Supply Voltage (Recommended)	7_12V
Power Supply Voltage (Limits)	6_20V
Digital Pins Input/output	14 (Of Which 6 Have A PWM Output)
Analog Input Pins	6 Usable In Input/output Digital Pins
Maximum Intensity Available Per Input/output Pin	40ma(Attention:200ma Cumulative For All Input/output Pins
Maximum Intensity Available For The Output 3.3V	50ma
Maximum Intensity Available For The Output 5V	Function Of The Power Supply Used _ 500 Ma Max If The USB Port Is Used Alone
Flash Program Memory	32kb (Atmega 328) Of Which 0.5kb Are Used By The Bootloader
SRAM Memory (Volatile Memory)	2KB (Atmega328)
EEPROM Memory (Non-Volatile)	1KB (Atmega328)
Clock Speed	16mhz

- **Basic components of Arduino Uno:**



15figure II.3: basic components of Arduino Uno board

table II.2: Basic component of Arduino Uno [8]

1	Power USB Arduino board can be powered by using the USB cable from your computer. All you need to do is connect the USB cable to the USB connection (1).
2	Power (Barrel Jack) Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack (2).
3	Voltage Regulator The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.
4	Crystal Oscillator The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.
5,17	Arduino Reset You can reset your Arduino board, i.e., start your program from the beginning. You can reset the UNO board in two ways. First, by using the reset button (17) on the board. Second, you can connect an external reset button to the Arduino pin labelled RESET (5).
6,7 8,9	Pins (3.3, 5, GND, Vin) 3.3V (6) − Supply 3.3 output volt 5V (7) − Supply 5 output volt Most of the components used with Arduino board works fine with 3.3 volt and 5 volt. GND (8)(Ground) − There are several GND pins on the Arduino, any of which can be used to ground your circuit. Vin (9) − This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.
10	Analog pins The Arduino UNO board has six analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.
11	Main Microcontroller Each Arduino board has its own microcontroller, often from ATMEL. The main IC varies between boards and is considered the board's brain. Check the top of the IC to identify it before uploading a new program from the Arduino IDE. For more details, refer to the data sheet.
12	ICSP pin Mostly, ICSP (12) is an AVR, a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It is often referred to as an SPI (Serial Peripheral Interface), which could be considered as an "expansion" of the output. Actually, you are slaving the output device to the master of the SPI bus.
13	Power LED indicator This LED should light up when you plug your Arduino into a power source to indicate that your board is powered up correctly. If this light does not turn on, then there is something wrong with the connection.
14	TX and RX LEDs On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led (13). The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.

15	Digital I/O The Arduino UNO board has 14 digital I/O pins (15) (of which 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labeled "~" can be used to generate PWM.
16	AREF AREF stands for Analog Reference. It is sometimes, used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

II.3. Components used with ARDUINO:

Arduino boards are versatile and flexible platforms that can be used with a wide range of components and sensors. In this section, we will discuss some of the most commonly used components with Arduino boards, including sensors, actuators, communication modules, and power supplies.

II.3.1. Actuators:

- **DC Motor:**

Motors convert electrical energy into mechanical energy. DC motors consist of a series of coils within a magnetic field. When an electrical charge is placed on the coils, it causes the coils to spin on their shared axis. Simple motors have the coils arranged and attached around a central shaft. As the shaft and coils spin, electrical connectivity is maintained with brushes that make contact with the shaft. The shaft, in turn, protrudes from the assembly to use the rotational force to perform work. [9]

.



16figure II.4: DC Motor

- **Description:**

This is a Smart Car Robot Plastic Tire Wheel with DC 3-6v Gear Motor for Arduino that used for vehicles and remote control toys. DC motors exhibit specific characteristics:

- Constant speed: Rotation speed remains consistent under constant loads.
- Speed/torque slope: Linear relationship between rotation speed and applied torque.
- Current proportional to load: Electric current varies with mechanical load.

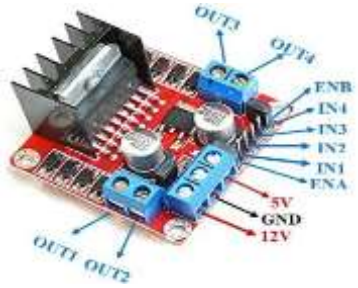
– Speed proportional to voltage: Rotation speed directly correlates with applied voltage. [10]

➢ **Features:**

- Voltage: DC: 3-6 V
- Current: 100-120 mA
- RPM (with tire): 100-240
- Redaction rate: 48:19
- Noise: <65dB
- Tire Diameter: 65mm
- Car Speed(M/minute): 20-48
- Motor Size: 70mm X 22mm X 18mm. [10]

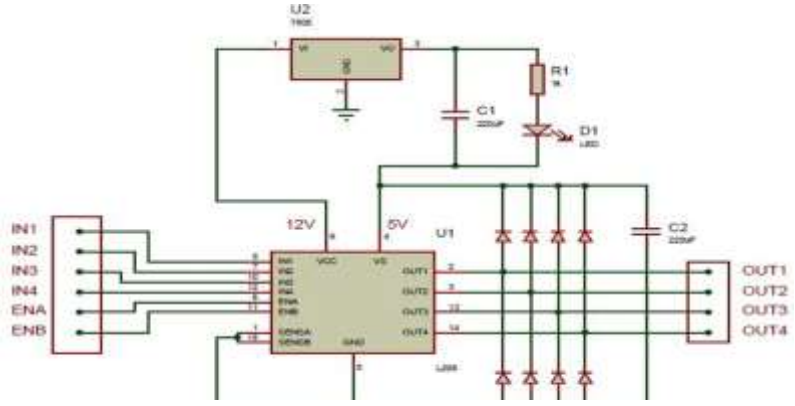
- **Driver L298N:**

This L298N Motors Driver Module is a high-power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control. [11]



17figure II.5: L298N Motor Driver

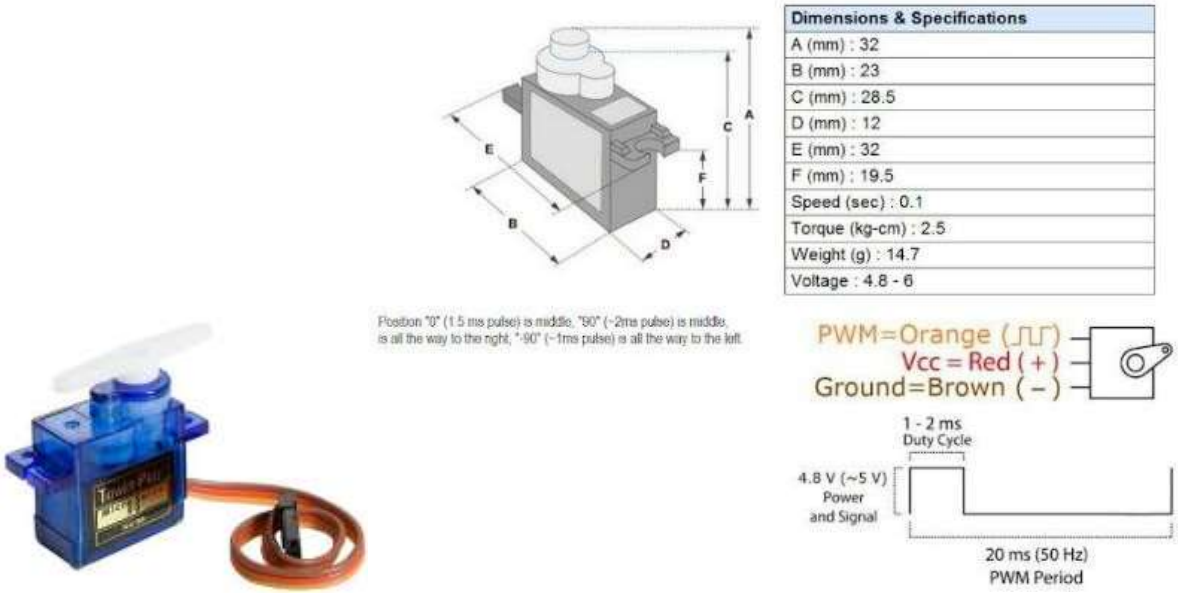
Internal circuit diagram of L298N Motor Driver module is given below:



18 Figure II.6 Internal circuit diagram of L298N Motor driver

- **Servo motor:**

The SG90 is a micro servo motor that is widely used in various DIY projects, including robotics, drones, and model aircraft. It is a popular choice for Arduino projects due to its compact size, ease of use, and low power consumption. [12]



19figure II.7: SG 90 Servo Motor

II.3.2. Sensors:

A sensor is a device that samples information by converting a physical quantity into another physical quantity, typically electrical, which serves as a representation of the original quantity and is usable for measurement and indication purposes.

