Research on Computer Aided Learning System for the Hybrid Electric Vehicle Control Platform

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Abstract. The paper proposes the design and implementation of the teaching platform of the automotive engineering course learning system, and discusses the development ideas of the teaching resources of the automotive engineering learning system. The article explains the functional modules of the platform. Then it describes the network topology and system structure model of the teaching platform of the course learning system. Through the construction and practice of the experimental platform of the automotive engineering course learning system, the experimental teaching functions that are not available or difficult to complete in real experiments are realized, and the engineering practice ability and scientific research innovation ability of students are improved.

Keywords: Automotive engineering, curriculum system, science and engineering courses, electric automotive.

1. Introduction
At this stage, the development of automotive-related theoretical teaching is very crucial to speeding up the development of the automotive industry, especially after the birth of hybrid vehicles, the teaching of their drive systems becomes even more important. How to effectively carry out the teaching design of the hybrid electric vehicle drive system has become a major problem that relevant teaching staff need to think about, and it must be highly valued [1]. Colleges and universities that set up automobile majors and automobile enterprise scientific and technical personnel not only need to learn the structure, composition and working principle of hybrid electric vehicles, but also need to understand the working principle of hybrid electric vehicle power drivetrain control system, so the development and design are suitable for teaching and research. The integrated experimental teaching system of hybrid electric vehicle power drive system will greatly promote the learning and research of hybrid electric vehicle technology.

2. Analysis of the status quo of automotive engineering teaching
According to the requirements of the talent training objectives of universities and colleges, the amount of time in experimental teaching and practical training needs to be further increased, and the content and quality of experiments need to be further improved [2]. At present, most of the automotive engineering experiments are demonstrative experiments, and students have little hands-on. For the rapidly developing new automobile technology and new energy automobile technology, the update
speed of experimental equipment is difficult to keep up with the teaching progress. Coupled with the constraints of the experimental site, weather conditions, funding conditions, and experimental dangers, the experimental teaching link has become a shortcoming in cultivating advanced automotive technical personnel.

In the actual experimental teaching process, colleges and universities gradually felt the insufficiency of physical experiments and fully realized the necessity of constructing a virtual simulation experiment teaching platform. For example, the disassembly and assembly experiment of the whole vehicle requires a long experiment period (3-4 days); a larger experimental site and a variety of tools are required; due to the heavy weight of each component assembly, the disassembly and assembly process has a certain degree of danger, and students cannot operate; Shen may be injured; students cannot understand the internal structure of each assembly [3]. Another example is the automobile engine disassembly and assembly experiment, which has a long experiment period (1-2 days); requires a variety of tools; students cannot deeply understand the internal structure of each component; students only understand the static structure relationship of the engine, and cannot master the intake and injection Dynamic processes and principles of oil, oil and gas mixing, combustion, and exhaust. Another example is the automobile handling and stability experiment, which requires a larger experimental field, which should generally be carried out in a special automobile experimental field; the risk is high, and the experiment with a speed greater than 50km/h is generally not carried out; due to a series of restrictions, the Higher Institute The automobile engineering department of the school is unable to carry out automobile dynamics related experiments so far.

3. The establishment of the automobile engineering engine and variable speed measurement and control learning system

3.1. Demand analysis

3.1.1. System administrator. Mainly responsible for the maintenance of the basic data of the virtual simulation experiment teaching platform, and have all the operating permissions of the platform. Specifically, it can manage and operate modules such as user management, experiment management, experiment operation, password modification, and information release.

3.1.2. Experiment instructor. The teacher who manages each course experiment is mainly responsible for the management and operation of experiment management, experiment operation, experiment demonstration, experiment guidance, experiment evaluation and other modules. The experimental instructor is generally served by the class teacher.

3.1.3. General users. The user of the experimental teaching platform can perform experimental demonstration, experimental operation, password modification, information feedback, training and learning. Ordinary users include teachers and students on campus and users outside the campus.

