Proposal for Open Invited Track on

Machine Learning in Automotive Powertrains

at IFAC World Congress 2023

Session code: 6w138

Organizers

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Abstract

Machine Learning (ML) is generally considered to be a disruptive technology. ML-based methods have received growing interest due to the increasing availability of data and the success of ML applications for complex problems. In the automotive sector, various studies can be found on applications in computer vision, autonomous driving or logistics and traffic planning. For powertrain applications, ML is believed to dramatically reduce the development time and costs and to enhance robust performance by self-learned adaptation. However, only limited studies are found so far. This open invited track aims to address the potential and challenges of ML-based concepts for automotive powertrains. It will create an inspiring discussion platform to bring together experts from relevant disciplines and helps to create new collaborations and to direct future research.

Evaluating IFAC Technical Committee

The organizers recommend the proposal to be evaluated by the following Technical Committee:

- IFAC TC 7.1. Automotive Control

Additional recommended TCs are:

- IFAC TC 1.1. Modelling, Identification and Signal Processing
- IFAC TC 6.3. Power and Energy Systems

Description

Today's powertrain control development relies on traditional map-based and model-based control approaches. Due to growing system complexity and real-world performance requirements, these expert-intensive and time-consuming approaches will lead to challenges of unacceptable development time and costs. Consequently, powertrain control development is facing a turning point in the near future.

Machine Learning (ML) is a disruptive technology, which offers powerful features to address these challenges. To significantly reduce the time, cost, and effort required for powertrain control calibration, ML methods offer opportunities to i) create dynamic models needed in predictive control approaches such as model predictive control (MPC), ii) design of supervisory learning-based controllers, iii) efficiently parametrize control models (e.g., PID gains or maps) and iv) design real-world powertrain load cycles for automated testing in the laboratory. Utilizing ML along with cloud computing and vehicle to infrastructure (V2I) communications enables even further reductions as well as improved real-world performance. For example, based on the availability of large sizes of data, ML-based methods enhance both internal system and situation awareness due to learned system behavior, improved prognostics and new fault detection methods. Also, prediction accuracy of physics-based models can be improved by grey-box (or hybrid) modeling approaches.

Enhanced awareness is an important step towards auto-calibration concepts, which optimize powertrain performance by on-road adaptation of control settings based on actual and predicted system behavior.

Currently, limited results are published on ML-based methods for powertrain applications. There is clearly a need to demonstrate the potential, limitations and challenges of these promising methods. This will concretize the anticipated ML benefits and accelerate industry adaption of Machine Learning. We target high quality publications that i) introduce new ML-based powertrain applications; ii) clearly specify the performance benefits and impact on development effort; and iii) deal with implementation challenges in real-world.

This open invited track solicits submissions of IFAC-regular papers or discussion papers (i.e. 2-4 page extended abstracts) based on original research. Focus is on application of supervised learning, unsupervised learning and reinforcement learning methods to powertrains equipped with internal combustion engines, electric motors, batteries or fuel cells. The topics of interest include, but are not limited to:

1) Modelling of advanced combustion processes;
2) Modelling of thermal systems for battery and fuel cell systems;
3) Battery state of charge estimation;
4) Thermal management of batteries and fuel cell stacks;
5) Smart charging and energy management;
6) Health/ageing modelling, diagnosis and prognostics;
7) Prediction of maintenance scenarios;
8) Anomaly Detection in Advanced Engine Concepts (incl. fuel quality, pre-ignition, knock);
9) AI-assisted powertrain control;
10) Transfer learning for control of similar powertrain systems with different sizes