# ROBO SPRINT

*"Every millisecond counts."*

TECHNICAL REPORT — PRAVEGA 2025

PROJECT TEAM

**Team Name:** amiarinjaysarkar

**Institution:** Jadavpur University

**Arinjay Sarkar** — Team Leader
+91 7003828489

**Saptarshi Nanda**
+91 8617471550

**Soureen Majumder**
+91 9123779351

# Table of Contents

# 1. Team Details

| | |
|---|---|
| **Team Name** | amiarinjaysarkar |
| **College / Institute** | Jadavpur University |
| **Competition** | Robo Sprint — Pravega 2025, IISc Bangalore |

**Team Members**

| Name | Role | Contact |
|---|---|---|
| **Arinjay Sarkar** | Team Leader | +91 7003828489 |
| **Saptarshi Nanda** | Member | +91 8617471550 |
| **Soureen Majumder** | Member | +91 9123779351 |

# 2. Abstract

This technical report presents the design and development of a high-performance obstacle course racing robot for the Robo Sprint competition at Pravega 2025, IISc Bangalore. The robot is engineered to navigate a challenging zig-zag track featuring ramps, tunnels, and speed breakers with maximum speed while maintaining stability and control.

The robot features a robust 4-wheeled chassis with integrated suspension system, high-torque geared DC motors, and a low center of gravity design for enhanced stability during high-speed maneuvers. The control system employs an Arduino-based architecture with optional gyroscope/IMU feedback for stability control and obstacle detection sensors for collision avoidance.

Key design objectives include minimizing completion time, maintaining traction on varied terrain, and achieving smooth navigation through obstacles without penalties. The modular design allows for rapid adjustments between practice runs and competition.

