IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.414 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 4, April 2026

DOI: 10.17148/IJIREEICE.2026.14415

E-Vehicle Recharge Hub: A Smart Location-Based Charging Solution

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Abstract: Electric vehicles are getting really popular these days. People like them because they are better for the environment and fuel prices keep going up. Plus theres this big push everywhere to cut down on carbon emissions. But even with all that, EV owners still have a hard time finding places to charge up. Especially if youre driving somewhere new, its frustrating not knowing where the stations are. That leads to delays and this thing called range anxiety, which I think just makes people worry about running out of battery.

The app I came up with is called E-Vehicle Recharge Hub.The whole point of this app is to make it simpler to find charging stations. You know, with info thats updated in real time so you dont waste time looking around. It pulls in your location using GPS, figures out where you are right now. Then it just pops up the nearest spots on the map. That seems pretty handy, I guess, but sometimes the real time part might lag a bit. Anyway, it shows them quick enough to get you going. You get details like how far they are and if theyre available. That seems like it would help a lot when youre on the road.

One part I focused on is letting users book a slot ahead of time. So you dont have to wait around if its busy. Then theres an admin side where people in charge can update the station info or handle bookings. Once you book something, you get a notification to confirm. It feels like that makes the whole process smoother, though im not totally sure how it handles super crowded areas.

For building it, I used Android Studio. The front end is XML and Java, and SQLite for storing data in the back. It processes things in real time and tries to be easy to use. I tested it some and it does make things more convenient, like optimizing how stations are used. Accessibility improves too, I guess.

Overall this app supports the EV world growing. Combining location stuff with good data handling and thinking about users. It might encourage more people to switch to electric, but theres still room to add more features maybe.

Keywords: Electric Vehicles, Location-Based Services, Android Application, Charging Stations, Booking System

I. INTRODUCTION

The rapid advancement of technology and the increasing concern for environmental sustainability have accelerated the adoption of electric vehicles (EVs) worldwide. As EV usage continues to grow, the demand for efficient and accessible charging infrastructure has become a critical challenge. Unlike conventional fuel stations, EV charging stations are limited in number and often lack real-time information regarding availability, leading to inconvenience for users.

One of the major issues faced by EV users is range anxiety, which refers to the fear of a vehicle running out of battery without access to a nearby charging facility. Additionally, users struggle with locating charging stations, long waiting times, and inefficient route planning. These challenges highlight the need for an intelligent system that can provide real-time assistance and optimize the charging experience.

To address these problems, this project proposes E-Vehicle
Recharge Hub: A Smart Location-Based Charging Solution Using AI Algorithms. The system is designed as a mobile application that integrates location-based services with Artificial Intelligence to help users find the most suitable charging stations. It not only identifies nearby stations but also predicts availability, estimates waiting time, and recommends the best option based on user preferences and real-time data.

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The proposed solution utilizes advanced AI techniques such as machine learning, clustering, and optimization algorithms to enhance decision-making. By analyzing historical data and current conditions, the system provides accurate predictions and personalized recommendations. This ensures efficient utilization of charging infrastructure and reduces congestion at charging stations.

Overall, the E-Vehicle Recharge Hub aims to improve user convenience, minimize waiting time, and promote the widespread adoption of electric vehicles by providing a smart, reliable, and user-friendly charging solution.

II. LITERATURE REVIEW

The increasing adoption of electric vehicles (EVs) has led to significant research in developing intelligent charging infrastructure systems. Various studies have focused on improving charging efficiency, reducing waiting time, and enhancing user experience using advanced computational and Artificial Intelligence techniques.
Several researchers have explored the use of machine learning algorithms to predict charging station availability and waiting time. Regression models and ensemble techniques

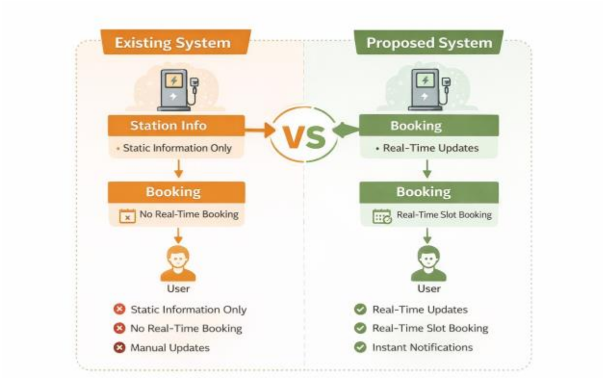

Fig. 1. Comparison Between Existing System and Proposed EV Recharge Hub System

are commonly used to analyze historical data, user patterns, and time-based factors. These approaches help in providing accurate predictions; however, most of them are limited to prediction tasks and do not integrate other functionalities such as routing or recommendation.

