MECHANICAL ENGINEERING

DIMEAS - Design Methodologies of Mechatronic Systems for Automotive Applications

Funded By	Dipartimento DIMEAS
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Context of the research activity	The research work is dedicated to the development of a methodology for the design of Mechatronic Systems for the control of (i) the chassis , (ii) the thermal management and HVAC systems and (iii) the transmission in hybrid/electric vehicles. The research will focus on the development of the methodology and its implementation to case studies by the construction of prototypes to be tested on dedicated test benches and installed on the vehicle for final vehicle validation.
Objectives	The PhD research program is embedded in an international context characterized by a highly active scientific community across Europe, the United States, Central America, Japan, and China. This is driven by strong industrial interest in the fields of automotive engineering. Research in this area is motivated by the need to develop increasingly flexible, efficient, and compact mechanical and mechatronic systems, with the ultimate goal of improving safety, comfort, and environmental impact of vehicles. The actuation systems under investigation in this research program are based on the development of electromagnetic devices, which are often integrated with motion transmission systems. These require the implementation and use of multiphysics and multi-domain numerical models, with varying levels of complexity depending on their specific function. Such tools are crucial for achieving increasingly stringent requirements, including (i) dynamic performance, (ii) low noise levels, (iii) compactness, and (iv) efficiency. Meeting these requirements also demands particular care in material selection and application to minimize friction, non-linearities, and component inertia, while still ensuring compliance with static, thermal, and fatigue sizing specifications. Experimental testing represents another crucial element in the development of these systems. It is conducted by leveraging the capability to virtualize processes within high-level hardware (dSpace,…), enabling the use of Hardware-in-the-Loop (HiL) strategies for partial system validation. This approach allows virtual elements to be simulated in real time for those system components that are not of immediate interest. Subsequently, it is necessary to proceed with the experimental validation of the complete system in a real vehicle.

	The main goal of the research is to define a design methodology dedicated to the development of smart actuation systems to be implemented in next generation vehicles. The methodology will be validated by case studies that will be identified at the end of the first year. They could refer to active suspensions, high adjustment systems, camber control, smart actuators for thermal management systems, steering and brake actuators of drive by wire systems. Validation means (i) detailed design of the prototypes, (ii) construction and assembly, (iii) functional tests, (iv) calibration of the control, (v) HiL tests in the Lab using dedicates test beds, (vi) test on vehicle. The final goal is to (i) enhance the background, (ii) identify a clear design methodology, (iii) implement some applications able to demonstrate how it is possible to improve the vehicle comfort, safety and environmental impact with solutions that are sustainable from an industrial cost/benefit perspective. The research program will be developed within the following EU founded research projects: SmartCorners (https://smartcorners.eu/), SHIFT2SDV (https://shift2sdv-project.eu/), HiPower 5.0 (https://hipower50.eu/) and Aether.

Skills and competencies for the development of the activity	The candidate should have a background in mechanical or automotive engineering. In detail are requested the following competences: • dynamic modelling of mechanical and mechatronic systems in Matlab - Simulink environment using energetic approaches (Lagrange, Hamilton,…), • use of Multiphysics numerical tools (COMSOL Multiphysics); • capabilities of 3D drawings using tool as CATIA, SOLIWORKS, … • knowledge of main control logics.