1. Annotation

Course Description

Industrial robots are used to do repetitive actions in various different manufacturing processes. They are automated, programmable and can be integrated with various external devices depending on the solving problem. Typical applications of industrial robots-manipulators include welding, painting, assembly, moving, palletizing, product inspection processes accomplished with high speed and precision. The main goal of this course is explain principles of controlling robots and solve different automation tasks demanded in industry.

In this course, a wide range of questions will be addressed, beginning from the basics of robot teaching and controlling up to integration of manipulators and external devices into a single system.

During laboratory class we will get acquainted with modern industrial robots. Students will be able to control and teach robots for solving different tasks: from simple movement of manipulators up to build an automated system for real manufacturing task.

Course Prerequisites / Recommendations

Basic knowledge of engineering and mechanics

2. Structure and Content
## Course Academic Level

Master-level course suitable for PhD students

## Number of ECTS credits

3

<table>
<thead>
<tr>
<th>Topic</th>
<th>Summary of Topic</th>
<th>Lectures (# of hours)</th>
<th>Seminars (# of hours)</th>
<th>Labs (# of hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>• The role of robots in industrial processes</td>
<td>1.5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• General safety principles of industrial robots</td>
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<tr>
<td></td>
<td>• Robot parts and controller description</td>
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<tr>
<td>First launch of the industrial robot</td>
<td>• First launch of the industrial robot</td>
<td>0.5</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>• Description of teach pendant interface and functions</td>
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<tr>
<td></td>
<td>• Robot coordinate systems</td>
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<tr>
<td>Defining of coordinate systems and tools installing</td>
<td>• Mounting and connecting of a gripper on the robot flange</td>
<td>1.5</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>• Basics of tool center point and user coordinate system teaching</td>
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<tr>
<td>Programming of robot motions</td>
<td>• Tool center point teaching</td>
<td>0.5</td>
<td>0</td>
<td>8</td>
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<tr>
<td></td>
<td>• User coordinate system teaching</td>
<td></td>
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<tr>
<td></td>
<td>• Programming of simple robot motions</td>
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<tr>
<td></td>
<td>• Launch of the prepared program in manual mode</td>
<td></td>
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<tr>
<td>Connection of external devices to the robot</td>
<td>• Connection of external devices to the robot</td>
<td>0.5</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>• External devices control using robot pendant</td>
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<tr>
<td>Launch in automatic mode</td>
<td>• Correction and adjustment of robot programs</td>
<td>0.5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Robot failures</td>
<td>• Launch of the prepared program in automatic mode</td>
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<tr>
<td>Service functions</td>
<td>• Operation with failures and messages of the robot</td>
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<td></td>
<td>• Programs and system files backup creation</td>
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<td></td>
<td>• Based principles of robot Software’s.</td>
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</tbody>
</table>

### 3. Assignments
<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Assignment Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>Essay of 2000 words on the perspectives of an industrial robotics in advanced manufacturing by a student choice (existing or future in frame works of the IoT and Industry 4.0 development) to check the understanding of theoretical course topics. This will for 15% of the final marks.</td>
</tr>
<tr>
<td>Project</td>
<td>Palletizing process. This will for 15% of the final marks.</td>
</tr>
<tr>
<td>Project</td>
<td>Automated welding. This will for 15% of the final marks.</td>
</tr>
<tr>
<td>Project</td>
<td>Automated milling. This will for 15% of the final marks.</td>
</tr>
<tr>
<td>Final Project</td>
<td>A final team presentation during concluding seminar ~ 20 min (with 5 min for answering questions) will be given by students in order to improve their oral communication skills by presenting results of assigned Projects (1-2-3). This will help to evaluate student learning level and performance by the end of the course term. This will for 30% of the final marks.</td>
</tr>
</tbody>
</table>

**4. Grading**

<table>
<thead>
<tr>
<th>Type of Assessment</th>
<th>Graded</th>
</tr>
</thead>
</table>

