PhD in Mechanical Engineering

Research Title: Battery monitoring for commercial vehicles

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Context of the research activity	The level of electrification in modern vehicles is witnessing a steady increase in the recent years. The development of new electric powertrains and the electrification of chassis components and accessories in the cabin is indeed promoting a relevant research effort in the optimization of the electric components and in their integration in the vehicle system. One subsystem that is attracting a relevant attention is the battery, which typically represents the primary source of energy. The performance of this component is affected by the number and type of the charge/discharge cycles, and also by environmental factors such as temperature and age. Regardless of the chemistry of the battery, a constant and accurate monitoring to check its condition is required. Specifically, the assessment of the level of the remaining available energy indicated by the State of Charge (SOC) as function of the level of ageing suffered by the battery, indicated by the State of Health (SOH) is of pivotal importance. These parameters cannot be directly measured with sensors and must be estimated by means of indirect approaches. Common solutions rely on the adoption of look-up tables, filled with time consuming tests conducted in a laboratory environment. Alternative methods adopt filter-based algorithms (Kalman filter, Extended Kalman Filter) but may suffer problems related to inaccuracies of the model tuning or lack in the representation of the battery behaviour in all the possible operating conditions. Recently, in this context, a relevant attention is gained by Artificial Intelligence. Specifically, Artificial Neural Networks (ANNs) represent a promising solution since they are not depending on any model and can guarantee a good level of

	accuracy, provided that the training dataset is complete and the network architecture is appropriate. This research activity is aimed to develop estimation techniques for the assessment of both SOC and SOH of batteries for automotive applications, and in particular for commercial vehicles, by means of ANN–based techniques. The research will be conducted in cooperation with the industrial partner IVECO SpA, in the framework of the activities of the Interdepartmental Center CARS (Center for Automotive Research and Sustainable Mobility) of Politecnico di Torino.

Objectives	The objective of the activity is the study, design and deployment on the real application of techniques to estimate the State of Charge (SOC) and State of Health (SOH) of batteries for commercial vehicles. The technique will allow improving the accuracy of the assessment of the remaining available energy in the battery and will be exploited to enable prognostics and predictive maintenance solutions. The activities will be conducted in cooperation with the industrial partner IVECO SpA, which will also provide the experimental measurements obtained on real commercial vehicles. The first phase will be dedicated to the state of the art analysis, which will be aimed to evaluate the current solutions. Afterwards, the study will be focused on the evaluation of techniques based on ANNs, to obtain the combined estimation of the SOC and SOH. In this phase, the training datasets will be provided by the industrial partner. The last part will be dedicated to the test and validation of the algorithm, which will be conducted in two phases: 1) Tests in a simulation environment. 2) Deployment of the resulting algorithm on a real BMS of a commercial vehicle and test in real operating conditions. The effectiveness of the proposed solution will be evaluated in terms of accuracy of estimation, computational cost, repeatability and scalability of the solution.

Skills and competencies for the development of the activity	The required skills and competencies are: - Basic knowledge of Artificial Intelligence techniques for identification, prediction and estimation tasks with classification and regression architectures. - Modelling and simulation of mechatronic systems.