EVtonomy: A Personalised Route Planner for Electric Vehicles

Demonstration Track

Alexandry Augustin
University of Southampton
Southampton, United Kingdom
alexandry.augustin@gmail.com

Elnaz Shafipour
University of Southampton
Southampton, United Kingdom
e.shafipour@soton.ac.uk

Sebastian Stein
University of Southampton
Southampton, United Kingdom
s.stein@soton.ac.uk

ABSTRACT

With the continuing growth of the electric vehicle (EV) market, planning long road trips should be a seamless and hassle-free experience for EV owners. Dedicated *EV route planning apps* have emerged recently as indispensable assistants providing essential mapping and data services. However, EV owners still face a number of challenges when planning their routes to prevent unnecessary delays or expenses. These challenges are not yet fully addressed with current EV planning apps. This paper introduces *EVtonomy*, an app that assigns an intelligent agent to each driver capable of planning personalised journeys. Specifically, the agent provides routes and charging stop recommendations aligned with the EV owner's individual preferences in terms of trip duration, including both driving time and the time spent charging the car, along with the total charging costs.

KEYWORDS

Human Agent Interaction; Electric Vehicles; Online Route Planning

ACM Reference Format:
Alexandry Augustin, Elnaz Shafipour, and Sebastian Stein. 2024. EVtonomy: A Personalised Route Planner for Electric Vehicles: Demonstration Track. In *Proc. of the 23rd International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2024), Auckland, New Zealand, May 6 – 10, 2024*, IFAAMAS, 3 pages.

1 INTRODUCTION

The rapid growth of EV route planning apps has played a major role in shaping the landscape of electric mobility as we see it today. These apps assist EV owners with powerful tools, helping them make informed decisions about their journey. A good EV planning app needs to allow users to filter charging stations based on location, type of connectors, charging speed, and availability, among other features. A feature that has notably received much less attention, however, is the provision of routing and charging recommendations based on the individual preferences of EV owners. It has been shown in previous studies that EV owners have widely different preferences when it comes to charging stations [18]. For example, while some EV owners prioritise driving time over cost, others elect to minimise expenditure, even if this leads to longer journeys.

A number of solutions to address advance planning for long EV journeys are currently available on the market. In what follows we review some of the most popular EV route planning apps; along with their most relevant features at the time of writing. With hundreds of thousands of users, Zapmap [20] is one of the leading EV route planning apps. While Zapmap offers key features such as live charger status information or a search for nearby chargers, it does not offer meaningful routing personalisation options beyond the choice of EV, the charging network, and basic charger locations. As a popular alternative to Zapmap, Iternio [9] has made available EV routing services since 2018 via an app (named A Better Route Planner [1]) as well as an API for third-party customers. In addition, Google Maps [12] has quickly become the leading mapping app in the world with more than 1 billion users a month [13] since its public launch in 2005. Features such as Street View, turn-by-turn navigation, and live traffic information have all contributed to its market dominance. Despite this success, it is only recently (2021) that dedicated EV route planning features have been added. Such features include dynamic and deep integration with the car and live data. For example, charging stations are automatically added to the route as required based on the actual battery *state-of-charge* (SoC) rather than an estimation. Like Zapmap, both ABPR and Google Maps offer basic personalisation based on the number of charging stops (e.g., few but long, or short but many), but do not take into account preferences that a user may have regarding the total charging cost of the journey (e.g. maximum budget, or the cheapest route).

Other commercial apps include, Watts Up [19], Plugshare [16], EV Navigation [7], Octopus Electroverse [15], and Bonnet [4]. Moreover, a number of research prototypes have also been developed. These include eco-friendly routing [11], routing with charging reservation [2, 3], and routing for solar-powered EVs [10]. Unfortunately, none of these solutions provide the level of personalisation desired.

Against this background, we introduce EVtonomy [17], a route planning app that helps EV owners plan charging stops on long journeys according to their preferences. In particular, our algorithm considers the users' preferences in terms of tradeoff between driving time and costs when suggesting route recommendations. A demonstration video is available at https://youtu.be/B5V1HP7M9O4.

2 THE EVTONOMY APP

In this section, we discuss the underpinning design and implementation of the EVtonomy app.

