D) AI and learning based Enhanced Model Reference Adaptive Control strategies applied to automotive control systems

Model Reference Adaptive Control (MRAC) is an effective control method for imposing the desired system behaviour, which is embedded into the dynamics of the reference model, despite the presence of uncertainties and disturbances as the control gains adapt based on the actual system response. To further improve the tracking of the reference dynamics, the Enhanced MRAC (EMRAC) have been proposed in [1], where the MRAC control action has been augmented with an adaptive integral control action and an adaptive switching control action. Nowadays, MRAC solutions are also used in conjunction with AI strategies, e.g., to approximate unmatched unknown disturbances for their compensation [2], thus improving the tracking of the reference model, or other forms of learning techniques, e.g., reinforcement learning to adjust online the reference model for improving closed-loop robustness [3]. The target of this project is to explore AI and learning based solutions for MRAC strategies that can be used for expanding the EMRAC strategy. The resulting algorithm/s will be then tested on automotive control problems. Possible application includes, a) direct-yaw moment control to improve vehicle stability during cornering and b) path tracking control strategies for autonomous vehicles.

Required skills:
-MATLAB & Simulink programming
- Python
- Knowledge of control engineering (e.g., gained from university courses)
- AI (highly desirable but not essential as it will be learnt during the project)
- Proactivity

References:
1) Montanaro et. al, *Synthesis and Experimental Validation of the Novel LQ-NEMCSI Adaptive Strategy on an Electronic Throttle Valve*, IEEE Transactions on Control Systems Technology, Vol. 18 , Issue: 6 , pages, 1325 - 1337 , 2010
2) G. Josh et al, *Deep Model Reference Adaptive Control*, 2019 IEEE 58th Conference on Decision and Control (CDC), 2019, pp. 4601-4608.
3) Yuksek, et al, *Reinforcement learning based closed-loop reference model adaptive flight control system design*. Int J Adapt Control Signal Process. 2021; 35: 420– 440