- **Ultrasonic sensor:**

Ultrasonic sensors are electronic devices that determine the distance to a target by emitting ultrasonic sound waves and converting these waves into electrical signals. The propagation speed of ultrasonic waves is faster than that of audible sound.

The ultrasonic sensor consists of two key components: the transmitter and the receiver. The transmitter, which uses piezoelectric crystals, generates ultrasonic sound waves that travel towards the target. These waves then reflect off the target and return to the receiver.

To determine the distance between the sensor and the target, the sensor calculates the time it takes for the sound waves to travel from the transmitter to the receiver and back. This calculation is performed as follows [13]

D=0.5T.C

Where T corresponds to time measured in seconds and C corresponds to sound speed = 343 measured in mts/sec.

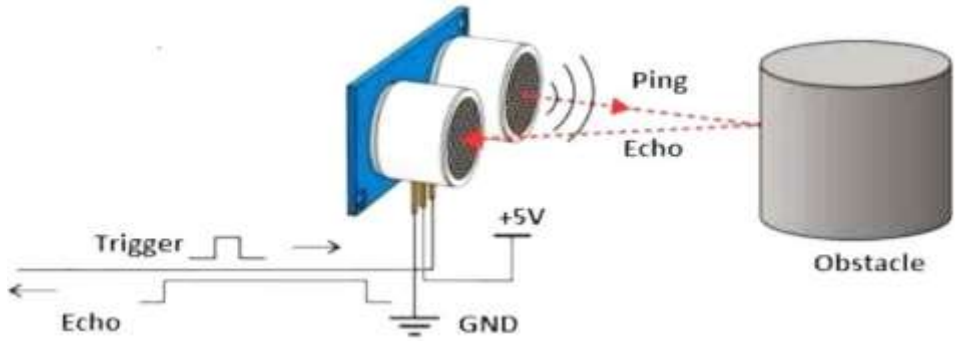


20Figure II.8: Ultrasonic sensor HC-SR04

- **Operating principle of Ultrasonic sensor HC-SR04:**

The HC-SR04 ultrasonic sensor uses sonar to accurately measure the distance to an object. It offers a wide detection range of 2cm to 500cm, making it suitable for various applications.

This contactless sensor provides stable readings and is not affected by sunlight or dark environments. It consists of a 40kHz ultrasonic transmitter and receiver module, making it easy to use and integrate into projects.



21Figure II.9: Working principle of ultrasonic sensor

- **IR sensor transmitter-receiver:**

The IR receiver module is designed to detect infrared (IR) signals within a spectrum commonly utilized for IR remote controls or IR intrusion sensors. Infrared light, with wavelengths up to about 850 nm, falls beyond the visible spectrum for human eyes, making it ideal for such applications. Operating the module is straightforward: simply connect the ground and power supply (either 3.3 or 5 V). Under normal conditions, the output remains HIGH. However, upon receiving an IR signal, the output pin emits a LOW pulse, accompanied by a flashing integrated LED, signaling the detection of a signal. [14]



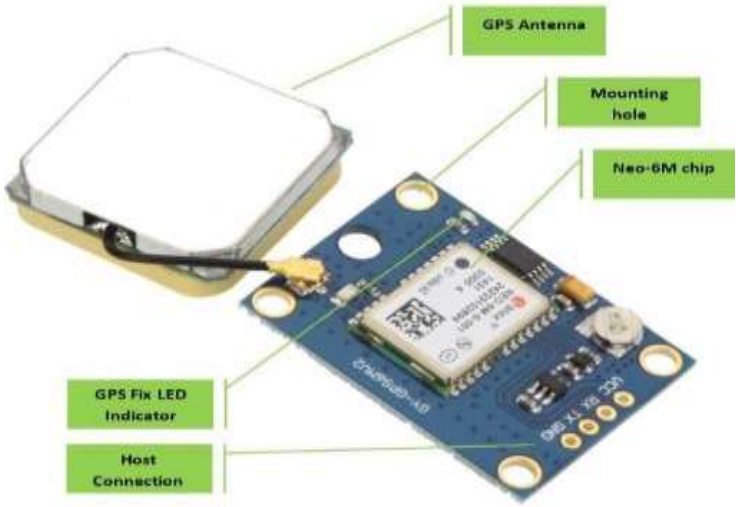
22figure II.10: IR sensor

- **GY-NEO6 sensor:**

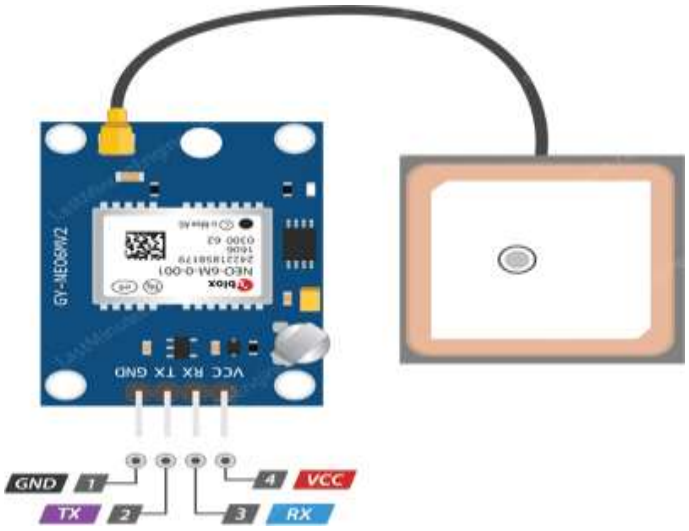
The GY-NEO6 is a GPS module that provides location data using the Global Positioning System (GPS). Here are some key points about the GY-NEO6:

- It uses the NEO-6M GPS chip, which offers high accuracy and fast acquisition time.
- The module supports up to 10Hz update rate, allowing for real-time tracking.
- It has a built-in antenna, eliminating the need for external antenna connections.
- The GY-NEO6 operates on a voltage range of 3.3V to 5V, making it compatible with a wide range of microcontrollers and systems.
- The module provides data through UART communication, allowing easy integration with microcontrollers and other systems.

The GY-NEO6 is commonly used in applications like robotics, drones, tracking systems, and location-based services.



23Figure II.11 GY-NEO6 sensor



24Figure II.12 GY-NEO6 sensor connection

- **Pinout of NEO-6M GPS module:**

– VCC: Power supply pin (3.3V or 5V)

– GND: Ground pin

– TX: Transmit pin for data output

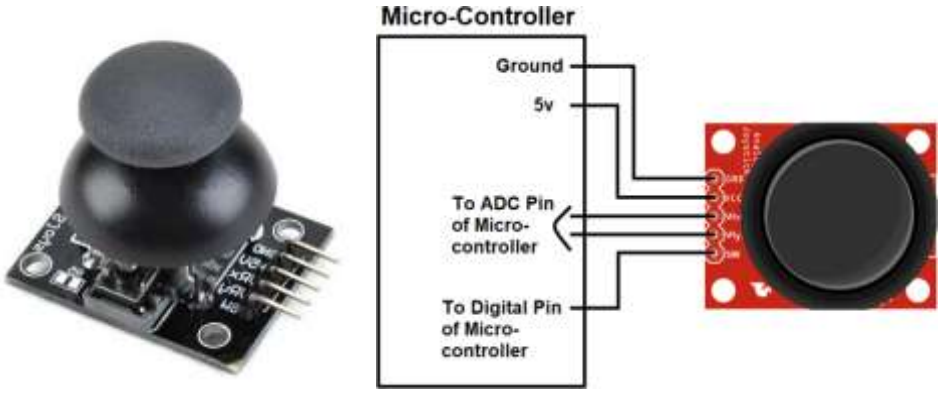
– RX: Receive pin for data input.

II.3.3. Power supplies:

A 9-volt battery (or a 9V battery) is a low-voltage electric battery. She is regularly called a transistor battery because of its great use in the first transistor stations. The stack has the shape of a rectangular prism with rounded edges with a connector having a positive terminal and a negative terminal on one of its sides. This stack format is mainly based on an alkaline, carbon-zinc lithium-iron type chemistry, in the form rechargeable, of the nickel-cadmium (NiCd), nickel-metal hydride (NiMH) type and lithiumion.

II.3.4. Analog joystick:

The Analog Joystick is similar to two potentiometers connected together, one for the vertical movement (Y-axis) and other for the horizontal movement (X-axis). The joystick also comes with a Select switch. It can be very handy for retro gaming, robot control or RC cars.



