COMPUTER AND CONTROL ENGINEERING

MUR DM 117/Stellantis - A global multi-objective approach to trip optimization and optimal propulsion system management in battery electric vehicles

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Context of the research activity	The aim of the proposed research activity is to develop a novel multi-objective approach to jointly optimize the following tasks (commonly addressed as two completely separated problems): - Trip optimization: minimization of the trip duration based on the selected destination and the online information provided by the navigation system - Optimal energy and thermal management of the electric propulsion system: maximization of the vehicle range and speed of recharge on the basis of the online information provided by Vehicle-to-everything (V2X) communications. Progetto finanziato nell'ambito del PNRR - DM 117/2023 - CUP E14D23002020004
	Research objectives The objectives of the PhD project are both methodological and applications-oriented. We summarize them as follows. 1) Methodological objectives: the considered multi-objective optimization problem will be formulated in terms of optimal predictive control. In particular, a multi-loop model predictive control (MPC) scheme will be looked for: the inner-loop will optimize the behavior of the low-level devices for thermal and energy management (battery, powertrain, cooling systems, etc.) over a relatively short prediction horizon (5-30 min); the outer-loop will optimally plan the vehicle trip (in terms of time duration, energy consumption and driver comfort) over the whole trip. The low-level inner-loop will be driven by the optimal long-term reference

Objectives	system behavior computed as solution of the high-level long-term optimization. Machine learning (ML) algorithms will be exploited in the long-term prediction in order to suitably account for all the information provided the V2X communication network. 2) Applications-oriented objectives: the problem of simplifying the obtained optimal algorithms/control structures will be studied in order to make them actually implementable on a real production vehicle. Particular attention will be devoted to the trade-off between computation complexity reduction and performance degradation. The obtained algorithms will be implemented and tested on an accurate model of the systems and/or a real prototype vehicle (in case it will be made available by Stellantis/CRF before the end of the project) Outline of the research work plan M1-M6: - Study of the literature on trip optimization and optimal energy and thermal management for battery electric vehicles. - Development of an accurate mathematical model of the whole system to be controlled/optimized M7-M18: General mathematical formulation of the problem. Design of the low-level optimal feedback control structure. Results obtained in this stage of the project are expected to be the core of both a conference contribution and a paper to be submitted to an international journal. M19-M31: Mathematical formulation of the long-term optimal prediction/planning problem. Design of the high-level control loop. Results obtained in this stage of the project are expected to be the core of both a conference contribution and a paper to be submitted to an international journal. M32-M36: Simulated/Experimental test and final performance assessment List of possible venues for publications Journals: IEEE Transactions on Control System Technology IEEE Transactions on Intelligent Transportation Systems Conferences: American Control Conference SAE World Congress IEEE Conference on Control Technology and Application (CCTA)

	Industrial Partner The research activity will be conducted in strict collaboration with STELLANTIS / CRF which is co-funding the Ph.D scholarship

Skills and competencies for the development of the activity	Strong background on: - Fundamental results on System theory and Automatic Control - System identification - Model predictive control At least some notions on Machine learning algorithms / Artificial neural networks structures and training