Chapter 1
Role of Computing Technology in Electric Vehicle Design and Optimization

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ABSTRACT

Electric vehicles (EVs) mark the beginning of a new era in the automotive sector, offering a future transportation alternative to conventional internal combustion engine cars. Computing technology is a key player in the design, simulation, and optimization stages of EV development. This paper focuses on integrating computing methodologies such as artificial intelligence (AI) & machine learning (ML), high-performance computing (HPC) & simulation tools into diverse EV aspects. By presenting a comprehensive literature review, case studies, and examples, we showcase the influence of computing technologies on battery management systems,

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powertrain optimization, aerodynamics, and energy efficiency. In addition, it also provides examples in tabular form where the implemented computational methods can be enhanced. Computing technology is argued in this study to be essential for EV performance and sustainability gains.

INTRODUCTION

The worldwide transition to sustainable transportation has spurred the progression of electric vehicles (EVs). Research and innovation in electric mobility have been driven by the need to cut carbon emissions, raise fuel efficiency, and reduce reliance on fossil fuels. Of course, it's not all smooth sailing for electric vehicles (EVs); there are battery life limits, longer charging times, powertrain efficiency, thermal management, and so forth. These kinds of problems demand advanced computing technologies to conduct high-fidelity simulations, predictive modelling, and data-driven optimizations. Starting from data, through the invention and evolution of computing, engineers and researchers in the field of mobility have built complex mathematical models and simulations to optimize the design of vehicles in the automotive industry. AI, ML, HPC, and simulation tools have elevated the efficiency with which EV development can take place *(Silvas et al., 2016;Gunasekaran et al., 2024)*. These technologies allow automakers to process petabytes of data, anticipate possible system failures, and also fine-tune components in vehicles for optimal performance.

Computing technology has a particularly outsized impact on battery management. Electric vehicles (EVs) use lithium-ion batteries, which require constant monitoring and optimization for longevity while remaining safe. Computing tools assist with SOC and SOH estimation, fault detection, and thermal management *(Schwarzer et al., 2011; Bhardwaj et al., 2021)*. So-called AI-powered algorithms are aiding the prediction of battery deterioration over time, allowing for charging strategies that optimize efficiency and lifespan.

In a similar vein, computing technology enables powertrain optimization. Credit: Similar to traditional internal combustion engine (ICE) vehicles, the classic IC vehicles are systems based on known mechanics, while EVs have a sophisticated interplay between the electric motricity, inverters, and analytical computation systems *(Boyalı et al., 2007;Skarka, 2018)*. We design lightweight and high-efficiency powertrains using computational tools, such as genetic algorithms, finite element analysis (FEA), computational fluid dynamics (CFD), etc., to run different configurations through multiple tests that simulate real-world conditions without having to build a prototype many times.

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