25Figure II.13 Analog joystick

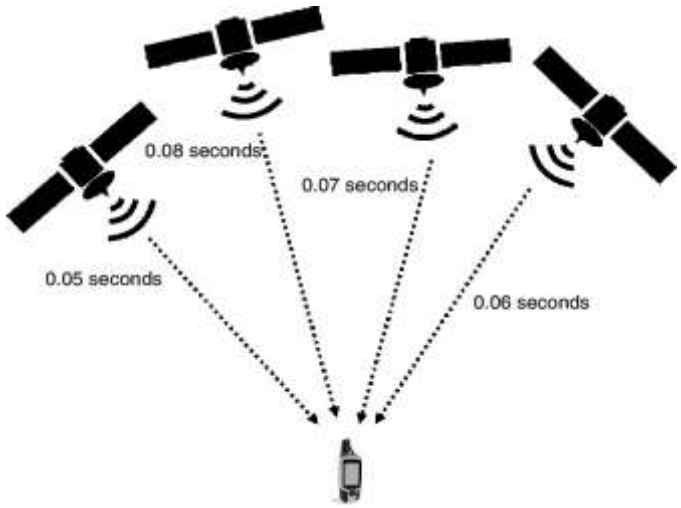
II.4. Global Positioning System (GPS):

II.4.1. Definition:

The Global Positioning System (GPS), also known as Navstar GPS, is a satellite positioning system owned by the United States federal government1. Established by the United States Department of Defense for military purposes starting in 1973, this system uses twenty-four satellites and has been fully operational since 1995. [15]

II.4.2. Operating principle:

GPS is based on the trilateration of synchronized electromagnetic signals emitted by satellites. Users equipped with a GPS receiver can know their location with unprecedented accuracy, whether on land, at sea or in the air. [15]



26Figure II.14 GPS: transmitter-receiver

II.4.3. Geopositioning:

Geopositioning refers to determining the location of a person or mobile system (such as vehicles, mobile robots, or phones) on Earth. This localization can be correlated with information systems for enhanced precision. Satellite positioning systems, including GPS, are utilized to achieve this localization. [15]

II.4.4. the three elements of GPS:

GPS is made up of three different components, called segments, that work together to provide location information. [15]

- **Space (Satellites):**

The satellites circling the Earth, transmitting signals to users on geographical position and time of day.

- **Ground control:**

The Control Segment is made up of Earth-based monitor stations, master control stations and ground antenna. Control activities include tracking and operating the satellites in space and monitoring transmissions. There are monitoring stations on almost every continent in the world, including North and South America, Africa, Europe, Asia and Australia.

- **User equipment:** GPS receivers and transmitters including items like watches, smartphones and telematics devices.

II.4.5. Measurement Principle:

GPS satellites transmit electromagnetic waves that travel at the speed of light. By knowing the speed of light, the distance between the satellite and the receiver can be calculated using the time taken for the signal to travel from the satellite to the receiver, with the formula:

distance(d)=speed of light(c)×time(t)

The GPS receiver measures the time by comparing the transmission time (included in the signal) with the reception time. This calculated distance is called pseudo distance. With signals from three satellites, three pseudo distances can determine the receiver's position. Due to imperfect synchronization between the receiver and satellite clocks, four satellites are needed to determine three coordinates and an additional clock offset.

II.4.6. Geographic Coordinates

The geographic coordinates of a point on Earth include:

- **Longitude:** The angle between the prime meridian (Greenwich) and the meridian passing through the point.
- **Latitude:** The angle between the equatorial plane and the normal to the ellipsoid passing through the point.
- **Height (h):**

The algebraic distance between the point and the ellipsoid.

Each satellite transmits the time of signal emission (T1, T2, T3) and the respective distances to the receiver (R1, R2, R3). These distances are determined by the formula:

$$R_i = \text{Speed} \times (\text{Time} - T_i) \qquad (2.1)$$

$$R_i = \sqrt{(X - Xi)2 + (Y - Yi)2 + (Z - Zi)2} \qquad (2.2)$$

Satellites Coordinates (Xi, Yi, Zi in km)

Receiver's estimated coordinates (X, Y, Z in km):

The Signal transmission times, T_i

$$R_i = Speed(T_c - T_i) \quad (2.2)$$

Or $$T_i = T_c - \frac{R_i}{Speed} \quad (2.3)$$

Where

T_c is the current time. (T_c = 0 seconds for simplicity.)

Speed is the speed of the signal (for example: the speed of light in a vacuum).

II.5. Conclusion

This chapter covers the key materials and components of our robotic wheelchair, explaining each one to ensure proper functioning of the entire system. In the next chapter, we will design the robot using these components.

Chapter 3:Electrical and mechanical Design

III.1. Introduction:

In this chapter, we detail the foundational system design that underpins our project, focusing on both the electrical architecture and the software development using Arduino IDE. These elements are pivotal in demonstrating the operational capabilities of our mobile robot. Additionally, we explore the mechanical design, specifically the external appearance, which is tailored to serve as an assistive wheelchair for individuals with disabilities.

III.2. Classes of wheeled mobile robots:

There are numerous categories of mobile wheeled robots, primarily classified based on the placement and quantity of wheels they employ. Here, we will discuss the four principal classes of these robots [16]

III.2.1. Unicycle-style mobile robot :

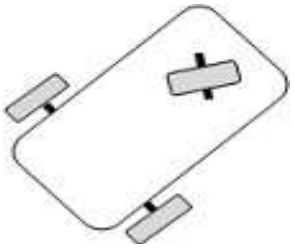
A unicycle-style mobile robot is propelled by two independent wheels and is equipped with auxiliary wheels to maintain stability. Its axis of rotation lies along the line connecting the two drive wheels. This robot is non-holonomic, meaning it cannot move in a direction perpendicular to its locomotion wheels. Controlling it is straightforward; it can easily navigate from one point to another through a sequence of simple rotations and straight-line movements.



27Figure III. 1 Unicycle-style mobile robot

III.2.2. Tricycle-type mobile robot:

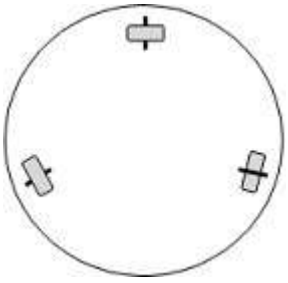
A tricycle-type mobile robot consists of two fixed wheels aligned on the same axis and a central, adjustable wheel positioned along the longitudinal axis. The robot's motion is driven by the speed of the two fixed wheels and the orientation of the steering wheel. Its point of rotation is at the intersection of the axis containing the fixed wheels and the axis of the steering wheel. This robot is non-holonomic, meaning it cannot move directly perpendicular to the plane defined by the fixed wheels. Its control is more complex, and typically, simple rotations are not feasible due to the steering wheel's limited turning radius.



28Figure III. 2 Tricycle-type mobile robot

III.2.3. Omnidirectional mobile robot:

An omnidirectional mobile robot is a type of robot capable of moving freely in any direction. Typically, it consists of three steerable wheels positioned at the vertices of an equilateral triangle. The significant advantage of an omnidirectional robot is its holonomic nature, allowing it to move in all directions seamlessly. However, this capability comes with the drawback of increased mechanical complexity.



29Figure III. 3 Omnidirectional mobile robot

III.2.4. Car-type mobile robot:

A car-type mobile robot resembles a tricycle, comprising two fixed wheels aligned on a single axis and two steerable wheels also positioned on the same axis. This design

enhances stability by providing an additional support point. The characteristics of the car robot are essentially the same as those of the tricycle robot, with the latter being convertible to the former by replacing the two front wheels with a single wheel centered on the axis, ensuring that the center of rotation remains unchanged. Our project is based on a car-type mobile robot.



30Figure III. 4 Car-type mobile robot

III.3. Development of wheeled mobile robots:

The development of mobile robots encompasses the integration of sophisticated mechanical and electrical systems, as well as sturdy programming environments. We will explore the design process of a car-type mobile robot, focusing on three essential stages: mechanical system design, electrical system design, and programming. Each stage is carefully planned to ensure the robot's functionality, efficiency, and reliability.

III.3.1. Mechanical system design:

The mechanical system forms the backbone of the car-type mobile robot, providing the necessary structural support and enabling movement. This stage encompasses the design of the chair and the chassis.

- **The Chair:**

The chair is a critical component for ensuring that the robot can accommodate passengers or payloads securely.

- **The Chassis:**

The chassis serves as the foundation of the robot, housing all other components and facilitating movement.



31Figure III. 5 wheelchair design

III.3.2. Electrical system design:

The electrical system is the heart of the mobile robot, driving its movements and enabling interaction with its environment. This step involves the integration of actuators, sensors, and a control unit.

- **Actuators (Motors):**

Actuators are responsible for converting electrical signals into mechanical movement. The design considerations for actuators include: Type of motor, Motor driver, and power supply.

- **Sensors:**

Sensors are crucial for the robot's perception of its surroundings, enabling it to navigate and interact intelligently. Key sensors include: Ultrasound Sensors, Infrared (IR), and GPS Module.

