SHAKE THE FUTURE.

CENTRALE NANTES

ENGINEERING PROGRAMME

SPECIALISATION

ROBOTICS

SPRING SEMESTER

Établissement public sous tutelle du
ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

GROUPE **CENTRALE**

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ROBOT CONTROL

ROBOTICS, ENGINEERING PROGRAMME SPECIALISATION
SPRING SEMESTER

Professor: Abdelhamid CHRIETTE

Objectives

This course's main objective is to apply the control techniques of nonlinear systems in particular cases of robot manipulators and mobile robots.

Course contents

Part 1: Introduction to classical robot control
Part 2: Computed torque of manipulator arms
Part 3: Position control / force
Part 4: Introduction to parametric identification of robots
Part 5: Control of mobile robots back by static, dynamic return and Lyapunov
Part 6: Follow path and trajectory

Labs:
LAB1: Control by torque calculated from a manipulator arm
LAB2: Control of mobile robots
LAB3: Parametric identification (geometric parameters, dynamic)

Course material

- W. Khalil, and E. Dombre, Modelling, identification and control of robots, Hermes Penton, London, 2002.
- C.Canudas, B. Siciliano, G.Bastin (editors), Theory of Robot Control, Springer-Verlag, 1996.
- R.Siegwart I.R. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press second edition 2010.
- B.Siciliano, O.Khatib, edt, Robots Handbook, Springer-Verlag 2008, Chapters 17, 34, 35.

Keywords

Computed torque, Position control / force, Trajectory planning

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	4	20 hrs	0 hrs	12 hrs	0 hrs

MOTION SYNTHESIS

ROBOTICS, ENGINEERING PROGRAMME SPECIALISATION
SPRING SEMESTER

Professor: Gaetan GARCIA

Objectives

This course presents the methods used in path and trajectory planning in robotics.

Course contents

- Introduction: the various classes of path planning and trajectory planning and their applications.
- Useful concepts: paths, trajectories, configuration space, localisation, mapping, computational complexity, completeness, online vs offline planning, obstacles in configuration space.
- Trajectory planning for robot manipulators:
  - Motion planning in configuration space vs in task space.
  - Normalized joint variables.
  - Polynomial interpolation (linear, third order, fifth order).
  - Non polynomial interpolators (bang-bang, trapezoidal).
- Configuration space continued: definitions, dimension, topology.
- Planning in finite spaces: data structures (tree, graph, valued graph) and their traversal algorithms, minimum cost paths, application examples. Dijkstras algorithm and A* algorithm, conditions for A* to be optimal.
- Sensor based path planning: Bug1, Bug2 and Tangent Bug algorithms.
- Potential field based algorithms.
- Road map based algorithms: visibility graph, Generalized Voronoî Diagrams, sensor based construction of the GVD.
- Sampling based algorithms: Probabilistic Road Maps, road map construction algorithms, local planner.

Course material

- Principles of Robot Motion - Theory, Algorithms and Implementation, by H. Choset, K. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. Kavraki and S. Thrun. Bradford Book, MIT Press.
- Planning Algorithms, S. M. LaValle. Cambridge University Press.
- Modeling, Identification and Control of Robots, W. Khalil and E. Dombre - Kogan Page Science

Keywords

Robotics, path planning, motion planning, configuration space.

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	20 hrs	0 hrs	12 hrs	0 hrs

Non conventional robots

Robotics, Engineering programme specialisation
Spring Semester

Professor: Stéphane CARO

Objectives

To familiarize students with parallel robots and humanoid robots.

Part A: Parallel Robot
A parallel robot comprises a movable platform with n degrees of freedom and a fixed base connected together by at least two kinematic chains. The movements of the movable platform are generally controlled by n motorized kinematic connections. The most common parallel robot is the platform of Gough-Stewart. This platform is among others used in flight simulators and is controlled via six motorized prismatic joints. However, many other parallel manipulators with six degrees of freedom or less have been developed over the past three decades. In this course, several parallel robots, including robots parallel cable, will be presented and analyzed.

