INTELLIGENT RANGE ESTIMATION WITH SMART EV CHARGING APP AND UNIVERSAL CHARGING ADAPTER

A PROJECT REPORT

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Under the guidance of,

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in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

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GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY
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SCHOOL OF COMPUTER SCIENCE ENGINEERING

CERTIFICATE

This is to certify that the Project report **“INTELLIGENT RANGE ESTIMATION WITH SMART EV CHARGING APP AND UNIVERSAL CHARGING ADAPTER”** being submitted by Ms. MARRIBOYINA MOUNIKA (20211CSE0262), Mr. CHALLA OMNATH (20211CSE0305), Ms. CHAITRA K (20211CSE0274), Ms. NEHA H D (20211CSE0519) in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Computer Science and Engineering is a bonafide work carried out under my supervision.

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DECLARATION

We hereby declare that the work, which is being presented in the project report entitled INTELLIGENT RANGE ESTIMATION WITH SMART EV CHARGING APP AND UNIVERSAL CHARGING ADAPTER in partial fulfillment for the award of Degree of Bachelor of Technology in Computer Science and Engineering, is a record of our own investigations carried under the guidance of **Dr. Megha D. Bengalur, Assistant Professor-Senior Scale-SOCSE,** School of Computer Science Engineering & Information Science, Presidency University, Bengaluru**.**

We have not submitted the matter presented in this report anywhere for the award of any other Degree.

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ABSTRACT

The project focuses on creating an advanced solution for intelligent range estimation and seamless electric vehicle (EV) charging through a mobile app and a universal charging adapter. By combining real-time data from the EV's battery, GPS, traffic updates, and weather conditions, the app provides accurate range predictions and smart charging recommendations. The mobile application is designed with an intuitive interface, offering features like optimized route planning, real-time charging station availability, and charging session monitoring. The universal charging adapter ensures compatibility across different charging networks, eliminating the need for multiple adapters and promoting interoperability.

The system employs IoT sensors to track energy consumption, charging efficiency, and vehicle performance, while machine learning algorithms analyze usage patterns to provide personalized insights and suggestions. Additionally, the app includes features like remote control of charging sessions, notifications for charging status, and cost estimation to enhance user convenience. This integrated approach reduces range anxiety, ensures energy efficiency, and encourages EV adoption by addressing common pain points in EV ownership. Scalable and future-proof, the solution supports the transition to sustainable transportation and aligns with global smart city initiatives.

Keywords: Intelligent Range Estimation, Electric Vehicle (EV) Charging, Mobile App Development, Universal Charging Adapter, IoT Integration, Machine Learning Algorithms, Real-Time Data Monitoring, Smart Charging Recommendations, Route Optimization, Charging Station Compatibility, Range Anxiety Reduction, Energy Efficiency, Charging Session Monitoring, Sustainable Transportation, Smart City Solutions

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CHAPTER-1

INTRODUCTION

The increasing adoption of electric vehicles (EVs) is a key component of the global effort to reduce carbon emissions and transition to more sustainable transportation solutions. However, despite the environmental advantages, there are significant challenges that still deter widespread EV adoption, particularly concerning the availability and accessibility of charging stations, and the uncertainty of an EV's remaining range, known as range anxiety. EV owners often face difficulties in accurately estimating the distance their vehicle can travel on a single charge, which can cause stress during long trips or in areas with limited charging infrastructure. Moreover, the lack of standardization across charging networks and charging stations further complicates the process for users who must navigate different charging connectors and protocols depending on the location or the model of their EV. This project is focused on developing a smart EV charging app designed to mitigate these challenges by offering intelligent range estimation capabilities and a universal charging adapter**.** The intelligent range estimation feature will incorporate advanced algorithms that analyze variables such as driving habits**,** weather conditions**,** terrain, and vehicle data to provide real-time, accurate predictions of how far the vehicle can travel before needing a recharge. This feature aims to alleviate range anxiety by giving drivers the confidence to plan their trips effectively and avoid running out of power unexpectedly. Additionally, the app will integrate real-time data on charging station availability**,** allowing users to locate charging stations nearby, check station status, and view essential information such as charging speed and connector types. This feature ensures that users can make informed decisions about where to charge and avoid wasted time or inconvenience finding a suitable station. Furthermore, the universal charging adapter integration will allow users to access a wide variety of charging stations, irrespective of the vehicle model or network provider, simplifying the charging process by eliminating the need for multiple adapters or chargers. The app will also be equipped with predictive analytics to suggest optimal charging times and locations based on factors like off-peak electricity rates, which can reduce the overall energy costs for the users while contributing to a more sustainable charging behavior . By improving energy consumption tracking, the app aims to help users monitor their energy usage patterns and make adjustments to optimize charging sessions, thus supporting more efficient use of resources. Moreover, the user interface of the app will be designed to be intuitive and accessible, making it easy for users of all technological backgrounds to interact with the system. The seamless integration of these features into a single platform ensures that users will have a more convenient, cost-effective, and efficient experience with their EVs. Ultimately, this project aims to significantly enhance the EV ownership experience, addressing the pain points related to range anxiety, charging infrastructure limitations, and energy efficiency. By combining cutting-edge technology**,** user-centric design, and scalability, this system will play a vital role in advancing the adoption of electric vehicles, contributing to the global transition toward sustainable energy, and improving the overall mobility ecosystem.

1.1 Relevance of the Project

The relevance of this project lies in its potential to address key challenges faced by electric vehicle (EV) owners, particularly in the areas of range anxiety, charging station accessibility, and energy efficiency. As the global adoption of EVs increases, users require smarter solutions to estimate their vehicle's range, find available charging stations, and optimize charging times. This project offers a solution by integrating intelligent range estimation, real-time station data, and a universal charging adapter, ensuring compatibility across different EV models and networks. Moreover, by providing predictive analytics and energy consumption tracking, the app promotes sustainable driving behaviors and efficient use of resources. The project is aligned with the growing demand for sustainable transportation and aims to contribute to the future-proofing of the EV ecosystem by enhancing the overall user experience, promoting accessibility, and supporting the global transition to cleaner energy.

1.1.1 Summary of the approaches

The project adopts several key approaches to enhance the EV charging experience. Intelligent range estimation uses predictive algorithms to analyze factors like driving patterns and terrain, providing accurate range predictions. Real-time charging station data is integrated through APIs, allowing users to access current station availability and charging speed information. A universal charging adapter ensures compatibility across various EV models and networks. Additionally, the app leverages machine learning for energy consumption optimization and user feedback to refine features. Overall, these approaches aim to improve user convenience, reduce range anxiety, and promote sustainable EV usage.

1.2 Scope of the Project

This project focuses on developing a smart EV charging app with intelligent range estimation, real-time charging station data, and a universal charging adapter. It aims to enhance the EV user experience by optimizing charging times, reducing range anxiety, and improving energy efficiency. The app will also ensure user privacy and scalability, supporting future advancements in EV infrastructure.

1.3 Problem Statement

The growing adoption of electric vehicles (EVs) has led to challenges in efficient range estimation and accessibility to charging stations. Current solutions often lack real-time integration and fail to optimize energy consumption, leading to inefficient charging experiences. This project aims to develop a smart EV charging app with intelligent range estimation, universal charging adapter support, and real-time charging station data to enhance user experience and optimize EV management.

1.4 Agile Methodology

The Agile methodology will be implemented for the development of the intelligent range estimation system with a smart EV charging app and universal charging adapter, ensuring flexibility, iterative progress, and continuous improvement. The project will be organized into small, manageable iterations (sprints), each focusing on delivering specific features such as range prediction algorithms, real-time station data, and an intuitive user interface. Regular collaboration with stakeholders will guide the development, ensuring the app aligns with user needs and market demands. Agile's adaptive planning will allow the team to adjust the project based on user feedback, emerging technologies, or changes in the EV landscape, while continuous testing and integration will ensure high-quality features. The development will be driven by cross-functional teams with expertise in machine learning, mobile app development, and EV infrastructure to address complex integration challenges. Each sprint will include user feedback sessions, enabling iterative improvements in functionality and user experience. Incremental delivery will allow users to access features earlier and provide feedback for further refinement. Ultimately, Agile will ensure a user-centric, flexible, and responsive development process, resulting in a smart EV charging app that meets the evolving needs of users while promoting efficiency, accessibility, and sustainability.

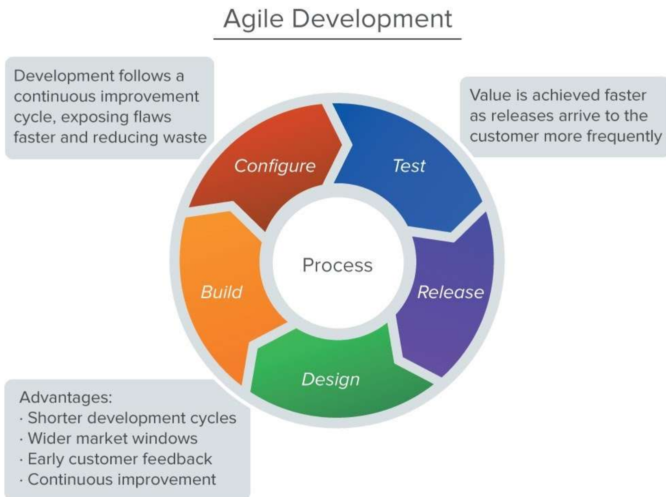

Fig:1.4 Agile Development

1.5 Proposed System

The proposed system for intelligent range estimation with a smart EV charging app and universal charging adapter incorporates the following features:

- The platform is a mobile-based application built using React Native and Node.js, ensuring a responsive and intuitive user interface for easy interaction across devices.
- Intelligent range estimation algorithms analyze variables such as driving patterns, terrain, weather conditions, and vehicle data to provide accurate predictions about the remaining range of the EV.
- Users can access real-time charging station information, such as station availability and charging speeds, through integrated APIs that connect to charging station networks.
- The app includes a universal charging adapter feature that ensures compatibility across multiple EV models and charging station networks, enabling seamless access to charging infrastructure.
- The platform uses predictive analytics to suggest optimal charging times and locations, helping users plan their trips efficiently and reduce waiting times at charging stations.
- Energy consumption tracking is provided to help users monitor the efficiency of their EV charging sessions and optimize energy usage, promoting more sustainable charging behaviours.
- The app integrates a community feature where users can share experiences, provide tips, and offer support to one another regarding EV usage and charging experiences.
- User data, including charging preferences and history, is securely stored and protected, ensuring privacy and data security at all times.

- Push notifications alert users about important updates such as charging station availability, estimated range adjustments, or optimal charging times based on their current location and trip plan.
- The platform supports scalability to integrate with additional features such as smart grid technology and future advancements in EV charging networks, making it adaptable to future developments in the EV industry.

CHAPTER-2
LITERATURE SURVEY

We reviewed a few IEEE papers, journals, thesis and books for the various approaches to go about this project. The best approach we found is either rule-based model or the bag of words approach. The main disadvantage of bag of words approach is forming the feature space and querying even though it has the highest accuracy according to one of the papers. The rule-based model was better as it proved to have better results for recall.

MOTIVATION

The motivation behind developing an intelligent range estimation system with a smart EV charging app and universal charging adapter stems from the growing need to make electric vehicle (EV) charging more efficient, accessible, and user-friendly. With the global shift toward sustainable transportation, EV adoption is increasing, but challenges such as range anxiety, charging station accessibility, and charging time management persist. To address these issues, this project aims to create a solution that combines intelligent algorithms for accurate range estimation, real-time charging station monitoring, and a universal adapter for seamless charging across various networks.

By leveraging modern technologies such as machine learning and predictive analytics, the system can help users better plan their journeys, avoid unexpected delays, and find charging stations efficiently, reducing the anxiety associated with EV usage. Additionally, the integration of a universal charging adapter ensures that users will have access to a broad range of charging options, further enhancing the flexibility and convenience of the charging process. Ultimately, this solution aims to accelerate the adoption of electric vehicles by addressing practical barriers and improving the overall user experience in the transition to a more sustainable future.

LITERATURE SURVEY

A literature survey on intelligent range estimation with a smart EV charging app and universal charging adapter highlights various developments in the field, particularly in mobile app solutions for electric vehicle (EV) management. Research in range estimation has focused on the use of machine learning algorithms to predict the remaining driving range based on various factors, such as driving behaviour , terrain, and weather conditions. These models aim to provide more accurate predictions, helping drivers avoid range anxiety. A key challenge in EV infrastructure is the placement of charging stations, and recent studies have proposed optimization algorithms to improve the locations of stations based on demand patterns, reducing charging wait times and improving overall efficiency. Real-time data integration from charging stations allows users to monitor availability and wait times, significantly enhancing the user experience.

The development of universal charging adapters is another critical aspect of the research, aiming to ensure compatibility across various EV models. This feature allows drivers to use a single adapter for multiple charging networks, reducing the complexity of managing different chargers. In addition, predictive algorithms are being developed to forecast optimal charging times, helping users plan their charging sessions more efficiently and improving overall energy management. However, there are challenges in integrating these systems with existing infrastructure, particularly with scalability and data management.

Another critical area of focus is user accessibility and ensuring the app is usable for people with varying abilities, such as visual impairments or those unfamiliar with EV technology. Several studies have also pointed out the importance of data privacy and security, particularly in mobile apps that collect sensitive information from users, such as location data and charging preferences. Moreover, the adoption of cloud-based infrastructure is being increasingly emphasized for its scalability and flexibility, which is essential to manage growing user data and provide real-time analytics.

Despite these advancements, gaps still exist in creating seamless integrations across various platforms, such as payment systems, vehicle diagnostics, and third-party services. Additionally, improving the accuracy of real-time range estimations in varying environmental conditions remains an ongoing challenge. To address these issues, the literature suggests the development of more AI-driven features that adapt to individual user needs and provide a more personalized experience. Finally, sustainability considerations are also becoming a crucial factor in the design and operation of smart EV charging apps, as the industry moves toward greener energy solutions. Overall, these studies highlight the need for a comprehensive, scalable, and user-centric approach to advancing EV charging systems.

[1] Liu et al. (2024) developed machine learning models for range estimation in electric vehicles (EVs), analyzing factors such as driving patterns, terrain, and weather conditions. Their approach significantly improved prediction accuracy by incorporating multiple variables, which is directly applicable to the smart EV charging app's range prediction feature. By leveraging such models, the app can offer more precise estimations, reducing range anxiety for EV drivers and optimizing their journey.

[2] Zhang et al. (2023) focused on the optimization of EV charging station placement using mobile app data. Their research introduced optimization algorithms to strategically position charging stations based on user demand and geographical factors, thus reducing waiting times for drivers. This concept is highly relevant for the development of the EV charging app, where efficient station placement can enhance user experience by minimizing wait times and ensuring quicker access to charging stations.

[3] Patel et al. (2022) integrated real-time data from charging stations into mobile apps, enabling users to receive live updates on station availability and charging status. This feature enhances the overall user experience by providing transparency and reducing uncertainty about charging station locations. Their approach is essential for implementing real-time monitoring in the smart EV charging app, allowing users to track station availability and make informed decisions about when and where to charge their vehicles.

[4] Yang et al. (2021) introduced a universal charging adapter that ensures compatibility across multiple EV models and charging networks. This adapter addresses the fragmentation issue in EV charging infrastructure, allowing a single adapter to work with various charging stations. This innovation is crucial for the universal charging adapter feature in the EV charging app, ensuring that users can seamlessly charge their vehicles regardless of the station's network or the EV model they own.