- **Control Unit:**

The control unit is the brain of the robot, processing inputs from sensors and sending commands to actuators. The Arduino platform is selected for its versatility and ease of use.

- **Arduino Card:** Choosing an appropriate Arduino board based on the number of required I/O pins and processing capabilities.
- **Circuit Design:** Designing the circuit to connect sensors, actuators, and the Arduino board, ensuring proper power distribution and signal integrity.

III.4. IDE Environment:

The Arduino IDE provides a user-friendly interface for writing, compiling, and uploading code to the Arduino board. The programming process includes:

- **Code Structure:**

Organizing the code into sections for setup, loop, and functions, ensuring readability and maintainability.

- **Sensor Integration:**

Writing code to read data from sensors, process the information, and respond appropriately.

- **Actuator Control:**

Developing algorithms to control motors and other actuators, implementing movement patterns, speed control, and obstacle avoidance.

- **Communication Protocols:**

Implementing communication protocols to enable data exchange between the robot and external devices or systems.

- **Debugging and Testing:**

Using the IDE's debugging tools to identify and fix errors, followed by extensive testing to validate the robot's performance under various conditions.

III.5. Overview of Tinkercad and Arduino IDE:

III.5.1. Presentation of Tinkercad:

Tinkercad is an innovative online platform that enables users to design and simulate 3D models with ease. It is a free, user-friendly tool that caters to various project needs, making it ideal for both beginners and experienced designers.

- **Key features of Tinkercad 3D Modeling:**

Tinkercad allows users to create detailed 3D models of objects, which can be exported for 3D printing or integrated into other projects. This feature supports the rapid prototyping and visualization of design concepts.

- **Educational Tools:**

Tinkercad offers a range of educational resources, including lesson plans, tutorials, and project ideas. These resources make it a valuable tool for teachers and students, facilitating learning in a hands-on and interactive manner.

- **Integration with Arduino:**

One of the standout features of Tinkercad is its compatibility with Arduino. The platform includes a set of electronic components for building circuits and controllers, along with an integrated Arduino emulator. This allows users to program and test circuits in a virtual environment, streamlining the prototyping and testing process before physical implementation.

In our project, we utilized Tinkercad to create wiring diagrams for the internal parts of our robot. The platform's intuitive interface and comprehensive component library made it easy to design accurate and functional diagrams. Once the diagrams were complete, we prepared the corresponding code in the Arduino IDE to test the efficiency and quality of the parts used. The combination of Tinkercad for design and the Arduino IDE for coding provided a robust workflow for developing and refining our robotic system.

III.5.2. Presentation of Arduino IDE:

The Arduino IDE (Integrated Development Environment) is a powerful, free, open-source platform that allows users to write code and upload it to Arduino boards. It is designed to be accessible to programmers of all skill levels, from beginners to advanced users.

- **Key features of Arduino:**

  - **IDE User-friendly interface:**

The Arduino IDE provides an intuitive interface that includes a text editor for writing code, a message area for displaying feedback, a text console for output, and a toolbar with buttons for common functions. This design ensures a smooth and efficient coding experience.

- **Hardware Compatibility:**

The IDE supports a wide range of Arduino boards, allowing users to upload programs and communicate with their hardware seamlessly.

- **Open-Source Nature:**

Being open-source, the Arduino IDE's code is freely available for inspection, modification, and distribution under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL). This promotes community-driven development and collaboration.

- **Cross-Platform Compatibility:**

The Arduino IDE is compatible with Windows, macOS, and Linux operating systems, ensuring accessibility for a diverse user base.

In our project, the Arduino IDE played a crucial role in programming and testing the robot's functionality. After designing the wiring diagrams in Tinkercad, we used the Arduino IDE to write and upload the code to the Arduino board. This process allowed us to test and refine the robot’s operations, ensuring that all components worked together effectively.

III.5.3. Fritzing: Simulation and PCB Design

Fritzing is an Electronic Design Automation (EDA) software designed with a low entry barrier, catering to the needs of designers and artists alike. It employs the metaphor of a breadboard, facilitating an easy transition from physical hardware sketches to digital design. Users can create PCB layouts within Fritzing, which can then be fabricated into robust printed circuit boards either independently or through a manufacturer.

While physical prototyping tools have simplified the process of transforming ideas into functional prototypes, these prototypes often remain fragile and unsuitable for long- term use. Fritzing addresses this gap by enabling designers to advance to the next stage— creating a finalized PCB layout of their custom circuit. This transformation ensures the circuit's durability and forms the foundation for permanent installations or batch production of the project.

Fritzing's intuitive interface and comprehensive features make it a valuable tool for transitioning from experimental prototypes to reliable, production-ready electronic designs. Its ability to bridge the gap between concept and manufacture enhances the accessibility and scalability of innovative projects in the realm of electronics and interactive design.

III.5.4. SolidWorks software:(mechanical design)

SolidWorks is a 3D parametric design software that is used to design all sorts of products such as automobiles, marine equipment, airplane parts, cell phones, cameras, furniture, electrical assemblies, glasses, lighting fixtures, toys, vacuum cleaners, or any other like product you can think of. SolidWorks is typically used to design assemblies that work mechanically that are typically less than 200 parts. There are 3 primary SolidWorks file types [17]

Parts

Assemblies

Drawings

Mechanical Designs are typically composed of one or more assemblies. Assemblies are made from parts and the design of parts are typically conveyed through 2D technical drawings.

III.6. Stages of robot development:

The development of our intelligent wheelchair system followed a structured methodology, ensuring a systematic and comprehensive approach to achieve the desired functionality and performance. The methodology encompassed several key stages, each focused on specific aspects of the project.

Initially, we focused on designing the electrical system for each individual function of the wheelchair. This approach facilitated the programming process for each system, helping to minimize the error of functioning. In the subsequent stage, we integrated all the systems into a single electrical architecture and consolidated all the programs into one cohesive software application.

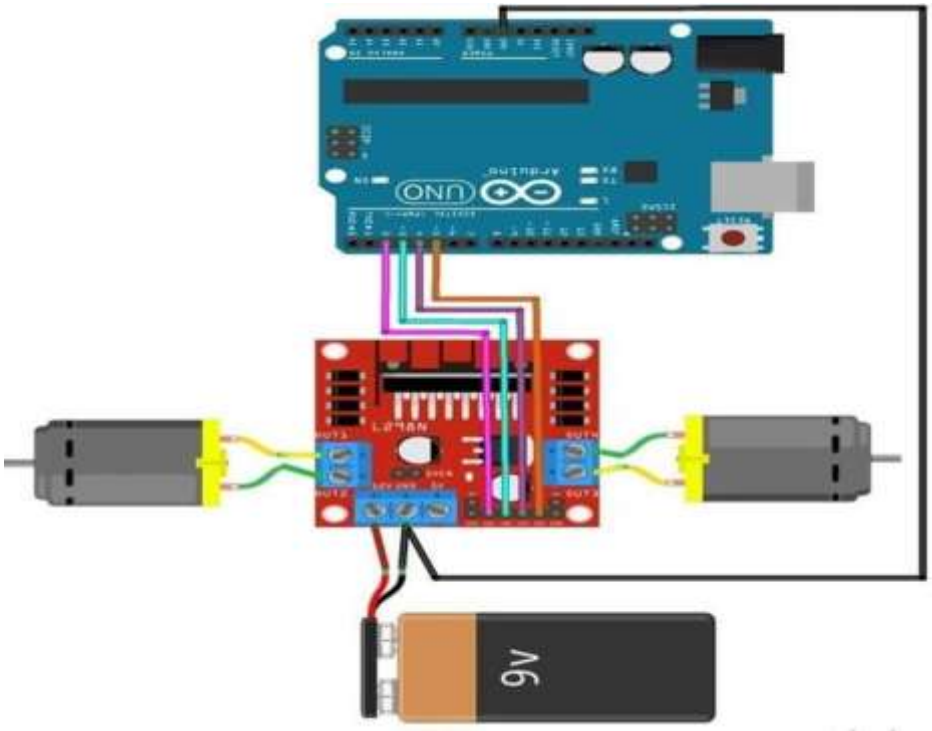
III.6.1. Command of DC motor:

- **Connecting the L298N Motor Driver to Arduino:**

To control DC motors using an Arduino, the L298N motor driver is a versatile and efficient choice. The following steps outline how to connect the L298N motor driver to the Arduino and ensure proper operation of the DC motors.

Connect the IN1 and IN2 pins of the L298N to pins of the Arduino.
Connect the ENA and ENB pins of the L298N to pins of the Arduino.
Connect the motor terminals (M1 and M2) of the L298N to the DC motor.

Connect the power supply terminals (VCC and GND) of the L298N to a voltage source.



