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Research on Practical Teaching of PLC Semi-physical Simulation Based on Digital Twins

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Abstract: In order to get rid of the reality of the disconnection between production and teaching in PLC practice teaching, and make up for the lack of intuition in the experimental link and the safety and reliability of equipment, based on the concept of digital twins, this paper uses virtual simulation software to build industrial scene, real PLC and I/O module, sensor module to complete the acquisition, update and processing of bottom layer signals, and constructs a semi virtual practice teaching mode to realize the real-time intuitive observation of the control process, Understand the operation characteristics of corresponding actual working conditions. The application in practical teaching has achieved good results.

1. Introductions

PLC programming and application is a core course in the engineering application field of automation specialty, which has strong practicality and is one of the main employment directions. During the experiment, students need to write programs and download them to the PLC equipment for debugging. The conventional experimental equipment is mostly the experimental box, which uses the indicator light to indicate the signal status, which is not only lack of intuition, but also not conductive to students' understanding of the actual working conditions. The large-scale teaching equipment for digital factory is not only expensive, but also has fewer types of training equipment. At the same time, the failure rate of mechanical installation and electrical connection is high, and there are some potential safety hazards, so it is difficult to be widely used in teaching, resulting in a large gap between PLC theory teaching and practical application.

Industrial control system is a combination of software and hardware. With the development of modern technology, industrial control system is gradually developing towards networking and

intelligence, and the industrial control industry has begun to be deeply integrated with the IT industry. The traditional industrial control technology based on simple I/O control can no longer meet the requirements of intelligent manufacturing, smart factory and IOT data. Industrial control technology will develop in the direction of remote and intelligent data communication.

In view of the disconnection between production and education and the needs of the development of industrial control technology, based on the idea of digital twins, this paper uses the form of semi physical simulation, uses virtual simulation software to build industrial scene, and uses real PLC, I/O module, sensor module to complete the acquisition, update and processing of the underlying signal, so as to realize the real-time visual observation of the control process and understand the operation characteristics of the corresponding actual working conditions. So as to make up for the lack of intuition in the experiment and the safety and reliability of the equipment, get rid of the reality of the disconnection between production and education, and enable teaching to keep up with the forefront of technology.

2. Reform Ideas of Semi Physical Practice Teaching

(1) Relying on digital twins' technology, create a professional characteristics semi physical simulation test practice teaching environment.

Digital twin technology makes full use of physical model, sensor update, operation history and other data, integrates multi-disciplinary, multi physical quantity, multi-scale, multi probability simulation process, and completes the mapping in the virtual space, so as to reflect the whole life cycle process of the corresponding physical equipment. This technology integrates a variety of modern cutting-edge means in contemporary science and technology, greatly expands human vision, time limit and ability, and plays an extremely important role in the field of science and technology.
Hardware in the loop simulation, refers to the real-time simulation of connecting part of the physical objects in the simulation loop of the simulation experiment system. As an important branch of simulation technology, it involves electromechanical technology, hydraulic technology, control technology and interface technology. It fits well with the training direction of the engineering technology field of automation specialty. The dynamic characteristics of the object entity are run on the computer by establishing a mathematical model. At the same time, various physical effect devices that simulate the sensor measurement environment are required to be connected to the loop, the hardware runs in the loop simulation system according to the actual working conditions.

(2) Build a professional characteristic controlled object and build a professional comprehensive training platform

As a major with strong engineering background, automation majors in Colleges and universities generally lack professional comprehensive training platform, which leads to students' unclear understanding of the major as a whole. By using digital twin technology, the controlled objects with professional characteristics are constructed, such as three-dimensional warehouse, automatic production line, multi volume liquid level control, distillation tower, etc., so that students can realize the closed-loop control of objects by integrating sensor technology, computer control technology, electronic technology, automatic control principle and other courses, so that students can better understand their majors, improve their engineering practice ability, and promote employment.

3. Specific Measures Of Digital Twin Practice Teaching

(1) Reform course contents and add contents of simulation environment

The content of the traditional PLC course is too focused on the principle and programming part. It often appears that the programming idea has been learned in the previous course, but the content

of engineering application has not been mentioned. There will be courses that have been learned, but the actual operation is impossible. Therefore, it is necessary to modify the course. The cumbersome principle and programming parts can be appropriately reduced. The focus should be on the connection between PLC and peripherals. The signals can be read up and sent down, so as to enhance the interest of the course and improve the attraction of the course to students. In addition, in view of the shortage of controlled objects, the learning of simulation software, especially factory IO and MCGS, is increased. Factory I/O provides more than 20 typical industrial application scenarios, allowing students to practice control tasks as if they were on the spot. Students can use the embedded editable typical industrial system template, and can also freely build and edit industrial systems.

