TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	September 16	September 17	September 18	September 19	September 20
9.00 - 9.45	Registration	Terze	Ding	Bruels	Murphey
9.45 - 10.30	Terze	Terze	Ding	Bruels	Murphey
11.00 - 11.45	Terze	Terze	Ding	Bottasso	Murphey
11.45 - 12.30	Terze	Mueller	Ding	Bottasso	Mueller
14.00 - 14.45	Terze	Mueller	Bruels	Bottasso	
14.45 - 15.30	Mueller	Mueller	Bruels	Bottasso	
16.00 - 16.45	Mueller	Ding	Bottasso	Murphey	
16.45 - 17.30	Mueller	Ding	Bottasso	Murphey	

ADMISSION AND ACCOMMODATION

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through our web site: http://www.cism.it or by post.

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

The 700,00 Euro registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday not included), hot beverages, on-line/downloadable lecture notes and wi-fi internet access.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel. Requests should be sent to CISM Secretariat by **July 16, 2013** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on our web site, or can be mailed upon request.

Please note that the centre will be closed for summer vacation the first three weeks in August.

For further information please contact:

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Piazza Garibaldi 18
33100 Udine (Italy)
tel. +39 0432 248511 (6 lines)
fax +39 0432 248550
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ACADEMIC YEAR 2013
The Troger Session

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

DIFFERENTIAL-GEOMETRIC METHODS IN COMPUTATIONAL MULTIBODY SYSTEM DYNAMICS

Advanced School
coordinated by

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University of Zagreb
Croatia

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Technical University of Chemnitz
Germany

Udine, ***September 16 - 20,*** **2013**

DIFFERENTIAL-GEOMETRIC METHODS IN COMPUTATIONAL MULTIBODY SYSTEM DYNAMICS

Introduction:
Multibody system (MBS) dynamics, a branch of computational mechanics dealing with modeling principles and computational methods for dynamic analysis, simulation and control of mechanical systems, requires efficient and reliable formulations and computational methods.
Within research of novel computational concepts, geometric aspects of kinematical and dynamical modeling of MBS are increasingly recognized to play a significant role. By operating on manifolds, and Lie-groups in particular, instead of linear vector spaces, geometric algorithms respect the geometric structure underlying many technical systems and hence offer attractive features such as numerical robustness and efficiency as well as avoidance of the kinematical singularities.
Also, it is well-known that differential-geometric methods are the key concepts in contemporary mechanism design, and control theory. As such, geometric methods can provide the unifying mathematical framework that allows for successful studying of multidisciplinary interactions within complex environments.

Objective and Audience:
The aim of the School is to deliver a panoramic overview of the mathematical concepts underlying modern geometric approaches to modeling, time integration, and control of MBS, followed by an in-depth introduction to the relevant computational algorithms and numerical methods. By merging geometric methods in MBS dynamics, non-linear control and mechanism theory, the School provides unique educational platform that will deliver novel modeling concepts as well as theoretical and computational insights into dynamics and control of mechanical systems.
The lectures take an application-driven approach, and numerous case-studies from many fields of engineering are presented and documented.
The School is primarily aimed for the audience of doctoral students and young researchers (post-docs) in engineering, mathematics and applied physics, but will be valuable also for senior researchers and practicing engineers who are interested in the field.

Lectures Outline:
The lectures provide a hands-on introduction to differential-geometric foundations and the audience will make acquaintance with these topics in a natural and application-driven way. A central topic of the school is efficient formulations using Lie-group concepts and screw theory, giving rise to numerically efficient and stable algorithms for MBS comprising rigid and flexible members. Special focus is given to energy and structure preserving numerical integration methods on manifolds for discrete and continuous systems. Natural coupling between mathematical modeling, numerical integration and control issues are covered by the lectures on variational integrators and optimal control with structure preserving integrators.
Specifically, lectures will include:
• introduction to mathematical concepts and differential-geometric modeling (manifolds, Lie-groups, Lie-algebras, exponential maps, screw theory etc.); • modeling of complex MBS using compact Lie-group formalisms; • time integration on Lie-groups; • geometrically exact formulations for beams and shells; • energy-consistent time integration procedures for MBS with flexible components; • numerical treatment of holonomic and non-holonomic constraints, constraint stabilization; • variational integrators, discrete mechanics and optimal control using structure-preserving integration schemes applied to high degree-of-freedom systems; • Lie-group/screw theoretic framework for design of MBS and articulated mechanisms; • multi-physics coupling procedures: aero-servo-elastic multidisciplinary models and applications.
A treatment of many numerical case-studies in the domain of robotics, wind energy systems, rotorcraft dynamics, aeronautical and mechatronical systems will highlight compact formulations, relevance and computational advantages of the geometric approach in the modern computational mechanics.
The unifying lecturing approach that combines computational procedures, control algorithms and design aspects, and provides new insights into the coupled modeling procedures, makes this School unique.

