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| <b>Course title</b>   | <b>Cognitive Robotics</b>   |
| <b>Course number</b>  | COMP 623  |
| <b>Credit hours (lecture and lab)</b>                                     | 3 (3+0)   |
| <b>ECTS (weekly contact and self-study load)</b>                          | 6 (3 + 3)   |
| <b>Prerequisites/co-requisites by course number and name</b>              |   |
| <b>Prerequisites by topic (other than the formal prerequisites above)</b> | None  |
| <b>Level and type (compulsory, elective)</b>                              | ME Core course  |
| <b>Year of study and semester</b>   | Any   |
| <b>Catalogue description</b>  | <p>This course provides an introduction to cognitive robotics, a branch of robotics in which knowledge plays a central role in supporting action selection, planning, and execution. Cognition is essential for robots to be able to perform tasks in a response to a request by a human, but without the human having to specify explicitly everything that is needed to fulfil the task. Many everyday activities fall into this category. The goal of the course is to give students an understanding of what is involved in the design a cognitive robot and give them the knowledge and skills to produce working implementations for simple instances of cognitive fetch and place tasks.</p> |
| <b>Objectives</b>   | <p>Students will be introduced to the general area of robotics. They will learn how to develop software using ROS (Robot Operating System) and they will learn the principles of robot manipulation and task level robot programming, including the mathematical tools required to specify the position and orientation of robots and objects in the robot environment. Students will be introduced to the main topics in artificial cognitive systems, including the different paradigms of cognitive science and cognitive architectures.</p>   |

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| <b>Intended learning outcomes</b>                                  | Upon successful completion of this course, students will be able to:   |   |             |
|  | <b>No</b>  | <b>Intended learning Outcome (ILO)</b>                            | <b>PLO*</b> |
|  | 1  | Learn the architectures and languages for cognitive robotics      | 1,4,5       |
|  | 2  | Teach the robot how to plan his motion                            | 1,2         |
|  | 3  | Be familiar with parallel working robots                          | 1,3,5       |
|  | 4  | program robotic in dynamic environment based on visual perception | 1,2         |
|  | 5  | Let the robot manipulate objects                                  | 1,3,6       |
|  | 6  | Be familiar with decision making                                  | 1,3,4,5     |
|  | 7  | Know how to let the robot handle risk-bounded motion              | 1,2,4,5,6   |
| (*) The Program learning outcome (PLOs) are listed in the appendix |  |   |             |
| <b>Teaching and learning methods</b>                               | <p>Development of ILOs is promoted through the following teaching and learning methods:</p> <ul style="list-style-type: none"> <li>• The Digital Systems Lab. is open for the students to practice the practical aspects and solve the programming homework assignments.</li> <li>• The student attends the class presentations and participates in the discussions.</li> <li>• The student joins the related online team/group and participates in its discussions.</li> <li>• The student studies the reference material, including books and videos.</li> <li>• The student solves the programming assignments in machine learning.</li> <li>• The student carries out a term project for solving a problem using machine learning techniques.</li> <li>• The student develops a professional report for the term report.</li> <li>• The student presents the term project in class.</li> </ul> |   |             |

