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Role of Statistics in improving performance of Electrical Vehicles A Short Review

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ABSTRACT

This electronic document is a short review about the role of a Statistical Modelling in analyzing the performance and an efficiency of Electrical Vehicles(EVs). The area of statistics deals with the collection, classification, presentation and analysis of data to make decisions, solve problems and design products and processes. Because many engineering fields involve working with data, some acquaintance with statistics is necessary for any engineer. Statistical modelling is the method of applying statistical analysis to observed data set through mathematical depiction. In this paper, we have presented some of the important papers that are based on the statistical tools like Descriptive statistics, Multi variate statistical techniques, Time series etc. that are vividly used in improving the performance of EVs as a review work.

Keywords : Statistical Modelling, Descriptive Statistics, Regression and Simulation

I. INTRODUCTION

Electric Vehicles are those vehicles which use one or more electric motors for propulsion. They are highly important in the present automotive industry. Environmental issues and expected reduction of conventional fuels in the near future attract manufacturers to the electric vehicle. Atmospheric temperature increases as a result of the greenhouse gas emission of conventional vehicles and depletion of fossil fuels make alternative fuel vehicles and electric vehicles popular. Electric motors emit no gases as Internal Combustion Engine does. So Battery Electric vehicles are zero emission vehicles and Hybrid Electric Vehicles (HEV) are low emission vehicles. Noise pollution from the electric vehicle is low compared to conventional vehicles. Noisy IC engines are replaced with silent electric motors in electric vehicles. The maintenance cost of electric motors is less compared to that of IC engines. They are eco-friendly in terms of air pollution. Electric vehicles can be classification into: Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV) and Plug-in Hybrid Electric Vehicle (PHEV).

The area of statistics deals with the collection, classification, presentation and analysis of data to make decisions, solve problems and design products and processes. Because many engineering fields involve working with data, some acquaintance with statistics is necessary for any engineer. Statistical modelling is the method of applying statistical analysis to observed data set through mathematical depiction. Through this the Researchers are able to comprehend and interpret the information more tactically. It allows them to visualize the data, to identify relationships among several variables and to make predictions. Simulation is also important in research. It enables to represent the real system either by changing the scale, or via mathematical models that allow representing the features of the system and enables to explore system's behaviour in an articulated manner which may not be feasible to obtain that data in the real world. Thus, statistical techniques are powerful aid in designing new products and systems, improving prevailing designs as well as production processes.

In this paper we have presented various statistical tools that are used by various researchers in improving the performance of electrical vehicles.

II. LITERATURE REVIEW

Yong Bing Khoo et.al (2014) predicted that the market share of Electric Vehicles (EVs), an attractive alternative to conventional vehicles, is expected to exceed 30% of all vehicles by 2033 in Australia. Their work reported the issue through both statistical analysis of the charge events and modelling the charging behaviours according to participant categories and vehicle models. The analysis was performed on 4933 charge events that were recorded by both private and public Electric Vehicle Supply Equipment. They have presented the descriptive statistics and statistical relationships between EVSE charge events and the vehicle/ participant types. It also presented statistical models for charge duration, daily charge frequency, energy consumed, start charge hour of EVSE charge event, and time to next charge event. The model parameters were estimated by fitting the inverse-transformed probability distribution function.

P. Ondruska (2014) et.al presented an efficient approach to compute probabilistic attainability maps for electric vehicles. They assumed energy consumption as random variable and leverages a feature-based linear regression tool to model the distribution parameters associated with it. The simplicity of the model allows it to merge with an efficient algorithm to model a driver's route preferences. This method provides prediction accuracies of a quality commensurate and also provides confidence.

Y. Zhang (2015) et.al employed a gradient boosting regression tree method (GBM) to analyze and model freeway travel time to improve the prediction accuracy and model interpretability. The gradient boosting tree method strategically combines additional trees by correcting mistakes made by its previous base models, therefore, potentially improves prediction accuracy. Sensitivity analysis is done to know different parameters' effect on model performance and correlations of input–output variables are explained by using travel time data . The proposed method is, then, compared with another popular ensemble method and a bench mark model

C. Bingham et.al(2015) investigated the impact of driver behaviour/driving-style on the energy consumption, state-of-charge (SOC) usage and range, of all-electric vehicles (EVs) based on the analysis of results from many driving cycles. Measurements of real-time quantities such as wheel speed and SOC over a number of driving trials showed that energy consumption is significantly affected by driving style, and that through basic statistical analysis of acceleration profiles.