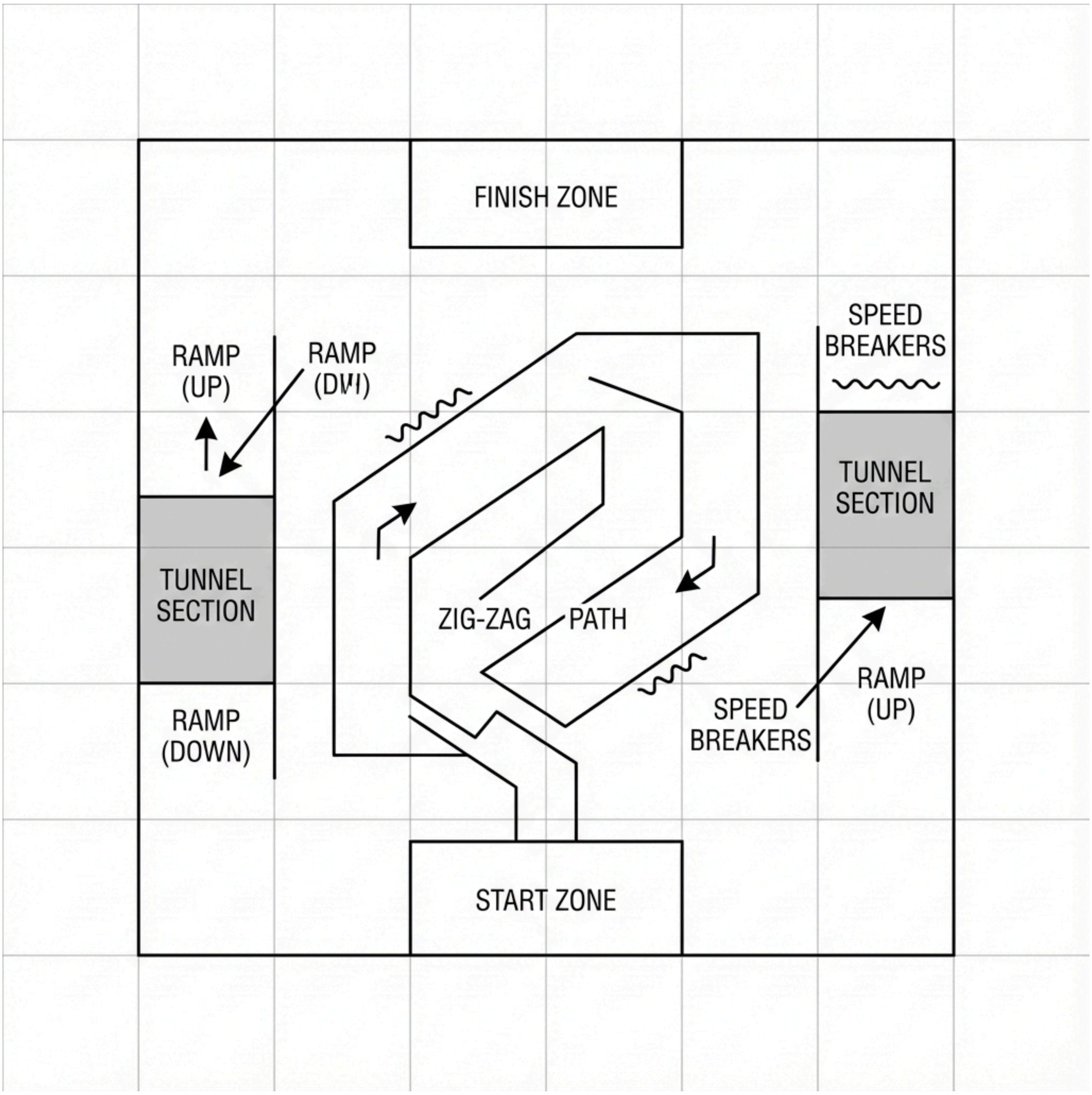


*Figure 1: Robo Sprint Arena — Zig-zag course with ramps, tunnels, and speed breakers*

# 3. Design Concept

## 3.1 Mechanical Design

The robot is built on a lightweight yet rigid aluminum/acrylic chassis optimized for speed and stability. The mechanical system incorporates:

- **Chassis Frame:** Low-profile rectangular frame with reinforced mounting points for motors and electronics. Designed to minimize weight while maximizing structural rigidity.
- **Suspension System:** Independent suspension on all four wheels using spring-loaded shock absorbers to maintain wheel contact on uneven terrain and absorb impacts from ramps and speed breakers.
- **Wheel Assembly:** Large-diameter rubber wheels with high-grip treads for maximum traction. Wheels are directly coupled to motor shafts for efficient power transfer.
- **Bumper Protection:** Front and rear bumpers to protect components during obstacle impacts and tunnel navigation.

