ISSN : 0974 - 7435 Volume 10 Issue 12

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(12), 2014 [6607-6613]

Research on construction and application of "Foundation of Control engineering" parameterized teaching and experiment simulation platform

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ABSTRACT

In view of the drawbacks of “Foundation of engineering control " course of theory teaching and experimental teaching, a method of constructing a parameterized teaching and experiment simulation platform based on the Matlab/GUI and Simulink is put forward, the general framework and interface style of the simulation platform is presented. The application of simulation platform in theory teaching and experiment by example is analyzed. The practice results show that the construction and application of the simulation platform can greatly improve the students' interest in learning and play an active role in cultivating the students' research learning ability, innovation ability and practice ability, it also provides new idea for teaching and experiment reform of University teaching.

KEYWORDS

Foundation of control engineering; Teaching and experimental reform; Matlab/GUI; Simulink.

INTRODUCTION

With the development of modern science and technology, automatic control system (technology) has been widely used in industry, agriculture, national defense military, aerospace, aviation and navigation and other fields. As the theoretical basis of automatic control technology, "foundation of control engineering" has become a required professional course for university students from all departments of engineering. However, the teaching and practice link also has some problems that cannot be ignored, influence teaching effect[1-2]. The construction and application research of parameterized teaching and experiment simulation platform aims at exploring and establishing a teaching mode with practice and application as the core, advocating the innovative teaching and experimental reform that takes the student as the main body, arousing student's enthusiasm, initiative and creativity, stimulating students' creative thinking and innovation consciousness, improving the students' ability of innovation practice.

THE INSUFFICIENCY OF TRADITIONAL TEACHING AND PRACITCE

Simple theoretical teaching mode

With the popularization of higher education in our country, except for a few brand-name colleges and universities, the others should cultivate talents to meet the needs of society for applied talents, which aims to develop the applied talents to solve actual problem and maintain the normal running of social production. So it determines the teaching mode must as "application, practical" to be the keynote and ability training as the core. The traditional theory of "engineering control foundation" teaching based on the classical control theory, teaching content focused on mathematical derivation and graphic analysis, it is theoretical and students are faced with the abstract theory, they can't see the shadow of the original system[3], have no practices, doesn't understand the course of engineering application too. And this course involves many subjects such as physics, mechanics, electrotechnics, and mechanics knowledge, Which generally makes students feel boring, hard to learn, it reduces their learning initiative. So some visual verification experiments of the abstract theory are urgently needed in the theoretical teaching, it can help students better grasp the theoretical knowledge, train the student to use the control system theory and methods to solve practical problems, but due to the limitation of teaching conditions, some Some contents have to be presented in class with figures and multimedia courseware. The class should be efficient, a diversified teaching activity, however it becomes a drab, cramming, content is boring and hard to understand, which influences the teaching effect.

The experimental teaching face difficulties

There are some problems in traditional experiment teaching. they are that materials consumption is big, laboratory management is difficulty, equipment maintenance cost is high. Especially after the enrollment expansion, many schools even have no basic experiment site and equipment to meet the teaching requirements, let alone timely update the outdated experimental equipment requirements with knowledge progress, innovation and the progress of electronic technology. So the experiment teaching content become obsolete, it can only provide some traditional verification experiment. Due to the modulization of experimental equipment, it has some drawbacks as following: (1) for the fixed experiment content, students are hard to participate in the design of the details of the experimental process and it only stay on the level that the experimental process is done just according to the teacher's simple imitation by demonstration and experimental handout, the experiment process is similar to the "building blocks"; (2) the experimental project is limited that students can’t make a further development and their new ideas, originalities can't be tested in the experiment, the comprehensive, designing experiments on rate is very low. It cannot reflect the subject status of students in the experimental process, as a result the students' practical ability and creative thinking ability has not been effective training and cultivating; (3) students have to do experiment in a fixed time and place, the teaching mode is singleness. The above problems greatly hinder the improvement of the student handling ability and the

development of innovative thinking. So a large number of students are cultivated that attach importance to theory not practice, to inheritance not innovation.