X. Yuan et.al(2017) proposed a method for evaluating the energy consumption features of electric vehicles under real time driving situations. They have derived a simplified analytical function for estimating the energy consumption of an electric vehicle. Using regression analysis, the effects of driving conditions are decoupled, and the independent energy consumption characteristics are obtained. Also proved that proposed method represents a possible alternative mechanism for providing a basis for the comprehensive assessment of the environmental benefits of electric vehicles.

Yang Zhao (2017) et.al presented a novel fault diagnosis method for battery systems in electric vehicles through big data statistical techniques. The irregular changes of cell terminal voltages in a battery pack can be spotted and calculated using probability measure based on machine learning algorithm and 3sigma multi-level screening strategy (3σ -MSS). Through this the abnormalities hidden beneath the surface, researchers can see the design flaws in battery systems and provide feedback on the upstream of designing. In addition to these techniques, they have also applied local outlier factor (LOF) algorithm and clustering outlier diagnosis algorithm to verify the calculation results. They have made a comparative study between between statistical diagnosis results and actual vehicle is given to further validate the effectiveness of the diagnosis method

III. STATISTICAL METHODOLOGY

Literature review of EVs, statistical modelling techniques were used to understand the performance or efficiency of EVs is given below.

3.1. Descriptive Statistics

Descriptive Statistics are basic statistical tools to understand the data. Most of the real life situations Descriptive Statistics do not good effective results. Hence we use different statistical tools like Regression analysis, ANOVA, Multivariate Analysis, Simulation methods etc. In analysing data sets. Literature review of EVs, statistical modelling techniques were used to understand the performance or efficiency of EVs is given below.

3.2. Regression Modelling

The result of any experiment depends on several variables and such dependence contains some arbitrariness which can be categorized by a statistical model. The regression analysis helps in shaping such relationships by using the sample experimental data. This aids further in describing the behaviour of the process of experiment. The unknown and unspecified form of relationship among the variables can be linear as well as nonlinear which is to be modelled on the basis of a sample of experimental data only. The tools in regression analysis help in finding such relationships under some standard statistical assumptions. Regression models are often applied to know which independent variables hold the most influence over dependent variables. The most traditional regression models that have been used for a long time are logistic regression, linear regression, and polynomial regression.

Xi Huang, Ying Tan and Xingui He (2011) proposed a new IMSD approach. Combining statistical analysis and machine learning, this approach can automatically analyze the HEV driving data, extract multiple features, and dynamically discriminate the driving conditions, which is helpful for the best control strategy of the HEV.

Bohan Zheng, Peter He, Lian Zhao, Hongwei Li (2016) proposed a hybrid approach, RT-SOM, embedding tree-based **regression analysis** into Self-Organizing Maps (SOM) in order to resolve the complex power consumption estimation problem practically. Here SOM is to transformed an incoming signal pattern of arbitrary dimension into a two dimensional discrete map, and to perform this transformation adaptively in a topologically ordered fashion. Regression Tree (RT) model could provide automated feature selection by evaluating the information gain on the training set.

Cedric De Cauwer, Wouter Verbeke, Thierry Coosemans, Saphir Faid and Joeri Van Mierlo (2017) presented a data-driven energy consumption prediction method for EVs, suited for energy-efficient routing. It uses a cascade of a neural Network (NN) and a linear regression model. The **Multiple Linear Regression** (MLR) model is used to estimate the energy consumption, given a number of predictor variables, while the NN serves to predict the unknown predictor variables (inputs) of the MLR. The proposed method predicts the energy consumption on the individual segments of the road network, allowing a cost allocation to each link in the road network, so cost-optimization algorithms can define energy-efficient routes.

3.3. Time Series Modelling

A time series is a sequence of observations taken in chronological order. Time series analysis is concerned with techniques for the analysis of the dependence of adjacent observations. This involves the development of stochastic and dynamic models for time series data. Time series analysis has been widely used in scientific research and engineering domains. Many theoretical developments and new methods for time series analysis have significantly contributed to the understanding of complex systems.

