EVS27 Symposium
Barcelona, Spain, November 17-20, 2013

An improved route Planner-Simulator with battery performance considerations for Electric Vehicles.

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Abstract

This paper shows the results of a development project that aims to provide Electric Vehicle (EV) drivers the opportunity to know, before making a trip, how the battery will progress during the route. This means drivers will know if they have to stop to recharge the battery and where they should do it, ruling out the idea that makes people reject buying an EV because they can´t make long trips for fear of running out of power supply halfway. This Planner, besides showing the technical data of the route, will display on a road map the selected route from "A to B" with the possibility of one or more intermediate stops to recharge, simulating all the route with a vehicle icon moving along it and a battery image that discharge following the real progress of that vehicle with the conditions of each trip. The data obtained from the Internet, in this case from Google Maps, will be sent to several mathematical algorithms already developed in Matlab. With these data and those obtained from sensors of the car the progress of the State of Charge (SOC) of the battery will be calculated, getting the planner-simulator these data back to display it during the simulation.

Keywords: battery model, BEV, simulation, range, modeling

1 Introduction

Two state-of-the-art technical for VE solutions – battery electric powertrains and information technologies - have the potential to offer convenient alternatives to cars within cities: Electric powertrains eliminate the problem of local air and noise pollution, while information architectures respond to typical urban mobility requirements for a fraction of the space and energy consumed by conventional cars. In recent years, car manufacturers devote large resources to the development of the Electric Vehicle (EV). Although engines are well designed the problem lies in the capacity of storage battery, the duration and the autonomy of that kind of vehicles, limiting the vehicle owner the chance of making long journeys.

Although cars are useful for getting around the city, where increasingly installed charging points and the authorities enhance and encourage its implementation as an efficient an ecological transport, if you want to make a trip of several hundred kilometres, there is the fear of not reaching the destination by the exhaustion of the battery (power source) [1].

This is the main barrier encountered by users when purchasing an EV [2], because its use would be limited to urban environments and if they want to make a long trip it would be necessary another vehicle with an internal combustion engine.

Despite the overall validity of these solutions, technologies have yet to mature in new mobility concepts [3]. Current offers still rely on conventional car design strategies, which introduces a main drawback: electric cars are excessively heavy and inefficient [4], highlighting the importance of charging infrastructures improvement.

Considering this problem, the quest for new mobility solutions seems a promising field for the information control and display design strategy of new dashboards based on an electric range optimization. Given the complexity of the design of a new dashboard for vehicle, which fits the definition of a wicked problem, the research takes advantage of an academic environment to focus on an inter-disciplinary approach, that addresses varied implications (Information Technologies, electronic engineering, design, sociology and business strategy).

2 Proposed solution

The solution to this problem here presented is the creation of a route planner with specific consideration for Electric Vehicles.

Battery performance is a key factor for travelling and an accurate route planner is needed in order to be able to know before and during the journey if the state of charge of the battery available in this moment will be enough to reach the destination or if it will be necessary to stop to recharge it. This route planner will display the information described below on the navigation screen of the vehicle dashboard or on an aftermarket device.

The route planner-simulator basically consists of four modules, where the driver selects the origin and destination of the journey and improved routes for electric vehicles with starting SOC will be shown in different colors depending on probability of success.

The route planner is composed of 4 modules:

<u>Module 1 - Planner User's Interface (PUI)</u>

This module collects all the input data and displays the results of the route planner.

The main input information required to calculate any route is the starting and arrival points though additional information can be considered (tolls avoidance, fastest way, shortest way, etc) in order to select the route that better fits the user's requirements as a standard navigator would do it. The interface is shown in Figure 1.

Input area of Planner User's Interface is designed to introduce all the relevant information required to calculate a route, check if this route can be completed by electric vehicle with a starting SOC and propose other improved routes in case of recharge of battery may be needed. Other options related with visual information layers to be shown in the map can be enabled/disabled (Figures 2 and 3).

Figure 1. Input Data

After the route has been calculated, checked and improved for electric vehicles (see next modules), the available paths will be displayed in a map seen at Figure 2. The user will select the most convenient path and the additional information will be shown (Figure 3).

