Holonomic Drive

October 16, 2022

To implement the Omni Wheel Robot which can move and rotate in all directions

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1 INTRODUCTION

Holonomic drive refers to the ability to move in all direction and rotate independently. It utilizes the rollers on the omni wheels to allow the robot to move in directions non-parallel to the wheels.

2 COMPONENTS AND SOFTWARE USED

2.1 SOFTWARE USED

2.1.1 PROTEUS 8 PROFESSIONAL

The PROTEUS DESIGN SUITE is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

Download link: https://drive.google.com/file/d/1bKfTUkJstJ5I3h16DkSMrEglp_xVoz-0/view?usp=sharing

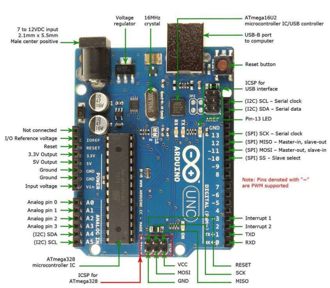
2.1.2 ARDUINO IDE

The Arduino integrated development environment (IDE) is a cross-platform application (for Microsoft Windows, macOS, and Linux) that is written in the Java programming language. It originated from the IDE for the languages Processing and Wiring. The Arduino IDE supports the languages C and C++ using special rules of code structuring

Download link - https://docs.arduino.cc/software/ide-v2

2.2 HARDWARE USED

2.2.1 ARDUINO UNO



Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button.

Microcontroller: Microchip ATmega328P
Operating Voltage: 5 Volts
Input Voltage: 7 to 20 Volts
Digital I/O Pins: 14
PWM Pins: 6 (Pin 3, 5, 6, 9, 10 and 11)
UART: 1
I2C: 1
SPI: 1
Analog Input Pins: 6
DC Current per I/O Pin: 20 mA
DC Current for 3.3V Pin: 50 mA
Flash Memory: 32 KB of which 0.5 KB used by bootloader
SRAM: 2 KB
EEPROM: 1 KB
Clock Speed: 16 MHz

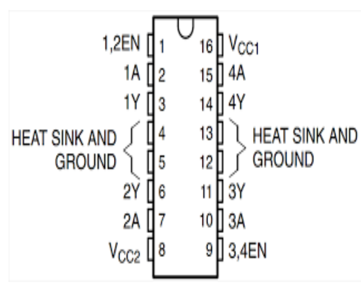
Length: 68.6 mm
Width: 53.4 mm
Weight: 25 g
ICSP Header: Yes
Power Sources: DC Power Jack and USB Port

2.2.2 Omni Wheels

Omni wheels or poly 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. Omniwheels are often used to allow for movement on the horizontal axis on a drivetrain, as well as forward and backward movement. Usually, this is achieved by using an H-drive.

Omniwheels combined with conventional wheels provide unique performance properties, such as on a six-wheeled vehicle employing two conventional wheels on a center axle and four omni wheels on front and rear axles.

2.2.3 L293D



The L293D is a dual-channel H-Bridge motor driver capable of driving a pair of DC motors or a single stepper motor. This means it can drive up to two motors individually which makes it ideal for building a two-wheeled robotic platform.It is capable of driving four solenoids, four uni-directional DC motors, two bi-directional DC motors or one stepper motor. The L293D IC has a supply range of 4.5V to 36V and is capable of 1.2A peak output current per channel, so it works very well with most of our motors.The IC also includes built-in kick-back diodes to prevent damage when the motor is de-energized.

Power Pins:

The L293D motor driver IC actually has two input power pins – VS and VSS. VS (Vcc2) pin gives power to the internal H-Bridge of the IC to drive the motors. You can connect an input voltage anywhere between 4.5 to 36V to this pin. VSS (Vcc1) is used to drive the internal logic circuitry which should be 5V. GND pins are common ground pins. All 4 GND pins are internally connected and used to dissipate the heat generated under high load conditions.

Output Pins:

The L293D motor driver's output channels for the motor A and B are brought out to pins OUT1,OUT2 and OUT3,OUT4 respectively. You can connect two 5-36V DC motors to these pins.

Each channel on the IC can deliver up to 600mA to the DC motor. However, the amount of current supplied to the motor depends on system's power supply.

Direction Control Pins:

By using the direction control pins, you can control whether the motor rotates forward or backward. These pins actually control the switches of the H-Bridge circuit inside the L293D IC. The IC has two direction control pins for each channel. The IN1 and IN2 pins control the spinning direction of motor A; While IN3 and IN4 control the spinning direction of motor B. The spinning direction of the motor can be controlled by applying logic HIGH (5V) or logic LOW (Ground) to these inputs. The chart below shows how this is done.

