2SC6010 – Autonomous Robotics

Instructors: Jeremy Fix
Department: CAMPUS DE METZ
Language of instruction: ANGLAIS
Campus: CAMPUS DE METZ
Workload (HEE): 60
On-site hours (HPE): 34,50

Description

This course will present the field of autonomous robotics (vehicle driving, exploration and inspection robots, etc.) by showing how this problem integrates very diverse technologies (localisation (SLAM), point clouds, planning, pattern recognition) and how this integration is achieved at the system level (illustrations with ROS). The laboratory works associated with the course will be carried out on the Turtlebots mobile robots available in the smartroom of the Metz campus. This work will be an opportunity to integrate different techniques of machine learning and signal processing on robots moving in their environment by progressively building a system allowing a manual control but also a mapping and an autonomous navigation in an unknown environment.

Quarter number

ST5

Prerequisites (in terms of CS courses)

1C1000 : Information systems and programming
1C4000 : Signal processing

Knowledge in probability theory will be helpful. Python programming practice is a definitive advantage.

Syllabus

- Lecture 1 (1h30) : Introduction to autonomous robotics
- Lecture 2 (1h30) : Introduction to ROS and simulation, experiment on real robot
- *Introductory Lab (6h00) : Simulator, ROS and ROS advanced*
- Lecture 3 (1h30) : Primer on Bayesian inference
- Lecture 4 (1h30) : State estimation
- Tutorial1 (1h30) : Kalman Filter and state estimation
- Lab2 (1h30) : Kalman Filter and state estimation

- Lecture 5 (1h30) : Localization
- Tutorial2 (1h30) : Localization (Markov and Monte Carlo)
- Lab3 (3h00) : Localization (Markov and Monte Carlo)
- Lecture 6 (1h30) : Mapping and SLAM
- Lab4 (3h00) : Mapping and SLAM
- Lecture 7 (1h30) : Motion planning
- Lab 5 (3h00) : Deterministic and stochastic planning
- Lecture 8 (1h30) : Navigation
- Lab 6 (3h00) : Trajectory tracking and obstacle avoidance
- Lecture 9 (1h30) : Architecture and interaction
- Lab 7 (3h00) : Integration on a real robot

Total:
Lectures : 13.5 HPE
Tutorials : 3 HPE
Introductory Lab : 6 HPE
Lab works: 16.5 HPE

Class components (lecture, labs, etc.)

The course is organized around lectures complemented with tutorials and lab works for practicing the concepts. The lab works, with real or simulated robotic platforms, will specifically be the opportunity to implement the various concepts seen in the class. In order for the practicals to be as profitable as possible, they will be prepared in advance by the students with the help of a worksheet that will be sent to them. This implementation will heavily rely on ROS, which will be presented in details at the beginning of the course. Programming will be done in Python and all the experiments will run on Linux.

Grading

Written exam of 1h30 in duration.

Course support, bibliography

- Latombe, **Robot Motion Planning**, Kluwer Academic Publishers, 1991.
- Thrun et al., **Probabilistic Robotics**, MIT Press, 2005.
- Lavalle, **Planning Algorithms**, Cambridge University Press, 2006.
- Siegwart et al., **Introduction to Autonomous Mobile Robots**, MIT Press, 2011.
- Siciliano et al., **Springer Handbook of Robotics**, Springer, 2016.

Resources

Instructor : Francis Colas (INRIA)
Teacher assistant : Francis Colas, Jeremy Fix
Tutorial classes : 30 students, 1 teacher
Labworks : 2 x 15 students, 2 teachers

Softwares : Only open source softwares (Linux, Python, ROS, Gazebo)
Hardware : Turtlebots equiped with a LIDAR (x6)
Lab works : The computers in the labs will have all the softwares pre-installed

Learning outcomes covered on the course

- Know the different components of an autonomous robotic system
- Conduct robotics experiments with ROS on simulated or real robots
- Mathematically stating a state estimation problem
- Implement and test algorithms for state estimation, localization, navigation, planning

Description of the skills acquired at the end of the course

C1 : Analyze, design and build complex systems with scientific, technological, human, and economic components
C2 : Develop in-depth skills in an engineering field and a family of professions