The Consortial Approach to Advanced Control Laboratory Education

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Abstract: A fundamental part of university education creates a connection between the theoretical or simulation approaches of experimental methods for verifying the coincidence of laboratory stands. An illustration of practical physical model properties is of cardinal importance for experimental engineering exercises, for comparing computer simulation tasks with practical experience and with real-time measured signals from technological aggregates. This paper deals with the important role laboratory experimental stands play with microcomputers for quality control engineering education and the design and verification of new control algorithms. At the Department of CSI VŠB-TU FME Ostrava a HAA2005 model (Hot-Air Aggregate) of climate unit with two controlled variables (temperature, air flow) was designed and produced. The HAA model, as an air tool (air-conditioning), is a dynamic system with multiple inputs and outputs. Experimental laboratory models allow us to easily understand the principles of the aggregate parts, measurement and control devices, signal character, noise, dynamic responses and to cross over easier to real technological systems. The consortial approach to project was completed by a group of five Czech universities – VŠB-TU FME Ostrava, UTB IIT Zlín, Univ. FCHE Pardubice, TU FM Liberec and CTU FME Prague, with the main proposer being the Institute of Computer Science of the Czech Science Academy of Prague. Every project participant designed and realized its own laboratory model with a real time control system and web support.

Key-Words: - Control, Laboratory education, Lab stand, Consortial approach, WEB support.

1 Introduction

The development of new communication infrastructures allows us to extend the function offered by distance learning to real laboratories whose physical processes can be remote controlled [1], [3]. A typical virtual laboratory tool proposes emulation or simulation allowing distance interaction with laboratory instruments. Simulation is the proper way to complement control education but in general, it cannot replace experiments in a real laboratory.

In this paper we present the results obtained during the completion of some real projects. Automation is an interdisciplinary technology. It covers design, materials, electrical components, automatic control, electronics, optical parts and so on. Hands-on experience in automation technology education is typically provided through laboratories and an expert's experience [4].

Significant advances in Internet and computer technology have made it possible to develop an Internet-based virtual lab system to support distance learning courses that require a laboratory component where Internet-based control laboratory experiments such as measurement, monitoring, and control applications can be accessed remotely. Remote engineering is becoming an import element in engineering education; accordingly there is a growing need for new learning media and tools [2].

2 Design, production and utilization of experimental stands for teaching purposes

The basic requirements for the design and production of laboratory experimental stands were described in [3] and [4] with these main topics:

- similarity of a physical laboratory model with real industrial apparatus,
- good dynamical responses of output signals,
- miniaturization of dimensions and power input,
- unified input and output electrical signals,
- good possibility of connection with a PC computer,
- availability of model function parts and their low price.

At the Department of Control Systems & Instrumentation of VŠB-TU FME Ostrava a number of laboratory experimental stands, models and education tools were designed and produced during the past few years [4]. These stands were utilized for practical exercises in the subjects *Measurement and Sensors, Means of Automatic Control, Microcomputer Measurement Systems, Design of Process Systems, Signal Processing*, etc.

In the next few figures we can see the main results of the GACZ project from the TU Ostrava and there are shown the technical design (HW) and properties verification of the HAA laboratory stand as a physical model of air-conditioning and examples of program support (SW) for the easy utilization of models for educational tasks.

In the Figure 1, we can see a block scheme of an HAA experimental laboratory model. This model can be used for two control variables (temperature and air flow) with adjusted disturbances (second ventilator with an opposite flow direction).

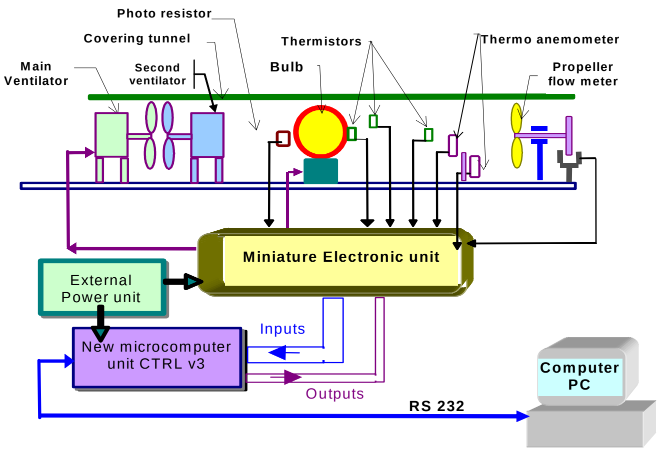

Figure 1 Block scheme of a HAA (Hot-Air Aggregate) experimental stand model

In the Figure 2 3D model of a HAA has two opposite ventilators, a bulb, and 3 sensors of temperature, light intensity and air-flow sensors.

