UNIVERSIDAD DE LA RIOJA

ROBOT PROGRAMMING AND CONTROL
2016-2017

Bachelor Degree:	Industrial Electronics and Automation Engineering		805G
Course title:	Robot programming and control		640
Year/Semester:	3/1S	ECTS Credits:	6

DEPARTMENT

Electrical Engineering					
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CONTENTS

UNIT1. Introduction to Robotics Introduction and definition History
- Automation and Robotics
- Classifications of robots
- Industrial robots and their applications
- Robot mechanical structure
- Robot features
- Typical manipulator structures: cartesian, cylindrical, spherical, antropomorphic, Scara, other structures

UNIT2. Review of mathematics and physics
- Introduction to joint and task spaces
  - Task, operational space. Task coordenates
  - Joint space. Joint coordenates
  - Introduction to redundant robots
- Spatial transformations applied to a rigid body
  - Pose of a rigid body. Position description and translation transformation
  - Planar rotation matrix
  - 3D elementary rotations
  - Rotation of a vector
  - Composition of rotation matrices
  - Translation and rotation transformations
  - Euler angles. Wrist angles. Direct, inverse and singular solutions Roll, pitch and yaw angles. Direct, inverse and singular solutions Angle and axis
  - Unit quaternion
  - Homogeneous transformations. Robots (arm, wrist, end efector) examples
  - Graphic model to describe the position and orientation of a rigid body. Transformation diagrams applied to a robotic system
- Physics transformations applied to a rigid body
  - Vector derivate in rotating frame

Cylindrical kinematic structure: position, linear velocity and linear acceleration
Spherical kinematic structure: position, linear velocity and linear acceleration
Combination (simultaneous) motions. Robotic examples: spherical structure motion and Euler wrist motion
Centroid. Basic examples: triangle, semisphere Center of mass. Basic axamples: semisphere Moment of inertia. Basic axamples: cylinder, cone
Inertia matrix for spatial movement of a rigid body. Basic example: parallelepiped
Mechanical energy
Kinematic energy of a rigid body: translational energy and rotational energy
Potential energy of a rigid body
Static laws of a rigid body

UNIT3. Kinematics
Direct Kinematics Problem (D.K.P.)
Introduction to the Direct Kinematics Problem
Direct kinematics analysis and solution
Denavit-Hartenber convention. Conditions and parameters
Procedure applied to the D.K.P.
Kinematics of typical manipulator structures: two-link planar arm, three-link planar robot, scara manipulator, Stanford manipulator, Euler wrist
Inverse Kinematics Problem (I.K.P.)
Introduction to the Direct Kinematics Problem Existence and uniqueness of I.K.P. solutions Geometric and algebraic methods
I.K.P. of a 2D planar arm. Geometric and algebraic solutions
I.K.P. decoupling into two subproblems: the position arm I.K.P. and the orientation wrist I.K.P. I.K.P. of a three-link planar manipulator
I.K.P. of a Scara robot
Velocity mapping. The Jacobian matrix
The geometric Jacobian Derivate of a rotation matrix
Link velocities and accelerations
Jacobian computation
Jacobian of typical manipulator structures: two-link planar arm, three-link planar arm, scarar robot
Kinematic singularities
Singularity decoupling: arm and wrist singularities
Singularities of typical manipulator structures: two-link planar arm, Euler wrist, Scara robot
Statics and manipulator design
Static laws applied to a link Forces acting on a link i Moments acting on a link i
Static laws applied to a two-link manipulator
Recursive calculations. Force and moments vectors
Static of a two-link planar arm

UNIT4. Dynamics
Lagrange-Euler formulation
Lagrange equation
Computation of kinetic energy
Computation of potential energy
Equations of motion
Dynamic model of simple manipulator structures: two-link cartesian arm, two-link planar arm
Newton-Euler formulation
Introduction to the Newton-Euler formulation

Link velocities y accelerations

Recursive algorithm

Dinamic model of simple manipulator structures: two-link cartesian arm, two-link planar arm

UNIT5. Kinematic control.

Trajectory planning

Introduction to path planning

Kinematic model and kinematic control Trajectory spaces and types of paths Path primities

UNIT6. Introduction to robot control Introduction to control problem Control spaces and types of control

Independent joint control and multivariable control

PID independent control

Feedforward compensation

PD control with gravity compensation

UNIT7. Robot programming

Robot programming methods Robot control system hardware Programming languages

Robot programming examples

UNIT8. Introduction to robotics technology

Introduction to robotics components

Actuators: electric actuators (stepper motors, dc motors, brushless motors, ac motors), pneumatic actuators (cylinder and motors), hydraulic actuators (cylinder and motors)

Internal sensors: position sensors (encoders, potenciometers, LVDT, synchros and resolvers), velocity sensors (tachometers, hall-effect sensors), acceleration sensors, force sensors

Grippers: mechanical grippers, magnetic grippers, vacuum grippers, adherise grippers, other grippers

Mechanical gears

REFERENCES

Title
Modelling and Control of Robot Manipulators. L. Sciavicco B. Siciliano. Springer-Verlag. ISBN: 1852332212
Introduction to robotics : mechanics and control / John J. Craig-- 3rd ed-- Upper Saddle River (New Jersey) : Pearson Education International, [2005]
Robot dynamics and control / Mark W. Spong, M. Vidyasagar-- New York : John Wiley & Sons, cop. 1989
Theory of Robot Control. Carlos Canudas de Wit. Springer-Verlag. ISBN: 3540760547.
Introduction to robotics. Mc Kerrow P.J. Addison Wesley. ISBN: 0201182408.
Robot Manipulators. Mathematics, programming and control. Paul R. P. MIT-Press. ISBN: 026216082X
Fundamentals of robotics : analysis and control / Robert J. Schilling-- Englewood Cliffs, New Jersey : Prentice Hall, cop. 1990
Analytical robotics and mechatronics / Wolfram Stadler-- New York : McGraw-Hill, cop. 1995
Theory of applied robotics : kinematics, dynamics, and control / Reza N. Jazar-- New York : Springer, [2007]
Robot analysis : the mechanics of serial parallel manipulators / Lung-Wen Tsai-- New York [etc.] : John Wiley & Sons, [1999]

EVALUATION SYSTEM

End-of-term exam: 60%
Oral exam: 20%
Continuous assessment: 20%