# MULTILINGUAL VIRTUAL CONTROL LABORATORY

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## ABSTRACT

*In this paper, the authors inform about the Multilingual Virtual Control Laboratory, which is gradually being developed at Institute of Instrumentation and Control Engineering, Faculty of Mechanical Engineering, Czech Technical University in Prague. The main purpose of the described Multilingual Virtual Control Laboratory is to give to all interested persons in the world (not only students of Faculty of Mechanical Engineering) with Internet access an opportunity to do control experiments on their own. The virtual laboratory models serve for practising the fundamentals of logic, analog and digital control. The Virtual Control Laboratory is an interactive environment where it is possible to design logic circuits; to find out static and dynamic characteristic of processes and closed-loop systems (e.g. transient responses, frequency responses); to select controller (P, I, PI, PD, PID, on-off controller, three positional controller); to design controller settings; to view time courses of the manipulated variable, the controlled variable, the load disturbances and the set point; to design time courses of the disturbances, the set point and the manipulated variable (in the manual control). The Virtual Control Laboratory is gradually being developed in English, French, German and Czech language.*

**Keywords:** control, virtual laboratory, multilingual

## 1. INTRODUCTION

Automatic control is one of today's most significant areas of science and technology. This can be attributed to the fact that automation is linked to the development of almost every form of technology. Automatic control is an indispensable branch of all engineering specializations. These days, all engineers and technicians need to know about control engineering. The increasing use and sophistication of automation in modern engineering systems has created the need for students of all engineering specialisation and academic levels to have more than just appreciation of the theoretical principles involved in control engineering. It is also important for them to have practical skills and abilities, usually only gained through experience, if they are to be successful in their chosen careers.



*Figure 1. A photograph of the laboratory apparatus "Bathyscaphe"*

In general, an engineer must have full working knowledge of the principles and techniques involved in control system design as well as having the practical experience to implement it successfully. This can only be gained by 'hands-on' use of equipment. Laboratory experiments play and will certainly play an important role in control engineering and control theory courses. It is considered essential, therefore, that the training given to all engineering students includes both theoretical and practical aspects of control engineering.

In Czech Technical University in Prague, Faculty of Mechanical Engineering there is a common course Automatic Control for all students in the third study year. Practical training as a component part of the course is realised in the laboratory of Automatic Control, which is one of the laboratories of Institute of Instrumentation and Control Engineering (IICE).

The laboratory models serve for practising the fundamentals of logic, analog and digital control (see [2, 5]). To arouse interest in control theory the old laboratory models were removed and substituted by new ones, which are more attractive for students. The apparatuses were manufactured in IICE with the help of students [3]. In Fig.1 there is the new model called "Bathyscaphe", which is used in this paper for demonstration of possibilities of the Virtual Control Laboratory.

The laboratory model "Bathyscaphe", (see Fig. 2) is an original laboratory model that demonstrates the motion of a hollow cylinder (bathyscaphe) within a water tank, see [3, 4]. The average density of the bathyscaphe (including the enclosed air) is almost the same as the density of water. When the pressure above the surface of the water is changed, the volume of the air within the bathyscaphe will also change. This means that the average density of the bathyscaphe will be changed by a density slightly above or below that of water allowing the bathyscaphe to move up or down. The motion of the bathyscaphe depends upon this pressure. The position of the bathyscaphe is measured by an ultrasonic sensor. The pressure above the water surface is adjusted with the aid of an air pump and an outlet valve. The



Figure 2. The introductory web page to the virtual model "Bathyscaphe"

pressure above the water surface may also be changed by the second outlet valve simulating a disturbance. Both the outlet valves are governed by servomotors, which are controlled by a computer. The basic aim of the control is to maintain the bathyscaphe in a desired position. The laboratory model is also equipped with a sensor for measuring the pressure above the water surface and thus utilizes advanced control strategies such as cascade control etc.

With the development of new computer technologies, JAVA -an interactive multimedia programming language, and the World Wide Web, it is now possible to simulate engineering and science laboratory projects on a computer. With Internet access, "virtual laboratories" can be offered to students via the
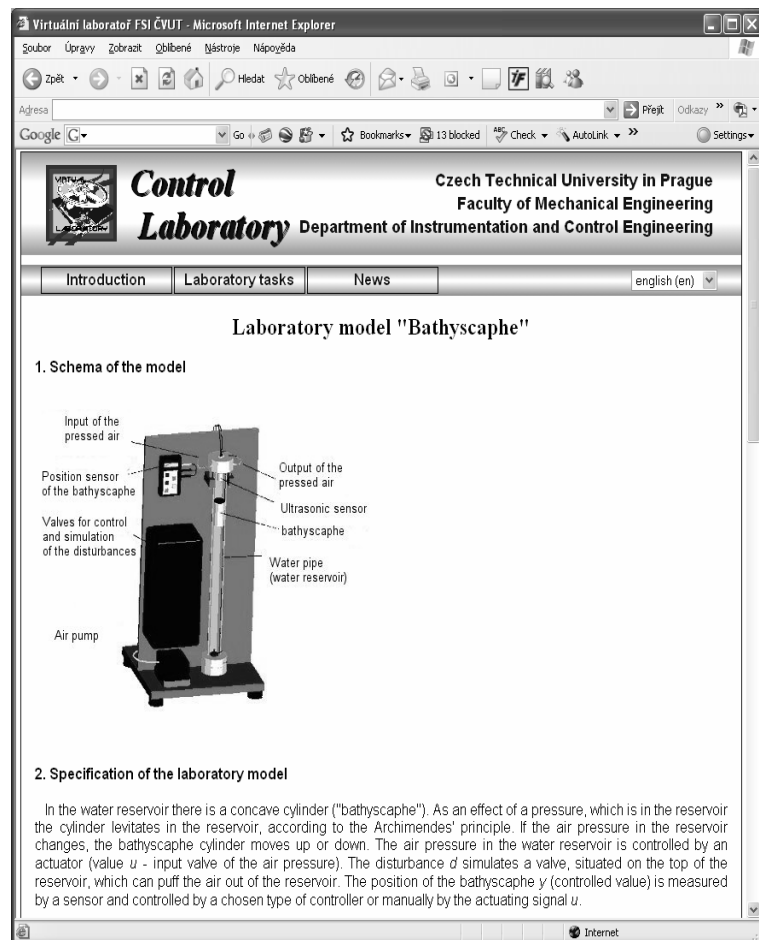
WWW or CD-ROM. Therefore the Virtual Control Laboratory is being gradually developed in IICE [1, 6].

