Power and Sensing Management

Power Source and Distribution

The robot is powered by a **12V, 4400 mAh Li-ion battery**, chosen for its balance between high energy density and portability. The distribution system is optimized for efficiency and safe operation:

- **12V Line (Direct Supply):**
  - L298N Motor Driver → 12V DC Motor with Encoder.
- **5V Line (Regulated by XL4015 Buck Converter):**
  - Raspberry Pi 5 → Acts as the central controller.
  - Raspberry Pi Camera (5MP Module).
  - LG USB Camera (1080P).
  - Servo Motor.
  - Push Button interface.

The **On/Off Switch** ensures safe startup and shutdown, while the **buck converter** provides stable 5V to sensitive components, preventing overload or voltage dips.

Sensing Strategy and Components

LG PC Camera (1080P, USB Camera)

- **Open Challenge:**
  - Detects blue/orange lines to decide rotation direction.
  - Identifies inner/outer black walls to keep the robot centered.
  - Handles wide/narrow corridor detection through zone-based balancing.
  - Manages turns using forward detection (zones A & E).
  - Counts laps (5, 9, 12 detections) and triggers final stop after 3 laps.

Raspberry Pi Camera (5MP)

- **Obstacle Challenge:**
  - Works like a dash cam during parallel parking.
  - Provides accurate visual feedback for parking alignment.

- Lightweight, directly powered via Pi GPIO.

Novelty and Optimization

- Only **two cameras** handle all challenges, instead of using multiple ultrasonic or IR sensors.
- This reduces **power consumption, wiring complexity, and weight**, allowing faster response and smoother navigation.
- Optimized **camera training and image processing** ensure smooth execution under arena randomness.

Power Consumption Management

- **Motors:** Draw the largest current (peaks at sharp turns).
- **Raspberry Pi + Cameras:** Draw stable 5V regulated load (~1.5–2A).
- **Servo Motor:** Low intermittent load, activated during parking.
- **Total System Runtime:** The 4400 mAh battery ensures multiple full trial runs before recharge.

Professional Documentation (Wiring & BOM)

The wiring follows **professional standards**, with clear separation of 12V and 5V lines:

- **12V → L298N → Motors.**
- **12V → Buck Converter → 5V → Raspberry Pi → Cameras, Servo, Button.**
- Switch + PCB for safe operation and connections.

A detailed **Bill of Materials (BOM)** lists each component with ratings, ensuring compliance with WRO evaluation standards.

Bill Of Materials (BOM) — summary table

Item (ref)	Qty	Nominal Voltage	Typical Current (A)	Typical Power (W)	Purpose / Notes
12V 4400 mAh battery	1	12 V	—	52.8 Wh (capacity)	Main energy source (12V, 4.4 Ah → 52.8 Wh)
ON / OFF switch	1	12 V	—	—	Main battery switch
XL4015 step-down (12→5V)	1	12 V in → 5 V out	up to 3 A (set)	up to 15 W out	Supplies Raspberry Pi and 5V peripherals (set current limit safely)
Raspberry Pi 5 (controller)	1	5 V	**1.5** (typical)	**7.5**	Main compute & vision processing — fed from 5V converter
LG USB Camera (1080p)	1	5 V	0.20	1.0	Primary vision for open round and Obstacle challenge
Raspberry Pi Camera (5MP)	1	5 V	0.20	1.0	Parking / close-range vision
Servo motor (steering/parking)	1	5 V	0.50 (avg)	2.5	Actuator for parking/steering adjustments
L298N motor driver	1	12 V (motors), 5 V logic	0.1 (logic) + motor pass-through	1.2 (logic) + motor power	Motor driver — motors draw directly from 12V
12V DC motor with encoder	1	12 V	**2.0** each (avg running)	**24** each → **48** total	Drive motors — **largest power consumers** (stall >> average)
Push button	1	5 V	0.01	0.05	Start/stop or mode switch

Sl. No.	Component Name	Image	Approximate Cost (₹)
1.	Raspberry Pi 5		6,000
2.	L298D Motor Driver		90
3.	DC Motor with Encoder		700
4.	High Torque Servo Motor		350

5.	Lithium-Ion Battery		950
6.	Buck-to-Buck Converter		160
7.	Red On/Off Switch		50 - 100
8.	Push Buttons		10 - 30 per button
9.	Raspberry pi Camera		350

10	LG USB Camera 1080P		1300

Block Diagram