3.2. System implementation

The realization of the system is divided into a hardware part and a software part as a whole. The hardware consists of an engine bench and a computer. The OBDII diagnosis, car oscilloscope and teaching assessment system are realized by software [4]. The powerful performance of the computer is used to improve system functions and reduce system costs. The realization block diagram of the control system is shown as in Fig. 1. The data acquisition function is mainly realized by hardware, which is divided into three parts: sensor, amplifying circuit and A/D conversion; the feedback control function is also mainly realized by hardware, which is divided into two parts, D/A conversion and execution circuit. The functions of data acquisition control, data storage, data processing, data output and control algorithm implementation are mainly realized by software.
3.3. Hardware design

3.3.1. Experimental system bench. The Corolla dual-engine hybrid drive system, power control system, anti-theft system, original wiring harness, fuse box electrical system and other parts are reasonably arranged on the bench and all parts can work normally. A simulated loading system is designed, which can simulate the actual working conditions of hybrid vehicles and the recovery of braking energy relatively realistically. The loading device is connected with the output shaft of the transaxle of the power drive assembly, and the loading controller adjusts the size of the loading. Taking into account the high voltage of the hybrid drive system, in order to ensure the safety of the operators, insulating ground glue is arranged on the bottom layer of the platform components and the power battery. The main frame design of the stand takes into account the principles of stable structure, convenient operation, and beautiful appearance [5]. The stand is made of 45# square steel welding, and the surface is treated with anti-corrosion and anti-rust. The front part of the platform is the engine guardrail and the operating table. The overall layout of the experimental system bench is shown in Figure 2.

3.3.2. Selection and configuration of capture card. DAQ (data acquisition refers to the process of automatically collecting or generating information from analog and digital units under test such as
sensors and other equipment under test. The data acquisition system is a combination of computer-based measurement software and hardware products to achieve flexible, user-defined the measurement system of the data acquisition system is shown in Figure 3. The hardware installation of PCI.6024E is relatively simple, insert it into the PCI slot in the PC, and connect with the external signal through the 68-pin dedicated connector BNC.2120. Complete the hardware connection After that, you can install the driver for the card.

![Data acquisition system](image)

**Figure 3.** Data acquisition system

3.3.3. **Load the system.** In the experiment, the hybrid powertrain and transaxle were fixed on the test bench, and the transaxle output shaft was coaxial with the eddy current dynamometer. The loading system of the eddy current loader adopts microcomputer technology to realize automatic loading, the loading model is stored in the computer, and the dynamometer should give the resistance torque corresponding to the road resistance, air resistance, and rolling resistance. As long as the road slope and rolling resistance coefficient are set, and the current output shaft speed is detected, the loading torque value can be obtained, and the corresponding loading excitation current value can be obtained according to the loading model [6]. In order to detect the load of the eddy current dynamometer in real time and implement feedback control on the load, a pressure sensor is installed in the stator part of the eddy current loader, and the signal of the pressure sensor is input to the control computer as the torque feedback signal. A photoelectric speed sensor is installed in the rotor part of the eddy current loader, and its signal is digitally processed and input into the single-chip microcomputer. By collecting the speed signal, the resistance to be applied is accurately calculated, and the eddy current loader is precisely controlled for resistance loading. This produces rolling resistance, wind resistance, ramp resistance, etc. at various vehicle speeds consistent with the road test. The signal transmission and feedback process are shown in Figure 4.

![Signal transmission and feedback control](image)

**Figure 4.** Signal transmission and feedback control
3.4. Function realization

(1) User management module: This module mainly manages user information. The system administrator has the authority to perform operations on all user accounts, and can perform account query, activation, modification, or prohibition operations. Experiment instructors and general users can only operate on their own accounts.

(2) Experiment management module: This module can manage the types of experiments, experiment content and experiment results performed by users. The user can choose the type of experiment, such as choosing to enter the experiment operation module, experiment demonstration module or experiment evaluation module.