Speed Control Pins:

The speed control pins ENA and ENB are used to turn on/off the motors and control its speed. Pulling these pins HIGH will cause the motors to spin, while pulling it LOW will stop them. But, with Pulse Width Modulation (PWM), you can actually control the speed of the motors.

2.2.4 USB Hostshield

The USB Host shield contains all of the digital logic and analog circuit necessary to implement a full-speed USB peripheral/host controller with Arduino. This shield adds USB Host capabilities to popular Arduino platform. C Software support for new devices is constantly added; at the moment, code for USB keyboard and PS3 controller are ready with Bluetooth and digital cameras in the works. USB 2.0 Full Speed compatible 3.3/5V operation level compatible All GPIOx pins break-out USB Host 5V/500mA supply for USB protocol

Are team first intended to use buck converter because of it higher efficiency and less heat issue but we decided to go with voltage regulator because buck converter was not in working conditions.

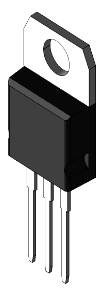
2.2.5 Bluetooth Dongle

A USB-based device that transmits and receives Bluetooth wireless signals. It plugs into the USB port to support Bluetooth mice, keyboards and other Bluetooth devices. Also called a "Bluetooth dongle."

2.2.6 PS3 Controller

The Dualshock 3 wireless controller for the PlayStation 3 system provides the most intuitive game play experience with pressure sensors in each action button and the inclusion of the highly sensitive SIXAXIS™ motion sensing technology. WE WILL BE USING PS3 FOR CONTROLLING THE DRIVE.

2.2.7 Voltage Regulator



A voltage regulator is a circuit that creates and maintains a fixed output voltage, irrespective of changes to the input voltage or load conditions. Voltage regulators (VRs) keep the voltages from a power supply within a range that is compatible with the other electrical components. While voltage regulators are most commonly used for DC/DC power conversion, some can perform AC/AC or AC/DC power conversion as well. Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobiles alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

2.2.8 Motors

A brushless DC electric motor (BLDC motor or BL motor), also known as an electronically commutated motor (ECM or EC motor) or synchronous DC motor, is a synchronous motor using a direct current (DC) electric power supply. It uses an electronic controller to switch DC currents to the motor windings producing magnetic fields which effectively rotate in space and which the permanent magnet rotor follows. The controller adjusts the phase and amplitude of the DC current pulses to control the speed and torque of the motor. This control system is an alternative to the mechanical commutator (brushes) used in many conventional electric motors.

The construction of a brushless motor system is typically similar to a permanent magnet synchronous motor (PMSM), but can also be a switched reluctance motor, or an induction synchronous motor. They may also use neodymium magnets and be outrunners (the stator is surrounded by the rotor), inrunners (the rotor is surrounded by the stator), or axial (the rotor and stator are flat and parallel). The advantages of a brushless motor over brushed motors are high power-to-weight ratio, high speed, nearly instantaneous control of speed (rpm) and torque, high efficiency, and low maintenance. Brushless motors find applications in such places as computer peripherals (disk drives, printers), hand-held power tools, and vehicles ranging from model aircraft to automobiles. In modern washing machines, brushless DC motors have allowed replacement of rubber belts and gearboxes by a direct-drive design.

2.2.9 12V LIPO Battery:

A printed circuit board (PCB; also printed wiring board or PWB) is a medium used in electrical and electronic engineering to connect electronic components to one another in a controlled manner. It takes the form of a laminated sandwich structure of conductive and insulating layers: each of the conductive layers is designed with an artwork pattern of traces, planes and other features (similar to wires on a flat surface) etched from one or more sheet layers of copper laminated onto and/or

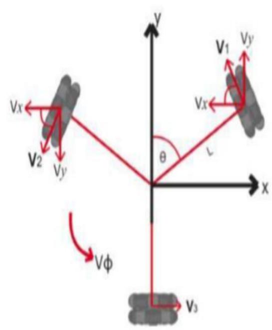
A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated as LiPo, LIP, Li-poly, lithium-poly and others), is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. High conductivity semisolid (gel) polymers form this 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 . 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.