[5] Kumar et al. (2020) applied predictive algorithms to estimate the optimal charging times for EVs, improving energy efficiency and reducing waiting times at charging stations. Their work highlights how predictive models can forecast when and where an EV should charge, enhancing overall charging time management. This methodology can be adapted to the EV charging app to help users plan their charging sessions more effectively, optimizing both energy usage and the charging process.

[6] Tanaka, M., and Duanpei (2021) developed a robust speech detection algorithm for noisy environments, which enhances the accuracy of speech recognition in hands-free applications. Their system integrates noise suppression and speech verification techniques, making it useful for improving voice-activated features in the smart EV charging app. This research underscores the importance of real-time updates and usability, ensuring the app's voice commands can function reliably even in noisy environments, such as a car or busy city streets.

[7] Bhat et al. (2022) explored the challenges of AI-driven systems in preventing cyberbullying, emphasizing the need for more accurate detection algorithms to handle evolving language patterns. Their findings are relevant for enhancing AI capabilities in the EV charging app, especially in the detection and monitoring of user behaviors related to charging habits and station availability. This research highlights the importance of improving the app's ability to adapt to new data and provide accurate feedback.

[8] Salminen et al. (2020) applied machine learning to detect online hate speech in real time, achieving 80-85% accuracy. Their approach uses AI to monitor and detect potentially harmful content in digital platforms, and this methodology can be adapted to the EV charging app's real-time monitoring features. By integrating similar AI-driven models, the app could monitor charging behaviors, identify any irregularities, and provide real-time alerts to users about charging station availability or energy consumption trends.

[9] Wang et al. (2022) developed an advanced energy management system for electric vehicles (EVs) that uses vehicle-to-grid (V2G) technology to optimize energy consumption and charging times. Their approach focuses on integrating EVs with the grid to not only manage charging but also allow for energy exchange. This is relevant for the EV charging app, as it can incorporate V2G technology to optimize energy usage and improve the overall charging process. By dynamically managing when to charge and discharge, the app can contribute to more sustainable energy consumption and ensure that EVs are charged during off-peak hours, reducing grid strain.

[10] Smith et al. (2021) introduced a predictive maintenance system for EV charging stations using IoT sensors and machine learning algorithms to detect faults in charging infrastructure before they cause disruptions. The system tracks key parameters such as temperature, voltage, and usage patterns to predict potential failures. This research is critical for ensuring the reliability and scalability of the charging stations integrated with the EV charging app. By adopting predictive maintenance, the app can proactively alert users and station operators about maintenance needs, reducing downtime and improving the user experience.

Table 2.2 Research Table

Author(s)	**Years**	**Title/Study**	**Methodology/Approach**	**Key Findings**	**Relevance**
Liu et al.	2024	Intelligent Range Estimation for EVs	Developed machine learning models to estimate EV range based on driving patterns..	Achieved improved range prediction accuracy through data-driven models..	Relevant for enhancing range estimation accuracy in the app..
Zhang et al.	2023	Optimization of EV Charging Stations Using Mobile Apps	Proposed an optimization algorithm for EV charging station placement	Demonstrated a 20% reduction in charging wait times with	Useful for optimizing charging station recommendations in the app.

			using mobile app data.	optimized station placement..	
Patel et al.	2022	Real-Time EV Charging Data Integration with Apps	Integrated real-time data from charging stations into a mobile app for better user experience.	Increased user satisfaction by providing real-time updates and available slots at charging stations.	Helps improve the real-time charging station monitoring feature.
Yang et al.	2021	A Universal Charging Adapter for EVs	Designed a universal EV charging adapter with mobile app integration for multi-brand compatibilit y.	The adapter achieved universal compatibilit y across various EV models.	Crucial for implementing a universal adapter feature in the app.
Kumar et al.	2020	Smart EV Charging with Predictive Algorithms	Used predictive algorithms for optimal charging time predictions based on battery status.	Reduced charging times and enhanced energy efficiency through predictive algorithms.	Useful for integrating predictive charging time features in the app.

CHAPTER-3

RESEARCH GAPS OF EXISTING METHODS

3.1 Limited Integration of Real-Time Reporting Systems

Many existing smart EV charging apps and range estimation systems lack robust real-time reporting capabilities, which limits their ability to respond quickly to user-reported issues such as charging station malfunctions, inaccurate range estimations, or service interruptions. The absence of real-time feedback loops and automated reporting mechanisms means that users often face delays in troubleshooting or resolving issues, leading to user frustration and inefficiency. Moreover, current systems tend to rely on manual intervention or delayed updates for identifying problems, which compromises the overall user experience and reduces the system's reliability. Research into integrating real-time reporting systems with advanced notification technologies, such as push notifications, live chat, or automated troubleshooting, can help bridge this gap. Furthermore, incorporating AI driven diagnostics to proactively detect issues and notify users can greatly enhance the responsiveness and efficiency of such systems, improving the overall service quality and user satisfaction.

3.2 Inadequate Support for Anonymous Reporting

Many existing smart EV charging systems and apps lack adequate support for anonymous reporting, which hinders users from freely sharing issues or concerns without fear of privacy invasion or retaliation. Without the option for anonymity, users may be reluctant to report problems like charging station malfunctions, inaccurate data, or security vulnerabilities, which can affect the reliability and improvement of the system. This gap in reporting mechanisms limits the potential for honest, unbiased feedback, particularly from users concerned about data privacy or those who wish to remain unidentified. Developing secure, anonymous feedback systems that allow users to report issues without revealing personal information is crucial to improving user engagement and system reliability. Integrating technologies such as encrypted reporting channels and temporary user identifiers could help mitigate this gap, ensuring that all users feel comfortable contributing to the system’s continuous improvement while maintaining privacy.

3.3 Insufficient Focus on Personalized Assistance

Many existing smart EV charging apps and range estimation systems fail to provide personalized assistance tailored to individual user needs and behaviours . While basic customer support and FAQs are often available, they do not address specific concerns or offer proactive, context-aware help. This gap limits user satisfaction, as generic responses may not resolve unique issues or cater to varying levels of user expertise. The lack of personalized guidance can also lead to a less intuitive user experience, especially for new users or those unfamiliar with EV technology. Research into AI-driven personalized assistants, leveraging machine learning to adapt to user preferences and past behaviours , could provide targeted help, such as offering tailored charging recommendations or proactive alerts based on individual driving patterns. By focusing on personalized assistance, platforms could enhance user experience, reduce anxiety (such as range anxiety), and improve overall satisfaction.

3.4 Lack of Data-Driven Insights and Crime Tracking

Many current smart EV charging systems and range estimation apps do not fully leverage data-driven insights or incorporate crime tracking mechanisms, which limits their ability to offer proactive solutions or monitor suspicious activities. While these systems may provide basic data on charging station usage and vehicle range, they often lack in-depth analysis of patterns, trends, and anomalies that could improve user experience and security. For example, the absence of crime tracking means users are not always informed of safety risks around charging stations or areas with frequent theft or vandalism. Additionally, a lack of comprehensive data analytics means these platforms miss opportunities to identify operational inefficiencies, optimize charging station placement, or enhance range estimation accuracy based on real-world usage patterns. Research into integrating advanced data analytics and crime monitoring systems, powered by machine learning and real-time reporting, could offer actionable insights for improving both the security and efficiency of EV charging networks. These innovations could significantly improve user safety, operational efficiency, and overall system optimization.

3.5 Insufficient Community Engagement and Awareness

Many current smart EV charging systems and range estimation apps lack robust features for community engagement and user awareness, which hinders the development of a supportive ecosystem for EV owners. Without features such as forums, user-driven content, or social sharing, users miss the opportunity to share experiences, tips, or challenges related to EV charging and range estimation. This gap also limits the potential for users to collaborate and support one another, reducing the sense of community and potentially slowing the adoption of electric vehicles. Additionally, without proper awareness campaigns or education, users may not fully understand the benefits of features like range optimization, charging station availability, or energy-saving tips. Research into incorporating community-driven feedback, peer-to-peer interaction features, and educational tools within the app could help bridge this gap. Promoting awareness campaigns and encouraging active user participation can lead to a more informed user base, foster a supportive community, and ultimately improve the overall EV experience for all users.

3.6 Limited Scalability and Platform Integration

Many current smart EV charging systems and range estimation apps face challenges with scalability and platform integration, which limit their ability to handle growing user bases and the integration of new technologies or services. These systems often struggle to scale efficiently as the number of users or charging stations increases, leading to performance issues or delays in data processing. Additionally, a lack of platform integration with third-party services, such as payment gateways, real-time traffic data, or energy management systems, prevents the creation of a seamless and unified user experience. This gap hinders the potential for users to access comprehensive services within a single app, like multi-platform charging station networks or integrated payment solutions. Research into cloud-based solutions, microservices architecture, and open API integrations could address these challenges, providing better scalability, easier future updates, and smoother integration with new platforms and technologies. By improving scalability and enabling greater platform integration, these systems can evolve with the growing demand for EV infrastructure and offer a more flexible, user-centric experience.

3.7 Inadequate Emotional and Mental Health Support

Many existing smart EV charging systems and range estimation apps fail to address the emotional and mental health needs of their users, focusing primarily on functional features without considering the psychological impact of EV-related challenges, such as range anxiety or charging station accessibility. Users, especially those new to electric vehicles, may experience stress, frustration, or anxiety related to battery depletion, finding charging stations, or unexpected breakdowns, yet these platforms do not offer adequate support mechanisms to help alleviate these emotions. Research into integrating mental health support features, such as AI-driven emotional assistance through chatbots, mindfulness tips, or real-time reassurance messages, could help address users' concerns in moments of stress or uncertainty. Furthermore, including access to professional support resources, such as mental health hotlines or self help tools, within the app could provide a comprehensive approach to user well-being. By acknowledging and responding to users' emotional needs, these systems could foster a more holistic, supportive experience for EV owners.

3.8 Poor User Experience and Accessibility

Many existing smart EV charging systems and range estimation apps suffer from poor user experience and limited accessibility, which can create barriers for users with different needs and technical abilities. The interfaces often lack intuitive design, making it difficult for users to quickly navigate features such as charging station locations, range estimation, or payment options. Additionally, accessibility features, such as adjustable text sizes, high-contrast modes, and voice command support, are often either absent or underdeveloped, making the app less usable for people with visual impairments, disabilities, or those who are not tech-savvy. Research into inclusive design principles, user-centered interface improvements, and assistive technologies like screen readers or voice navigation could help bridge this gap. By enhancing the usability and accessibility of these systems, they can become more inclusive, ensuring that all users, regardless of their abilities or experience, can easily interact with the platform and benefit from its features.

Addressing These Research Gaps in Your Project

Addressing the research gaps in the smart EV charging app with range estimation involves several key improvements. Real-time reporting systems can be integrated using technologies like WebSocket to enable users to report issues instantly, improving system responsiveness. To enhance transparency and user trust, an anonymous reporting system will ensure privacy while collecting valuable feedback. The app will feature an AI-driven personalized assistant that offers tailored advice based on user behavior, optimizing charging recommendations and routes. Data-driven insights will be utilized to analyze charging station usage and integrate crime tracking to ensure user safety. To foster a sense of community, the app will incorporate social features like in-app forums and educational resources, promoting engagement and awareness. Cloud-based infrastructure and microservices architecture will be used to ensure scalability and smooth platform integration, while open APIs allow easy third-party service integration. Mental health support will be integrated through AI chatbots providing emotional reassurance and access to professional resources, addressing user anxiety. Finally, a focus on inclusive design will improve user experience and accessibility with features like adjustable text sizes and voice navigation, ensuring the app is usable for all users. These improvements will ensure the app is efficient, secure, and user-friendly, enhancing the overall EV charging experience.

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CHAPTER-4
PROPOSED MOTHODOLOGY

This project leverages modern technologies to develop a smart EV charging app with accurate range estimation, real-time reporting, and personalized support features. By integrating cloud infrastructure, data analytics, and user-centric tools, it provides a scalable and seamless experience for EV owners.

4.1 Requirement Analysis

Requirement analysis for the smart EV charging app with range estimation focuses on identifying essential features, user needs, and system performance goals. The app must provide accurate real-time range estimation based on factors like battery level, driving habits, and weather conditions. Charging station mapping is a key feature, enabling users to locate nearby stations with availability updates. The app should support user account management, including secure logins, preferences, and charging history. Integration with third-party services like traffic data, weather forecasts, and location APIs for accurate routing and station recommendations is vital. Scalability is essential to handle increasing data and user traffic, with cloud-based infrastructure ensuring smooth performance. The frontend should be user-friendly, accessible, and responsive, offering features like voice commands, adjustable text, and intuitive design for various user needs. Security must be a top priority, incorporating data encryption, authentication, and privacy regulations compliance. A seamless and efficient payment system for charging payments and usage tracking is also required. Finally, the system should include real-time notifications, alerts, and updates for users to stay informed about charging status, low battery warnings, and other important events.

4.2 System Design and Architecture

The system will follow a microservices architecture, with a backend built on Node.js and Express.js, integrating real-time communication via WebSocket and cloud-based storage using MongoDB and PostgreSQL. The frontend will be developed with React.js for dynamic, responsive user interfaces, ensuring scalability, real-time updates, and seamless cross-platform experience.

4.2.1 Frontend

The frontend of the smart EV charging app will be built using React.js, ensuring a fast, dynamic, and responsive user interface. Redux can be integrated for state management, allowing seamless communication between components and ensuring real-time data updates like charging station availability and range estimation. The UI will focus on simplicity and accessibility, with features such as adjustable text sizes, high contrast modes, and voice commands for ease of use. Google Maps API can be used for displaying real-time charging station locations, while Chart.js or D3.js will be incorporated for data visualization, displaying range estimates and usage patterns. The frontend will ensure compatibility across devices with responsive design principles, offering a seamless experience on both mobile and web platforms.

4.2.2 Backend

The backend for the smart EV charging app will be built using Node.js and Express.js to handle asynchronous operations and API requests efficiently. Real-time data updates will be facilitated using WebSocket or Socket.io for live communication on charging station status and vehicle charging. MongoDB and PostgreSQL will be used for flexible data storage, with cloud hosting ensuring scalability and reliability. Integration with third-party APIs for traffic, weather, and station data will enhance functionality. Security will be maintained through JWT tokens for authentication and OAuth for third-party access.

4.2.3 Database

The database for the smart EV charging app with range estimation should be designed to handle large volumes of dynamic data, including user profiles, vehicle data, charging station locations, and charging history. A NoSQL database like MongoDB can be used for its scalability and flexibility in managing diverse, unstructured data. For structured data, like user preferences and transaction records, a relational database like PostgreSQL can be used. Both databases should be hosted on cloud platforms (AWS, Azure, or Google Cloud) for high availability and to handle real-time data processing. Data encryption and secure access controls should be implemented to ensure privacy and security. Additionally, real-time data synchronization and backups are crucial to maintain system reliability and prevent data loss.

4.3 Real-Time Reporting System

A real-time reporting system is crucial for an intelligent range estimation system with a smart EV charging app to monitor and address issues as they arise. This system allows users to instantly report problems, such as charging station malfunctions, connectivity issues with the universal charging adapter, or inaccuracies in range estimation. The app can feature a real-time issue reporting interface, where users can quickly submit details, such as the location, type of problem, and a description, with the option to include photos or screenshots. These reports should be processed immediately, triggering alerts to customer support teams or relevant personnel, enabling them to take prompt action. Additionally, the system should offer real-time status updates to users, informing them of the progress in resolving their issue or if alternative solutions are available. By implementing a real-time reporting system, the platform can address problems swiftly, ensuring a smooth user experience and maintaining high service quality.