32Figure III.6 Command of DC motor

moteur_copy_20240228122317 srvo1

```
int M1=3;
int M1P=5;
int M2=9;
int M2p=10;

void setup() {

  // put your setup code here, to run once:
 pinMode(M1,OUTPUT);
 pinMode(M1P,OUTPUT);
 pinMode(M2,OUTPUT);
 pinMode(M2p,OUTPUT);
}

void loop() {
  // put your main code here, to run repeatedly:
digitalWrite(M1,HIGH);
digitalWrite(M1P,LOW);

digitalWrite(M1,LOW);
digitalWrite(M1P,LOW);

digitalWrite(M2,HIGH);
digitalWrite(M2p,LOW);

digitalWrite(M2,LOW);
digitalWrite(M2p,LOW);
}
```

33Figure III.7 Program for command of DC motor

III.6.2. IR sensor:

An IR sensor in a mobile robot is used for obstacle detection and distance measurement. It emits infrared light and detects its reflection to identify nearby objects, enabling the robot to navigate and avoid collisions.

- **Advantages:**

-Cost-Effective: IR sensors are relatively inexpensive.

-Low Power Consumption: They use minimal power, extending battery life.

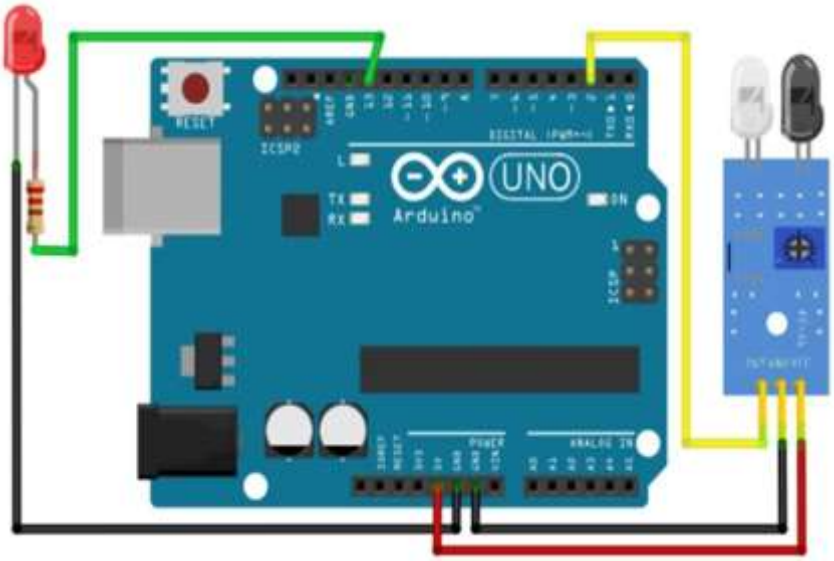
-Compact Size: Small and easy to integrate into various designs.

- **Disadvantages:**

-Limited Range: Effective only over short distances.

-Sensitivity to Ambient Light: Performance can be affected by sunlight and other IR sources.

-Surface Dependence: Accuracy varies with different object surfaces and colors.



34Figure III.8 IR sensor



35Figure III. 9: Program for IR sensor

III.6.3. Ultrasonic Sensor HC-SR04:

The Ultrasonic Sensor HC-SR04 is used in mobile robots for obstacle detection and distance measurement. It emits ultrasonic waves and measures the time taken for the echo to return, calculating the distance to objects.

- **Advantages:**

-High Accuracy: Provides precise distance measurements.

-Wide Detection Range: Detects objects from 2cm to 4m.

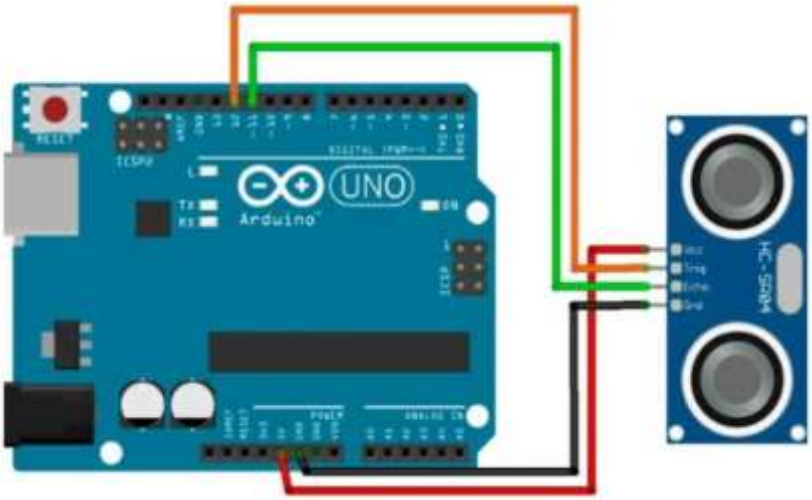
-Low Cost: Affordable for various projects.

-Easy Integration: Simple to connect with microcontrollers like Arduino.

- **Disadvantages:**

-Environmental Sensitivity: Performance can be affected by temperature and humidity.

-Surface Dependency: Less effective on soft or angled surfaces that absorb or deflect sound waves.



36Figure III.10: Ultrasonic Sensor HC-SR04

File Edit Sketch Tools Help

sketch_mar17a

```
pinMode(echoPin, INPUT); // Sets the echoPin as an Input

Serial.begin(9600); // Starts the serial communication

 }

void loop()

{

// Clears the trigPin

digitalWrite(trigPin, LOW);

delayMicroseconds(2); // Sets the trigPin on HIGH state for 10 micro seconds

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW); // Reads the echoPin, returns the sound wave travel time in microseconds

duration = pulseIn(echoPin, HIGH); // Calculating the distance

distance = duration * 0.034 / 2; // Prints the distance on the Serial Monitor

Serial.print("Distance: ");

Serial.println(distance);

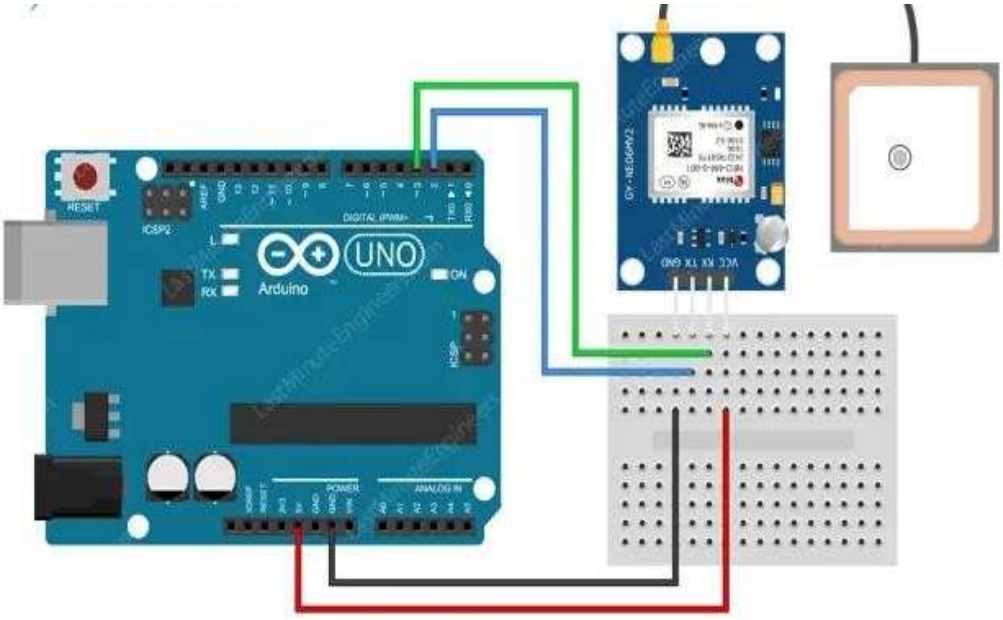
}
```

Done compiling.

37Figure III.11: Program for Ultrasonic Sensor

III.6.4. NEO6MV2 GPS Module:

The NEO6MV2 GPS module is used in mobile robots for precise location tracking and navigation. It offers high sensitivity, fast time-to-first-fix, and low power consumption, making it ideal for real-time positioning. Advantages include its accuracy, compact size, and ease of integration with microcontrollers like Arduino. However, it has disadvantages such as susceptibility to signal loss in obstructed environments and dependence on clear sky visibility for optimal performance. Despite these, the NEO6MV2 enhances the robot's autonomous navigation capabilities, making it a valuable component for mobile robotics applications.



