POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Control of flying robots [S2AiR1E-ISLiSA>ASRL]

## Course

Field of study
Automatic Control and Robotics

Year/Semester
1/2

Area of study (specialization)
Smart Aerospace and Autonomous Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
English

Form of study
full-time

Requirements
compulsory

## Number of hours

Lecture
15

Laboratory classes
15

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

## Number of credit points

4,00

## Coordinators

dr inż. Wojciech Adamski

## Lecturers

## Prerequisites

Before taking the course the student should have basic knowledge of the Python programming language. Basic knowledge of mathematical description of rigid body movement, both kinematics and dynamics. The knowledge of matrix and vector calculus is also required. Within the scope of control theory, knowledge of Lyapunov stability analysis and basic knowledge of the properties of linear and non-linear systems is required.

## Course objective

Expanding the knowledge of modeling and control of physical objects, with particular emphasis on flying robots. Presentation of the methods of considering the realistic characteristics of objects in the process of modeling and control algorithm synthesis. Teaching methods of simulation verification and implementation of the analyzed algorithms.

## Course-related learning outcomes

Knowledge
1. Modeling of flying objects with different types of actuators with consideration of the influence of the environment in which they operate. [K2_W5]
2. Knowledge of different types of sensors used in flying robots. [K2_W4, K2_W6]

3. Knowledge about the design and analysis of flying robot motion control algorithms. [K2_W8, K2_W5]
4. Knowledge about methods of selecting parameters of controllers ensuring operational stability of flying robots. [K2_W5, K2_W8]
Skills
1. Design and implementation of flying robot simulation with consideration of actuator limitations, external disturbances and aerodynamic effects. [K2_U9, K2_U10]
2. Design of motion control algorithm for a flying robot with an analysis of its stability and robustness to disturbances and modeling uncertainties. [K2_U12, K2_U13]
3. Design of observers enabling identification of the value of components of state of an object not available directly from the measurement system. [K2_U13]
4. Literature research to provide solutions to a variety of flying robot control problems. [K2_U1]
5. Definition of basic technical requirements for application-specific flying robots. [K2_U13, K2_U5]
Social competences
1. Awareness of the need for constant knowledge updating due to rapid technological changes in the field of flying robot technology. [K2_K1]
2. Awareness of the need for taking into account the environmental conditions in which flying robots operate during the process of designing a control algorithm. [K2_K4]
3. Understanding the need for clarification of the difficulties involved in developing autonomous robots, in particular flying robots. [K2_K6]

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
1. Lectures: Final rating is decided upon the exam in the form of a selection test. The test comprises questions with 4 answers, where only one is correct. For each correct answer student obtain 1 point. To pass the exam it is necessary to obtain at least 50% of possible points.
2. Laboratory classes: Final rating results from the overall quality assessment of the tasks realized by the students; the assessment concerns: (a) technical quality of the obtained results, (b) quality of the implementation details, and (c) a 'defense' of the tasks in the form of answers to detailed questions related to topics covered by the laboratory classes.

## Programme content

1. Lectures:
The categorization of flying robots.
Explanation of basic problems specific to the task of controlling flying robots.
Methods of modeling dynamic effects influencing motion of flying robots.
Sensors used in aviation.
Deriving equations of kinematics of an object for different representations of rotation.
Mathematical model of the movement of a flying object in three-dimensional space, with consideration of aerodynamic effects such as thrust, drug, lift, added mass and wind influence.
Description of the mathematical model of the propulsion system of an airplane, helicopter, quadrotor and airship.
Derivation of linearly approximated models of motion in three-dimensional space for canonical autopilot tasks.
An overview of control algorithms for linear objects with state feedback, output feedback, and dynamic inversion.
Optimal selection of parameters of the controller of a linearly approximated object.
Reconstruction of the state with the use of Luenberger and sliding observer.
An overview of the operation and applications of the Kalman filter and polynomial filter.
2. Laboratories:
Symbolical derivation and implementation of mathematical model of motion of a quadrotor with use of Python programming language.
Implementation of control algorithm for altitude and orientation stabilization for quadrotor.
Implementation of control algorithm for trajectory tracking in three dimensional space.

## Course topics

none

## Teaching methods

1. Lectures: multimedia presentations (slides) illustrated with selected numerical/simulation examples, together with additional mathematical derivations provided on a blackboard.
2. Laboratory classes: practical computer excercises performed in the 2-person groups in the Jupyter-Python environment.

## Bibliography

Basic
1. Lighter than air robots : guidance and control of autonomous airships, Yasmina Bestaoui Sebbane, International Series on Intelligent Systems, Control and Automation: Science and Engineering vol. 58, Springer-Verlag, 2012
Additional
2. Linear and nonlinear control of small-scale unmanned helicopters, Ioannis A. Raptis, Kimon P. Valavanis, International Series on Intelligent Systems, Control and Automation: Science and Engineering vol. 45, Springer-Verlag, 2011

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 110 | 4,00 |
| Classes requiring direct contact with the teacher | 30 | 1,00 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 80 | 3,00 |