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CONNECTED AUTOMATED VEHICLES AND ITS, VEHICLE DYNAMICS AND CONTROL

Stabilizing Electric Vehicle Systems Using Proximal Policy-Based Self-structuring Control

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Abstract

An active disturbance rejection control (ADRC) has been developed for stabilizing electric vehicle (EV) systems without the need for model identification. The proximal policy optimization (PPO) algorithm, along with actor and critic neural networks, has been used to fine-tune the adjustable parameters of the ADRC controller to achieve optimal performance in a specific case study. The architecture of PPO implements separate neural networks and ameliorates the PPO adaptability to handle continuous action spaces. By maximizing a reward function based on system output, the PPO agent optimally tunes the gains to reduce undesired speed fluctuations of EVs and improve system stability. Performance evaluation under the new European driving cycle and federal test procedure has been conducted to examine the feasibility of the suggested controller. The disturbance rejection capability of the ADRC controller designed by the PPO algorithm has been tested and compared with prevalent control methodologies. Moreover, real-time examinations of the dynamic behavior of EV systems have been made to identify the capability of the suggested controller in real-world hardware. The results show that the suggested controller outperforms other designed controllers in terms of transient behavior and numerical performance metrics.

Keywords Electric vehicles (EVs) · Active disturbance rejection control (ADRC) · Proximal policy optimization (PPO) · New European driving cycle (NEDC) · Federal test procedure (FTP-75)

1 Introduction

Electric vehicles (EVs) have recently emerged as a prominent solution to face environmental problems and the shortage of conventional fossil fuel sources (Pazouki & Olamaei, 2019; Mamo, Gopal, and Yoseph 2024; Hasan et al., 2024). The EVs have the potential to tackle these problems and many more benefits over the traditional internal combustion engine (ICE) vehicle like quiet operation, low fueling costs, and high efficiency. Their popularity in the transformation industry has been further fueled by advances in battery technologies, making EVs more practical for a wide reasonable range of consumers. With increased research and development in the EV sector, it is anticipated that these technologies will soon experience a greater transition toward sustainability (Alrubaie et al., 2023; Bozhi et al., 2023; Bristi et al., 2023).

The battery pack, electric motor, power electronic components, charging ports, power train, and control mechanism are the main elements of an electric vehicle system. Among the various components, the controller in EV plays a critical role in managing and optimizing various aspects of the vehicle's performance (Djouahi et al., 2023; Hwang et al., 2024). However, the regulation of EV output is a challenging task, because these technologies have a time-variant nature (e.g., parametric variation of system dynamic, change in the

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