# Evaluation questions and automatic data retrieved

## December 2018

This document contains the questions answered by the students for the Furuta Pendulum Experience described in the paper "Customized online laboratory experiments. A general tool and its application to the Furuta inverted pendulum"

1. About the environment used. A 5-degree Likert scale (Strongly agree, Agree, Neutral, Disagree, Strongly disagree) has been used to respond to these questions.

   (a) In the laboratory/experimentation environment, it was easy to identify the different elements that make it up.

   (b) During the course of the work, it was clear to me what each element of the laboratory/experimentation environment was for.

   (c) Took me longer than I thought it would take to finish the assignment.

   (d) The laboratory/environment offered the necessary additional help.

   (e) The lab/experimentation environment has worked as expected.

   (f) The way of the laboratory/experimentation environment works was intuitive.

   (g) The laboratory/experimentation environment has allowed me to clear up doubts I had previously.

   (h) I didn't need many of the concepts learned in the theory to do the experience.

   (i) The laboratory/experimentation environment has allowed me to realize insights or concepts that I was not aware of before.

   (j) Thanks to the laboratory/experimentation environment I was able to do other experiments that I thought were interesting.

   (k) I consider the use of the laboratory/experimentation environment a good tool to complement the theory.

   (l) In general, I find the laboratory/experimentation environment useful for my learning.

2. Usability (Data retrieved for each student from the web application where they perform the experiences).

    (a) Time (in minutes) using the laboratory/experimentation environment.

    (b) Times an experiment has been launched or the laboratory has been started.

    (c) Time (in minutes) visualizing the documentation of the experiences.

    (d) Times that the student has participated in the forum on a topic related to the experience.

    (e) Accesses to the website of the experience.

    (f) Contacts with the teacher for questions regarding the work requested.

    (g) Files associated with the experience stored in their web space (data obtained, experiments or auxiliary documents).

3. Learning. In order to analyze the learning outcomes of the students, they carried out a test of 10 questions with four possible answers. Wrong answers did not penalize the final result.

    (a) The Furuta Pendulum have:
        i. No equilibrium points at all because it is unstable.
        ii. Only one stable equilibrium point on the bottom.
        iii. An equilibrium point for any value of beta and a discrete set of alphas.
        iv. Only one unstable equilibrium point at the top.

    (b) The pendulum is easy to control when:
        i. alpha=0.
        ii. beta=0.
        iii. alpha=beta= $\pi/2$.
        iv. alpha=$\pi$.

    (c) The linear controller is able to:
        i. Stabilize the pendulum upwards for any initial condition.
        ii. Stabilize the pendulum starting close to the upwards position.
        iii. Stabilize the pendulum only in the downwards position.
        iv. Swing-up the pendulum.

    (d) Once the system is stabilized on the upwards position and a change in beta's reference is applied
        i. The system show minimum-phase behavior.
        ii. The system shows non-minimum-phase behavior.
        iii. The minimum-phase behavior arises for some values of the constants.

    iv. Alpha does not change because it is decoupled from beta.

(e) In order to stabilize the pendulum in the upwards position:

    i. The energy must be increased to a maximum.

    ii. The energy must reach a minimum.

    iii. The energy must approach a saddle point.

    iv. It is impossible to reach the upwards position by controlling the Energy.

(f) The sampling time of the controller Ts:

    i. Affects only to the velocity of the controller.

    ii. Could degrade performance but stability is unaffected.

    iii. Un-stabilize the Swing-up if it is too low.

    iv. Un-stabilize the linear controller if it is too high.

(g) The Swing-up controller:

    i. Have the same structure of the linear controller.

    ii. Is able to maintain the pendulum in the upwards position.

    iii. Need to be replaced when the pendulum is in the upwards position.

    iv. Needs a very precise model of the pendulum to operate.

(h) The Swing-up controller changes the sign of u:

    i. Based on a fixed schedule.

    ii. When the change could increase the energy.

    iii. When alpha changes its sign.

    iv. u is always positive, only its module change.

(i) The energy of the pendulum:

    i. Is only used to derive the equations of motion.

    ii. Is used by the linear controller.

    iii. Is used by the Swing-up controller.

    iv. Is only used at Lyapunov function to show stability.

(j) Which variables need to be measured/estimated to lift the pendulum to the upwards position:

    i. alpha and beta.

    ii. alpha derivative and beta derivative.

    iii. alpha and alpha derivative.

    iv. beta and beta derivative.

4. Other aspects. A 5-degree Likert scale (Strongly agree, Agree, Neutral, Disagree, Strongly disagree) has been used to response these questions.

(a) The instructions for my assignment were clear and concise.

(b) The information relating to the experience was sufficient to carry it out.

(c) I have felt lost at some point during the development of the experience.

(d) I've had problems I couldn't solve.

(e) I had to make use of other means (internet, forum, colleagues, books,...) to solve the problems raised.

(f) I consider that this laboratory/experimentation environment would be useful in other subjects.

(g) I had taken other subjects where these experiences could have helped me.

(h) I had fun during this experience.