5 MSc Projects with Imad Jaimoukha

Model Predictive Control:
Project #: IMJ1

Model Predictive Control (MPC), sometimes termed Receding Horizon Control, is one of the few advanced control schemes taken up by industry. It is model-based, applied in real time and incorporates optimal control. The main aim of the project is to synthesize MPC controllers that achieve the design specifications despite the presence of model uncertainties and disturbances.

The project uses robust control theory techniques, linear matrix inequalities and global optimization methods. All algorithms will be developed using Matlab and Simulink.

Fault Detection & Isolation
Project #: IMJ2

Feedback control systems are vulnerable to faults in system components and control loop sensors and actuators, because feedback action may cause abrupt and damaging responses when faults occur. The object of this project is to review some available methods of fault detection for feedback control systems. Emphasis will be given to methods based on the construction of diagnostic observers to register occurrence of a fault in the system and to locate it. The project involves mathematical analysis and use of MATLAB packages for simulation and computation.

Robust Controllers for Structured Uncertainties
Project #: IMJ3

The main aim of control design is to ensure closed-loop stability and achieve the design specification in the face of uncertainties in system and signal description. When these uncertainties are unstructured, the design exercise is relatively easy.

This project deals with the case of structured uncertainties: for example, when the parameters of some system are known only partially, or when some signal components are known while others are uncertain.

Current techniques for dealing with structured uncertainty are computationally intensive and lead to very high order controllers. This project aims to develop computationally tractable design algorithms, based on mu-analysis and synthesis techniques, which give controllers that adequately satisfy the design specifications. All algorithms will be developed using MATLAB. The student is expected to have a good background in linear algebra, control theory and system modelling.

Semidefinite Relaxation for Global Optimization Problems
Project #: IMJ4

Many interesting problems in economics and engineering can be reduced to global optimization problems which cannot be solved using standard calculus based techniques. One such problem is the integer programming problem where the aim is to maximize a cost function with the variables being constrained to be either 0 or 1. The exact solution for such problems involving large number of variables is intractable because of its combinatorial nature.

This project aims to investigate a class of approximation techniques for such problems, where the constraints of the problem are slightly relaxed resulting in upper bounds on the exact solution. A secondary aim of the project is to reduce the gap between the exact value of the maximum cost function and its upper bound. These techniques will be tested on case studies from the fields of engineering and economics.

The student is expected to have a good background in linear algebra. All programs will be developed and tested in MATLAB.

Control of Large Scale Systems
Project #: IMJ5

Many control system modelling procedures produce large order models. For purposes of efficient simulation and subsequent controller design, it is essential to replace these large models by reduced order approximations.

This project aims to carry out this model reduction step efficiently using a combination of Krylov subspace, balanced truncation and Linear Matrix Inequality (LMI) techniques. All algorithms will be developed and tested using MATLAB. The techniques will be verified using case studies involving large scale power systems and RLC circuit models. The student is expected to have a good background in linear algebra.