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Combining Curriculum Construction of *Control Theory* with Cloud Platform Based Virtual Case Simulation

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Abstract

With the wide application of AI in various fields, *Control Theory*, an indispensable curriculum for the new generation of AI related specialties, has become increasingly important. Taking full account of the rapid development of intelligent car industry and the characteristics of *Control Theory* curriculum, a virtual simulation laboratory is designed based on cloud platform service, conducting virtual simulation of optimal control of active suspension, optimal design of ABS, optimal control of four-wheel steering system, and autopilot system so on. Through case analyzing, students can master basic concepts, modeling methods, basic analysis and correction methods of *Control Theory*, and make all the portions work together well. Simultaneously, the skill of modeling, simulation and optimization of actual system is greatly enhanced for the students.

Subject Areas

Education

Keywords

Control Theory, Vehicle Engineering, Cloud Platform, Curriculum Construction

1. Current Situation of Curriculum Construction on *Control Theory*

The curriculum of *Control Theory* is based on information transmission, interaction and feedback, which are ubiquitous in systems. It studies the dynamics of generalized systems. It is not only a compulsory curriculum for undergraduates and postgraduates of traditional majors such as Mechanical and Electronic En-

gineering, Automation, Equipment and Control Engineering, but also a compulsory curriculum for undergraduates and postgraduates of emerging majors such as Artificial Intelligence and Vehicle Engineering [1] [2] [3] [4]. At the crucial moment of the rapid development of intelligent automobile, AI and Vehicle Engineering are deeply intertwined. Vehicle Engineering-related specialties are inseparable from the curriculum of *Control Theory*.

In terms of curriculum construction related to *Control Theory*, colleges and universities have made different explorations in different aspects to fit in with the characteristics of their own specialties. Liu's team of Beijing University of Information Science and Technology has reformed and practiced the *Control Theory* course system in an integrated way, and put forward the conception of constructing a practical teaching system which integrates curriculum experiment, computer simulation design, curriculum design, extracurricular scientific and technological innovation activities together [5]. Chen's and Wang's groups have constructed intensive curriculums of *Automatic Control Principle* based on mechanical system and electrical engineering and automation system. They mainly explore the optimization of teaching content and strengthening of practical sessions [6] [7]. Han and Meng have constructed the curriculum of *Control Theory* based on Super Star Learning and GUI teaching platform respectively. They mainly study the teaching modes of combining online and offline teaching resources together by means of practical teaching and virtual experiment [8] [9]. Duan's team has optimized the curriculum system strengthening case teaching mode based on the engineering during new period [4]. Zhang's team has carried researches on the influence of curriculum construction on teaching quality under the background of professional certification [10]. However, the curriculum construction projects mentioned in the literatures are based on certain professional background. The curriculum construction based on Vehicle Engineering is seldom mentioned in the literatures. It is difficult to adapt to the rapid development of intelligent vehicle, which is a deep cross-integration of AI and Vehicle Engineering.

In this work, combining the theoretical knowledge of *Control Theory* and the characteristics of Vehicle Engineering, the curriculum construction adopted the virtual case simulation of vehicle sub-systems to implement theoretical teaching. A simulation platform based on cloud service was established, so that students could realize more complex simulation calculation by their own computer client, and solved the problem of devoicing between theoretical teaching and practice.

2. Curriculum Construction Scheme of *Control Theory*

1) Constructing Teaching Material System for *Control Theory*

The teaching materials are mainly based on *Foundation of Mechanical Engineering Control* (the seventh edition) compiled by Mr. Yang, academician of Chinese Academy of Sciences. The textbook mainly focuses on mathematical models, time response, frequency response, stability, performance index and correction of

linear systems, preliminary and linear discretization of the non-linear system. It consists theoretical teaching and MATLAB simulation sessions. The text is refined and the emphasis is prominent, but the cases of Vehicle Engineering are less involved. Zhang's *Vehicle Control Theory and Application* is elaborately created for Vehicle Engineering, but the first edition of this book was published in 2007. The basic knowledge of *Control Theory* is less explained, and the MATLAB simulation session is not used. The later edition has not been updated yet. However, according to the requirements of program "Education and Training Plan for Excellent Engineers" and the concept of "5G + AI", the teaching content, methods and materials of this curriculum urgently need to be further explored and studied. The advantages of the above two textbooks were combined in this curriculum construction, at the same time the latest research results were supplemented in the teaching materials. Hence, an initially form of a textbook on *Control Theory* based on modern technology platform was drafted, which serves the modern Vehicle Engineering and deeply integrating theoretical knowledge with MATLAB simulation technology.

