Chapter 16
High-Performance Computing for Electric Vehicle Performance Analysis and Simulation

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ABSTRACT

High Performance Computing (HPC) has established an important place in the performance analysis and simulation of electric vehicles. An enhanced study built on HPC answers to the high computational requirements of performance evaluation of electric vehicles, namely battery management, energy efficiency, and thermal dynamics. HPC, with parallel processing and improved algorithms, can intensively simulate powertrain systems, aerodynamics, and vehicle dynamics, keeping a stream of avenues to improve the design and functionality of electric vehicles. Further, it optimizes battery life and energy consumption as well as charging systems. This is useful for manufacturers and researchers to work toward enhancing

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the efficiency of EVs. The current chapter also deals with real-time simulations of HPC that allow prototyping, reduce development costs, and enable sustaining innovations in the electric vehicle business.

INTRODUCTION

An electric vehicle (EV), for sure, will be the defining trend of the automotive industry in response to the pressing need for the reduction of carbon emissions, an enhancement in energy efficiency, and the shift towards solutions in sustainable transportation. The changes of the last ten years have created a new atmosphere through modifications in the face of the auto industry, drawing further ongoing pursuits in innovations such as better vehicle performance, improved energy storage, and power management. The increasing importance of High-Performance Computing (HPC) in the analysis and simulation of EV performance also brings about further transformation. HPC ensures the real-time simulation of complex systems due to the provision of computational power, enabling researchers and engineers to make very precise evaluation and optimization of a vehicle's performance. In this chapter, I indicate where it becomes possible to find an intersection between EV technology and HPC, wherein performance analysis and simulation play a pivotal role in driving innovations (Aghabali et al., 2020a).

The primary distinction between EVs and conventional internal combustion engine (ICE) vehicles is the utilization of electric powertrains and battery systems. As such, some questions arise in vehicle design, performance analysis, and testing because of the absence of fuel-burning engines and the presence of advanced electronic components. Therefore, the capabilities of EVs can only be maximized if designers simulate all conceivable factors-affecting factors including battery dynamics, thermal management, energy consumption, and powertrain efficiency. Each one of these encompasses complex, multi-physics problems that require advanced computational models and simulation to understand. That is where HPC steps in as the ability to run complicated simulations that would otherwise be computationally infeasible using traditional computing systems is possible (Alawneh et al., 2023).

HPC is using the techniques of supercomputers and parallel processing to solve problems computationally at high speeds that appear too difficult for traditional computers. In EV technology, HPC enables the simulation of hundreds of thousands of variables and scenarios whose optimization is critical to a well-performance vehicle. This means that an EV's battery system, consisting of thousands of individual cells, requires monitoring and management for optimal operational characteristics to last for a long time. This will demand vast computational resources in simulating the thermal and electrical behavior of these cells and their interaction with other cells within the battery pack. Such detail in HPC models will bring factors like temperature, charge cycles, and energy demand under different operating conditions (Pozzato et al., 2023).

Aerodynamics is another thing related to EVs and tremendously affects overall efficiency. Unlike in the ICE vehicles, wherein the primary goal is to focus on efficiency at the engine level, for EVs, it shall be focused on drag and airflow optimization toward attaining full range. Simulation of aerodynamics performance of an EV usually involves complex fluid dynamics which require significant computational effort to represent with adequate precision. The HPC will allow detailed simulation for interactions between body design and power-consuming energy of airflow to further the aerodynamics efficiency of the vehicle, thus increasing its driving range and lowering its energy consumption (Sharma et al., 2019).

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Pablo Ariel Negroand Claudia Pons (2024). *International Journal of Artificial Intelligence and Machine Learning (pp. 1-22).*
www.irma-international.org/article/rule-extraction-in-trained-feedforward-deep-neural-networks/347988