

Viterbi

Biologically Inspired Robotics

Units: 3

Spring 2017

Lectures: Wed 2:00 to 3:20PM Fri 1:00 to 2:50

Location: VPD LL101

Instructor: Satyandra K. Gupta

Office: OHE 430G

Office Hours: Wed 12 to 1:30PM and 3:30 to 5PM

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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
- Actuators and Sensors

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 labs in AME labs.

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

- 2 Quizzes

- 6 Home Works
- One Course Project
- One Final Exam

Grading Breakdown

Assignment	Points	% of Grade
HW1	100	3
HW2	100	3
HW3	100	3
HW4	100	3
HW5	100	3
HW6	100	3
Quiz1	100	6
Quiz2	100	6
Project	100	40
Final	100	30
TOTAL	1000	100

Assignment Submission Policy

Assignment will be submitted on Blackboard.

Additional Policies

Penalty will be applied to late assignments. The full allocated points will be reduced by 50 percentage points for each day after the deadline for the submission of assignment.

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/academicssupport/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.