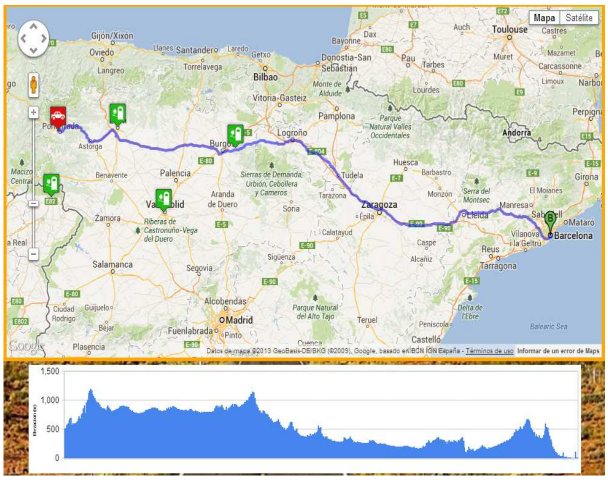

Figure 2. Route calculation with elevation profile and recharging points

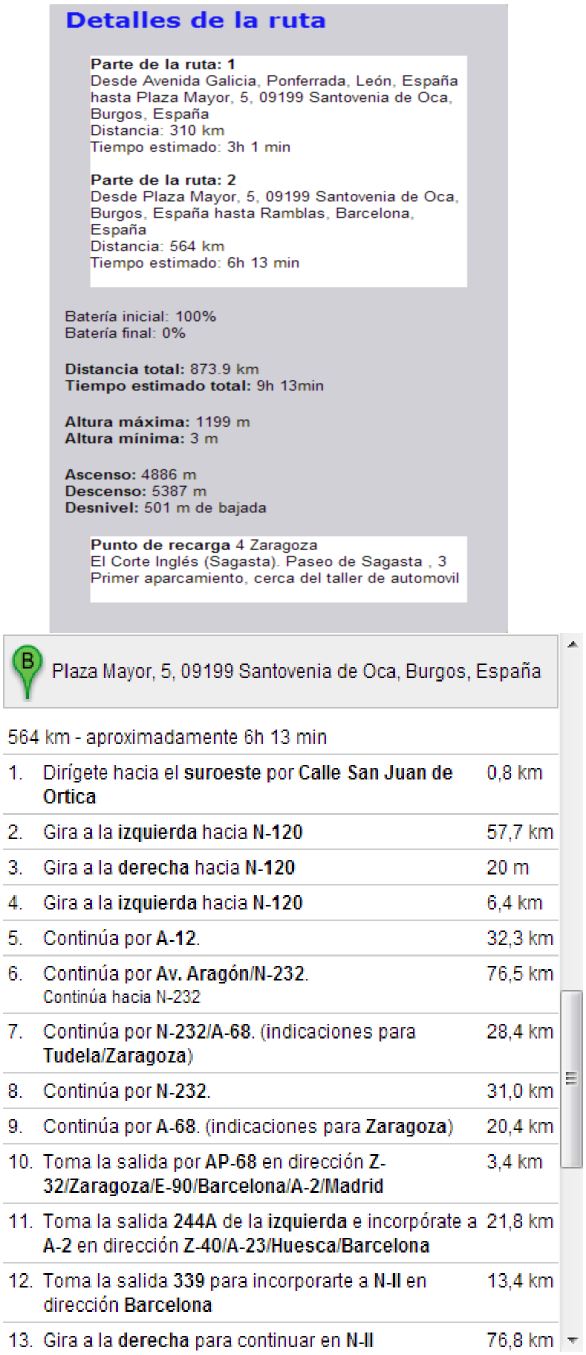

Figure 3. Route information

Output route information includes the distance to travel, time duration, velocity and elevation profiles of the route, recharging points, indications of the directions to follow and actual SOC.

The route chosen by the user will be simulated on a map and it will display the discharge of the battery with actual SOC for each step of simulation. So, battery performance can be checked for each geographic location of the route.

The simulation speed can be configured by the user.

Figure 4. Battery range evolution on travel

<u>Module 2 – Standard Route Calculator (SRC)</u>

This module is the same you could find in a standard navigator and it calculates a route between starting and arrival point taking into account the data introduced by the user before. This module provides the total distance to travel, time duration, velocity and elevation profiles of the route, weather conditions and current traffic information to PUI module to show the results and RDM module to check if the route can be completed by electric vehicles with a starting SOC. All these data are supplied by Google Maps Api.

