



Robotics Group

## International Summer School

# Screw-Theory Based Methods in Robotics



Università degli  
Studi di Genova

August 22-30, 2009  
University of Genoa, Italy

SUMMER 20  
SCREWS 09

[http://www.dimec.unige.it/PMAR/summer\\_screws\\_09/](http://www.dimec.unige.it/PMAR/summer_screws_09/)

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Istituto Italiano di tecnologia



SIRI  
Italian Association of  
Robotics and Automation

Summer Screws '09 will gather five experts in the robotics applications of screw-theory and up to 30 participants at the University of Genoa and the Italian Institute of Technology during the last week of August. The summer school will teach attendees how to apply existing methods and empower them to develop new ones in their own research. The basic theoretical notions will be introduced in a rigorous manner, with emphasis on examples, applications, and exercises

The applications of the theory of screws are based on the combined representation of angular and linear velocity, or similarly force and moment, as one element of a six-dimensional vector space.

The importance of screw theory in robotics is widely recognised, in principle. In practice, almost nowhere is it taught to mechanical-engineering students and few know how to use it. Yet, in a variety of areas of robotics, methods and formalisms based on the use of screw geometry and algebra have shown to be superior to other techniques and have led to significant advances. These include the development of fast and efficient dynamics algorithms, discoveries in the nature of robot compliance and mechanism singularity, and the invention of numerous parallel mechanisms.

The instructors in the summer school are the authors of many of these results. They will teach the participants to apply existing techniques and to develop new ones in their own research. The basic theoretical notions will be introduced in a rigorous manner, but the emphasis will be on applications, with examples and exercises.

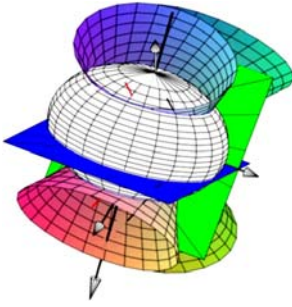
### The City

The summer school will be held in Genoa, Italy. The city of [Genoa](#) is the capital of Liguria and the centre of the Italian Riviera.

Founded as a Roman port, it became a mercantile centre and a powerful maritime republic. The city is the birthplace of Christopher Columbus and prides itself as a leading participant in the Risorgimento and the anti-fascist resistance.

Among its many sights are numerous medieval churches and Renaissance palaces. La Strada Nuova (now via Garibaldi) was proclaimed a UNESCO World Heritage Site in 2006. Nearby places of interest include Portofino, a famous fishing village and tourist resort, as well as the Cinque Terre National Park, also on the UNESCO World Heritage List.



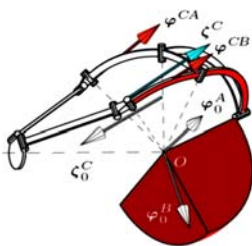
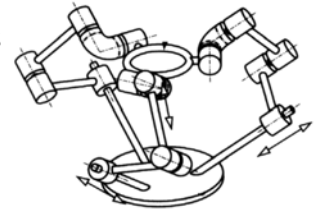


Basic vector-space properties of twists and wrenches: physical interpretation of the linear operations; linear dependence and independence, subspaces; bases and coordinates. (Lecturer: Dimiter Zlatanov)

Dimiter Zlatanov has used screw theory in the singularity and mobility analysis of mechanisms. He is the inventor of one of the first-known 4-dof parallel mechanisms and has presented courses and talks on screw-based methods in various universities

Scalar products, dual spaces, reciprocity. Constraint and freedom in mechanisms. Constraint analysis. Type synthesis of single-loop mechanisms and parallel manipulators. (Lecturers: Xianwen Kong and Dimiter Zlatanov)

Xianwen Kong is the inventor of numerous parallel mechanisms and the co-author of the book Type synthesis of parallel mechanisms. His results have been based on methods from screw-system theory.

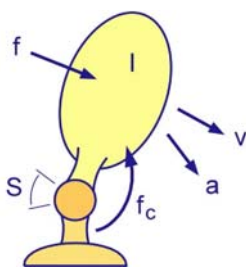
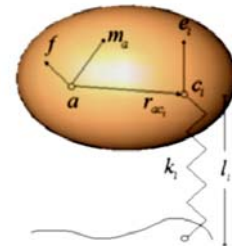


Velocity and singularity analysis of parallel and interconnected-chain mechanisms. Derivation of input-output velocity equations and singularity conditions. (Lecturers: Matteo Zoppi and Dimiter Zlatanov)

Matteo Zoppi has developed screw-theoretical techniques for the derivation and application of velocity equations for complex-chain manipulators. He is also the inventor of a number of mechanisms.

Mappings between screw spaces, stiffness and inertia. Structure of robot compliance. Eigenvalue problems and eigenscrews. Synthesis with springs. (Lecturer: Harvey Lipkin)

Harvey Lipkin has worked more than any one on applying screw-theoretical methods in different areas of robotics and mechanisms, such as hybrid control, compliance, vibrations, and dynamics. He has taught various aspects of screw theory and supervised graduate students in the use of such methods.



6D formulation of the dynamics of individual rigid bodies and rigid-body systems. Equations of motion. Dynamics algorithms. (Lecturer: Roy Featherstone)

Roy Featherstone is the inventor of the Articulated-Body Dynamics Algorithm, and the author of the books Robot Dynamics Algorithms and Rigid Body Dynamics Algorithms. His ground-breaking work in dynamics has relied on a screw-theoretical formalism for the formulation of the equations of motion.



## Organization

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