Clustering techniques have also been widely applied in EV charging systems to identify high-demand regions and optimize the placement of charging stations. By grouping stations based on geographical location and usage patterns, these methods help in better infrastructure planning. However, they primarily focus on large-scale planning rather than realtime user assistance.

In addition, routing algorithms have been proposed to guide EV users to the nearest or most efficient charging stations. These approaches consider factors such as distance, travel time, and traffic conditions. While effective in navigation, they often lack integration with real-time availability and waiting time prediction, which limits their practical usability.

Recent advancements in deep learning have introduced models such as Long Short-Term Memory (LSTM) networks for time-series forecasting of charging demand. These models improve prediction accuracy by capturing temporal dependencies in data. Despite their effectiveness, such models are computationally complex and are not always suitable for realtime mobile applications.

Furthermore, some studies have proposed intelligent systems that incorporate user preferences and pricing factors for selecting charging stations. However, these systems often lack a comprehensive approach that combines prediction, clustering, routing, and personalized recommendation into a single platform.

III. METHODOLOGY

The proposed E-Vehicle Recharge Hub system is designed using a combination of Artificial Intelligence techniques and location-based services to provide efficient and intelligent EV charging solutions. The methodology begins with data

DOI: 10.17148/IJIREEICE.2026.14415

collection, where both real-time and historical data are gathered from multiple sources, including user location through GPS,

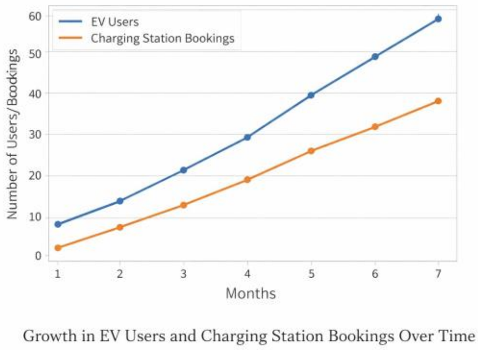

Fig. 3. Growth of EV Users and Charging Station Bookings Over Time

charging station details such as location and availability, and historical usage patterns like peak hours and occupancy rates. Additional data such as traffic conditions can also be integrated to improve system accuracy.

Once the data is collected, it undergoes preprocessing to ensure quality and consistency. This involves removing missing or inconsistent values, normalizing features such as distance and time, and transforming raw data into meaningful inputs, such as identifying peak and off-peak hours. This step is essential to improve the performance and accuracy of the AI models used in the system.

The system then identifies nearby charging stations based on the user's current location. To determine the most efficient route, pathfinding algorithms like Dijkstra's Algorithm or A* Search Algorithm are applied, which calculate the shortest and fastest path by considering distance and traffic conditions.

To manage demand and reduce congestion, clustering techniques such as K-Means Clustering are used to group charging stations based on geographical location and usage density. This helps the system identify high-demand and low-demand areas, enabling better distribution of users across available stations.

For predicting charging station availability and waiting time, supervised learning algorithms such as Linear Regression and Random Forest are utilized. These models analyze input features like time of day, day of the week, and historical occupancy data to estimate available slots and expected waiting time at each station.

To enhance user experience, a personalized recommendation system based on Collaborative Filtering is implemented. This system suggests charging stations tailored to user preferences and past behavior, making the recommendations more relevant and efficient.

Furthermore, to predict future demand and congestion, deep learning models such as Long Short-Term Memory (LSTM) are employed. These models analyze time-series data to forecast peak usage periods and help users avoid crowded stations.

Finally, all these components are integrated into a mobile application where the frontend handles user interaction, the backend manages data processing, and the AI layer performs predictions and recommendations. The system provides outputs such as the nearest charging station, optimal route, realtime availability, estimated waiting time, and personalized suggestions, ensuring a seamless and intelligent EV charging experience.

