COURSE DESCRIPTION CARD - SYLLABUS

Course name

Sensors Integration

Course

Field of study
Automatic Control and Robotics

Area of study (specialization)
Smart Aerospace and Autonomous Systems

Level of study
Second-cycle studies

Form of study
full-time

Year/Semester
1 / 1

Profile of study
general academic

Course offered in
English

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

3

Lecturers

Responsible for the course/lecturer:

dr Magdalena Szymkowiak

email: magdalena.szymkowiak@put.poznan.pl

tel. 61 665 2199

Faculty of Computing

ul.Piotrowo 3, 60-965 Poznań

Responsible for the course/lecturer:

mgr inż. Marek Trączyński

email: marek.r.traczynski@doctorate.put.poznan.pl

tel. 61 224 4501

Faculty of Computing

ul.Piotrowo 3, 60-965 Poznań

Prerequisites

Knowledge: Student starting this module should have basic knowledge regarding:

- basics of control systems theory (state space system, feedback loop, linearization, structure of control scheme)

- mathematics (calculus, trigonometry)

- probability and statistical data analysis

- physics (mechanics, electromagnetism, optics, Coriolis effect, oscillatory movement, dynamics)

Skills: He/she should

- have basic programming skills

- be able to acquire information from given sources of information

- understand the need to extend his/her competences

- be ready to counteract in a group

Social competencies: 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

1. Presentation capabilities of using various techniques and measurement systems for the detection and perception as well as localization in robotics.

2. Consolidation of knowledge regarding techniques of data acquisition and discuss the principle of operation the measuring systems.

3. Provide students knowledge regarding selected methods of signal filtration and estimation. Acquire such skills to practical using with real measurement data.

4. Indentify the main causes of measurements errors and discuss ways to liquidations.

Course-related learning outcomes

Knowledge

1. understands methods employed to design specialized analog and digital electronic systems - [K_W4];

2. has detailed knowledge in the field of building and employing advanced sensor systems - [K_W6];

3. has theoretical detailed knowledge related to control systems and control and measuring systems - [K_W11];

4. has well-established detailed knowledge of specialized microprocessor systems designed for control systems and measurement systems;

Skills

1. is able to analyze and interpret technical design documentation and make use of literature related to a specific problem - [K_U2];

2. is able to employ advanced methods of processing and analyzing signals, including visual signals, and extract information from analyzed signals - [K_U11];

3. is able to select and integrate elements of a specialized measuring and control system, including a control unit, an execution system, a measuring system as well as peripheral and communication modules - [K_U13];

4. is able to work in accordance with the safety rules related to the profession of automatics and robotics specialist - [K_U17];

5. is able to propose improvements (enhancements) to existing design solutions and models of automatics and robotics elements and systems - [K_U20];

6. is able to evaluate usefulness of methods and tools for solving a robotics and automatics problem; is able to use innovative and non-conventional tools in the field of automatics and robotics - [K_U22];

7. is able to develop an algorithm for solving a complex measurement and computational-control task, and to implement, test and run it in a chosen programming environment on a microprocessor platform;

Social competences

1. is aware of responsibility for their own work, is able to collaborate and cooperate in a team, and take responsibility for the jointly performed tasks; is able to lead a team, set goals and assign priorities to realize a specific task - [K_K3]

2. is aware of the necessity to approach technical aspects professionally, to acquaint themselves in detail with documentation and environmental conditions in which devices and elements will operate - [K_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) lectures:

- based on answers to question in the written exam,

b) laboratory classes:

- evaluation of doing correctly assigned tasks (following provided lab. instructions),

Total assessment:

a) verification of assumed learning objectives related to lectures:

- evaluation of acquired knowledge on the basis of the written assessment test.

b) verification of assumed learning objectives related to laboratory classes:

- evaluation of student?s knowledge necessary to prepare, and carry out the lab tasks,

- monitoring students? activities during classes,

- evaluation of lab reports (partly started during classes, finished after them)

Additional elements cover:

- discussing more general and related aspects of the class topic,

- showing how to improve the instructions and teaching materials.

Programme content

The lecture covers the following topics

1. Basic concepts of Sensor Integration

- robotic perception process (gathering information through sensors, feature extraction, prediction on the basis of previously obtained data, association and matching, model update)

- different types of classification of sensors, depending on the applied criterion

- operation of the basic sensors used in robotics

- main sources and reasons of error in perception process

- basic concepts of probability, Bayes theorem

2. Random variables

- function characteristics

- central tendency and dispersion measures

- examples connected with error detection

3. Multivariate random variables

- function characteristics of bivariate distributions

- central tendency, dispersion and correlation measures

- multivariate Gaussian distribution

4. Random process

- Gaussian process (stationary process, white noise)

- Markov process (Markov sequence, Markov chain)

- examples connected with signals perception

5. Signal estimation

- prediction, on the basis of state transition model

- correction, using predicted value and the data gathered by sensors

- Bayes filter

6. Optimal Kalman Filter KF

- assumption - Gauss-Markov sequence, Bayes filter

- implementation examples

7. Suboptimal filter - Extended Kalman Filter EKF

- mathematical fundaments of estimators - linearization

- theoretical and practical aspects of implementation

The laboratory classes are held in two-hour exercises. During the first meeting the safety issues and an introduction to laboratory exercises are preformed. Students work in the groups of two. The exercises focus on the following issues:

- practical aspects of detection and perception in robotics

- principle of operation of chosen sensors (i.a. IMU, 2D laser scanner, pulse oximeter, EMG sensor)

- software development for data acquisition

- implementation of chosen filters in Matlab/Simulink environment

- evaluation of filtration quality

Teaching methods

- lectures: multimedia presentation, presentation illustrated with examples presented on blackboard

- labs: solving tasks, practical exercises, discussion, teamwork in groups of two, multimedia showcase, competitions or case studies. The exercises focus on the practical use of the real sensors

Bibliography

Basic

1. B. Anderson, J. Moore, Optimal Filtering, Prentice-Hall, 1979

2. Y. Bar-Shalom, X. Rong Li, T. Kirubarajan, Estimation with Applications To Tracking and Navigation, John Wiley & Sons, Canada, 2001

3. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, S. Thrun, Principles of Robot Motion: Theory, Algorithms, and Implementations (Intelligent Robotics and Autonomous Agents series), MIT Press, Boston, 2005

4. W. A. Gardner, Introduction to Random Processes, With Applications to Signals and Systems, Macmillan, New York, 1985

Additional

1. N. Sunderhauf, Robust Optimization for Simultaneous Localization and Mapping, Technischen Universitat, Chemnitz, 1981

2. S. Sarkka, Bayesian Filtering And Smoothing, Cambridge University Press, Cambridge, 2013

3. P. S. Maybeck, Stochastic models, estimation and control. Volume 1, Department of Electrical and Computer Engineering, Air Force Institute of Technology, Wright-Patterson Air Force Base Ohio, 1979

4. R. Negenborn, Robot Localization and Kalman Filters. On finding your position in a noisy world, Institute of Information and Computing Sciences in partial fulfilment of the requirements for the degree of Master of Science, specialized in Intelligent Systems, 2003

5. G. Welch, G. Bishop, An Introduction to the Kalman Filter, University of North Carolina at Chapel Hill Department of Computer Science Chapel Hill, NC 27599-3175, 2006

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3
Classes requiring direct contact with the teacher	40	2
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests, project preparation)[1]	35	1

[1] delete or add other activities as appropriate