Module Guide

Robotics

EEE-7-ROB School

of Engineering

Level 7

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1. MODULE DETAILS

Module Title:	Robotics
Module Level:	7
Module Reference Number:	EEE-7-ROB
Credit Value:	20
Student Study Hours:	200
Contact Hours:	48
Private Study Hours:	152
Pre-requisite Learning (If applicable):	Bachelors degree in a relevant subject
Co-requisite Modules (If applicable):	none
Course(s):	MSc Mechatronics, Robotics and Embedded Systems
Year and Semester	2019-2020, Semester I
Module Coordinator:	Dr. J.M. Selig
MC Contact Details (Tel, Email, Room)	7815 7461, seligjm@lsbu.ac.uk, T811
Teaching Team & Contact Details (If applicable):	Dr Zhanfang Zhao, zhaoza@lsbu.ac.uk, T815.
Subject Area:	Electrical & Electronic Engineering
Summary of Assessment Method:	70% Exam 30% Coursework
External Examiner appointed for module:	Dr. Mahdi Mahfouf, The University of Sheffield.

2. SHORT DESCRIPTION

This module aims to introduce students to the basic elements and principles of modern robotics. Essential geometric concepts of rigid-body displacements will be introduced and these will be applied to the kinematic analysis of several different types of machines. Differential kinematics will be developed and this will lead on to a study of the statics and dynamics of robots. Finally, some of the problems concerned with the control of these machines will be considered.

A key feature of the module will be the wide range of robotic devices studied, from industrial serial and parallel manipulators, through mobile robots to quadcopters.

The laboratory exercises are designed to consolidate understanding of the complex topics of robot kinematics and programming as well as extending the appreciation of the practical considerations of the subject.

The coursework assignment is designed to develop student's knowledge of practical state-of-the-art applications and developments in the field.

3. AIMS OF THE MODULE

The aim of this module is to develop a thorough theoretical and practical understanding of the fundamental concepts of modern robotics. High level knowledge, critical evaluation and practical skills for real-world research problems will also be developed.

4. LEARNING OUTCOMES

4.1 Knowledge and Understanding

To gain a comprehensive knowledge of the concepts of robotics and robot mechanisms to a specialist level. To develop a critical awareness of the mathematics of rigid-body displacements and its applications to problems in kinematics and dynamics of robots.

4.2 Intellectual Skills

To be able to critically evaluate a problem and then select and apply specialised methods to produce a solution.

To acquire a high-level of analytical skills in modelling kinematics and dynamics of robot mechanism.

4.3 Practical Skills

To appreciate the problems of programming robots, using a variety of hardware and programming languages.

4.4 Transferable Skills

To effectively communicate and critically evaluate observed results in a technical format. Problem solving, communication, working with others, information retrieval and the effective use of general IT facilities.

5. ASSESSMENT OF THE MODULE

The assessment for this module will be in three parts. The end of module exam will be a 2 hours exam and will account for 70% of the final mark. The coursework component of the module will be in 2 parts, the completed laboratory logbook will be marked and will make up 15% of the mark for the module. This will be marked every other week by the Lab tutor. Finally, a formal assignment will be set. This will be in the form of an essay. The essay should be between 5,000 and 10,000 words. The deadline for the assignment will be Friday 13 December 2019.

6. FEEDBACK

Feedback will normally be given to students 15 working days after the final submission of an assignment or as advised by their module leader.

General feedback, applying to all students, will also be placed on the module VLE site within 15 working days.

7. INTRODUCTION TO STUDYING THE MODULE

7.1 Overview of the Main Content

The Introduction will give a general overview of the subject and its historical background. The next few lectures will cover the representation of rigid-bodies and their displacements. This will be done by building up the theory looking at planar bodies first, then pure rotations in space and finally the full 4x4 representations of rigid-body displacements in space. The theory will be illustrated by examples deriving the forward kinematics of several standard robot structures. A lecture on Coordinate frames will make links to the traditional method of deriving the forward kinematics of serial robots using the Denavit-Hartenberg parameters. This lecture will also introduce the tool frame and show how to derive its kinematics.

