# COURSE DESCRIPTION CARD - SYLLABUS

Course name

AUTONOMOUS ROBOTS AND VEHICLES: SELECTED PROBLEMS IN PERCEPTION, ESTYMATION AND PLANNING

## Course

| | |
|---|---|
| Proposed by Discipline | Year/Semester |
| Automation, electronic and electrical engineering | II/3, III/5 |
| Type of studies | Course offered in |
| Doctoral School | English |
| Form of study | Requirements |
| full-time | elective |

## Number of hours

| Lecture | Tutorials | Projects/seminars |
|---|---|---|
| 4 | | |

## Number of credit points

1

## Lecturers

Responsible for the course/lecturer:

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Responsible for the course/lecturer:

## Prerequisites

Knowledge: has an organized and in-depth knowledge of artificial intelligence methods and their application in automation and robotics systems. Has advanced detailed knowledge of the construction and use of advanced sensory systems.

Skills: the graduate can construct an algorithm for solving a complex and unusual engineering task and a simple research problem, as well as implement, test and run it in a selected development environment for selected operating systems. The graduate can construct an algorithm for solving a complex and unusual measurement and computing-control task as well as implement, test and run it in a selected development environment on a microprocessor platform.

Social competencies: the graduate is aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which the equipment and its components can operate. The graduate is ready to observe the rules of professional ethics and to demand it from others, to respect the diversity of opinions and cultures.

## Course objective

This monographic lecture is devoted to the problems of autonomy in robotics and focuses on selected problems in state estimation, action planning and learning in embodied systems. Modern robotics increasingly adopts artificial intelligence methods and techniques that allow the recent generation of robots to discount the technological leap in sensing and computer power. In parallel, robots that a decade ago were only laboratory models start to be marketed in several application areas - good examples are walking and aerial robots that made great progress in the last years. However, the new age of robot autonomy is also related to industrial applications, as we are witnessing the proliferation of co-operative robots for manipulation. In these robots the accurate, but heavy and costly mechanical components are replaced by much more lightweight ones, while the accuracy is no longer ensured by mechanics, but by intelligent control and on-line sensing.

The lecture demonstrates the most important methods that made this progress possible in the areas of:
- state estimation, focusing on efficient localisation of mobile robots in unstructured environments,
- action and motion planning, focusing on legged robots and manipulation/grasping of objects,
- machine learning algorithms applied to robotic perception and control.

In each of these areas we define the problem, demonstrate some basic algorithmic solutions, comment on the adoption of these methods to robots dealing with real-world problems, and then show application examples.

## Course-related learning outcomes

### Knowledge

A PhD student who graduated from doctoral schoolknows and understands:

1) key developmental trends of science disciplines in which education takes place at the doctoral school, [P8S_WG/SzD_W02]

2) scientific research methodology in disciplines represented at the doctoral school, [P8S_WG/SzD_W03]

3) fundamental dilemmas of the contemporary civilization. [P8S_WK/SzD_W05]

### Skills

A PhD student who graduated from doctoral school can:

1) use the knowledge from different branches of science to creatively identify, formulate and to innovatively solve complex problems or to execute research tasks in particular:
-define the aim and subject of scientific research, form a research hypothesis,
-develop research methods, techniques and tools and use them creatively,
-draw conclusions on the basis of research results, [P8S_UW/SzD_U01]

2) critically analyze and asses scientific research results, work of experts and other creative activities together with their contribution into knowledge development, [P8S_UW/SzD_U02]

3) communicate on specialist issues on the level that allows active participation in the international

scientific community, [P8S_UK/SzD_U04]
4) use the English language on at least B2 level, according to the Common European Framework of Reference for Languages (CEFR), to a degree which allows active participation in the international scientific and professional community. [P8S_UK/SzD_U08]

Social competences

A PhD student who graduated from doctoral school is ready to:
1) critically assess the achievements within a given scientific discipline,[P8S_KK/SzD_K01]
2) critically evaluate their own contribution to the development of a given scientific discipline, [P8S_KK/SzD_K02]
3) acknowledge the importance of knowledge in solving cognitive and practical problems. [P8S_KK/SzD_K03]

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

| PQF code | Methods for verification of learning outcomes | Assessment criteria |
|---|---|---|
| W02, W03, W05 | Written essay in English concerning a specific topic selected among several topics proposed by the lecturer | Completeness and quality of the yopic coverage |
| U01, U02, U04, U08 | Written essay in English concerning a specific topic selected among several topics proposed by the lecturer | Quality of conclusions and the observed relevance to the own thesis topic |
| K01, K02, K03 | Participation in the lectures, asking questions and participation in the discussion | Activity observed by the lecturer |

## Programme content

This monographic lecture is devoted to the problems of autonomy in robotics and self-driving cars, and focuses on selected problems in state estimation, action planning and learning in embodied systems. Modern robotics increasingly adopts artificial intelligence methods and techniques that allow the recent generation of robots to discount the technological leap in sensing and computer power. In parallel, robots that a decade ago were only laboratory models start to be marketed in several application areas - good examples are walking and aerial robots that made great progress in the last years. However, the new age of robot autonomy is also related to industrial applications, as we are witnessing the proliferation of co-operative robots for manipulation. In these robots the accurate, but heavy and costly mechanical components are replaced by much more lightweight ones, while the accuracy is no longer ensured by mechanics, but by intelligent control and on-line sensing.
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In each of these areas we define the problem, demonstrate some basic algorithmic solutions, comment on the adoption of these methods to robots dealing with real-world problems, and then show application examples.

The presented material should be particularly useful to PhD students interested in robotics, artificial intelligence, machine learning, computer vision and high-performance computing, but any student that considers to work with embodied software agents and software/hardware systems should find in this lecture an inspiration to his/her own studies on the applications of mathematical and computer science methods to the real, dynamic world.

## Teaching methods

Lecture: multimedia presentation including illustrations and examples.

## Bibliography

### Basic

1. S. Thrun, D. Fox, W. Burgard, Probabilistic Robotics, MIT Press, Cambridge, 2005.

2. I. Nourbakhsh, R. Siegwart, D. Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, Cambridge, 2011.

3. R. Murphy, An Introduction to AI Robotics, Second edition, MIT Press, Cambridge, 2019.

### Additional

1. S. Russel, P. Norvig, Artificial Intelligence: A Modern Approach, Second edition, Pearsons, 2003.

2. N. Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann, 1998.

3. C. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 12 | 1.0 |
| Classes requiring direct contact with the teacher | 4 | 0.5 |
| Student's own work (literature studies, preparation for tutorials, project preparation) [1] | 8 | 0.5 |

[1] delete or add other activities as appropriate