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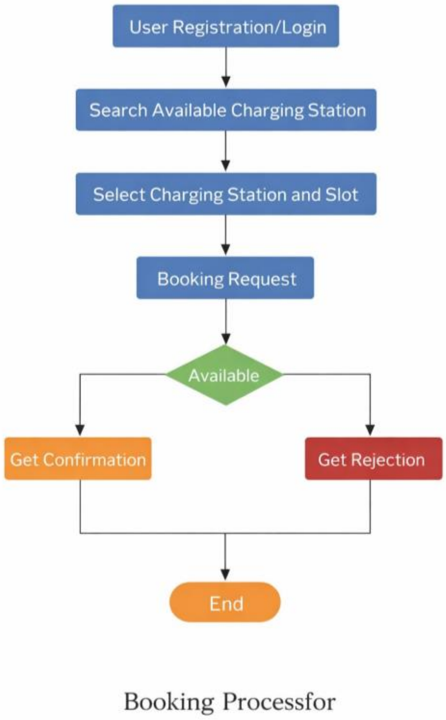

Fig. 4. Flowchart of EV Charging Station Booking Process

IV. SYSTEM ARCHITECTURE

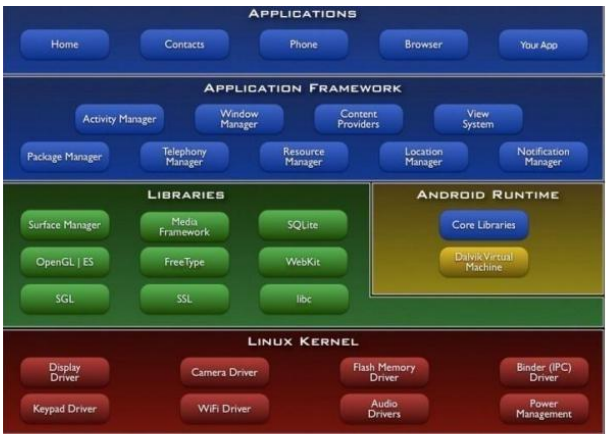

Fig. 6. Android System Architecture Overview

The proposed E-Vehicle Recharge Hub system follows a multi-layered architecture that integrates mobile application interfaces, backend services, and Artificial Intelligence models to deliver intelligent EV charging solutions. The architecture is primarily divided into three main layers: the frontend layer, backend layer, and AI/ML layer, along with external services for location and mapping.

The frontend layer consists of a mobile application developed using frameworks such as Flutter or React Native, which serves as the user interface. It allows users to input their current location, battery level, and preferences, and displays relevant outputs such as nearby charging stations, optimal routes, availability status, and estimated waiting time. This layer ensures smooth interaction between the user and the system.

The backend layer acts as the core processing unit of the system. It is implemented using technologies such as Node.js or Firebase and is responsible for handling user requests, processing data, managing APIs, and ensuring secure communication between different components. The backend also connects to the database, where all relevant data such

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as charging station details, user information, and historical usage patterns are stored using databases like MongoDB or Firestore.

The AI/ML layer is the intelligence engine of the system, where various algorithms are applied to provide smart recommendations and predictions. Pathfinding algorithms such as Dijkstra’s Algorithm or A* Search Algorithm are used for route optimization. Clustering is performed using K-Means Clustering to group charging stations based on demand and location. Availability and waiting time predictions are carried out using supervised learning models such as Linear Regression and Random Forest. Personalized recommendations are generated using Collaborative Filtering, while future demand forecasting is achieved using deep learning models like Long Short-Term Memory (LSTM).

In addition to these layers, the system integrates external services such as Google Maps API and GPS for real-time location tracking and map visualization. These services enable accurate navigation and help users identify nearby charging stations efficiently.

The overall data flow begins when the user interacts with the mobile application, which sends a request to the backend server. The backend retrieves relevant data from the database and passes it to the AI models for processing. The processed results, including optimal routes, availability predictions, and recommendations, are then sent back to the frontend and displayed to the user in an intuitive format.

Thus, the system architecture ensures seamless communication between components, efficient data processing, and intelligent decision-making, providing a reliable and userfriendly EV charging solution.

V. IMPLEMENTATION VI. IMPLEMENTATION

The application provides a secure login and registration system for users to access EV charging services.
The system uses GPS to detect the user’s current location and provides options such as booking, feedback, and logout.
Users can book EV charging slots by entering necessary details such as name, mobile number, location, date, and time.