(2) Multi-platform information transmission to create an interactive simulation environment

Computer is the core part of simulation system. It runs the mathematical model and program of entity object and simulation environment. As shown in Figure 1, the lower computer uses PLC as the core to read in and send out AI/AO and DI/DO signals. The upper computer runs the controlled object built by the simulation software, and the information needs to be transmitted on multiple platforms such as sensors, PLCs, actuators, computers, controlled objects, etc. Therefore, an interoperable distributed interactive simulation environment is formed through high-speed network interconnection following unified communication standards, specifications, and protocols, It is an ideal system to realize the simulation of huge complex systems.

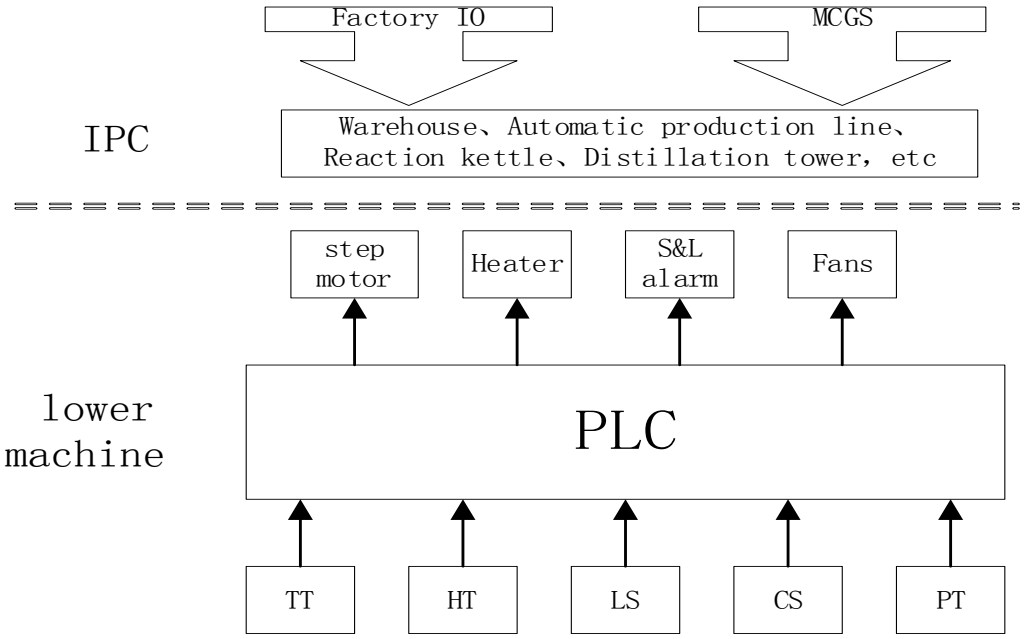

Fig 1. Operation diagram of typical industrial control objects

4. Typical Application of Hardware in the Loop Simulation Practice Link

Automated warehouse

The automated warehouse is mainly composed of warehouses, shelves, roadway Stacking Cranes, inbound and outbound conveyors, pallets, controllers and sensors. As an upgraded version of the traditional warehouse, compared with the traditional warehouse, its characteristics are mainly reflected in the use of high-rise shelves, combined with modern control technology, communication technology and information management technology, which can not only save space to a great extent, improve the utilization of storage space, save a lot of unnecessary capital investment and human resources investment, but also realize the visual management of storage information, It

greatly improves the efficiency of warehouse management. The automated three-dimensional warehouse is mainly composed of five parts, including: logic control unit, high-rise three-dimensional shelves, roadway stacking crane, conveyor belt or AGV, and upper computer control unit. Reflective sensors, limit switches and proximity switches are mainly used to realize the perception and positioning of loading vehicles, goods and warehouses, and temperature and humidity sensors are used to monitor the warehouse environment. The operation status of the warehouse is monitored by the upper computer configuration software MCGS, and the goods in and out of the warehouse are controlled.

