OMNI – DIRECTIONAL ROBOT

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May, 2023

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in

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Dr. A.P.J. Abdul Kalam Technical University, U.P., Lucknow.
May, 2023

DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree ordiploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

Signature

Name

Roll No.

Date

CERTIFICATE

This is to certify that Project Report entitled “**OMNI - DIRECTIONAL ROBOT** ” which is submitted by **Sachin Shakya, Updesh Pandey, Aditya Kumar, Shivbodh Pal** in partial fulfillment of the requirement for the award of degree B. Tech. in Department of **Electrical Engineering** of Dr. A.P.J. Abdul Kalam Technical University, U.P., Lucknow., is a record of the candidate own work carried out by him under my/our supervision. The matter embodied in this thesis is original and has not been submitted for the award of any other degree.

Date: **Supervisor**

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ABSTRACT

This project is about building a four wheeled robot car with Omni wheels. Omni wheels can make a robot drive sideways without rotating first. They can make a robot rotate at the same time as it goes straight ahead. An Omni wheel robot can for example be a good choice for tracking robot, though it can drive more effective than a robot car with regular wheels. The thing that speaks against Omni wheels is that it has more friction and it takes more power to rotate the wheels.

This robot car is a mobile controlled robot which can easily move in every direction with the help of mobile software. With the help of Omni wheels the robot should drive without rotating much which makes it more effective than a robot car with regular wheels.

The Omni-directional drive is a popular challenging trend in today's mobile robotics where different areas such as swarm, humanoid, legged, train-based, underwater, air flying, and wheeled mobile robotics have been involved. Among them all, Omni-directional Wheeled Mobile Robots (OMR) due to their low cost, simplicity, and their power in navigation have attracted a significant number of applications in various environments. Different wheel mechanisms including different mechanical wheel designs and various wheel topologies, and different navigation approaches, including control, driving, path planning methods and etc., are designed to achieve Omni-directional drive with different characteristics. For instance, some works attempt to reach a better speed, some others increase the robot's payload capacity, some works improve the motion stabilization and some others deal with uncertainty, vibration, slippage, and etc. In this paper, we present a review of the most effective Omni-directional wheel mechanisms and present the main challenges and navigation approaches that play important roles in OMR development. The important background works regarding each wheel mechanism are presented, the most important wheel mechanisms are presented and the current trending approaches are presented in order to assist designers and researchers to select appropriate mechanism and control approach fit to their requirements.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

WMR	Wheeled Mobile Robot
OMR	Omni-directional Mobile Robot
PID	Proportional Integral Derivative
PWM	Pulse Width Modulation
IDE	Integrated Development Environment
UNO	One In Italian
GND	Ground Pin of module
VCC	Voltage Common Collector
TXD	Transmit Data
RXD	Receive Data
AREF	Analogue Reference
USB	Universal Serial Bus
EN	Enable
ICSP	In-Circuit Serial Programming pin
LIPO	Lithium Polymer
I/O	Input/Output
MCU	Micro Controller Unit

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

Recently a large number of various mobile robots have been entered into human life in many different indoor and outdoor environments such as factories, offices, kitchens, warehouses and etc. Based on the applications, maneuverability, and locomotion systems, different kinds of mobile robots have been designed. Navigation is the key aspect in mobile robotics that can be achieved based on the applications, by actuating different mechanisms and locomotion systems. Traditionally a Wheeled Mobile Robot (WMR) was not able to perform holonomic drive wherein translation and rotation movements can be performed simultaneously. Omni-directional Mobile Robot (OMR) however is able to perform the holonomic motion, in other words, OMR can drive in any direction without requiring a turn in the robot's heading direction. This ability makes OMR be capable of navigation even in narrow and complex spaces. An OMR can be designed based on a variety of Omni-directional mechanisms also knows as multi-directional locomotion systems, for instance, legs, copters, steam engines, fins, and Omni-wheels. The Omni-directional wheel, also known as multi-directional or Omni-wheel is a very popular mechanism that benefits from low cost and simplicity in design as well as their ability to achieve reliable Omni-directional drive. Hence there has been a wide range of researches conducted on OMR based on Omni-directional wheels in order to enhance the holonomic navigation of mobile robots. Wheels such as Universal Wheels, steerable wheels, Mecanum wheels, Ball-driven wheels, orthogonal wheels and etc., have been proposed throughout history.