| <b>Learning material type</b>        | Textbook, class handouts, some instructor keynotes, selected YouTube videos, and access to a personal computer and the internet.   |  |            |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|--------------------------------------|--|--|------------|------------------|-----------------|------|----------|------|----------------------|-----|---------------------|--------|--------------|-----|--------------|----|--------------------------------------|-----|------------------------------------|--------|------------|-----|--------------|-----|--------------|-------------|--|--|
| <b>Resources and references</b>      | A- Required book(s), assigned reading and audio-visuals: <ol style="list-style-type: none"> <li>1. Srikanta Patnaik, "Robot Cognition and Navigation", Springer, 2007</li> </ol> B- Recommended book(s), material and media: <ol style="list-style-type: none"> <li>2. "John-Hwan Kim et al.", Robot Intelligence Technology and Applications 4, Springer, 2017</li> </ol>   |  |            |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
| <b>Topic outline and schedule</b>    | <b>Week</b>  | <b>Topic</b>                                       | <b>ILO</b> | <b>Resources</b> |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 1  | Architectures and Languages for Cognitive Robotics | 1          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 2  | Spatial Perception for Robotics                    | 2          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 3  | Self-Monitoring, Self-Diagnosing Systems           | 22         | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 4  | Dynamic Scheduling and Uncertainty                 | 2          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 5  | Sampling-based Motion Planning                     | 2          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 6  | Single-Robot and Multi-Robot Path Planning         | 3          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 7  | Trajectory Optimization for Under-actuated Robots  | 3          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 8  | Classical Activity Planning                        | 2          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 9  | Hybrid Activity and Motion Planning                | 2          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 10   | Planning Concurrent Timelines                      | 3          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 11   | Visual Perception for Dynamics Environments        | 4          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 12   | Fundamentals of Robotics Manipulation and Grasping | 5          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 13   | Multi-Vehicle Routing with Time Windows            | 3          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 14   | Probabilistic Planning                             | 6          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 14   | Risk-bounded Motion Planning                       | 7          | 1                |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
|                                      | 15   | Project Presentations                              | All        |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
| <b>Evaluation tools</b>              | Opportunities to demonstrate achievement of the ILOs are provided through the following assessment tools: <table border="1" data-bbox="500 1415 1484 1675"> <thead> <tr> <th>Assessment tool</th> <th>Mark</th> <th>Topic(s)</th> <th>Time</th> </tr> </thead> <tbody> <tr> <td>Homework assignments</td> <td>10%</td> <td>Theoretical aspects</td> <td>W1-W14</td> </tr> <tr> <td>Midterm exam</td> <td>30%</td> <td>Applications</td> <td>W8</td> </tr> <tr> <td>Term project report and presentation</td> <td>20%</td> <td>Practical and presentation aspects</td> <td>W3-W15</td> </tr> <tr> <td>Final exam</td> <td>40%</td> <td>All material</td> <td>W16</td> </tr> <tr> <td><b>Total</b></td> <td><b>100%</b></td> <td></td> <td></td> </tr> </tbody> </table> |  |            |                  | Assessment tool | Mark | Topic(s) | Time | Homework assignments | 10% | Theoretical aspects | W1-W14 | Midterm exam | 30% | Applications | W8 | Term project report and presentation | 20% | Practical and presentation aspects | W3-W15 | Final exam | 40% | All material | W16 | <b>Total</b> | <b>100%</b> |  |  |
| Assessment tool                      | Mark   | Topic(s)   | Time       |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
| Homework assignments                 | 10%  | Theoretical aspects                                | W1-W14     |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
| Midterm exam                         | 30%  | Applications                                       | W8         |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
| Term project report and presentation | 20%  | Practical and presentation aspects                 | W3-W15     |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
| Final exam                           | 40%  | All material                                       | W16        |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
| <b>Total</b>                         | <b>100%</b>  |  |            |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |
| <b>Student requirements</b>          | The student should have a computer and internet connection.  |  |            |                  |                 |      |          |      |                      |     |                     |        |              |     |              |    |                                      |     |                                    |        |            |     |              |     |              |             |  |  |

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| <p><b>Course policies</b></p>        | <p>A- Attendance policies:</p> <ul style="list-style-type: none"> <li>• Attendance is required. Class attendance will be taken every class and the university polices will be enforced in this regard.</li> </ul> <p>B- Absences from exams and not submitting assignments on time:</p> <ul style="list-style-type: none"> <li>• A makeup exam can be arranged for students with acceptable absence causes.</li> <li>• Assignments submitted late, but before announcing or discussing the solution can be accepted with 25% penalty.</li> <li>• The project report must be handed in in time.</li> </ul> <p>C- Health and safety procedures:</p> <ul style="list-style-type: none"> <li>• All health and safety procedures of the university and the school should be followed.</li> </ul> <p>D- Honesty policy regarding cheating, plagiarism, misbehavior:</p> <ul style="list-style-type: none"> <li>• Open-book exams</li> <li>• All submitted work must be of the submitting student.</li> <li>• Other text or code must be properly quoted with clear source specification.</li> <li>• Cheating will not be tolerated.</li> </ul> <p>E- Available university services that support achievement in the course:</p> <ul style="list-style-type: none"> <li>• Moodle course page</li> <li>• AI Lab for practicing the practical aspects and solving the programming assignments.</li> <li>• Program announcements Facebook group</li> </ul> |
| <p><b>Additional information</b></p> | <p>None</p>   |