38Figure III.12: NEO6MV2 GPS Module

sketch_may18b.ino

```
#include <SoftwareSerial.h>

// Choose two Arduino pins to use for software serial
int RXPin = 2;
int TXPin = 3;

//Default baud of NEO-6M is 9600
int GPSBaud = 9600;

// Create a software serial port called "gpsSerial"
SoftwareSerial gpsSerial(RXPin, TXPin);

void setup()
{
  // Start the Arduino hardware serial port at 9600 baud
  Serial.begin(9600);

  // Start the software serial port at the GPS's default baud
  gpsSerial.begin(GPSBaud);
}

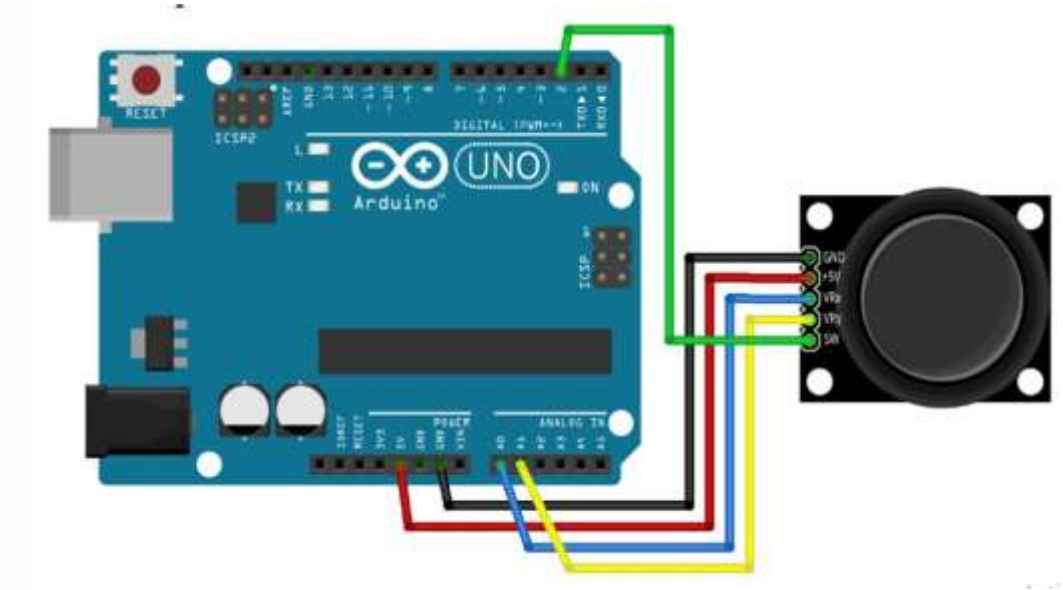
void loop()
{
  // Displays information when new sentence is available.
  while (gpsSerial.available() > 0)
    Serial.write(gpsSerial.read());
}

```

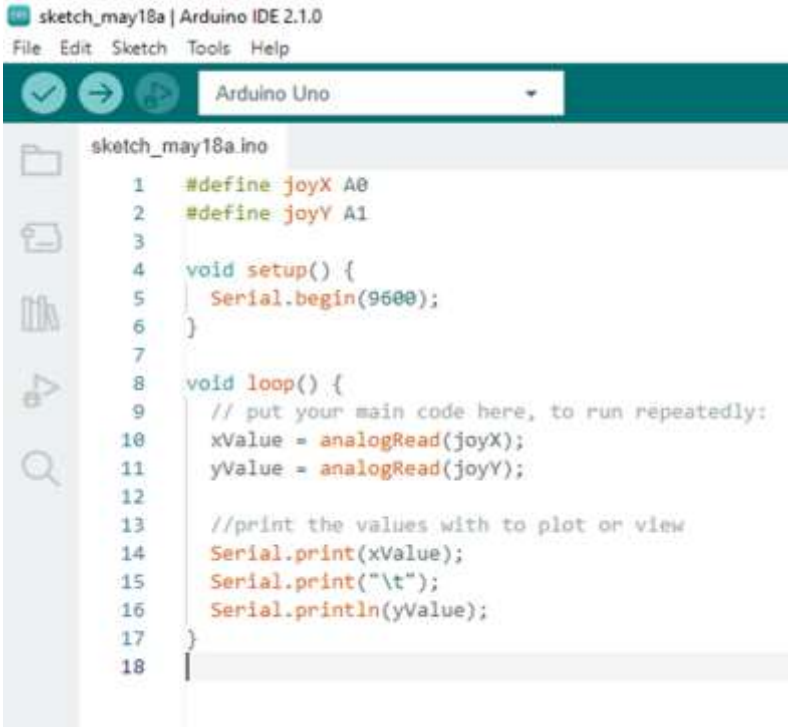
39Figure III.13: Program for NEO6MV2 GPS module

III.6.5. Analog joystick:

The analog joystick is utilized in mobile robots for precise control over movement, offering advantages such as intuitive maneuverability and real-time directional adjustments. Its analog nature allows for proportional speed and direction control, enhancing navigation in dynamic environments. However, drawbacks include potential complexity in implementation and sensitivity to mechanical wear. Overall, the analog joystick enhances user interaction with the robot, enabling smooth and responsive operation ideal for tasks requiring fine motor control and adaptability to varying terrain or obstacles.



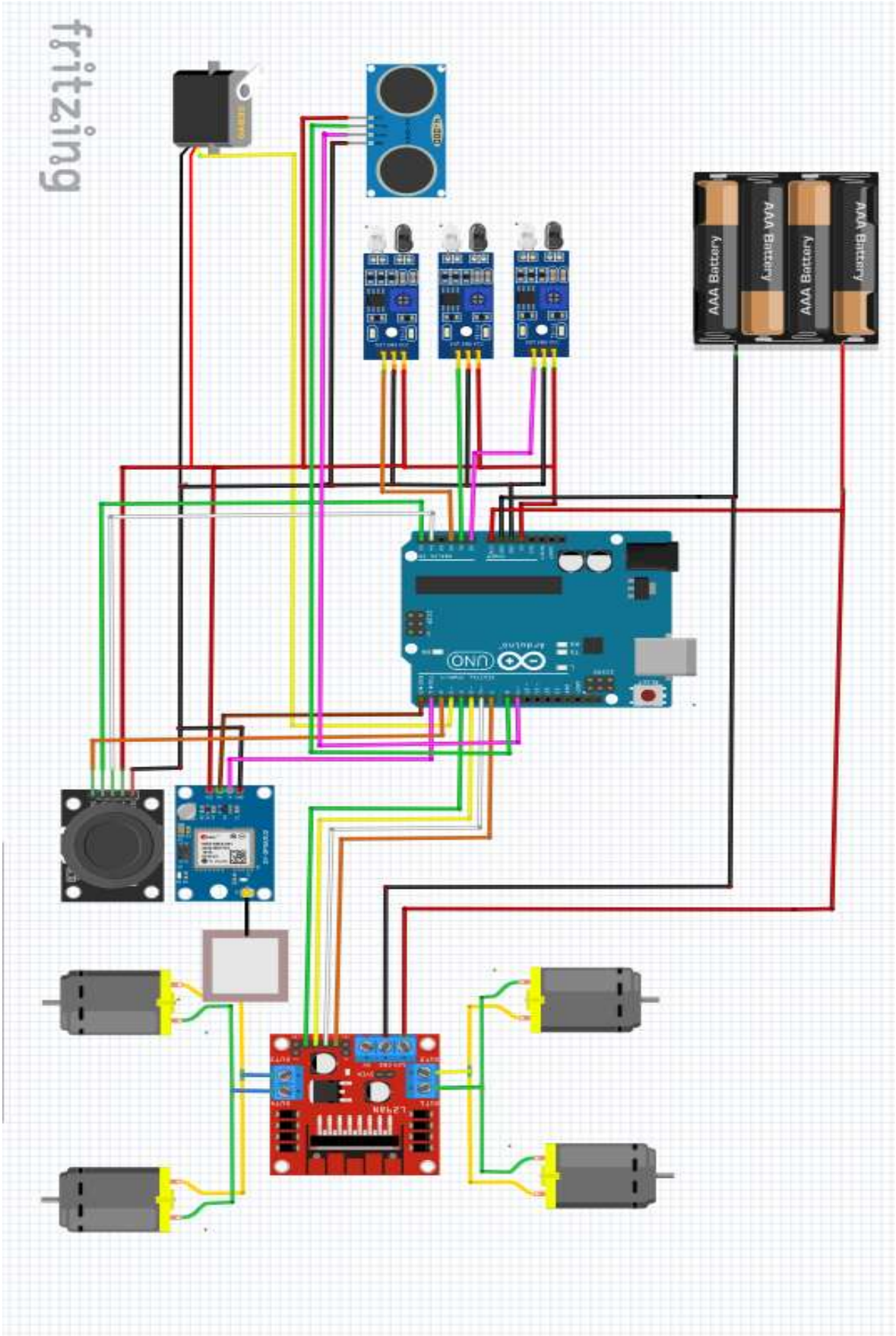
40Figure III.14: Analog joystick



41Figure III.15: Program for Analog joystick

III.6.6. The Electric system for mobile robot developed:

During this phase, the subsystems are brought together, the final program is verified to achieve the desired innovation and verify the engineering objectives are met.