In this paper, we discuss the main navigation challenges and approaches of WMRs regarding the common ground among different wheel-based locomotion systems and we present the advancements and the advantages of holonomic drive systems over the traditional non-holonomic locomotion. The challenges and the advancements of the most important holonomic Omni-directional wheel mechanisms and their characteristics and the important background works have been done based on each type of wheel mechanism are presented. Besides, we discuss the main navigation methods in the state of the art as well as the current trending approaches been conducted on holonomic OMRs. The key goal of this paper is to update the OMR's state of the art as well as categorizing the major trends and approaches towards the Omni-directional wheel mechanisms and the holonomic navigation approaches regarding the robot design and control. This paper presents the most interesting approaches that have had an impact on the direction of researches in order to provide the readers with an efficient amount of knowledge on Omni-directional wheel differences and trends of studies that can help researches to efficiently understand the subject and to have a comparison in their choice of wheels as well as their direction of study towards building applications based on OMR.

Background

There have been several literature reviews on WMRs in the history that some of them also partially cover OMRs. One of the earliest reviews on WMRs was conducted in 1986 by P. Muir and C. Neuman wherein the authors articulated the kinematics of wheeled mobile robots and surveyed the existed WMRs. This work covered the researches up to over three decades ago and surely many things have been changed in today's mobile robotic. Later in about two decades later, another review on WMRs focusing on Mecanum wheels was conducted by F. Adascalitiei and I. Doroftei at the year 2011. However, this study was limited to only OMRs based on Mecanum wheels and thus the whole other worlds of the Omni-directional drive were missed in this paper. Two years later a work by Kalman concentrated on a specific type of OMRs with configurable wheels regarding the dynamic parameters and simulation of the OMRs. C. Ren and S. Ma studied dynamic modelling of OMR based on two categories, switch-wheel and non-switch wheels which are categorized based on their contacting point to the ground whether if they need to be switched during robot's motion or not. In the year 2014, T. Jacobs et al presented the strength and the limitation of different Omni-directional wheel mechanisms based on their payload capacity and J. Parmar and C. Savant described an approach to choose between two types of Omni-directional wheels for mobile robotics. This study comes interesting in the state of the art; however, it did not present the background works on the field. A year later, in a more detailed study, K. Kanjanawanishkul servyed the OMRs based on two categories, the special Omni-directional mechanisms, and the conventional wheels. Kanjanawanishkul covered the Universal wheel topology, Mecanum, Castor, and Steerable wheels regarding only the commercially available platforms. However, some of the most recent Omnidirectional mechanisms like ball-drive spherical wheels, Omni crawlers and etc are missed in his work and the classification of the wheels in such categories is not quite accurate, because, despite the physical appearance of those wheels, the performance and the force transformation of some other types of wheels are not different in such groups that could be considered as special and conventional terms. Moreover, both categories of the wheels have been re-arranged, re-designed, and enhanced in several works that could not stand in this type of classification.M. J. A. Safar briefly reviewed several holonomic wheel mechanisms, although this study also is rather limited to only several especial wheels. The more recent reviews of Omni-directional mobile robots are conducted based on other types of locomotion systems rather than wheels i.e. legged robots. Table 1 shows a brief information of some of the main reviews of OMR in the state of the art. Holonomic WMRs and their main navigation challenge and approaches. Section 3, reviews the most important Omni-directional wheel mechanisms The rest of the paper is as such: in Section 2 we discuss the traditional non-and discusses their characteristics and the important background works that have been done regarding each wheel mechanism. The main navigation methods in the state of the art, as well as the current trending approaches been conducted on OMRs, are reviewed in Sections 4, and 5 is the conclusion. There are a waste number of studies conducted regarding the term and we cannot present all works been conducted throughout the history, however here in this paper we chose the most important studies that have either become the lead studies attrackting many studies being conducted based on their methods, getting recited by many scholars, or they have overcome some important challenges regarding the mechanism. We updated the state of art and we gathered the essential information regarding the major aspects of wheeled Omni-directional mechanism and control.

1.2 Purpose

The purpose of an omnidirectional robotic car or vehicle is to provide a flexible, efficient, and versatile mode of transportation that can move in any direction. Unlike traditional cars, which can only move forward and backward and turn left or right, omnidirectional robotic cars can move in any direction, including diagonally, and rotate on the spot. This unique capability makes them well-suited for a range of applications, including:

Personal transportation: Omnidirectional robotic cars can provide a more efficient and convenient mode of personal transportation, especially in urban areas, where traffic congestion and limited parking can be major challenges.

Package delivery: With their ability to move in any direction, omnidirectional robotic cars can navigate through narrow streets and tight spaces to deliver packages more efficiently.

Manufacturing and logistics: Omnidirectional robotic cars can be used in manufacturing and logistics to transport goods within factories and warehouses, where space is often limited.

Autonomous transportation: Omnidirectional robotic cars can be integrated into autonomous transportation networks, providing a more seamless and efficient transportation experience.

Medical transport: Omnidirectional robotic cars can be used to transport patients and medical supplies in hospitals and healthcare facilities, where navigating tight spaces and corridors can be challenging.

Overall, the purpose of omnidirectional robotic cars is to provide a flexible and versatile mode of transportation that can adapt to a range of environments and applications.

