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Problem Definition & Design Thinking

Title : AI-Powered Autonomous Vehicle and Robotic System

Problem Statement:

Levels of urbanization increase, levels of mobility demands increase, and more clever transportation and robotic automation are certainly needed. For autonomous vehicles and robots, real-world challenges include dynamic environments in addition to unpredictable human behavior. Navigating traffic requires rapid choices.

A number of current models struggle with safe human-robot interaction, adaptive navigation, and real-time perception, notwithstanding autonomous systems and robotics. AI systems must additionally not only make decisions but also explain those decisions within critical scenarios, for example, traffic stops, accident avoidance, and emergency rerouting because of a growing need.

The problem is designing an AI-based system for enabling autonomous vehicles as well as robots to operate safely, cleverly, and autonomously enough in dynamic, real-world environments while still maintaining human trust, transparency, and also efficiency.

Target Audience:

- Urban transportation authorities implementing smart mobility systems
- Logistics and delivery companies seeking autonomous last-mile solutions
- Elderly or disabled individuals who require mobility assistance
- Smart city planners looking to integrate intelligent transport and robotics
- Manufacturers and researchers in robotics and AI

Objective:

- Develop now an AI-powered system that then perceives objects, and avoids obstacles, and navigates dynamically.
- Carry out adaptive path planning, using environmental data and traffic data in real-time.
- To build up trust, design human-in-the-loop systems for explaining AI decisions.
- Be sure to interact in a safe manner with pedestrians, vehicles, as well as changing environments.
- A deployable modular architecture is usable by vehicles and mobile robots. The architecture must be easily and readily created.
- Integrate Io T sensors and cloud analytics for continuous improvement and remote monitoring

Design Thinking Approach:

Empathize:

- Understand the fears, challenges, and expectations of users:
- Pedestrians and passengers fear unsafe or unpredictable robot behavior
- Urban planners need scalable, cost-effective solutions
- Drivers and logistics personnel worry about job security and reliability
- Developers and engineers face high costs and integration complexities

Key User Concerns:

- Trust in AI decision-making (especially in critical situations)
- Safety and reliability in diverse environments
- Cost of implementation and scalability
- Ethical concerns and transparency of AI choices

Define:

The solution should enable for a robotic vehicle system to precisely perceive of its environment, and then interpret of it in such real time rerouting, decisions of speed, and also navigation decisions should be explainable as well as safe.

In certain shared spaces, do interact with other humans in a safe manner. Coordination does improve in instances when you do communicate to the cloud systems. AI is used to perceive via computer vision and sensor fusion.

Navigate in an adaptive manner via the use of reinforcement learning or the employment of deep learning. Transparency and trust in human-AI interaction interface. Real-time decisions through edge computing, coupled with data feedback through IoT. Emergency response protocols as well as fail-safe mechanisms

Ideate:

Potential Solutions:

- AI-driven perception system using LiDAR + cameras + neural networks
- Fleet of delivery robots with shared AI models learning from each other
- Vehicle-to-everything (V2X) communication for smarter routing
- Simulation environments for AI training before deployment
- Voice-enabled interface for human feedback during autonomous operation

Brainstorming Results:

- A robotic vehicle that maps indoor or outdoor areas using SLAM and navigates autonomously
- Cloud-connected AI model that improves navigation decisions using real-world driving data
- Explainable AI modules that let users “ask why” a robot made a decision
- A microcontroller-based low-cost demo version for educational and pilot purposes

Prototype:

Prototype Development Includes:

- A small autonomous robot (e.g., RC car or ground vehicle)
- Sensors (camera, ultrasonic, LiDAR), controlled via Raspberry Pi or Jetson Nano
- AI models for object detection (YOLO or MobileNet)
- Reinforcement learning agent for navigation
- Web or mobile app to show path, decision logs, and alerts

Key Components of Prototype:

- Edge AI module (TinyML or TensorFlow Lite for embedded systems)
- Real-time obstacle avoidance using CNNs
- Path-planning with Deep Q-learning or A* enhanced by AI prediction
- Dashboard for monitoring and remote control

Test:

Prototype Testing Strategy:

- Simulate dynamic obstacles and real-time navigation
- Test on campus or closed-loop environments with variable complexity
- Collect feedback on accuracy, responsiveness, and user trust
- Iterate based on real-world performance data and edge cases

Testing Goals:

- Measure decision-making accuracy and safety margins
- Ensure the AI adapts to new conditions over time
- Validate whether users trust and understand the robot’s actions
- Identify failure points and system limitations for improvement