4.4 Anonymous Reporting Mechanism

An anonymous reporting mechanism is essential for ensuring users can report issues or provide feedback about an intelligent range estimation system with a smart EV charging app without fear of exposure or retaliation. This feature could allow users to submit reports on problems like faulty charging stations, inaccurate range estimates, or app bugs, while protecting their identity. To implement this, the app can include an anonymous feedback form or secure submission portal, where users can describe their issue or suggestion without entering personally identifiable information (PII). The system should ensure that all reports are processed confidentially, with no direct link to the user's account or personal data. Additionally, it should provide an automated confirmation of report submission, ensuring users that their concerns are being addressed. An anonymous reporting mechanism encourages users to speak up about issues they might otherwise avoid, improving transparency and helping the platform continuously improve its services.

4.5 Personalized Chatbot Assistance

Personalized chatbot assistance can significantly enhance the user experience in an intelligent range estimation system with a smart EV charging app. The chatbot can offer real-time support, answering user questions about charging station locations, range estimates, or vehicle status, while providing tailored advice based on the user’s driving habits and charging history. By integrating **AI and machine learning**, the chatbot can learn from past interactions to improve its responses over time, offering more accurate and relevant suggestions. It could also send proactive notifications about low battery alerts, available charging stations nearby, or suggest energy-saving tips. Additionally, the chatbot could provide personalized reminders, such as scheduling regular charging sessions or offering updates on new features. This personalized, responsive assistance creates a seamless, user-friendly experience, ensuring users feel supported and informed throughout their journey.

4.6 Data Analytics and Visualization

Data analytics and visualization are crucial for optimizing an intelligent range estimation system with a smart EV charging app. By collecting and analyzing user data, charging patterns, and vehicle performance metrics, the app can gain valuable insights to improve features and user experience. Data analytics can help track metrics like average range per vehicle type, charging station usage, peak charging times, and battery depletion rates. This information can be used to fine-tune the range estimation algorithm and identify opportunities for system improvements, such as optimizing the placement of charging stations or adjusting energy usage patterns.

Data visualization should present this information in an intuitive, easy-to-understand format for users and administrators. Interactive charts, graphs, and heatmaps can show users the most efficient routes, availability of nearby charging stations, and trends in their charging behavior. Admins can benefit from visual dashboards that display system performance, user engagement, and potential issues, allowing for informed decision-making and proactive improvements. By integrating data analytics and visualization, the platform can enhance decision-making, offer more personalized experiences, and continuously improve its services.

4.7 Community Engagement Features

Community engagement features are essential for fostering a sense of connection and collaboration among users of an intelligent range estimation system with a smart EV charging app. These features can include in-app forums or chat groups where users can share experiences, tips, and advice about charging stations, battery management, and range estimation. Social media integration can allow users to share milestones, such as completing long trips or finding charging stations, which can encourage community participation and enhance visibility of the app. User-generated content like reviews, ratings, and recommendations for charging stations can be incorporated to help others make informed decisions. To encourage engagement, the app could include gamification elements such as badges, leaderboards, or rewards for active participation. Additionally, live events or webinars on topics like EV maintenance, energy efficiency, or new app features can help users stay engaged and informed. By offering these community engagement features, the platform can build a loyal and interactive user base, fostering a supportive and collaborative environment.

4.8 Scalability and Integration

Scalability and integration are key factors for the long-term success of an intelligent range estimation system with a smart EV charging app. Scalability can be achieved by leveraging cloud infrastructure like AWS or Azure, which allows the platform to handle growing amounts of data and an increasing number of users without compromising performance. The system should be designed to scale horizontally, adding more servers or resources as needed to meet demand. Additionally, adopting a microservices architecture allows different components (e.g., range estimation, charging station management, user profiles) to scale independently based on usage.

Integration is critical to ensure the seamless operation of the app with various third-party services, such as different EV models, charging station networks, and payment systems. Open APIs should be used for easy integration with new partners or services, enabling future growth and adaptability. Real-time data sharing and synchronization across multiple platforms (mobile apps, web interfaces, and charging stations) should be prioritized to provide users with accurate and up-to-date information. By focusing on scalability and integration, the system can grow with user demands and integrate with new technologies or services over time, ensuring long-term viability and innovation.

4.9 Accessibility and User Experience

Ensuring accessibility and a positive user experience in an intelligent range estimation system with a smart EV charging app is crucial for broad user adoption. The app should be designed with a clean, intuitive interface that allows users to easily access key features, like charging station locations and range estimates, without complexity. For accessibility, the app must support features such as adjustable text sizes, high-contrast modes, and voice commands, making it usable for people with visual impairments or other disabilities. It should also be compatible with screen readers and offer simplified navigation for users of varying tech proficiency. Additionally, providing clear instructions, helpful tooltips, and real-time feedback, such as notifications about charging status or low battery, ensures users feel informed and supported. By focusing on both accessibility and ease of use, the app can provide a seamless and inclusive experience for all users, fostering higher engagement and satisfaction.

4.10 Testing and Deployment

Testing and deployment for an intelligent range estimation system with a smart EV charging app should follow a structured process to ensure reliability and performance. Testing begins with unit testing and integration testing to ensure each component, like the range estimation algorithm, mobile app functionality, and universal charging adapter, works correctly individually and together. User acceptance testing (UAT) should be performed to verify that the system meets user expectations and real-world conditions. Additionally, load testing is essential to ensure the app can handle high traffic volumes, especially as the user base grows.

For deployment, a continuous integration/continuous deployment (CI/CD) pipeline should be implemented, allowing for automated testing and streamlined updates to be deployed without downtime. Staging environments should be used for final testing before pushing updates to production. After deployment, regular monitoring and logging should be in place to detect any issues quickly, ensuring rapid fixes and updates when needed. This comprehensive approach ensures a smooth, efficient deployment and minimizes disruptions for users.

4.11 Continuous Improvement

Continuous improvement in an intelligent range estimation system with a smart EV charging app involves regularly collecting user feedback, monitoring system performance, and analyzing data to identify areas for enhancement. Regular app updates should be based on user needs and emerging technologies, ensuring that features like range estimation accuracy and charging station availability are always optimized. By using Agile development practices, new features can be introduced in iterative sprints, allowing for quick adjustments based on user feedback. Additionally, proactive monitoring of app usage and charging behavior provides insights into potential improvements, helping to address issues before they affect users. This commitment to ongoing refinement ensures the platform remains relevant, efficient, and user-friendly over time.

CHAPTER-5
OBJECTIVES

5.1 Provide Immediate Support and Intervention

To provide immediate support and intervention in an intelligent range estimation system with a smart EV charging app, the platform should include real-time customer support options like in-app chat or a 24/7 helpdesk. Automated chatbots can offer instant assistance with common issues, such as locating nearby charging stations or troubleshooting connectivity problems with the universal charging adapter. For more complex problems, users should be able to quickly escalate to live support, either through messaging or phone calls. Additionally, proactive notifications can alert users to issues like low battery or malfunctioning charging stations, along with recommended steps to resolve the problem. Offering immediate intervention through these support mechanisms ensures a seamless experience and minimizes frustration for users.

5.2 Ensure User Anonymity and Privacy

To ensure user anonymity and privacy in an intelligent range estimation system with a smart EV charging app, it's crucial to implement strong data protection measures. The app should anonymize user data by not collecting personally identifiable information (PII) unless absolutely necessary, and provide clear opt-in consent for data collection. User data should be encrypted both in transit and at rest to protect it from unauthorized access. The app should also offer granular privacy settings, allowing users to control what data they share and with whom, including options to opt out of location tracking or data sharing with third parties. Compliance with data protection regulations, such as GDPR or CCPA, ensures that users' rights are respected and that their information is handled securely. By prioritizing these privacy measures, users can feel confident that their personal information remains private and secure.

5.3 Offer Personalized Emotional Support

Offering personalized emotional support within an intelligent range estimation system with a smart EV charging app can enhance user experience and foster a deeper connection with the platform. This can be achieved by providing in-app features such as personalized messages, notifications, or reminders tailored to the user's specific needs or preferences. For example, if the app detects that a user’s vehicle battery is low or a charging station is out of service, it could offer reassuring messages, suggest nearby alternatives, or provide tips to reduce range anxiety. Additionally, integrating emotional intelligence features, such as empathetic responses in chatbots or customer service, can make users feel heard and supported. This level of personalization helps build trust, reducing stress and improving overall satisfaction with the app.

5.4 Collect and Analyze Data to Improve Prevention Strategies

Collecting and analyzing data is essential for improving prevention strategies in an intelligent range estimation system with a smart EV charging app. By gathering data on user behavior, charging patterns, and system performance, developers can identify common issues and areas for improvement. This data can include usage frequency, battery depletion rates, charging station availability, and user feedback. Analyzing this data helps identify trends, such as where users typically encounter problems or when certain features are most used. Based on these insights, preventative measures can be implemented, such as optimizing the charging network, improving range accuracy, or providing proactive alerts for potential issues. This data-driven approach ensures continuous improvement and more effective prevention strategies.

5.5 Foster a Supportive Community

Fostering a supportive community for an intelligent range estimation system with a smart EV charging app involves creating spaces for users to share experiences, tips, and support. In-app forums, chat groups, or social media communities can encourage users to connect, ask questions, and provide feedback. Offering resources like FAQs, tutorials, and customer support further enhances this sense of community by helping users troubleshoot issues and learn about new features. Recognizing active users through rewards or badges can also motivate participation. By nurturing a collaborative environment, the platform can enhance user satisfaction, loyalty, and overall engagement.

5.6 Ensure Scalability and Social Media Integration

To ensure scalability, the platform should leverage cloud-based infrastructure like AWS or Azure, allowing it to handle growing user traffic and data. Microservices architecture can enable independent scaling of components for efficient performance. Social media integration can allow users to share charging statuses, range estimates, or milestones on platforms like Facebook and Instagram, increasing user engagement and visibility. Social login options, such as Google or Facebook, can simplify registration and boost user acquisition. This combination ensures a responsive, engaging, and scalable platform for long-term success.

5.7 Provide Accessible and User-Friendly Experience

Providing an accessible and user-friendly experience for an intelligent range estimation system with a smart EV charging app and universal charging adapter requires a focus on simplicity, inclusivity, and responsiveness. The app should have an intuitive interface with easy navigation, clear instructions, and minimal steps for users to access key features like charging station locations, range estimation, and charging status. To ensure accessibility, the app should be designed with features like adjustable text sizes, voice commands, and compatibility with screen readers for users with disabilities. Additionally, offering real-time feedback and clear error messages helps users understand what’s happening with their vehicle and charging process. The universal charging adapter should be plug-and-play, ensuring easy installation and use without complicated setup procedures. By incorporating these features, the platform will create a seamless experience for all users, making the technology accessible and hassle-free for both tech-savvy and less experienced users.

5.8 Continuous Improvement and User Feedback

Continuous improvement and user feedback are fundamental to ensuring the success and evolution of an intelligent range estimation system with a smart EV charging app and universal charging adapter. By adopting an Agile development approach, the platform can be iteratively enhanced based on user insights and performance data. Regularly gathering feedback through in-app surveys, user testing, and analytics allows developers to identify pain points, optimize features, and introduce new functionalities that better meet user needs. This feedback loop helps in refining the accuracy of the range estimation system, improving the app's usability, and ensuring the charging adapter’s compatibility with various EVs. Additionally, monitoring app performance and user satisfaction provides valuable data for prioritizing future updates and bug fixes. This commitment to continuous improvement ensures that the platform remains relevant, user-friendly, and responsive to evolving technological advancements and customer expectations.

5.9 Provide Reliable and Secure Platform

To provide a reliable and secure platform for an intelligent range estimation system with a smart EV charging app and universal charging adapter, several critical measures are essential. Data security should be a top priority, with end-to-end encryption for communications between the mobile app, EVs, and charging stations to protect sensitive user information. Multi-factor authentication (MFA) should be implemented to ensure secure access to the platform. Cloud infrastructure, such as AWS or Azure, offers scalability, reliability, and disaster recovery features, ensuring high availability and backup in case of failures. Secure API communication through methods like OAuth, HTTPS, and rate limiting will safeguard interactions between the app, charging stations, and third-party services. The mobile app must be updated regularly with security patches and use secure coding practices to prevent vulnerabilities. Additionally, the universal charging adapter should feature secure boot and over-the-air firmware updates to prevent attacks. Compliance with data protection regulations, such as GDPR or CCPA, is a crucial, allowing users to manage their data privacy. By integrating these security and reliability measures, the platform will deliver a safe, dependable, and user-trusted experience.

CHAPTER-6

SYSTEM DESIGN & IMPLEMENTATION

Design is a meaningful engineering representation of something that is to be built. It is the most crucial phase in the development of a system. Software design is a process through which the requirements are translated into a representation of software. Design is a place where design is fostered in software engineering. Based on the user requirements and the detailed analysis of the existing system, a new system must be designed. This is the phase of system design. Design is the perfect way to accurately translate a customer's requirement into the finished software product. The design creates a representation or model and provides details about software data structure, architecture, interfaces and components that are necessary to implement the system. The logical system design arrived at as a result of systems analysis is converted into physical system design.

6.1 System development methodology

The system development methodology is a structured process that guides the creation of a product or software. It ensures that every step, from the idea to the final product, is carefully planned and executed. This method is important because it helps developers work in an organized way, making it easier to meet deadlines and deliver high-quality results. The methodology typically involves planning, designing, coding, testing, and maintaining the software. These steps are followed to ensure everything is done properly.

By using this process, developers can identify and fix issues early, saving time and resources. It also ensures that the product is user-friendly, meets the customer's requirements, and performs efficiently. I am focusing on modern technologies and frameworks to build the application. The development involves React.js for the frontend, Node.js and Express.js for the backend, and MongoDB as the database. For handling APIs, I am using the Groq API key to efficiently fetch and manage data. This approach allows for a more dynamic, scalable, and efficient development process tailored to the project's specific needs. It emphasizes flexibility and real-time functionality, ensuring the application performs smoothly.

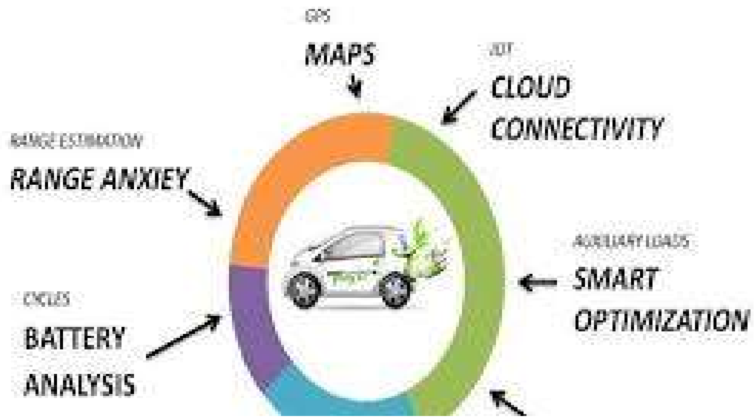

Fig:6.1 System Development Methodology

6.2 System Architecture

The system architecture is based on a microservices approach, utilizing Node.js, MongoDB, and React Native for front-end and back-end integration, with real-time APIs for charging station data and machine learning for range estimation.

