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ENG ME/SE 740: Vision, Robotics, and Planning—Intelligent Machines

Course Outline: (Spring 2011)

1. Foundations of intelligent mechatronics
2. Geometry and robot coordinate systems
 - (i) Rigid motions of 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: information-based control
 - (i) Nyquist frequency and Shannon's theorem
 - (ii) The zero order hold and quantization alternatives
 - (iii) The data-rate theorem and feedback control with communications constraints
9. Advanced topics: algebraic and geometric methods
 - (i) Nonlinear/geometric control theory
 - (ii) Motion control in living organisms: paradigms and puzzles
 - (iii) Networked control systems
 - (iv) Graph theoretic structures for distributed control and control motifs
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



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
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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:

→ Recommended:

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.

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.

→ Suggested further reading:

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.

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

Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, & Giuseppe Oriolo, *Robotics: Modelling, Planning and Control*, Springer; 1st edition, New York, ISBN-10: 1846286417, ISBN-13: 978-1846286414, Dec., 2008.

John J. Craig, *Introduction to Robotics: Mechanics and Control*, 3rd Ed., Prentice Hall 2004.

Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, *Robot Modeling and Control* John Wiley & Sons, Inc., New York, 2006.

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. For up-to-date information about the class, visit: <http://people.bu.edu/johnb/ME740.html>.

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