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A Remote PLC Laboratory Design and Realization

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Abstract

The development of computers and the internet have made distance learning easier and faster. In this field, remote laboratories are enabling intensive use of university facilities, while aiding the work of professors and students. The paper introduces a remote laboratory designed to be used in PLC practical work. The relative experiments are described. The students can complete the programming exercises at different location and different time on campus. The evaluation is conducted and the experience has proved to be positive, and the students have valued it accordingly.

Keywords: PLC, Remote Laboratory, Distance learning;

1. Introduction

With the overwhelming developments of Internet technologies, many new teaching methods arise. There is a trend that the traditional local laboratories are being replaced by open and remote laboratories \cite{1-6}. PLC is widely used in manufacturing to coordinate a variety of complex tasks such as security monitoring, energy consumption management, and control of automatic production lines. As a result, there is a great need for engineers with strong skills and knowledge in this area.

Although many educational institutions cover PLC in undergraduate courses, but students lack the resources to become a proficient PLC programmer. Limited access to labs and limited equipment availability make it difficult for students to have sufficient opportunities to practice.

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Among the research of remote laboratories, there are two major classifications. The first category is based on some software simulation technology [2, 4, 5]. The second category is based on some hardware interface [1, 3, 6]. No matter which method is adopted, some specific knowledge would be necessary. But for a PLC teacher, it is often less possible to have so much knowledge for application. To overcome these shortcomings, a famous remote control software is adopted for realizing the PLC remote operation which would provide students with real experiment environment.

In this paper, an open laboratory based on LAN intranet is put forward. And the remote laboratory is used. Such a course is part of electronic information engineering degree and is optional in the student curriculum. The structure of this paper is as following: In section II, the campus network model is introduced firstly. Then the laboratory structure is explained. And in section III, the monitoring method is explained. In section IV, the evaluation of the remote laboratory is discussed. And in section V, a positive conclusion is made.

2. Laboratory Realization

2.1. Campus Network Model

A campus is generally a portion of a university (or a college) that is constrained to a fixed geographic area. The campus network is a specific group of buildings all connected into one enterprise network that consists of many local-area networks (LANs). The composite network model of campus network is shown in figure 1. The campus network topology is primarily LAN technology connecting all the end systems within the building. It generally uses LAN technologies, such as Fast Ethernet, Fiber Distributed Data Interface (FDDI), Gigabit Ethernet, Ethernet, Token Ring, and Asynchronous Transfer Mode (ATM).

2.2. Laboratory Structure

The remote laboratory is set up based on the campus network. The topology structure is shown in fig2. Different PLC training models at different place can be connected to the LAN via a local computer as web
On the laboratory server, specific necessary programming software (such as FPWIN) and configuration software (such as MCGS) are installed. Thus students can complete the programming, debugging and monitoring/controlling of PLC training model locally.

PC-anywhere is an excellent software for remote access control. It enables one computer to remotely control and access another computer, establishing a one-to-one connection. The host components are installed on the laboratory server computer and the remote components are installed on the computer that students chose to use as the terminal for remote access. Reliable, protected remote connectivity—Gateway functionality makes it easier for remote users to find the hosts they need—even when they're behind firewalls or routers or that don’t have fixed or public IP addresses.

With this structure, every computer within the campus network can access the PLC laboratory flexibly. And this scheme can overcome the experiment resource shortage. At anytime and at anywhere on campus, student can access the PLC training model as long as he wants. Then he could program and debug the plc training model remotely as if he just seat nearby.

Fig2 Topology of the Remote Laboratory

3. Supervision

All that is necessary for a student to be able to work with the remote laboratory are the installation of pcanywhere on his terminal, some necessary configuration setting, and a connection to the LAN in order to download the program to the PLC and to check the functioning through an camera. As shown in Fig. 2.

Distance learning using remote laboratories requires a visualization device, to allow checking and supervising of the correct functioning of the applications when downloading the programs to the PLC. This visualization enforces “real-world” perception for the students and really demonstrates to them that they are not performing a simulation, but carrying out real laboratory work.

In the design structure of the remote laboratory, a camera is installed on the PC server of every laboratory. Its field of vision is limited to the PLC training model with the functions of monitoring and supervising the educational system.

