Viterbi

Biologically Inspired Robotics

Units: 3
Spring 2017
Lectures: MW 2:00 to 3:20PM
Lab: Friday Friday 2:00 to 3:20PM

Location: GFS 108

Instructor: Satyandra K. Gupta
Office: OHE 430G
Office Hours: Wednesday from 2 to 4PM

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Course Description

Taking inspiration from the nature offers new possibilities for realizing novel robots. Bio-inspired robotics has emerged as an important specialization within the field of robotics. Explorations in this area have included designing and building walking, crawling, and flying robots that mimic kinematics and dynamics of their biological counterparts, understanding and replicating control mechanisms found in biological creatures, and mimicking biological sensing and actuation mechanisms. This course will begin by introducing robotics terminology and reviewing limitations of the conventional robots. This course will then introduce the general principles behind taking inspiration from a biological source and converting the inspiration into implementable engineering concepts that can be incorporated into a robot.

This course will consist of the following three main parts:

- ***Fundamentals of Traditional Robotic Manipulators***: In order to conceive, analyze, and create new robot designs, one must be familiar with the fundamentals of traditional robots. This part of the course will begin with the history and taxonomy of traditional robots. Different popular robot configurations will be introduced. This part will also cover forward kinematics, inverse kinematics, and dynamics of serial manipulators to analyze proposed robot designs.
- ***Fundamentals of Biologically Inspired Robotics***: This part of the course will begin with a discussion on the role of biological inspiration in robot design. Some of the questions being explored include "What can nature offer to engineers?" and "Can biologically inspired designs outperform traditional technology?" The next topic that is discussed is how engineers can quantify and evaluate nature in order to select the animal that best meets a set of design requirements. Several examples of bio-inspired robots will be discussed in detail, including the motivation and biological inspiration for their design, as well as technical specifications and comparisons to conventional robots.
- ***Design and Fabrication of Biologically Inspired Robots***: This part of the course will cover techniques for designing and fabricating biologically inspired robots. This part will also cover selecting and programming micro controllers for controlling biologically inspired robots and servo motors for driving the robots. This part will also describe the basics of rapid prototyping process to create the robot structure.

Topics to be Covered in the course include:

- Homogenous Transformations
- Forward Kinematics
- Inverse Kinematics
- Velocities and Jacobians
- Robot Dynamics
- Trajectory Generation
- Legged Locomotion
- Body Undulation Based Locomotion
- Actuators and Sensors

- Robot Programming

Learning Objectives

After taking this course, students will be able to:

- Perform forward and inverse kinematics for serial manipulators
- Develop equations to describe dynamics of the robot
- Design and construct a simple legged robot
- Program simple gaits for legged robots

The student will acquire the following skills in his course:

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design and conduct experiments, as well as to analyze and interpret data
- an ability to design a system or component to meet desired needs within engineering constraints
- an ability to identify, formulate, and solve engineering problems
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Prerequisite(s): Undergraduate Course in Statics and Dynamics
Co-Requisite (s): NONE
Concurrent Enrollment: NONE
Recommended Preparation: NONE

Course Grading
Regular Letter Based Grading

Technological Proficiency and Hardware/Software Required
The course will be taught in a traditional classroom. Students will have access to the required hardware/software in the Center for Advanced Manufacturing.

Required Readings

- J.J. Craig. *Introduction to Robotics: Mechanics and Control*. Prentice Hall; 3rd edition, 2003

Supplementary Materials

- G. A. Bekey. *Autonomous Robots*. MIT Press, 2005
- Karl Williams. *Amphibionics: Build Your Own Biologically Inspired Reptilian Robot*. McGraw-Hill/TAB Electronics, 2003
- David Cook. *Robot Building for Beginners*. Apress, 2002

Description and Assessment of Assignments

- 8 Home Works
- Course Project
- Final Exam

Grading Breakdown

Assignment	Points	% of Grade
HW1	100	2.5
HW2	100	2.5
HW3	100	2.5
HW4	100	2.5
HW5	100	2.5
HW6	100	2.5
HW7	100	2.5
HW8	100	2.5
Project	100	40
Final	100	40
TOTAL	1000	100

Assignment Submission Policy

Assignment will be submitted in class.

Additional Policies

Penalty will be applied to late assignments. The full allocated points will be reduced by 10 percentage points for the day after the deadline for the submission of coursework. Score will be reduced by a further 40 percentage points each day if coursework is submitted during the following two days.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	**Readings and Homework**	**Deliverable/ Due Dates**
Week 1	Introduction to Biologically Inspired Robotics	Course Notes provided by instructor HW 1 Assigned	
Week 2	Project Discussion and Assignment	Course Notes provided by instructor	Project Proposals
Week 3	Robotics Terminology	Chapter 1 from Textbook	HW1
Week 4	Homogenous Transformations	Chapter 2 from Textbook HW2 assigned	
Week 5	Forward Kinematics	Chapter 3 from Textbook HW3 assigned	HW2
Week 6	Inverse Kinematics	Chapter 4 from Textbook HW4 assigned	Project Design Concept
Week 7	Mechanical Design of Robots	Course Notes provided by instructor	HW4
Week 8	Robot Fabrication	Course Notes provided by instructor	Final Mechanical Design for Project
Week 9	Jacobians	Chapter 5 from Textbook HW5 assigned	Fabrication Plan for Project
Week 10	Dynamics	Chapter 6 from Textbook HW6 assigned	HW5
Week 11	Dynamics	Chapter 6 from Textbook	Preliminary Course Project Demo
Week 12	Actuators and Sensors	Course Notes Provided by instructor	HW6
Week 13	Robot Programming	Course Notes Provided by instructor	Final Course Project Demo
Week 14	Trajectory Generation	Chapter 8 from Textbook HW7 assigned	HW7
Week 15	Control	Chapter 9 from Textbook HW8 assigned	HW8

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards* https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu or to the *Department of Public Safety* http://adminopsnet.usc.edu/department/department-public-safety. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage http://sarc.usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* *http://emergency.usc.edu* will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.