42Figure III.16: Electric system

The program for the developed system can be found in the appendix. This section shows detailed information on the software architecture and code implementation.

III.7. Operating principle:

The project operates on a multi-step principle. Initially, the wheelchair's current and target locations are determined using the Global Positioning System (GPS). It is equipped with a GPS module that continuously receives signals from satellites to ascertain its current position and the user-defined destination.

The wheelchair's movement is controlled by DC motors, which facilitate forward, backward, left, and right turns. Motor control can be either manual, with the user guiding the wheelchair via a joystick, or automatic, where the wheelchair navigates itself to the GPS-derived coordinates.

Moreover, the wheelchair is equipped with sensors to detect obstacles. Ultrasonic sensors are positioned at the front to detect obstacles by emitting high-frequency sound waves and measuring the time taken for the echoes to return, calculating the distance to the obstacle. Infrared (IR) sensors on the sides and back detect obstacles by emitting infrared light and sensing reflections from nearby objects.

Upon detecting an obstacle, the wheelchair automatically halts to prevent collisions. A servo motor, capable of rotating to a specific angle, adjusts the wheelchair's direction to bypass the obstacle.

Finally, the wheelchair navigates to the target location using the GPS-derived current and target coordinates. It can autonomously adjust its path to avoid obstacles, ensuring safe and efficient travel even in complex environments.

III.8. Conclusion:

The design of a car-type mobile robot is a multifaceted process involving meticulous planning and execution of mechanical, electrical, and software components. Each step is crucial to achieving a functional and efficient robot capable of performing its intended tasks. By following a systematic approach, we can ensure that the final product is reliable, adaptable, and ready for real-world applications. This chapter provides a comprehensive overview, laying the foundation for further advancements and innovations in mobile robotics.

General Conclusion:

Robotic wheelchairs represent a significant advancement in enhancing mobility, independence, and social participation for disabled individuals, offering superior capabilities compared to traditional wheelchairs. This project focused on developing an intelligent wheelchair system utilizing a mobile robot platform controlled by an Arduino board. The design process for this car-type mobile robot involved intricate planning and execution of mechanical, electrical, and software components, each critical to ensuring a functional and efficient robot. Users can control the wheelchair through GPS commands, which are processed by an onboard GPS module to manage the motor driver IC for wheel steering. The system also includes automatic obstacle detection using ultrasonic and IR sensors.

The project's outcomes demonstrated partial success, validating the feasibility of the proposed intelligent wheelchair system. This work lays a robust foundation for future advancements and innovations in the field of mobile robotics, promising further enhancements in the autonomy and usability of robotic assistive.

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Appendix:

