Master's Department of Engineering Sciences

Name of the unit: Serial robot dynamics

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Course code: UM4RBR23
Student workload: 10h of lectures, 10h of tutorial sessions, 8h of lab sessions@
Credits: 3 ECTS

Specialization tracks:	- **E3A** :	☐ CIMES	☐ Syscom	☐ IPS
	- **AR** :	☐ ROBOT	☐ SI	☐ MeDH
	- **MECA** :	☐ MS2	☐ MF2A	☐ CompMech
		☐ ACOU	☐ EE	☐ EE APP

Semester offered: ☐ S1 ☒ S2 ☐ S3 ☐ S4
Language of instruction: ☐ French ☐ English
Targeted audience: ☐ Engineering Sciences students ☐ Other (specify):
Localization : ☐ PMC Campus ☐ Other (specify):

Course Overview

This course aims to train students in the dynamic modeling of serial robots. It presents the Newton-Euler and Lagrange methods for obtaining the equations of motion for tree-like kinematic systems.
Keywords: Rigid body, kinematics, kinetics, kinetic energy, potential energy, fundamental principle of dynamics, Newton-Euler equations, Lagrange equations, equations of motion, recursive Newton-Euler for inverse dynamics.

Prerequisites

Students should have previously acquired the following prerequisites to follow this course:

- Knowledge of the following mathematical tools: trigonometric functions, vector calculus, linear algebra, matrix calculus, differential calculus ;
- Knowing how to determine the geometric model of a robot;
- Know how to model a mechanical action and apply the Fundamental Principle of Statics;
- Know how to calculate linear velocity and angular velocity, calculate the kinetic energy of a point mass and a solid, calculate potential energy.
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Intended Learning Outcomes

By the end of this course, students will be able to:

1. Knowing how to use the right method of obtaining data depending on the complexity of the robot and the interest of the model;
2. Knowing how to write the equations of motion for a serial robot with multiple degrees of freedom
3. Know how to physically identify each term in the equations of motion

Indicative Teaching Sequence and Methods

Week	C/TD/TP*	Content	Preparation	Learn. outc.
S1	C1 (2H)	The different models for serial robots part 1		AAV1
S2	C2 (2H)	The different models for serial robots part 2		AAV1-AVV2
S3	TD1 (2H)	Training in obtaining kinematic models		AAV1-AVV2
S4	TD2 (2H)	Entrainement à l'obtention des modèles cinématiques		AAV1-AVV2
S5	Exam1	Obtaining the kinematic model of serial robots		AVV2
S6	C3 (2H)	Dynamic model based on general theorems		AVV2
S7	TD3 (2H)	Dynamic model based on general theorems		AAV1-AVV2
S8	C4 (2H)	Newton-Euler algorithm for obtaining the dynamic model of serial robots		AAV2-AAV3
S9	TD4 (2H)	Newton-Euler algorithm for obtaining the dynamic model of serial robots		AAV2-AAV3
S10	C5 (2H)	Obtaining the dynamic model of serial robots by writing Lagrange equations		AAV2-AAV3
S11	TD5 (2H)	Obtaining the dynamic model of serial robots by writing Lagrange equations		AAV2-AAV3
S12	TP1	Getting to grips with the equipment, open-loop speed control of two serial robots, analysis and comparison of the behavior of the two robots with Motion Capture		AAV1-AVV2
S13	TP2	Handling of equipment, dynamic open-loop control of two serial robots, analysis and comparison of the behavior of the two robots with Motion Capture		AAV1-AVV2-AVV3
S14	ER	Obtaining the dynamic model of serial robots		AAV1-AVV2-AVV3

* C/TD/TP respectively corresponds to lectures, tutorials and lab sessions.

Indicative Assessment of Intended Learning Outcomes (1st session)

Week	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
S7	Individual	In-person	Written	AAV1-AAV2	25 %
S12	Individual	In-person	Labs	AAV1-AAV2	25 %
S13	Individual	In-person	Labs	AAV1-AVV2-AVV3	25 %
S14	Individual	In-person	Written	AAV1-AVV2-AVV3	25 %

2nde session of exam

Session	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
2	Individual	In-person	Written	AAV1-AVV2-AVV3	50 %
1	Individual	In-person	Labs	AAV1-AAV2	25 %
1	Individual	In-person	Labs	AAV1-AVV2-AVV3	25 %

Bibliographic references

- Fondamentaux de la robotique: Géométrie, cinématique, dynamique et commande; Clément Gosselin; Sciences Sup
- Arduino pour débutants: Créer son propre projet électronique; Benjamin Spahic
- Springer Handbook of Robotics; Bruno Siciliano, Oussama Khatib, Springer edition

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