2.1 Algorithm

Our algorithm considers an EV driver with specific preferences for choosing charging stops which can be paying low cost for the charge or charging the car as fast as possible. Depending on the destination, the driver can make multiple stops at various charging

Proc. of the 23rd International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2024), N. Alechina, V. Dignum, M. Dastani, J.S. Sichman (eds.), May 6 – 10, 2024, Auckland, New Zealand.

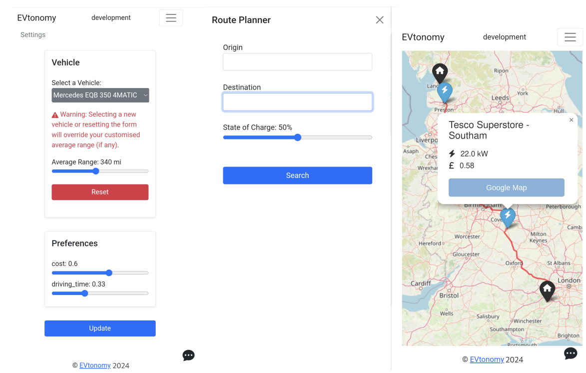
stations along the route to charge the car. As charging stations typically have highly heterogeneous specifications, such as varying charging costs and speeds, the optimal stops will depend on the driver's preferences. To address this, we implemented an intelligent agent for each driver, considering their given preferences. This agent suggests a route with different charging stops based on the driver's preferences and the chosen origin a and destination b.

For the agent to recommend a route it needs information about the car's average range and the current SoC in addition to the defined preferences of the driver. Using this data, the agent can determine the charging stations $\mathbf{S}_a$ that can be reached by the car considering the SoC from the starting point a. The starting point a is the origin at the beginning of the journey and later it is where the car is charged at a charging point and intends to move toward the destination and might need some more stops to charge. Each station $s \in \mathbf{S}_m$ is defined by its features $\mathbf{X}_s = \{x_c, x_t\}$, where x_c is the charging cost at the station s and x_t is the driving time from m to s in addition to the total charging time at all stops along the route. Additionally, we assign a weight $\mathbf{W} = \{w_c, w_t\}$ to denote the marginal contribution of each feature to the driver's utility. Both w_c and w_r are real numbers ranging from 0 to 1. To do the route planning we used the A* algorithm [8]. We calculate the cost for each station, which is the sum of the utility u and the heuristic function h associated with that station. In this context, we assume that utility can be denoted as $u : u(\mathbf{W}, \mathbf{X}_s) = w_t x_t + w_c x_c$. On the other hand, the heuristic cost h is calculated considering similar weights with the remaining driving time to reach the destination. This calculation also takes into account charging time and charging costs, assuming that the charging stops will incur the lowest possible cost and offer the highest charging speed.

2.2 Software Design

The EVtonomy app is a responsive web app built upon the Django web framework [5] and accessible via a web browser. It makes use of two publicly available datasets. The EV charging station data is provided by the National Chargepoint Registry [14]. It is a repository that currently contains 25,801 EV charging stations with their geographic coordinates (i.e., latitude, longitude), their address, and outlets available, among other information. The vehicle data is provided by the European Alternative Fuels Observatory [6]. Prior to any interaction with the app, each user must create an account by providing a unique username, email, and password on the registration form. This ensures that subsequent route planning requests are tailored to each user. As the users' preferences are not fully known a priori, we elicit them directly on the settings page (Figure 1(a)). As such, when a user registers for the first time, they are presented with the settings panel where he is invited to select their vehicle and can amend the default range with a custom value if needed. The user is required to state their preferences in terms of cost and driving time. Once the initial setup is completed, the user can access the route planning page to request recommendations for their journey. The routing panel contains a number of required fields: the *origin* and *destination* and the current SoC (Figure 1(b)). Fuzzy address matching is performed on both the *origin* and *destination* whereby the most likely addresses are retrieved even in the absence of an exact match. Upon completion of a search request, the map is updated with the recommended route and charging stops (Figure 1(c)). A popup window is associated with each charging stop on the map with additional information such as its *name*, the *charging speed*, and the *cost of charge* (Figure 1).

To further improve user experience, the EVtonomy app collects feedback via a dedicated panel accessible at any time while using the app. Users may share their thoughts, ideas, bug reports, or their general experience interacting with the app.