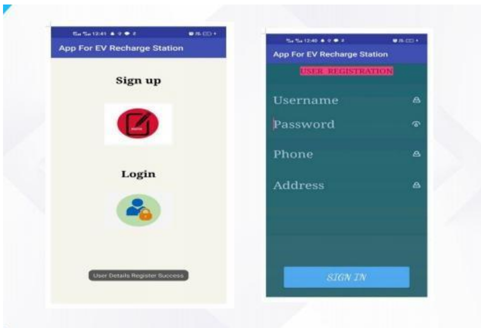

Fig. 7. User Registration and Login Interface

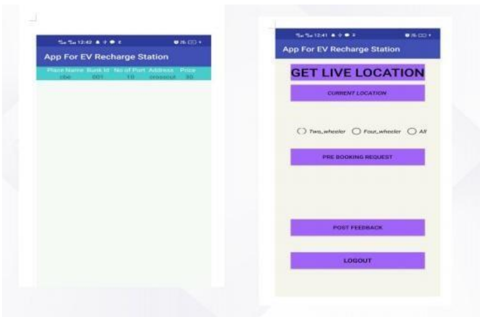

Fig. 8. Location Detection and User Options Interface

The system includes an admin module that allows management of charging stations, booking requests, and user details.
The implementation of the E-Vehicle Recharge Hub system is carried out using a combination of mobile application development, backend services, and machine learning models. The system is developed as a mobile application using frameworks such as Flutter or React Native, which provide a user-friendly interface for interacting with the application.

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The frontend allows users to access features such as location detection, viewing nearby charging stations, route navigation, and checking availability and waiting time.

The backend of the system is implemented using technologies such as Node.js or Firebase, which handle API requests, data processing, and communication between the frontend and the database. The backend server is responsible for fetching charging station data, processing user inputs, and sending relevant information to the AI models for prediction and recommendation. It also manages user authentication and ensures secure data handling.

The database is implemented using MongoDB or Firestore, where all relevant data such as charging station details, user profiles, and historical usage data are stored. This data is continuously updated to ensure real-time accuracy. The system also integrates external services like Google Maps API and GPS to enable real-time location tracking and route visualization.

The core intelligence of the system is implemented using machine learning models developed in Python with libraries such as TensorFlow and Scikit-learn. For route optimization,

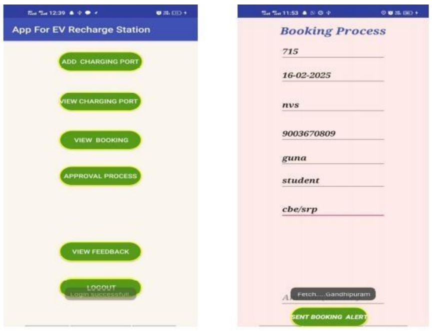

Fig. 9. EV Charging Slot Booking Process

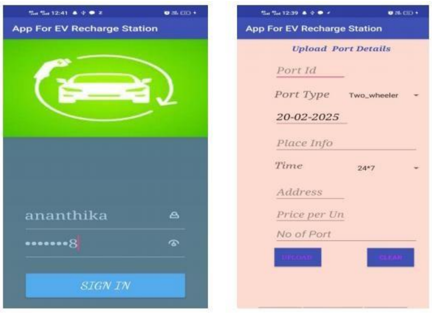

Fig. 10. Admin Dashboard for Charging Station Management

algorithms like Dijkstra's Algorithm or A* Search Algorithm are used to calculate the shortest and fastest path. Clustering is performed using K-Means Clustering to group charging stations based on demand and location.

To predict charging station availability and waiting time, supervised learning models such as Linear Regression and Random Forest are trained using historical data. A recommendation system based on Collaborative Filtering is implemented to provide personalized suggestions to users. Additionally, deep learning models like Long Short-Term Memory (LSTM) are used for forecasting future demand and identifying peak usage periods.

The integration of all components is achieved through APIs, where the frontend sends requests to the backend, and the backend communicates with the AI models and database to generate results. The processed output, including optimal routes, available charging stations, waiting time predictions, and personalized recommendations, is then displayed to the user through the mobile application interface.

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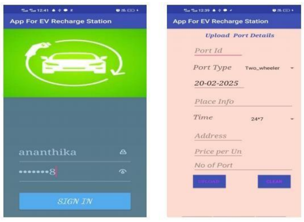

Fig. 11. Enter Caption

Overall, the implementation ensures seamless interaction between different system components, efficient data processing, and accurate predictions, resulting in a smart and reliable EV charging solution.

