Engineering Journal

Team ID: 1783

Team Name: QuantaBots

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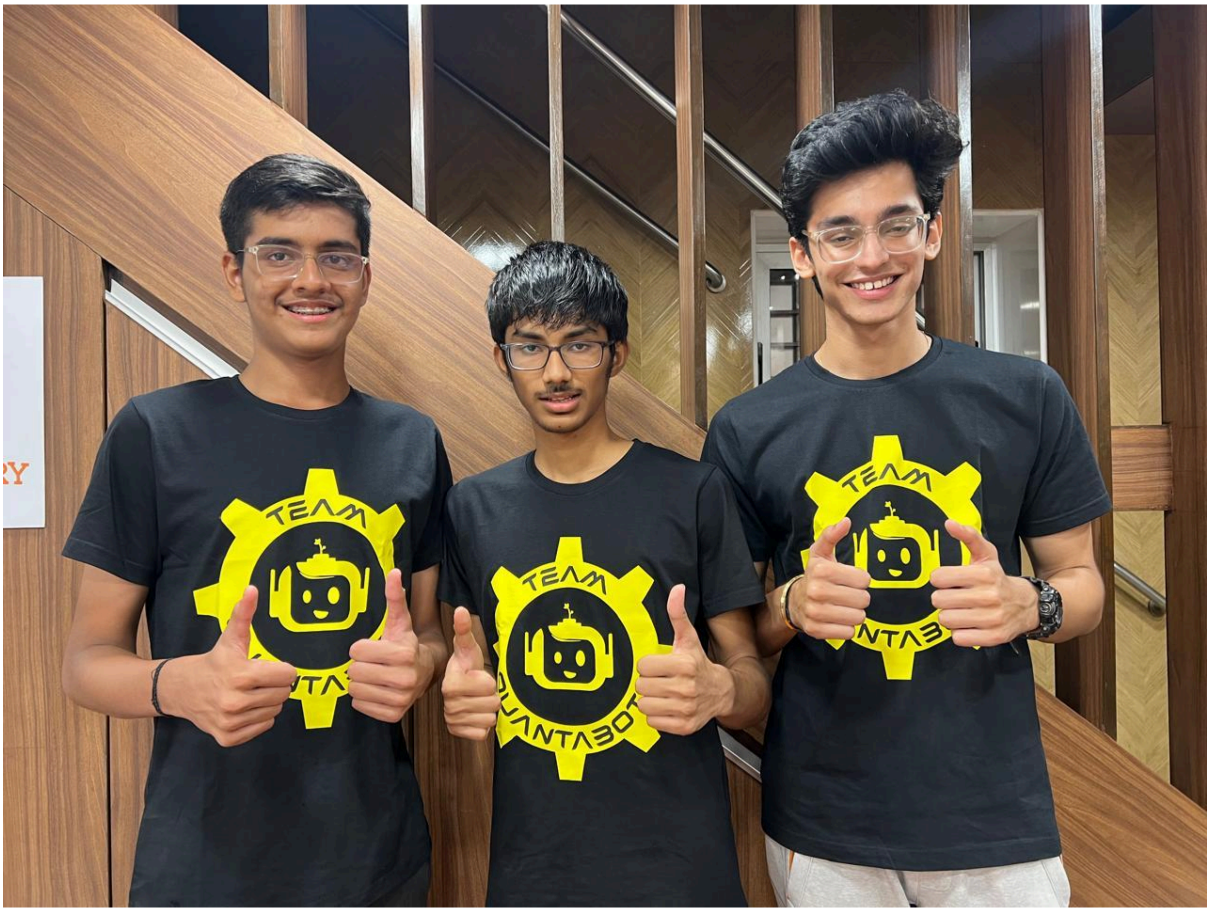
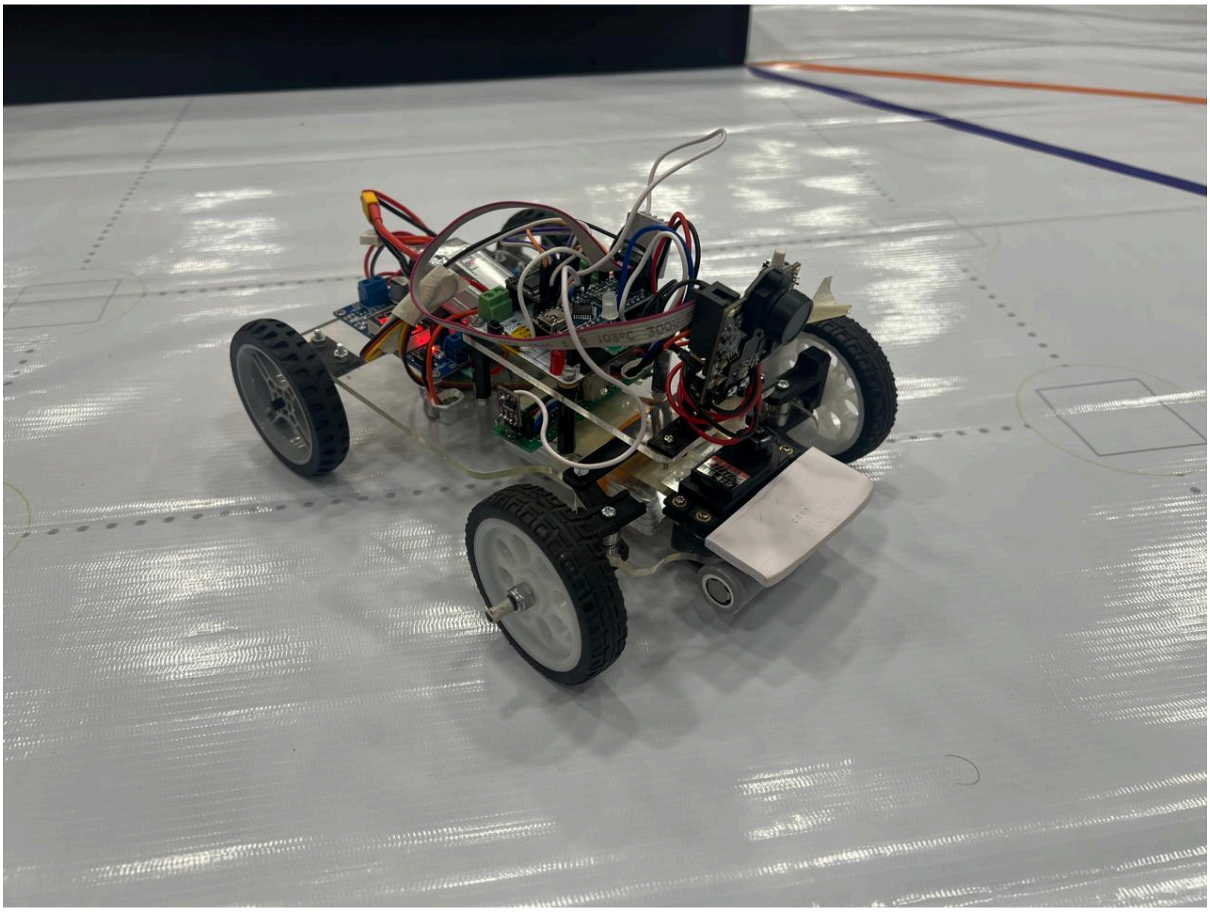


