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ENG AM/MN 740: **Vision, Robotics, and Planning—Intelligent Machines**

Course Outline: (Spring 2005)

1. Foundations of intelligent mechatronics
2. Geometry and robot coordinate systems
 - (i) Rigid motions of \mathbb{R}^3
 - (ii) Kinematic pairs and the lattice of subgroups of the special Euclidean group
 - (iii) Free vectors and bound vectors
3. Euclidean group theory and kinematic equations
 - (i) The Denavit-Hartenberg formalism
 - (ii) The product of exponentials formula
 - (iii) Screw theory
4. Differential relationships
 - (i) The manipulator Jacobian for spatial mechanisms
 - (ii) The propagation of joint velocities and forces
5. Specifying robot motions
 - (i) The theory of motion interpolation
 - (ii) Nonholonomic motion planning
6. Analytical dynamics of mechanical systems
 - (i) Lagrangian mechanics
 - (ii) Hamiltonian mechanics
7. Control: basic issues
 - (i) Controllability
 - (ii) Design and synthesis
 - (iii) Stability of feedback control laws
8. Control: sampled data systems
 - (i) Nyquist frequency and Shannon's theorem
 - (ii) The zero order hold as basic control element
9. Advanced topics: nonlinear control
 - (i) Nonlinear/geometric control theory
 - (ii) Motion control in living organisms: paradigms and puzzles
10. Advanced topics: cooperative control
 - (i) Control of multiple mobile agents
 - (ii) Data-structures for distributed control of mobile agents
 - (iii) Distributed sensing and sensor fusion
 - (iv) The *blind robot problem*
11. Advanced topics: information-based control theory
 - (i) The control theory of micro-mechanical systems
 - (ii) The control theory of distributed mobility

- (iii) Real-time data-structures for control of distributed systems
- (iv) Data-rates; source and channel coding for control

12. Advanced topics: kinematic redundancy

- (i) Survey of techniques for resolving kinematic redundancy
- (ii) The extended Jacobian technique and constrained motions
- (iii) Super-articulated mechanical systems

Suggested Reading

Text:

Richard M. Murray, Zexiang Li, S. Shankar Sastry, *A Mathematical Introduction to ROBOTIC MANIPULATION*, CRC Press, Boca Raton, 1994. (Ordering information to be given in class.)

Other books:

→ *Highly recommended:*

A.M. Bloch, J. Baillieul, P.E. Crouch & J.E. Marsden, *Nonholonomic Mechanics and Control*, Springer-Verlag, Interdisciplinary Applied Mathematics, ISBN:0-387-95535-6, 483 pages.

V. Kumar, N. Leonard, & A.S. Morse (Eds.), *Cooperative Control*, Springer Lecture Notes in Control and Information Sciences, V. 309, Springer-Verlag, Berlin Heidelberg, ISBN 3-540-22861-6, 2005.

→ *Previous AM740 text:*

Brockett, R.W., ed., *Robotics*, Proceedings of Symposia in Applied Mathematics, Vol. 41, American Math. Soc., Providence, 1990.

→ *Suggested further reading:*

John J. Craig, *Introduction to Robotics, Mechanics and Control, 2nd Ed.*, Addison Wesley, 1989.

Carlos Canudas de Wit, Bruno Siciliano, and Georges Bastin, *Theory of Robot Control*, Springer (Communications and Control Engineering Series), New York, 1996.

J. Baillieul, Shankar Sastry, and Hector J. Sussmann (Editors), *Essays on Mathematical Robotics*, (Ima Volumes in Mathematics and Its Applications, V. 104.), Springer Verlag; ISBN: 0387985964, 1998.

J. Baillieul & J.C. Willems (Editors), *Mathematical Control Theory*, Hardcover - 385 pages, Springer Verlag; ISBN: 0387983171, 1998.

Grading

Grades will be given for homework assignments (one every week or so), class participation, and most importantly, for a term project which will be assigned during the first few weeks of the class.

Current information about the class may be found at

<http://people.bu.edu/johnb/MN740.html>