CHAPTER 2

LITERATURE STUDY

2.1 DC Motor

A DC motor is any of a class of rotary electrical motors that converts direct current (DC) electrical energy into mechanical energy. The most common types rely on the forces produced by induced magnetic fields due to flowing current in the coil. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

DC motors were the first form of motors widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor, a lightweight brushed motor used for portable power tools and appliances can operate on direct current and alternating current. Larger DC motors are currently used in propulsion of electric vehicles, elevator and hoists, and in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

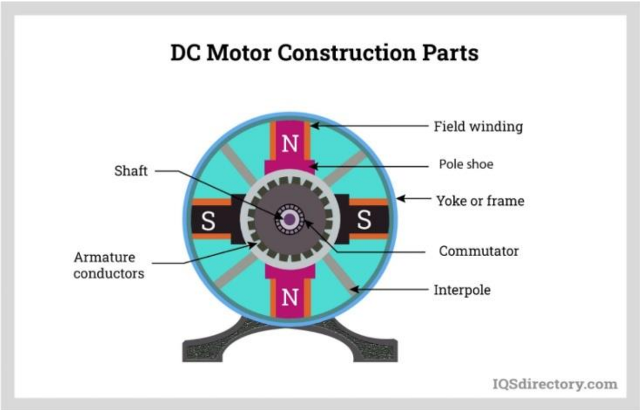

Figure no. 2.1

A dc motor or direct current electrical motor is a rotating electro-mechanical device that turns electrical energy into mechanical energy. When dc voltage is applied to the motor terminals, an Inductor (coil) generates a magnetic field that creates rotary motion, as indicated in figure 1 below.

Inside the electric motor is an iron shaft wrapped in a coil of wire. This shaft contains two fixed, North and South, magnets on either side. These magnets causes both a repulsive and attractive force, in turn producing torque. ISL Products designs and manufactures both brushed DC motors and brushless dc motors. In addition, we tailor our DC motor's size and performance to meet your desired specs.

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Figure no. 2.2

2.2 Microcontroller

A microcontroller (MCU for *microcontroller unit*, also MC, UC, or μC) is a small computer on a single VLSI integrated circuit (IC) chip. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals.
Program memory in the form of ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips.

Figure no. 2.3

2.2.1 How do microcontrollers work?

A microcontroller is embedded inside of a system to control a singular function in a device. It does this by interpreting data it receives from its I/O peripherals using its central processor. The temporary information that the microcontroller receives is stored in its data memory, where the processor accesses it and uses instructions stored in its program memory to decipher and apply the incoming data. It then uses its I/O peripherals to communicate and enact the appropriate action.

2.3 Battery

2.3.1 Introduction

A lithium polymer battery, or more correctly lithium-ion polymer battery, is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. High conductivity semisolid (gel) polymers form this electrolyte. These batteries provide higher specific energy than other lithium battery types and are used in applications where weight is a critical feature, such as mobile devices, radio-controlled aircraft and some electric vehicles.

2.3.2 Working Principle of LiPo Battery:

Just as with other lithium-ion cells, LiPos work on the principle of intercalation and de-intercalation of lithium ions from a positive electrode material and a negative electrode material, with the liquid electrolyte providing a conductive medium. To prevent the electrodes from touching each other directly, a microporous separator is in between which allows only the ions and not the electrode particles to migrate from one side to the other.

Figure no. 2.4

CHAPTER 3

OMNI WHEELS

3.1 Introduction

Omni wheels or poly wheels, similar to Mecanum wheels, are wheels with small discs (called rollers) around the circumference which are perpendicular to the turning direction. The effect is that the wheel can be driven with full force, but will also slide laterally with great ease. These wheels are often employed in holonomic drive systems.

There are several ways to enable robots to move on a solid surface, such as using wheels and legs. Because wheels provide speed and ease of control, they are typically the first choice for robots in the middle size, small size, and junior robot soccer leagues.

The omni-directional wheel is a kind of wheel that can freely roll in more than one direction. It’s popular for mobile robots since it doesn’t need to rotate first for moving from one point to another in a straight path. Moreover, moving along a path can be combined with rotation, so the robot can arrive to its goal at the correct angle.

Figure no. 3.1

3.2 Wheels Arrangements

The most common wheel arrangements for a robot are three or four wheels. A two-wheeled arrangement is possible, but problematic. For example, if it were possible to place both omni-directional wheels orthogonally oriented exactly under the center of a circular base robot, one could drive the robot in any desired direction without rotation.