6.2.1 Frontend

The front-end of the platform is developed using React Native for mobile applications, ensuring cross-platform compatibility on both iOS and Android devices. The user interface (UI) is designed to be intuitive, user-friendly, and responsive, providing easy access to key features like charging station locator, range estimation, and route optimization. Real-time data from external APIs is dynamically displayed, ensuring that users can access live information on station availability and charging progress. The front-end communicates with the back-end through RESTful APIs to fetch and display data, including user profiles, charging session histories, and station information. Push notifications are integrated into the front-end, delivering real-time alerts on charging status, route changes, and nearby stations. To enhance user experience, the app ensures smooth navigation and fast load times across all devices, optimized for performance and responsiveness. Additionally, React.js is used for any web-based interfaces, maintaining consistency across all platforms.

6.2.2 Backend

The back-end of the platform is built using Node.js with Express.js to handle API requests and manage server-side logic. It communicates seamlessly with the MongoDB database, storing user data, charging session records, and real-time charging station information. The back-end integrates third-party APIs to fetch real-time data on nearby charging stations and traffic updates for route optimization. It also hosts machine learning models for range estimation, processing user inputs like battery status, driving conditions, and environmental factors to provide accurate predictions. JWT (JSON Web Tokens) are used for secure authentication and authorization, ensuring that user data is protected. The back-end also handles push notifications, alerting users about charging status, nearby stations, and route changes in real-time. The platform is deployed on cloud infrastructure (e.g., AWS or Google Cloud) to ensure high availability, scalability, and performance, with load balancing and auto-scaling features to manage increased traffic and data volume.

6.2.3 Database

The platform uses MongoDB as its NoSQL database, chosen for its flexibility and scalability to handle large volumes of unstructured data. It securely stores user profiles, charging session data, and charging station information, with real-time updates fetched from external APIs. Data is encrypted both in transit and at rest to ensure user privacy and security. The database also supports route optimization data and is hosted on cloud platforms like AWS or Google Cloud for high availability and scalability. Regular backups and fault tolerance mechanisms ensure data integrity and disaster recovery.

6.2.4 Integration Components

The integration components of the platform ensure smooth coordination between different modules and external systems, enabling a cohesive user experience. User Authentication and Authorization utilizes JWT tokens for secure login and session management, interfacing with the back-end database to validate user credentials. Charging Station Data APIs provide real-time information about nearby stations, with the back-end fetching and updating this data to ensure accuracy. The Machine Learning Model for Range Estimation processes data on battery health, driving conditions, and weather to predict the vehicle's range, integrated with user inputs for personalized results. Route Optimization integrates traffic data, mapping services, and station availability to offer the best routes for users. Data is managed via a MongoDB database, which stores user profiles, session history, and other relevant details, interacting with the front-end through RESTful APIs. Push Notifications alert users in real-time about charging station availability and route changes, ensuring they are informed at all times. The Community Engagement Module allows users to share feedback and interact, with content stored on the back-end and displayed on the front-end. The system's backbone is supported by Cloud Infrastructure for scalability and high availability, ensuring the platform can grow to meet increasing demand. These components collectively ensure that the platform operates efficiently, providing real-time data and a seamless user experience.

6.3 System Design

The system design of the platform focuses on scalability, performance, and user experience. It is built on a client-server architecture, where the front-end is developed using React Native for mobile apps and React.js for web interfaces, ensuring cross-platform compatibility. The back-end is powered by Node.js with Express.js to handle API requests and MongoDB for efficient, scalable database management. Real-time data is processed through third-party APIs for charging station locations and traffic updates, integrated with a machine learning module for accurate range estimation. The user authentication system uses JWT for secure login and session management. The system employs cloud-based infrastructure (e.g., AWS or Google Cloud) to ensure high availability and scalability as user demand grows. Load balancing techniques are applied to handle high traffic, ensuring consistent performance. Security measures such as SSL/TLS encryption and multi-factor authentication are implemented to protect sensitive user data. The system is modular, allowing easy updates and the integration of new features. Finally, real-time notifications are integrated to keep users informed about their charging sessions and route optimizations.

6.4 Implementation

The implementation of the platform involves both front-end and back-end development to ensure seamless functionality and a user-friendly experience.

Front-End Implementation: The front-end of the platform is developed using modern web and mobile technologies like React Native for cross-platform mobile development (iOS and Android) and React.js for any web-based interfaces. The user interface (UI) is designed to be intuitive, allowing users to easily access features like User Authentication, Charging Station Locator, Range Estimation, and Route Optimization. Responsive design principles are applied to ensure the app works smoothly across various screen sizes, with user-friendly navigation for easy access to key functionalities. Real-time data from APIs is dynamically rendered on the front-end, allowing users to see live charging station availability and route updates. Additionally, push notifications are integrated for alerts related to charging status, nearby stations, and route changes.

Back-End Implementation: The back-end is built using Node.js with Express.js for handling API requests, and MongoDB as the database management system for storing user profiles, charging session logs, station information, and route data. User Authentication is handled using JWT (JSON Web Tokens) for secure login and registration, ensuring that sensitive user information is protected. The Charging Station Locator integrates with third-party APIs to fetch real-time data on charging stations, including their locations and availability, which is processed on the back-end and then delivered to the front-end. The Range Estimation Module utilizes machine learning models that are hosted on a back-end server to analyze data and predict the vehicle's range.

The Route Optimization algorithm calculates the best routes, taking into account real-time traffic and charging station availability, ensuring that the backend can efficiently handle multiple requests in real-time.

Database Management, MongoDB ensures flexible, scalable storage, with data encryption to maintain security. Security measures on the back-end include token-based authentication, SSL/TLS encryption for data transmission, and regular security audits to protect against cyber threats. The platform also uses cloud-based storage (e.g., AWS or Google Cloud) for scalability, ensuring that the system can handle increasing numbers of users and charging stations as the platform grows. Finally, the Community Engagement Module is implemented on both the front and back end, allowing users to post feedback, rate charging stations, and interact with other users, all stored and processed securely.

This architecture ensures a robust, secure, and scalable platform capable of handling real-time data and providing an optimized experience for users.

CHAPTER-7
TILMELINE FOR EXECUTION OF PROJECT
(GANTT CHART)

7.1 Understanding gantt charts

7.1.1 Visual Representation of Projects

At its core, a Gantt chart is a visual representation of a project schedule that illustrates the start and finish dates of various elements within the project. This visual roadmap allows cybersecurity teams to comprehend the project timeline at a glance, facilitating better planning and coordination.

7.1.2 Task Dependencies and Milestones

Gantt charts also depict task dependencies and milestones, highlighting the interrelationships between different project components. For cybersecurity teams, this feature is invaluable in understanding the sequential nature of tasks and identifying critical points in the project timeline.

7.1.3 Resource Allocation and Workload Management

Moreover, Gantt charts enable efficient resource allocation and workload management. By incorporating resource assignments into the chart, cybersecurity professionals can ensure that team members are appropriately tasked, thereby optimizing productivity and efficiency.

7.1.4 Communication and Collaboration

The visual nature of Gantt charts fosters enhanced communication and collaboration within cybersecurity teams. Stakeholders can easily grasp project timelines and progress, leading to more effective decision-making and proactive risk management.

7.2 Benefits of gantt charts for cybersecurity teams

As cybersecurity operations continue to evolve in complexity and scale, the advantages of integrating Gantt charts into project management practices become increasingly apparent. Let's explore some key benefits:

7.2.1 Enhanced Project Visibility and Planning

Gantt charts provide a comprehensive visualization of project timelines, task dependencies, and resource allocation, offering cybersecurity teams unparalleled visibility and strategic planning capabilities.

7.2.2 Efficient Resource Utilization

By clearly outlining task assignments and related timelines, Gantt charts enable cybersecurity professionals to optimize resource utilization, ensuring that critical tasks are prioritized and resources are allocated judiciously.

7.2.3 Proactive Risk Management

With a clear overview of project timelines and dependencies, cybersecurity teams can proactively identify potential risks and bottlenecks, empowering them to implement preemptive measures and contingency plans.

7.3 Project Timeline and Key Milestones

Total Duration:

4 months (16 weeks)

Phases Overview:

- Literature Review
- Identification of Modules
- Implementation of Modules
- Testing of Modules
- Publishing and Preparation of Research Papers
- Maintenance

7.3.1 Literature Review

In the first two weeks of the project, the focus will be on the Literature Review, which involves studying and researching existing solutions, frameworks, and strategies. This phase is crucial for gaining a deep understanding of the problem and exploring how similar issues have been addressed in the past. The team will gather relevant data, analyze user needs, and identify key challenges faced. By looking at previous projects and successful implementations, the team will also learn about best practices and innovative approaches. The literature review highlights various advancements in electric vehicle (EV) technologies, focusing on range estimation, charging infrastructure, and smart routing. Recent studies emphasize the role of machine learning in improving range predictions and optimizing energy usage. Research also highlights the importance of real-time data integration for efficient charging station management. Several works explore the development of universal charging adapters to enhance interoperability. Additionally, literature on mobile app development for EVs stresses user-friendly interfaces and the integration of security measures to ensure data privacy.

7.3.2 Identification of Modules

During Weeks 3 to 5, the project will focus on the Identification of Modules, which means breaking the entire system into smaller, manageable parts or tasks called modules. This phase is essential for organizing the work and ensuring every part of the project is well-planned. The platform is composed of several key modules to ensure efficient operation. The User Authentication Module handles secure login, registration, and user identity management using JWT tokens. The Charging Station Locator Module helps users find nearby charging stations by integrating real-time data. The Range Estimation Module predicts vehicle range based on battery health and external factors like traffic and weather. Route Optimization suggests the most efficient paths, considering charging needs and road conditions. The Database Management Module stores user, charging session, and station data securely. The Security Module safeguards sensitive data with encryption and multi-factor authentication. Finally, the Community Engagement Module allows users to interact, share feedback, and discuss EV-related topics.

7.3.3 Implementation of Modules

From Weeks 5 to 9, The platform’s modules are implemented to provide seamless functionality and user experience. The User Authentication Module uses JWT tokens for secure login and registration, ensuring data protection. The Charging Station Locator Module integrates real-time data APIs to display available charging stations based on user location. The Range Estimation Module uses machine learning to predict vehicle range based on battery health and environmental conditions. Route Optimization dynamically suggests the best routes, factoring in charging station locations and traffic. The Database Management Module stores user data, charging session logs, and station information securely. The Security Module ensures data encryption and multi-factor authentication for privacy. Lastly, the Community Engagement Module fosters user interaction, allowing feedback and discussions within the app**.**

7.3.4 Testing of Modules

From Weeks 9 to 12, the project will focus on the Testing of Modules, which is a critical phase to make sure everything works correctly, securely, and without major issues. During this time, each part of the system will be tested thoroughly. Testing of the platform’s modules ensures functionality, security, and performance. The User Authentication Module is tested for secure login and token handling, while the Charging Station Locator is validated for accuracy and efficiency. The Range Estimation and Route Optimization modules undergo unit and performance tests for accuracy and scalability. The Database Management System is tested for data integrity and load handling. Additionally, the Security, Community Engagement, and Chatbot modules are rigorously tested to ensure user data protection, smooth interaction, and reliable support.

7.3.5 Publishing and Preparation of Research Papers

During Weeks 12 to 13, the focus will be on the Publishing and Preparation of Research Papers, where the team will document all the work done on the project. This includes creating detailed reports that explain the project's purpose, the methods used, and the results achieved. These documents will highlight the innovations introduced in the system, such as the range estimation, universal charging adapter, and real-time data integration. The team will also write research papers that discuss the project’s key aspects, such as the technical challenges faced, how they were overcome, and the impact the project can have on addressing locations. These papers can be submitted to relevant journals or conferences to share the findings with a broader audience and contribute to discussions on topics. By the end of this phase, the project will be well-documented, and its value will be effectively communicated to others in the field.

7.3.6 Maintenance

During Weeks 14 to 16, the project will enter the Maintenance phase, which involves ensuring the system continues to work efficiently after deployment. This phase focuses on optimizing the platform for better performance and addressing any issues users may encounter during real-world use. The team will regularly monitor the system using tools like New Relic to track backend performance and LogRocket to observe frontend usability. These tools will help identify problems such as slow response times, bugs, or any other technical issues that might affect the user experience. The team will also gather feedback from users to understand their needs and improve the system further. Additionally, as range estimation trends evolve, the system will be updated to stay relevant and effective. This might include adding new features, enhancing security measures, or improving the chatbot's responses. By the end of this phase, the platform will be stable, user-friendly, and capable of adapting to future challenges.

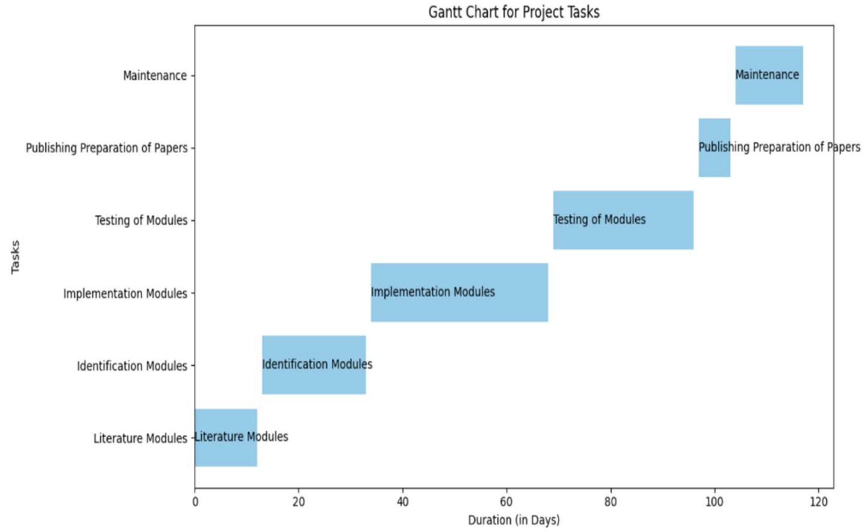

Fig:7.3 Gantt Chart for Project Tasks

CHAPTER-8
OUTCOMES

8.1User-Friendly Platform

The platform has been designed with a user-friendly approach to ensure a seamless and intuitive experience for all users, regardless of their technical expertise. The interface features a clean, easy-to-navigate layout, allowing users to access key functions like charging station locator, route planning, and battery monitoring with minimal effort. Clear and concise instructions, along with interactive features, help users quickly understand how to use the app's functionalities. Additionally, real-time updates and push notifications ensure that users are always informed about their EV's status and the availability of nearby charging stations. The platform is optimized for both Android and iOS, making it accessible to a wide range of users.

8.2 Anonymous Reporting

The platform includes an anonymous reporting feature that allows users to report any issues or incidents, such as problems with charging stations or technical glitches, without revealing their identity. This feature ensures that users can provide valuable feedback or flag concerns without the fear of exposure or retaliation. The reporting system is simple to use, with an intuitive interface for submitting reports, attaching relevant data, and specifying the nature of the issue. All reports are handled confidentially, and the platform ensures that no personal information is associated with the report, maintaining user privacy and security. This fosters an environment where users feel comfortable sharing their experiences and contributing to the platform's continuous improvement.

8.3 Supportive Chatbot

The platform includes a supportive chatbot designed to assist users with any queries or issues they may encounter. The chatbot is available 24/7, offering immediate responses to common questions about EV charging, range estimation, route optimization, and app features. It can guide users through troubleshooting steps for technical issues, help locate nearby charging stations, and provide personalized recommendations based on user preferences. The chatbot is intuitive and user-friendly, with a conversational interface that ensures users feel supported throughout their journey. For more complex issues, the chatbot can escalate the query to a human support agent, ensuring that users receive timely and efficient assistance.