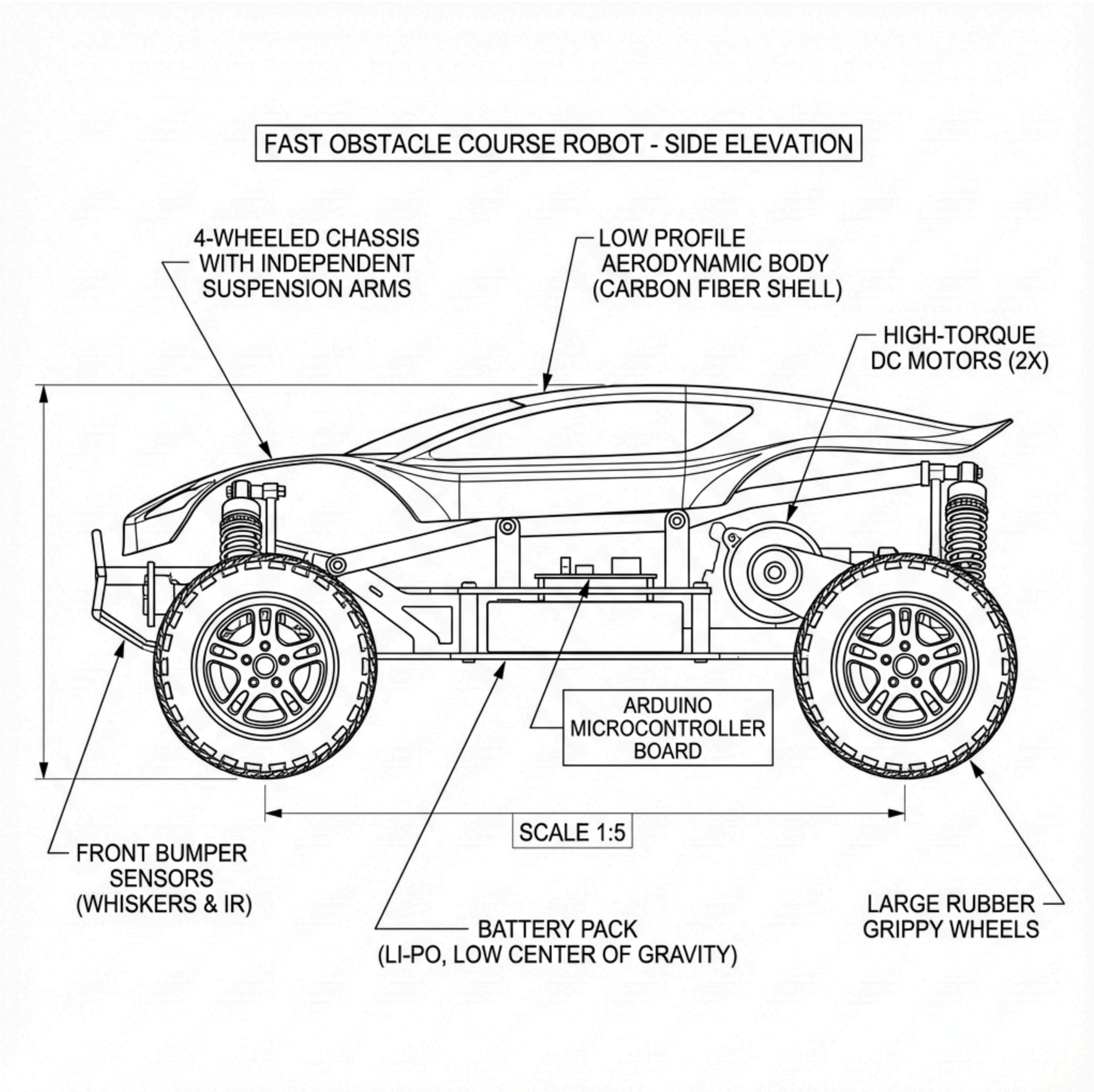


*Figure 2: Robot Structure — Side view showing chassis, suspension, and component layout*

### 3.2 Electronics & Components

- **Arduino Uno/Nano:** Main microcontroller for motor control and sensor processing.
- **L298N Motor Driver (×2):** Dual H-bridge drivers for independent 4-wheel control.
- **DC Geared Motors (×4):** High-torque 300-500 RPM motors with metal gearboxes for speed and torque balance.
- **Ultrasonic Sensors (HC-SR04 ×2):** Front-facing for obstacle detection and collision avoidance.
- **MPU6050 Gyroscope/IMU:** For stability monitoring and tilt detection on ramps.
- **IR Sensors (×2):** Optional line detection for semi-autonomous navigation.
- **Power Source:** 11.1V LiPo Battery (2200mAh, 25C) for high current delivery during acceleration.
- **Wireless Module (HC-05/NRF24L01):** For remote control operation.