Theoretical teaching separated from engineering practice

Due to the lack of practice, the student cannot better apply the knowledge of automatic control engineering to practice. For example, in class the principle of proportion, integral and differential link are clearly explained, the differential equation and transfer function are deduced and the effect of the link to improve the performance of the role of control system is realized. However, when a student facing a control system with PID controller the student don't know which part is the PID controller, or when the performance of the control system is not perfect, the students can only blindly to adjust potentiometer, capacitance, etc. This is not only easy to damage the experimental equipment, but cannot get a good experimental result.

THE CHARACTERISTICS AND THE ADVANTAGES OF THE PARAMETRIC TEACHING EXPERIMENT SIMULATION PLATFORM

The structure of parameterized simulation platform

This simulation platform[4,5] takes the Matlab/GUI and Simulink as development environment and simulate the actual instrument interface. By man-machine interaction, inputting needed parameters of actual control system, using the powerful data processing and graphical display function of the software, the subsystem can be integrated to formed a comprehensive platform for the teaching and experiment. Its structure is shown in Figure 1.

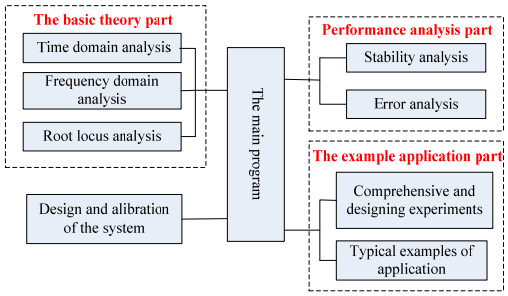

Figure : 1 Simulation platform structure diagram

(1) Basic theory part includes: typical link simulation circuit and mathematical model, the second order system analog circuit and dynamic performance analysis, the typical link frequency characteristic test, Nyquist diagram and its stability analysis, bode diagram and frequency domain analysis and root locus and its performance analysis, etc.

(2)Performance analysis, analysis part includes: the stability of the control system analysis and error analysis.

(3)The system design and correction: continuous system series correction device realization of analog circuit, series design, advanced correction series lag correction design, design of series lead/lag correction.

(4)It is set in simulink, in combination with each chapter to the development of comprehensive and designing experiments, the PID controller design and parameter setting, etc.

Characteristic of parameterized simulation platform

(1) It can achieve all the functions of the traditional hardware experiment by software, experiment content can be updated quickly, students can be involved in the experiment design process, developed a more comprehensive and designed experiments. Through the supplement of comprehensive and designing experiments, it can connect isolated course knowledge, improve the students'

comprehensive application of computer system design and the ability to solve practical engineering problems.

(2) It helps pay more attention to the combination of theory teaching and practice teaching and takes the laboratory into the classroom. In class the teacher can freely switching theory teaching and practice teaching environment according to the teaching requirements. In the process of virtual simulation experiment, students can learn by handling. It meets the requirement of "integration of teaching, learning and doing" teaching in true sense. Combining learning process and the practice and experience, emphasizing practical application of knowledge, skills to arouse the students' innovative thinking, improve the students' interest in learning, at the sametime it raises teaching efficiency and teaching effectiveness, promotes the reform of teaching.

(3)The emphasis on research learning process. Simulation platform using parameterized design method can completely simulate various control circuits of actual control system, the flexibility to change parameters in teaching and experiment makes it easy to repeate to observe results and show the response of the wave and various performance indicators, students can experience knowledge analysis from the experimental process, get rich perceptual cognition, it not only has the function of the auxiliary teaching, but helping the students to design the practical control circuit.

(4)It is effective in relieving college difficulties and pressure in funds, sites, equipment, etc. Simulation platform break the limit in time, space, and the limitation of the number of students of the traditional experiment, both students and teachers are free to anywhere at any time into the virtual experiment environment, which improving the teaching efficiency.

