Control Theory and Self-Regulation

1. Teaching activity identification

The Control Theory and Self-Regulation course is an 5 ETCS mandatory subject in the third year of the Biomedical Engineering degree that will be offered in the second trimester.

2. Coordination and teaching staff

Teaching activities will be coordinated by Ivan Herreros (ivan.herreros@upf.edu). The course will be mainly taught by Ivan Herreros and Xerxes Arsiwalla (x.d.arsiwalla@gmail.com), but additional lectures will be given by Stephane Lallée (stephane.lallee@gmail.com) and Anna Mura (anna.mura@upf.edu).

3. Competences

1) To be able to conceptualize the interactions between systems (including biological systems) from a control theory perspective.
2) To learn how biological and mechanical machines can be engineered to generate a rich class of functionalities beyond its natural dynamics.
3) To assess various control design strategies based on stability and performance.
4) To understand the role of feedback control in neural motor control and to be able to implement neural control strategies to robot control.

4. General objectives

This course intends to give students a conceptual understanding of basic concepts in control theory and training with computer simulation of engineered systems, both biological (drug administration models, genetic circuits, predator-prey dynamics) and non-biological (coupled oscillators, vehicle steering, etc). Additionally, in the seminar sessions, they will be challenged to apply this thinking beyond text-book examples.

5. Teaching methodology

5.1 Lectures

Lectures will use slides that will be available for the students to download beforehand.

5.2 Laboratories

Practical work during the laboratories will carried on with computers, using Matlab. Students can rely either on the computers from the computer rooms or in their personal laptops, as long as they have a Matlab copy installed.
Additionally, two laboratory sessions will be performed with the iCub robot.
Students will have to write reports on the lab sessions than will be evaluated for the final grade.

5.3 Seminars

There will be two type of seminar lectures. During the first part of the course seminar lectures will be used as tutorials, where exercises and assignments will be solved in the blackboard.
In the second part, the students will be provided with selected readings and will have to present

them in the seminar lectures.

6. Course Program

7/1 9/1	**T** Introduction to feedback control. Performance, robustness L Simple feedback controller-object, heuristic demonstration of PID control
14/1 16/1	T Dynamical Systems Theory S Tutorial: Introducing Dynamical Systems [Basic Models]
21/1 23/1	T Linear analysis S Tutorial: Introducing Dynamical/Control Systems [Basic Models]
29/1 30/1	L Control of biological models T State-space models
4/2 6/2	T Feedback design L Applied Exercises
10/2 11/2 13/2	Exam T Output Feedback - Kalman Filter S Paper reading - control theory applied to biological systems
18/2 20/2	T Application Kalman Filter to Motor Control L iCub
24/2 25/2 27/2	L iCub T Homeostasis and self-regulation in biology S Paper reading - control theory applied to neural motor control
4/3 6/3	T Adaptive and predictive control strategies L Adaptive motor control
11/3 12/3	T Homeostasis and self-regulation in biology S Paper reading - cognitive control

T: Theory
L: Lab
S: Seminar

7. Evaluation

The final grade will be computed as follows

40% Practical work, comprising the lab sessions and the seminars.
20% Midterm exam (week 6)
40% Final exam

8. Bibliography and didactic resources

The main text used in this course is “Feedback Systems” which is freely available online at the author’s web page:
http://www.cds.caltech.edu/~murray/amwiki/index.php/Main_Page