Virtual simulation of EFPT-D process control experiment

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Abstract. With the development of green experiment and online teaching, using virtual simulation technology to provide experimental equipment and platform for students has become an effective choice. It can solve many problems in experimentation, such as a shortage of equipment, fast iteration speeds, etc. In this paper, Unity3d engine is used as the virtual reality development platform to simulate the liquid level setting control experiment of B&R EFPT-D process control experimental platform, which can completely restore the experimental steps, and further use the code to simulate the mathematical model and PID control algorithm, which has guiding significance for practical teaching.

1. Introduction
With rapid societal development, the life of automation is also becoming increasingly popular. At the same time, the demand for talent training in this area is also increasing rapidly. Currently, there are many problems with experimental teaching in colleges and universities, such as large demand and fewer opportunities for updating hardware. This also leads to the small number of instruments available in experimental courses in colleges and universities, and the maintenance workload is large, which makes it difficult to achieve a good teaching effect.

To address this problem, the paper proposes that the application of virtual simulation technology to develop virtual experimental equipment and platforms can solve the problem to a certain extent. Virtual reality technology is a rapidly growing technology that has been adopted by many and has been well combined in the field of education. [1-3]

The design is based on the B&R EFPT-D process control experimental platform as the prototype. The experimental system is mainly divided into control part and transmission part. According to the order of operation, the correct valve, connection circuit and switch parameters are adjusted to ensure the control parameters are stable. The simulation software allows students to complete the experiment in a virtual environment. It can consolidate the students' professional knowledge and improve their practical abilities. [4-6].

2. Simulation design based on Unity3d

2.1. System overall design
Unity3d software is an engine tool for developing games and virtual reality. After development, it can be released directly to the most commonly used operating systems, such as Windows, Mac systems, Linux systems, Android systems, and iOS systems, and can also be used for web development. Unity3d is modular, easy to develop, and has good package performance. It integrates good physics engines to simulate the physical environment better. Unity3d has the following advantages compared with similar simulation software such as Virtual4 and Virtools, which has the following advantages:
free; It has good compatibility with all kinds of media files; You can purchase extended resources in the asset store to save development time. Unity3d is preferred as a development tool. As shown in Fig.1, Unity3d includes five views: scene, game, project, hierarchy and inspector. For Unity3d software, the C# and Unityscript languages can be used. This development adopts the C# language.

![Fig.1 Unity3d development interface](image1)

2.2. Establishment of virtual model
In building 3D models, although Unity3d has its own modelling function, it does not match the simulation of the software, so the powerful 3dsmax is selected. Measuring the actual size of the equipment and recording different sounds when the equipment is working, so as to ensure the simulation is as accurate as possible. After the model is built, the similarity of the model is further improved by using the mapping, lighting, material and animation functions of 3dsmax. At the same time, it should be noted that the EFPT-D process control experimental simulation system is a complex system, and an object-oriented programming idea is used in the design and programming of the simulation. Therefore, before the development, the object design idea of components should be clear in the modelling, so as to reduce the coupling between components, and it also brings convenience for software updates and maintenance. The model within 3dsmax is shown in Fig.2. 3dsmax has good compatibility with Unity3d. After the work is finished in 3dsmax, the project file in FBX format is exported in the software and directly copied to Unity3d.

![Fig.2 3dsmax model of EFPT-D process control experimental equipment](image2)

3. Experimental principle and system composition
3.1. Experimental principle and algorithm
The EFPT-D process control object and process control console are composed of two parts, and communicate with the computer directly through the controller. The experimental principle is shown in Fig.3.
In the liquid level setting experiment, the controller is PID controller, the actuator is valve, the controlled process is the controlled process equipment, which refers to the boiler, and the measurement and transmission refers to the liquid level transmitter.

PID control algorithm is a classical control algorithm which has been tested for a long time. It has a relatively simple structure, a wide range of applications, and a number of convenient settings. For the control object "first-order delay + pure delay", PID control is an optimal control.

In software design, the mathematical model is established based on the actual experimental data, and the PID (code module) is written as an algorithm for the actual data. In this way, the result curve can be simulated in the software and PID tuning can be carried out.

In the actual experiment, first let the water flow in the boiler clean, so that the boiler liquid level remains at 0 for a period of time, and then give the boiler system a set liquid level, which can be regarded as a step signal. The mathematical model of the system is identified according using a two-point method and a step response method to process mathematical model identification. The process object is treated as a first-order object with pure delay, and the liquid levels of values at different time points are substituted into the calculation:

$$G(s) = \frac{K_0}{T_0s + 1} e^{-\tau} \quad (1)$$

After normalization and the Laplace transform, the formula is obtained:

$$C(t) = h - h * 1.1 * e^{-1.6687} \quad (2)$$

In the simulation system, the expression of the PID control law is as follows:

$$\Delta u = K_c \left( e + \frac{1}{T_i} \int_0^t e \, dt + T_d \frac{de}{dt} \right) \quad (3)$$

The algorithm is verified in Simulink, the waveform diagram of the conclusion is shown in Fig.5.
3.2. system implementation
Import the 3dsmax home model and animation into Unity3d, and complete the design and production of the landing page, main scene and code writing of each module in the Unity3d software. Using the convenient packaging feature of Unity3d, package the EXE file on a Windows system, and carry out the test run. Based on the steps in the experiment, set the liquid level to 80, as shown in Fig.6, and the resulting curve is obtained.

4. Conclusion
The purpose of this design is to provide a feasible method of online green experiment teaching, and provide a simple experimental method for students to experiment with EFPT and obtain a positive
teaching effect. By using the EFPT-D process control platform as the simulation object, the preliminary simulation experiment is carried out through an experimental platform based on Unity3d for experimental and teaching purposes. The conclusions are as follows:

1. Through the actual experiment, the mathematical model of the liquid level setting control experiment is constructed. Through the Simulink simulation, the experimental results under the optimal PID are obtained, and the time-domain expression under the model is calculated. Through a certain algorithm, it is written into Unity3d to get the actual liquid level of the final boiler.

2. In the development process, enough interfaces are left for the later experiments, which have good scalability.

3. The classic process control experiments are used to simulate and make software. The software still has defects in many places, such as human-computer interaction, model fidelity and so on. The ultimate goal is to verify the effectiveness of process control experiments by teaching them using a virtual simulation system. In the future, more experimental modules can be written and added, which is of great significance to process control experiment teaching.

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