Introduction

This document contains the engineering journal of team QuantaBots participating in the Future Engineers event 2024



Contents:

A copy of this engineering journal can be found on GitHub at QuantaBots.

Team Quantabot's Demonstration can also be found on Youtube

Channel Name- QuantaBots

Link- https://www.youtube.com/@QuantaBots2024

1) Hardware Overview

Parts	Brand	Model	Quantity
Motor	-	25GA-370	1
Servo	Hitec Servo	HS-422	1
Camera	Pixy	Pixy2	1
Time of Flight {Sensor}	-	VL53L0X	2
Microcontroller-Arduino Nano	-	AtMega328P	1
Motor Driver	-	TB71312	1
LiPo Battery 7.6-8.0V	-	Nano-Tech 330mAh	1
Buck step down converter		LM2596	1

2) Mobility Management

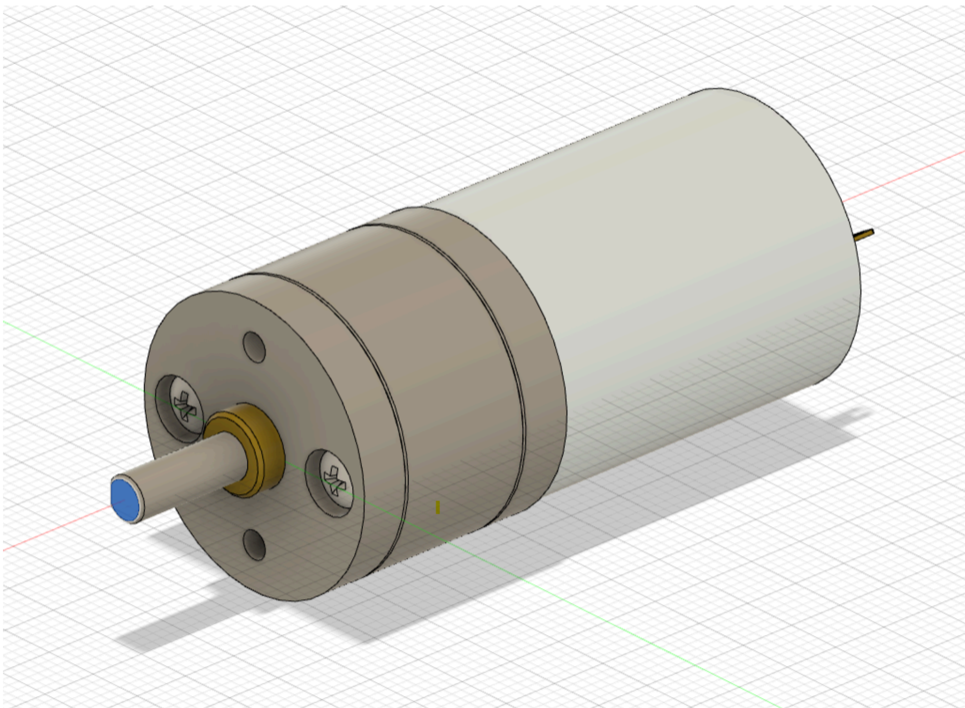
Motor

The motor we used is the 25GA-370, a small yet powerful DC gear motor that's perfect for a project like ours. It's part of the 25mm diameter motor range, with "GA" meaning it comes with a built-in gearbox. The "370" refers to the internal motor type.

One of the coolest things about this motor is its built-in gear reduction system, which boosts its torque output while keeping it compact. This makes it ideal for a project like ours where you need precise control and enough power to handle small loads. Depending on the model, you can get gear ratios from 1:10 to 1:200, giving you a lot of flexibility based on what you're working on.

It runs on a 6V to 12V DC input, which is pretty standard for motors in its range. In terms of performance, you're looking at speeds from 20 to 100 RPM, with torque that ranges from 1 to 10 kg-cm. This makes the 25GA-370 a great choice for things like lightweight robotic arms, small conveyor belts, or even mini self-driving cars—exactly like the one we're designing.