(3) Experimental guidance module: When students are performing experimental operations, the experimental instructor can use this module to guide students online to achieve real-time communication between the two.

(4) Experimental evaluation module: when students perform experimental operations, the name of the experiment and the experiment process can be stored in the server through this module. The experiment instructor can view and review the student's experiment operation process from the server at any time, and the results are stored on the server.

(5) Experimental demonstration module: Through this module, the experimental instructor can carry out the demonstration of the experiment and store it on the server. Through this module, students can view the experimental demonstration process at any time.

(6) Experimental operation module: Through this module, students can select the corresponding experimental items and store them, and they can continue unfinished experiments in the future.

(7) Training and learning modules: mainly provide general users with instructions on operations and related management systems.

4. Signal denoising algorithm

4.1. Decomposition and reconstruction of automobile engine related signals

Car engine-related signal filtering large-scale multiplicative noise must first decompose and reconstruct the signal pixels, set the car engine-related signal image block as x*x, and form x*x from top to bottom and from left to right [7]. In the case of an n-dimensional vector, then the Gray value vector of a block containing large-scale multiplicative noise is expressed by the formula:

$$y = y_0 + w = (y_1, y_2, \cdots, y_n)$$  \hspace{1cm} (1)

In the formula, $w = (w_1, w_2, \cdots, w_n)$ is the multiplicative noise vector of the gray value vector $y_0$. The noise-free part of the vector is represented by v. For the signal without multiplicative noise, the image similar block with multiplicative noise is selected, and the error between the two is represented by the formula:

$$u_i = \frac{1}{n} \sum_{k=1}^{n} (v_{0k} - y_{0k})^2 = \frac{1}{n} \sum_{k=1}^{n} (v_k - y_k)^2 + 2\sigma^2$$  \hspace{1cm} (2)

Let the critical value be L. When $u_i < L + 2\sigma^2$, w and y are similar, otherwise, the two are not similar. The large-scale multiplicative noise part is reconstructed by computational decomposition.

4.2. Filter large-scale multiplicative noise

After analysing and processing the signal and image of the car engine-related signal, it is assumed that the large-scale multiplicative noise k pollution of the car engine-related signal t is a random independent distribution of the multiplicative noise, and a is the observed multiplicative noise signal, namely:

$$a = t + k$$  \hspace{1cm} (3)
When the estimated value after filtering the multiplicative noise, a is $\hat{a}$, it can be expressed as:

$$\hat{a}(s) = a(s) * j(s) = \sum_n j(n)a(s-n)$$  \hspace{1cm} \text{(4)}$$

In the formula, $j(s)$ is the filter function, which should satisfy:

$$J(\nu) = \frac{p_{aj}(\nu)}{p_a(\nu)}$$

$J(\nu)$ is the conversion formula of function $j(s)$; $p_a(\nu)$ is the autocorrelation function of multiplicative noise; $p_{aj}(\nu)$ represents the correlation function of multiplicative noise and signal. When $g(m,n)$ represents the gray value of the car engine related signal with multiplicative noise at the pixel point $(m,n)$, $F$ represents the local gray value of the signal point $(m,n)$, $\sigma^2$ represents the local variance of the car engine related signal, and $\sigma^2_w$ represents the multiplicative noise variance. The large-scale multiplicative noise filtering formula is:

$$\hat{g}(m,n) = F + \frac{\sigma^2}{\sigma^2+w}[g(m,n) - F]$$ \hspace{1cm} \text{(6)}$$

**Conclusion**

As a preparation for teaching and training, the integrated experimental teaching system of automobile power drive system can assist teachers in completing the experimental training teaching goals. By using the experimental platform, students can solidly grasp the structure and working principle of the hybrid vehicle power drive system. If you set up faults on the system, you can use testing instruments and equipment to detect and eliminate the faults, so as to achieve the purpose of efficient learning.

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