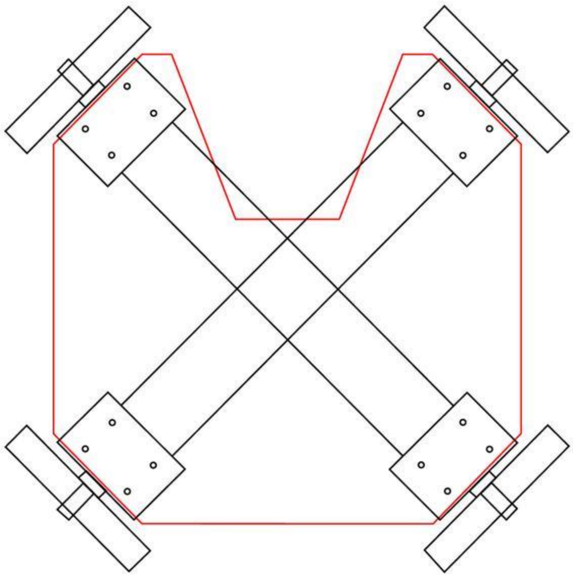

Figure no. 3.2

It is common practice that omni wheel robots have symmetric wheel arrangements. However, it is desirable to arrange the wheels as flexibly as possible, as there may be cases where it is preferable to have a less symmetrical wheel arrangement for specific applications.

Depending on the wheel arrangement, the robot may spontaneously turn without following previously proposed inverse kinematic models One reason is that the inverse kinematic models proposed so far are derived from a geometric approach and do not consider the dynamic loads applied to the robot. If the torque exerted on the robot's center of mass by the propulsive force generated by each wheel is not balanced, the robot turns even under straight-line control. We define "easy-to-operate" as a state where the vehicle can be correctly controlled in a straight line without causing this unexpected behavior.

3.3 Wheels Mechanism

This arrangement has a more complex mechanism. A popular configuration is locating the wheels around the periphery of the robot. Because of this arrangement, wheels can rotate the robot's frame in addition to moving the robot forward. A DC motor for each wheel can be used and each motor can be controlled by a PID controller.

Since the Omni wheel is a complex structure with multiple freewheel rollers, it is difficult to determine the propulsive force generated by the Omni wheel in a precise manner. Therefore, we focused on the wheel's ground velocity instead of the propulsive force. All wheels must reach the target velocities simultaneously to control the robot correctly. Therefore, in accelerating the wheels at the same time, the accelerations of the wheels are proportional to the target velocities. Moreover, the wheel's propulsive force is proportional to the wheel's acceleration. Thus, we assume that the propulsive forces generated by the Omni wheels are proportional to the wheel's ground velocity. Using this assumption, we can compute the moments that the velocity exerts on the robot's center of mass, *velocity moments*. If the moments are balanced, the robot would follow the straight-line motion correctly, otherwise, it would turn as it moves.

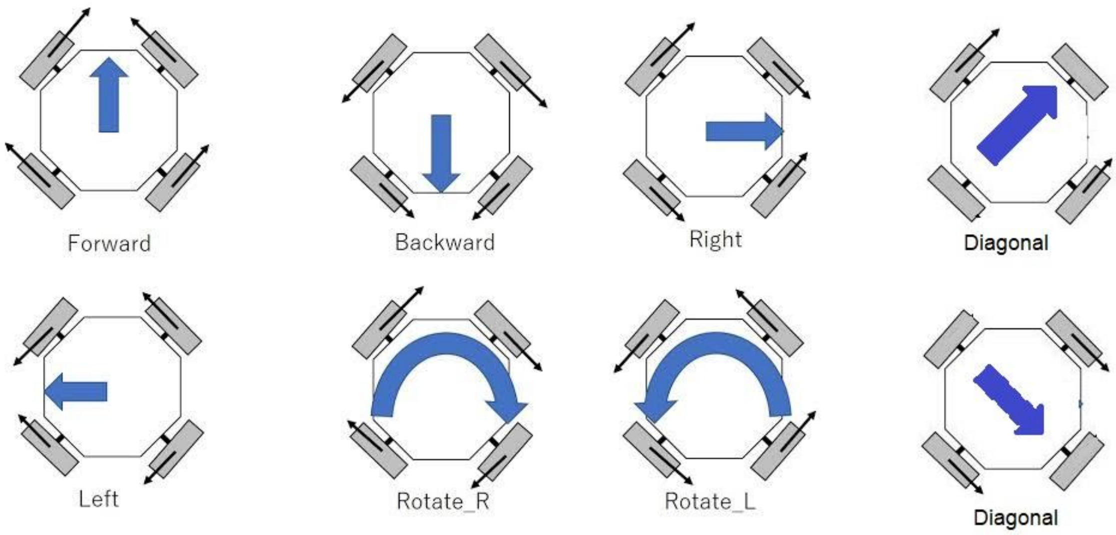

Figure no. 3.3

CHAPTER 4

DEMONSTRATOR

4.1 Software

The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as **Windows, Mac OS X, and Linux**. It supports the programming languages C and C++. Here, IDE stands for **Integrated Development Environment**.