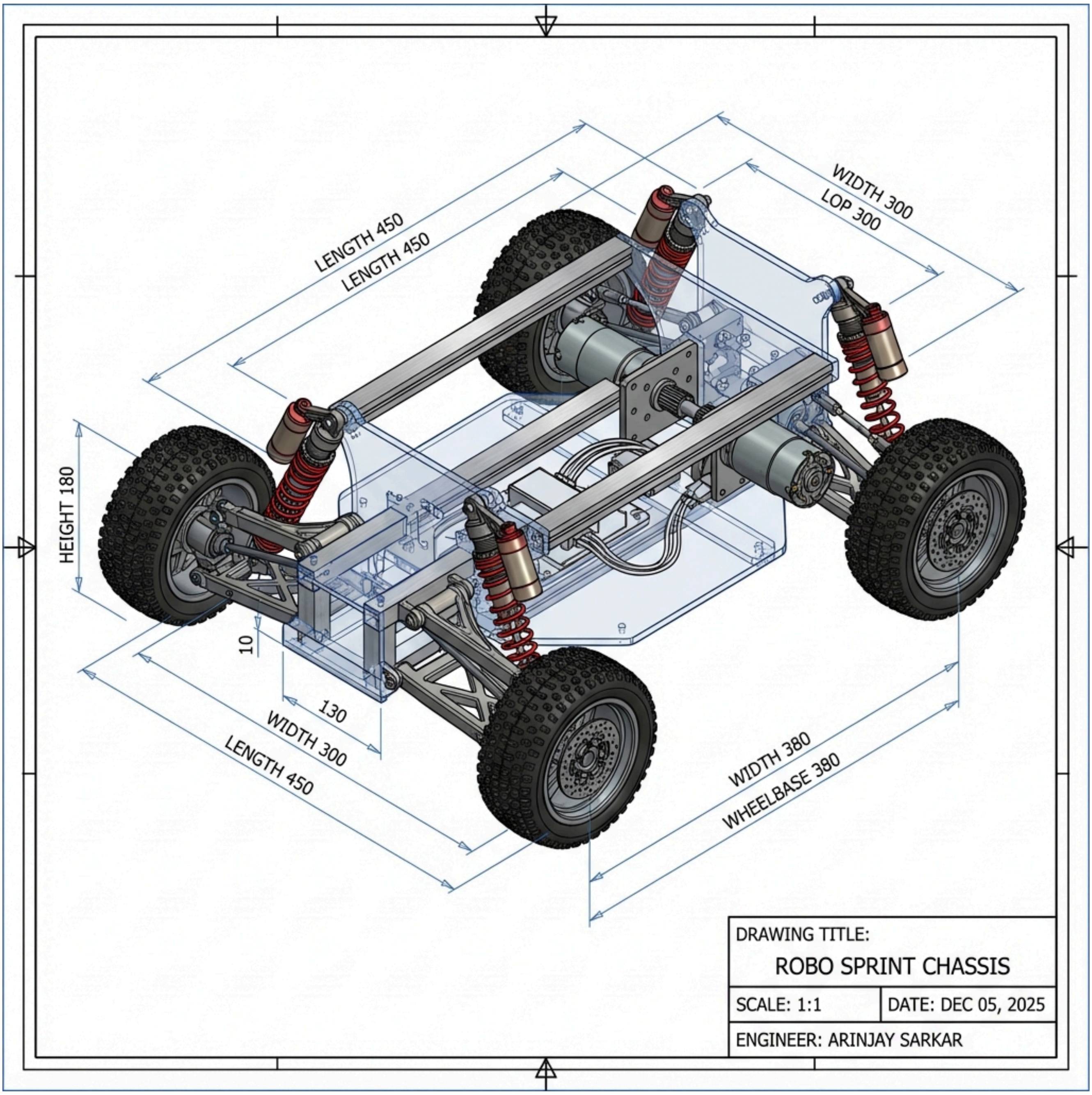


*Figure 3: Chassis CAD Model — Isometric view with suspension and motor mounts*

### 3.3 Control Strategy

The robot supports both manual and semi-autonomous operation modes:

- **Manual Mode:** Wireless remote control with proportional speed control via joystick inputs.
- **Semi-Autonomous Mode:** Ultrasonic sensors provide obstacle feedback; IMU assists with ramp stabilization.
- **Speed Optimization:** PWM-based motor control with acceleration curves to prevent wheel slip.

# 4. Working Principle

## 4.1 Movement & Navigation

The robot uses a 4-wheel drive (4WD) configuration with differential steering:

- **Forward/Backward:** All four motors driven at equal PWM for maximum traction.
- **Turning:** Differential speed between left and right wheel pairs enables turning while moving.
- **Pivot Turn:** Opposite rotation of left/right pairs for sharp in-place turns.
- **Speed Control:** Variable PWM (0-255) allows fine speed adjustment from crawl to sprint.

## 4.2 Obstacle Handling

The robot is designed to handle various arena obstacles:

- **Ramps:** High-torque motors and low CoG prevent tipping. Suspension absorbs landing impact.
- **Tunnels:** Low-profile design (height ≤ tunnel clearance) allows smooth passage.
- **Speed Breakers:** Suspension system absorbs bumps; continuous power maintains momentum.
- **Zig-Zag Path:** Quick response steering and grippy wheels enable sharp turns at speed.