THE INSTANCE AND THE APPLICATION RESEARCH OF THE SIMULATION PLATFORM

The simulation platform application in classroom teaching

In traditional teaching, in the teaching of "second order system step response", teachers often present the actual physical system, lists the differential equation,then deduce the transfer function and export its normal form, such as formula (1)

$$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2} \quad \textbf{(1)}$$

Then discussing the pole distribution and time response when the system is in overdamping ($\xi > 1$), critical damping ($\xi = 1$), under-damped damping ($0 < \xi < 1$), zero damping ($\xi = 0$) and negative damping ($\xi < 0$). The solving process involved in calculation of residues and the Laplace transformation is dull, tedious and time-consuming,leaves poor intuitive impression. In addition, two important parameters affecting the control system puzzled the students and also can produce a lot of questions: how to adjust them in a practical control system? Has any impact on system performance indicators? The introduction of the simulation platform completely changed the original teaching mode, from the perspective of the actual control system, using the experiment guide type teaching method, teaching emphasis on understanding of basic concepts, principle and method in the process, weakening the derivation and calculation of theory and the formula, analyzing the experimental phenomena observed to promote the understanding of theoretical knowledge. The simulation platform interface can be realized in physical system, for example, as shown in Figure 2, 3, right comes with a simple interface to the theory expounded, export system resistance (R), capacitance (C), inductor (L), quality (m), modulus of elasticity (k), damping coefficient (C) and (ξ), undamped natural frequency, damping ratio (ω_n), the relationship between the time constant (T), central interface for the adjustable parameter input part, through the input of different regulation of simulation system, such as resistors, capacitors can calculate the performance index of the system and show the response curve on the left side, which is easy to observe the affect of the performance of control system with the change of parameters, especially the

high order system. The application of the simulation platform moves some verification experiments to the classroom that originally is going to do in the laboratory, the teaching content intuitive is enhanced and some abstract concepts or theories can be quickly grasped in a vivid way. It obviously improves the teaching quality and teaching efficiency. The design and adjustment of the control system throughout the teaching process, so the students' interest in learning is aroused and practical ability is developped.

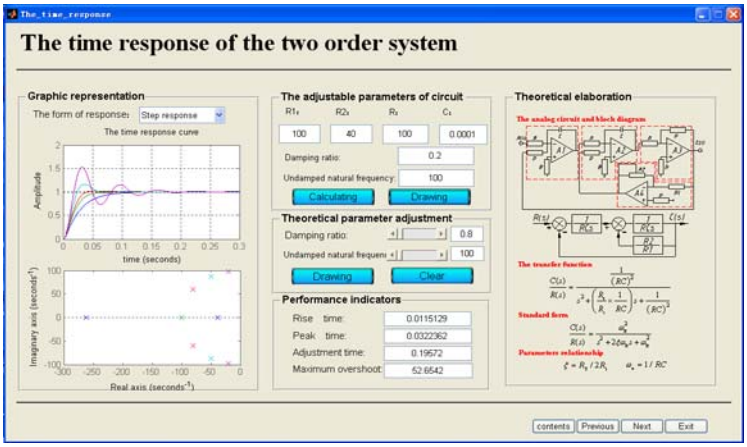

Figure 2 : Time response analysis of the two order system interface

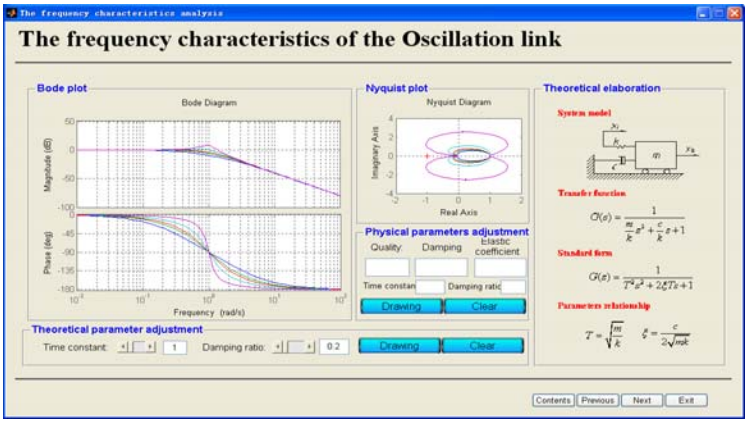

Figure 3 : Second-order oscillation link frequency characteristic analysis interface

The instances that the simulation platform involving can be combined with the existing hardware experiment system to be designed. So in the classroom after understanding the experiment principle, the platform can guide the connection and adjustment of hardware circuit experiment,which avoids the blindness of wiring and adjustment leading to equipment damage.

