COMPUTER AND CONTROL ENGINEERING

MUR DM 117/Stellantis - Innovative Automated Driving functional architecture based on APF/MPC approaches for new sustainable mobility systems

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Context of the research activity	Automated Driving (AD) systems are a promising evolution of current vehicle technology. They pave the way to a sustainable mobility future for enhanced road safety, efficient traffic flow and improved fuel consumption. The research project focuses on the development of an innovative encapsulated control architecture that implements the AD functions needed to reach high driving automation in low complexity driving scenarios, such as smart cities, according to the SAE level L4+. Intelligence Augmentation (IA) principles are employed to integrate Artificial Intelligence (AI) perception of unpredictable events and vehicle control. The core approach relies on the use of Artificial Potential Field (APF) combined with Model Predictive Control (MPC) methods to generate an optimal and safe path, given by the minimum energy trajectory over time. Progetto finanziato nell'ambito del PNRR - MUR DM 117/2023 - CUP E14D23002020004
	This proposal refers to an industrial collaboration with STELLANTIS group and Centro Ricerche Fiat. Research objectives The main goal is to provide an innovative methodology and solution for high level AD systems, that allows to enlarge the Operational Design Domain (ODD) progressively, leading to the realization of higher levels of AD (L4+). Several but strongly interrelated Research Objectives should be pursued to achieve it. Initially, focus mainly on low-speed velocities AD function but methodology extendable in highway scenarios as well. Several but strongly interrelated research objectives (RO) should be pursued to achieve this goal:

Objectives	• RO1 – Hybrid and flexible architecture, capable of accommodating various sensory configurations, on the one hand, and integrating Infrastructure info on the other; it will have to be designed with a robust approach to obtain an AD of L4+, employing AI developments (perception, scene understanding) and robust control techniques (motion planning and control), to provide relevant content and functionality. • RO1a - Hypothesis of different degrees of responsibility / autonomy • RO1b - How to model automotive eco-system contexts using a multimodal sensing approach (on-board sensors, environmental data, off-board information, etc.) to provide relevant content and functionality • RO1c - Correct individualization of the subtasks of the function to be solved with AI or model-based techniques and moreover, their right semantic integration in the perspective of Intelligence Augmentation • RO2 - AD functional architecture allows the design of scalar solutions (different configurations of vehicle sensors and infrastructure info, remote-controlled vs full ego approach) • RO3 - Flexibility - suitable architecture for the so-called low complexity environments (valet parking, to reserved areas in a smart city context, but also extendable in highway scenario). • RO4 - Benchmark and evaluate the proposed solution with alternative/other Stellantis solutions. The above objectives open a broad multidisciplinary research landscape that touches core aspects of new mobility models and systems for Industry 4.0 applications and automotive sector. Such a framework is considered very important for the incremental process of ODD augmentation vs. high level AD systems, and for safety and robustness implications the APF&MPC approach can bring to the operations of AVs, relative to the in-depth synthesis & analysis of these issues and root cause identification, as well as countermeasure development. Outline of the research work plan In the first year, the candidate will carry out an overall study evaluation of the functional architecture (hierarchical) that incapsulates a structured pipeline of separate functional blocks. Focus will be mainly on global planner, global-in-the-loop and local planner concepts. Also, a first feasibility evaluation, considering different sensors configuration and infrastructure information will be performed as well. In the second year, the candidate will be focalized on the motion planning design based on the so-called one and two step design approaches for the trajectory planning function. Semantic interactions between planning and control modules are included as well. Specificities in LSM context (AVP, smart city), but also will explore the possibility of method extension in a highway context. In the third year, the candidate will be dedicated mainly on the validation of the proposed solution performance obtained with this approach, based on APF/MPC for motion planning design, integrated in the overall AD architecture (AVP in the defined ODD with specialized infrastructure areas); it will be implemented and run in the Matlab / Simulink / SCANer simulation platform. Feasibility evaluation for a demo vehicle implementation, since the beginning two plausible sensors set configuration of the vehicle will be considered (full ego and an infrastructure info based). During the 2nd and 3rd years, the candidate will perform many testing at Stellantis premises. The central part of the activity will be carried out at the CRF facilities in Turin, and in remote with AEES/SCIC team & facilities (Vélizy – Villacoublay, Paris). The Ph.D. candidate will also be involved in a period abroad in a STELLANTIS group facilities in France and Germany.

Skills and competencies for the development of the activity	Solid background in the field of Automatic Control including advanced methodology such as Model Predictive Control. Furthermore, deep expertise of MatLab programming and Simulink environment is required. Finally, basics of mechanical modeling of ground vehicles and automated driving tasks are needed as additional specific knowledge.