Advanced Science and Technology Letters
Vol.51 (ITCS 2014), pp.242-245
http://dx.doi.org/10.14257/astl.2014.51.55

State-of-charge Stream Processing for Electric Vehicles

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Abstract. This paper processes SoC (State of Charge) streams to develop a battery consumption model of EVs (Electric Vehicles) on a target road. A stream consists of a series of SoC records, each of which is made up of temporal and spatial stamps, altitude, SoC reading, velocity, and the like. For a specific road, a probe EV has collected SoC records while driving multiple times. The driving distance is calculated by adding up the line segment connecting two consecutive sensor points. For streams starting and ending at the same two end points, we plot the absolute SoC change first to figure out the SoC change pattern. Next, the consumed amount is traced to find the similarity between different streams. Finally, each stream is normalized to develop a common SoC change model out of multiple drives.

Keywords: electric vehicle, state-of-charge stream, common pattern, Normalization

1 Introduction

Electric vehicles (EVs) are one of the key elements in the smart grid, making even the transport a part of the power system. An EV consumes electricity stored in its battery while driving. Limited battery shortens their driving range, and a fully charged EV can drive up to 100 *km* in practice. Hence, a driver, usually a long-distance driver, sometimes wonders if his or her EV can reach its destination with current battery remaining, interchangeably, SoC (State of Charge) [1]. However, how much energy will be needed is very hard to accurately estimate, as it is affected by so many factors including distance to the destination, road shape, velocity, starting SoC, driving habit, and so on [2]. Particularly, different road features, such as elevation change and curvature, necessitate the road-by-road consumption model.

One of the simplest but most efficient ways is to measure the amount of consumption multiple times and then conduct a statistical analysis for a specific road, which is usually taken by many EVs. With the estimation models for main roads, it is

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[*] Prof. Gyung-Leen Park is the corresponding author.
This research was financially supported by the Ministry of Trade, Industry and Energy (MOTIE), Korea Institute for Advancement of Technology (KIAT) through the Inter-ER Cooperation Projects.

ISSN: 2287-1233 ASTL

Now, Figure 2(a) plots the SoC change for each stream. Each curve tracks the absolute SoC values and we can find out that the total consumption is different according to the initial SoC level due to battery dynamics. The distance value is obtained by adding up the length of each line segment connecting two sensor points. This distance may have a gap from the distance actually taken by the EV, but it will be negligible as the inter-record time is just one second [3]. The first trip starts at 64.5 % and consumes 24 %, the second starts at 73.5 % and consumes 19 %, and the third starts at 69.5 % and consumes 22 % in total. Here, the distance is obtained by adding up the length of each line segment connecting two sensor points.

Figure 2(b) shows the amount of battery consumption from the start point for each trip. The consumed battery is calculated by subtracting the initial value from the current SoC. Figure 3 indicates that there is a similarity for 3 trips. However, Drive 3 consumes more electricity when the EV starts, possibly due to the initial speed.

By the comparison of absolute values, we can find just a rough consumption pattern. Hence, Figure 2(c) normalizes the consumption by taking the maximum value as 1.0 for each trip. Three curves get much closer except the interval from 0 *km* to 5 *km* in which Drive 3 spends more electricity. With this result, we can develop a common battery consumption model by statistical analysis.

3 Conclusions

For wide penetration of EVs, the information technology is of essence and this paper has processed raw SoC streams as a preliminary step of developing refined battery consumption models for main roads of a city. 3 drives on the same road interval undergo different SoC change in absolute values and spend different amount. However, the normalization process makes them much similar, finding out the feasibility of building a common consumption model from repeated trips.

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