Exploratory Workshop on geometric control theory and applications to engineering

January 16-18, 2012. Aula Gris 1, ICMAT, Madrid, Spain.

	Monday 16	Tuesday 17	Wednesday 18
9.30-11	Mario Sigalotti	Joris Vankerschaver	Kurusch Ebrahimi-Fard
11-11.30	COFFEE	COFFEE	COFFEE
11.30-13	María Barbero	Sandra Ricardo	David Martín
13-15	LUNCH	LUNCH	LUNCH
15-17	Discussion session 1. D. Martín de Diego	Discussion session 2. A. Ibort	Discussion session 3. M. de León

MONDAY 16

Motion planning for the bilinear Schroedinger equation through the control of its Galerkin approximations.
Mario Sigalotti (INRIA, Centre de Recherche Saclay-Île-de-France, France)

Abstract: We present an approximate controllability result and motion planning algorithm for the bilinear Schroedinger equation in an infinite-dimensional Hilbert space. The sufficient condition is expressed as a non-resonance hypothesis on the discrete spectrum of the uncontrolled Schroedinger operator. The control operator is not required to be bounded and we are able to extend the controllability to the density matrices. The proof is based on fine controllability properties of the finite-dimensional Galerkin approximations and allows to get estimates for the L^{1} norm of the control.

Interconnection of kinematic reduction and Hamilton-Jacobi equation. María Barbero (ICMAT-UC3M, Spain)

Abstract: Hamilton-Jacobi theory has strong similarities with kinematic reduction by means of decoupling vector fields of nonholonomic mechanical control systems. We describe that interconnection on a geometric structure called skew-symmetric algebroid, which generalizes the notion of Lie algebroids. The results that will be presented in this talk give some insights into future developments in motion planning for nonholonomic mechanical control systems.

Discussion session 1 on Discrete Mechanics.
Chair: David Martín de Diego (ICMAT-CSIC, Spain)

TUESDAY 17

Control systems on symplectic fiber bundles. Joris Vankerschaver (UCSD, USA) .

Abstract : In this talk I will describe a class of control systems which are characterized by the fact that the configuration space depends on the controls. Such systems arise, for instance, when considering the control of a fluid by one or several immersed rigid bodies, where the fluid configuration space changes as the controlling bodies are moved around. I will show that these systems can be described using symplectic fiber bundles and symplectic connections, and I will discuss the link between the geometry of such bundles and aspects of control theory.

A tour through the geometry of mechanical control systems. Sandra Ricardo (UTAD and ISR, Portugal).

Abstract: In the first part of the talk, we characterize nonlinear control systems that are state equivalent to a mechanical control system and describe the canonical mechanical structure attached to it. We distinguish a special class: the class of geodesically accessible mechanical systems, for which the uniqueness of the mechanical structure is guaranteed (up to an extended point transformation).

In the second part of the talk we discuss the mechanical state equivalence of two mechanical control systems in terms of two families of structure functions which are equivariants for the mechanical state equivalence (and, more generally, for the state equivalence) of two mechanical control systems satisfying the geodesic accessibility property.

Discussion session 2 on Quantum control theory.
Chair: Alberto Ibort (UC3M, Spain).

WEDNESDAY 18

Expansions growing on trees, algebras living in forests... a day in the life of an amateur numerical gardener.
Kurusch Ebrahimi-Fard (ICMAT-CSIC, Spain).

Abstract: A. Connes and D. Kreimer wrote in a paper that they: "[We] regard Butcher's work on the classification of numerical integration methods as an impressive example that concrete problem-oriented work can lead to far reaching conceptual results."
Recall that numerical integration methods are used for calculating numerical solutions of differential equations. Butcher introduced in his work on an algebraic theory of integration methods, in the late 1960s - early 1970s, so-called B-series. They provide important tools in the analytic and structural study of -particular classes of- such numerical methods. In fact, Butcher's discovery was a group structure for Runge-Kutta methods, whose elements are scalar functions of rooted trees. He showed how the standard solution of a differential equation is obtained from a particular (continuous) method which he called the Picard method. Hence, from the group point of view the natural things to do with such B-series is to combine them. The composition law for B-series then allows for a simple derivation of order conditions. Recently, another group structure on B-series was discovered. This substitution law for B-series makes the notion of modified differential equations in the context of backward error analysis more transparent. In this talk we will show in detail how these two laws give rise to groups, and (pre-)Lie and Hopf algebras of trees. We will show how these results enable us to recover recent results in the field of numerical methods for differential equations due to Chartier, Hairer and Vilmart as well as Murua. If time permits we will report on recent progress made in the context of geometric integration methods (KEF and Manchon: pre-Lie Butcher series), and nonlinear feedback systems (Gray et al.: Faà di Bruno Hopf algebra for Fliess operators).

Hamiltonian dynamics and constrained variational calculus: continuous and discrete settings.
David Martín de Diego (ICMAT-CSIC, Spain).

Abstract: The aim of this talk is to study the relationship between Hamiltonian dynamics and constrained variational calculus. We describe both using the notion of Lagrangian submanifolds of convenient symplectic manifolds and using the so-called Tulczyjew's triples. The results are also extended to the case of discrete dynamics and nonholonomic mechanics. Interesting applications to geometrical integration of Hamiltonian systems are obtained.

Discussion session 3 on Mechanics in Field Theory.
Chair: Manuel de León (ICMAT-CSIC, Spain).