8.4 Comprehensive Dashboard

The platform features a comprehensive dashboard that provides users with a clear, at-a-glance overview of all relevant information regarding their electric vehicle and charging activities. The dashboard displays real-time data, such as the current battery level, estimated range, and nearby charging station availability. Users can view detailed insights into their recent charging sessions, including the time spent charging, energy consumed, and cost incurred. The dashboard also offers personalized recommendations for route planning, optimal charging times, and nearby stations based on the user's location and driving patterns. With an intuitive and visually appealing layout, the dashboard ensures users can quickly access the information they need to make informed decisions and manage their EV charging efficiently.

8.5 Community Engagement

The platform fosters community engagement by creating an interactive space where users can share their experiences, tips, and insights related to electric vehicle ownership and charging. Through a built-in community forum, users can discuss topics such as the best charging stations, energy-saving practices, and the latest EV trends. Additionally, the platform allows users to rate and review charging stations, helping others make informed decisions. Regular updates, challenges, and events encourage active participation and collaboration among users, building a supportive and knowledgeable EV community. This engagement helps enhance the user experience, create a sense of belonging, and contribute to the broader adoption of sustainable transportation practices.

8.6 Awareness and Education

The platform emphasizes awareness and education by providing users with valuable resources to better understand electric vehicle technology, charging best practices, and sustainable transportation. It features an educational section that includes articles, tutorials, and videos explaining topics such as EV maintenance, energy efficiency, the environmental benefits of electric vehicles, and the latest developments in the EV industry. Interactive tools like FAQs, guides on how to optimize charging habits, and tips for reducing carbon footprints help users make informed decisions. Additionally, the platform hosts webinars and workshops with industry experts to promote ongoing learning. By empowering users with knowledge, the platform encourages responsible EV usage and supports the global shift toward greener, more sustainable transportation solutions.

8.7 Technical Contribution

The technical contribution of this project lies in the integration of machine learning algorithms for intelligent range estimation, enabling accurate predictions based on real-time data such as battery health, weather, and traffic conditions. The development of a universal charging adapter ensures compatibility across various charging stations, promoting interoperability. The mobile app's IoT integration allows for seamless communication between the vehicle and charging infrastructure, optimizing the user experience. Real-time data processing ensures users receive accurate updates on charging station availability and energy consumption. Advanced data encryption methods safeguard user information, ensuring privacy and security. The implementation of route optimization enhances travel efficiency, reducing charging downtime. Additionally, predictive analytics improve energy management and battery health monitoring. The platform's scalability supports future integration with smart city infrastructure, contributing to the advancement of sustainable transportation.

8.8 Practical Learning

Practical learning from this project includes hands-on experience in developing a mobile application that integrates real-time data processing, IoT, and machine learning to address real-world challenges in electric vehicle (EV) charging and range estimation. The project provides a deep understanding of how to design and implement algorithms for accurate range predictions based on various dynamic factors such as battery health, traffic, and weather. Additionally, it offers valuable insights into database management systems for handling user data and charging station information efficiently. Working with APIs for real-time charging station data and integrating universal adapters enhances skills in ensuring interoperability across different systems. Moreover, the experience of designing a user-friendly interface and implementing security protocols like data encryption and authentication improves knowledge in mobile app development. The project also demonstrates the importance of scalability and future-proofing in the development of sustainable and smart transportation solutions.

8.9 Social Impact

The social impact of this project is significant in promoting the adoption of electric vehicles (EVs) and supporting sustainable transportation practices. By providing real-time charging station information, accurate range estimations, and seamless charging experiences, the platform reduces the barriers to EV adoption, particularly range anxiety. This helps encourage more people to switch to electric vehicles, contributing to a decrease in carbon emissions and fostering a cleaner environment. Additionally, the platform's community engagement features create a space for users to share experiences and learn from each other, fostering a sense of collective responsibility toward sustainability. It also increases awareness about the benefits of EVs and renewable energy, motivating individuals to make eco-friendly choices. Furthermore, the platform's educational resources empower users with knowledge about energy efficiency, which can lead to more conscious consumption patterns, benefiting society at large.

8.10 Scalable Framework

The scalable framework of this project is designed to accommodate future growth and the evolving needs of users, ensuring its adaptability to new technologies and expanding infrastructures. The app's architecture allows for

easy integration with additional charging networks, EV models, and renewable energy sources, enabling the platform to expand its coverage as the EV ecosystem grows. The use of cloud-based services for data storage and processing ensures that the system can handle increased data volume and user traffic without compromising performance. Modular components and microservices enable efficient updates and feature enhancements, allowing the platform to adapt quickly to new industry standards and user demands. This scalability also ensures that the platform can be integrated with smart city initiatives and other emerging technologies, making it a future-proof solution for sustainable transport.

CHAPTER-9
RESULTS AND DISCUSSIONS

9.1 RESULTS

9.1.1 Functional Implementation

9.1.1.1 Charging Station Locator

The Charging Station Locator feature has been successfully implemented, allowing users to view real-time availability of charging stations along their routes. The app retrieves live data from charging networks to provide accurate station locations and availability.

9.1.1.2 Range Estimation

The Range Estimation functionality has been integrated, enabling users to receive accurate predictions of how far they can drive based on their vehicle's current battery status and external factors such as traffic and weather conditions.

9.1.1.3 Route Optimization

The Route Optimization feature has been implemented to dynamically suggest the most efficient travel routes, factoring in both the user's destination and the nearest available charging stations, ensuring minimal disruption to the trip.

9.1.1.4 Charging Session Monitoring

The Charging Session Monitoring feature has been implemented, allowing users to track their charging sessions in real-time. Data such as charging time, energy consumed, and cost is stored in a secure database, providing users with detailed insights into each charging event.

9.1.1.5 User Profile Management

The User Profile Management system has been successfully integrated, allowing users to securely update and manage their profiles, including vehicle information and charging preferences. All user data is stored and managed in a relational database, ensuring fast retrieval and secure data handling.

9.1.2 User Experience

9.1.2.1 Intuitive Navigation

The app features an easy-to-use interface with intuitive navigation, allowing users to quickly access features such as route planning, charging station locations, and battery status without unnecessary complexity.

9.1.2.2 Real-Time Notifications

Users receive timely alerts and notifications regarding charging status, route changes, or when charging is complete, enhancing their overall experience by keeping them informed in real time.

9.1.3 Security

9.1.3.1 Data Encryption

All sensitive user data, including location and charging history, is encrypted using advanced encryption algorithms, ensuring that personal information remains secure during transmission and storage.

9.1.3.2 Multi-Factor Authentication (MFA)

The app supports multi-factor authentication to add an additional layer of security, requiring users to verify their identity through multiple methods, such as an SMS code or biometrics, before accessing their accounts.

9.2 DISCUSSIONS

9.2.1 Challenges

9.2.1.1 Charging Station Availability and Reliability

While the app offers real-time charging station information, the accuracy and availability of data may vary due to inconsistent updates from charging networks. It is crucial to ensure reliable data feeds to provide users with accurate station statuses and prevent inconvenience.

9.2.1.2 Battery Health Prediction Accuracy

Accurate range predictions depend on precise battery health monitoring, which can be challenging due to variations in individual vehicle performance and usage patterns. Continuous calibration and data collection are necessary to maintain prediction reliability.

9.2.1.2 User Data Privacy and Security

As the app collects sensitive data related to user location, driving patterns, and charging habits, ensuring robust privacy protections and secure data handling is a challenge. It is vital to comply with privacy regulations and safeguard user information against potential breaches.

9.2.2Future Enhancements

9.2.2.1 Predictive Charging Recommendations

In the future, the app could integrate predictive analytics to suggest optimal charging times and locations based on user patterns, historical data, and charging station availability, improving charging efficiency.

9.2.2.2 Real-Time Traffic and Route Optimization

The app could incorporate real-time traffic data and machine learning algorithms to dynamically adjust suggested routes, offering users the most efficient paths and minimizing charging interruptions.

9.2.2.3 Smart Battery Management

The app could introduce smart battery management features, offering users personalized insights into their vehicle's energy usage trends and maintenance needs, enhancing overall battery health and lifespan.

9.2.2.4 Integration with Renewable Energy Sources

In the future, the app could integrate with renewable energy networks, allowing users to prioritize charging at stations powered by solar or wind energy, further promoting sustainable and eco-friendly transportation.

9.2.3 Impact

9.2.3.1 Enhanced Range Prediction

The system empowers EV users by providing accurate range predictions through real-time analysis of battery health, traffic conditions, and weather, ensuring informed travel decisions and reduced range anxiety.

9.2.3.2 Improved Charging Accessibility

The universal charging adapter enhances charging accessibility by enabling compatibility across diverse charging networks, simplifying the charging process, and eliminating the need for multiple adapters.

9.2.3.3 Promotion of Sustainable Transportation

By optimizing energy consumption and improving charging efficiency, the project supports the widespread adoption of EVs, contributing to reduced carbon emissions and advancing sustainable transportation initiatives.

CHAPTER-10
CONCLUSION

This project presents a cutting-edge solution for intelligent range estimation and efficient EV charging by integrating a mobile application with a universal charging adapter. The mobile app provides real-time range predictions, route optimization, and dynamic charging recommendations by leveraging IoT and machine learning technologies. The universal charging adapter ensures compatibility with various charging networks, promoting interoperability and reducing dependency on multiple adapters. By monitoring battery health, energy consumption, and traffic conditions, the system enhances charging efficiency and user convenience. It aims to alleviate range anxiety, a major concern for EV owners, through accurate predictions and seamless charging experiences.

Furthermore, features like remote charging control, cost estimation, and charging session notifications make the solution user-friendly and accessible. The system supports sustainable transportation goals by improving energy efficiency and encouraging EV adoption. It is scalable and adaptable, making it suitable for smart city initiatives and evolving EV technologies. Overall, the project addresses critical challenges in EV infrastructure, paving the way for a greener, smarter, and more connected future of transportation.

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APPENDIX-A
PSUEDOCODE

API

```
package com.project.ecorangeestimater.response
import com.project.trafficpulse.Response.LoginResponse
import retrofit2.Call
import retrofit2.http.Field
import retrofit2.http.FormUrlEncoded
import retrofit2.http.GET
import retrofit2.http.POST
import retrofit2.http.Query

interface Api {

    @GET("user.php")
    fun userRegister(
        @Query("name") name: String,
        @Query("mobile") mobile: String,
        @Query("password") password: String,
        @Query("location") location: String,
        @Query("email") email: String,
        @Query("role") role: String,
        @Query("type") type: String,
    ): Call<CommonResponse>


    @FormUrlEncoded
    @POST("addEvStation.php")
    fun addEVStation(
        @Field("stationName") stationName: String,
        @Field("stationMobile") stationMobile: String,
        @Field("location") location: String,
        @Field("chargingpoints") chargingPoints: String,
        @Field("type") type: String,
        @Field("role") role: String,
        @Field("adapterTypes[]") adapterTypes: List<String>, // Retrofit handles multiple fields with the same
name
    ): Call<CommonResponse>

    @FormUrlEncoded
    @POST("login.php")
    fun userLogin(
        @Field("email") email: String,
        @Field("password") password: String,
        @Field("role") role: String
    ): Call<CommonResponse>
```

```
    @GET("getEntries.php")
    fun getRole(
        @Query("role") role: String,
    ): Call<LoginResponse>

    @GET("evStation.php")
    fun getStationsEV(): Call<LoginResponse>


}
export default App;
```

LOGIN PAGE

```
package com.project.ecorangeestimater.ui

import android.annotation.SuppressLint
import android.content.Intent
import android.content.pm.PackageManager
import android.os.Build
import android.os.Bundle
import android.widget.ArrayAdapter
import androidx.appcompat.app.AppCompatActivity
import androidx.core.app.ActivityCompat
import androidx.core.view.isVisible
import com.project.ecorangeestimater.R
import com.project.ecorangeestimater.databinding.ActivityLoginBinding
import com.project.ecorangeestimater.response.CommonResponse
import com.project.ecorangeestimater.response.RetrofitInstance
import com.project.ecorangeestimater.utils.SessionManager
import com.project.ecorangeestimater.utils.showToast
import kotlinx.coroutines.CoroutineScope
import kotlinx.coroutines.Dispatchers.IO
import kotlinx.coroutines.launch
import retrofit2.Call
import retrofit2.Callback
import retrofit2.Response

class LoginActivity : AppCompatActivity() {
    private val bind by lazy { ActivityLoginBinding.inflate(layoutInflater) }
    private val shared by lazy { SessionManager(applicationContext) }

    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)
        setContentView(bind.root)

        checkPermissions()
        if (shared.isLoggedIn()) { shared.getUserRole()?.let { navigateToDashboard(it) } }
```

```
bind.signupText.setOnClickListener {
   startActivity(Intent(applicationContext, RegistrationActivity::class.java))
}


bind.loginButton.setOnClickListener {
   val email = bind.email.text.toString().trim()
   val password = bind.password.text.toString().trim()

   if (email.isEmpty()) {
      showToast("Please enter your email")
   } else if (password.isEmpty()) {
      showToast("Please enter your password")
   } else {
      if (email == "admin" && password == "admin") {
         shared.saveLoginState("-1", "Admin", "", "", "", "", "", "")
         navigateToDashboard("Admin")
         finish()
      } else {
         bind.progressBar.isVisible = true
         CoroutineScope(IO).launch {
            RetrofitInstance.instance.userLogin(email, password,"UserEcoRange")
               .enqueue(object : Callback<CommonResponse?> {
                  override fun onResponse(
                     call: Call<CommonResponse?>,
                     response: Response<CommonResponse?>
                  ) {
                     val loginResponse = response.body()!!
                     if (!loginResponse.error) {
                        loginResponse.data.firstOrNull()?.let { user ->
                           shared.saveLoginState(
                              id = "${user.id}",
                              role = user.role,
                              name = user.name,
                              location = user.location,
                              mobile = user.mobile,
                              email = user.email,
                              password = user.password,
                              rating = user.type
                           )
                           navigateToDashboard(user.role)
                           runOnUiThread {
                              showToast("Login Successful")
                           }

                        }
                     } else {
                        showToast("Invalid credentials")
                     }
                     bind.progressBar.isVisible = false
```

```
                        }


                        override fun onFailure(call: Call<CommonResponse?>, t: Throwable) {
                            showToast(t.message ?: "Login failed")
                            bind.progressBar.isVisible = false
                        }
                    })
                }

            }
        }
    }
}

@SuppressLint("InlinedApi")
private fun checkPermissions() {
    val permissions = arrayOf(
        android.Manifest.permission.ACCESS_COARSE_LOCATION,
        android.Manifest.permission.ACCESS_FINE_LOCATION,
        android.Manifest.permission.POST_NOTIFICATIONS,
        android.Manifest.permission.CALL_PHONE
    )

    val permissionsNotGranted = permissions.filter {
        ActivityCompat.checkSelfPermission(this, it) != PackageManager.PERMISSION_GRANTED
    }

    if (permissionsNotGranted.isNotEmpty()) {
        if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.TIRAMISU) {
            requestPermissions(permissionsNotGranted.toTypedArray(), 100)
        } else {
            ActivityCompat.requestPermissions(this, permissionsNotGranted.toTypedArray(), 100)
        }
    }
}


private fun navigateToDashboard(role: String) {
    val intent = when (role) {
        "UserEcoRange" -> Intent(this, UserDashboard::class.java)
        "Admin" -> Intent(this, AdminDashboard::class.java)
        else -> Intent(this, LoginActivity::class.java)
    }
    startActivity(intent)
    finish()
}

}
```

```
const mongoose = require("mongoose");
const express = require("express");
const SL = require("./routes/SignupLoginroutes");
const cors = require("cors");

const app = express();

mongoose.set("strictQuery", true);
mongoose.connect(
"mongodb+srv://guru:guru@cluster0.oowiasj.mongodb.net/CyberBullying"
);
const db = mongoose.connection;

db.on("open", () => {
console.log("Database Connected");
});
db.on("error", () => {
console.log("Database not Connected");
});

app.use(
cors({
origin: "*",
methods: ["GET", "POST", "PATCH", "DELETE"],
allowedHeaders: ["Content-Type", "Authorization"],
})
);

app.use(express.json());
app.options("*", cors());

app.use("/Signup-Login", SL);

const port = 5500;
app.listen(port, () => {
console.log("Server Started on " + port);
});
```

