

UE Robotics



Niveau d'étude
Bac +5



ECTS
6 crédits



Crédits ECTS
Echange
6.0



Composante
UFR
Informatique,
mathématiques
et
mathématiques
appliquées
(IM2AG)



Période de
l'année
Automne (sept.
à dec./janv.)

Diplômes intégrant cet élément

- Master Informatique

- › **Langue(s) d'enseignement:** Anglais
- › **Ouvert aux étudiants en échange:** Oui
- › **Crédits ECTS Echange:** 6.0
- › **Code d'export Apogée:** GBXO9MO62

Présentation

Description

Robots are mechatronic systems with perception, decision and action capabilities, they are designed to perform different tasks in an autonomous way in the real world. Born in the 50s, Robotics is a driving force in the world economy, fostering innovation, enhancing productivity, creating high-tech jobs, and contributing to the global competitiveness of nations and industries. As technology continues to evolve, the role of robotics is likely to expand across diverse sectors, further shaping the economic landscape. Thanks to recent technological progress (AI in particular), it is expected that robots will increasingly be present in our daily lives for service and assistance. Robotics is considered an imminent technological and societal revolution and the "France 2030" investment plan has earmarked 800 millions Euros for Robotics alone (<https://www.economie.gouv.fr/france-2030>).

The integration of AI into robotics has been a gradual process but it has been transformative. The adoption of deep learning techniques since the mid-2010s revolutionized perception in robotics. Computer vision systems have become more sophisticated, enabling robots to recognize and understand visual information with unprecedented accuracy. More recently, Reinforcement

Learning has gained prominence, allowing robots to learn through trial and error. This approach is particularly powerful for training robots to perform complex tasks, such as manipulation and navigation, in dynamic environments.

However, making intelligent decisions remains an elusive goal and several challenges remain to be solved. To that end, it is crucial for AI system designers to understand the core concepts of Robotics. Robotics is inherently interdisciplinary, it involves hardware and software components that need to be integrated seamlessly which poses practical challenges and constraints. Robotics involves working with various sensors whose information is crucial for decision-making. AI system designers need to understand how these sensors work and their limitations. Robotics also involves designing and implementing control systems to ensure precise and accurate movements. This includes understanding feedback control, kinematics, and dynamics. In summary, a solid understanding of Robotics is integral for AI system designers because it provides a broader perspective, practical insights, and hands-on experience that can enhance their ability to design, implement, and optimize AI systems for real-world applications.

Objectifs

The purpose of the course is to present the main concepts, tools and techniques that Roboticists have developed in the past fifty years. The course has three parts that focus on different aspects:

The first part is about robot state estimation and world modeling. It presents the most popular approaches to perform state estimation. The basic equations of the Bayes filter are derived first. Then, the Extended Kalman Filter is introduced. These methods are then used to explore the following fundamental estimation problems: 1) robot localization, 2) Simultaneous Localization and Mapping (SLAM), 3) cooperative localization, and 4) simultaneous localization and self-calibration. The structural properties of these problems are studied. In particular, it is shown how the computational complexity scales with the size of the state. Finally, more theoretical aspects related to estimation with special focus on state observability are discussed.

The second part focuses on the decision-making aspects. Motion planning is addressed first in the seminal configuration space framework, the main configuration space-based motion planning techniques are reviewed. Then, to deal with the uncertainty of the real world and the discrepancy between the world and its model, reactive collision avoidance techniques are presented. Finally, motion safety is formally studied thanks to the Inevitable Collision State concept.

The third part is an introduction to control theory for articulated robots. The objectives are to understand basic concepts about the kinematics and dynamics of articulated robots and basic control theory in order to approach classical control methods, as well as a few selected advanced topics. The kinematics of articulated robots is introduced first, covering advanced topics such as singularities, hierarchies of objectives, inequality constraints. A brief reminder about Newton, Euler and Lagrangian equations of motion as well as basic Lyapunov stability theory is also provided before discussing standard motion control schemes such as Proportional-Derivative, Computed Torque, Operational Space and Task Function approaches. Advanced topics such as space robots, biped robots, Viability theory and optimal control are also touched.

Heures d'enseignement

CM	CM	36h
Période : Semestre 9		

Infos pratiques

Contacts

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Campus

➤ Grenoble - Domaine universitaire