# Monday Morning: Behavioral approach

### 1. An overview of nD behaviors - 9am

Eva Zerz (RWTH Aachen University)

### 2. Towards a geometric approach to nD behaviors? - 10.30am

Paula Rocha (University of Porto)

In this talk we try to introduce for nD behaviors the basic notion of invariant subspace,and the properties of controlled-invariance
and conditioned-invariance (well-known from the classical geometric approach). Further, we study the characterization of the newly defined properties, and show their relevance for the solution of certain behavioral control problems.

# Tuesday Morning: Applications

### 1. Modelling and structural properties of distributed parameter wind power systems - 9am

Hugues Mounier (Univ. Paris Sud, L2S)

in collaboration with Luca Greco (Univ. Paris Sud, L2S)

We examine two distributed parameter models for strings of generators connected to a wind farm. We show that these models boil down to delay systems either with or without continuous dynamics, depending on the type of the chosen boundary conditions. We then investigate the differential flatness of the systems, giving some solution to the actuation placement problem (i.e. where to place the farms along the generators string).

**2. Nash equilibrium with wave dynamics, boundary control, disturbance rejection and stabilization - 10.30am**

Teresa Perdicoulis (Univ. UTAD)

We model the gas network as a 2-player differential game with quadratic performance criteria constrained by a wave 2D repetitive process and its players are the required boundary conditions of a pipeline. Different solutions for this model of game exist. We opt for an OL Nash equilibrium. Necessary and sufficient conditions for the existence/uniqueness of the solution of the differential game are derived using a value function approach; these are expressed in terms of the solution of a system of coupled matrix Riccati difference equations. An algorithm to calculate the OL Nash solution is outlined. Furthermore, we study boundary controllability, observability and disturbance rejection for this model. We are also very interested in stabilisation.

# Wednesday Morning: Stability and stabilization of multidimensional systems Part I

**1. Structural stability, asymptotic stability and exponential stability: from 1D to 2D systems - 9am**

Nima Yeganefar (Univ. Poitiers, LIAS)

in collaboration with Olivier Bachelier (Univ. Poitiers, LIAS), Thomas Cluzeau (Univ. Limoges, XLIM), Ronan David (Univ. Poitiers, LIAS), Nader Yeganefar (Univ. of Marseille, CMI)

We will consider and try to answer two questions :
1. How to generalize usual definitions from 1D to 2D systems, depending on the choice of the initial conditions.
2. What are the links between these definitions and how does it compare to the 1D case.

### 2. On structural stability/stabilization of 2D discrete models - 10.30am

Olivier Bachelier (LIAS, University of Poitiers)

This work is issued from a collaboration with many other researchers.

In this talk, we recall several results on structural stability analysis and structural stabilization obtained in the recent years. These conditions are expressed in terms of LMIs and are restricted to Roesser models. Once these conditions recalled, we take advantage of what the algebraic analysis approach offers to investigate the control of Fornasini-Marchesini by making use of the notion of strict equivalence between models.

## Thursday Morning & beginning of afternoon: Stability and stabilization of multidimensional systems Part II

## 1. An introduction to stabilization problems of multidimensional systems - 9am

Alban Quadrat (Inria Lille, Non-A)

The purpose of this talk is to give an introduction to stabilization problems of multidimensional systems defined in the frequency domain. Based on module theory, lattice theory and homological algebra, we first explain how the fractional representation approach to analysis and synthesis problems, developed by Desoer, Vidyasagar, Francis, Callier, … in the eighties, can be used to reformulate different stabilization problems for general classes of systems. In particular, we give necessary and sufficient conditions for a plant to admit (weakly) doubly coprime factorizations and for internal stabilizability. We illustrate these results on multidimensional systems by giving algebraic equivalent formulations of these properties. The development of implementable algorithms for testing them will be studied in the next two talks. We show how to parametrize all the stabilizing controllers of a stabilizable plant and prove that this parametrization reduces to the standard Youla-Kucera parametrization when the plant admits doubly coprime factorizations. Based on the above results and on two theorems due to Pierre Deligne and to Bridges, Mines, Richman et Schuster, we prove two Zhiping Lin's conjectures. In particular, we show that every stabilizable multidimensional plant admits a doubly coprime factorization and thus that all its stabilizing controllers can be parametrized by the Youla-Kucera parametrization.

