DeCAIR Course Syllabus Form

Author(s)	Clovis Francis		
Organization Name(s)	Lebanese University		
WP Number & Title	Work Package 5: Improving Existing M.Sc. Programs in Jordan and Lebanon by Implementing or Including AI and Robotics Courses		
Activity Number & Title	Task 5.1: Developing syllabi and content for added/modified courses in existing master programs in universities of partner countries		
WP Leader	Peter Eberhard, University of Stuttgart		
Due Date of Delivery	1/2/2022	**Project Month**	M14
Submission Date	1/7/2021	**Project Month**	M7

Revision History

Version	Date	Author	Description	Action *	Page(s)
1	1/8/2021	Clovis Francis	Master RSI Updated Courses Syllabus	C	1-6
2	22/10/2021	Clovis Francis	Version 2		
3					
4					

(*) Action: C = Creation, I = Insert, U = Update, R = Replace, D = Delete

Disclaimer

This project has been co-funded by the Erasmus+ Programme of the European Union.

Email: DeCAIR@ju.edu.jo

Project Website: http://DeCAIR.ju.edu.jo/

<table>
<tr><td>Course title</td><td>Non Linear Control Applied to Robotics Systems</td></tr>
<tr><td>Course number</td><td>RSI08</td></tr>
<tr><td>Credit hours (lecture and lab)</td><td></td></tr>
<tr><td>ECTS (weekly contact and self-study load)</td><td>3 (Total 18 contact hours)</td></tr>
<tr><td>Prerequisites/co-requisites</td><td>Linear Control (Continuous and discrete), Analysis of Non Linear Systems</td></tr>
<tr><td>Prerequisites by topic</td><td>Students are assumed to have good background in mathematics and Linear Control Systems, particularly, calculus, linear algebra, time and frequency responses of dynamics systems, regulator synthesis techniques for continuous and time discrete systems). The students are also assumed to be familiar with nonlinear systems analysis: first harmonic method, phase plane method, linearization by Jacobian method.

Additionally, the students should have good programming skills, preferably, using Matlab Simulink, Python..</td></tr>
<tr><td>Level and type (compulsory, elective)</td><td>Masters’ compulsory course</td></tr>
<tr><td>Year of study and semester</td><td>Year 2, first semester</td></tr>
<tr><td>Description</td><td>The students will be introduced to: control of conventional rigid robots by linearization and decoupling, Singularity problem, Control of conventional rigid robots by a Lyapunov type approach, Control of under actuated rigid robots by linearizing dynamic looping.</td></tr>
<tr><td>Objectives</td><td>1. Introduce students to the techniques used in Non Linear control: Lyapunov, Feedback Linearization, Input-output Linearization, input-state Linearization
2. Introduce students to the different Mathematical tools for nonlinear Control: Diffeomorphism, Frobenius theorem.</td></tr>
<tr><td>Intended learning outcomes</td><td>Upon successful completion of this course, students will be able to:
<table>
<tr><th>No</th><th>Intended learning Outcome (ILO)</th><th>Program learning outcome (PLO)*</th></tr>
<tr><td>1</td><td>Demonstrate a sound understanding of the main areas of nonlinear control.</td><td>1</td></tr>
<tr><td>2</td><td>Solve a nonlinear control problem by developing an appropriate control approach.</td><td>2</td></tr>
<tr><td>3</td><td>Communicate the development of a nonlinear control problem through a detailed technical report and a short presentation.</td><td>3,4</td></tr>
<tr><td>4</td><td>Use Matlab, Python libraries to develop programs for solving non linear control problems.</td><td>3</td></tr>
</table></td></tr>
</table>