The PLC collects the information of sensor switching value and analog value, and the PLC displays the information to the MCGS upper computer through serial communication. The upper computer sends the control command to the PLC, and sends the signal to the actuator through the PLC control program. The actuator automatically or manually executes the action step by step according to the status information.

MCGS is used to build the operation interface, which is equipped with the main interface and the operation interface of the three-dimensional warehouse. Students can add various registers in the PLC device window to control the internal resources of PLC by the upper computer. Generally, the input port I of PLC is set as read-only, and the output port Q is readable and writable. In the experiment, we send control instructions or control program execution steps to PLC through the M register, or we can control the animation demonstration execution steps of MCGS by reading the value of the M register, so that the actual operation can be synchronized with the upper computer screen.

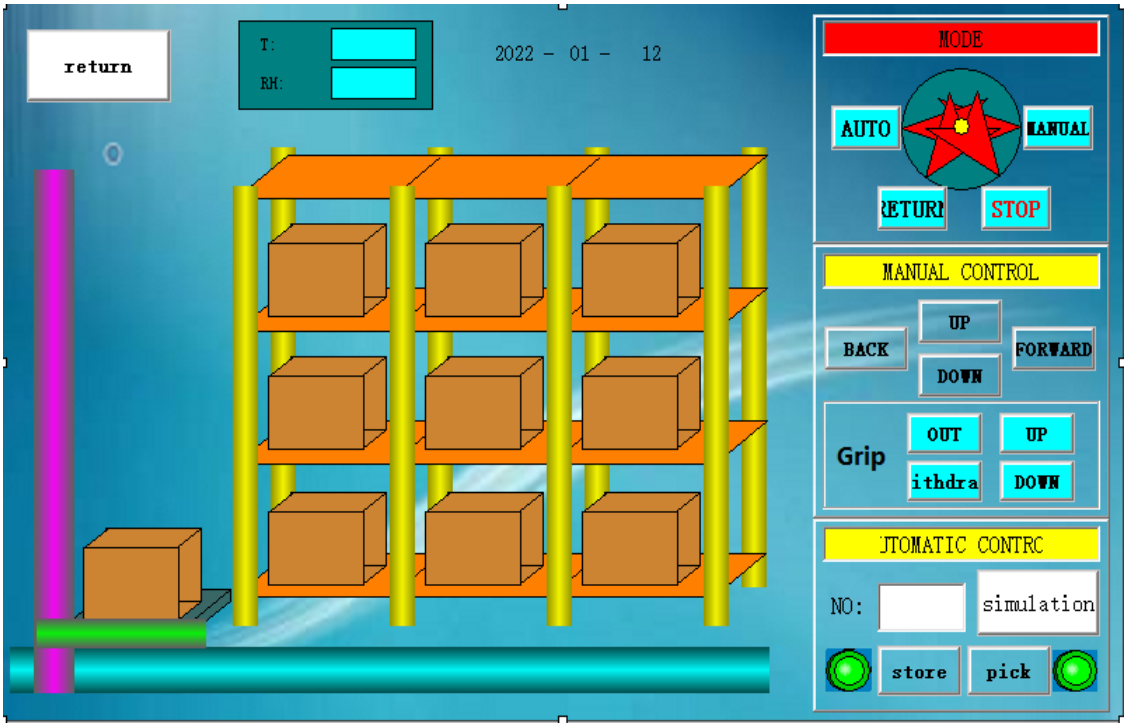

Fig 2. automated warehouse based on MCGS

In addition to MCGS, Factory IO is used to complete the comprehensive training platform of three-dimensional warehouse. Factory IO is a powerful 3D factory virtual simulation software. It can establish connections with a variety of controllers, including Siemens PLC. It has more than 20 typical industrial application scenarios and more than 80 industrial components. It can create a virtual factory and build its own industrial scenarios using a variety of highly simulated industrial

components, including sensors, transmitters, multi elevator, workstations and so on. Similar to the actual environment of the factory, the operation of the actuator is controlled by collecting the switch value and analog value information of each component and according to the control conditions. And Factory IO has its own drive control programming language, which is similar to PLC ladder diagram and has a large number of logic control units, which can easily verify various control logics on the Factory IO simulation platform.

