# COURSE OUTLINE

## (1) GENERAL

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|---|---|---|---|
| **SCHOOL** | School of Science | | |
| **ACADEMIC UNIT** | Department of Digital Industry Technologies | | |
| **LEVEL OF STUDIES** | Postgraduate (MSc on Robotics and Industrial Control) | | |
| **COURSE CODE** | **004** | **SEMESTER** | 1st |
| **COURSE TITLE** | Advanced Robotic Vision | | |
| **INDEPENDENT TEACHING ACTIVITIES** if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits | **WEEKLY TEACHING HOURS** | | **CREDITS** |
| Lectures | 3 | | 6 |
| *Total* | 3 | | 6 |
| **COURSE TYPE** *special background, specialised general knowledge, skills development* | Specialization Course | | |
| **PREREQUISITE COURSES:** | --- | | |
| **LANGUAGE OF INSTRUCTION and EXAMINATIONS:** | Greek and/or English | | |
| **IS THE COURSE OFFERED TO ERASMUS STUDENTS** | Yes, under conditions | | |
| **COURSE WEBSITE (URL)** | https://ric-en.dind.uoa.gr/el/studies/curriculum/1st_semester/advanced_robotic_vision/ | | |

## (2) LEARNING OUTCOMES

**Learning outcomes**

*The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.*

*Consult Appendix A*

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The aim of the course is to familiarize students with the basic robotic vision system tools, with an emphasis on studying and analyzing three-dimensional information and extracting information about the static and dynamic characteristics of robotic workspace. Upon successful completion of the course, students will be able to:

• Understand tools of computational visual perception,
• Handle tools for image processing and analysis,
• Analyze aspects of two-dimensional and three-dimensional geometry as well as relevant geometric transformations,
• Design and apply robotic vision systems for the estimation of the position and orientation of robotic mechanisms,
• Design and apply robotic vision systems for representing three-dimensional objects,
• Understand the principles of three-dimensional scanning,
• Design and implement algorithms for robotic task through computer vision tools,
• Apply tools of artificial intelligence to robotic vision applications, and
• Apply the above knowledge in industrial applications.

**General Competences**

*Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?*

*Search for, analysis and synthesis of data and information, with the use of the necessary technology*
*Adapting to new situations Decision-making*
*Working independently Team work*
*Working in an international environment Working in an interdisciplinary environment Production of new research ideas*
*Project planning and management Respect for difference and multiculturalism Respect for the natural environment*
*Showing social, professional and ethical responsibility and sensitivity to gender issues*
*Criticism and self-criticism*
*Production of free, creative and inductive thinking*
*……*
*Others…*
*…….*

Search for, analysis and synthesis of data and information, with the use of the necessary technology, Decision-making, Working independently, Team work, Project planning and management , Criticism and self-criticism, Production of free, creative and inductive thinking.

## (3) SYLLABUS

Elements of visual perception. Image Sampling and Quantization. Tools for Image Processing and Analysis. Image Formation: Camera Models, Calibration, Single view geometry, Multiple view geometry, Epipolar geometry, Feature extraction. Position and Orientation: Feature based alignment, Pose estimation. Time varying pose and trajectories. Estimation of 3-D structures from 2-D images. Visual Odometry (VO): Semi-direct VO, direct sparse odometry. Localization and Mapping: Initialization, Tracking, Mapping, geometric Simultaneous Localisation and Mapping (SLAM) formulations. Sensor combinations for 3D object reconstruction (Inertial Measurement Unit - IMU, RGB-Depth). 3D scanning systems. Recognition and Interpretation: Object detection, Instance recognition, Category recognition, Context and Scene understanding. Robotic vision toward position, orientation, and velocity estimation. Vision guided robotic systems, trajectory planning for pick-and-place tasks. Robotic vision in Industrial Applications: cutting and shaping, inspection and sorting, palletization and primary packaging, etc. AI algorithms in robotic vision.