<table>
<tr><td></td><td>(*) The PLOs are listed in the appendix</td></tr>
<tr><td>Teaching and learning methods</td><td>Development of ILOs is promoted through the following teaching and learning methods:
Lectures will be delivered through Microsoft Teams/ZOOM and will be recorded for later access.
The Control Lab is open for the students to practice the practical aspects and solve the programming homework assignments.
The student attends the class presentations and participates in the discussions.
The student joins the related online team/group and participates in its discussions.
The student studies the reference material, including books and videos.
The student solves the programming assignments
The student carries out a term project for solving a problem using nonlinear control techniques.
The student develops a professional report for the term report.
The student presents the term project in class.</td></tr>
<tr><td>Learning material</td><td>Textbook, class handouts, some instructor keynotes, selected YouTube videos, and access to a personal computer and the internet.</td></tr>
<tr><td>Resources and references</td><td>Recommended book(s), material and media:
Lecture notes prepared by the Instructor
Non Linear Systems by Hassan Khalil, Prebtice Hall
Nonlinear Systems, Analysis, Stability and Control by Shankar Sastry, Springer</td></tr>
<tr><td>Topic outline and schedule</td><td>
<table>
<tr><th>Lecture</th><th>Topic</th><th>Hours</th><th>ILO</th><th>Resources</th></tr>
<tr><td>1</td><td>Introduction and motivation: Linear vs Nonlinear systems. Jacobian Linearization techniques limitations. Examples of nonlinear phenomena (chaos, limit cycles, bifurcation).</td><td>2</td><td>1</td><td>1, 2,3</td></tr>
<tr><td>2</td><td>Analysis of systems properties : stability, controllability, observability</td><td>2</td><td>1</td><td>1, 2,3</td></tr>
<tr><td>3</td><td>Diffeomorphism</td><td></td><td>3</td><td>1, 2,3</td></tr>
<tr><td>4</td><td>Linearization techniques: Feedback Linearization</td><td>2</td><td>2, 3, 4</td><td>1, 2,3</td></tr>
<tr><td>5</td><td>Linearization techniques: Input-output Linearization</td><td>2</td><td>2, 3, 4</td><td>1, 2,3</td></tr>
</table>
</td></tr>
</table>

	6	Linearization techniques: Input-state Linearization	2	2, 3, 4	1, 2,3
	7	Frobenius theorem	2	2, 3, 4	1, 2,3
	8	Advanced NL control techniques: SMC control	2	2, 3, 4	1, 2,3
	9	Various applications: control of robotic manipulators, control of under actuated systems (drones)	2	2, 3, 4	1

Evaluation tools

Opportunities to demonstrate achievement of the ILOs are provided through the following assessment tools:

Assessment tool	Mark	Topic(s)	Time
Report	60%	Programming and use of nonlinear control techniques for engineering problem solving	W12
Presentation	40%	Work presentation and public discussion	W12
Total	**100%**		

Student requirements

The student should have a computer and internet connection.

Course policies

A- Attendance policies:

- Attendance is required. Class attendance will be taken every class and the university polices will be enforced in this regard.

B- Absences from exams and submitting assignments on time:

- A makeup exam can be arranged for students with acceptable absence causes.
- Assignments submitted late, but before announcing or discussing the solution can be accepted with 25% penalty.
- The project report must be handed in in time.

C- Health and safety procedures:

- All health and safety procedures of the university and the school should be followed.

D- Honesty policy regarding cheating, plagiarism, misbehavior:

- Open-book exams
- All submitted work must be of the submitting student.

	• Other text or code must be properly quoted with clear source specification. • Cheating will not be tolerated. E- Available university services that support achievement in the course: • Microsoft Teams team • Control Lab for practicing the practical aspects and solving the programming assignments.
Additional information	None

Appendix

Learning Outcomes for the MSc in Artificial Intelligence and Robotics

Students who successfully complete the MSc in Artificial Intelligence and Robotics (AIR) will be able to:

1. Demonstrate a sound understanding of the main areas of AIR including artificial neural networks, machine learning, data science, industrial and service robots, and intelligent and autonomous robots.

2. Apply a critical understanding of essential concepts, principles and practices of AIR, and critically evaluate tools, techniques and results using structured arguments based on subject knowledge.

3. Apply the methods and techniques of the AIR fields in the design, analysis and deployment of AIR solutions and solving practical problems.

4. Demonstrate the ability to produce a substantial piece of research work from problem inception to implementation, documentation and presentation.

5. Demonstrate life-long learning, independent self-learning and continuous professional development skills in the AIR fields.

6. Demonstrate a sound understanding of the ethical, safety and social impact issues of AIR solutions and products.