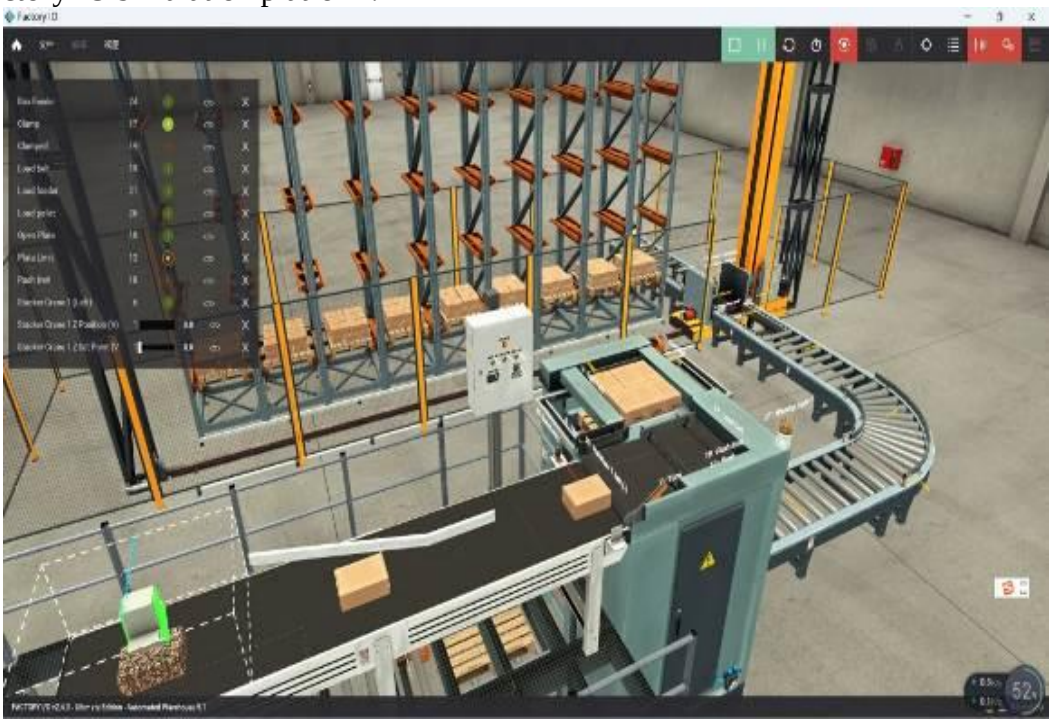

Fig 3. Automated warehouse based on Factory IO

5. Conclusion

By using the PLC experimental environment constructed by digital twin technology, abandoning the investment in the controlled object in the traditional PLC experimental teaching, creating a comprehensive training environment with both engineering application and professional characteristics, and increasing the investment in communication interface, sensor actuator and other peripherals, students can complete the multi-platform information interaction closer to the actual object on it, which improves students' professional engineering practice ability.

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If any, should be placed before the references section without numbering.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest

References

[1] Chai Tianyou, Zhang Jingwen, Yang Tao. Demand Forecasting of the Fused Magnesia Smelting Process with System Identification and Deep Learning . IEEE Transactions On Industrial Informatics, 2021.

[2] Khan W Z, Rehman M H, Zangoti H M, et al. Industrial internet of things: recent advances, enabling technologies and open challenges . Computers & Electrical Engineering, 2020, 81: 106522-106535.

[3] Luo Ruiping, Sheng Buyun, Huang Yuzhe, et al. Key technologies and development trends of digital twin-based production system simulations of tware.

[4] Zhu Xuezhong, Hu Cheng. Industrials of tware innovation in China: Driving mechanism and paths election .China Soft Science, 2022 (7):38-47.

[5] Tao Fei, Cheng Ying, Cheng Jiangfeng, et al. Theory and technology of digital twin workshop information physics fusion. Computer Integrated Manufacturing Systems,2017,23(8):1603-1611.

[6] Pu Tianjiao, Chen Sheng, Zhao Qi et al. Framework design and application prospect of digital twin system of energy Internet .ProceedingsoftheCSEE,2021,41(6): 2012-2029.

[7] Jing Qianfeng, Shen Helong, Yin Yong. A ship digital twin frame work based on virtual reality system.Journal of Beijing Jiaotong University,2020,44 (5):117-124.

[8] Liao Ying, Lu Bin, Deng Fanglin, et al. Simulation languages and simulation software present and future . Computer Engineering & Science, 1999, 21(1):10-15.