The program or code written in the Arduino IDE is often called as sketching. We need to connect the Genuino and Arduino board with the IDE to upload the sketch written in the Arduino IDE software. The sketch is saved with the extension '.ino.'

The Arduino IDE will appear as:

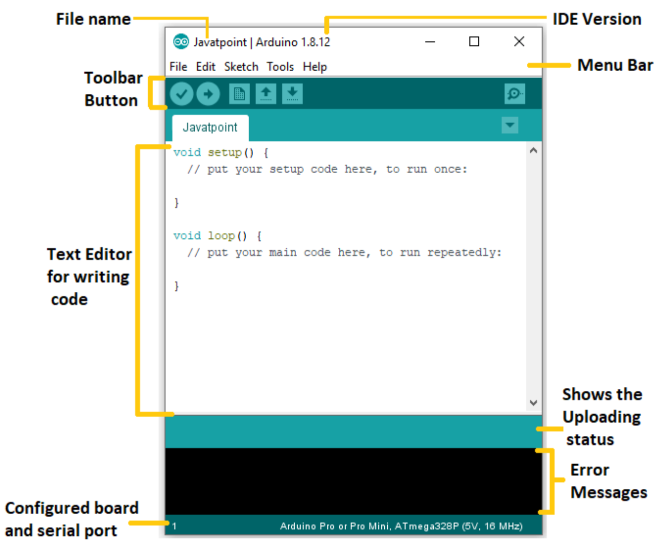

Figure no. 4.1

Let's discuss each section of the Arduino IDE display in detail

4.1.1 Toolbar section

The icons displayed on the toolbar are **New, Open, Save, Upload,** and **Verify**.

It is shown below:

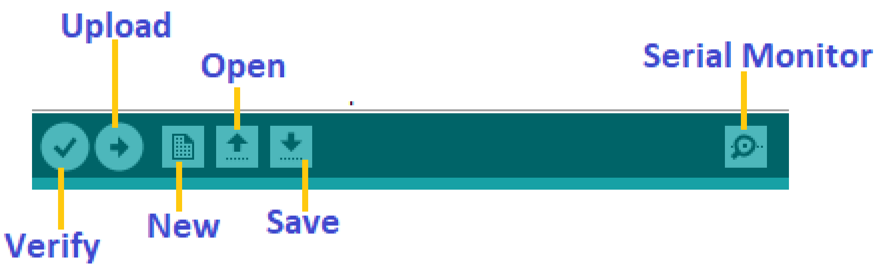

Figure no. 4.2

4.1.2 Upload

The Upload button compiles and runs our code written on the screen. It further uploads the code to the connected board. Before uploading the sketch, we need to make sure that the correct board and ports are selected.

We also need a USB connection to connect the board and the computer. Once all the above measures are done, click on the Upload button present on the toolbar.

The latest Arduino boards can be reset automatically before beginning with Upload. In the older boards, we need to press the Reset button present on it. As soon as the uploading is done successfully, we can notice the blink of the Tx and Rx LED.

4.1.3 Sketch

When we click on the Sketch button on the Menu bar, a drop-down list appears. It is shown below:

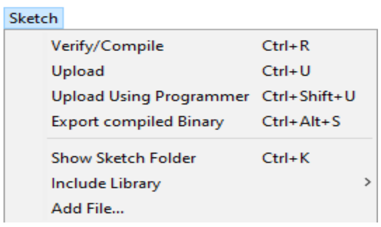

Figure no. 4.3

Verify/Compile

It will check for the errors in the code while compiling. The memory in the console area is also reported by the IDE.

Upload

The Upload button is used to configure the code to the specified board through the port.

Upload Using Programmer

It is used to override the Bootloader that is present on the board. We can utilize the full capacity of the Flash memory using the '**Upload Using Programmer**' option. To implement this, we need to restore the Bootloader using the **Tools**-> **Burn Bootloader** option to upload it to the USB serial port.

Export compiled Binary

It allows saving a **.hex** file and can be kept archived. Using other tools, .hex file can also be sent to the board.

Show Sketch Folder

It opens the folder of the current code written or sketch.

Include Library

Include Library includes various Arduino libraries. The libraries are inserted into our code at the beginning of the code starting with the #. We can also import the libraries from .zip file.

Add File...

The Add File... button is used to add the created file in a new tab on the existing file.

4.2 Electronics

4.2.1 Arduino UNO

The Arduino UNO is a standard board of Arduino. Here UNO means 'one' in Italian. It was named as UNO to label the first release of Arduino Software. It was also the first USB board released by Arduino. It is considered as the powerful board used in various projects. Arduino.cc developed the Arduino UNO board.

Arduino UNO is based on an ATmega328P microcontroller. It is easy to use compared to other boards, such as the Arduino Mega board, etc. The board consists of digital and analog Input/Output pins (I/O), shields, and other circuits.

