

SMART EV TRIP PLANNER WITH CHARGING STATION OPTIMIZATION

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Abstract:

The increasing adoption of electric vehicles has introduced new challenges in travel planning, particularly regarding charging accessibility and route optimization. Unlike conventional vehicles, electric vehicles depend heavily on charging infrastructure, making efficient trip planning an essential requirement for drivers. This project presents an intelligent web-based application called IntelliCharge EV Navigator, designed to assist electric vehicle users in planning journeys while identifying optimal charging stations along the route.

Keyword:Electric Vehicles (EV), Route Optimization, Charging Station Allocation, Smart Navigation System, Energy Consumption Prediction, Geographic Information System (GIS), Real-time Data Processing, Web-based Application, Sustainable Transportation, Intelligent Trip Planning

Introduction:

Electric vehicles are becoming one of the most important alternatives to traditional fuel-powered transportation systems. Governments and automobile manufacturers are actively promoting EV adoption due to environmental concerns, reduced carbon emissions, and increasing fuel costs. Although EV technology has improved significantly, one major issue still affecting users is charging management during long-distance travel.

Many EV drivers experience “range anxiety,” which refers to the fear of battery depletion before reaching a charging station. Existing navigation systems generally provide only basic route information and do not fully support electric vehicle requirements such as charger availability, charging speed, reliability, and optimized charging decisions.

To solve this issue, the IntelliCharge EV Navigator system has been developed as an advanced EV route

planning and charging assistance platform. The application combines map visualization, charger discovery, route planning, and intelligent charger filtering into a single interface. Users can efficiently locate charging stations, compare charger information, and optimize their travel experience.

The system is designed using modern full-stack web technologies to ensure scalability, responsiveness, and real-time interaction. By integrating route planning with charger analytics, the platform provides a practical solution for improving EV travel convenience.

Existing System

Existing navigation systems and EV charging applications mainly focus on basic route guidance and limited charger location services. Most applications do not provide advanced charger

analysis features such as reliability estimation, charging optimization, or intelligent charger filtering. Many systems rely heavily on commercial APIs and paid services, limiting accessibility and flexibility for users and developers. Some platforms also lack real-time visualization and proper user interaction, making EV travel planning less efficient. In several cases, users are unable to compare charging stations based on important factors such as charging speed, pricing, and reliability. These limitations create inconvenience for EV users and reduce the efficiency of long-distance electric vehicle travel.

Proposed System:

Interview anxiety is a primary factor in candidate underperformance. Cognitive Behavioral Theory suggests that repeated exposure to a stressful stimulus in a controlled environment can desensitize the individual to that stress. By utilizing Generative AI to create immersive, unpredictable interview scenarios, PrepWise acts as a tool for "exposure therapy," allowing students to build muscle memory for both technical responses and behavioral interactions. The proposed IntelliCharge EV Navigator system introduces an advanced web-based platform designed specifically for electric vehicle route planning and charging management. The system integrates interactive maps, charger visualization, route generation, and optimization tools into a single application. Users can search locations, generate routes between destinations, and view charging stations directly on the map interface. The system also allows filtering chargers based on speed, reliability, and pricing information. In addition, the platform supports charger observations and charging analytics to improve user decision-making. By combining route planning and charger intelligence, the proposed system offers a complete EV travel management solution that improves efficiency, convenience, and user experience.

Objectives of the Project

The main objective of this project is to develop an intelligent electric vehicle trip planning system capable of assisting users during long-distance travel. The system aims to provide accurate route generation, charger visualization, charging optimization, and charger filtering through an interactive web interface. Another important objective is to reduce range anxiety among EV users by helping them locate reliable charging stations efficiently. The project also focuses on improving user experience through responsive design and real-time map interaction using modern full-stack web technologies.

System Methodology:

The IntelliCharge EV Navigator system follows a structured workflow for route planning and charging management. Initially, the user enters the starting and destination locations through the search interface. The application processes the input and generates a driving route using routing APIs integrated with OpenStreetMap services. Once the route is generated, nearby charging stations are identified and displayed on the interactive map. The user can apply filters such as fast charging support, charger reliability, and charging cost preferences. The application then analyzes available chargers and provides optimized recommendations based on user requirements. All information is displayed dynamically using an interactive graphical interface to improve accessibility and usability.