(a) Settings Panel. **(b) Search Form.** **(c) Map.**

Figure 1: Screenshots of (a) the user settings panel where user can select their vehicle and preferences in terms of cost and driving time. (b) the search panel where two valid postcodes should be entered and (c) shows the recommended route with all preferred charging stops.

2.3 Demo Requirements

The EVtonomy app is hosted on a public virtual machine that can be reached with a defined URL or served on a local laptop. As such, the only requirement needed from the organisers for the demo setting at the conference is an internet connection and a dedicated space to house a laptop and an external monitor with an HDMI cable.

3 FUTURE WORK

As EVs continue to gain popularity, the evolution of route planning apps will continue to play a pivotal role in shaping the future of transportation. We believe that a key consideration will be the ability to provide personalised recommendations based on users' preferences. As such, this paper introduced EVtonomy as a first-step solution to address this need in the growing electric mobility industry.

We plan for EVtonomy to offer a more comprehensive solution for EV owners in the future. This may include routing optimisation over charger status, waiting time and availability, the discovery of facilities (e.g. restaurants, restrooms or childcare) around the stations, as well as turn-by-turn navigation. With such features, users will easily be able to reach their intended destination without detours and avoid unnecessary long waiting times by monitoring the chargers remotely. Finally, we will make our app available to countries beyond the United Kingdom in the future.

REFERENCES

[1] A Better Route Planner (ABRP). 2018. https://https://abetterrouteplanner.com/.

[2] Matthias Baldauf, Sandford Bessler, and Peter Fröhlich. 2012. Prototyping A Mobile Routing Assistant for Optimizing Energy Scheduling and Charging of Electric Vehicles. *Adj. Proc. AutoUI* 2102 (2012), 106–110.

[3] Luca Bedogni, Luciano Bononi, Alfredo D'Elia, Marco Di Felice, Simone Rondelli, and Tullio Salmon Cinotti. 2014. A Mobile Application to Assist Electric Vehicles' Drivers with Charging Services. In *2014 Eighth International Conference on Next Generation Mobile Apps, Services and Technologies*. 78–83. https://doi.org/10.1109/NGMAST.2014.49

[4] Bonnet. 2021. https://www.joinbonnet.com/.

[5] Django Software Foundation. 2005. Django web framework. https://www.djangoproject.com/.

[6] European Alternative Fuels Observatory. 2015. https://alternative-fuels-observatory.ec.europa.eu/consumer-portal/available-electric-vehicle-models.

[7] EV Navigation. 2021. https://evnavigation.com/.

[8] P. E. Hart, N. J. Nilsson, and B. Raphael. 1968. A Formal Basis for the Heuristic Determination of Minimum Cost Paths. *IEEE Transactions on Systems Science and Cybernetics* 4, 2 (1968), 100–107.

[9] Iternio. 2018. https://www.iternio.com/.

[10] Landu Jiang, Yu Hua, Chen Ma, and Xue Liu. 2017. SunChase: Energy-efficient route planning for solar-powered EVs. In *2017 IEEE 37th International Conference on Distributed Computing Systems (ICDCS)*. IEEE, 383–393.

[11] José R Lozano-Pinilla, Iván Sánchez-Cordero, and Cristina Vicente-Chicote. 2023. Smart-Routing Web App: A Road Traffic Eco-Routing Tool Proposal for Smart Cities. In *International Conference on Intelligent Transport Systems*. Springer, 247–258.

[12] Google Maps. 2005. https://www.google.com/maps.

[13] Scott McQuire. 2019. One map to rule them all? Google Maps as digital technical object. *Communication and the Public* 4, 2 (2019), 150–165.

[14] National Chargepoint Registry (NCR). 2021. https://chargepoints.dft.gov.uk/.

[15] Octopus Electroverse. 2021. https://electroverse.octopus.energy/.

[16] Plugshare. 2021. https://www.plugshare.com/.

[17] Elnaz Shafipour and Sebastian Stein. 2022. EVtonomy. https://www.evtonomy.com/.

[18] Elnaz Shafipour, Sebastian Stein, and Selin Ahipasaoglu. 2023. Personalised electric vehicle routing using online estimators. (2023).

[19] Watts Up. 2021. https://www.wattsup.app/.

[20] Zap-map. 2014. https://www.zap-map.com/.