Because it's small, efficient, and packs enough torque, it fits really well into our project. Plus, it's affordable and durable, which is a big deal when you're on a budget but still want reliability. Overall, the 25GA-370 motor is a solid pick for a range of robotics and automation applications.



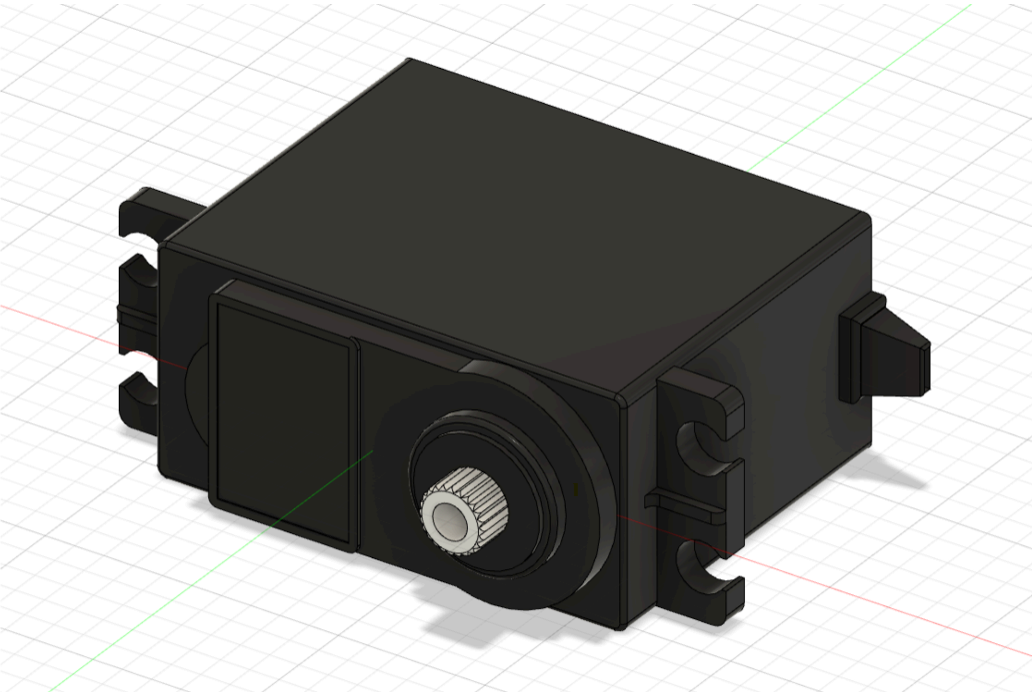
Hitec Servo HS422

The motor we used is a Hitec Servo motor, which is known for its precision and reliability, making it a popular choice for robotics and control systems. What makes servo motors like this one special is their ability to move to a specific position based on the control signal. Unlike regular motors, they don't just spin continuously — they stop at exact angles, which is perfect for applications requiring fine control.

The Hitec Servo we used operates on a standard pulse width modulation (PWM) signal, which allows us to control the angle of rotation with great accuracy. Typically, this type of servo motor has a rotation range of 0 to 180 degrees, but some models can go beyond that, depending on the requirements. The feedback system in the motor helps it correct its position, ensuring it moves exactly where it's told to, which is super important for precision tasks.

In terms of power, these servo motors usually run on 4.8V to 6V, making them energy-efficient while still providing good torque. Depending on the model, the torque can range from a few kg-cm up to 20 kg-cm or more, giving it enough strength to handle heavier loads. This makes the Hitec Servo ideal for robotic arms, steering systems, or anything that needs controlled motion.

For our project, the Hitec Servo motor is a great fit because it's easy to control, reliable, and strong enough to do the job. Plus, it's known for being durable, so we can count on it to last through lots of testing and adjustments. Overall, it's a fantastic motor when you need precision and reliability in one package.

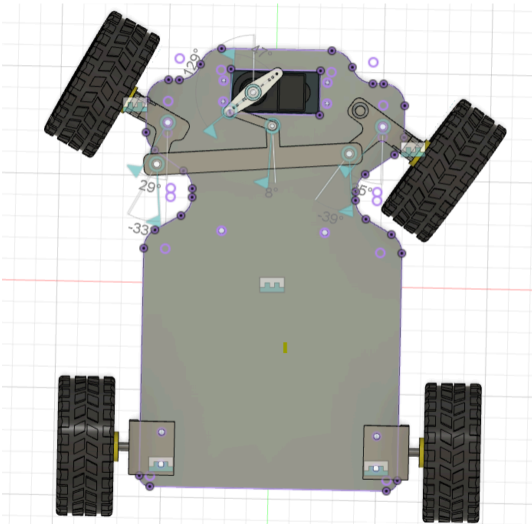


Steering - Servo Mechanism

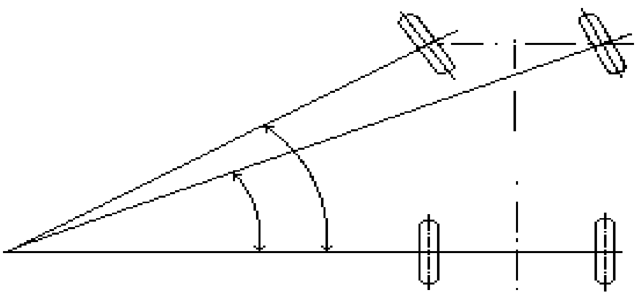
Our mini self-driving car uses a servo motor to control the steering, and it operates based on the Ackermann steering mechanism. This mechanism is essential for ensuring that the wheels turn at the correct angles, especially when navigating curves or tight turns. In typical steering setups, both front wheels are made to point in the same direction. However, when a vehicle takes a turn, the inner wheel travels on a smaller radius than the outer wheel, requiring the two wheels to turn at slightly different angles.

