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Remote Identification and Control Experiments on a DC Motor

1. Introduction

Remote laboratories are surely one of the most important tools for distance learning in the Automatic Control field [1, 2]. In this paper, a case study involving remote identification and control experiments on a DC motor is reported. Students are required to find a suitable model of the physical system, and to design a controller which achieves some requirements. All these tasks can be carried out remotely. The DC motor along with other processes are part of the "Automatic Control Telelab", a remote lab developed at the University of Siena.

2. The Automatic Control Telelab

The Automatic Control Telelab (ACT) is a remote laboratory developed at the University of Siena. It is mainly used for educational purposes, and since 1999 it has been used in control systems and robotics classes [3]. The aim of this project is to allow students to put in practice their theoretical knowledge of control theory in an easy way and without restrictions due to laboratory opening times and process availability. In fact, the ACT is accessible 24 hours a day from any computer connected to the Internet by means of any common Internet browser.

Through this lab, students can run control and system identification experiments. A key feature of the ACT is that students can design their own controllers by using the Matlab/Simulink environment. Since Matlab/Simulink is a standard tool in control system classes, students can design their own controllers in an easy way as a Simulink model similar to those commonly used to run simulations. During a control experiment, students can change controller parameters and reference signals, observe the signals of interest and a live video of the process. At present, five processes are available for remote experiments: a DC motor, a water tank, a magnetic levitation system, a 2-DOF helicopter and a Lego mobile robot (Figure 1). In the following we will focus on the DC motor experiment. The ACT home page is: http://act.dii.unisi.it.

Figure 1. The processes available for remote experiments

3. Remote experiments on the DC motor

In this section, some experiences based on the DC motor are reported. The motor can be used to perform position control experiments as well as speed control experiments. In the following we focus on the speed control experiment. Students are committed to perform two experiments:

➢ **Identification experiment:** students must build a mathematical model of the process by performing remote experiments. Students can choose the input signal to apply to the system and run the experiment. Once a set of input/output data has been gathered, a special interface (Figure 2) allows them to choose the desired model structure and the related order. Moreover, it is possible to remove mean and trend as well as choose which data can be used for identification and which for validation purposes. It is possible to perform remote identification through statistical as well as set-membership techniques [4]. Once a model has been obtained, some benchmark functions and plots are reported, so that, if the model is satisfactory, it is possible to use it to design a controller.

➢ **Control experiment:** students have to design a controller in order to achieve some performance requirements. They can use the estimated model obtained in the previous step as nominal model for design purposes. Several kinds of controllers can be designed, such as PID controllers, lead-lag controllers, nonlinear controllers, etc. All these controllers are Simulink models which students can upload to the ACT server and run on the remote process. When the experiment is in progress, a graphical interface allows them to see all the relevant signals as well as change online the reference input and the controller parameters (Figure 3). At the end of the experiment, all data can be downloaded and used to verify if the requested specifications have been achieved.
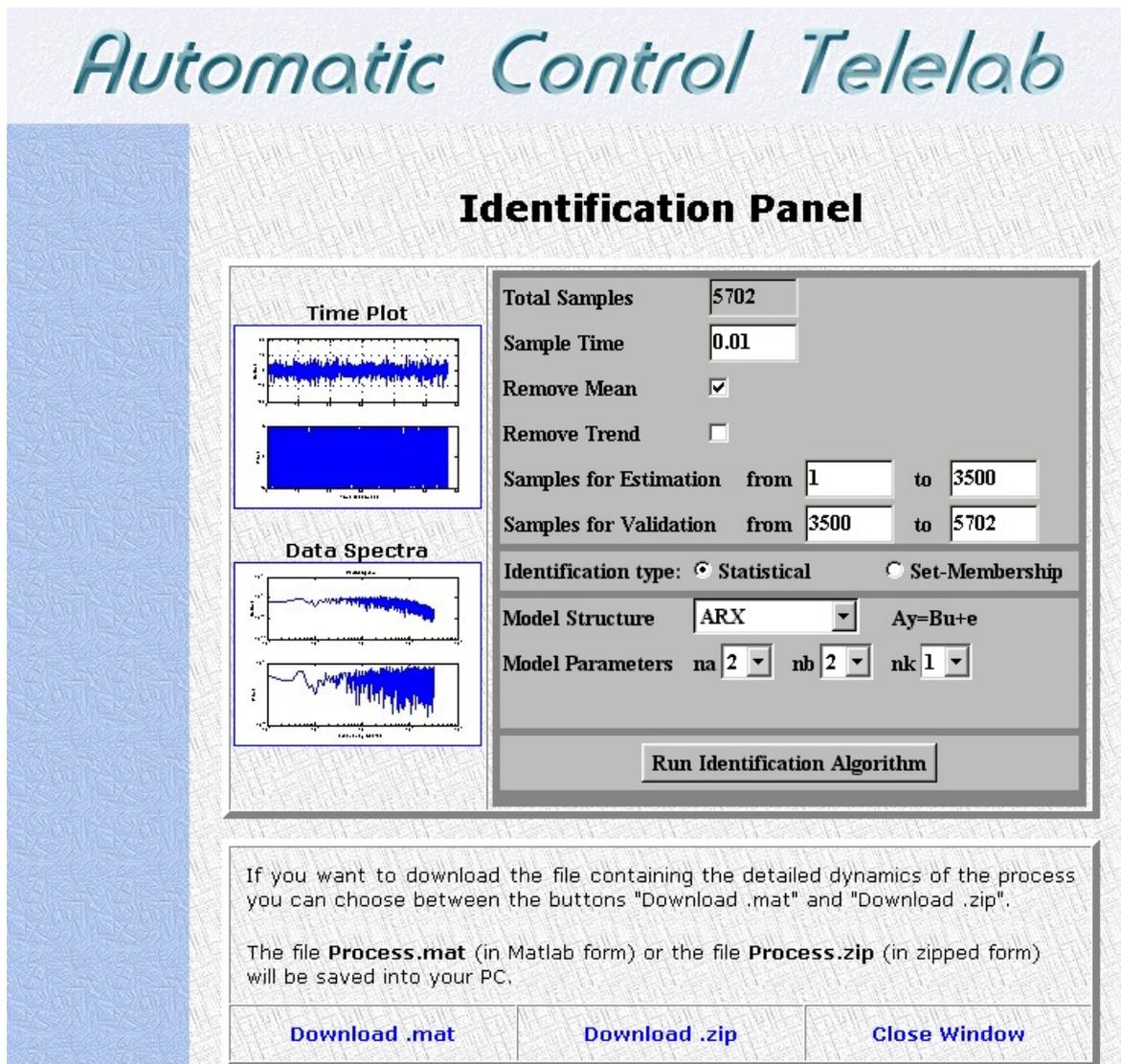

