UNIVERSITY OF BIRMINGHAM

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Energy Management System for Plug-in Hybrid Electric Vehicle

Improved efficiency of PHEVs using battery and fuel power sources

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IP Status

Provisional patent

Seeking

Licensing, Commercial partner, Development partner

About **University of Birmingham**

At the University of Birmingham our research leads to new inventions and fuels innovation and business growth.

Background

Inefficient use of electric and internal combustion engine power in plug-in hybrid electric vehicles (PHEV) results in reduced battery life and an increase in fuel consumption and emissions.

The University has developed a novel energy management system for PHEVs in which a model-free predictive energy management method is used. The results show that the model-free method can save up to 14% energy compared with the conventional model based method.

Tech Overview

Hybrid electric vehicles are expected to play an important role in achieving targets for CO_2 emissions and clean air requirement. PHEVs will play an increasing role as their typical range of 20 miles on battery power covers the daily commute that many vehicles are used for.

A hybrid vehicle comprises multiple sources of power to provide motive power to the vehicle. Each of the power sources provides motive power to the vehicle in accordance with a power distribution. The power or energy management system (EMS) is responsible for determining the power distribution from different power sources to ensure the maximum system efficiency over the driving period and sustain the energy source within the proper level. EMS play an important role in hybrid vehicle performance, and efforts have been made to determine the optimal power distribution to satisfy the motive power requirements of the vehicle, while minimising emissions and maximising energy efficiency.

Existing EMS can be roughly classified into two categories, rule-based method and optimization-based method. Both offline and online optimization for EMS have been under research for many years, and the online optimization based on Model-based Predictive Control is considered the most effective approach among the existing energy management methods.

Researchers at the University of Birmingham have developed an intelligent energy management system for hybrid electric vehicle, which can learn, optimize and update the control policy during the real-world driving. The hybrid electric vehicle with a continuously optimized control policy will always be running in the most efficient mode.

The vehicle EMS developed by researchers at the University of Birmingham provides an intelligent EMS for determining which fractions of total required power are provided by the first and second power sources. The vehicle EMS achieves this by implementing a method that learns, optimises, and controls a power distribution policy executed by the vehicle EMS. One or more of the steps of learning, optimising, and controlling are implemented continuously during real-world driving of the vehicle. The steps of optimising and learning a power distribution policy are performed by the learning system. The step of controlling a power distribution based on that policy is performed by the control system. The learning and optimising steps are based on a number of samples, each sample comprising vehicle state data, vehicle power distribution data, and corresponding reward data. Each sample is measured at a respective point in time.

Figure 1 Interaction between the learning system with HEV system

Figure 2 Performance comparison of model-based predictive control and model-free predictive control

Benefits

The energy management system provides:

- A reduction in energy of up to 14%
- Optimized management of power sources ensures maximum system efficiency
- Intelligent energy management system learns and updates control policy based on real world driving with multiple-step reinforcement learning.

Applications

The technology has been developed for plug-in hybrid electric vehicles such as cars, buses, light goods and heavy goods vehicles.

Opportunity

Extensive proof of concept work carried out using state-of-the-art tools. Looking for collaboration and licensing opportunities.

ZSR1103

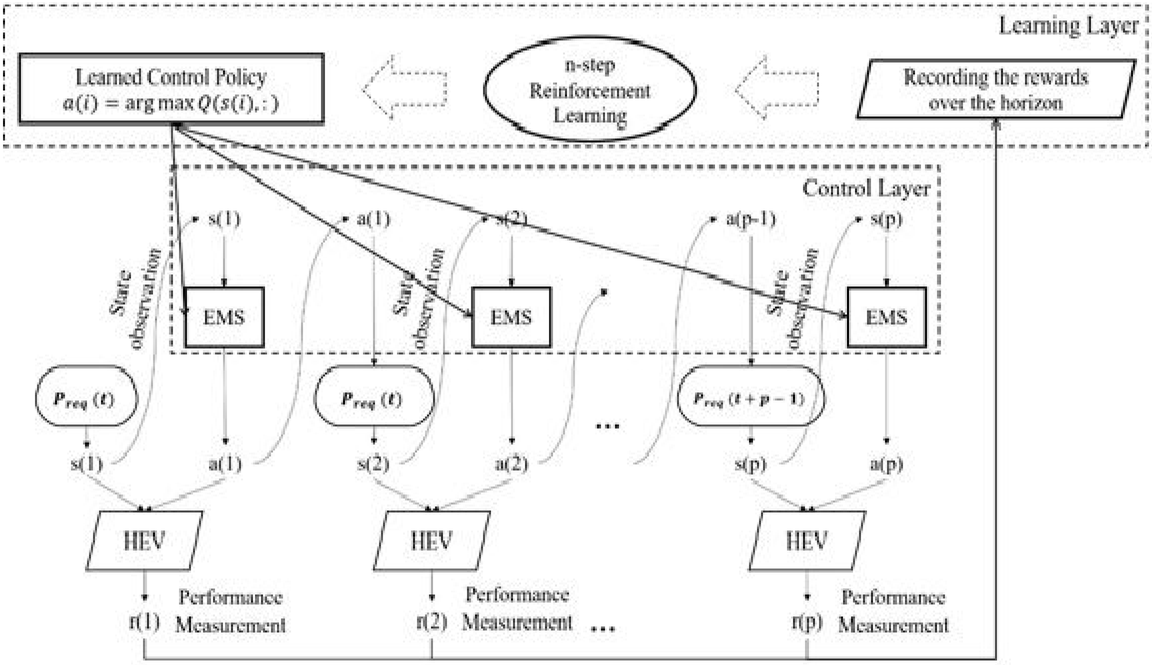
Patents

- GB1810755.7

Appendix 1

Figure 1

Interaction between the learning system with HEV system



Appendix 2

Figure 2

Performance comparison of model-based predictive control and model-free predictive control.

Cycle Name	Cycle Length (s)	Strategy	Energy Loss (J)	Saving
PBDC-I	8505	Model-Based	5.09E+08	---
PBDC-I	8505	Model-Free	4.42E+08	15.11%
PBDC-II	4908	Model-Based	1.32E+08	---
PBDC-II	4908	Model-Free	9.76E+07	34.96%
PBDC-III	4056	Model-Based	8.27E+07	---
PBDC-III	4056	Model-Free	7.05E+07	17.40%
PBDC-IV	4152	Model-Based	1.85E+08	---
PBDC-IV	4152	Model-Free	1.59E+08	15.80%