The Ackermann mechanism accounts for this difference by adjusting the angle of the wheels so that they follow different arcs. This is achieved through a combination of linkages that connect the wheels, ensuring that the inner wheel turns more sharply than the outer wheel. The advantage of this setup is that it reduces tire friction and wear, while also improving handling and control.

By using a servo motor, we have precise control over the steering angles, allowing for accurate navigation and smooth turns. The servo motor responds to input signals, positioning the steering components according to the exact requirements for the turn. This combination of a servo motor and Ackermann steering is ideal for our car, offering both efficiency and precision when making turns, even in tight spaces.



THIS IS WHAT ACKERMANN MECHANISM LOOKS LIKE



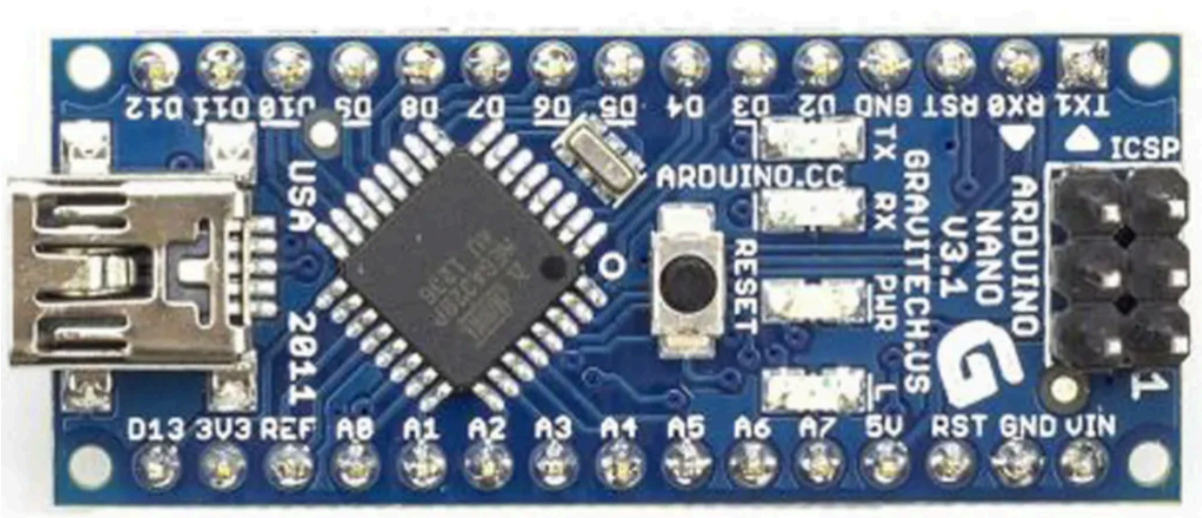
3) Choice of Components

Microcontroller

The Arduino Nano is a small and versatile microcontroller board based on the ATmega328 chip. It Measures just 45mm by 18mm, which makes it ideal for projects with space constraints.

The Arduino Nano has 14 digital input/output pins, with 6 supporting PWM (Pulse Width Modulation) for controlling devices like motors and LEDs. It also features 8 analog input pins for reading sensors and collecting environmental data.

The board is powered through a USB connection or an external power source ranging from 7 to 12 volts. The Nano supports various communication protocols, including UART (serial), I2C, and SPI, enabling it to interface with different sensors, modules, and other devices. Its small size and affordability was also a key point to make it a perfect choice for our project .