Module 3 – Route Decision Maker (RDM)

Route Decision Maker determines if the calculated route could be completed by an electric vehicle with a starting SOC. If not, improved routes will be calculated and they will include every necessary stop in recharging points. Obviously, the information of starting SOC will be known.

A mathematical model simulator has been developed [5] to load all the route information, evaluate it and obtain the battery range. It is important to highlight that driver's profile, elevation and speed profiles of the route, current traffic and weather conditions has been included in this mathematical model to obtain an accurate battery range.

Based on this battery range, the route planner can face two possibilities:

- It is possible to complete the route. The map will show the route colored in green and the remaining SOC at the arrival point will be shown.

- It is not possible to complete the route from origin to destination with the starting SOC and battery range calculation. So, the battery must be recharged to complete it. The map will show the route coloured in red. The route planner provides the available recharging points on the path taken from charging points database and taking into account the range of the battery supplied by the EV simulator. A warning message will be displayed. See Figure 5.

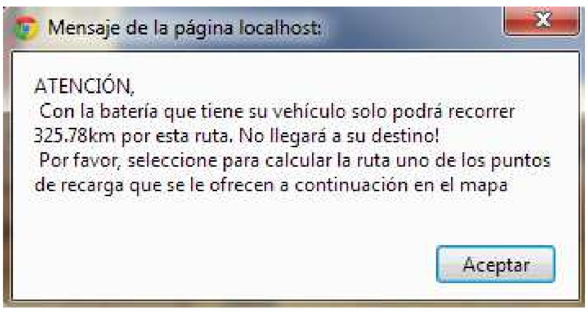

Figure 5. Battery recharge required

Module 4 – Real Time Estimator for Deviations (RTED)

This module calculates on travel deviation between estimated SOC for each step of the route and current SOC of the vehicle every certain time. It will inform the driver about the premature exhaustion of the battery, for example due to a deviation in the velocity profile of the route, changing in the driver's profile, etc. The display is shown in Figure 4.

3 Resources required and market potentials

Route details and the map display will be achieved with the Google Maps API Version 3 of JavaScript, which is an open source to web developers and allow everyone to integrate its maps and information for free. There is also a paid version that allows knowing the real-time traffic data based on traffic characteristics at the time desired for traveling. This project will be developed with the free version.

Achieving this will require:

- Knowledge of programming in Javascript, PHP and AJAX (Programming Languages)

- Computer with internet working as a server, to send to the external mathematical program these data supplied by Google Maps.

- Interaction with the external mathematical program to this Project, already developed in Matlab [5, 6], to show on the planner how the battery will progress in each route request is made. This program interacts with vehicle sensors to determine the state of charge of the battery and its discharge behavior.

- Other general web programming skills, secondary programs for the correct operation of the user interface, etc.

The planner will run from a web browser, on the client-side, for this Project Google Chrome is chosen.

4 Conclusions

The paper explains so many possibilities that can be offered with this solution. As cars in a near future will have internet, that planner can be implemented as a web site. It would be enough having a server where driver can access to check their route knowing the vehicle and receiving data from the vehicle. Necessary calculations will be made on that server to show the final information to the user.

Until there are more public recharging points, trip planning information will be an important part of operating an electric vehicle and growing of electric vehicle's industry. In fact, the owners of electric vehicles will need a useful driver interface to achieve efficient driving and help them to enjoy the trip, rather than worry about battery range. This paper started with discussing the development of a route planner simulation. The electric range of a vehicle linked to a selected route, the effects of drive style, type of route, weather effects…. all are taken into account in order to give an accurate and robust estimation that could reduce the "range anxiety" phenomenon.

The idea is to engineer an interface to serve as a friend trip guide that provides expert knowledge and full information that allows the driver to simply enjoy the drive.

Nevertheless, there are some factors that the authors have not included in the analysis: state-of-health (SOH), temperature,… these factors will affect the driving range and further research is needed to study the influence in more detail.

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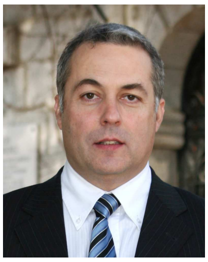

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