Ricardo Aler, Ricardo Martín, José M. Valls, and Inés M. Galván (2015) performed different machine learning techniques in the context of solar energy forecasting using NWP models computed from the NOAA/ESRL Global Ensemble Forecast System (GEFS) for different nodes located in a grid. Three different regression methods (linear SVM, RBF-SVM, and GBR) have been used to build forecasting models and studied the influence of the grid nodes number on prediction accuracy.

3.4. Stochastic Modelling

Farshad Rassaei, Wee-Seng Soh and Kee-Chaing Chua (2015) presented a model for uncoordinated charging power demand of a typical EV by formulating it as a stochastic process based on the arrival time and charging time of the vehicle. illustrated an EV's expected daily power demand profile for different charging time distributions through simulation.

Xiaohua Wu, Xiaosong Hu, Scott Moura, Xiaofeng Yin, Volker Pickert (2016) developed a **stochastic optimization** framework for energy management of a smart home with PEV energy storage and PV power supply. An SDP problem is formulated to optimize the electric power allocation in the PEV battery, home load demand, PV power supply and utility grid.

Waldemar Wojcik et al (2017) proposed to create a mathematical model for the distribution of emissions from vehicles by using the probabilistic and statistical approach for modelling the distribution of harmful impurities in the atmosphere from vehicles. a simplified methodology of **stochastic modelling**, it is possible to construct effective numerical computational algorithms that significantly reduce the amount of computation without losing their accuracy.

3.5. Machine Learning

Wang Junping, Chen Quanshi and Cao Binggang (2006) used support vector machine (SVM) to model the battery nonlinear dynamics. They observed that the **simulation** results of the SVM battery model can simulate the battery dynamics better with small amounts of experimental data.

Chaitanya Sankavaram(2014) et.al presented a systematic data-driven process for detecting and diagnosing faults in the regenerative braking system of hybrid electric vehicles.They used wavelet-based feature extraction and MPLS-based data reduction to extract salient fault discriminating information, and subsequently, different diagnosis algorithms such as pattern recognition techniques, Euclidean distance criteria, and inference-based algorithms are used for classifying faults in the RBS simulation model.

Dr. Jangala. Sasi Kiran, N. Vijaya Kumar, N. Sashi Prabha, M. Kavya (2015) presented a brief overview of digital **image processing** techniques such as Feature Extraction, Image Restoration and Image Enhancement. A brief history of OCR and various approaches to character recognition is also discussed.

Dario Pevec et al (2017) presented a methodology to address the challenge of EV charging station deployment. They provided a methodology for extending electric vehicle charging infrastructure (EVCI) that is based on **machine learning predictive techniques**.

3.6. Statistical Methods

Based on the samples, multiple features for the discrimination of driving conditions are extracted. Their significance is proved by histogram, boxplot, and ANOVA.

Nikolaos G. Paterikas et al (2016) expressed that the introduction of electric vehicles (EV) into the transportation sector has lately emerged as a solution to environmental and economic challenges. As a result, governments throughout the world have been providing subsidies and other benefits to drivers who switch from a conventional car to an electric vehicle in order to encourage the latter's commercialization. However, when compared to conventional vehicles, EVs have a significant drawback that may limit their general adoption: charging an EV takes several hours. EV parking lots have been proposed for this purpose in order to recharge automobiles at a faster rate. According to recent studies, vehicles are parked for the majority of the day, meaning that alternative operational tactics could be employed to provide operational or economic benefits for EV parking lot owners. The goal of this research is to provide representative load profiles for parking lots using various operational tactics.To do so, the parameters of the EV fleet are modelled by calculating kernel distributions from available traffic data, and representative price patterns are obtained using a time series transformation combined with a clustering approach.

3.7. Clustering

Gae-won You , Sangdo Park, Dukjin Oh (2016) proposed a **data-driven approach** to trace SOH on the fly by using sensible BMS data such as current, voltage, and temperature while leveraging their historical distributions. Proposed a method to trace the SOH of EV batteries using sensible data (current, voltage, and temperature) from a BMS where batteries are cycled dynamically according to various driving patterns. They estimated SOH using extensive driving profiles to consider EV environments in a more practical way.

Xinmei Yuan et.al(2017) proposed a physical-based statistical method for assessing the energy consumption features of electric vehicles using real time data and also derived an analytical function for estimating the energy consumption of an electric vehicle. Using regression analysis, the effects of driving conditions are decoupled, and the independent energy consumption characteristics are obtained.

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