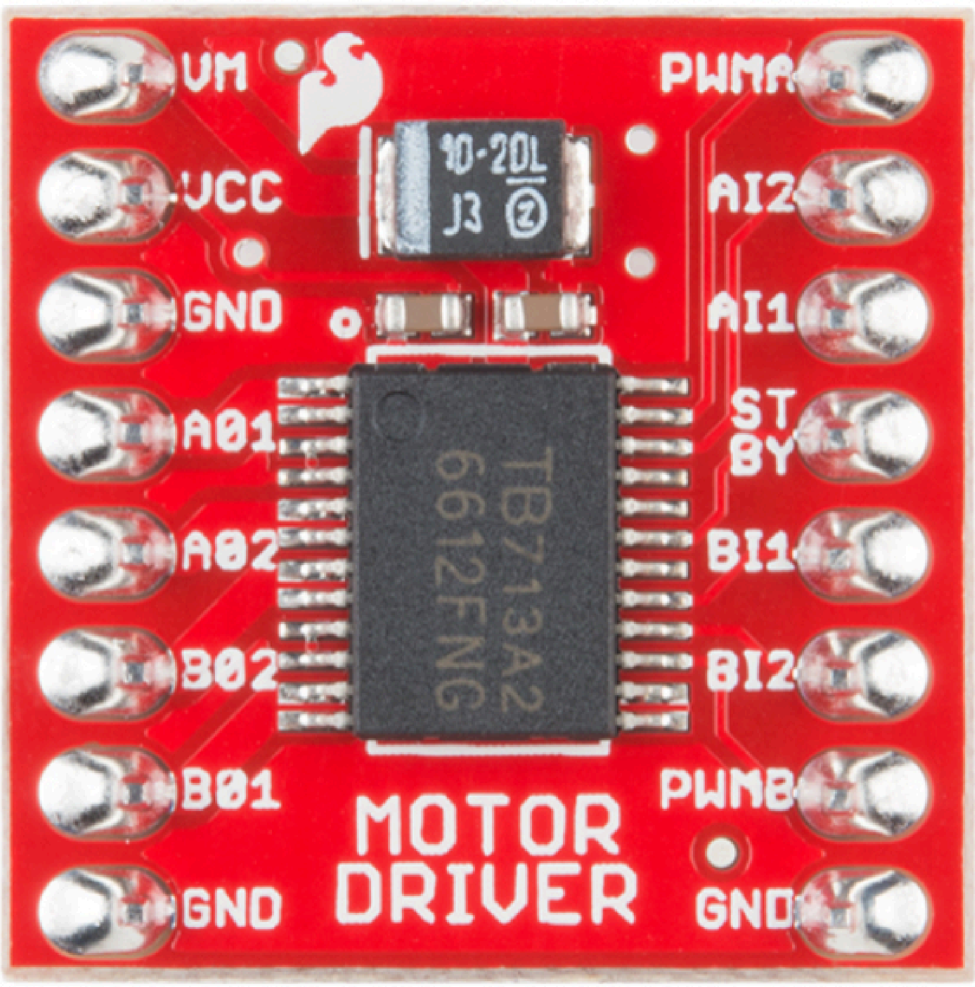


Motor Shield (TB6612FNG)

The TB6612FNG is a small, dual motor driver chip that helps control the speed and direction of two DC motors or one stepper motor, making it a popular choice for robotics and DIY electronics projects. It can handle motor voltages from 2.5V to 13.5V and provide up to 1.2A of continuous current per motor . This means it's great for running the motors in our challenge.

The driver has built-in safety features, such as thermal shutdown protection to prevent overheating, overcurrent protection to avoid damage if too much current flows through, and low-voltage detection to ensure proper operation when the power supply is too low. It also supports PWM control (Pulse Width Modulation), which allows you to adjust motor speed smoothly and control the direction by changing the voltage signals from the microcontroller we have used which is the Arduino Nano.

This motor driver is efficient while consuming little power, making it a key reason on why we chose it.



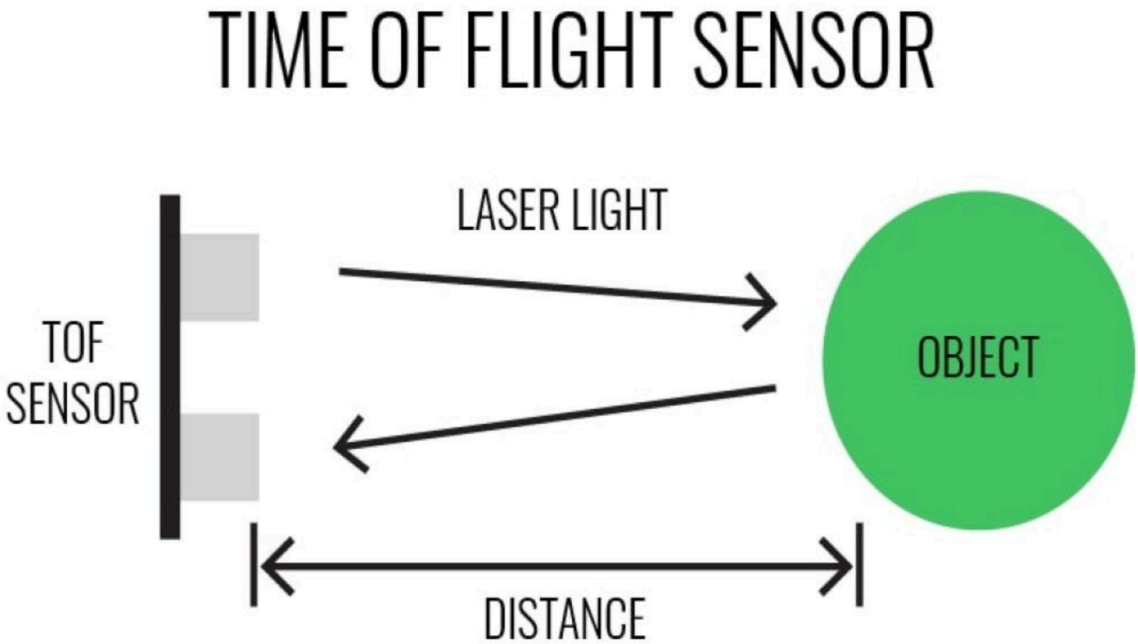
Distance Measurement:

Time of Flight sensor(ToF)

The Time of Flight (ToF) sensor is an advanced and highly accurate tool for measuring distances using light. It works by emitting an infrared light pulse and measuring the time it takes for that light to bounce off an object and return to the sensor. This method allows it to determine distances with impressive precision, often within a range of millimetres to several metres which fits the parameters of this project perfectly

One of the key advantages of The time of flight sensor is its reliability in a wide range of lighting conditions. Unlike traditional infrared or ultrasonic sensors, Time of flight sensors are unaffected by ambient light because they generate their own infrared pulse, making them effective in both bright and dim environments. Additionally, they offer faster and more consistent measurements compared to other distance sensors. These attributes make them popular in applications like gesture recognition, proximity detection, and obstacle avoidance in autonomous vehicles or drones

When integrated with an Arduino Nano, the Time of flight sensor typically communicates through the 12C interface, allowing for easy and efficient data transfer. The sensor's small size and low power consumption make it ideal for space-constrained projects, while its high accuracy and fast response times ensure dependable performance in real-time applications making it one of the key reasons for us choosing it. Furthermore, Time of flight sensors can detect not only distance but also velocity, making them ideal for our challenge



Vision System:

Pixy Camera 2.1

The **Pixy cam** is a smart vision sensor that's designed to track objects based on colour. It's commonly used in robotics and other automation projects where real-time object tracking is required. What makes Pixy cam unique is its ability to process images quickly and send only the important data to the controller, such as the location, size, and colour of detected objects. This offloads the heavy processing from microcontrollers, allowing them to focus on other tasks.

