COLLEGE CODE : 1128

COLLEGE NAME : TJS ENGINEERING COLLEGE

DEPARTMENT : ELECTRONIC AND COMMUNICATION ENGINEERING

STUDENT NM-ID : aut112823106305,
aut23ece39a,
aut23ece41a,
autece43a,
aut112823106302

ROLL NUMBER : 112823106305,
112823106039,
112823106041,
112823106043,
112823106302

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COMPLETE THE PROJECT NAME AS

AI-Powered Autonomous Vehicle and Robotics System

SUBMITTED BY

NAME : **Rajesh B,**
Karthick G,
Samuel kirubagaran.J,
Sanjay krishnan.c,
Dinesh.K

MOBILE NUMBER : **9566336823,**
9600861301,
8015464817,
63856 59197,

Phase 5: Project Demonstration & Documentation
Title: AI-Powered Autonomous Vehicle and Robotics System

Abstract:

This phase documents the final demonstration and technical deliverables of the AI-Powered Autonomous Vehicle and Robotics System. It includes real-time testing, performance metrics, control validation, sensor fusion, and cybersecurity protocols. The system integrates refined AI models, robust control systems, and optimized sensor handling to demonstrate a secure, scalable, and deployment-ready autonomous platform.

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1. Project Demonstration

Overview:
The system demonstration will exhibit real-time autonomous navigation, robotic control precision, and integrated sensor fusion in dynamic environments.

Demonstration Details:

- **System Walkthrough:** Live demonstration of autonomous vehicle maneuvers using AI-driven navigation and obstacle avoidance.
- **AI Performance:** Showcase of improved decision latency, path-planning accuracy, and object detection in real-time.
- **Sensor Data Processing:** Real-time multi-sensor fusion outputs (LiDAR, cameras, IMUs) under variable conditions (e.g., low light, simulated rain).
- **Control Accuracy:** Demonstration of precise motion execution using tuned PID parameters and feedback loops.
- **Cybersecurity Measures:** Real-time encryption (TLS), intrusion detection, and fail-safe protocol simulation under test scenarios.

Outcome:
A full-scale demonstration proving readiness for real-world deployment with robust AI, control, and security layers.

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2. Project Documentation

Overview:
Comprehensive documentation covers system architecture, control mechanisms, codebase, user/admin guidelines, and performance reports.

Documentation Sections:

- **System Architecture:** Diagrams and flowcharts of AI modules, control subsystems, and sensor fusion layers.
- **Code Documentation:** Annotated source code for AI models, ROS nodes, sensor drivers, and vehicle control scripts.
- **User Guide:** Instructions for operating the vehicle, monitoring outputs, and using manual override.
- **Admin Guide:** Deployment, maintenance, and remote troubleshooting procedures.
- **Testing Reports:** Load tests, actuation delays, cybersecurity simulations, and feedback-based refinements.

Outcome:
A self-contained reference for system maintenance, scalability, and continued development.

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3. Feedback and Final Adjustments

Overview:
Stakeholder feedback will guide final refinements prior to deployment.

Steps:

- **Feedback Collection:** Through live demo sessions and structured questionnaires for testers and mentors.
- **Refinements:** Tuning model parameters, sensor thresholds, and improving user interaction interfaces.
- **Final Testing:** Post-feedback testing in simulation (e.g., CARLA/Gazebo) and physical environments.

Outcome:
System refinement ensures high usability, reliability, and robustness in field conditions.

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4. Final Project Report Submission

Overview:
The report consolidates the project's journey from inception to real-world simulation.

Sections:

- **Executive Summary:** Overview of goals, implementations, and outcomes.
- **Phase Summary:** Detailed insights into AI model tuning, control improvements, and security integrations.
- **Challenges & Solutions:** Addressing scalability, cybersecurity under load, and real-time control delays.
- **Outcomes:** Readiness for real-world testing and deployment in smart transport or robotics environments.

Outcome:
A comprehensive record of the system's development, challenges, and performance.

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5. Project Handover and Future Works

Overview:
Guidelines for future upgrades and broader implementations.

Handover Details:

- **Next Steps:** Suggestions include highway and urban test deployments, deep reinforcement learning integration, and multilingual feedback interfaces.
- **Documentation & Codebase:** Delivery of the full codebase, architectural blueprints, and versioning guide for developers.

Outcome:
Official project closure with a roadmap for continuous enhancement and scaling.

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1. AI Navigation (Path Planning & Obstacle Avoidance)

```
# ai_navigation.py
import numpy as np

def plan_path(current_pos, goal_pos, obstacles):
    """
    A* or Dijkstra-like path planning (simplified).
```

```python
    """
    # Placeholder for a full path planning algorithm
    return [current_pos, goal_pos]  # Stub path

def avoid_obstacle(sensor_data):
    """
    Obstacle avoidance logic based on LiDAR/camera.
    """
    if sensor_data.get("front") < 1.0:  # threshold in meters
        return "left"
    return "forward"
```

2. Sensor Fusion

```python
# sensor_fusion.py
def fuse_sensors(lidar, camera, imu):
    """
    Basic sensor fusion combining LiDAR, camera, and IMU.
    """
    return {
        "position": imu["position"],
        "obstacles": lidar["distances"],
        "visual_objects": camera["objects"]
    }
```

3. PID Motion Control

```python
# control.py
class PIDController:
    def __init__(self, kp, ki, kd):
        self.kp = kp
        self.ki = ki
        self.kd = kd
        self.prev_error = 0
        self.integral = 0

    def update(self, setpoint, current):
        error = setpoint - current
        self.integral += error
        derivative = error - self.prev_error
        self.prev_error = error
        return self.kp*error + self.ki*self.integral + self.kd*derivative
```

4. Cybersecurity Simulation

```
# security.py
import ssl
import socket

def simulate_tls_connection():
    """
    Simulate a secure TLS connection.
    """
    context = ssl.create_default_context()
    with socket.create_connection(("example.com", 443)) as sock:
        with context.wrap_socket(sock, server_hostname="example.com") as ssock:
            return ssock.version()
```

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5. Main Integration Script

```
# main.py
from ai_navigation import plan_path, avoid_obstacle
from sensor_fusion import fuse_sensors
from control import PIDController
from security import simulate_tls_connection

def main():
    # Simulated data
    imu = {"position": [0, 0]}
    lidar = {"distances": {"front": 0.5}}
    camera = {"objects": ["car", "pedestrian"]}

    # Fuse sensor data
    fused = fuse_sensors(lidar, camera, imu)

    # Plan and avoid
    path = plan_path([0, 0], [10, 10], fused["obstacles"])
    move = avoid_obstacle(fused["obstacles"])

    # Control vehicle
    pid = PIDController(1.0, 0.1, 0.05)
    throttle = pid.update(10, 5)  # Example: target speed 10, current speed 5
```

```
    # Simulate secure connection
    tls_version = simulate_tls_connection()

    print(f"Move: {move}, Throttle: {throttle}, TLS: {tls_version}")

if __name__ == "__main__":
    main()
```