The application of the simulation platform in experiment teaching

If students can master the development method of the simulation platform, can independently design research, design and open experiments, there is no doubt it contributes greatly to student's comprehensive analysis, practical application and research learning ability. Therefore the simulation platform is mainly about the design and development of comprehensive and designing experiment in the experimental teaching. But let the students master the Matlab language in a relatively short time for the software design is not an easy thing. For this reason, on one hand, each chapter of the self-made "control engineering foundation" teaching material has a section about introducing the function of control system Matlab toolbox and some Matlab routines and Simulink modeling are given, the program design methods are added into classroom teaching too; the other hand open structure is used in the simulation platform, comprehensive and designing experiments are given, source code is completely open to the students for reference. According to the teaching contents of the section at the same time, the

comprehensive, designing experiments are set aside for students after class. Third, the course design is added into the practice teaching link to give students enough time to study. After several years of practice, it proved that the vast majority of students can quickly master the development design method on the simulation platform, they also showed great interest in using Matlab software to the design of the research, design and opening experiment, some new experimental design is selected and added to the simulation platform, which enriched the content of the simulation platform.

Part in experiment teaching of the simulation platform, for example, for every design experiment,first,elaborates the experimental principle: for example of the PID control law, given expression type (2), transfer function (3), PID control block diagram 4 and the circuit diagram 5.

$$u(t) = K_p e(t) + K_I \int_0^t e(t)dt + K_D \frac{de(t)}{dt} \quad \textbf{(2)}$$

$$G(s) = \frac{U(s)}{E(s)} = K_p + \frac{K_I}{s} + K_D s \quad \textbf{(3)}$$

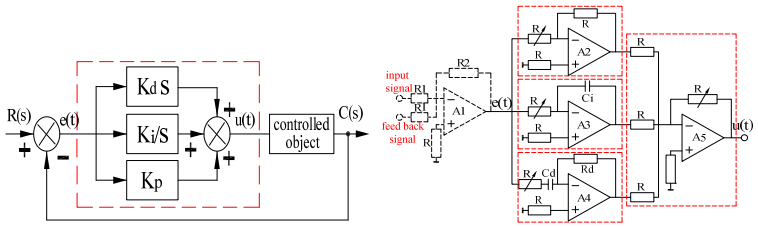

Figure 4 : PID control block diagram Figure 5 PID control circuit

According to Figure 4, Figure 5, detailed the circuit implementation method of proportion (A2), differential (A3), integral (A4), sum (A1, A5). And to realize negative feedback, it just needs add the reverse proportion circuit shown in Figure 6 in the feedback loop, the input port is the voltage signal converted from output signal c (t) of control system by the sensor, the output end b (t) is connected to the Figure 5 feedback signal input, the error signal e (t) is got by contrasted A1.

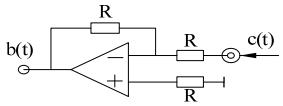

Figure 6 : Negative feedback circuits

Then deducing the relationship between each resistor, capacitor with the Kp, Ki, Kd in Figure 5 to build a parameterized simulation interface that is similar to Figure 2. It can also build a Simulink model shown in Figure 6 by changing the Kp, Ki, Kd. When meet the control requirements, the actual circuit and the size of the components can be deduced according to the simulation model and parameter values, which offers a guidance to the actual control system.

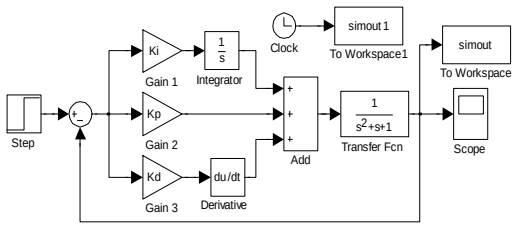

Figure 7 : Simulink model PID control

CONCLUSION

(1) The construction and application of the simulation platform makes it possible that doing experiments in class, it visualizes the abstract concept and analysis process and has the true sense of the "integration of teaching, learning and doing". The students' interest in learning is aroused, so better teaching efficiency and teaching effectiveness are achieved.

(2) Met the requirement of the "verification combined with design" and "pay attention to the foundation and application". It also improves the ability of using computer to solve practical problems with theoretical approaches.

The platform alleviates the shortage of teaching resources and reduces the dependence on the laboratory hardware conditions and realizes fast update of teaching contents. It also promoted the teaching method reform that towards modernization and informatization.

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