NAAN MUDHALVAN

PHASE-1

ARTIFICIAL INTELLIGENCE & DATA SCIENCE
(2nd YEAR)

AUTONOMOUS VEHICLES AND ROBOTICS

AI-BASED ROUTE MEMORY AND SELF LEARNING

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Problem Definition & Design Thinking

Title: AI-Based Route Memory and Self Learning

Problem Statement:

In the current landscape of autonomous vehicles and robotics, navigation systems largely rely on pre-programmed routes and static algorithms. These systems are unable to adapt in real time to changing environments, dynamic obstacles, or new challenges. As a result, they are limited in their ability to learn and optimize their navigation over time.

This project seeks to address this limitation by developing an **AI-based self-learning navigation system** that enables robotic agents or autonomous vehicles to **learn from past experiences**, **store learned paths**, and **optimize their travel routes** dynamically. The proposed system will use **reinforcement learning** techniques such as **Q-learning** to continuously improve navigation decisions, adapting to different environments, obstacles, and traffic conditions. The goal is to create a model that can make intelligent decisions in real-time, navigate efficiently, and progressively optimize its route memory.

Target Audience:

- Focus on integrating autonomous vehicles into smart cities to optimize traffic and public services
- Empowering people with disabilities by offering accessible, autonomous transport solutions
- Promote **sustainable transport** by reducing emissions through optimized, self-learning routes
- Improve public transportation and traffic management by implementing intelligent autonomous systems

Objectives:

- To build a system that uses reinforcement learning to allow vehicles to learn and adapt routes dynamically.
- To enable the system to store and recall learned paths for better route efficiency.
- To ensure the system can adapt to larger, more complex environments like city streets or warehouses.
- To provide tools to visualize and analyze the system’s learning progress and path efficiency.

Design Thinking Approach:

Empathize:

Navigating cities is tough, especially for people with mobility issues or in areas with inefficient transport. An **AI-based self-learning navigation system** can adapt to dynamic conditions, improve accessibility, reduce travel time, enhance safety, empower individuals, and improve urban mobility.

Key User Concerns:

- **Accessibility**: Struggles with navigating crowded or unfamiliar spaces.
- **Efficiency**: Slow systems that can't adapt to changes.
- **Safety**: Concerns about navigating safely in dynamic environments.

Define:

It will address key concerns by adapting routes for better accessibility, ensuring smoother navigation for people with mobility issues. It will improve efficiency by optimizing routes in real-time, avoiding delays and obstacles. Additionally, it will enhance safety by dynamically adjusting paths to avoid hazards and ensure secure navigation.

Key Features Required:

- Self-learning route memory to improve and recall optimal routes over time.
- Real-time adaptation to dynamic obstacles and changing environments.
- Reinforcement learning to continuously optimize navigation decisions.
- Path optimization for efficiency and safety, with obstacle detection.

Ideate:

Some potential ideas for this solution include:

- Develop real-time route adjustment to avoid dynamic obstacles and traffic.
- Implement multi-agent systems where vehicles/robots share learned routes for collective optimization.
- Use predictive path planning to foresee and avoid potential obstacles or changes.

Brainstorming Results:

- Store historical route data to optimize future paths.
- Adjust routes in real-time based on traffic, weather, and road conditions.
- Share data between vehicles to improve overall route efficiency.

Prototype:

The prototype will be a **self-learning navigation system** that:

- Uses **reinforcement learning** to dynamically adapt and optimize routes based on environmental conditions (traffic, obstacles, etc.).

- Allows the system to **store and recall optimal routes** based on past experiences, continuously improving its performance.
- Enables real-time communication between multiple vehicles or robots to share learned routes and adjust accordingly**.**

Key Components of Prototype:

- **Environment Simulator**: Virtual map with paths, obstacles, and dynamic changes.
- **Reinforcement Learning Engine**: Learns optimal routes using reward-based learning.
- **Route Memory Module**: Stores past routes, outcomes, and adapts based on experience.
- **Navigation Agent**: Makes decisions and moves through the environment.
- **Obstacle/Event Generator**: Simulates real-time challenges like traffic or blocks.
- **Performance Visualizer**: Shows learning progress, route choices, and stats.

Test:

The model will be tested for how efficiently it learns optimal routes over time by tracking the steps or time taken to reach the goal. Its adaptability will be evaluated by introducing dynamic changes like obstacles or traffic and observing how quickly it adjusts. The system's ability to optimize routes will be checked by comparing paths chosen across runs. It will also be tested for how well it uses stored memory to avoid relearning, and finally, a stress test will be done by increasing environment complexity to assess stability and performance.

Testing Goals:

- Test how efficiently the system learns, adapts, and improves route choices over time.
- Check the effective use of route memory to avoid relearning and enhance navigation.
- Evaluate stability and performance under dynamic and complex conditions.