Part B: humanoid robot
A humanoid robot reproduces the appearance of the human body and its proportions, and some of its sensory possibilities. The course objective is to introduce students to the multiple social promises linked to humanoids, and the scientific and human problems they pose. From the viewpoint of the interaction with the human, we will focus on the imitation of human movement endeavoring to show the importance of the generation of a movement as close to that of humans as possible. The possibilities of human gesture imitations will be addressed both from a technical point of view (online conversion movements of the human to the humanoid based on inverse kinematics, with the balance of the projection of the criterion center of mass on the ground) from the point of view of the human faces in this technology. From a practical standpoint, students will use imitation in line for two types of robots: NAO (Aldebaran Robotics), to manage its balance to avoid falling, and BAXTER (Rethink Robotics), fixed platform reproducing only the top of the human body.

Course contents

Part A: Parallel Robots (10 hours of lectures, 2 hours in the lab)
Part 1: Enumeration and classification of existing parallel robots.
Part 2: Geometric modeling of parallel robots
Part 3: Workspace Analysis of parallel robots
Part 4: Kinematic Modeling of parallel robots
Part 5: Analysis of singularities of parallel robots
Part 6: Presentation of parallel manipulators with several modes of motion

Tuto1: Plotting the workspace of parallel planar robots
Tuto2: Search singular configurations of parallel manipulators

Part B: humanoid robot (10 hours of lectures, 10 hours in the lab)
Part 1: Overview and definitions
Part 2: Social acceptability
Part 3: Anthropomorphism
Part 4: Imitation as a social function and motor remediation

Part 5: balance management and redundancy
Part 6: Human Movement Imitation

Labs:
LAB1: Human motion capture
LAB2: Generating humanoid movement
LAB3: Online Imitation of human movement by a humanoid
LAB4: Driving remediation
LAB5: Bio-inspired Behavior

Course material

- J. Angeles, Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, 3rd edition, 2007
- Merlet, J. P., 2006, Parallel Robots (Solid Mechanics and Its Applications), Springer, New York, Vol. 128.
- Amine, S., Tale-Masouleh, M., Caro, S., Wenger, P., and Gosselin, C., 2012, Singularity Analysis of 3T2R Parallel Mechanisms using Grassmann-Cayley Algebra and Grassmann Line Geometry, Mechanism and Machine Theory, Vol. 52, pp. 326--340. hal-00833520
- Amine, S., Caro, S., Wenger, P. and Kanaan, D., 2012, Singularity Analysis of the H4 Robot using Grassmann-Cayley Algebra;, Robotica, Vol. 30(7), pp. 1109-1118, hal-00642230
- Amine, S., Tale-Masouleh, M., Caro, S., Wenger, P., and Gosselin, C., 2012, Singularity Conditions of 3T1R Parallel Manipulators with Identical Limb Structures, ASME Journal of Mechanisms and Robotics, Vol. 4(1), pp. 011011-1{011011-11, doi:10.1115/1.4005336. hal-00642238
- Baddoura, R. & Venture, G. (2013). Social vs. Useful HRI: Experiencing the familiar, perceiving the robot as a sociable partner and responding to its actions. International Journal of Social Robotics, 5(4), 529-547.
- Guay, F., Cardou, P., Cruz Ruiz, A. L. and Caro, S., 2013, Measuring How Well a Structure Supports Varying External Wrenches;, The Second Conference on Mechanisms, Transmissions and Applications (MeTrApp 2013), Bilbao, Spain, October 2-4, 2013.
- Wisama Khalil, Etienne Dombre. Modelling, identification and control of robots. Butterworth-Heinemann 2004.
- Shuuji Kajita, Hirohisa Hirukawa, Kensuke Harada, Kazuhito Yokoi: Introduction à la commande des robots humanoïdes: De la modélisation à la génération du mouvement. Springer 2009.

Keywords

Parallel robots, Humanoid robots

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	20 hrs	2 hrs	10 hrs	0 hrs

Robotic Project 2

Robotics, Engineering programme specialisation
Spring Semester

Professor: Abdelhamid CHRIETTE

Objectives

Introduce students to robotics engineering tools (modelling, identification and control) through the projects proposed by teachers of the specialisation.

Course contents

Continuous project.

Course material

Depending on the project.

Keywords

Robotics, control, parallel robots, ROS, underwater robots, drones.

Links with other programmes

All courses of the specialisation.

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	**2**	**0 hrs**	**0 hrs**	**0 hrs**	**48 hrs**