Figure 2. The interface which allows the real execution of remote identification experiments

Student feedback is in general very positive, especially for the possibility of performing experiments at any time and from any location. So, they can organize their time in a flexible way, without constraints due to laboratory opening times. One more positive aspect is the easiness to put in practice their theoretical notions; in fact, they already know the Matlab/Simulink environment, so they have no problems regarding the software aspects of controller design.

In addition to the previously reported exercises, some other experiments guided by the lecturer are executing during a class. In these experiments, it is possible to practically explain the concepts of time and frequency performance requirements, asking students to perform suitable experiments in order to evaluate such specifications.
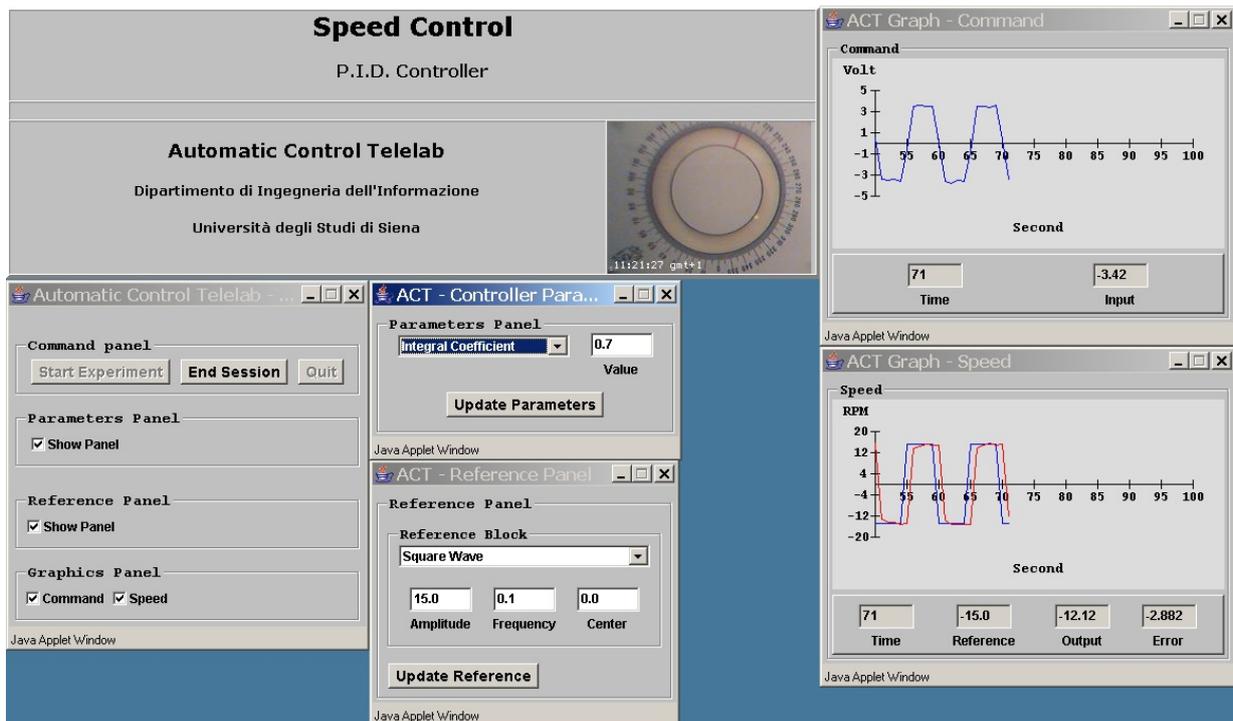

Figure 3. The interface for remote control of the experiment

4. Conclusions

In this paper, a set of remote experiments based on a DC motor are described. In particular, students have to perform remote system identification experiments in order to find a mathematical model of the process. Once a suitable model has been obtained, they are asked to design a controller in order to achieve some performance specifications. All these tasks can be executed remotely at any time and by any computer connected to the Internet.

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