The Arduino UNO includes 6 analog pin inputs, 14 digital pins, a USB connector, a power jack, and an ICSP (In-Circuit Serial Programming) header. It is programmed based on IDE, which stands for Integrated Development Environment. It can run on both online and offline platforms.

The IDE is common to all available boards of Arduino.

The Arduino board is shown below:

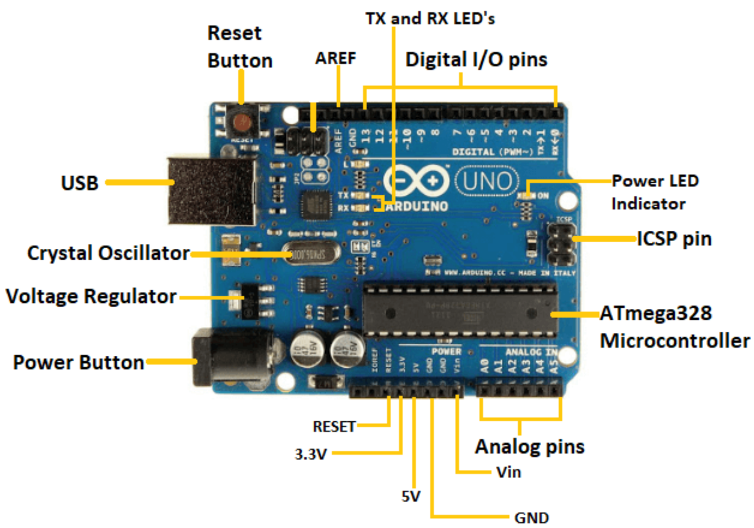

Figure no. 4.4

Let's discuss each component in detail.

- **ATmega328 Microcontroller**- It is a single chip Microcontroller of the ATmel family. The processor code inside it is of 8-bit. It combines Memory (SRAM, EEPROM, and Flash), Analog to Digital Converter, SPI serial ports, I/O lines, registers, timer, external and internal interrupts, and oscillator.
- **ICSP pin** - The In-Circuit Serial Programming pin allows the user to program using the firmware of the Arduino board.
- **Power LED Indicator**- The ON status of LED shows the power is activated. When the power is OFF, the LED will not light up.

- **Digital I/O pins**- The digital pins have the value HIGH or LOW. The pins numbered from D0 to D13 are digital pins.
- **TX and RX LED's**- The successful flow of data is represented by the lighting of these LED's.
- **AREF-** The Analog Reference (AREF) pin is used to feed a reference voltage to the Arduino UNO board from the external power supply.
- **Reset button**- It is used to add a Reset button to the connection.
- **USB**- It allows the board to connect to the computer. It is essential for the programming of the Arduino UNO board.
- **Crystal Oscillator**- The Crystal oscillator has a frequency of 16MHz, which makes the Arduino UNO a powerful board.
- **Voltage Regulator**- The voltage regulator converts the input voltage to 5V.
- **GND**- Ground pins. The ground pin acts as a pin with zero voltage.
- **Vin**- It is the input voltage.
- **Analog Pins**- The pins numbered from A0 to A5 are analog pins. The function of Analog pins is to read the analog sensor used in the connection. It can also act as GPIO (General Purpose Input Output) pins.

4.2.2 HC05 Bluetooth Module

HC-05 is a Bluetooth module which is designed for wireless communication. This module can be used in a master or slave configuration.

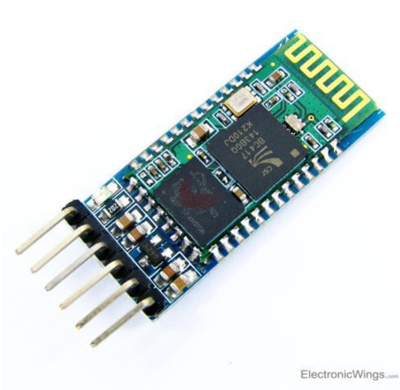

Figure no. 4.5

The pin diagram of HC05 Bluetooth Module is shown below in the figure:

Figure no. 4.6

1. **Key/EN:** It is used to bring Bluetooth module in AT commands mode. If Key/EN pin is set to high, then this module will work in command mode. Otherwise by default it is in data mode. The default baud rate of HC-05 in command mode is 38400bps and 9600 in data mode.
2. **VCC:** Connect 5 V or 3.3 V to this Pin.
3. **GND:** Ground Pin of module.
4. **TXD:** Transmit Serial data (wirelessly received data by Bluetooth module transmitted out serially on TXD pin)
5. **RXD:** Receive data serially (received data will be transmitted wirelessly by Bluetooth module).
6. **State:** It tells whether module is connected or not

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4.2.3. L298 Motor Driver Shield

The L293D is a dual-channel H-Bridge motor driver that can control two DC motors or a single stepper motor. Because the shield includes two such motor drivers, it can control up to four DC motors or two stepper motors.