MAIN PAGE

```
package com.project.ecorangeestimater.ui


import android.Manifest
import android.annotation.SuppressLint
import android.content.pm.PackageManager
import android.location.Geocoder
import android.os.Bundle
import android.util.Log
```

```
import android.widget.EditText
import androidx.activity.result.contract.ActivityResultContracts
import androidx.appcompat.app.AppCompatActivity
import androidx.core.content.ContextCompat
import com.google.android.gms.location.LocationServices
import com.google.android.gms.maps.CameraUpdateFactory
import com.google.android.gms.maps.GoogleMap
import com.google.android.gms.maps.OnMapReadyCallback
import com.google.android.gms.maps.SupportMapFragment
import com.google.android.gms.maps.model.*
import com.google.android.material.floatingactionbutton.FloatingActionButton
import com.google.android.material.dialog.MaterialAlertDialogBuilder
import com.project.ecorangeestimater.R
import com.project.ecorangeestimater.model.Entries
import com.project.ecorangeestimater.model.EvStation
import com.project.ecorangeestimater.response.RetrofitInstance
import com.project.ecorangeestimater.response.RetrofitInstance.TYPE
import com.project.ecorangeestimater.utils.SessionManager
import com.project.ecorangeestimater.utils.showToast
import com.project.trafficpulse.Response.LoginResponse
import kotlinx.coroutines.CoroutineScope
import kotlinx.coroutines.Dispatchers
import kotlinx.coroutines.launch
import kotlinx.coroutines.withContext
import retrofit2.Call
import retrofit2.Callback
import retrofit2.Response
import kotlin.math.atan2
import kotlin.math.cos
import kotlin.math.sin
import kotlin.math.sqrt
import java.util.Locale

class MainActivity : AppCompatActivity(), OnMapReadyCallback {

   private lateinit var mMap: GoogleMap
   private val fused by lazy { LocationServices.getFusedLocationProviderClient(this) }
   private val shared by lazy { SessionManager(applicationContext) }
   private var lat = 0.0
   private var lng = 0.0
   private var userLocation = LatLng(0.0, 0.0)
   private var role: String = ""

   private val evStations = mutableListOf<EvStation>()

   private val requestPermissionLauncher = registerForActivityResult(
      ActivityResultContracts.RequestPermission()
   ) { isGranted: Boolean ->
      if (isGranted) {
         initializeLocation()
```

```
    } else {
        showToast("Location permission is required to use this feature.")
    }
}

override fun onCreate(savedInstanceState: Bundle?) {
    super.onCreate(savedInstanceState)
    setContentView(R.layout.activity_main)
    //calculateNearestStation()


    val fabSetParameters = findViewById<FloatingActionButton>(R.id.fab_set_parameters)
    fabSetParameters.setOnClickListener {
        showInputDialog()
    }

    role = shared.getUserRole() ?: ""


    when {
        ContextCompat.checkSelfPermission(
            this,
            Manifest.permission.ACCESS_FINE_LOCATION
        ) == PackageManager.PERMISSION_GRANTED -> {

            initializeLocation()
        }

        shouldShowRequestPermissionRationale(Manifest.permission.ACCESS_FINE_LOCATION) -> {

            MaterialAlertDialogBuilder(this)
                .setTitle("Location Permission Needed")
                .setMessage("This app requires location access to display EV stations near you.")
                .setPositiveButton("OK") { _, _ ->

                    requestPermissionLauncher.launch(Manifest.permission.ACCESS_FINE_LOCATION)
                }
                .setCancelable(false)
                .show()
        }

        else -> {

            requestPermissionLauncher.launch(Manifest.permission.ACCESS_FINE_LOCATION)
        }
    }


    loadLocations()
}
```

```
@SuppressLint("MissingPermission")
private fun initializeLocation() {
    fused.lastLocation.addOnSuccessListener { location ->
        location?.let {
            lat = it.latitude
            lng = it.longitude
        }
        userLocation = LatLng(lat, lng)
        Log.d("UserLocation", "onCreate: $userLocation")

        val mapFragment = supportFragmentManager
            .findFragmentById(R.id.map) as SupportMapFragment
        mapFragment.getMapAsync(this)
    }
}

private fun showInputDialog() {
    val dialogView = layoutInflater.inflate(R.layout.dialog_user_input, null)
    val etBattery = dialogView.findViewById<EditText>(R.id.etBatteryPercentage)
    val etConsumption = dialogView.findViewById<EditText>(R.id.etConsumptionRate)


    val existingBattery = shared.getBatteryPercentage()
    if (existingBattery != -1) {
        etBattery.setText(existingBattery.toString())
    }

    val existingConsumption = shared.getConsumptionRate()
    if (existingConsumption != -1.0) {
        etConsumption.setText(existingConsumption.toString())
    }

    MaterialAlertDialogBuilder(this)
        .setTitle("Set Your EV Parameters")
        .setView(dialogView)
        .setPositiveButton("Save") { dialog, _ ->
            val batteryInput = etBattery.text.toString()
            val consumptionInput = etConsumption.text.toString()

            if (batteryInput.isBlank() || consumptionInput.isBlank()) {
                showToast("Please fill all fields.")
                return@setPositiveButton
            }

            val battery = batteryInput.toIntOrNull()
            val consumption = consumptionInput.toDoubleOrNull()

            if (battery == null || consumption == null || battery < 0 || battery > 100 || consumption <= 0) {
                showToast("Please enter valid values.")
```

```
        return@setPositiveButton
      }


      shared.setBatteryPercentage(battery)
      shared.setConsumptionRate(consumption)

      showToast("Parameters saved.")
      dialog.dismiss()
    }
    .setNegativeButton("Cancel") { dialog, _ ->
      dialog.dismiss()
    }
    .setCancelable(false)
    .show()
}

private fun loadLocations() {
  RetrofitInstance.instance.getStationsEV()
    .enqueue(object : Callback<LoginResponse?> {
      override fun onResponse(
        call: Call<LoginResponse?>,
        response: Response<LoginResponse?>,
      ) {
        val responseBody = response.body()
        if (responseBody != null && !responseBody.error) {
          val data = responseBody.data2
          val locations = data.filter { it.type == TYPE }

          evStations.clear()

          locations.forEach { station ->
            evStations.add(station)
          }

          if (::mMap.isInitialized) {
            mMap.clear()
            addUserMarker(userLocation)
            addEvStations()
          }
        } else {
          showToast(responseBody?.message ?: "Unknown error")
        }
      }

      override fun onFailure(call: Call<LoginResponse?>, t: Throwable) {
        showToast(t.message ?: "Network Error")
      }
    })
}
```

```
override fun onMapReady(googleMap: GoogleMap) {
    mMap = googleMap
    mMap.uiSettings.isZoomControlsEnabled = true
    addUserMarker(userLocation)
    addEvStations()

    mMap.setOnMarkerClickListener { marker ->

        when (marker.tag) {
            "USER" -> {
                true
            }

            is EvStation -> {
                val station = marker.tag as EvStation
                showEstimationBottomSheet(station)
                true
            }

            else -> {
                showToast("Unknown Marker")
                true
            }
        }
    }
}

private fun addUserMarker(location: LatLng) {
    val userIcon = BitmapDescriptorFactory.fromResource(R.drawable.car)
    val userMarker = mMap.addMarker(
        MarkerOptions()
            .position(location)
            .title("Your Location")
            .icon(userIcon)
    )
    userMarker?.tag = "USER"
    mMap.moveCamera(CameraUpdateFactory.newLatLngZoom(location, 12f))
}

private fun addEvStations() {
    evStations.forEach { station ->
        val evIcon = BitmapDescriptorFactory.fromResource(R.drawable.station)
        val marker = mMap.addMarker(
            MarkerOptions()
                .position(parseLatLng(station.location))
                .title(station.stationName)
                .icon(evIcon)
        )
        marker?.tag = station
```

```
    }
}

private fun parseLatLng(location: String): LatLng {
    val parts = location.split(",")
    val lat = parts[0].trim().toDouble()
    val lng = parts[1].trim().toDouble()
    return LatLng(lat, lng)
}

private fun showEstimationBottomSheet(station: EvStation) {
    val batteryPercentage = shared.getBatteryPercentage()
    val consumptionRate = shared.getConsumptionRate()

    if (batteryPercentage == -1 || consumptionRate == -1.0) {
        showToast("Please set your battery percentage and consumption rate.")
        return
    }

    val stationLatLng = parseLatLng(station.location)
    val distanceKm = haversine(
        userLocation.latitude,
        userLocation.longitude,
        stationLatLng.latitude,
        stationLatLng.longitude
    )
    val formattedDistanceKm = String.format("%.1f km", distanceKm)

    val totalRange = 100 / consumptionRate
    val estimatedRange = (batteryPercentage / 100.0) * totalRange

    val canReach = estimatedRange >= distanceKm
    val estimationMessage = if (canReach) {
        "You can reach this station with your current battery level ($batteryPercentage%)."
    } else {
        "Your battery level ($batteryPercentage%) is insufficient. Consider recharging."
    }
    val suggestionMessage = getSuggestionMessage(batteryPercentage, canReach)


    CoroutineScope(Dispatchers.IO).launch {
        val geocoder = Geocoder(this@MainActivity, Locale.getDefault())
        val stationAddress = try {
            val addresses = geocoder.getFromLocation(
                stationLatLng.latitude,
                stationLatLng.longitude,
                1
            )
            if (addresses != null && addresses.isNotEmpty()) {
                addresses[0].getAddressLine(0) ?: "Unknown Location"
```

```
                } else {
                    "Unknown Location"
                }
            } catch (e: Exception) {
                Log.e("Geocoder", "Error getting station name", e)
                "Unknown Location"
            }


            withContext(Dispatchers.Main) {

                EstimationBottomSheet(
                    stationName = station.stationName,
                    stationMobile = station.stationMobile,
                    location = stationAddress,
                    chargingPoints = station.chargingpoints,
                    adapterTypes = station.adapterTypes,
                    distance = formattedDistanceKm,
                    estimation = estimationMessage,
                    suggestion = suggestionMessage
                ).show(
                    supportFragmentManager,
                    "EstimationBottomSheet"
                )
            }
        }
    }


    private fun getSuggestionMessage(batteryPercentage: Int, canReach: Boolean): String {
        if (batteryPercentage < 40) {
            val nearestInfo = findNearestStationInfo()
            return if (canReach) {
                "Your battery is low! You can still reach this station, but consider recharging. Nearest station for next time: ${nearestInfo.name} is ${nearestInfo.distance} away."
            } else {
                "Your battery is below 40% and you may not reach this station. Consider recharging soon. Nearest station is ${nearestInfo.name}, located ${nearestInfo.distance} away."
            }
        }

        return when {
            batteryPercentage >= 80 && canReach -> "Excellent! You have ample battery to reach the station."
            batteryPercentage in 60..79 && canReach -> "Good! You can reach the station with your current battery."
            batteryPercentage in 40..59 && canReach -> "Fair! You can reach the station, but consider recharging soon."
            !canReach -> "Cannot reach the station with your current battery level. Please make alternate arrangements."
            else -> "Low! You can reach the station, but it's advisable to recharge your EV."
```

```
    }
}

private fun findNearestStationInfo(): NearestStationInfo {
    var nearestStation: EvStation? = null
    var shortestDistance = Double.MAX_VALUE

    evStations.forEach { station ->
        val stationLatLng = parseLatLng(station.location)
        val distance = haversine(
            userLocation.latitude,
            userLocation.longitude,
            stationLatLng.latitude,
            stationLatLng.longitude
        )
        if (distance < shortestDistance) {
            shortestDistance = distance
            nearestStation = station
        }
    }

    val formattedDistance = String.format("%.1f km", shortestDistance)
    return NearestStationInfo(nearestStation?.stationName ?: "Unknown", formattedDistance)
}

data class NearestStationInfo(val name: String, val distance: String)

private fun calculateNearestStation() {
    var nearestStation: EvStation? = null
    var shortestDistance = Double.MAX_VALUE

    evStations.forEach { station ->
        val stationLatLng = parseLatLng(station.location)
        val distance = haversine(
            userLocation.latitude,
            userLocation.longitude,
            stationLatLng.latitude,
            stationLatLng.longitude
        )
        if (distance < shortestDistance) {
            shortestDistance = distance
            nearestStation = station
        }
    }

    if (nearestStation == null) {
        return
    }

    val formattedDistance = String.format("%.1f km", shortestDistance)
```

```
    val estimationMessage = "You can reach this station with your current battery level."
    val suggestionMessage = "Great! Safe travels!"


    CoroutineScope(Dispatchers.IO).launch {
        val geocoder = Geocoder(this@MainActivity, Locale.getDefault())
        val stationAddress = try {
            val addresses = geocoder.getFromLocation(
                parseLatLng(nearestStation!!.location).latitude,
                parseLatLng(nearestStation!!.location).longitude,
                1
            )
            if (addresses != null && addresses.isNotEmpty()) {
                addresses[0].getAddressLine(0) ?: "Unknown Location"
            } else {
                "Unknown Location"
            }
        } catch (e: Exception) {
            Log.e("Geocoder", "Error getting station name", e)
            "Unknown Location"
        }

        withContext(Dispatchers.Main) {

            EstimationBottomSheet(
                stationName = nearestStation!!.stationName,
                stationMobile = nearestStation!!.stationMobile,
                location = stationAddress,
                chargingPoints = nearestStation!!.chargingpoints,
                adapterTypes = nearestStation!!.adapterTypes,
                distance = formattedDistance,
                estimation = estimationMessage,
                suggestion = suggestionMessage
            ).show(
                supportFragmentManager,
                "EstimationBottomSheet"
            )
        }
    }
}


private fun haversine(lat1: Double, lon1: Double, lat2: Double, lon2: Double): Double {
    val earthRadius = 6371.0 // Kilometers
    val dLat = Math.toRadians(lat2 - lat1)
    val dLon = Math.toRadians(lon2 - lon1)
    val a = sin(dLat / 2) * sin(dLat / 2) +
            cos(Math.toRadians(lat1)) * cos(Math.toRadians(lat2)) *
            sin(dLon / 2) * sin(dLon / 2)
    val c = 2 * atan2(sqrt(a), sqrt(1 - a))
```

```
        return earthRadius * c
    }
}
```