2) Construction Scheme of Curriculum Content Architecture

The constructed *Control Theory* roots in the theory of modeling, analysis and design of linear control systems, and focuses on the theoretical study of linear systems, simulation analysis by MATLAB and comprehensive case design. The main teaching contents are divided into six topics: introduction, mathematical model, time response analysis, frequency characteristic analysis, stability analysis, correction and case analysis. The contents of each part are organically combined with virtual simulation. Cloud platform is mainly used in the case teaching part of the fourth modules. The particular structure construction scheme is shown in Figure 1.

3) Virtual Simulation Experiments based on Private Cloud Platform and the Implementation Methods

Based on cloud platform services, the Virtual Simulation Laboratory of MATLAB

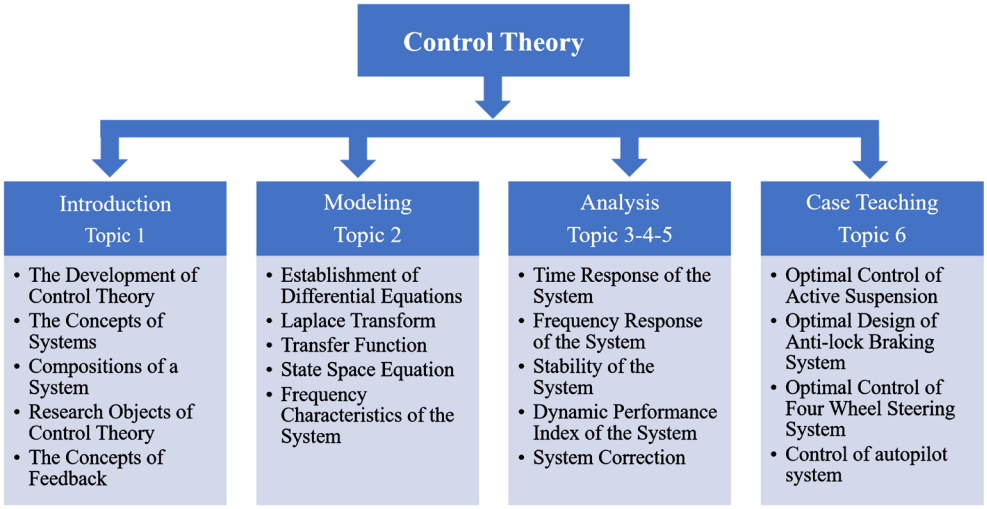

Figure 1. Construction scheme of curriculum content architecture.

is built, and large-scale calculations and virtual simulations can be carried out with the help of the resources of cloud platform. Through virtual simulation experiments, the students can learn the basic concepts, modeling methods, system analysis and correction methods; master the practical system modeling, simulation and optimization methods and practical experience; master the basic commands, modeling, project operation and error handling methods of MATLAB; be familiar with the relevant concepts of cloud computing; be familiar with the virtual environments, software operating platform and virtual laboratory application. The Specific implementation methods are as follows:

Firstly, laboratory instructions are compiled for typical vehicle control subsystems such as the optimal control of active suspension, the optimal design of ABS, the optimal control of four-wheel steering system, and the automatic steering system. According to the contents of the experimental guidance book, the students can be familiar with the method of establishing mathematical models of the corresponding control modules.

Secondly, group discussion is adopted for preparing virtual simulation experiments. Students are asked to complete the analysis of the physical laws of the parts or control modules in the corresponding control systems in extra-curricular time; write out their differential equations, eliminate intermediate variables, find out the relationship between the input and output of the control system and establish the differential equations or state equations of the systems.

Thirdly, private cloud accounts are assigned to each group. Students can open the local computer clients for remote desktop connection, enter the host address and their usernames, log in the cloud host, open the software on the cloud host, write codes, complete modeling and virtual simulation experiments of the optimal control of the active suspension, the optimal design of the ABS, the optimal control of the four wheel steering system and the automatic driving system.

Finally, the students' performance in the curriculum is evaluated by checking the virtual simulation results. The results pinpoint areas where teachers should spend more time or change their current approach. At the same time, the timely feedback to the students can promote the interaction between teachers and students.

3. Conclusion

A cloud platform based virtual simulation laboratory is established in the curriculum construction of *Control Theory*. Case analysis based on virtual simulation makes the drifting theoretical teaching of *Control Theory* closely link with the Vehicle Engineering specialty and change the situation of the devoice between pure theoretical teaching and practical training. The modern technology is employed to the teaching practice, giving full play to the advantages of virtual laboratory, such as flexibility, mobility, easy maintenance and upgrading. As a result, the time and cost of physical laboratory construction are saved.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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