Toward an Efficient and Resilient Electric Vehicle Charging Place Allocation Using Multiagent Approach

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***Abstract*—In this paper, we propose a smart charging prediction and automatic booking system for long-distance EV travel using multi-agent approach. Our approach includes three main modules: a charge prediction module that forecasts travel time and distance based on EV models, a smart booking module that suggests booking a slot before the EV charge is depleted, and an optimal route selection module that collaboratively recommends the best path based on charging station locations along with traffic status and overall travel time.**

***Index Terms*—Electric Vehicles; Multiagent Learning; Charge Prediction; Optimal Route;**

I. Introduction

This paper introduces a smart charging navigation booking system designed specifically for long-distance EV travels. The proposed approach is intended to integrate multi-agent learning techniques [1] and comprises three distinct modules. The charge prediction module integrates common machine learning techniques to predict travel time and distance, grounded in the characteristics of the EV models in use. The smart booking module is prepared to realize strategic recommendations of the reservation of a charging slot well in advance of the EV's charge depletion. The main contribution of this paper is to give a preliminary idea of the development of an integrated framework that combines facility location design with EV charging decision-making to provide a comprehensive solution for optimizing charging locations and routes based on the aforementioned user-centric factors.

II. Approach

Our approach is utilizing the three key components: A. The Charge Prediction Module, B. The Smart Booking Module, and C. The Optimal Route Selection Module.

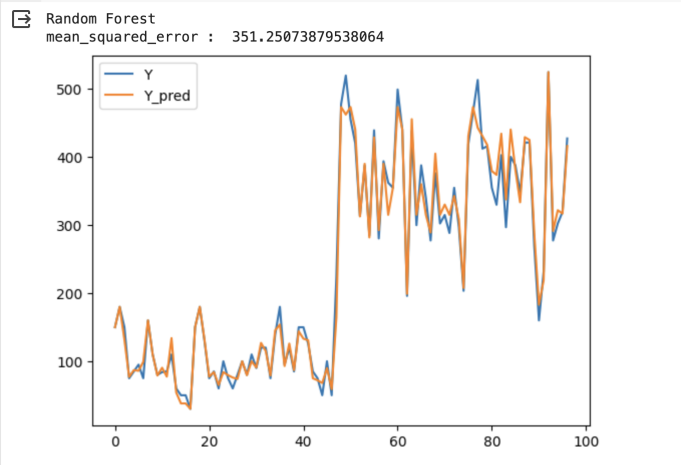

Fig. 1. Result of random regression algorithm

A. The Charge Prediction Module

The "Charging Prediction Module" is a component of our system that aims to predict the electric vehicle's (EV) travel distance. It operates by considering a multitude of relevant factors, including the current battery charge level, the age of the EV, the brand of the vehicle, detailed engine specifications, engine type, the current driving speed, the prevailing weather conditions, and the usage of interior appliances.

To accomplish this prediction task, the module utilizes a combination of existing techniques, specifically regression-based machine learning methods. In the context of regression-based machine learning, the module produces predictions based on historical and real-time data.

Using these machine learning techniques, the system generates range predictions for the electric vehicle (EV) output. Based on our preliminary evaluations of these algorithms, the Random Forest method consistently outperformed others, exhibiting a remarkable accuracy with an error margin of

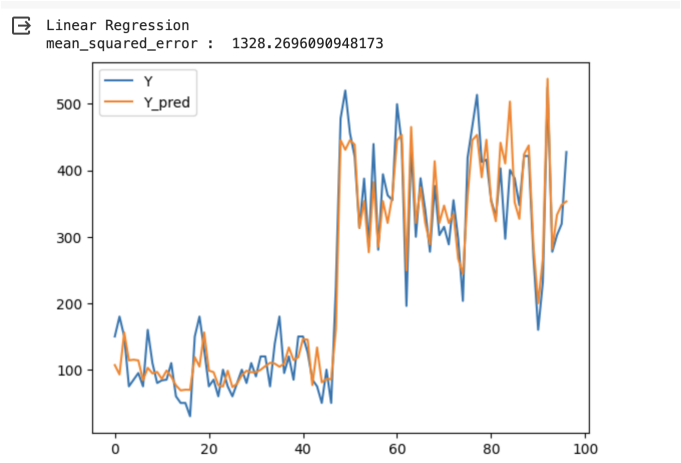

Fig. 2. Result of linear regression algorithm

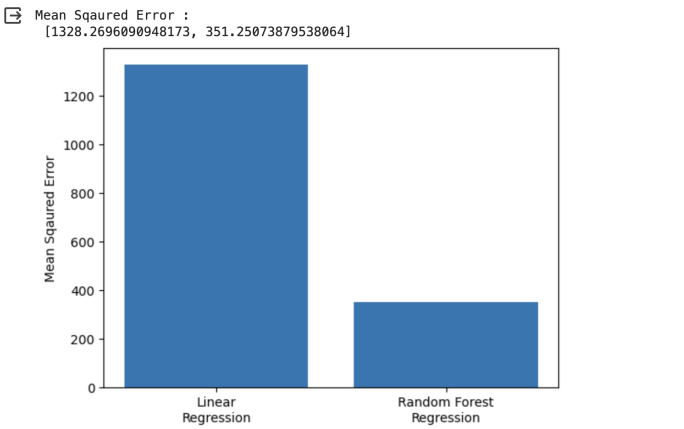

Fig. 3. Result of the overall least mean squared error

just +/- 5%. Figure 1 and Figure 2 showed the prediction performance of random forest regression and linear regression on the dataset's electrical vehicle dataset.csv obtained from Kaggle.

B. The Smart Booking Module

Our proposed system agent individually manages EV charging. These agents observe the charging station's current state, receive charging requests from travelers, and provide real-time recommendations. By considering factors such as available charging space, existing requests, estimated charging times, and distance between the traveler and the charging station, the agents optimize the charging experience and enhance overall efficiency.

C. The Optimal Route Selection Module

The optimal route selection module aims to identify and recommend the most efficient and effective routes for EVs based on a holistic evaluation of various factors specific to electric vehicles. Its integration with the Charge Prediction and Smart Booking Modules will be implemented in future.

III. Conclusions

The charge prediction module employs a combination of machine learning techniques to predict travel distance and time, taking into account variables, including battery charge, vehicle attributes, and environmental factors.

One limitation in our approach is the accuracy of charge predictions, which may vary under dynamic and unpredictable conditions. The performance may be influenced by data availability, and real-world implementation may introduce further complexities. While market-based approaches have been presented on toward efficient and resilient allocations of resources [2], they still have various issues on the prediction errors to the future. Further investigations about this issues is future work.

References

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[2] N. Fukuta, "An analysis of allocation stability on approximation-based pricing for multi-unit combinatorial auctions," *Advances in Intelligent Systems and Computing*, pp. 256–269, 2018.