**Grade Structure**

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Activity weight, %</th>
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<tbody>
<tr>
<td>Attendance</td>
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</tr>
<tr>
<td>Projects</td>
<td>45</td>
</tr>
<tr>
<td>Homework Assignments</td>
<td>15</td>
</tr>
<tr>
<td>Final Project</td>
<td>30</td>
</tr>
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</table>

**Grading Scale**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Score</th>
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<tbody>
<tr>
<td>A</td>
<td>86</td>
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<tr>
<td>B</td>
<td>76</td>
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5. Basic Information

Maximum Number of Students

<table>
<thead>
<tr>
<th></th>
<th>Maximum Number of Students</th>
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</thead>
<tbody>
<tr>
<td>Overall:</td>
<td>9</td>
</tr>
<tr>
<td>Per Group (for seminars and labs):</td>
<td>3</td>
</tr>
</tbody>
</table>

Course Stream
Science, Technology and Engineering (STE)

Course Term (in context of Academic Year)
Term 2

Course Delivery Frequency
Every year

Students of Which Programs do You Recommend to Consider this Course as an Elective?

<table>
<thead>
<tr>
<th>Masters Programs</th>
<th>PhD Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Manufacturing Technologies</td>
<td>Engineering Systems</td>
</tr>
<tr>
<td>Energy Systems</td>
<td>Materials Science and Engineering</td>
</tr>
<tr>
<td>Materials Science</td>
<td>Mathematics and Mechanics</td>
</tr>
<tr>
<td>Petroleum Engineering</td>
<td>Petroleum Engineering</td>
</tr>
<tr>
<td>Space and Engineering Systems</td>
<td>Physics</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Course Tags</th>
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</thead>
<tbody>
<tr>
<td>Math</td>
</tr>
<tr>
<td>Physics</td>
</tr>
<tr>
<td>Programming</td>
</tr>
<tr>
<td>Engineering</td>
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</table>

6. Textbooks and Internet Resources

<table>
<thead>
<tr>
<th>Required Textbooks</th>
<th>ISBN-13 (or ISBN-10)</th>
</tr>
</thead>
</table>
7. Facilities

<table>
<thead>
<tr>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot FANUC M710</td>
</tr>
<tr>
<td>Robot KUKA KR120 + Gripper</td>
</tr>
<tr>
<td>Robot KUKA KR9 + Milling Instrument</td>
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<tr>
<td>Belt Conveyor</td>
</tr>
<tr>
<td>Fanuc LR Mate 200iD - compact 6 axis robot</td>
</tr>
<tr>
<td>ABB IRB 2600 - industrial 6 axis robot</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roboguide – FANUC Robot Simulation Software and System Animation Tool</td>
</tr>
<tr>
<td>RobotStudio – ABB’s Simulation and Offline Programming Software</td>
</tr>
<tr>
<td>KUKA VisualWorks</td>
</tr>
<tr>
<td>Matlab</td>
</tr>
<tr>
<td>Wolfram Mathematica Player Visualization</td>
</tr>
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</table>

8. Learning Outcomes

<table>
<thead>
<tr>
<th>Knowledge</th>
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</thead>
<tbody>
<tr>
<td>Basic level of industrial robot operation</td>
</tr>
<tr>
<td>Safety precautions</td>
</tr>
<tr>
<td>Manufacturing technology for industrial robotics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming of robot motions and external devices</td>
</tr>
<tr>
<td>Mounting and tuning of additional equipment for industrial robots</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming movement modern industrial robot</td>
</tr>
<tr>
<td>Integration of external device in robot system</td>
</tr>
<tr>
<td>Solving manufacturing automation task</td>
</tr>
</tbody>
</table>