## (4) TEACHING and LEARNING METHODS - EVALUATION

**DELIVERY**
*Face-to-face, Distance learning, etc.*

Face to face, Synchronous and Asynchronous distance learning

**USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY**
*Use of ICT in teaching, laboratory education, communication with students*

Supporting the learning process through

- use of an electronic platform for interactive two-way communication and participation,
- use of an electronic classroom platform for providing educational material, discussions, announcements, assignments,
- e-mail communication,
- use of projectors during lectures
- use of software packages for the development of simulation
- use of software packages to control robotic systems
- use of software packages for image processing and analysis
- use of software packages to collect and exchange data among robotic mechanisms

**TEACHING METHODS**
*The manner and methods of teaching are described in detail.*
*Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.*

*The student's study hours for each learning activity are given as well as the hours of non- directed study according to the principles of the ECTS*

| *Activity* | *Semester Workload* |
|---|---|
| Lectures | 39 |
| Literature study & analysis | 45 |
| Project / Essay writing | 66 |
| Course Total | 150 |

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|---|---|
| **STUDENT PERFORMANCE EVALUATION**<br>*Description of the evaluation procedure*<br><br>*Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other*<br><br>*Specifically-defined evaluation criteria are given, and if and where they are accessible to students.* | The evaluation of postgraduate students and their performance in the course takes place at the end of each semester with written or oral examinations or assignments throughout the semester or can be based on intermediate progress exams, written assignments, laboratory exercises or a combination of all the above. The method of evaluation is defined by the instructor of the course and announced to the students. The language for written and oral examinations is the same with that used for teaching. The assignments essays may be written in Greek and/or English language.<br>When conducting written or oral examinations as assessment methods, the integrity of the procedure must be ensured. Scoring is done on a scale of 0-10. The results of the examinations are announced by the instructor and sent to the Secretariat of the Postgraduate Program within four weeks at the latest from the examination of the course. The participation rate of exercises, assignments, etc. The final grade of the course is determined by the course instructor and announced to students at the beginning of the semester.<br>Alternative assessment methods may be applied, such as the conduct of written or oral examinations using electronic means, provided that the integrity of the evaluation process is ensured and the provisions of the relevant regulations of the MSc are met. Alternative methods may also be applied for the assessment of students with disabilities and special educational needs following a decision of the Board of Directors and the recommendation of the head of the Department for Disabled Persons and taking into account the relevant instructions of the Accessibility Unit for Students with Disabilities. |

## (5) ATTACHED BIBLIOGRAPHY

*- Suggested bibliography:*


1. A. K. Sood and H. Wechsler (eds), Active Perception and Robot Vision, Springer Berlin Heidelberg, 2012.
2. Á. M. Alberola, G. M. Gallego and U. G. Maestre, Artificial Vision and Language Processing for Robotics: Create End-to-end Systems that Can Power Robots with Artificial Vision and Deep Learning Techniques, Packt Publishing, 2019.
3. A. Pugh (ed), Robot Vision, Springer Berlin Heidelberg, 2013.
4. D. Kragic and M. Vincze, Vision for Robotics, Now Publishers, 2009.
5. E. R. Davies, Computer Vision: Principles, Algorithms, Applications, Learning, Academic Press, 2017.
6. Jose Garcia-Rodriguez and Miguel A. Cazorla Quevedo, Robotic Vision: Technologies for Machine Learning and Vision Applications, Information Science Reference, 2012.
7. P. Corke, Robotic Vision: Fundamental Algorithms in MATLAB, Springer International Publishing, 2021.
8. R. Klette, Concise Computer Vision: An Introduction into Theory and Algorithms, Springer, 2014.
9. R. Szeliski, Computer Vision: Algorithms and Applications, Springer, 2022.
10. S. J. D. Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.
11. T. Binford, J. Ruby and J. Nedumaan, Advanced Robotic Vision, Independently Published, 2019.
12. Y. Xu, H. Tan, Y. Mao and L.-A. Derose, Computer Vision And Robotics In Perioperative Process, World Scientific Publishing Company, 2018


*- Relative academic journals:*

1. Nature Machine Intelligence, Springer Nature Switzerland AG
2. Foundations and Trends in Computer Graphics and Vision, Now Publishers Inc
3. AI Open, KeAi Communications Co
4. Transactions on Pattern Analysis and Machine Intelligence, Institute of Electrical and Electronic Engineers

5. Transactions on Robotics, Institute of Electrical and Electronic Engineers
6. International Journal of Computer Vision, Springer Netherlands
7. Medical Image Analysis, Elsevier
8. Pattern Recognition, Elsevier
9. Computer Vision and Image Understanding, Academic Press Inc.
10. Cognitive Computation, Springer New York
    IPSJ Transactions on Computer Vision and Applications, Information Processing Society of Japan