The 74HC595 shift register, on the other hand, extends the Arduino’s four digital pins to the eight direction control pins of two L293D chips.

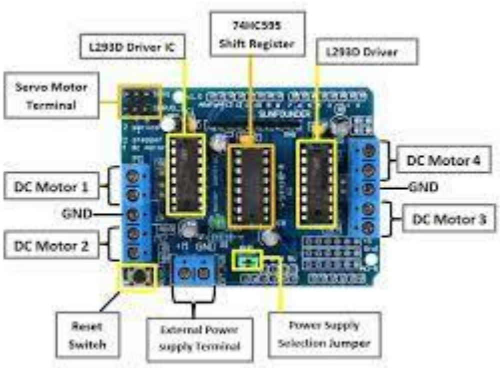

Figure no. 4.7

Arduino to Shield Pin Connections

For DC and stepper motor control, the shield makes use of pins D3, D4, D5, D6, D7, D8, D11, and D12.

D9 and D10 are used to control the servo motors. D10 is connected to Servo 1, while D9 is connected to Servo 2.

Please note that the shield does not use the D2 or D13 pins.

Installing AFMotor Library

To communicate with the shield, we must first install the AFMotor.h library. This will let us control DC, stepper, and servo motors with simple commands.

To install the library, navigate to Sketch > Include Library > Manage Libraries… Wait for the Library Manager to download the libraries index and update the list of installed libraries.

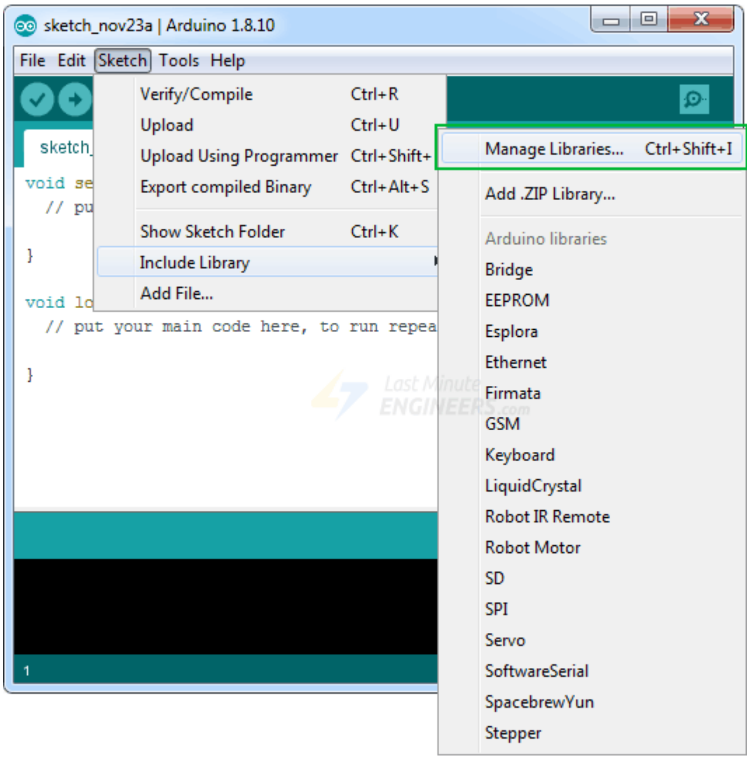

Figure no. 4.8

- Filter your search by entering ‘motor shield’.
- Look for Adafruit Motor Shield library(V1 Firmware) by Adafruit.
- Click on that entry and then choose Install.

