Control and nonlinearity
by J.-M. Coron, Université Pierre et Marie Curie et Institut universitaire de France, Paris, France.
September 10th, 09:00-12:15.
Abstract: We present methods to study the controllability and the stabilizability of nonlinear control systems modeled with partial differential equations. The emphasis is put on specific phenomena due to the nonlinearities. In particular we study cases where the nonlinearities are essential for the controllability or the stabilizability. We illustrate these methods on various physical systems: Euler and Navier-Stokes equations of incompressible fluids, Korteweg de Vries equations, Burgers equations, Saint-Venant equations Schrödinger equations, Bloch equations.

To be defined
by G. Bastin, Center for Systems Engineering and Applied Mechanics, Louvain-la-Neuve, Belgium.
September 10th, 14:00-17:15.
Abstract: To be defined.

Analysis of port-Hamiltonian Systems, Part I
by H.J. Zwart, University of Twente, The Netherlands.
September 11th, 09:00-12:15.

Analysis of port-Hamiltonian Systems, Part II
by B. Maschke, Université Claude Bernard, Lyon, France.
Abstract: Port-Hamiltonian systems appear naturally as models of distributed parameter systems formulated as systems of balance equations. Hyperbolic systems such as flexible structures form a typical example. Associated to these systems is a natural energy (Hamiltonian), which may only change by influences coming in via the boundary (ports) of the spatial domain on which the system is described. These systems may be described by linear or non-linear partial differential equations. However, to show analytic properties such as existence and uniqueness of solutions, the class of non-linear partial differential equation is too large. In this lecture we restrict ourselves therefor to linear partial differential equations, i.e., linear port-Hamiltonian systems. For this class there are easy checkable conditions for existence and uniqueness of solutions. Furthermore, placing inputs and outputs at the ports lead to a well-defined system, which can easily be used for control.

- Transport in nonhomogeneous media: from modeling to control with Lyapunov techniques: Part I
  by E. Witrant, Université J. Fourier / GIPSA-Lab, Grenoble, France.
  September 12th, 09:00-11:00.

- Transport in nonhomogeneous media: from modeling to control with Lyapunov techniques: Part II
  by C. Prieur, CNRS / GIPSA-Lab, Grenoble, France.

Abstract: One of the major difficulties in the analysis of physics associated with transport phenomena in nonhomogeneous media is the complexity of the process model. This complexity is mainly due to the large-scale aspect, the medium heterogeneity (anisotropic - direction dependent - transport coefficients) and the dynamics of the interconnections (equilibrium, flow exchange, transport and propagation between the nodes). Such models come from hydrodynamics (e.g. transport in porous media), aerodynamics (e.g. Poiseuille flows) or magnetohydrodynamics (e.g. thermonuclear fusion) and are described with partial or functional differential equations. Their use in control strategies imply to take into account the fact that the infinite dimensional aspect of the system (physical continuum) is affected by both space and time variations.

The first part of the lecture is focused on the modeling and identification aspects. Starting from a generic formulation of the conservation laws, the impact and inclusion of the nonhomogeneous property of the surrounding medium is first described. The resulting dynamics are classified depending on the main transport tendency (e.g. diffusive or convective, with or without sink). The importance of dynamical and exogenous inputs is emphasized, in order to formulate the asso-
ciated identification or control problem. These issues are illustrated on different challenging problems: ventilation control in large plants, profiles control for tokamak plasmas and quantification of the anthropogenic impact on atmospheric composition from firn air measurements.

In the second part of this lecture, the focus is on the computation of Lyapunov functions for the safety factor profile control for the Tore Supra tokamak. Such systems involve rapidly time-varying distributed diffusivity coefficients. It is shown how a constrained control law (incorporating nonlinear shape constraints in the actuation profiles) is designed by means of a Lyapunov function. These Lyapunov techniques ensure exponential stability and input-to-state stability (ISS) properties of the closed-loop system. The convergence of the nominal system and its robustness with respect to disturbances and estimation errors are exhibited on numerical simulations of all the Tore Supra dynamics.