In the next class the inverse kinematics of robots will be discussed, that is the solution of the forward kinematics

A lecture on velocities and twists will introduce the Jacobian of a manipulator and simple ways to compute the Jacobian matrix of the robot. This will involve a study of the six dimensional vectors known as twists. The exponential form of the robot's A-matrices will be given and the product-of-exponentials formula for the forward kinematics will be explained. The following lecture concerns the statics of robots and rigid bodies. The concept of a wrench as the dual to a twist will be introduced and applications to force sensing will be examined. This work acts as a bridge between the first half of the module which concerns mainly kinematics and the second half which addresses the problems of dynamics and control of robots.

The dynamics of serial robot are considered in the next couple of lectures. In the first of these only a single body is considered, then in the second simple methods are used to combine the equations of motion for each link of the robot to produce the dynamic model of the robot. Algorithms to compute the inverse dynamics of the robot will be discussed along with other algorithms to compute the generalised mass matrix of the robot and to solve the forward dynamics problem.

The final pair of lectures look at robot control. In the first lecture the computed torque method will be introduced both as a feed-forward open loop and as part of a feed-back method to cancel the dynamics of the robot. In the final lecture force control and hybrid force-position control will be discussed.

7.2 Overview of Types of Classes

The course will be composed of lectures and laboratory classes. Notes for the classes including tutorial exercises will be made available via the Virtual Learning Environment (Moodle).

7.3 Importance of Student Self-Managed Learning Time

Student responsibility in the learning and development process will be emphasised. Students are required to undertake directed self-study and prepare solutions/discussions to questions relative to various topic areas. Students will be encouraged to identify for themselves particular problems of difficulty and to use seminar discussions, where appropriate, for the resolution of these. Students must regularly access the Moodle site for this module. They should download the class/lecture material from the Moodle site, and do the recommended reading, before each lecture/class.
Where appropriate, students are also expected to download the relevant seminar questions and study them in advance of each seminar, in order to derive maximum benefit from seminar time. The programme of teaching, learning and assessment gives guidance on the textbook reading required for each week, the purpose of which is to encourage further reading both on and around the topic.

7.4 Employability

This module will provide students with a high-level knowledge of pattern recognition algorithms and machine learning techniques. This knowledge will help students gain employment in the fields of electronic engineering, business and financial fields.

8. THE PROGRAMME OF TEACHING, LEARNING AND ASSESSMENT

SEMESTER 1		
WEEK	TOPIC	READING (CORE TEXT)
1 25/09/2019	Introduction	See Lecture notes
2 02/10/2019	Rigid Body Displacements in the Plane	
3 09/10/2019	Rotations in Space	
4 16/10/2109	Rigid Body Displacements in Space	
5 23/10/2019	Coordinate Frames	
6 30/10/2019	Inverse Kinematics	
7 06/11/2019	Jacobians	
8 13/11/2019	Statics	
9 20/11/2019	Dynamics of a Single Rigid Body	
10 27/11/2019	Dynamics of Serial Arm	
11 04/12/2019	Position Control of Robot Arms	
12 11/12/2019	Force Control and Hybrid Control of Robot Arms	

9. STUDENT EVALUATION

Only one student, out of three completed the online module evaluation questionnaire last year.

10. LEARNING RESOURCES

Weekly notes will be provided via the moodle site for the module. These will contain exercises to be completed by students.

Reading List

1. K. M. Lynch, F. C. Park, Modern Robotics: Mechanics, Planning and Control, Cambridge, 2017. [ISBN: 1107156300]
2. B. Siciliano, L. Sciavicco, L. Villani, and G. Oriolo, Robotics: Modelling, Planning and Control (Advanced Textbooks in Control and Signal Processing), Springer, 2010. [ISBN: 1849966346]
3. M. W. Spong, S. Hutchinson, M. Vidyasagar, Robot Modeling and Control, Wiley, 2005. [ISBN: 0471649902]