4.3. HARDWARE

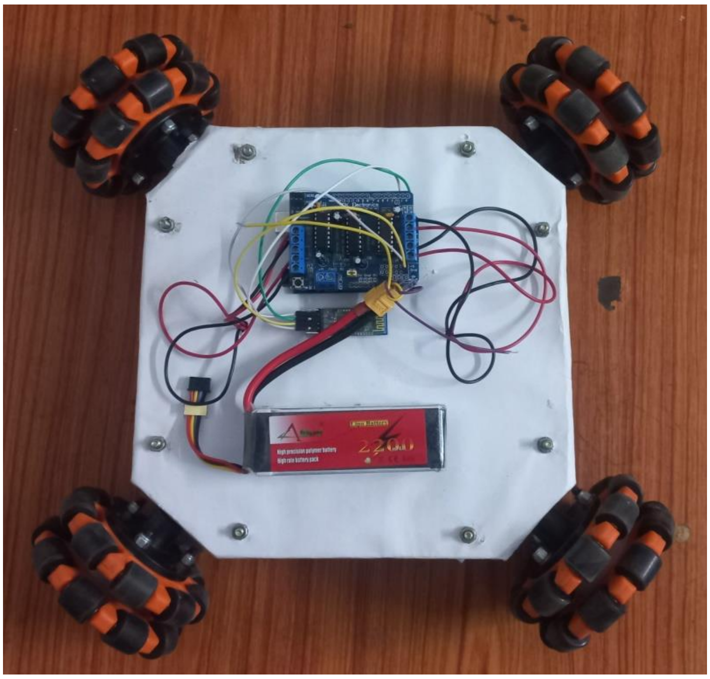

Figure No. 4.9

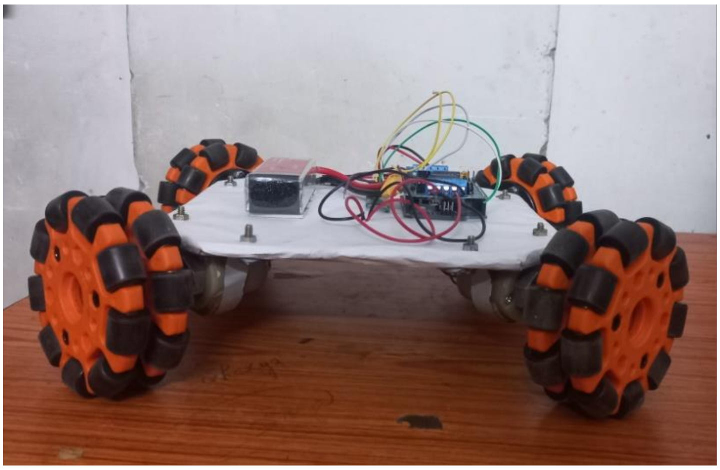

Figure No. 4.10

CHAPTER 5
CONCLUSION

Omnidirectional vehicles have great advantages over conventional (non-holonomic) platforms, with car-like Ackerman steering or differential drive system, for moving in tight areas. They can crab sideways, turn on the spot, and follow complex trajectories. These robots are capable of easily performing tasks in environments with static and dynamic obstacles and narrow aisles. Such environments are commonly found in factory workshop offices, warehouses, hospitals, etc. Flexible material handling and movement, with real-time control, has become an integral part of modern manufacturing. The development of an omnidirectional vehicle was pursued to further prove the effectiveness of this type of architecture and to add a ground vehicle platform that is capable of exceptional maneuverability. Omni-directional vehicles are divided into two categories that describe the type of wheel arrangement they use for mobility: conventional wheel designs and special wheel designs. This chapter introduced an omnidirectional mobile robot with Omni wheels for educational purposes. The robot has full omnidirectional motion capabilities, thanks to its special Omni wheels. Some information about conventional and special wheels designs, mechanical design aspects of the Omni wheel and also of the robot, kinematic models, as well as electronics and control strategies have been presented. Thanks to its motion capabilities and to its different control possibilities, the robot discussed in this chapter could be used as an interesting educational platform.

At this time, three solutions for motion control have been implemented in the microcontroller:

• Remote control mode;

• Line-follower mode;

• Autonomous mode, thanks to an ultrasonic pair sensors and bumper bars.

CHAPTER 6

FUTURE SCOPE

The topic of electronics and robotics provides a wide range of chances for furthering present research. A wide range of sensors and equipment, like as thermal cameras, heat sensors, and pressure sensors, are available on the market and may be put on the platform to help improve the rover's existing capabilities.

Omnidirectional robotic cars have a promising future with numerous potential applications. Here are some of the future scope of Omnidirectional robotic car:

1. **Personal transportation**: Omnidirectional robotic cars have the potential to revolutionize personal transportation by providing a more efficient and convenient way to travel. With the ability to move in any direction, these vehicles can maneuver through traffic and navigate around obstacles more easily than traditional cars.

2. **Package delivery**: Omnidirectional robotic cars can also be used for package delivery in urban areas, where navigating through narrow streets and crowded areas can be challenging. These vehicles can easily move in any direction and make deliveries more efficiently.

3. **Manufacturing and logistics**: Omnidirectional robotic cars can also be used in manufacturing and logistics to transport goods within factories and warehouses. Their ability to move in any direction and carry heavy loads makes them ideal for this purpose.

4. **Autonomous transportation**: As self-driving technology advances, omnidirectional robotic cars can be integrated into autonomous transportation networks. These vehicles can move seamlessly between different modes of transportation, including trains, buses, and airplanes, to provide a seamless and efficient transportation experience.

5. **Medical transport**: Omnidirectional robotic cars can be used to transport patients and medical supplies in hospitals and healthcare facilities. With their ability to move in any direction and navigate tight spaces, they can help improve the efficiency of healthcare services.

Overall, the future scope of omnidirectional robotic cars is vast and varied, with potential applications in various industries and sectors. As technology continues to advance, these vehicles will become even more advanced, capable, and versatile.

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