• **Introduction to Backstepping Control for PDEs**
  by *M. Krstic*, University of California, San Diego.
  September 13th, 09:00-12:15.
  **Abstract:** Boundary control is a natural formulation for control of fluid flows (such as oil production systems), flexible structures (such as flapping wings), energy storage systems (Li-ion batteries), lasers, systems with input/output delays, and numerous other engineering systems. Backstepping transformations for boundary control of parabolic and hyperbolic PDEs will be introduced. The controllers for transport PDE systems will be specialized to ODE systems with arbitrarily long delays. The lecture will emphasize unstable PDEs and feedback design for their stabilization.

• **Stabilization Methods for the Korteweg-de Vries equation**
  by *E. Cerpa*, Universidad Técnica Federico Santa Mara, Valparaso, Chile.
  September 13th, 14:00-17:15.
  **Abstract:** This lecture is concern with the stabilization of the Korteweg-de Vries equation, which is an important PDE describing approximately long waves in water of relatively shallow depth. Boundary and internal feedback laws stabilizing exponentially the system to the origin will be designed. Three different tools are used: a damping method, a Gramian-based approach and the Backstepping method.

• **Stability of nonlinear locally damped partial differential equations: the continuous and discretized problems: Part I**
  by *F. Alabau-Boussouira*, Université de Lorraine, Metz, France,
  September 14th, 09:00-12:15.

• **Stability of nonlinear locally damped partial differential equations: the**
Abstract: The purpose of this course is to give an overview of recent progresses for nonlinear stabilization of continuous and discretized PDE’s. In the first part of the course, we first show how to derive quasi-optimal energy decay rates for general nonlinear dissipations. This can be performed by a direct (see [1], [2]) or an indirect method (see [3]). The indirect method is based on an observability estimate for the undamped PDE’s (see [13] in the linear bounded feedback case, and [8, 9] in the unbounded linear feedback case). It has been recently combined with the optimal-weight convexity method (see [4, 1, 2]) to handle nonlinear dampings (see also [10]). Optimality of energy decay rates, in particular for the semi-discretized PDE’s is also presented. These optimal estimates are based on an energy comparison principle and comparison between pointwise and energy estimates. The resulting estimates are nonuniform with respect to the discretization parameter. In the infinite dimensional case, optimality or lower energy estimates have been obtained only in a few, specific cases (see [18,19] and [14]). We shall give a methodology based on the dissipation relation and interpolation properties to derive lower energy estimates for several new problems and indicate the open problems (see [2, 5, 6]). The second part of the course will be devoted to the discretized problems. More precisely we show how uniform optimal energy decay rates with respect to the discretization parameter can be derived by adding a numeric viscosity, extending to the nonlinear damping case, results in [17, 11, 12] and [16]. We also give an overview of the full discretization problems and filtering methods.

Contents: I Energy decay estimates for the continuous problem

1. The indirect method via observability estimates
2. Optimality in finite dimensions and nonuniform energy estimates for semi-discretized PDE’s
3. Lower energy estimates in the infinite dimensional case

II Energy estimates for the discretized problem

1. Uniform decay estimates with respect to the discretization parameter
2. Full discretized systems
3. Filtering methods
References


The subject of control of distributed parameter systems is vast; the available literature consists of literally thousands of articles on every conceivable aspect of what, is by, its very nature, a subject of great diversity. Any representative bibliography would, literally, fill all of the pages allotted to us for this chapter. Recent papers in Control of Distributed Parameter Systems. Papers. People. Optimal feedback control of singularly perturbed distributed parameter systems. A presentation is made of the optimal feedback controller equations for a class of distributed parameter systems containing a small parameter multiplying the time derivatives of some state variables. By allowing this small parameter to more. A presentation is made of the optimal feedback controller equations for a class of distributed parameter systems containing a small parameter multiplying the time derivatives of some state variables.