A Robust Fuel Optimization Strategy For Hybrid Electric Vehicles: A Deep Reinforcement Learning Based Continuous Time Design Approach

Abstract

This paper deals with the fuel optimization problem for hybrid electric vehicles in deep reinforcement learning framework. Firstly, considering the hybrid electric vehicle as an uncertain non-linear system with unknown dynamics in continuous time frame, we solve an open-loop deterministic trajectory optimization problem without explicitly considering the system model. This is followed by the design of a deep reinforcement learning based optimal control law for the non-linear system (i.e., hybrid electric vehicles) such that the actual states and the control policy remain close to the optimal trajectory and optimal policy even in the presence of external disturbances, modeling errors, uncertainties and noise. The low value of the H-infinity (H_∞) performance index (i.e., the ratio of the disturbance to the control energy) of the RL based optimization technique in comparison with the traditional methods addresses the robustness issue. The control strategy will also autonomously learn the optimal policy and adapt itself to the different conditions which is in sharp contrast to the conventional techniques that mostly depend on a set of pre-defined rules and provide sub-optimal solutions to the fuel management problem. The controller thus designed is compared with the traditional fuel optimization strategies for hybrid electric vehicles to illustate the efficacy of the proposed method.

Keywords: deep reinforcement learning, optimal control, fuel management system, hybrid electric vehicles, H_∞ performance index

TL ; DR: A state-of-the-art continuous time deep reinforcement learning based fuel optimization strategy for hybrid electric vehicles which aims to formulate a robust control law such that the actual states always remain close to the optimal states even in the presence of modeling errors, parametric uncertainties, external disturbances and noise which is in contrast to the conventional methods that provide a sub-optimal solution to the fuel management problem under similar conditions of parameter variations and environmental disturbances.