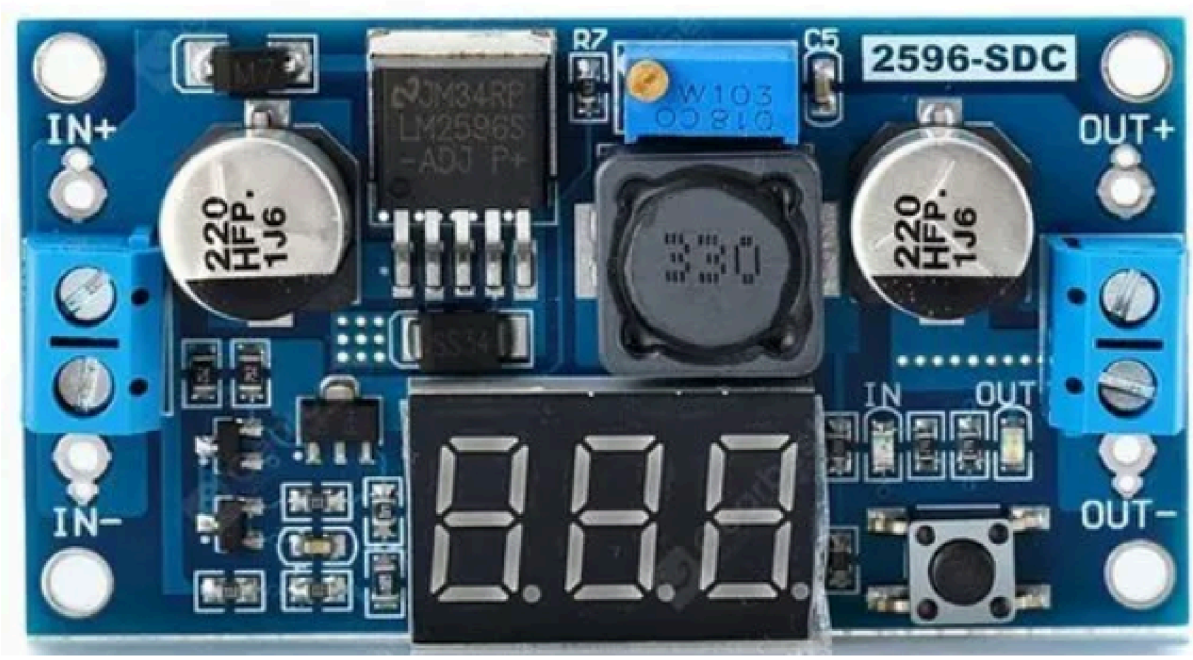
The camera works by teaching it to recognize specific colours, often referred to as "signatures." Once these colour signatures are defined, Pixy can detect and track multiple objects of those colours in its field of view. It's capable of recognizing up to seven different colours simultaneously, making it versatile for various applications.

One of the standout features of the Pixy cam is its speed. It can process up to 50 frames per second, meaning it can track fast-moving objects with ease. The camera is compatible with a range of controllers, including Arduino, Raspberry Pi, and BeagleBone, making it a flexible choice for many projects. It uses a simple interface to communicate with the controller, either through SPI, I2C, UART, or USB. For our project, the Pixy cam is ideal because it helps in tracking objects or obstacles in real time, enhancing the automation capabilities of the system. With its combination of speed, simplicity, and flexibility, it's a popular choice for hobbyists and professionals alike.

LM2596 DC Buck Step Down Power Converter Module

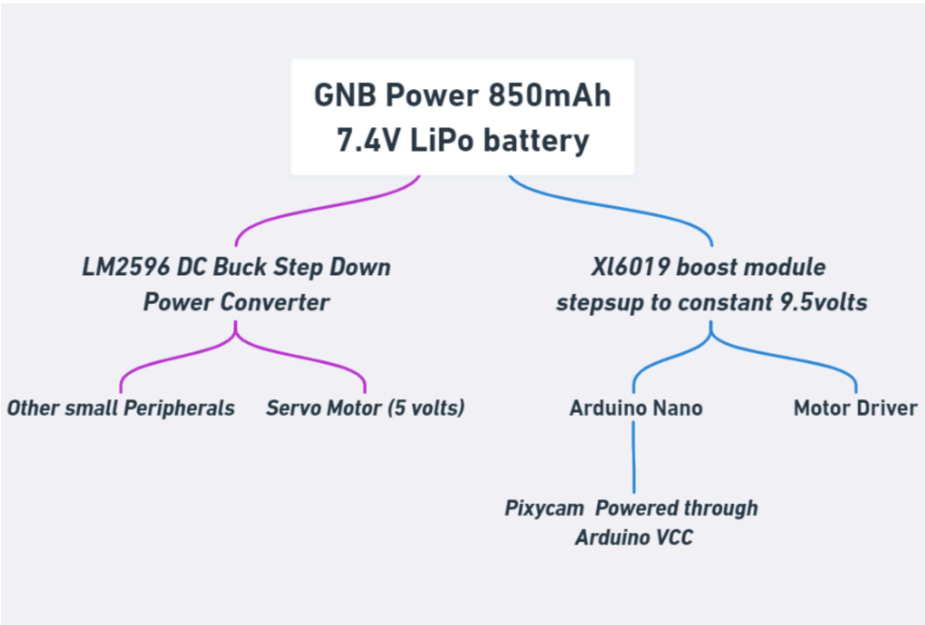
The LM2596 DC Buck Step Down Power Converter Module is a vital component due to its ability to efficiently convert higher voltage DC inputs to lower, more usable voltages. This model is especially good in voltage regulation which is crucial for protecting sensitive devices like microcontrollers and sensors. which typically require stable, lower voltages to function correctly.