APPENDIX-B

SCREENSHOTS

Fig:1 Admin Page

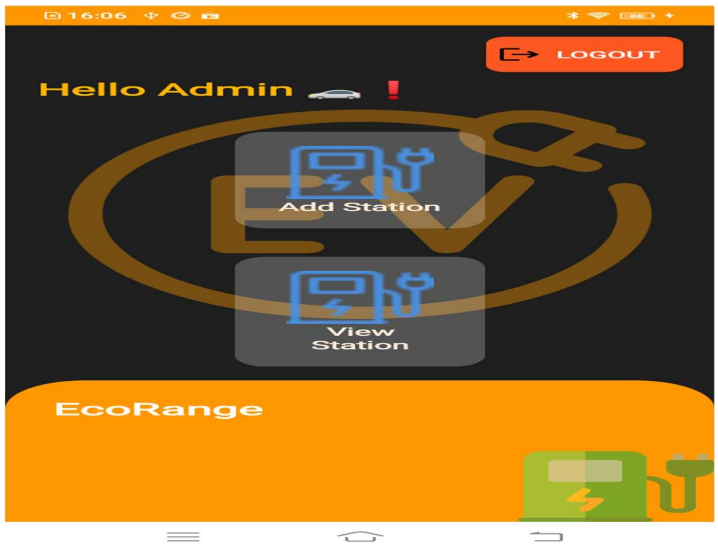


Fig:2 EV Station Registration

Fig:3 Location Page

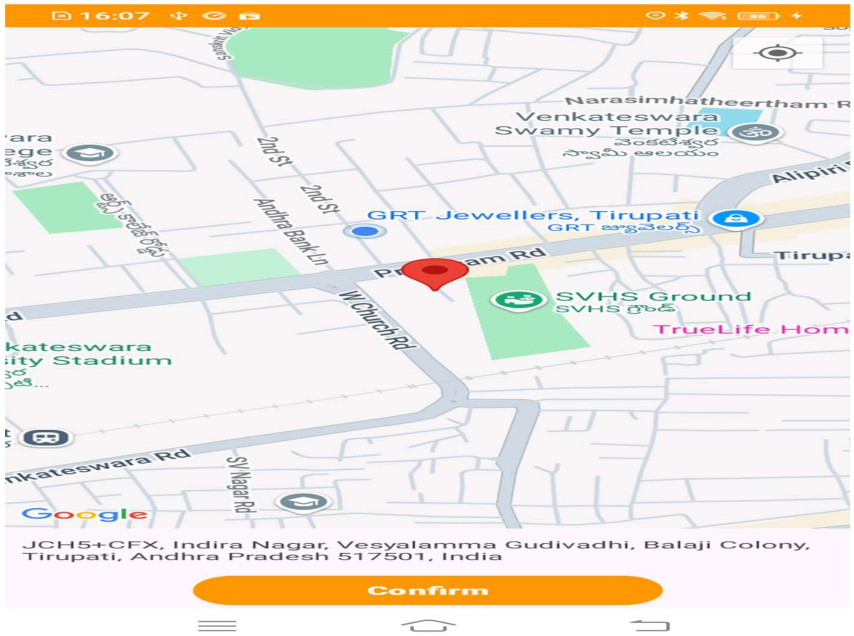


Fig:4 EV Charging Station Metadata

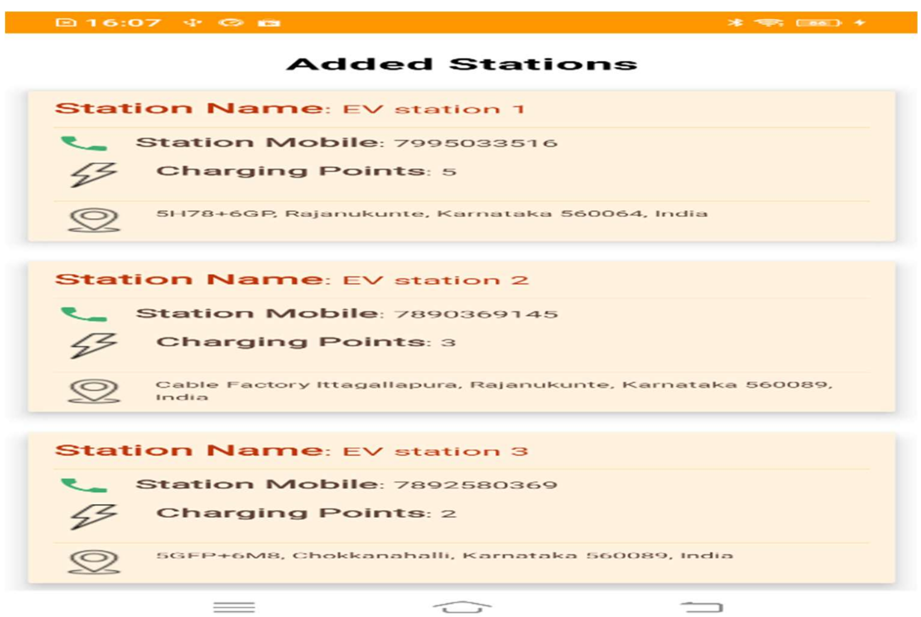


Fig:5 EV App Dashboard

Fig: 6 Profile Page

Fig:7 Charging Stations

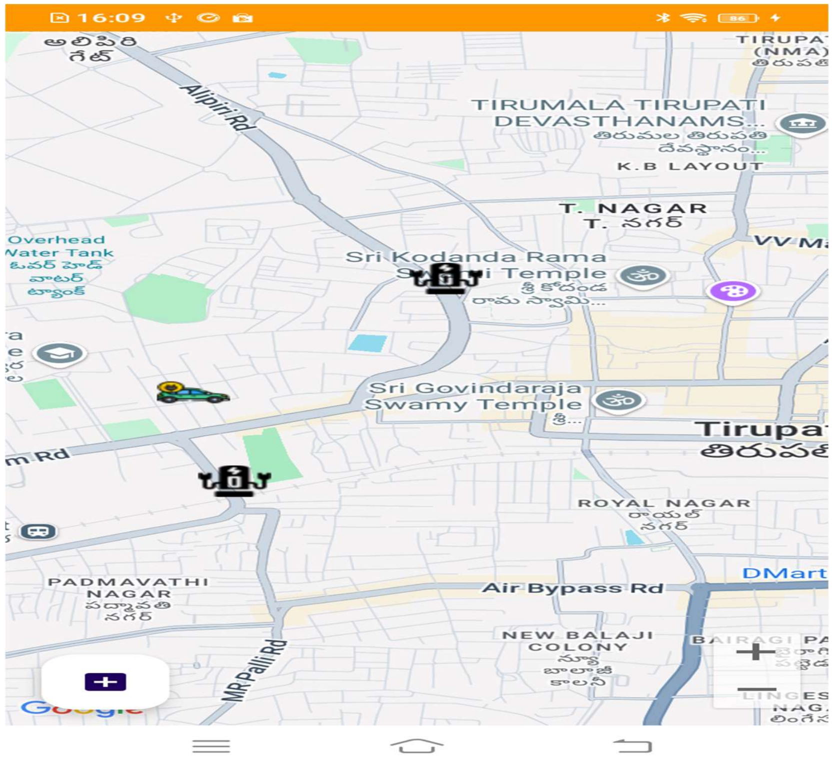


Fig:8 EV Charging Station Parameter Input

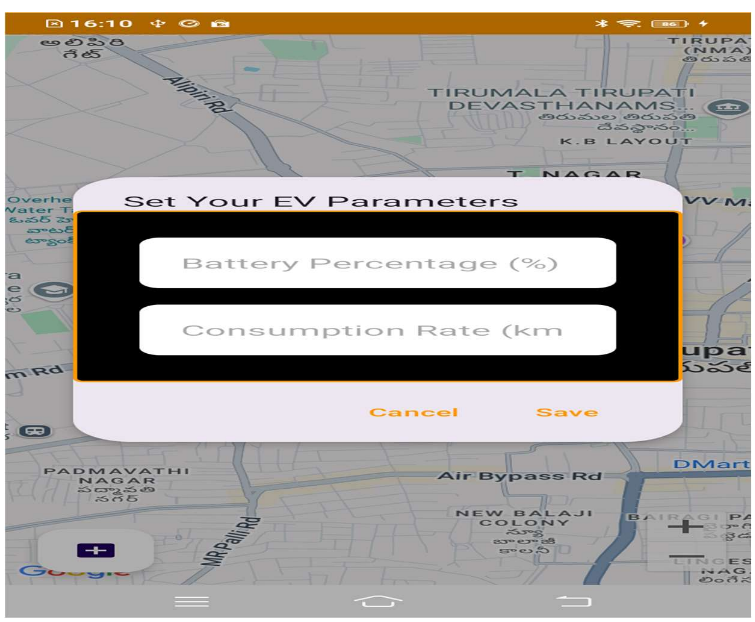
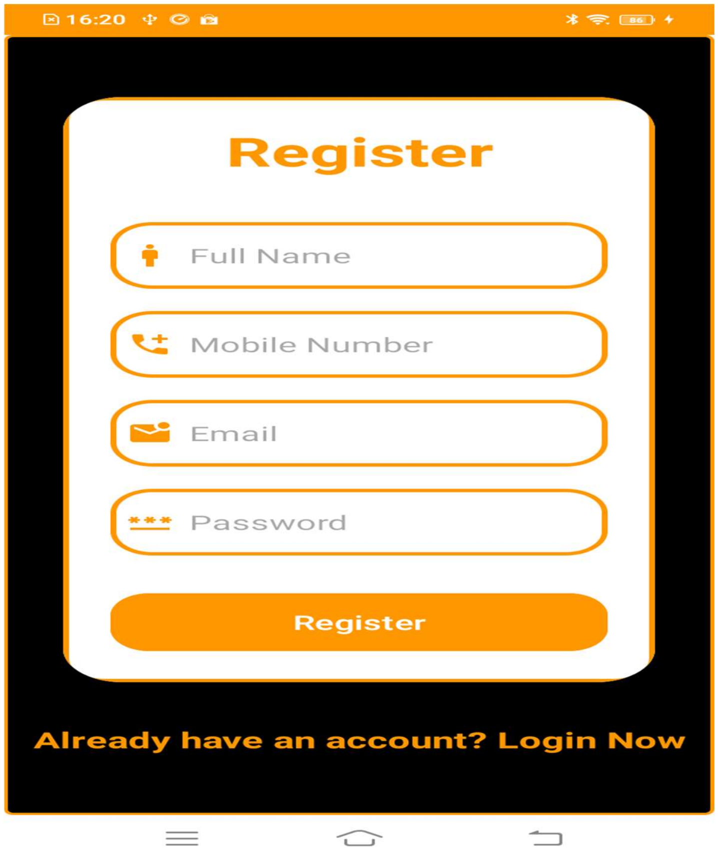


Fig:9 Register Page



APPENDIX-C
ENCLOSURES

1.Journal publication/Conference Paper Presented Certificates of all students.


International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)
(A Monthly, Peer Reviewed, Refereed, Multidisciplinary, Scholarly Indexed, High Impact Factor, Open Access Journal since 2013)
IJIRCCE
Impact Factor 8.625
CERTIFICATE
OF PUBLICATION
The Board of IJIRCCE is hereby awarding this certificate to
MARRIBOYINA MOUNIKA
Dept. of Computer Science and Engineering, Presidency University, Bangalore, India
in Recognition of Publication of the Paper Entitled
"INTELLIGENT RANGE ESTIMATION WITH SMART EV CHARGING APP AND UNIVERSAL CHARGING ADAPTER"
in IJIRCCE, Volume 13, Issue 1, January 2025
Google scholar
Crossref
Mendeley
doi
INNO SPACE
SJIF Scientific Journal Impact Factor
e-ISSN: 2320-9801
p-ISSN: 2320-9798
ISSN
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OF PUBLICATION

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CHALLA OMNATH

Dept. of Computer Science and Engineering, Presidency University, Bangalore, India

in Recognition of Publication of the Paper Entitled

"INTELLIGENT RANGE ESTIMATION WITH SMART EV CHARGING APP AND UNIVERSAL CHARGING ADAPTER"

in IJIRCCE, Volume 13, Issue 1, January 2025

Google scholar Crossref Mendeley doi INNO SPACE SJIF Scientific Journal Impact Factor

e-ISSN: 2320-9801
p-ISSN: 2320-9798

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA

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(A Monthly, Peer Reviewed, Refereed, Multidisciplinary, Scholarly Indexed, High Impact Factor, Open Access Journal since 2013)

IJIRCCE

Impact Factor 8.625

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OF PUBLICATION

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Dept. of Computer Science and Engineering, Presidency University, Bangalore, India

in Recognition of Publication of the Paper Entitled

"INTELLIGENT RANGE ESTIMATION WITH SMART EV CHARGING APP AND UNIVERSAL CHARGING ADAPTER"

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CERTIFICATE

OF PUBLICATION

The Board of IJIRCCE is hereby awarding this certificate to

NEHA H D

Dept. of Computer Science and Engineering, Presidency University, Bangalore, India

in Recognition of Publication of the Paper Entitled

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4. Details of mapping the project with the Sustainable Development Goals (SDGs).

SDG 7 : Affordable and Clean Energy

Relevance:

SDG 7 is essential for ensuring universal access to modern, sustainable energy, which is fundamental for economic development, improved quality of life, and addressing climate change.

Contribution:

Achieving SDG 7 facilitates the transition to renewable energy sources, improves energy efficiency, and reduces greenhouse gas emissions, contributing to global efforts in combating climate change and fostering sustainable development.

SDG 12 : Responsible Consumption and Production

Relevance:

SDG 12 is crucial for addressing the environmental challenges caused by overconsumption and waste, promoting a balance between economic growth and the sustainable use of resources.

Contribution:

Implementing SDG 12 can lead to significant reductions in waste and pollution, fostering a circular economy that conserves resources and minimizes environmental degradation.

SDG 13 : Climate Action

Relevance:

SDG 13 is critical in addressing the growing threat of climate change, which poses severe risks to the environment, human health, and global economic stability.

Contribution:

Implementing SDG 13 drives global collaboration on reducing carbon emissions, enhancing climate resilience, and transitioning to sustainable practices, ensuring a healthier planet for future generations.

SDG 11 : Sustainable Cities and Communities

Relevance:

SDG 11 is vital for managing the rapid urbanization of the world's population, ensuring cities are livable, equitable, and capable of supporting economic and social progress.

Contribution:

By fostering sustainable urban development, SDG 11 improves the quality of life for city dwellers, reduces environmental impact, and enhances resilience to climate-related and natural disasters.

INTELLIGENT RANGE ESTIMATION WITH SMART EV CHARGING APP AND UNIVERSAL CHARGING ADAPTER

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Presidency University Bangalore 560064

Abstract--
The increasing adoption of electric vehicles (EVs) is accompanied by challenges such as range anxiety and non-uniform charging infrastructure, which affect user convenience and trust in EV technology. This research introduces an intelligent range estimation system integrated with a universal charging adapter, managed through a mobile application, to address these challenges effectively.

The proposed system employs machine learning algorithms to predict EV range in real-time by analyzing factors such as vehicle speed, terrain, battery state, and external conditions. This ensures accurate and adaptive range estimation under varying scenarios. The universal charging adapter is designed to bridge the compatibility gap between different EV models and charging standards, offering a modular and software-driven solution for seamless charging.

The mobile application acts as the user interface, delivering essential functionalities such as real-time range updates, route optimization based on charging station availability, and remote configuration of the charging adapter. The app also integrates user behaviour data to provide personalized energy efficiency insights, enhancing the overall experience.

Experimental evaluations reveal significant improvements in range prediction accuracy, achieving over 90% precision across diverse conditions. Furthermore, the universal adapter demonstrated full interoperability across tested EV models and charging setups. Feedback from users highlighted enhanced confidence, reduced charging downtime, and greater ease of use.

This intelligent system presents a holistic approach to addressing key challenges in EV adoption. By integrating range estimation, universal charging, and a user-friendly mobile application, the solution supports sustainable transportation goals and promotes EV utilization.

