MECH 6324 Robot Control

Course Information Fall Semester, 2014

Class Meeting: Tuesdays and Thursdays, 2:30 – 3:45 PM
Starts: August 26, 2012
Ends: December 18, 2012
Location: FO 2.404

Instructor: Dr. Robert D. Gregg
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Office Hours: Fridays, 2-3:30 PM or by appointment

Course Pre-requisites, Co-requisites, and/or Other Restrictions

An Introduction to Control Theory at the level of MECH 6300 is necessary. Basic knowledge of linear algebra and differential equations are also required; Knowledge of Matlab and Mathematica is desirable.

Course Description

MECH 6324 - Robot Control *(3 semester hours) Dynamics of robots; methods of control; force control; robust and adaptive control; feedback linearization; Lyapunov design methods; passivity and network control; control of multiple and redundant robots; teleoperation. Prerequisite: MECH 6300. (3-0) T*

Student Learning Objectives/Outcomes

Upon successful completion of this course, students will:

1. *have a basic understanding of the kinematics of robot manipulators and mobile robots.*
2. *understand the dynamics of Lagrangian mechanical systems and be able to compute the dynamic equations of motion of any robot manipulator.*
3. *have a basic understanding of nonlinear control methods such as feedback linearization, passivity-based, robust, and adaptive control, and be able to analyze the stability and tracking performance of closed loop systems using Lyapunov theory.*
4. *be able to model, design, and simulate nonlinear controllers for manipulators and mobile robots.*

Required Textbooks and Materials

(MLS) *R. Murray, Z. Li, and S. Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press, Boca Raton, FL, 1994.*
Free download: *http://www.cds.caltech.edu/~murray/books/MLS/pdf/mls94-complete.pdf*

(SHV) *Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Robot Modeling and Control, John Wiley & Sons, Inc., New York, NY, 2006.*
A free download of this book will be made available via eLearning.

Required Software

MathWorks MATLAB
Access/installation: *http://www.utdallas.edu/ir/howto/matlab/*

Wolfram Mathematica
Access/installation: *http://www.utdallas.edu/ir/howto/mathematica/*
Tutorials: *http://www.wolfram.com/broadcast/screencasts/handsonstart/*

Exams and Grading Policy

There will be homework assignments involving worked problems and computer simulations, a midterm exam, and a final exam. Grades will be determined based on the following formula:

Homework 25%
Midterm 25%
Final 40%
Class Participation 10%

Topical Outline

1. *Screw Theory for Kinematics* (MLS)

   - *Rotation Matrices and Homogeneous Transformations*
   - *Exponential Coordinates for Rigid Motion*
   - *Twists and Wrenches*
   - *Forward and Inverse Kinematics*
   - *The Manipulator Jacobian*

2. *Dynamics* (MLS/SHV)

   - *Virtual Work and D'Alembert's Principle*
   - *The Euler-Lagrange Equations*
   - *The Dynamics of Example Manipulators*
   - *Properties of Manipulator Dynamic Equations*

3. *Independent Joint Control* (SHV)

   - *Actuator Dynamics*
   - *Set-Point Control*
   - *Feedforward Control*
   - *Drive-Train Dynamics*
   - *State Space Design*

4. *Multivariable Nonlinear Control* (SHV)

   - *Inverse Dynamics*
   - *Passivity-Based Robust and Adaptive Control*
   - *Force Control*
   - *Energy Shaping*

5. *Geometric Nonlinear Control* (SHV)

   - *Vector Fields and Distributions*
   - *The Frobenius Theorem*
   - *Feedback Linearization*

6. *Introduction to Mobile Robots* (SHV)

   - *Nonholonomic Constraints*
   - *Kinematics and Dynamics of Mobile Robots*
   - *Motion Planning and Obstacle Avoidance*
   - *Controllability and Chow's Theorem*
   - *Controller Design for Mobile Robots*

Course & Instructor Policies
(make-up exams, extra credit, late work, special assignments, class attendance, classroom citizenship, etc.)

Class attendance will count toward the 10% class participation portion of the grade. No late homework or make-up exams will be accepted without prior approval of the instructor. You must inform the instructor in advance if you will miss class for any reason.

Technical Support

If you experience any problems with your UTD account you may send an email to: assist@utdallas.edu or call the UTD Computer Helpdesk at 972-883-2911.

Policies and Procedures for Students

Email Use: Emails to Prof. Gregg should be sent from the student's official UT Dallas email account. Per FERPA policy, grades *cannot* be discussed via email.

Cell Phone Use: Cell phone use (e.g., texting) is disruptive to class and will not be tolerated.

Laptop Use: Laptop use is not permitted during lecture. Touchscreen devices will be allowed for note-taking unless such use becomes disruptive to the class.

Scholastic Dishonesty: The faculty expects from its students a high level of responsibility and academic honesty. Because the value of an academic degree depends upon the absolute integrity of the work done by the student for that degree, it is imperative that a student demonstrate a high standard of individual honor in his or her scholastic work.

Any student who commits an act of scholastic dishonesty is subject to discipline. Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, submitting for credit any work or materials that are attributable in whole or in part to another person, taking an examination for another person, or any act designed to give unfair advantage to a student or the attempt to commit such acts.

Student Conduct and Discipline: The University of Texas System and The University of Texas at Dallas have rules and regulations for the orderly and efficient conduct of their business. It is the responsibility of each student to be knowledgeable about the rules and regulations which govern student conduct and activities. General information on student conduct and discipline is contained in the UT Dallas printed publication, *A to Z Guide*, which is available to all registered students each academic year.

The University of Texas at Dallas administers student discipline within the procedures of recognized and established due process. Procedures are defined and described in the *Rules and Regulations, Series 50000*, Board of Regents, The University of Texas System, and in *Title V, Rules on Student Services and Activities* of the university's *Handbook of Operating Procedures*. Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations (SU 1.602, 972/883-6391) and online at http://www.utdallas.edu/judicialaffairs/UTDJudicialAffairs-HOPV.html.

NOTE: Prof. Gregg will refer *all* cases of academic dishonesty to the Dean of Students for adjudication.

University Policies and Procedures: The University of Texas at Dallas provides a number of policies and procedures designed to provide students with a safe and supportive learning environment. Brief summaries of the policies and procedures are provided for you at http://go.utdallas.edu/syllabus-policies and include information about technical support, field trip policies, off-campus activities, student conduct and discipline, academic integrity, copyright infringement, email use, withdrawal from class, student grievance procedures, incomplete grades, access to Disability Services, and religious holy days. You may also seek further information at these websites:
http://www.utdallas.edu/BusinessAffairs/Travel_Risk_Activities.htm
http://www.utdallas.edu/judicialaffairs/UTDJudicialAffairs-HOPV.html
http://www.utsystem.edu/ogc/intellectualproperty/copypol2.htm
http://www.utdallas.edu/disability/documentation/index.html

These descriptions and timelines are subject to change at the discretion of the Professor.