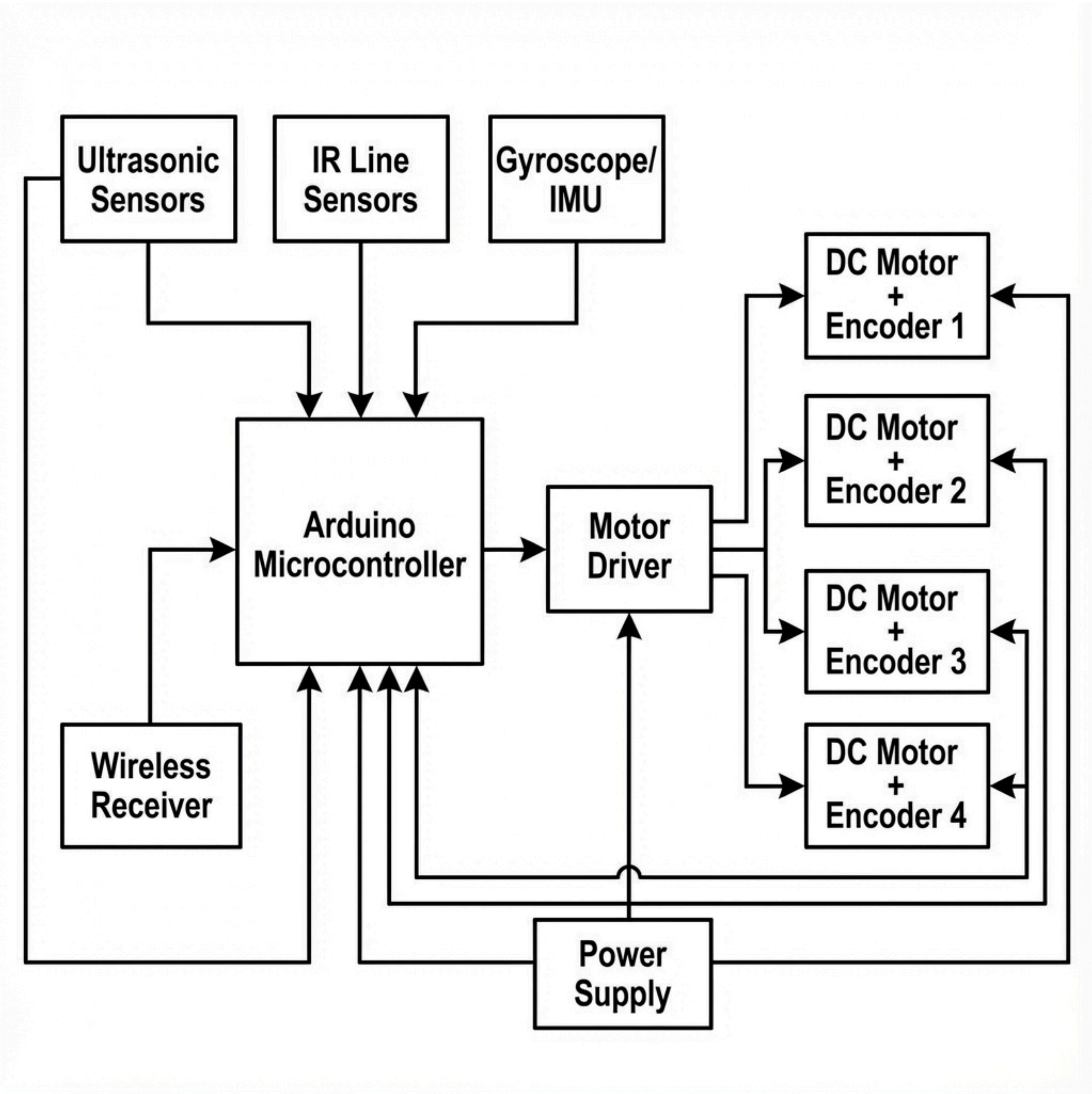


*Figure 4: Control System Block Diagram — Sensor inputs and motor control flow*

### 4.3 Control Logic

The Arduino executes the following control loop:

1. **Input Processing:** Read wireless commands (throttle, steering) and sensor data.
2. **Stability Check:** IMU readings detect excessive tilt; reduce speed if unstable.
3. **Obstacle Detection:** Ultrasonic distance < threshold triggers speed reduction.
4. **Motor Output:** Calculate individual motor PWM based on steering input and speed.
5. **Execute:** Send PWM signals to motor drivers; repeat loop at 50Hz.

### 4.4 Motor Control Table

| Action | Left Motors | Right Motors | Notes |
|---|---|---|---|
| Full Speed Forward | 255 PWM | 255 PWM | Maximum acceleration |
| Gradual Turn Left | 150 PWM | 255 PWM | Maintains speed in turn |
| Gradual Turn Right | 255 PWM | 150 PWM | Maintains speed in turn |
| Sharp Turn Left | 0/REV | 200 PWM | For tight corners |
| Emergency Stop | 0 | 0 | Instant brake |

# 5. Innovation & Special Features

**Active Suspension**

Spring-loaded shock absorbers on all wheels maintain traction over ramps and speed breakers.

**Low Center of Gravity**

Battery and heavy components mounted at chassis base prevent tipping on steep ramps.

**High-Grip Wheels**

Custom rubber tread pattern maximizes grip on varied surfaces including smooth ramps.

**IMU Stabilization**

MPU6050 gyroscope detects tilt angle; auto-reduces speed when approaching tip-over threshold.

**Quick-Swap Battery**

Slide-out battery mount enables rapid battery changes between runs without tools.

**Collision Protection**

Front bumper with ultrasonic sensors auto-slows robot before obstacle impact.

## 5.1 Proposed Enhancements

Future iterations may incorporate:

- PID-controlled speed for smoother acceleration and deceleration curves.
- Encoder feedback for precise speed measurement and odometry.
- Camera-based path detection for fully autonomous navigation.
- Brushless motors for higher speed-to-weight ratio.

# 6. References


- Pravega 2025 Robo Sprint Competition Rulebook — IISc Bangalore
- Arduino Uno/Nano Technical Documentation
- L298N Dual H-Bridge Motor Driver Datasheet
- MPU6050 6-Axis Gyroscope/Accelerometer Specifications
- HC-SR04 Ultrasonic Sensor Datasheet
- LiPo Battery Safety and Usage Guidelines
- Jadavpur University Robotics Club Technical Resources