9. Assessment Criteria
**Input or Upload Example(s) of Assignment 1:**

<table>
<thead>
<tr>
<th>Select Assignment 1 Type</th>
<th>Homework Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Example(s) of Assignment 1 (preferable)</td>
<td>Essay of 2000 words on the perspectives of an industrial robotics in advanced manufacturing by a student choice (existing or future in frame works of the IoT and Industry 4.0 development) to check the understanding of theoretical course topics.</td>
</tr>
<tr>
<td>Assessment Criteria for Assignment 1</td>
<td>Graded from 0 to 15. Essay submission (PDF file, every student via e-mail to Supervisor) after the end of the theoretical part of the course (middle of Term 2). Late Submission Policy: 30% for each week (or fraction thereof) that they are late; after two week, zero credit will be given.</td>
</tr>
</tbody>
</table>

**Assessment Criteria (15 is 100 %):**
- Clear problem synopsis 15 p
- State of art 10 p
- Materials, devices & sensors (equipment) and / or approaches 30 p
- Results & Discussion 30 p
- Conclusions 15 p

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**Input or Upload Example(s) of Assignment 2:**

<table>
<thead>
<tr>
<th>Select Assignment 2 Type</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Example(s) of Assignment 2 (preferable)</td>
<td>1. Palletizing process; 2. Automated welding; 3. Automated milling.</td>
</tr>
<tr>
<td>Assessment Criteria for Assignment 2</td>
<td>Every project will graded from 0 to 15. Every project report should be submitted (PDF file, sended from Team via e-mail to Supervisor) after the end of the Project, but no later than start of last week of Term 2. Late Submission Policy: 30% for each day (or fraction thereof) that they are late; after two days, zero credit will be given.</td>
</tr>
</tbody>
</table>

See Assessment Criteria for Assignment 1.

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**Input or Upload Example(s) of Assignment 3:**

<table>
<thead>
<tr>
<th>Select Assignment 3 Type</th>
<th>Final Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Example(s) of Assignment 3 (preferable)</td>
<td>Team Project. Final presentation of Team of 3 students. A final team presentation (PPT or PDF format, 12-15 slides) during concluding Seminar ~ 20 min (with 5 min for answering questions) will be given by students in order to improve their oral communication skills by presenting results of finished Projects (1-2-3).</td>
</tr>
<tr>
<td>Assessment Criteria for Assignment 3</td>
<td></td>
</tr>
</tbody>
</table>
Outlines of presentation:
Proposal: 1-2 slides description of projects + goals for milestone. This part describes the initial proposals and tasks of the projects.
Equipment: 3 slides of equipment description.
Results and Discussion: 8-9 slides.
Conclusions: 1 slide. Please, estimate your results, compare your results with results of other Teams and References (if possible).
Ideally, the presentation should be included interesting ideas from Essays of Team participants.

Schedule: The presentation needs to be 15 minutes long; There will be a maximum of 5 minutes for questions after the presentation. If your presentation lasts more than 15 minutes, it will be stopped. So please make sure the presentation does not go over.
Evaluation: Each team will evaluate their colleagues’ presentations. This will for 30% of the final marks.

Input or Upload Example(s) of Assignment 4:

Input or Upload Example(s) of Assignment 5:

10. Additional Notes

Free Style Comments (if any)

PhD students will not to take part in the Final presentation. By own choice (optional – please, inform of Supervisor about your choice no late two weeks from Term 2 beginning), they can replace one of the planned projects with independent research.

After Week 1 the Supervisor will share the bunch of research papers. Each PhD student will choose a paper on the interesting him (her) topic and try to repeat study idea (optional - this will for 15% of the final marks) and prepare the presentation on this paper. The slides should be presented during concluding Seminar.

Requirements for the presentation:
1. Presentation time 20 minutes.
2. Number of slides 12-15.
3. Be prepared for Questions and Answers session (5 minutes).
4. Slides must clearly demonstrate: - context of the paper - goal of the study - problem to be solved - approach, its pros and cons - novelty - conclusions - your study (optional).

This will for 30% of the final marks.