3 MECHANICAL OPERATIONS PERFORMED TO BUILD THE BOT

1) With the appropriate angles and dimensions, the chassis of the bot was drawn onto a flat piece of plywood.
2) The chassis was cut out with the help of angle grinder under expert supervision.
3) A pair of holes on each side were drilled with the help of drilling machine under expert supervision.
4) one hole was drilled on each corner of the triangular chassis in order to pass the soldered pair of wires of each motor on the upper side.
5) three L clamps were fitted with the help of nuts and bolts on each corner and respective motors were also fit in using the same procedure.
6) Omni wheels were then mounted on the shafts of each motors with the help of allen key screw.
7) In order to integrate the power circuit and the GCB with the chassis, an elevated wooden platform was created by using 2 L clamps and 1 rectangular wooden slab.
8) the power circuit was placed at bottom and main gcb was placed on top mounted with the help pf styrofoam sheet and double sided tape.
9) Encoder was mounted in the middle of two motors at the bottom of the chassis with help of two L clamps and a fourth omni wheel is mounted on the shaft of the encoder.

4 MATH AND LOGIC BEHIND 3-WHEELED OMNIDIRECTIONAL ROBOT

Holonomic motion system is a system that represents the number of degrees of freedom equal to the number of coordinates used to define system configuration.



The holonomic concept is applied to determine the angle where α is the motor axis angle drawn from the x-axis coordinates of the robot frame. α is the motor axis angle from the x axis of the robot coordinate frame, each $\alpha 1 = 30°$, $\alpha 2 = 150°$ and $\alpha 3 = 270°$. The drive axis of the wheel s as shown in below Figure, is 90 ° or π / 2 of each α. To solve the vector into its x and y components, we use some simple trigonometry. For each of the three wheels, the x and y components of the orientation of the robot are described in Equations (1) to (6).

$$x_1 = cos\left(\alpha_1 + \frac{\pi}{2}\right) s_1 \quad (1)$$

$$x_2 = cos\left(\alpha_2 + \frac{\pi}{2}\right) s_2 \quad (2)$$

$$x_3 = cos\left(\alpha_3 + \frac{\pi}{2}\right) s_3 \quad (3)$$

$$y_1 = sin\left(\alpha_1 + \frac{\pi}{2}\right) s_1 \quad (4)$$

$$y_2 = sin\left(\alpha_2 + \frac{\pi}{2}\right) s_2 \quad (5)$$

$$y_3 = sin\left(\alpha_3 + \frac{\pi}{2}\right) s_3 \quad (6)$$

There is also a rotational component ω, in which the robot can rotate its z-axis. Robot rotation is just a simple sum of each motor speed. Even if the motor turns in the opposite way, we generally still get the overall number of robot rotations. Just add the motor speed to find the robot rotation ω. Motor speed for robot rotation ω in Equation (7).

$$\omega = s_1 + s_2 + s_3 \qquad (7)$$

The inverse kinematic formula for a robot with three wheels is defined as in Equation (8).

$$\begin{pmatrix} x \\ y \\ \omega \end{pmatrix} = \begin{pmatrix} \cos\left(\alpha_1 + \frac{\pi}{2}\right) & \cos\left(\alpha_2 + \frac{\pi}{2}\right) & \cos\left(\alpha_3 + \frac{\pi}{2}\right) \\ \sin\left(\alpha_1 + \frac{\pi}{2}\right) & \sin\left(\alpha_1 + \frac{\pi}{2}\right) & \sin\left(\alpha_1 + \frac{\pi}{2}\right) \\ 1 & 1 & 1 \end{pmatrix} \begin{pmatrix} s_1 \\ s_2 \\ s_3 \end{pmatrix} \qquad (8)$$

Where s1 is motor velocity 1, s2 is motor velocity 2 and s3 is motor velocity 3. Although x is the x-axis, y is the y-axis, and each robot rotation has a value of 1, -1, and 0.

By inverting Equation 1 means that get Equation (9).

$$M^{-1} = \frac{1}{3}\begin{pmatrix} -1 & \sqrt{3} & 1 \\ -1 & -\sqrt{3} & 1 \\ 2 & 0 & 1 \end{pmatrix} = \begin{pmatrix} -0.33 & 0.58 & 0.33 \\ -0.33 & -0.58 & 0.33 \\ 0.67 & 0 & 0.33 \end{pmatrix} \qquad (9)$$

Then,

$$\begin{pmatrix} s_1 \\ s_2 \\ s_3 \end{pmatrix} = \begin{pmatrix} -0.33 & 0.58 & 0.33 \\ -0.33 & -0.58 & 0.33 \\ 0.67 & 0 & 0.33 \end{pmatrix} \begin{pmatrix} x \\ y \\ \omega \end{pmatrix} \qquad (10)$$