Appendix A: Programm

```
#define enA 10//Enable1 L298 Pin enA
#define in1 9 //Motor1  L298 Pin in1
#define in2 8 //Motor1  L298 Pin in1
#define in3 7 //Motor2  L298 Pin in1
#define in4 6 //Motor2  L298 Pin in1
#define enB 5 //Enable2 L298 Pin enB

#define L_S A0 //ir sensor Left
#define R_S A1 //ir sensor Right

#define echo A2    //Echo pin
#define trigger A3 //Trigger pin

#define servo A5

int Set=15;
int distance_L, distance_F, distance_R;

void setup(){ // put your setup code here, to run once

Serial.begin(9600); // start serial communication at 9600bps

pinMode(R_S, INPUT); // declare if sensor as input
pinMode(L_S, INPUT); // declare ir sensor as input

pinMode(echo, INPUT );// declare ultrasonic sensor Echo pin as input
pinMode(trigger, OUTPUT); // declare ultrasonic sensor Trigger pin as Output

pinMode(enA, OUTPUT); // declare as output for L298 Pin enA
pinMode(in1, OUTPUT); // declare as output for L298 Pin in1
pinMode(in2, OUTPUT); // declare as output for L298 Pin in2
pinMode(in3, OUTPUT); // declare as output for L298 Pin in3
pinMode(in4, OUTPUT); // declare as output for L298 Pin in4
pinMode(enB, OUTPUT); // declare as output for L298 Pin enB

analogWrite(enA, 200); // Write The Duty Cycle 0 to 255 Enable Pin A for Motor1
Speed
analogWrite(enB, 200); // Write The Duty Cycle 0 to 255 Enable Pin B for Motor2
Speed
```

```
pinMode(servo, OUTPUT);

 for (int angle = 70; angle <= 140; angle += 5)  {
   servoPulse(servo, angle);  }
 for (int angle = 140; angle >= 0; angle -= 5)  {
   servoPulse(servo, angle);  }

 for (int angle = 0; angle <= 70; angle += 5)  {
   servoPulse(servo, angle);  }

distance_F = Ultrasonic_read();

delay(500);
}


void loop(){
//=============================================
//     Line Follower and Obstacle Avoiding
//=============================================

distance_F = Ultrasonic_read();
Serial.print("D F=");Serial.println(distance_F);


//if Right Sensor and Left Sensor are at White color then it will call forword
function
 if((digitalRead(R_S) == 0)&&(digitalRead(L_S) == 0)){
  if(distance_F > Set){forword();}
                  else{Check_side();}
 }
//if Right Sensor is Black and Left Sensor is White then it will call turn Right
function
else if((digitalRead(R_S) == 1)&&(digitalRead(L_S) == 0)){turnRight();}

//if Right Sensor is White and Left Sensor is Black then it will call turn Left
function
else if((digitalRead(R_S) == 0)&&(digitalRead(L_S) == 1)){turnLeft();}

delay(10);
}

void servoPulse (int pin, int angle){
int pwm = (angle*11) + 500;      // Convert angle to microseconds
 digitalWrite(pin, HIGH);
 delayMicroseconds(pwm);
 digitalWrite(pin, LOW);
 delay(50); // Refresh cycle of servo
```

```
}
long Ultrasonic_read(){
  digitalWrite(trigger, LOW);
  delayMicroseconds(2);
  digitalWrite(trigger, HIGH);
  delayMicroseconds(10);
  long time = pulseIn (echo, HIGH);
  return time / 29 / 2;
}

void compareDistance(){
    if(distance_L > distance_R){
  turnLeft();
  delay(500);
  forword();
  delay(600);
  turnRight();
  delay(500);
  forword();
  delay(600);
  turnRight();
  delay(400);
  }
  else{
  turnRight();
  delay(500);
  forword();
  delay(600);
  turnLeft();
  delay(500);
  forword();
  delay(600);
  turnLeft();
  delay(400);
  }
}
void Check_side(){
    Stop();
    delay(100);
 for (int angle = 70; angle <= 140; angle += 5)  {
   servoPulse(servo, angle);  }
    delay(300);
    distance_R = Ultrasonic_read();
Serial.print("D R=");Serial.println(distance_R);
    delay(100);
for (int angle = 140; angle >= 0; angle -= 5)  {
   servoPulse(servo, angle);  }
    delay(500);
```

```
distance_L = Ultrasonic_read();
    Serial.print("D L=");Serial.println(distance_L);
    delay(100);
 for (int angle = 0; angle <= 70; angle += 5) {
   servoPulse(servo, angle);  }
    delay(300);
    compareDistance();
}

void forword(){  //forword
digitalWrite(in1, LOW); //Left Motor backword Pin
digitalWrite(in2, HIGH); //Left Motor forword Pin
digitalWrite(in3, HIGH); //Right Motor forword Pin
digitalWrite(in4, LOW); //Right Motor backword Pin
}

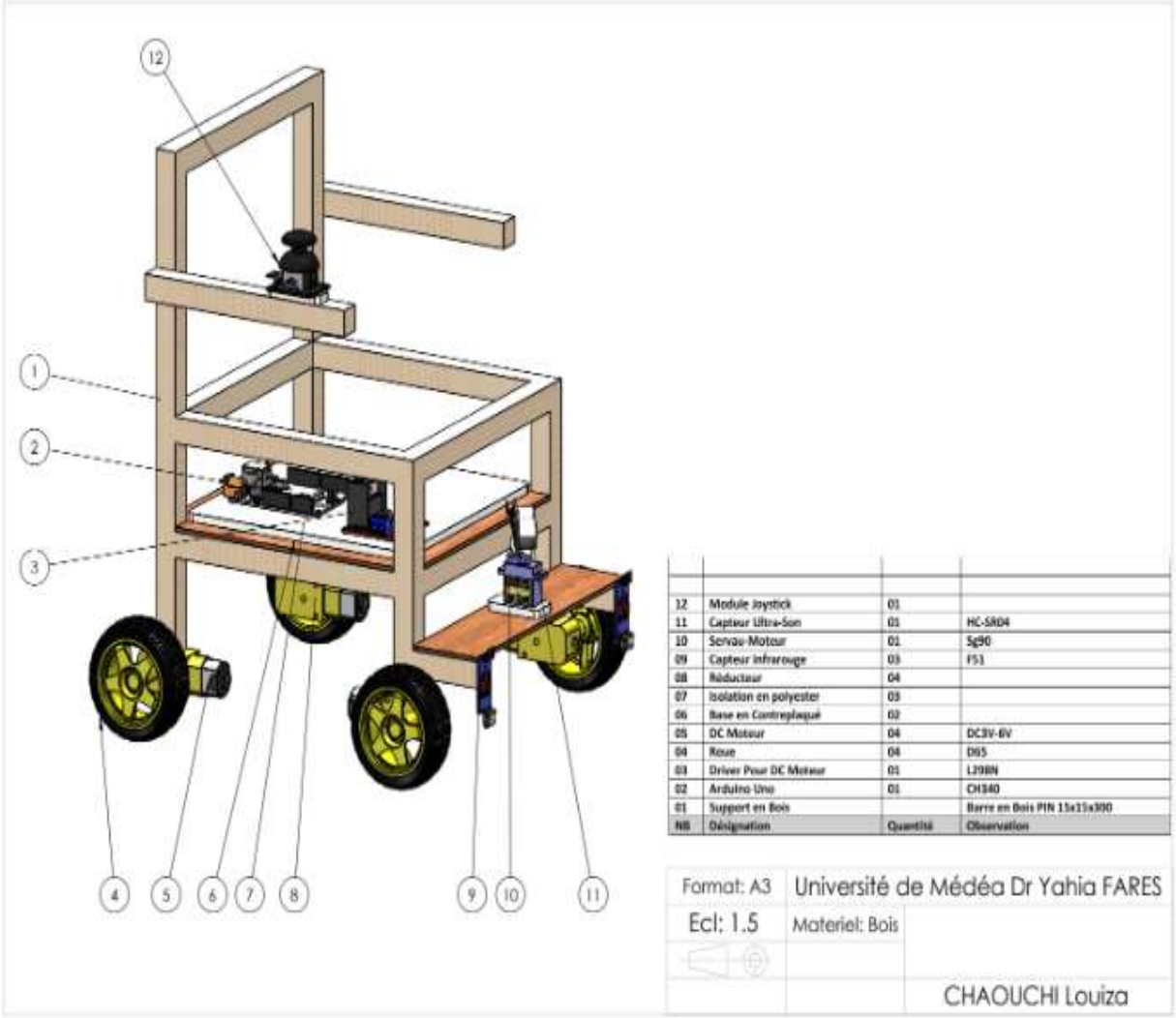
void backword(){ //backword
digitalWrite(in1, HIGH); //Left Motor backword Pin
digitalWrite(in2, LOW); //Left Motor forword Pin
digitalWrite(in3, LOW); //Right Motor forword Pin
digitalWrite(in4, HIGH); //Right Motor backword Pin
}

void turnRight(){ //turnRight
digitalWrite(in1, LOW); //Left Motor backword Pin
digitalWrite(in2, HIGH); //Left Motor forword Pin
digitalWrite(in3, LOW); //Right Motor forword Pin
digitalWrite(in4, HIGH); //Right Motor backword Pin
}

void turnLeft(){ //turnLeft
digitalWrite(in1, HIGH); //Left Motor backword Pin
digitalWrite(in2, LOW); //Left Motor forword Pin
digitalWrite(in3, HIGH); //Right Motor forword Pin
digitalWrite(in4, LOW); //Right Motor backword Pin
}

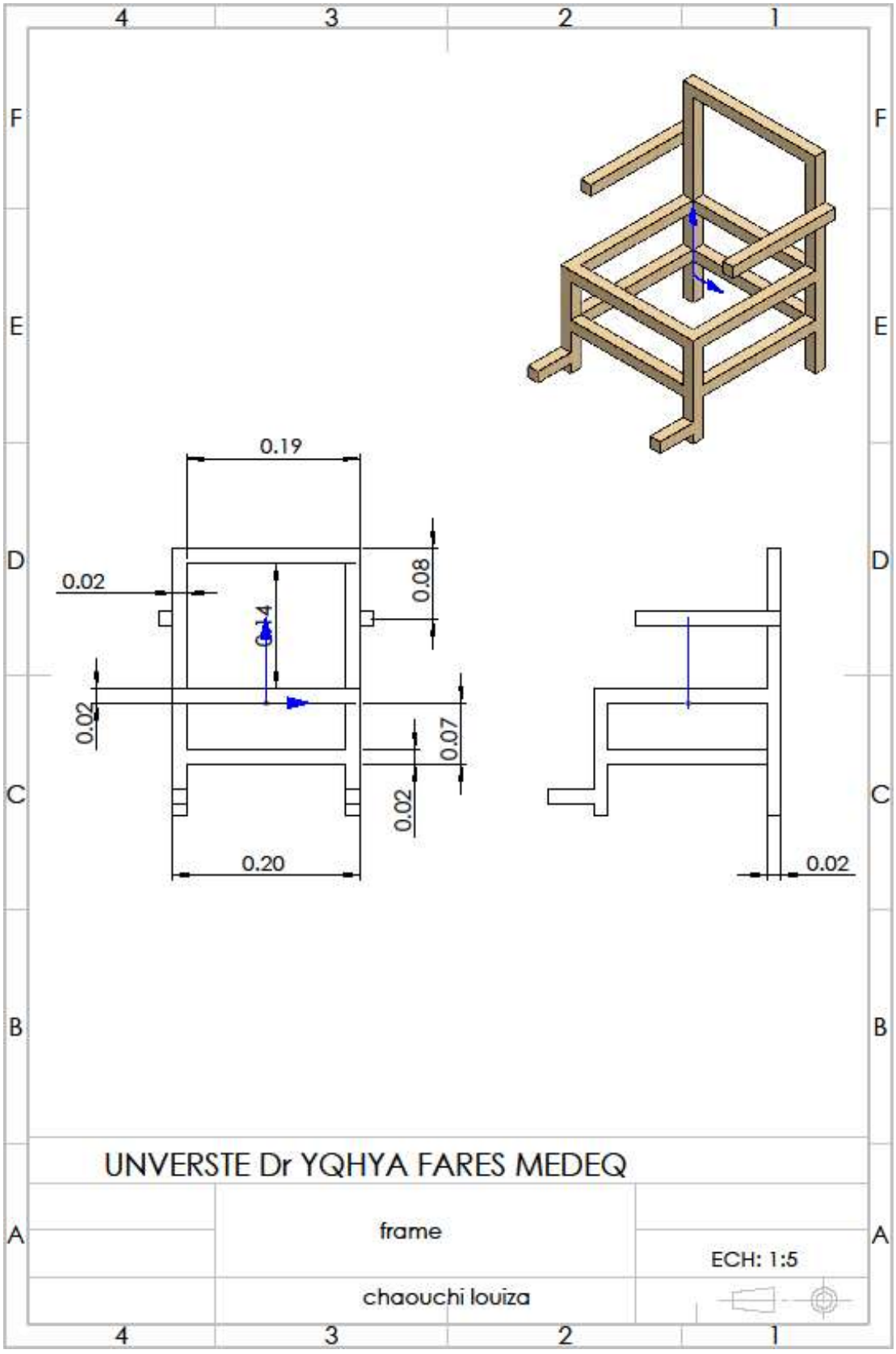
void Stop(){ //stop
digitalWrite(in1, LOW); //Left Motor backword Pin
digitalWrite(in2, LOW); //Left Motor forword Pin
digitalWrite(in3, LOW); //Right Motor forword Pin
digitalWrite(in4, LOW); //Right Motor backword Pin
}
```

Appendix B: mechanical design



NB	Désignation	Quantité	Observation
12	Module Joystick	01	
11	Capteur Ultra-Son	01	HC-SR04
10	Servo-Moteur	01	Sg90
09	Capteur infrarouge	03	F51
08	Réducteur	04	
07	Isolation en polyester	03	
06	Base en Contreplaqué	02	
05	DC Moteur	04	DC3V-6V
04	Roue	04	D65
03	Driver Pour DC Moteur	01	L298N
02	Arduino Uno	01	CH340
01	Support en Bois		Barre en Bois PIN 15x15x300

Format: A3	Université de Médéa Dr Yahia FARES	
Ecl: 1.5	Materiel: Bois	
		CHAOUCHI Louiza


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UNVERSTE Dr YQHYA FARES MEDEQ
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ECH: 1:5
chaouchi louiza