## 2. Computer algebra technique for testing the stability and the stabilizability of multidimensional systems - 10.30am

Yacine Bouzidi (Ecole Centrale de Lille) and Fabrice Rouillier (Inria Paris, Ouragan)

in collaboration with Alban Quadrat (Inria Lille, Non-A)

In the theory of multidimensional systems, several fundamental properties such as stability and stabilizability translate as the non-vanishing of algebraic systems of polynomial equations inside certain regions of the complexe space (e.g. the unit polydisc for discrete systems). For 1-dimensional systems, this problem reduces to the localization of complexe roots of univariate polynomials, and several algebraic criteria that are both exact and computationally efficient has been derived for this purpose. For $n$-dimensional systems with $n \geq 2$, the problem become more involved since it requires the study of higher dimensional algebraic varieties that correspond to the zero sets of polynomial systems of equations and few implementations has been developed. In this presentation, we consider the case of 2D and 3D discrete systems and propose new algebraic approaches for studying the stability and the stabilizability of these systems. More precisely, using state-of-the-art techniques for solving algebraic systems of equations (Gröbner Basis, Univariate Representation, Critical point methods, …), we design efficient and certified algorithms for testing both the stability and the stabilizability of 2D and 3D discrete systems. Examples will be given to illustrate the practical efficiency of our algorithms.

**3. Constructive and effective stabilization of 2D linear systems - 2pm**

Guillaume Moroz (Inria Nancy-Grand Est, Vegas)

in collaboration with Yacine Bouzidi (Ecole Centrale de Lille), Thomas Cluzeau (XLIM, University of Limoges) and Alban Quadrat (Inria Lille, Non-A)

For two-dimensional linear systems, the problem of stabilizing the output feedback can be reduced to the polydisk Nullstellensatz problem. Given a polynomial ideal I that has no zeroes in the unit polydisk, the polydisk Nullstellensatz theorem states that there exists a polynomial f in I that doesn't vanish in the unit polydisk. There exist constructive methods to find such a f, but they are based on exact polynomial factorization in the complex field, which is not effective. We will present in this talk a constructive and effective method based on subresultants theory to solve the polydisk Nullstellensatz problem for bivariate systems.

# Friday Morning: Optimization problems

### 1. Introduction to polynomial optimization - 9am

Didier Henrion (LAAS, CNRS)

The talk surveys the fundamentals of polynomial optimization and hierarchies of moment-sum-of-squares semidefinite programs or linear matrix inequalities, as implemented in our Matlab package GloptiPoly. This mathematical technology allows to solve globally non-convex optimization problems at the price of solving a hierarchy of convex optimization problems of increasing size.

### 2. A symbolic-numeric method for the parametric $H_\infty$ loop-shaping design problem - 10.30am

Guillaume Rance (Sagem)

in collaboration with Yacine Bouzidi (Ecole Centrale de Lille), Alban Quadrat (Inria Lille, Non-A) and Arnaud Quadrat (Sagem)

We present a symbolic-numeric method for solving the H∞ loop-shaping design problem for low order single-input single-output systems with parameters. Due to the system parameters, no purely numerical algorithm can indeed solve the problem. Using Gröbner basis techniques and the Rational Univariate Representation of zero-dimensional algebraic varieties, we first give a parametrization of all the solutions of the two Algebraic Riccati Equations associated with the H∞ control problem. Then, a certified symbolic-numeric algorithm is obtained for the computation of the positive definite solutions of these two Algebraic Riccati Equations. Finally, we present a certified symbolic-numeric algorithm which solves the H∞ loop-shaping design problem for the above class of systems. This algorithm is illustrated with a standard example.