COURSE DESCRIPTION CARD - SYLLABUS

Course name
Measurement systems in automation and robotics [N2AiR1-SSiR>SPwAiR]

Course

Field of study Automatic Control and Robotics	Year/Semester 1/1
Area of study (specialization) Control and Robotic Systems	Profile of study general academic
Level of study second-cycle	Course offered in Polish
Form of study part-time	Requirements compulsory

Number of hours

Lecture	Laboratory classes	Other
20	10	0
Tutorials	Projects/seminars	
0	10	

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

Knowledge: Student starting this module should have basic knowledge regarding the basics of metrology, analog and digital electronics, microprocessor systems, control theory in the field of linear systems. Skills: He/she should have skills allowing solving basic problems related to the design of basic electronic analog systems, feedback and observer design, programming and starting microprocessor systems and the ability to obtain information from various sources. Social competencies: In addition, in respect to the social skills the student should show attitudes as honesty, responsibility, perseverance, curiosity, creativity, manners, and respect for other people.

Course objective

To provide students with knowledge of data processing methods, architectures and design of measurement systems in automation and robotics and the basics of algorithms for state estimation and data fusion in multi-sensor systems; the aim of the course is also to provide students with knowledge of measurement methods and sensors used in robotics for the localization purpose. Developing students' skills in solving problems of designing input/output electronic circuits, writing low-level software responsible for handling data exchange interfaces and implementation of basic algorithms of measurment data processing, implementation of mobile robot localization methods.

Course-related learning outcomes

Knowledge
The student:
1. understands the methodology of designing analog and digital electronic measurement systems - [K2_W4].
2. has detailed knowledge of the construction and use of advanced sensory systems - [K2_W6]
3. has extended knowledge within selected areas of robotics (localization and mapping) – [K2_W10]
4. has detailed knowledge related to control and measurement systems - [K2_W11]
5. has a structured and in-depth knowledge of specialized microprocessor systems designed for control and measurement systems - [K2_W18]
Skills
The student:
1. is able to process analogue and digital signals using hardware and software - [K2_U11]
2. is able to design and select measurement blocks and integrate them into control and monitoring systems - [K2_U13]
3. is able to apply simulation methods to the design of measurement paths and data processing algorithms - [K2_U22]
4. is able to construct an algorithm to solve a complex and unusual engineering task and a simple research problem, and to implement, test and run it in a selected programming environment for selected operating systems - [K2_U25]
5. is able to construct an algorithm for a solution to a complex and unusual measurement task and to implement, test and run it in a selected programming environment on a microprocessor platform -[K2_U26]
Social competences
The student:
1. is aware of the necessity of a professional approach to technical issues, scrupulous familiarization with the documentation and environmental conditions in which the equipment and its components can operate - [K2_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Formative assessment:
a) lectures:
based on answers to question in the written test,
b) project classes:
evaluation of doing correctly assigned tasks (following provided lab. instructions),
Total assessment:
a) verification of assumed learning objectives related to lectures:
i. evaluation of acquired knowledge on the basis of the written exam.
ii. discussion of correct answers in the exam
b) verification of assumed learning objectives related to laboratory classes:
i. evaluation of student knowledge necessary to prepare, and carry out the lab tasks,
ii. monitoring students activities during classes,
iii. evaluation of lab reports (partly started during classes, finished after them)
Additional elements cover:
i. discussing more general and related aspects of the class topic,
ii. showing how to improve the instructions and teaching materials.

Programme content

Modelling the measurement process and errors, the concept of a virtual sensor, advanced stochastic and deterministic observers (linear/non-linear), Bayesian filtering and data fusion methods, oversampling techniques and signal processing, selected analogue and digital interfaces, robot localisation methods and measurement sensors in robot environment perception tasks.

Course topics

Basic concepts: measurement, measurement error and its propagation, input and output interfaces, selected wired and wireless interfaces, low-level software architecture of microprocessor-based

measurement systems. Classification of measurement methods, determination of systematic and stochastic error propagation, standardized error evaluation methods. Measurement system in the structure of automatic control system, hardware sensors and observers. Observers, state estimation methods, data fusion methods.
Methods of analog-digital and digital-analog conversion, oversampling techniques and their application. Time and frequency measurement methods, error analysis, application of methods in automation and robotics. Analog electronic conditioning systems, differential interfaces (voltage and current), input filters. Analog output circuits, basic topologies and their properties. Digital input and output circuits, load capacity and matching. Analog and digital communication interfaces, current loop, differential tracks, local (e.g. SPI, I2C) and remote (e.g. RS232, RS485) serial interfaces. Galvanic isolation, analog and digital structures, applications.
Basic division of robot localization methods. Relative localization methods: path integration, inertial localization, continuous and discrete description, numerical algorithms, evaluation of measurement errors and uncertainty modeling, technical realization of relative localization methods, sensors (sensors for angle measurement, doppler sonars, accelerometers, gyroscope). Absolute localization methods: trilateration and triangulation method, numerical algorithms, evaluation of measurement errors, technical realization of absolute localization methods, sensors and their model (ultrasonic and laser distance meters), examples of existing systems. Probabilistic localization as a method of combining local and global data.
Laboratory exercises: state observers and data fusion methods (simulation), quantification and oversampling (simulation), design of analog measuring tracks (simulation), software of microprocessor-based measuring system and basic data processing algorithms (embedded system, C++ programming).

Teaching methods

1. Lectures: multimedia presentation, presentation illustrated with examples presented on black board, solving tasks
2. Labs and project: solving tasks, practical exercises, experiments, teamwork, multimedia presentation, instructions for exercises, discussion of project topics.

Bibliography

Basic
1. J. Borenstein (edytor), Where am I - Systems and Methods for Mobile Robot Positioning, 1996, http://www-personal.umich.edu/~johannb/shared/pos96rep.pdf.
2. T. Kaczorek (red.), Podstawy teorii sterowania, WNT, Warszawa 2005.
3. P. Horowitz, W. Hill, Sztuka elektroniki, WKŁ, Warszawa, 2004.
4. W. Nawrocki, Rozproszone systemy pomiarowe, WKŁ, Warszawa 2006.
5. P. Skrzypczyński, Metody analizy i redukcji niepewnści percepcji w systemie nawigacji robota mobilnego, Rozprawy, nr 407, Wydawnictwo Politechniki Poznańskiej, Poznań 2007.
Additional
1. K. Paprocki, Mikrokontrolery STM32 w praktyce, Wydawnictwo BTC, Legionowo 2009.
2. Wybrane dokumentacje techniczne mikrokontrolerów oraz czujników pomiarowych.
3. R. C. Arkin (edytor), Principles of Robot Motion Theory, Algorithms and Implementation, Massachussets Institute of Technology (MIT), 2005.

Breakdown of average student's workload

	Hours	ECTS
Total workload	80	3,00
Classes requiring direct contact with the teacher	40	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	40	1,00