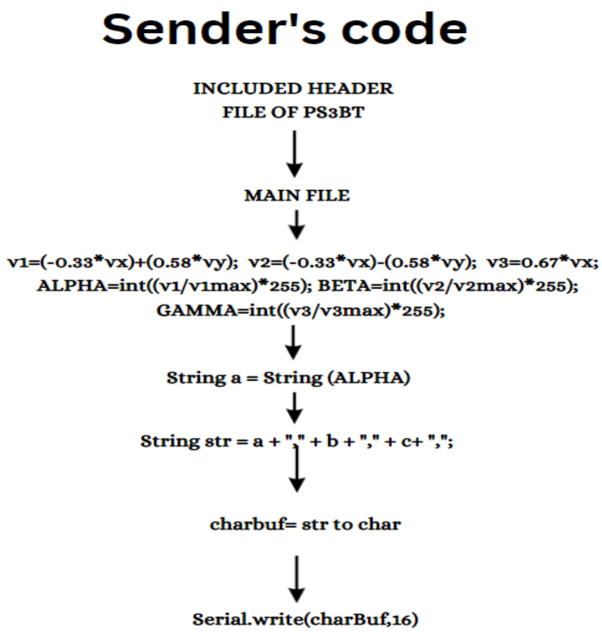
5 SERIAL COMMUNICATION

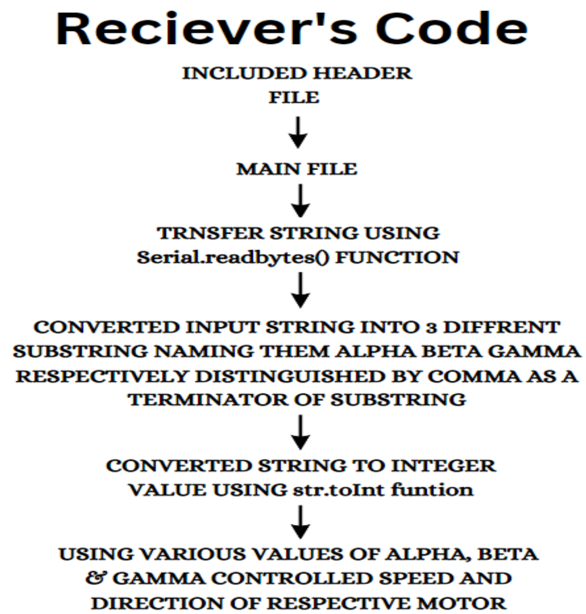
In telecommunication and data transmission, serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus. This is in contrast to parallel communication, where several bits are sent as a whole, on a link with several parallel channels.

In serial communication, data is in the form of binary pulses. In other words, we can say Binary One represents a logic HIGH or 5 Volts, and zero represents a logic LOW or 0 Volts. Serial communication can take many forms depending on the type of transmission mode and data transfer. The transmission modes are classified as Simplex, Half Duplex, and Full Duplex. There will be a source (also known as a sender) and destination (also called a receiver) for each transmission mode.

How to serially connect two Arduino Boards?

6 FLOWCHART





7 TIMELINE

- Motors and components used
- Learning of basics of Arduino and Proteus simulation
- Interfacing of PS3 with USB Host Shield , Bluetooth Dongle and Arduino
- Maths and logic behind mechanical working of Omni wheel drive
- Serial monitor data analysis of different PS3 controls
- Latex Documentation format was introduced
- Understanding PS3 by Controlling brightness of LED
- Controlling speed of motors using L293D
- Measure Rpm using audacity
- Chassis designing and manufacturing
- Soldering practice: Spiral and L shape
- Design and soldering of power circuit
- Design of controller circuit with minimum jumps and its soldering.
- Mounting L clamp, motors and omni wheel on chassis
- Research on encoders
- Algorithm and code for 3 wheel omni drive
- Mounting of encoders on bot

BOT IS READY TO ROCK!!

8 ERRORS AND SOLUTIONS

- Analog pin value below 127 was not give ong output and motors were not working
  Solution :- used enable pin as output pin
- Fault in GCB main circuit soldering(due to incorrect orientation of IC bed).

  Solution: Redrawing and resoldering the initial circuit with 3 jumps.
- Soldering error in Power circuit(due to reverse polarity of buck converter and input source)

  Solution: Resoldering to find another circuit path.
- Irregular working of PS3 joystick.

  Solution: We were advised to reset the arduino uno repeatedly.
- Arduino's pin no. 9,10,11 were used by USB host shield therefore we were unable to get the output on 10th and 11th pin.

  Solution:Serial connection between two arduino unos.
- Buck converter was not working properly.

  Solution: We decided to use voltage regulator instead of buck converter.
- Misalignment of holes in shaft of motor and coupler of wheel.

  Solution: We used double sided tape to fit the screw tight and reduce the wobbliness.

9 REFRENCES

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https://www.youtube.com/watch?v=ULQLD6VvXio
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