Technologies Used:

The project is developed using modern web technologies and open-source tools. React.js is used for frontend development and user interface rendering. Node.js and Express.js are used for backend processing and API management. Leaflet.js is integrated for interactive map visualization, while OpenStreetMap provides geographic map data. Axios is used for API communication and data retrieval. CSS is used for interface styling and responsive design implementation. The combination of these technologies ensures scalability, performance, and smooth user interaction throughout the application.

System Implementation:

The frontend of the application was designed with a modern user interface that supports real-time interaction and dynamic map rendering. Users can search for locations, generate routes, and access charger details through the interactive dashboard. The backend handles charger data processing, filtering operations, optimization calculations, and API communication. The system uses OpenStreetMap and routing APIs to display accurate geographic information and route paths. Charger details such as reliability percentage, connector type, charging speed, and estimated pricing are processed dynamically and displayed within the application. The system also includes a charger observation module where users can submit charging experiences and waiting time information.

Results and Discussion:

The developed system successfully demonstrated efficient EV route planning and charging station visualization. The application was tested across different city locations including Chennai,

Coimbatore, and Madurai. Route generation and charger visualization were performed accurately using OpenStreetMap services. The charger filtering mechanism successfully displayed charging stations based on user-selected conditions such as fast charging and reliability scores. The interactive map interface improved user navigation and charger accessibility. The system showed smooth frontend performance and responsive behavior during route generation and charger analysis. The integration of charger optimization features further improved the usability and effectiveness of the application.

Advantages:

The IntelliCharge EV Navigator system provides several advantages for electric vehicle users. The platform offers an interactive and user-friendly interface for route planning and charging management. The integration of open-source maps reduces dependency on expensive commercial APIs. The system supports intelligent charger filtering and charging optimization, improving travel efficiency and user convenience. Real-time visualization and charger analysis reduce uncertainty during EV travel and help users make better charging decisions. The scalable architecture of the system also allows future feature expansion and integration of advanced technologies.

Limitations:

Although the proposed system provides significant improvements in EV trip planning, certain limitations still exist. The application depends on internet connectivity for map rendering and API communication. The accuracy of charging station information may vary depending on external datasets and API updates. Real-time charger occupancy and charging availability are not fully supported in the current implementation. Some charging data may also be incomplete due to limited public dataset availability.

Future Enhancements:

The system can be further enhanced by integrating artificial intelligence and machine learning algorithms for predictive charger recommendations and battery analysis. Future improvements may include real-time traffic integration, live charger occupancy monitoring, mobile application support, voice-based navigation, and personalized route optimization. Additional features such as battery health prediction, smart charging scheduling, and AI-powered travel suggestions can further improve the effectiveness and intelligence of the platform.

System Architecture:

The IntelliCharge EV Navigator system follows a three-layer architecture consisting of the frontend layer, backend layer, and external service integration layer. The frontend layer is developed using React.js and provides an interactive user interface for map visualization, route planning, charger filtering, and charging analysis. The backend layer is implemented using Node.js and Express.js, which handle API requests, charger processing, optimization calculations, and route management operations. The external integration layer connects the system with OpenStreetMap, routing APIs, and charging station datasets to provide real-time geographic information and charger details. Communication between the frontend and backend is performed using REST APIs and Axios for efficient data transfer. This architecture ensures scalability, flexibility, real-time interaction, and smooth user experience for electric vehicle trip planning and charging management applications.

Flow chart:



Conclusion:

The IntelliCharge EV Navigator project successfully demonstrates an intelligent and practical solution for electric vehicle route planning and charging optimization. The system integrates interactive maps, charger analytics, and route management into a unified platform that improves the travel experience for EV users. The application effectively reduces charging uncertainty and provides optimized charger recommendations through a responsive and modern interface. By using open-source technologies and scalable web development frameworks, the project establishes a strong foundation for future intelligent EV navigation systems and sustainable transportation applications.

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