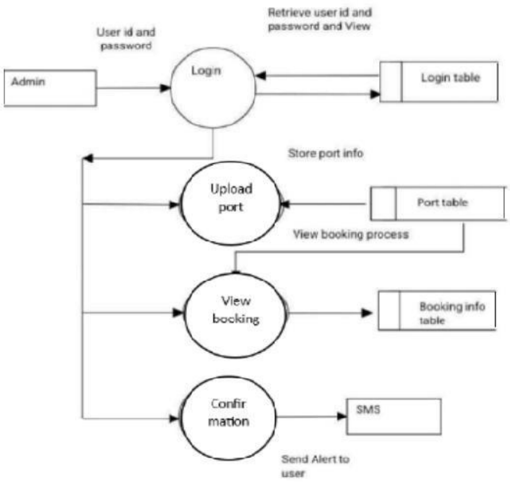

Fig. 12.Admin Module Workflow Showing Login, Port Upload, Booking Management, and Confirmation Process

VI. RESULTS AND DISCUSSION

The proposed E-Vehicle Recharge Hub system was implemented and tested to evaluate its performance in providing efficient and intelligent EV charging solutions. The results demonstrate that the integration of Artificial Intelligence algorithms significantly improves the overall user experience by offering accurate predictions, optimized routing, and personalized recommendations.

The routing module, implemented using algorithms such as Dijkstra's Algorithm and A* Search Algorithm, successfully identifies the shortest and fastest paths to nearby charging stations. The system was able to reduce travel time by guiding users through optimal routes, even when multiple stations were available.

The prediction models, including Linear Regression and Random Forest, were evaluated using historical data and showed good accuracy in estimating charging station availability and waiting time. The predictions helped users avoid crowded stations, thereby reducing waiting time and improving efficiency.

The clustering technique, implemented using K-Means Clustering, effectively grouped charging stations based on demand and location. This enabled better distribution of users across different stations and minimized congestion in highdemand areas.

The recommendation system based on Collaborative Filtering provided personalized suggestions by analyzing user preferences and past behavior. Users received more relevant and convenient charging options, which enhanced satisfaction and usability.

Furthermore, the use of Long Short-Term Memory (LSTM) for demand forecasting allowed the system to predict peak usage periods with reasonable accuracy. This helped in proactive decision-making, enabling users to plan their charging schedules more effectively.

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Overall, the system demonstrated improved performance in terms of reduced waiting time, optimized route selection, and enhanced user experience. However, the accuracy of predictions depends on the availability and quality of data. In real-world scenarios, factors such as sudden demand spikes, network issues, or incomplete data may affect system performance.

Despite these limitations, the proposed system proves to be an effective and scalable solution for smart EV charging management. The integration of multiple AI techniques into a single platform provides a significant advantage over existing systems, making it a practical approach for real-time applications in smart cities and sustainable transportation.

VII. ADVANTAGES

The proposed E-Vehicle Recharge Hub system offers several advantages by integrating Artificial Intelligence with location-based services to improve EV charging efficiency and user experience. The system provides realtime information about nearby charging stations, allowing users to quickly locate available stations without unnecessary searching. By using routing algorithms such as Dijkstra's Algorithm and A* Search Algorithm, it ensures optimal route selection, thereby reducing travel time and energy consumption. Another major advantage is the prediction of charging station availability and waiting time using machine learning models like Linear Regression and Random Forest. This helps users avoid crowded stations and plan their charging effectively, minimizing delays. The system also incorporates clustering techniques such as K-Means Clustering, which helps in identifying high-demand and low-demand areas. This improves load distribution across charging stations and reduces congestion. Additionally, the use of a personalized recommendation system based on Collaborative Filtering enhances user experience by suggesting stations according to individual preferences and past behavior. The integration of advanced models like Long ShortTerm Memory enables future demand prediction, helping users avoid peak hours and improving overall system efficiency. Furthermore, the system is designed as a userfriendly mobile application, making it easily accessible and convenient for everyday use. It also supports scalability, allowing it to be implemented in smart cities and large-scale EV infrastructure systems. Overall, the system reduces waiting time, optimizes resource utilization, enhances user satisfaction, and promotes the adoption of sustainable electric vehicles.

