Artificial Intelligence Solutions to Enhance Energy Saving and Battery Management in Electrified and Connected Vehicles

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Abstract

This thesis explores cutting-edge solutions applied to electrified vehicle technologies, focusing on the interaction between artificial intelligence (AI) and the performance of hybrid electric vehicles (HEVs) and battery electric vehicles (BEVs) in the context of environmental sustainability , operational efficiency and system reliability. It addresses pivotal research questions aimed at optimizing fuel economy and passenger comfort in HEVs, enhancing traffic flow and reducing energy consumption in BEVs through trajectory optimization, and accurately estimating the state of health (SoH) of high-voltage batteries, crucial for battery management and their lifespan. The study transitions from HEVs to BEVs, reflecting regulatory trends and focusing on AI-based control algorithms' adaptability for real-time applications, evaluating their potential to make a significant step toward operational efficiency and environmental sustainability.

The thesis comprises AI techniques in energy management for HEVs, apply AI in cooperative adaptive cruise control (CACC) for BEVs, and delve into estimating the SoH of BEV batteries. It begins with an exploration of energy management in HEVs, utilizing LSTM neural networks and reinforcement learning (RL) to enhance fuel efficiency, engine efficiency, and passenger comfort under varying driving conditions. The narrative then shifts to optimizing BEV trajectories using deep learning and vehicle communication technologies, highlighting the potential of GRU architectures and subsequently RL in developing robust CACC systems amid sensor and communication uncertainties. Lastly, it examines machine learning algorithms' efficiency in estimating the SoH of high-voltage batteries in electric vehicles, considering experimental data from vehicles with diverse mileage conditions.

Through these chapters, the thesis presents a blend of supervised learning and RL approaches, applying machine learning and deep learning techniques to tackle distinct challenges within the electrified vehicle technology domain. The research underlines the transformative potential of AI in advancing electrified vehicle technologies, aiming for a sustainable future in transportation.