The module's wide input voltage range (3V to 40V) and adjustable output make it highly adaptable, allowing it to supply to various devices and projects. Moreover, Its efficiency is another critical factor, as it minimises energy loss in the form of heat, making it suitable for battery-powered devices where maximising power use is essential. Additionally, features like over-current and thermal protection ensure safe operation, shielding both the module and connected devices from damage due to electrical surges or overheating.



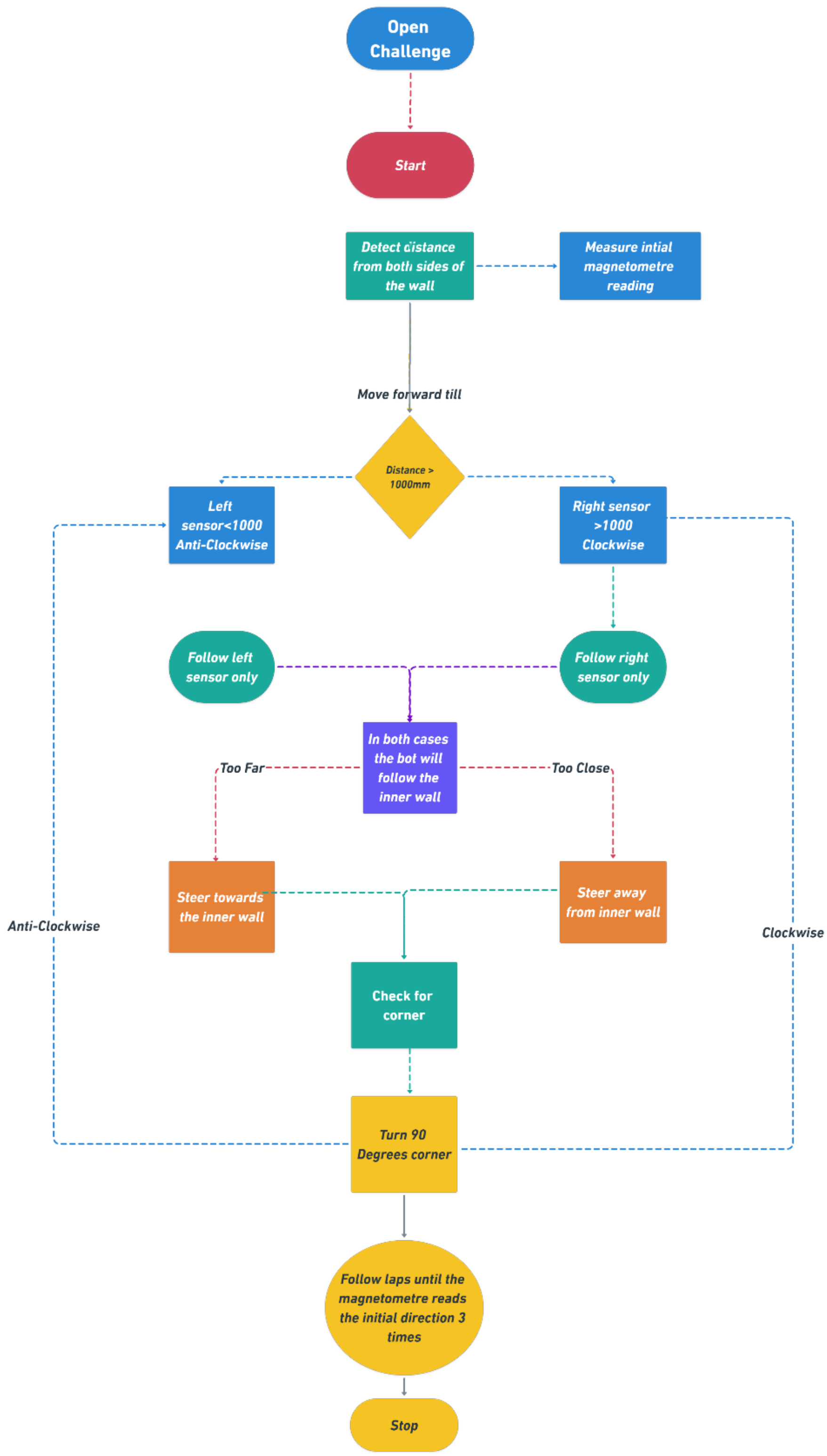
3) Power and Sense

The Battery choice- This GNB Power 850mAh 7.4V LiPo battery is a great choice for projects that need a small but powerful energy source. It has a capacity of 850mAh, which means it can run our project for a decent amount of time before needing to be recharged. The 7.4V voltage is perfect for many small electronics and motors, making it a good fit for things like our robot. It's lightweight and packs a lot of power, which is useful when you need high energy in a small space. The Lipo battery ,In order to suffice the voltage requirement for the servo motor provides a 7.4-volt supply to the LM2596 DC Buck Step Down Power Converter, which is then used to step down the voltage to 5 volts specifically for the servo motor. This lower voltage is specifically tailored to the servo's operating requirements, ensuring efficient and precise control. However For the other components like the Arduino Nano, time of flight sensors, magnetometer, and PixyCam, the 7.4-volt supply from the battery is directly used. These components typically require higher voltages to function optimally. Supplying 7.4 volts directly to these components avoids unnecessary voltage conversion losses, resulting in improved power efficiency and overall system performance ticking all the