A fast Internet connection is recommended, so that the refresh rate of the screen allows the observation of the functioning of the drivers at an acceptable speed. Nevertheless, the PC-anywhere has been used with low-speed Internet connections, but it is acceptable.
4. Result Evaluation

This open PLC laboratory has been tested by 50 volunteer students, divided into two different groups: the local group, composed of 25 students and the remote group, composed of 25 students. All the students had the same initial level, since none of them had ever attended a PLC programming course nor programmed a PLC. The students have been able to implement the programs and make the training model work, but they achieved different complexity levels. Although the course has been valued in general terms very positively, three students enrolled in the remote group have pointed out that the major drawback is the necessity of a good Internet connection to watch the real-time camera at an acceptable rate.

Table 1  Student Response Result

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was the course challenging and interesting</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>15</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>Have you learned this course</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>14</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Do you think that you will apply the learned concepts in future</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Robustness of the remote laboratory</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td>Real system similarity</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>How do you rate this course</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>16</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>There are enough exercise or not</td>
<td>0</td>
<td>10</td>
<td>4</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>I have acquired basic automation concepts</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>15</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>It has been easy to work from home</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
</tbody>
</table>

The students’ response is evaluation as table 1, and the survey results show that students agree that the course was interesting and that the material they learnt may be useful for them in the near future. The general rating of the course is rather good, but it has to be noted that the best score was given to the remote laboratory, where students agree that the lab worked without problems. The analysis of the results shows that the introduced remote laboratory significantly improved the quality of the course. At the same time, the course methodology has proved to be satisfactory, and students have valued it accordingly.

In order to assess the results obtained with the introduction of the new remote laboratory, the initial objectives course have to be evaluated. Such objectives, along with the assessment criteria to evaluate whether each objective was accomplished or not, and the assessment results, are presented in Table 2.

The assessment criteria for the course evaluation are as follows:.
- Report prepared by the students and submitted to the instructor.
- Oral presentation and debate about the different solutions proposed by students.
- Final exam.

Each objective was assessed according to each criterion and the average value calculated shown in the
third column of Table 2. It can be noted that the results are satisfactory. Nonetheless, further work will be done to try to improve both the laboratory environment and the course, focusing in the issues which obtained the worst results in the assessment. In particular, special attention will be given to photo file transport speed in the further research.

5. Conclusions

The present paper introduces an open laboratory based on campus network and an automatic remote learning PLC course. The laboratory realization and the course structure have been presented. The course teaches PLC programming skills to the students and makes them acquire basic knowledge in the field, allowing them to work with some of the common situations of industry.

As seen in the survey, the students have shown a good opinion about the course. Furthermore, the results obtained in the reports are also encouraging. Hence, one can conclude that the experience has been positive and is worth repeating in the following years. Regarding further improvements, the main challenge is the Internet connection speed. High speed of image transmission would make the application more perfect.

Table 2  Course Evaluation Result

<table>
<thead>
<tr>
<th>Course evaluation</th>
<th>Local</th>
<th>Remote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to real industrial automation component</td>
<td>92%</td>
<td>93%</td>
</tr>
<tr>
<td>Programming skills in ladder language</td>
<td>67%</td>
<td>90%</td>
</tr>
<tr>
<td>Grasping the automation sequence concepts</td>
<td>80%</td>
<td>87%</td>
</tr>
<tr>
<td>Developing supervision system</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>Grasping motor control concepts</td>
<td>88%</td>
<td>86%</td>
</tr>
<tr>
<td>Grasping transport light control concepts</td>
<td>86%</td>
<td>87%</td>
</tr>
<tr>
<td>Average number of experiments completed/all basic experiments</td>
<td>70%</td>
<td>95%</td>
</tr>
<tr>
<td>The number of students who has completed the expansion experiments</td>
<td>1%</td>
<td>10%</td>
</tr>
</tbody>
</table>

References

[3] Oriol Gomis Bellmunt A Distance PLC Programming Course Employing a Remote Laboratory Based on a Flexible Manufacturing Cell; IEEE TRANSACTIONS ON EDUCATION, VOL. 49, NO. 2, MAY 2006: 278-284