MECHANICAL ENGINEERING

DIMEAS - Advanced and integrated chassis control for electric vehicles with multiple actuators benefitting from road preview

Funded By	Dipartimento DIMEAS

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Contact	

Context of the research activity	The research will deal with the development of integrated chassis controllers for electric vehicles, e.g., including multiple powertrains, active toe angle control, active camber angle control, and active or semi-active suspension actuation. The algorithms will be based on the combination of rule-based approaches, quasi-static offline optimisations, computationally efficient optimal control, and artificial intelligence implementations. Elements of road preview, e.g., related to the driver behaviour, curvature, or expected speed and road profile ahead, will be implemented.
	PhD Workplan Year 1 • Literature review on control and actuation methodologies for integrated chassis control • Preparation and submission of a high-quality review paper (e.g., for Annual Reviews in Control, see the following examples: Model predictive path tracking control for automated road vehicles: A review - ScienceDirect, Preview-based techniques for vehicle suspension control: a state-of-the-art review - ScienceDirect, Anti-jerk controllers for automotive applications: A review - ScienceDirect, Integrated chassis control: Classification, analysis and future trends - ScienceDirect) • Simulation model (in CarMaker by IPG) for control system assessment, based on one of the SmartCorners demonstrator vehicles, targeting the baseline vehicle • Experimental assessment of the baseline vehicle • Experimental validation of the simulation model • Inclusion of the high-fidelity models of the relevant in-wheel/on-board motors and suspension actuators (for individual corner force control, individual toe angle control, camber angle control as well as half-track width control), including consideration of the coupling implications (interaction among the different actuations in terms of variation of suspension elasto-kinematics), and the actuation dynamics aspects • Set-up of the V2X interface within the vehicle simulation model (preview of road curvature, road irregularities, speed profile, steering profile, yaw rate profile, optionally tyre-road friction factor)

Objectives	• Toolchain for the development of nonlinear model predictive controllers (ACADO toolkit / ACADOS / ForcesPro / CasADi), neural network tools, and deep reinforcement / imitation learning tools (Matlab, Python) • End of year presentation Year 2 • Digital twins based on physics-derived formulations • Digital twins based on artificial intelligence techniques (deep neural networks) • Experimental validation of the resulting digital twins • Integrated chassis control systems using the physics-based digital twins • Neural network model predictive controller for torque-vectoring and active suspension forces and kinematics using the AI-derived digital twins • Simulation-based critical analyses on: i) potential benefits of the different integrated chassis control actuations; ii) comparison between different algorithmic approaches • Preparation of a quartile 1 journal paper on critical analysis i) and a quartile 1 journal paper on critical analysis ii) • End of year 2 presentation Year 3 • Adaptive AI approaches for torque-vectoring, active suspension force control, and active suspension kinematics • Critical analysis of AI performance including comparisons with NMPC and NNMPC, with focus on computational efficiency related aspects • Experimental sessions for controller validation on the available demonstrator vehicles • Preparation and submission of a journal paper on AI algorithms and respective critical analysis, and a paper on the experimental validation aspects • Final PhD thesis write-up During the PhD project, at least 6 months will be spent at another company or academic institution. Funding is available for attending conferences, project meetings, and testing sessions at the facilities of industrial and academic partners.

Skills and competencies for the development of the activity	Vehicle dynamics, vehicle dynamics simulation, vehicle dynamics control, vehicle testing