PRELIMINARY SUGGESTED READINGS

Bauchau, O., Bottasso, C: On the design of energy preserving and decaying schemes for flexible nonlinear multi-body systems, Computer Methods in Applied Mechanics and Engineering 169 (1999) 61–79.

Brüls, O. and Cardona, A.: On the Use of Lie Group Time Integrators in Multibody Dynamics, ASME Journal of Computational and Nonlinear Dynamic, Vol. 5, 1-23, 2010.

Selig, J., Xilun, D.: A Screw Theory of Timoshenko Beams, ASME Journal of Applied Mechanics, Vol. 76, 2009.

Johnson, E., Murphey T. D.: Scalable variational integrators for constrained mechanical systems in generalized coordinates, IEEE Transactions on Robotics, (25)6: 1249–1261, 2009.

R. M. Murray, Z. Li, S. S. Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press, 1993.

Terze, Z., Naudet J.: Geometric Properties of Projective Constraint Violation Stabilization Method for Generally Constrained Multibody Systems on Manifolds, Multibody System Dynamics, 20 (2008).

INVITED LECTURERS

Zdravko Terze - University of Zagreb, Croatia
7 lectures on: Geometric concepts in numerical ODE/DAE integration of multibody system (MBS) dynamics. Mathematical framework will be introduced and dynamics of discrete mechanical systems in Lie-group settings described, together with the topics of MBS geometric time-integration and constraint violation stabilization on manifolds.

Andreas Mueller - Technical University of Chemnitz, Germany
7 lectures on: Geometric modeling of complex rigid body systems making use of the Lie-group of Euclidean motions and the algebra of screws. Efficient recursive formulations for kinematics and dynamics are introduced, and the computational aspects are discussed.

Xilun Ding - Beijing University of Aero. & Astro, China
6 lectures on: Geometric modeling of flexible MBS. The lectures briefly recall the required fundamentals of continuum mechanics, and method for spatial discretization, further on, will present the analysis approach of mechanisms with spatial continuum compliance in the context of screw theory and Lie-groups, and applications in robotics and mechanical design.

Olivier Bruels - University of Liège, Belgium
4 lectures on: Lie-group formalisms in flexible multibody dynamics: definition of the configuration space, DAE form of the equations of motion, Lie-group generalized-alpha time integrator, sensitivity analysis methods, practical implementation and numerical examples.

Carlo Bottasso - Politecnico di Milano, Italy
6 lectures on: Geometrically exact flexible MBS modeling/energy-consistent time integration and applications in domain of aero-servo-elastic systems, wind turbines and rotorcrafts. The lectures will consist of two parts, first part focusing on methodological aspects and second part being devoted to application issues.

Todd Murphey - Northwestern University, Evanston, IL, USA
5 lectures on: Trajectory optimization, regulation, and estimation for discrete mechanical systems with emphasis on variational integrators. Discretization of the action principle along with properties of resulting integrators will be examined in the context of constrained multibody systems. Applications of the resulting numerical methods to robotics applications will be presented.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from CISM web site, instructions will be sent to accepted participants.

DIFFERENTIAL-GEOMETRIC METHODS IN COMPUTATIONAL MULTIBODY SYSTEM DYNAMICS

Udine, September 16 - 20, 2013
Application Form
(Please print or type)

Surname _____

Name _____

Affiliation_____

Address_____

_____

E-mail _____

Phone _____Fax_____

Method of payment upon receipt of confirmation (Please check the box)

The fee of Euro 700,00 includes IVA/VAT tax and excludes bank charges

❑ *I shall send a check of Euro* _____

❑ *Payment will be made to CISM - Bank Account N° 094570210900, VENETO BANCA - Udine (CAB 12300 - ABI 05035 - SWIFT/BIC VEBHIT2M - IBAN CODE IT46 N 05035 12300 09457 0210900). Copy of the receipt should be sent to the secretariat*

❑ *I shall pay at the registration counter with check, cash or VISA Credit Card (Mastercard/Eurocard, Visa, CartaSi)*

IMPORTANT: CISM is obliged to present an invoice for the above sum. Please indicate to whom the invoice should be addressed.

Name _____

Address _____

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C.F.* _____

VAT/IVA* No. _____

(*) Only for EU residents or foreigners with a permanent business activity in Italy.

Only for Italian Public Companies

❑ *I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10).*

Privacy policy: I understand that data received via this form will be used only to provide information about CISM and its activities, within the limits set by the Italian legislative decree no. 196/2003 and subsequent amendments.
Complete information on CISM's privacy policy is available at www.cism.it.

I have read the "Admission and Accommodation" terms and conditions and agree.

Date _____ Signature _____