2SC6090 – Building inspection by a semi-autonomous drone (quadricopter)

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Department: DOMINANTE - MATHÉMATIQUES, DATA SCIENCES
Language of instruction: ANGLAIS
Campus: CAMPUS DE METZ
Workload (HEE): 40
On-site hours (HPE): 27,00

Description

The students will work on issues related to the technical inspection of indoor environments by UAVs (visual and thermal diagnosis). They will thus provide answers to needs in terms of improving energy performance and detecting possible damage, in particular allowing significant savings for the considered sites.
During this week of practicals, the focus is on helping a human operator by automating drone control as much as possible and providing the operator with a high level of logical control. The students will have implemented servoing techniques with the particularity of including a human operator in the control loop. They will also have integrated machine learning and pattern recognition techniques for the interpretation of information flows from the embedded sensors (mainly video). This is a first contact, through the application and experimental side, with the field of machine learning.
Through this experience, they will have acquired a more general competence in the design of robotic systems with ROS.
Warning: One of the major achievement of the sequence is the experimental validation on real quadrotors in the corridors and gymnasium of the school. This requires you to master several tools (ROS, Linux, ...) and skills in Python programming. A lot of work and a real motivation are required from the students; The volume of the ST5 and the availability of the teaching staff are reinforced to help you to achieve these goals.

Quarter number

ST5

Prerequisites (in terms of CS courses)

Students should be comfortable with Linux/Ubuntu, ROS and OpenCV.
These prerequisites will be taught during the thematic sequence with which this practical is associated.

Syllabus

The practical is divided into three main modules. The first module deals with 1) the low level control loop regulating roll/pitch angles and upward and rotational speeds and 2) some higher level controls (U-turn, translation along an axis). The second module focuses on the management over time of direct behaviors (linear/angular speeds) and logical behaviors (taking the door to the left, moving into the corridor). The third module includes all the image processing functionalities (detection of vanishing lines, calculation of optical flow, etc.). These three modules are further divided with a finer granularity so that the students can parallelize the work.

Class components (lecture, labs, etc.)

- Presentation of case studies by industrial partners
- Designing solutions to proposed problems
- Development of proposed solutions in a real environment
- Implementation on real drones and possible adjustment of solutions
- Presentation/Demonstration of solutions to industrial partners

Grading

Individual and group work will be assessed during the EI period, for competency C6. The oral presentation of each group at the end of the EI on the problem introduced by a company will assess competences C4 and C7.

Resources

Instructor : Hervé Frezza-Buet, Jérémy Fix
Student groups: 5 students
Softwares : Only open source softwares (Linux, Python, ROS, Gazebo-Sphinx)
Hardware: Each group of students will have one bebop2 (lent by Parrot), a joystick, and a laptop
Lab works : The computers in the labs will have all the softwares pre-installed

Learning outcomes covered on the course

- Be able to carry out an ambitious project from start to finish
- Working as a team
- Split the work of a project into subtasks
- Experiment with real robotics platform
- Carry out a software project combining robotics, signal processing and computer science

Description of the skills acquired at the end of the course

C4. Have a sense of value creation for his company and his customers
C6. Be operational, responsible, and innovative in the digital world
C7. Know how to convince

ST5 – 61 – SMART PHOTONICS SYSTEMS FOR CONTROL AND MEASURE

Dominante : PNT (Physics and NanoTechnology), SCOC (Communicating Systems and Connected Objects)
Langue d'enseignement : English
Campus où le cours est proposé : Metz

Engineering problem

Systems using photonics - science and technology exploiting light - allow to measure, regulate and control physical quantities. These properties of photonic systems are widely used in the regulation of a laser for production systems, in the control of the deflection of a beam to visualize an object or observe the dynamics of biological cells, or in the stabilization of ultra-short pulses in telecommunications. In addition, photonic systems are intelligent systems whose measurements are used to facilitate regulation, for example with the development of telemetry and laser velocimetry - techniques widely used in industrial production and in our vehicles, and essential for the industry of the future and the autonomous vehicle.

Very recently, photonic systems have undergone a revolution in their principle and their use with the development of systems that exploit light at the nanometer and attosecond scales. These innovative systems by their new physics pose important challenges for both the measurement of their physical properties - given the very short spatial and temporal scales - and the exploitation of this measurement for the development of sensors and innovative control systems, given the limitations of our signal processing systems. By studying photonic systems, this thematic sequence will also be an opportunity to learn and master the general notions of analysis, identification and control of non-linear physical systems.

Adviced prerequisites

Basic knowledge of electromagnetism, materials, general electricity and electronics

Context and issue modules: This part is structured in conferences, round table and visit of the GDI SIMULATION site - Elancourt, in particular around the theme of "laser remote sensing".

Specific course (60 HEE) : *Photonics for the control of physical systems*

Brief description: This course will teach the essential concepts of measurement and exploitation of physical quantities of optical electromagnetic waves, in the context of the exploitation of photonics for the observation and control of physical systems. Thus this course will assemble knowledge of:

- Optical measurement and instrumentation: general metrology and error analysis, photometry, and optical detectors, holographic metrology, velocimetry, interferometry.
- Laser source technologies: solid state physics, materials and semiconductors.
- Modeling and control of sources: analysis and non-linear dynamics of laser sources.
- Optical signal generation: techniques for spatial and temporal modulation of optical signals; engineering and design of optical beams.

The concepts covered in the course are :

- Optical metrology
- Photonic technologies including semiconductor materials and optical fibers, phase and intensity modulation
- Signal analysis using the non-linear dynamics of a physical system
- Properties and control of non-linear systems

Challenge Week : *Laser remote sensing (LIDAR) for optronic surveillance and target detection*

Associated partner: GDI SIMULATION - Elancourt

- Location: Metz campus

- Brief description : This EI is based on the use of lasers as tools to control the infinitely small and the ultra fast for, in particular, applications in the field of optronic surveillance and target detection. It is proposed to develop a photonic system whose target application is laser ranging (LIDAR). These lidars have a huge potential for defense, environment, security: identification of mobiles, gas detection, active imaging ... The detection and identification of danger or targets is a key element of defense and security devices, and are key elements for example of the devices developed by GDI SIMULATION for civil aviation or the simulation of laser fire for the training of armed forces. The students will perform the experimental realization of the LIDAR using ARDUINO plat-forms. They will have: i/ to understand the essential physical quantities related to an optical electromagnetic wave ii/ design and realize a servo-driven photonic system iii/ engineer and control innovative optical beams by exploiting spatial and temporal signal modulation techniques v/ make a choice of devices to answer an economic problem of sizing and energy consumption.

Recent advances in the realization of innovative optical beams will also allow the exploration of new beam topologies (e.g. Airy beams: non-diffracting, curvilinear trajectory, self-regenerating in case of obstacles) which open the way to improved performances (spatial resolution, speed, etc.).