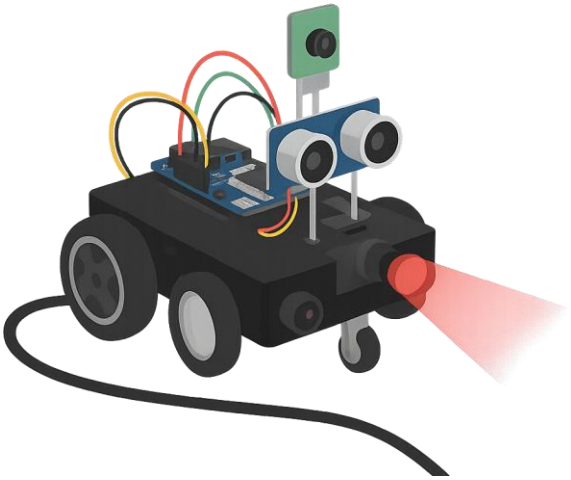
Batwave Object Detective Car (B.O.D)

A Line-Following Surveillance and Alert Robot



Course Title: Microprocessor and Microcontroller Lab

Course Code: CSE 316

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Segment 1

Project Title: Batwave Object Detective Car (B.O.D)

Project Subtitle: A Line-Following Surveillance Robot with Object Detection, Alerts, and CCTV Recording

Project Goals:

- To design and develop a line-following robot capable of autonomous indoor/outdoor patrolling.
- To implement ultrasonic and PIR sensors for real-time obstacle and human detection.
- To integrate alert mechanisms (buzzer, LEDs, and laser) for signaling the presence of obstacles or people.
- To add a camera system (ESP32-CAM/Raspberry Pi Camera) for continuous video recording like CCTV.
- To ensure stable and efficient operation using rechargeable Li-ion batteries and a regulated power supply.
- To make the system scalable with IoT connectivity (remote monitoring & logging).

Project Description

The **Batwave Object Detective Car (B.O.D.)** is an autonomous line-following robot designed for smart surveillance and security. It navigates predefined paths using an IR sensor array, detects obstacles with ultrasonic sensors, and identifies human presence with a PIR sensor. Upon detection, the system triggers alerts through a buzzer, LEDs, and a laser beam. Additionally, an onboard camera module records or streams video, similar to a mobile CCTV unit, making the project a practical integration of robotics, sensing, and monitoring technologies.

Segment 2

Project Overview:

The **Batwave Object Detective Car (B.O.D.)** is a robotic vehicle that combines **line-following navigation, object detection, and CCTV-style surveillance**. It follows a marked path using an IR sensor array, detects obstacles with ultrasonic sensors, and identifies human presence with a PIR sensor. When detection occurs, it triggers alerts through a buzzer, LEDs, and a laser pointer.

A camera module (ESP32-CAM or Raspberry Pi Camera) records or streams video, turning the robot into a **mobile surveillance unit**. Powered by a rechargeable Li-ion battery pack with regulated output, the system runs efficiently for extended patrols. With its modular design, the B.O.D. is a **cost-effective and scalable platform** for smart home security, robotics learning, and automation applications.

Functional Description:

- **Line Following:** IR sensor array detects path lines, allowing the car to navigate predefined routes.
- **Object Detection:** Ultrasonic sensors measure distance; PIR sensors detect human presence.
- **Alert System:** When a human/object is detected, the buzzer sounds, the LED flashes, and a laser beam activates.
- **Camera System:** ESP32-CAM or Raspberry Pi Camera records or streams live video for surveillance.
- **Power Management:** |Rechargeable battery pack powers motors, sensors, and controllers with regulated outputs.

Operational Workflow:

- IR sensors guide the robot to follow a line/patrol path.
- Ultrasonic & PIR continuously monitor surroundings.
- If object/human detected →robot halts→ activates buzzer, LED, and laser → records video evidence.
- Camera stores/streams video to SD card or server.
- System resumes patrol after clearance.

Key Features:

1. Smooth **PID-controlled line following**.

2. Human & object detection with **Ultrasonic + PIR combo**.
3. **Alert system**: buzzer + LEDs + low-power laser module.
4. **CCTV-like recording**: ESP32-CAM or Raspberry Pi camera.
5. Rechargeable **Li-ion battery power system**.
6. Expandable with IoT cloud monitoring.

Segment 3

Required Modules:

1. Main Controller:

- Arduino Nano / ESP32 → controls motors, sensors, and alerts.
- Raspberry Pi (optional) → handles video recording & advanced processing.

2. Sensors:

- **IR sensor array (QTR-5RC)** → line following.
- **Ultrasonic sensors (3x HC-SR04)** → obstacle/object detection.
- **PIR motion sensor** → human detection.