VIII. LIMITATIONS

Despite the advantages of the proposed E-Vehicle Recharge Hub system, there are certain limitations that need to be considered. One of the major limitations is the system's dependence on data availability and quality. The accuracy of prediction models such as Linear Regression and Random Forest relies heavily on historical data. If the data is incomplete, outdated, or inaccurate, the predictions for availability and waiting time may not be reliable. The system also depends on real-time internet connectivity for fetching data, processing requests, and updating results. In areas with poor network coverage, the application may not function effectively, leading to delays or incorrect recommendations. Another limitation is the computational complexity of advanced algorithms such as Long Short-Term Memory. These models require higher processing power and may increase response time if not optimized properly, especially in real-time scenarios. The routing algorithms like Dijkstra's Algorithm and A* Search Algorithm may not always account for sudden changes such as unexpected traffic congestion, station breakdowns, or temporary unavailability of charging points. Additionally, the recommendation system based on Collaborative Filtering may face challenges such as the cold start problem, where new users or new charging stations have insufficient data for accurate recommendations. The system also requires continuous updates and maintenance, including regular data synchronization and model retraining, to ensure accuracy and efficiency over time. Finally, integration with external services like maps and GPS may introduce dependency issues, where any failure or inaccuracy in these services can affect the overall system performance.

IX. FUTURE WORK

The proposed E-Vehicle Recharge Hub system can be further enhanced by incorporating several advanced features and technologies to improve its efficiency, scalability, and real-world applicability. In the future, the system can be integrated with Internet of Things (IoT) devices installed at charging stations to provide real-time updates on slot availability, charging status, and equipment health. This will improve the accuracy of predictions and reduce dependency on historical data. Advanced deep learning models beyond Long Short-Term Memory can be explored to achieve higher accuracy in demand forecasting and user behavior analysis. Techniques such as hybrid models combining multiple algorithms can further enhance system performance. The system can also be extended to include dynamic pricing mechanisms, where charging costs vary based on demand, time, and availability. This will help in better load balancing and encourage users to utilize charging stations during non-peak hours. Another improvement is the integration of vehicleto-grid (V2G) technology, which allows EVs to supply energy back to the grid. This can contribute to energy optimization and support

DOI: 10.17148/IJIREEICE.2026.14415

smart grid systems. The recommendation system based on Collaborative Filtering can be enhanced using hybrid recommendation approaches to overcome limitations such as the cold start problem and provide more accurate suggestions. Future versions of the system can also include voice assistant support and multilingual interfaces to improve accessibility and user convenience. Additionally, integration with smart city infrastructure can enable seamless coordination between transportation systems, energy management, and urban planning. Security and privacy can be strengthened by implementing advanced encryption techniques and secure authentication mechanisms to protect user data. Overall, these future enhancements will make the system more intelligent, scalable, and suitable for large-scale deployment, contributing to the development of sustainable and smart transportation ecosystems.

X. CONCLUSION

The proposed E-Vehicle Recharge Hub: A Smart Location Based Charging Solution Using AI Algorithms provides an effective and intelligent approach to address the challenges faced by electric vehicle users. With the increasing adoption of EVs, the need for efficient and reliable charging infrastructure has become essential, and this system offers a practical solution by integrating Artificial Intelligence with location-based services.

The system successfully combines multiple AI techniques to deliver real-time and accurate results. Routing algorithms such as Dijkstra's Algorithm and A* Search Algorithm ensure optimal navigation, while machine learning models like Linear Regression and Random Forest provide reliable predictions for charging station availability and waiting time. Additionally, techniques such as K-Means Clustering and Collaborative Filtering enhance system efficiency through demand management and personalized recommendations. The use of Long ShortTerm Memory further strengthens the system by enabling accurate future demand forecasting.

The results demonstrate that the system effectively reduces waiting time, optimizes route selection, and improves overall user experience. It also promotes better utilization of charging infrastructure and contributes to reducing range anxiety among EV users. Despite certain limitations such as dependence on data quality and network connectivity, the system proves to be a scalable and practical solution.

In conclusion, the E-Vehicle Recharge Hub represents a significant step towards the development of smart and sustainable transportation systems. By leveraging AI technologies, it not only enhances convenience and efficiency but also supports the widespread adoption of electric vehicles, contributing to a greener and more sustainable future.

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