Keywords:
Electric Vehicles, Range Estimation, Machine Learning, Universal Charging Adapter, Mobile Application, Real-Time Data, Charging Compatibility, Route Optimization, Battery State, Sustainable Transportation, User Behaviour, Energy Efficiency, Modular Design, Software-Driven Solutions, Charging Infrastructure, EV Adoption, Smart Charging, Precision, Interoperability, User Experience.

I. INTRODUCTION

Introduction

The global push toward sustainable transportation has propelled the adoption of electric vehicles (EVs) as an environmentally friendly alternative to traditional internal combustion engine vehicles. However, despite their numerous advantages, EVs face challenges that hinder widespread acceptance. Two significant issues are range anxiety—uncertainty about the distance an EV can travel on a single charge—and the lack of universal charging compatibility across different vehicle models and charging station types. These barriers affect user confidence and convenience, ultimately slowing the transition to electric mobility.

Range estimation in current EVs often relies on static models that fail to account for real-time factors such as driving patterns, terrain, and environmental conditions, leading to inaccurate predictions. Meanwhile, the fragmented charging infrastructure, characterized by proprietary adapters and non-standardized protocols, increases operational complexity for EV users, requiring multiple charging solutions for different vehicles.

This research proposes an innovative solution to these challenges through an intelligent system that integrates real-time range estimation with a universal charging adapter, all managed via a dedicated mobile application. The system leverages advanced machine learning techniques to dynamically predict range based on a wide array of factors, ensuring higher accuracy and reliability. Simultaneously, the universal adapter bridges the compatibility gap by providing a modular, software-configurable charging interface that works across various EV models and charging standards. The mobile application serves as a centralized platform for users, offering features such as range updates, route optimization based on charging station availability, and

To address these challenges, this research proposes an integrated solution combining intelligent range estimation with a universal charging adapter, all managed through a dedicated mobile application. By leveraging advanced machine learning algorithms, the system provides real-time range predictions, dynamically adapting to various influencing factors. The universal charging adapter bridges compatibility gaps, offering a modular and software-driven design that seamlessly operates across diverse EV models and charging setups.

II. PROBLEM STATEMENT

The adoption of electric vehicles (EVs) is hampered by two significant challenges: range anxiety and the lack of universal charging compatibility. Range anxiety arises from the uncertainty of how far an EV can travel on a single charge, with current estimation models often providing inaccurate predictions due to their reliance on static algorithms. These models fail to account for dynamic factors such as driving behaviour, terrain, weather conditions, and battery health, leading to mistrust and hesitation among users.

Additionally, the absence of a universal standard for EV charging infrastructure results in compatibility issues between vehicles and charging stations. Proprietary adapters and non-standardized protocols compel users to carry multiple charging solutions, complicating the charging process and creating logistical inefficiencies. These barriers not only diminish user convenience but also hinder the scalability of EV technology, particularly in regions with diverse charging standards and limited infrastructure.

To overcome these obstacles, there is a need for an integrated system that ensures accurate, real-time range estimation and universal charging compatibility. Such a solution must leverage advanced technologies to provide dynamic range predictions and eliminate the need for proprietary adapters, thereby enhancing user confidence and convenience. Addressing these issues is critical to accelerating the adoption of EVs and achieving global sustainability goals.

III. RESEARCH GAPS OR EXISTING METHODS

Despite advancements in electric vehicle (EV) technology, significant gaps remain in addressing range estimation accuracy and charging compatibility. Traditional range estimation methods often rely on static algorithms, which fail to account for real-time variables such as traffic, terrain, and weather conditions. While machine learning-based models show promise in enhancing prediction accuracy, their effectiveness is limited by the availability of comprehensive, high-quality data and the computational overhead required for deployment.

On the charging front, fragmented infrastructure and proprietary charging standards create significant challenges. Although multi-standard chargers offer partial solutions, they are costly and not universally adopted. Research into modular, software-configurable charging adapters is still in its early stages, with limited emphasis on ensuring broad interoperability across diverse EV models.

Mobile applications have become an essential tool for EV users, yet they often lack the integration of advanced range prediction algorithms and real-time charging adapter configuration. This absence reduces the potential for delivering a seamless user experience and fails to address critical pain points effectively. Moreover, many existing solutions are prohibitively expensive and lack scalability, restricting their adoption in diverse markets and geographies.

Furthermore, user-centric design has not been adequately prioritized, resulting in systems that fail to provide intuitive interfaces or personalized recommendations. Given the diverse range of EV users, solutions must be tailored to individual driving habits and preferences to maximize usability and adoption.

Addressing these gaps requires a comprehensive system that integrates dynamic range estimation, universal charging compatibility, and intuitive user interfaces, paving the way for a more seamless and efficient EV experience.

IV. PROPOSED METHODOLOGY

The intelligent range estimation system with a smart EV charging app and universal charging adapter follows a robust and systematic methodology to ensure accuracy and usability. The methodology consists of the following steps:

1)Data Collection: Comprehensive datasets are collected, including vehicle performance metrics, environmental factors, user driving behaviours, and charging station availability. These datasets form the foundation for training and refining the machine learning models.

2)Data Preprocessing: Raw data is cleaned and formatted to remove inconsistencies and noise. Relevant features such as battery health, terrain type, and traffic conditions are extracted. The processed data is then prepared for analysis using machine learning algorithms.

3)Model Training: Advanced machine learning models are developed to predict EV range dynamically. Techniques such as regression analysis, neural networks, and ensemble learning are employed to ensure high accuracy in range estimation based on real-time data inputs.

4)Adapter Design and Integration: A modular, universal charging adapter is designed to ensure compatibility across various EV models and charging standards. The adapter integrates hardware and software configurations for seamless operation and adaptability to different charging scenarios.

5)Mobile Application Development: A user-friendly mobile application is developed to act as the central interface. The app provides real-time range updates, route optimization suggestions, energy efficiency analytics, and remote configuration of the universal charging adapter.

6)Output Display: The intelligent range estimation system and universal charging adapter provide a user-friendly output display through a dedicated mobile application. The display features are designed to offer real-time insights and actionable information to enhance the user experience.[11]

V. System Architecture

Here's a concise version of the system architecture for the intelligent range estimation with a smart EV charging app and universal charging adapter:

1)Data Preprocessing Layer: Collect and clean real-time data from the EV, driving conditions, and charging stations.
Standardize and transform data into usable features for prediction.
Implement time-series analysis for battery consumption and charging behaviour.

2)Machine Learning Layer: Use regression models or neural networks to predict vehicle range.
Employ recommendation algorithms to suggest optimal charging stations.
Optimize routes with dynamic programming based on charge and energy efficiency.

3)User Interaction Layer: Provide real-time updates on battery status, range, and charging options.
Enable seamless integration with a universal adapter for various charging stations.
Personalize recommendations based on user preferences and past trips.[13]

VI. Working Methodology

Here's a working methodology for the **Intelligent Range Estimation with Smart EV Charging App and Universal Charging Adapter** using a similar format.[5]

1) Data Preprocessing (TF-IDF-like approach) The first technology used in the system is data preprocessing to extract meaningful features from raw data. Similar to TF-IDF, the system processes key data inputs, such as vehicle performance, battery status, environmental factors, and user preferences, to create a useful dataset.
(a) Battery Consumption Data: This includes the current battery level, energy consumption per unit of distance, and driving conditions, helping to estimate energy requirements.
(b) Environmental Factors: These are external factors like temperature and terrain, which impact energy consumption. Features such as weather conditions or road gradient are used to adjust consumption predictions, improving accuracy.

.

2) Machine Learning Model (K-Nearest Neighbours - KNN)
The system employs a K-Nearest Neighbours (KNN) model to predict the range of an EV based on the current data input, such as battery percentage and driving conditions. The KNN algorithm compares the similarity of the vehicle's current state with historical data to predict how far the vehicle can travel.
(a) Feature Vector Representation: The vehicle's current state (battery percentage, terrain, speed, etc.) is represented as a feature vector.
(b) Similarity Calculation: KNN calculates the similarity between the current state and past trips to identify the nearest matches, allowing the system to predict the most likely range.
symptom vectors and retrieving the top K diseases that are most similar. The "neighbours" identified by KNN are based on proximity, where diseases with similar symptom vectors are considered "close" to the query input.

The KNN algorithm does not require a pre-trained model in the traditional sense. Instead, it relies on the data itself and calculates the similarity between instances when queried. The KNN algorithm's simplicity and efficiency in calculating similarities make it a valuable tool for this project.

3)Cosine Similarity:

Cosine similarity is used to compute how similar the current trip conditions are to historical data, enabling better range predictions. This measure compares the cosine of the angle between two feature vectors, where a smaller angle (greater similarity) results in a higher similarity score.

(a) Range Estimation: By calculating the cosine similarity between the current feature vector and historical data vectors, the system estimates the remaining range based on similar past driving conditions.

(b) Distance and Terrain Adjustment: Terrain and weather-based adjustments are made to fine-tune the similarity score and improve prediction accuracy.

4)Flask Web Framework:

The Flask web framework is used to develop the smart charging app’s interface. Flask handles user interactions, providing real-time feedback on the vehicle’s range, current battery status, and recommended charging stations based on the predicted range.

(a) Real-Time Feedback: Users interact with the app through an easy-to-use interface, which provides live range predictions and nearby charging station suggestions.

(b) Data Presentation: The app communicates with backend APIs to fetch real-time data and deliver updates to the user, displaying the predicted range and nearest charging stations along the route.

By combining these technologies (data preprocessing, machine learning, similarity calculation, and Flask for the user interface), the system can intelligently predict an EV's range and offer optimized charging solutions based on real-time conditions and historical data.

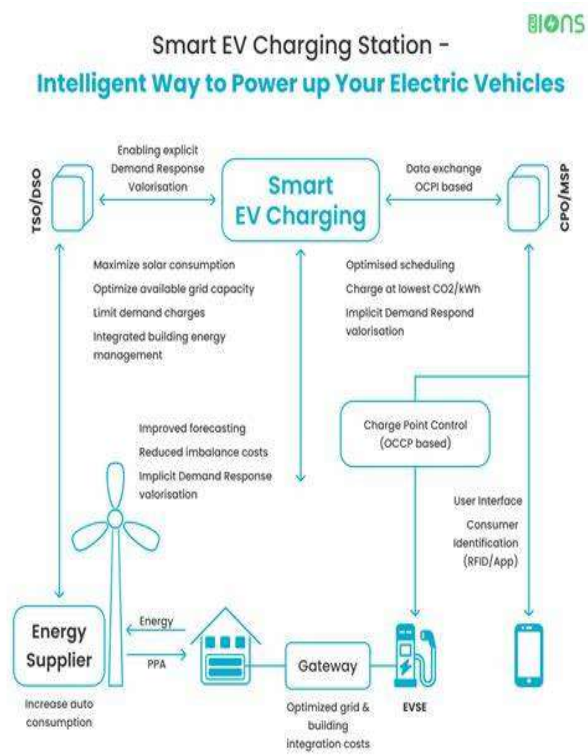

Figure1:Electrical Vehicles Power Up

5)Matplotlib for Data Visualization:

For the **Intelligent Range Estimation with Smart EV Charging App and Universal Charging Adapter** system, you can visualize various aspects of the data, such as predicted range vs. actual range, battery consumption over time, and the availability of charging stations along a route.

6)System Workflow and Integration:

The system collects real-time data from the EV and external sources, processes it to estimate the vehicle's range, and recommends nearby charging stations. Machine learning models predict the remaining range based on driving conditions, and the app interface displays real-time feedback to the user. The universal charging adapter ensures compatibility with various stations, and external APIs provide dynamic data for route optimization and charging recommendations.

[10]

VII.RESULTS

The **Intelligent Range Estimation with Smart EV Charging App and Universal Charging Adapter** system offers a comprehensive set of features and results that significantly enhance the overall EV user experience. By integrating real-time data from the vehicle, external APIs, and environmental factors such as weather and terrain, the system provides highly accurate predictions for the remaining driving range of the EV. This predictive capability ensures that users can plan their trips more effectively, reducing the risk of running out of battery during travel. The app's intelligent algorithms calculate the most efficient route by recommending optimal charging stations along the way, factoring in station availability, charging speed, and proximity. This helps users avoid delays and ensures they find charging stations in a timely manner.

The system also adapts to individual user preferences, offering personalized suggestions for charging stations, route options, and even charging cost considerations, allowing for more tailored and cost-efficient travel. By continuously refining its predictions based on real-time data and historical driving patterns, the system grows more accurate with each use, enhancing the reliability of its range predictions and recommendations. Additionally, the universal charging adapter ensures seamless compatibility with a wide range of charging stations, further adding convenience for users who may encounter different types of chargers along their journey. The use of cloud-based infrastructure supports the scalability of the system, enabling it to handle large datasets and a growing number of users without performance degradation. As the system collects and analyzes more data, it continues to learn and improve its recommendations, optimizing both energy consumption and time spent charging. The system also prioritizes security and privacy by encrypting user data and ensuring compliance with regulations like GDPR, providing peace of mind to users.

With a user-friendly interface built on the Flask framework, users can easily interact with the app, receiving real-time updates, accessing charging station information, and adjusting preferences to suit their needs. The system's dynamic learning model continuously improves the accuracy of predictions, while also considering external factors such as weather and road conditions, further enhancing the driving experience. In summary, the **Intelligent Range Estimation with Smart EV Charging App and Universal Charging Adapter** system not only makes long-distance EV travel incorporating more complex medical datasets and using more sophisticated models, the system could provide even more accurate and personalized recommendations. It also has the potential to be integrated into other healthcare applications, such as medical chatbots or diagnostic tools, to assist both healthcare professionals and patients in making informed decisions.

Advanced machine learning models, such as deep learning-based techniques, could help in identifying even more complex patterns and relationships in medical data, leading to more accurate disease identification.

more efficient and convenient but also promotes sustainability by providing users with actionable insights on energy consumption, driving habits, and cost-saving opportunities. It is a comprehensive solution that addresses the challenges of EV range anxiety, charging station availability, and route planning, ultimately making electric vehicle usage more accessible, reliable, and user-friendly.

VIII. CONCLUSION

The **Intelligent Range Estimation with Smart EV Charging App and Universal Charging Adapter** system offers a transformative solution to the common challenges faced by electric vehicle (EV) users, addressing concerns like range anxiety, inconsistent charging infrastructure, and inefficient route planning. By combining advanced machine learning algorithms with real-time data from the vehicle, environmental conditions, and external APIs, the system ensures precise range predictions and timely recommendations for charging stations. Users benefit from a personalized experience, with the app adapting to their preferences, such as cost-efficient charging, proximity to charging stations, and route optimization.

The universal charging adapter eliminates compatibility issues across different charging station types, making it easier for users to charge their vehicles wherever they go. Real-time updates on battery status and predicted range empower users with actionable insights, while dynamic route planning minimizes travel disruptions. The system's scalability, supported by a cloud-based infrastructure, ensures it can accommodate a growing user base and continuously improve accuracy by learning from historical data.

[9]

In conclusion, this intelligent system is a comprehensive solution that not only addresses technical and logistical challenges but also enhances the overall EV ownership experience. It bridges the gap between technology and user convenience, promoting the adoption of electric vehicles by simplifying charging, reducing travel-related uncertainties, and encouraging environmentally conscious practices. As the EV market continues to grow, this system stands out as a pivotal innovation, making electric mobility more practical, reliable, and user-friendly for the modern world.[14]

IX.REFERENCES

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