Ben Gurion University of the Negev
Department of Mechanical Engineering
362-1-4231
Kinematics and Dynamics of Robots
Spring semester, 2021
Online course

Instructor Information

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Course Description

This course focuses on robotics in the context of manufacturing procceses. After an overview of the field of robotics in industry, the core of the course involves the analysis of robotic arms and other robotic systems. Essential subjects in robotic arm control will be learned, including reference frames, rigid-body transformations, direct kinematics, inverse kinematics, collision-free path planning, and end-effectors. The course subjects will be applied and integrated by using a robotic arm simulator, to construct a simulated robotic manufacturing process. The students will have the unique opportunity to apply a robotic arm simulation on a real robotic arm.

Course Goals and Learning Outcomes

The field of robotics in manufacturing is too vast for one course to cover. However, it is the goal of this course to teach the students basic concepts of robotic planning and control that are essential to robotic manufacturing procceses. Practical, brand-agnostic tools will be learned to allow easy transition to real-world manufacturing robotics.

Upon completion of this course, students should be able to:

A. Analyze robotic arms and systems
    - Apply direct kinematics to any robotic arm
    - Apply inverse kinematics to simple robotic arms
    - Define robotic arms by D-H parameters
B. Understand and plan collision-free paths
    - Understand configuration space in the context of robotics
    - Apply probabilistic search methods to find collision-free paths
C. Select end-effectors and sensors for an application
    - Understand the advantages and disadvantages of different end effectors and grippers
    - Understand the purpose and limitations of internal and external sensors
D. Plan a simulated robotic manufacturing process
    - Use a brand-agnostic robotic simulator to plan a manufacturing environment
    - Use a robotic simulator to control a real robotic arm in a simple manufacturing task

Course Textbooks

- Spong and Vidyasagar, "Robot Dynamics and Control", John-Wily, 1989.
- Fu, Gonzales, and Lee, "Robotics: Control, Sensing, Vision, and Intelligence", McGraw Hill, 1987.
- Elon Rimon, Joel Burdick, “The Mechanics of Robot Grasping”, Cambridge University press, 2019.
- Low K.H, “Industrial Robotics: Programming, Simulation and Applications”, I-Tech, 2007

Please note that the textbooks are NOT mandatory, and there is no need to purchase the books if your University library does not hold them. Please contact the course lecturer for further guidance.

Course Requirements and Assessment

The course grade will be determined by several assignments during the semester, and a final assignment at the semester’s end.

Assessment	Date of Evaluation	Weighting
Assessment 1 - Kinematics	31.3.2021	10%
Assessment 2 – Path planning	12.5.2021	20%
Assessment 3 – Simulation and real-world execution of a simple task	26.5.2021	10%
Assessment 3 – Full manufacturing process robotic simulation	TBD	60%
Total		100%

Assessment 1 - Kinematics

The students will be given robotic systems to analyze. Direct and inverse kinematics are to be determined for the given systems in accordance to the assignment guidelines.

Assessment 2 – Path planning

The students will be asked to realize a probabilistic method of collision-free robotic movement using an agreed upon programming language.

Assessment 3 – Robotic simulation of a simple task

The students will use a robotic simulator to plan a simple manufacturing task. The plan will be executed by a real robotic arm in the robotics laboratory on Ben-Gurion University.

Assessment 4 – Robotic simulation

The students will design a robotic manufacturing process in a robotic arm simulator.

Course Outline

Week	Date	Topic
1	10.3.2021	Robotics in Industry- past, present and future
2	17.3.2021	Reference frames, linear transformations
3	24.3.2021	Rotational transformations, direct kinematics

Week	Date	Topic
4	31.3.2021	Kinematics cont., D-H parameters
5	7.4.2021	Inverse kinematics
6	14.4.2021	Robot velocities and the Jacobian matrix
7	21.4.2021	Configuration space and path planning
8	28.4.2021	Path planning cont., RRT, PRM
9	5.5.2021	Robotic end effectors and grasping
10	12.5.2021	Internal and external sensors
11	19.5.2021	Robotic arm simulation programs
12	26.5.2021	Planning a robotic manufacturing process using simulation
13	TBD	Planning a robotic manufacturing process using simulation cont.

Late Work

Late work will be incur an automatic point deduction, unless the student has attained the course lecturer's approval to submit their work late.

Attendance Policy

Students are expected to attend all of the online classes. If a student misses a class for any reason, they are expected to watch the class recording (if available) or make up the class material by using other student's notes and/or course reading material.

Appeals

A student may appeal the grade on any or all assignments. The appeal should be submitted as a PDF file explaining the appeal. The appeal shall be submitted to the course lecturer, no later than 5 days after receiving the grade for the assignment.