Course Program – Applied Robotics (FRTF20), 7.5 credits, Fall 2022, Study Period 1

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Course Homepage and Canvas
- http://www.control.lth.se/education/engineering-program/frtf20-applied-robotics/
- https://canvas.education.lu.se/login

1 Overview
Robotics is a broad and interdisciplinary subject, which involves various subjects such as mechanics, automatic control, computer science, sensors and various process-specific applications and methods in production systems. Traditionally, robots have mostly been applied and developed for industrial use in processes like welding, spray painting, and material handling. During recent years, the subject has been broadened to include more complex operations like assembly tasks and human–robot interaction with an emerging need for new areas such as robots in various service applications. An illustrative example is the application area "health care", where robots are used by disabled people to increase the independent living and possible rehabilitation.

This course in robot technology intends to introduce robotics for, primarily, applied industrial robotic applications. Within this scope, the course will provide general understanding of concepts in robotics and engineering-related issues like robotic systems design and efficient use of robots in industry. From an application point of view, most examples and case studies will make references to industrial robotics. Where appropriate, however, reference to other areas such as service robotics will be made as well.

2 Objectives
The content of the course follows the schedule described in this document. Examination is based on assignments: computer and lab exercises, hand-in exercises, and a project (report and presentation/demonstration) and an optional take-home-exam for higher grades (4 and 5). The assignments have a defined "pass" level and are a requirement to pass the course. The lectures are important for the understanding of the lab/exercises and the projects, and it is highly recommended to follow these lectures. Also, they provide an important source of information for the final take-home-exam.

The course focuses on three areas:

1. Characteristic features of robots, simulation, programming, and designing robot systems for industrial applications.
2. Modeling of robots within the scope of kinematics, calibration, and design of robots.
3. Basics of robot dynamics.

The areas are supported through lectures and computer and hands-on lab/exercises. These areas define the course, which is examined through lab/exercise work.

3 Literature

- Literature related to the lectures and texts related to exercises/lab work within the course are available at https://canvas.education.lu.se/login.

All requirements concerning literature and other material related to the lab/exercise work are defined in the lab/exercise descriptions. Additional material will be provided through the course Canvas site (lab/project descriptions, papers/articles, movies, etc.).

4 Computer Labs

Work related to exercises will be done in the computer labs (in the KC building). Your student account (STiL) is working in most computer labs on campus where the software used also should be available. You can also connect via VPN to the campus network and access the needed software. The KC building is locked during evenings and weekends. Your LU card will give you access to both the building and the computer labs. If not, please notify Björn Olofsson (bjorn.olofsson@control.lth.se).

5 Examination

Examination is based on the following assignments:

- Computer and lab exercises:
  - Compulsory hands-on exercise in the lab.
  - RobotStudio Exercises 1–3 (Windows-software run via https://apps.lu.se/). A teaching assistant should approve the simulation before running on the real robot (assignment experimentally demonstrated in RobotLab in the KC building).
- Hand-in exercises on kinematics and dynamics.
- Projects (short written report and demo-presentation in the lab).
- **Optional**: Additional take-home-exam for higher grades (4 and 5).

The assignments have a defined "pass" level and are a requirement to pass the course. The take-home-exam is optional and is needed for higher grades (4 and 5).

A prerequisite for the take-home-exam is that **all** RobotStudio exercises are approved, and hand-in exercises are handed-in **before midnight October 21, 2022.**

The 24 h take-home exam is to be solved independently and you are requested to upload your typed solutions and possibly Matlab file(s) or a *readable* scanned version of your solutions to the examiner in the next 24 hours after downloading your exam. The exam will be available to download in Canvas from **October 24, 2022 to October 29, 2022**.

6 Schedule

The schedule describes a timetable for the course divided into weeks. Computer exercises and labs are made with one student per computer, and the number of computers in each room is posted in connection with the sign-up lists. Links to sign-up lists are posted weekly in Canvas for alternative times. There is a limitation in the number of simultaneous RobotStudio licenses of 100, but this should not be a problem for this course. Teacher-supported exercises for the simulation and programming of robots will be in computer rooms in the Chemistry Center (KC) building and the RobotLab in the basement of the KC4-building according to bookings in the sign-up lists available on Canvas. Your own work can be done at other times as needed, and it is expected that *you will have to work on your own* to finish the exercises.

- The schedule of the lectures and computer exercise sessions is available through Canvas (https://canvas.education.lu.se/).

6.1 Lectures

The purpose of the lectures is to introduce and provide you with necessary knowledge and insights to fulfil the tasks which should be documented in the presentations or reports related to the lab and project works. You can also use the lectures to discuss or ask the lecturer on topics related to the lecture or the lab works.

6.2 Assignments: Computer and Lab Exercises

Computer and lab exercises, as described in separate documents available in Canvas, are mandatory to fulfil the requirements of the course. Detailed information about these will be given during the first part of the course.

Kinematics

Kinematics is about three interconnected areas within the scope of robot modeling:

1. Kinematics modeling,
2. Analysis, optimization, and planning,
3. Understanding of general robotic manipulator systems.

The goal is to introduce the basics in robotics modeling related to kinematics, aspects on analysis, optimization, and planning related to singularities, trajectory generation and motion planning, and issues related to calibration. During the lectures the theory is presented, and examples are given. A number of exercises are to be solved and handed in. Computer tools will include the simulation software used for programming the robot and Peter Corke's Robot Toolbox in Matlab. Please make sure you use Robot toolbox version 10 or later, see https://petercorke.com/toolboxes/robotics-toolbox/.

Programming

The robot programming and simulation environment *ABB RobotStudio* will be used to illustrate concepts of modern robot programming. The program can be run on Windows-PCs in the campus computer rooms by using the Google Chrome browser via the link https://apps.lu.se. The RobotStudio exercises will contain **both simulation parts *and* hands-on exercises to be verified on an industrial robot**. Detailed instructions for the RobotStudio exercises are available on Canvas.

Dynamics

There will be one optional lab exercise on practical servo/robot joint control lab exercise and one mandatory hand-in exercise of the more theoretical part. Detailed instructions for the optional lab and the mandatory hand-in exercises are posted on Canvas.

Course Projects

In study week 2, a number of different project proposals to choose from will presented and posted on Canvas. The projects are typically carried out in groups of 4-5 students and should be documented by a short report and a presentation/demo in the lab.