The underlying motivation for research in learning-based control is to develop control methods and algorithms that can accommodate sensor and actuator limitations, account for complex, uncertain, and unpredictably changing dynamics, and operate robustly in the presence of disturbances and noises. The promise of learning-based control methods is the ability to account for all of these effects with less plant or system knowledge. Specifically, the contribution of this research project will be the development of learning-based methods that can achieve control performance beyond the reach of classical feedback control. As commonly known, a successful application of classical feedback control, even when feedforward action is used to increase the resulting control performance, depends foremost on plant or system uncertainty since high performance drastically increase plant modeling requirements. Clearly, there exist control strategies which take into account uncertainty, i.e. robust control, and seek to trade performance for robustness to the assumed level of uncertainty. In contrast, learning-based control attempts to learn about the plant dynamics during operation, in order to overcome prior uncertainty. Moreover, plants or systems that are inherently difficult to model and/or control with classical methods can potentially be effectively controlled with learning-based methods. Therefore, the project tries to combine learning methodologies with the ideas of modern robust control strategies to account plat uncertainty and produce control laws of a high performance.

To satisfy project objectives it is required to develop the following tasks:

1. *Analysis of limitations on performance in systems with learning-based control*. As known, the performance versus robustness tradeoff is one of the most important aspects of modern control theory. Therefore, it is important to investigate which factors limits the performance learning-based control and their relation to robustness. Specifically, the aim is to provide insight into the limitations that safe operation requirements (good transients and stability) impose on the achievable performance of a learning algorithm.

2. *Improving robustness against uncertainties and disturbances for learning-based control*. To proceed, the plants models with additive or multiplicative uncertainty are considered and a more detailed frequency domain analysis is performed to characterize the tradeoff between performance and robustness. Then optimization procedures will be used to maximize the uncertainty level under constraints on performance indexes. A key problem to be examined is to know if a given control system remains stable for all possible plant perturbations and disturbances.

3. *Development of iterative schemes in control and identification of distributed-parameter systems*. Increasing complexity of modern control systems together with restrictive requirements in the area of spatio-temporal physical systems also called distributed parameter systems (DPSs) are associated with using sophisticated methods of control. Classical approaches to design the control systems dedicated for lumped parameter systems are insufficient to achieve the required results or are not straightforward to apply. Therefore, iterative learning schemes can strongly contribute to control strategies for DPSs as it provides the robustness to the modelling errors and parameter changes.

4. *Synthesis of learning-based control schemes for nonlinear systems using neural modelling*. The main purpose of this task is to propose learning based control schemes to nonlinear systems. In many cases there is impossible to get correct mathematical models of the considered system. In such cases the nonlinear behavior of the control system can be determined using black-box models. In this context artificial neural networks can be effectively applied. One of the distinct characteristics of neural networks is universal approximation property according to which any nonlinear mapping can be approximated with any degree of accuracy using neural network with suitable structure and parameters. The second key property, from the project objectives point of view, is possibility of their training and adaptation from historical data. What is the most important neural network training can be carried out through optimization of a cost function defining the performance of the control system. These features make it possible to apply neural networks to synthesis learning-based control for nonlinear systems.

5. *Design of iterative learning control schemes for systems of interacting subsystem*. Our aim here is to apply the learning-based method to control of complex interconnected systems. In most cases these systems are characterized by a large number of variables representing the system, a strong interaction between the system variables, and a complex structure. Therefore, due to structural complexity of interconnected systems, the classical methods are not suitable for improving tracking and disturbance rejection. The project aims at achieving acceptable tradeoff between the conflicting goals of tracking performance versus robustness to plant uncertainty.