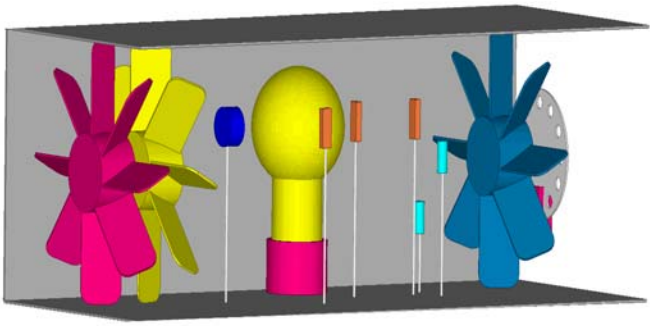

Figure 2 Scheme of a HAA 3D model with two opposite ventilators, a bulb, and 3 sensors of temperature, light intensity and air-flow sensors.

In the Figure 3 there is photo documentation of a real HAA experimental laboratory model in its final mobile version with a portable aluminum case and its connection to a PC computer by miniature CTRL V3 microprocessor measurement unit.

Web–based laboratories are divided into two classes: virtual labs and the remote labs. The main difference between them is that virtual labs allow to remotely run simulations with possible animations of the controlled system [3], [4], while remote labs are laboratories where students can remotely interact with real experiments [5].

In remote labs, users can change control parameters, run an experiment, see the results and download data through a web interface.

From a pedagogical point of view, remote labs allowing for the design and implementation of the control law are the most exciting.

Figure 3 Photo of the final version of an experimental HAA model in mobile form with portable case (5 prototypes were produced)

3. Program support of control tasks with a HAA model

The completion of programs support of HAA measuring and control tasks, with personal computer PC connection and with an interface environment unit (a new CTRL V3 or AD 512 analog/digital card). In the project there was designed a WinCTRL innovative program module in versions 2.0 and 2.1 [6] for Real-Time control of two values (temperature, air-flow) with 4 basic types of control algorithms (On-Off, On-Off with penalization, PID, Fuzzy control). The next program module was designed on a MATLAB-SIMULINK simulation system. It allows the completion of the experimental identification of dynamic system properties, and contains 16 synthesis methods for PID controller algorithms and the support of method of aggregation variables [4].

In the next figures we can see the program screens with an air-flow control task (Figure 4) and robust control with the method of aggregation variables (Figure 5).

4 The main constraints of a WEB-control system

The main constraints of a Web-control system are the uncertain Internet time-delay, multi-user access and conflict resolution, and the safety system. Multi-user access and the safety system constraints have been largely discussed through bibliography. Multiple solutions have been suggested in order to overcome these constraints. These solutions are essentially based on software applications ensuring user priority management and the checking of the system safety.

Figure 4 The screen with robust control submenu with method of aggregation variables (Czech version)

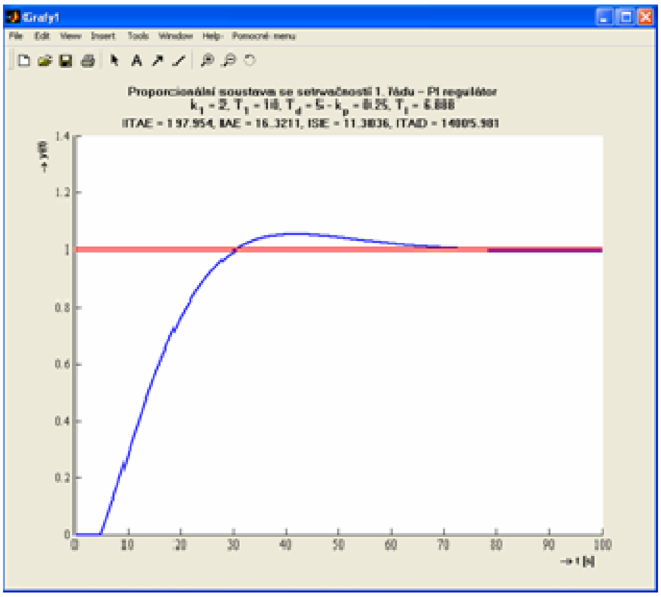

Figure 5 The response of an adjustment controller by the selected method and input signal type

As for the time delay constraint, it is still under study. Data flow between a WEB-based process and WEB clients fixes the efficiency of supervision and control operations. One of the difficulties in Internet-based process control is the dynamic delay caused by Internet traffic [3].

3 Conclusion

The teaching of engineering issues with practical aspects involves problems essentially in a features' availability. In fact, the student should apply theoretically studied concepts by leading experiments in a laboratory equipped with real processes. The paper deals with the important role of laboratory experimental stands with microcomputers for quality control engineering education, and the design and verification of new control algorithms. The proposed virtual lab system architecture includes such features as control, measurement, networking, and reporting.

Innovative instrumental laboratory stands of five university co-proposers were then presented. At the DCSI TU of Ostrava a Hot-Air Aggregate of climate unit with two controlled variables was designed and produced. Consortial designed models allow virtual laboratory experiments from an internet environment as a important part of distance university learning. Experimental laboratory models allow us to easily understand aggregate parts principles, measurement and control devices, signal character, noise, dynamic responses and to cross over easier to real technological systems.

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