## 2. DESCRIPTION OF THE MULTILINGUAL VIRTUAL CONTROL LABORATORY

The Virtual Control Laboratory is an interactive environment where it is possible

- to design logic circuits,
- to find out static and dynamic characteristic of processes and closed-loop systems (e.g. transient responses, frequency responses),
- to select controller (P, I, PI, PD, PID, on-off controller, three positional controller),
- to design controller settings
- to view time courses of the manipulated variable, the controlled variable, the load disturbances and the setpoint,
- to design time courses of the disturbances, the setpoint and the manipulated variable (in the manual control).

All virtual models are described and governed in the same manner. Each experimental apparatus contains the following items (see Fig. 2):

- title
- schematic diagram
- colour photography + video
- description
- tasks
- visual simulation
- literature

WWW pages were built up in the hypertext mark-up language (PHP). The hypertext of the individual items contains links to additional Web-based resources with related information. Three applets for visual simulation were developed in Java code. Netscape Navigator version 4.6 or Microsoft Internet Explorer version 4.0 and higher may be used to display and execute all actions of the user.

Most of the real laboratory apparatuses are simulated in the Virtual Control Laboratory. It means that nowadays the Virtual Control Laboratory contains the following virtual models:

- Air Jet
- Ball and Beam
- Water reservoir
- Ball and Plate
- Bathyscaphe
- Water Levitation
- Railway
- Bullet on the ellipse
- Air Levitation
- Vehicle on the pitched surface



Figure 3. Layout of the elements in the window determined for visual simulations

The layout of graphs, animations, text fields, check boxes, radio buttons, drop-down lists, push buttons etc. is the same for all windows of the visual simulations (see Fig.3). Simulated time courses of the controlled variable $y$ (blue line), desired value $w$ (red line), the load disturbance $d$ (green line) and the manipulated variable $u$ (violet line) are at the top left of the window. Text fields for loading desired values are at
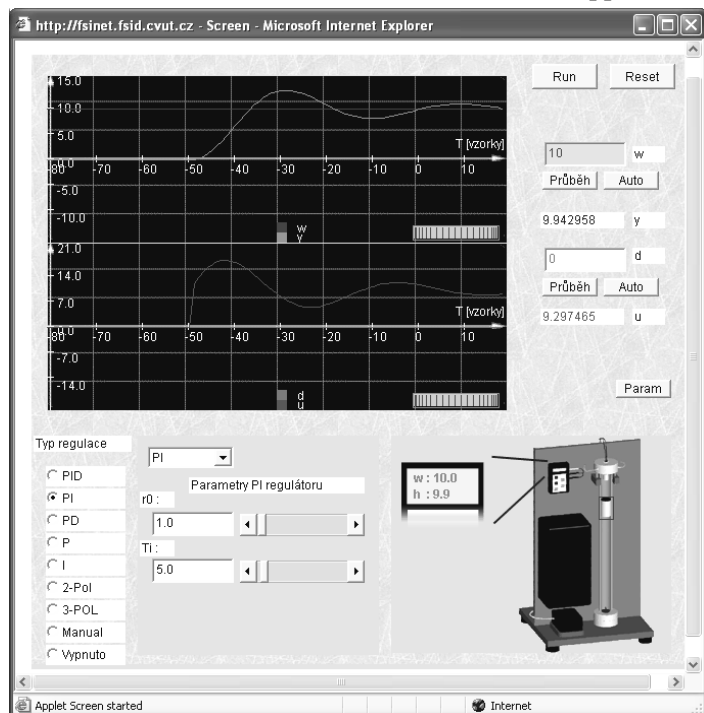
the top right of the window. At the bottom left it is possible to choose among controllers. The model animation is at the bottom right of the window.

## 3. CONCLUSION
Nothing can replace the real, hands-on experience of lab work but with the Virtual Control Laboratory

- all students can now do every control experiment in their own time,
- virtual experiments can be carried out either as a teaching aid before actual physical lab experiments, or for comparison after these experiments,
- if some aspect of the process or system is not understood properly then simulations can be used for clarification,
- it is possible to obtain results more rapidly than in a physical laboratory and so more examples can be tried.

The Multilingual Virtual Control Laboratory is gradually updated in order to correspond to the Real Control Laboratory of IICE [1, 4]. The Virtual Control Laboratory is gradually being developed in English, French, German and Czech language for all interested persons in the world (not only students of Faculty of Mechanical Engineering) with Internet access.

## 4. REFERENCES
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