MORE master basic syllabus

Title:
Wave to wire control

Credit value:
4,5 ECTS

Mandatory/Optional:
Optional

Semester:
2

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University:
University of the Basque Country UPV/EHU

Department:
Automatic Control and Systems Engineering

Description:
This subject presents two main objectives. In its first part, modern control theory basics are introduced, focusing on State Space system modeling and control. Using these concepts, Model based Predictive Control approaches are introduced, an advanced control approach that combines optimum and multivariable control. This strategy is based on the use of an explicit dynamic model to calculate an optimum control law that optimizes the dynamic performance of the controlled system in a predefined sliding horizon. In the second part, different wave energy extraction devices will be analyzed from the control point of view, determining the control goal and the actuated and measurable variables. Lectures will be complemented with a practical application in a test rig, which will be used to analyze the control implementation issues that arise when considering the energy extraction process from its generation in the device to its injection in the network.

Objetives:
- *Introduce and review State Space basic control concepts in order to address advanced control approaches.*
- *Provide advanced control concepts that can be applied to wave energy extraction*
- *Provide the tools to allow the students to apply control concepts to a wave energy extraction test rig and analyse the implementation issues of the procedure.*

Skills:

Subject skills	MORE Master Skills						
	L2.1	**L2.2**	**L2.3**	**L2.4**	**L2.5**	**L2.6**	**L2.7**
L3.1. Students know and assimilate reasoned and rigorously the concepts related to advanced State Space control systems 50%	X		X				
L3.2. Students are able to implement advanced control algorithms. 30%	X	X					
L3.3. Students know the problem to be solved in the wave energy caption field. 10%	X	X	X				X
L3.4. Students are able to apply basic control concepts to the design of control systems for wave energy extraction. 10%	X	X	X				X

Teaching and learning methods:

La asignatura consta de 4,5 créditos ECTS correspondientes a 115 horas de trabajo del alumnado, distribuidas conforme a las siguientes actividades:

- *Lectures, where the lecturer explains the main concepts of the subject to the whole group, projecting presentations which are complemented with additional considerations, figures and mathematical derivations on the blackboard, as well as with computer simulations. 18 hours*
- *Problem and exercise resolution classes, where some exercises may be solved by the lecturer, and other may be proposed to be solved individually or in groups. 7 hours*
- *Computer practices of 2 hours per session, where, if possible, each student works individually in a computer, coping with the design phases and learning how to analyse and validate the control systems designed. Simulation tools, SIMULINK y MATLAB: 15 hours*
- *A laboratory practice where students will be introduced into aspects related to the implementation and validation of control algorithms previously designed with a simulated model of the test bench: 5 hours*
- *Personal student work (70 hours), comprising:*
  - *Self-study, for assimilation of the content taught during lectures: 40 hours*
  - *Previous work related to the Computer practices: 20 hours*
  - *Previous work related to the Laboratory practices (Test bench)10 hours*

Allocation of student time:

	Attendance (classroom, lab…)	**Non attendance (lecture preparation, self study…)**
Lectures and self-study	18 hours	25 hours
Problem/Exercise solving classes	7 hours	15 hours
Computer practices	15 hours	20 hours
Laboratory practice	5 hours	7,5 hours

Assessment:

Achievement of subject skill L3.1 will be assessed by means of a written examination, in which a 70% of the final mark will be assigned. The remaining 35% of the final mark will correspond to a computer practice assignment and its associated documentation, which will allow assessing the achievement of skills L32.2, L3.3 and L3.4.

Assessment Matrix:

Subject skills	**Assessment method**		
	Written examination	**Practical Work**	**Report**
L3.1	100%		
L3.2		100%	
L3.3		70%	30%
L3.4		70%	30%

Programme:

Lesson 1	*State Space system modeling. Internal representation. State-transition equation solving.* *Distribution: 4 h theory*
Lesson 2	*The design of State variable feedback systems. Time response. Controllability and Observability. Stability. Design con controllers based on state vector feedback. State observers.* *Distribution: 3 h theory + 2 h computer*
Lesson 3	*Discrete State Space control systems. Discretization. Controllability and Observability. Stability.* *Distribution: 3 h theory + 2 h computer*
Lesson 4	*Introduction to MPC. Origins. General Structure. Characteristics. Basic Elements.* *Distribution: 2 h theory*
Lesson 5	*Industrial MPC. Model Algorithmic Control. Dynamic Matrix Control.* *Distribution: 2 h theory + 2 h computer*
Lesson 6	*MPC in State Space domain. Formulation. MIMO systems. Control horizon. Measurable disturbances. Stability and Constraints.* *Distribution: 4 h theory + 5 h computer*
Lesson 7	*Wave Energy extraction system modeling. General vision of the wave energy extraction devices. Control objectives and main control variables. Mathematical model of OWC devices and their predictive control.* *Distribution: 4 h theory + 4 h computer*
Lesson 8	*Experimental Validation of Control Strategies. The need for experimentation. Hardware in the Loop. Test rig introduction. Implementation of modeling and tests in the test rig.* *Distribution:2 h theory + 5 h laboratory*

Resources:

- *A classroom, equipped with a blackboard and audio-visual resources (laptop/computer with Matlab/Simulink installed and Internet connection + projector), for the lectures. A blackboard and a projector may be enough if the lecturer uses her/his own laptop.*
- *A computer room with Matlab/Simulink installed, equipped with a blackboard and a projector, for the computer practices. It is assumed that the lecturer uses her/his own laptop or one of the computers in the room.*
- *A Hardware-in-the-Loop (HIL) test rig that simulates the dynamic behaviour of a rotational Wave Energy Converter (WEC) and the attached turbine (PTO), where the developed control approaches can be tested. This test rig is currently available in TECNALIA.*
- *Library resources provided by the University of the Basque Country UPV/EHU, including inter-centre book loan and Internet-based access and retrieval of journal articles.*

Bibliography:

Basic textbooks

- Richard C. Dorf; Robert H. Bishop; ***Modern Control Systems***; 12th edition, 2014, Pearson, ISBN 13: 978-1-292-02405-9
- Katsuhiko Ogata; ***Modern Control Engineering***; 5th edition, 2010, Prentice Hall, ISBN 13: 978-0-13-615673-4
- E. Camacho, C. Bordons; ***Model Predictive Control***; 2th edition, 2007, Springer, ISBN 13: 978-1-85233-694-3

Deepening bibliography

Internet addresses of interest

Specific journals

IEEE Transactions on Industrial Electronics

Further comments: