EPiCo
Electric Vehicle Propulsion and Control

E-Pico Master's Thesis

Integrated Battery and Regenerative Braking Control on Connected HEV

Hybrid electric vehicles (HEVs) are more energy efficient and cleaner than conventional vehicles. Recently, the implementation of connected and automated driving system has been applied to HEVs to further reduce fuel consumption with the improvement of safety and traffic congestion.
However, connected and automated hybrid electric vehicles involve several technical challenges. Among them the battery thermal management is crucial because battery packs have to operate within a certain temperature range to ensure safety, optimum performance, and long service life. A crucial problem of the connected and automated hybrid electric vehicles is that the Lithium-ion batteries are highly temperature-sensitive and may be premature aging at high working temperatures.
In [7] it is presented a simulation study of various electric vehicle types and compare the performance when driving on real-road drive cycles to highly optimized eco-driving cycles using advanced CAV technologies, in particular it is shown that eco-driving provides a larger reduction in the conventional vehicle's braking energy loss.

Goals

In the literature, several studies have been conducted in recent years on the management of battery (see [1], [2], [3], [4], [5], [6]) in electric or hybrid vehicles. With the technological advancement of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) there will be various information available that can be used to achieve even more refined goals. Several control problems can be faced related to battery use in a scenario with connected HEVs. A goal can be linked to maximizing the life of a battery on the basis of a mathematical model of life, some characteristic magnifications in some operating ranges. Having an arrangement of the information of nearby vehicles, it is possible to use this data to minimize consumption by satisfying the driver's requests for comfort and travel objectives, as well as manage the charging and discharging times of the battery.
Morever, in recent research (see [8], [9]) has shown how control strategies in electric vehicles can be useful for improving the efficiency of the regenerative system in terms of energy and efficiency. The idea of improving the performance of the regenerative brake system in hybrid electric vehicles from an energy point of view through the use of information from nearby vehicles is a challenge that goes between the various objectives that the connected vehicle system poses.
A research challenge of the future will be to control in an integrated and coordinated way, optimizing both battery life and recovered energy

Requirements

You should have a good understanding of Hybrid Electric Vehicles models, Battery models, Automatic Control Theory, Connected Vehicles, MATLAB-SIMULINK.

[1] Marcelo A. Xavier, Aloisio Kawakita de Souza, M. Scott Trimboli, A Split-Future MPC Algorithm for Lithium-Ion Battery Cell-Level Fast-Charge Control, IFAC-V 2020, Germany, July 11-17 2020.

[2] Gabriele Pozzato, Matteo Corno, Closed-loop Battery Aging Management for Electric Vehicles, IFAC-V 2020, Germany, July 11-17 2020.

[3] Minh Vu, Shen Zeng, Huazhen Fang, Health-aware battery charging via iterative nonlinear optimal control syntheses, IFAC-V 2020, Germany, July 11-17 2020.

[4] Quan Ouyang, Rui Ma, Zhaoxiang Wu, Zhisheng Wang, Optimal Fast Charging Control for Lithium-ion Batteries, IFAC-V 2020, Germany, July 11-17 2020.
[5] Chong Zhu, Fei Lu, Hua Zhang, Kangxi Zhu, and Chris Mi, A Finite-Set Model-Based Predictive Battery Thermal Management in Connected and Automated Hybrid Electric Vehicles, IEEE Applied Power Electronics Conference and Exposition (APEC), pp. 3428-3433, 2018.
[6] Li Tang, Giorgio Rizzoni, and Simona Onori, Energy Management Strategy for HEVs Including Battery Life Optimization, IEEE Transactions on Transportation Electrification, Vol. 1, No. 3, October 2015.
[7] Gao Z. et al., Evaluation of electric vehicle component performance over eco-driving cycles, Energy, 172, pp. 823-839, 2019.
[8] Gao Z. et al., Multi-Objective Optimization Study of Regenerative Braking Control Strategy for Range-Extended Electric Vehicle, Applied Sciences, 10, 1789, 2020.
[9] Yang Yang, Chang Luo and Pengxi Li, Regenerative Braking Control Strategy of Electric-Hydraulic Hybrid (EHH) Vehicle, Energies, 10, 1038, 2017.

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