3. Actuators:

- 2 × DC gear motors with wheels → drive system.
- Motor driver TB6612FNG → efficient motor control.
- Laser module (5V) → detection pointer.
- Buzzer & LEDs → alert system.

4. Camera System:

- ESP32-CAM module (budget option) OR
- Raspberry Pi + Pi Camera (high-quality option).

5. Power Supply:

- 2 × 18650 Li-ion batteries (7.4V pack).
- TP4056 charging module.
- UBEC 5V regulator for a stable supply.

6. Mechanical Structure:

- · **Chassis & Sensor Mounts** – Securely hold and support all components
- 4-wheel acrylic/metal chassis.
- Mounts for sensors, camera, and battery pack.

Segment 8

Project Timeline (Gantt Chart):

Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Requirement Analysis							
Circuit & Mechanical Design							
Component Selection & Purchase							
Line Following Module							
Detection Module							
Testing & Debugging							
Final Demo & Documentation							

Segment 9

Budget Preparation of the Project:

Serial	Component	Quantity	Unit Price (৳)	Total (৳)
1	Arduino Nano / ESP32	1	350–800	350–800
2	ESP32-CAM or Pi Camera	1	1000–3500	1000–3500
3	IR Line Sensor Array (QTR-5RC)	1	700	700
4	HC-SR04 Ultrasonic Sensor	3	90	270
5	PIR Sensor	1	200	200
6	TB6612FNG Motor Driver	1	500	500
7	Plastic Chassis	1	400	400
8	Li-ion Battery Pack (2S)	1	1200	1200
9	Battery Case	1	60	60
10	Female-to-Female Jumper Wires	1 set	120	120
11	On/Off Switch	1	80	80
12	100 cm General Wiring	1 roll	25	25
13	Wiring, PCB, mounts	1	500	500
14	microSD Card (64GB)	1	600	600
	Total Estimated Cost			**6000৳ Approx**

Segment 10

CEP Mapping of the Project

1. Knowledge Profile (K's) Mapping

K's Attributes How K's Are Addressed Through Our Project CO PO				
K Code	Attribute	How K's Are Addressed Through Our Project	Related COs	Related POs
K4	Specialist Knowledge	Applied knowledge of robotics, embedded systems, sensor fusion (IR, ultrasonic, PIR), and camera integration for surveillance.	CO1, CO2	PO1
K5	Engineering Design	Designed line-following algorithm (PID), integrated detection & alert system, developed recording/streaming logic using ESP32-CAM / Raspberry Pi.	CO2, CO3,CO 4	PO3, PO5,
K6	Engineerig Practice	Practically implemented using Arduino/ESP32, ultrasonic sensors, PIR, IR array, motor driver, buzzer, and laser, following prototyping standards.	CO3,CO 4,CO5	PO4, PO5, PO6

2. Complex Engineering Problems (P's) Mapping

P's Attributes How P's Are Addressed Through Our Project CO PO				
P Code	Attribute	How P's Are Addressed Through Our Project	Related COs	Related POs
P4	Practical Implementation	Assembled modules including IR array, ultrasonic sensors, PIR, motor driver, and camera into one integrated platform.	CO2, CO3	PO4, PO5
P5	Experimentation & Testing	Calibrated line-following PID values, tested ultrasonic distance thresholds, PIR sensitivity, and camera recording quality.	CO3, CO4	PO4, PO9

P6	Prototyping & Validation	Built a functional prototype of the patrol robot with real-time detection & recording, validated through indoor roaming tests.	CO4, CO5	PO5, PO6

3. Complex Engineering Activities (A's) Mapping

A's Attributes How A's Are Addressed Through Our Project CO PO				
A Code	Attribute	How A's Are Addressed Through Our Project	Related COs	Related POs
A3	Teamwork & Collaboration	Worked collaboratively in design, coding, circuit wiring, sensor integration, and debugging.	CO4	PO9, PO11
A5	Ethics & Sustainability	Ensured safe use of laser (<5mW), followed surveillance ethics, used rechargeable batteries for eco-friendly power.	CO3, CO5	PO6, PO7

Segment 11

Conclusion

The Batwave Object Detective Car (B.O.D.) is a **multi-functional patrol robot** that combines **line-following navigation, real-time detection, alerts, and CCTV-style video recording**. With modular expansion, it can evolve into a complete home surveillance robot with IoT monitoring. This project demonstrates a **fusion of robotics, embedded systems, and security applications**, making it useful for real-world home safety and automation.

References

For our project:

- Arduino Official Website – https://www.arduino.cc
- ESP32 IoT Documentation – https://docs.espressif.com
- RoboticsBD, TechShopBD component datasheets
- TinkerCAD Circuits – https://www.tinkercad.com
- Blynk IoT Platform – https://blynk.io
- IEEE Robotics & IoT research papers (2021–2024)