checklists for our challenge. The specific current requirements for each component vary based on their individual characteristics and usage. For instance, the Arduino Nano might typically draw between 50 mA to 200 mA, while the time of flight sensors could require anywhere from 100 mA to 500 mA. The magnetometer and PixyCam may have similar current demands, ranging from 50 mA to 200 mA. By supplying 7.4 volts directly to these components, we ensure that they have sufficient power to operate reliably. Additionally, it simplifies the power distribution system and reduces the overall number of components needed. While it's possible to use additional voltage regulators to step down the voltage for specific components, this can introduce additional complexity and potential points of failure. Therefore, supplying 12 volts directly to the majority of components seemed to be the best and the most efficient approach whilst being practical in this scenario.

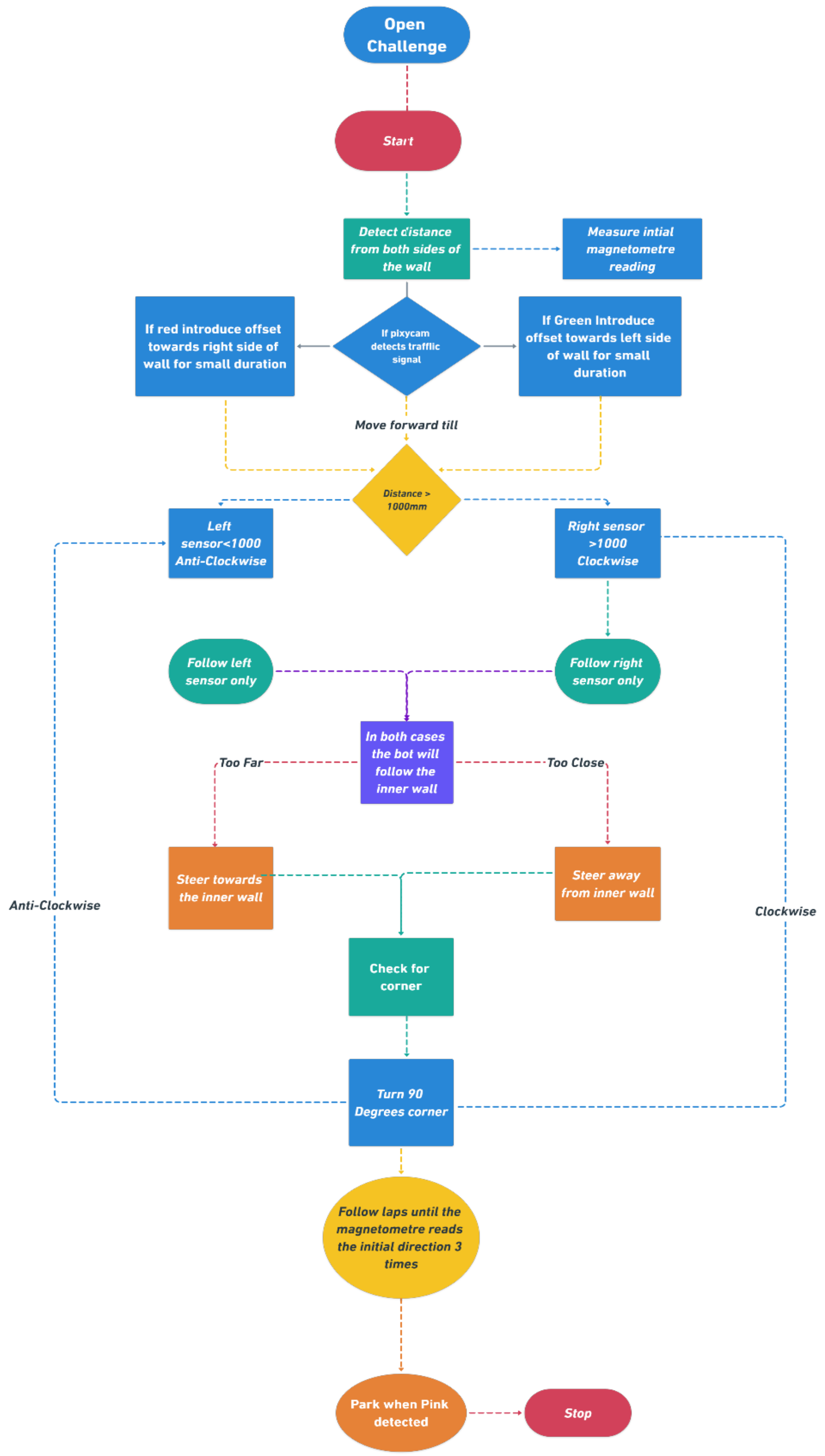


4) Obstacle Management

i)Open Challenge



ii) Obstacle challenge



5) Future Development

If we had a little more time to work on the bot we would have made several developments on it:

1. **Differential Gear Mechanism for the rear Drive** - It was a tedious process to find a differential mechanism that would fit perfectly to our robot considering the torque and the RPM. We tried several 3D printed designs but none of them would work; It would either slip through the gears or it would generate less torque than needed. At last we gave up and switched to gt2 belt and gears.
2. **Parking Mechanism** - The toughest part from our point of view was the parking at the end of round 2.
3. Test the magnetometer properly with the code to make sure that the robot stops at the desired location
4. Better robot design to make it more appealing to the eye.