Web-Based Nuclear Physics Laboratory

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Nuclear radiation is met in many branches of science, technology, and medicine in everyday life. Therefore it is important that people should be properly educated in this field. Unfortunately, measurements in nuclear physics are always very sophisticated and needed highly expensive equipments. Laboratory experiments in science education are essential for understanding natural phenomena and principles related to the subject. The laboratory activity is also required even for distance learners, providing a vivid interaction between learners and nature. In this paper, we proposed a remote control nuclear physics experiment system which can operate through the Internet. The following reasons are why the radiation measurement system is proper for a Web based remote control experiment: (1) the nuclear laboratory equipment is too expensive and is not usually available to local schools, and (2) the treatment of radiation materials is too dangerous for untrained persons. (3) Our system can be adapted to Geiger counting, alpha ray, beta ray, gamma ray spectroscopy, Compton scattering, coincidence technique, nuclear lifetime measurements, radiation biology, environment radiation, etc., in the field of nuclear physics. We have used HTTP, HTML, and a CGI program to construct the Web based remote control laboratory system. The CGI program is a major tool for communication between the HTTP server and experimental radiation equipment. Our system may be very useful for distance learners as well as regular school students. The questionnaire for distance learners in a gifted students center was analysed.

Keywords nuclear physics; radiation measurement; remote control; Web-based laboratory

1. Introduction

The web-based learning environment has some advantages such as stretching the spatial and temporal barriers, flexibility, interactivity, and interoperability. Some organizations have developed their web-based learning environments to have lessons. The learning environments which have imitated the traditional learning environment are comprised of some kinds of web based learning tools. At the same time, learning theories and technologies for designing web-based learning environment are widely studied [1-5].

Nuclear radiation is met in many branches of science, technology, medicine and in everyday life. Therefore it is important that students should be properly educated in this field. Unfortunately, measurements in nuclear physics are always very sophisticated and need highly expensive equipment. As a rule, major universities have good organized nuclear laboratories in nuclear physics but they are not commonly accessible to the public. On the other hand, secondary level schools are completely devoid of such experimental setups and pupils learn this subject from books only.

Laboratory experiments in science education are essential for understanding natural phenomena and principles related to the subject. The laboratory activity is also required even for distance learners, providing a vivid interaction between learners and nature.

In this paper, we propose a Web-based nuclear physics laboratory (WNPL) in physics education for distance learning and for the regular school by introducing a remote control experiment system through the Internet. A remote control laboratory for science education should be implemented in an integrated environment with the user controlling the real device from a remote site and conducting the actual experiments through a computer network. The remote control laboratory consists of a cluster of general-purpose and specialized instruments interfaced to a set of personal computer systems connected to the

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Internet. With the ability to configure instruments and data analyzing remotely via the Internet, the laboratory will facilitate the sharing of expensive instruments and equipment, and may well be important in distance learning. In this paper, we present a general method for developing WNPL by using the Internet and interface techniques, which enables students learning physics to control real instruments through the Internet and to conduct physics experiments remotely.

2. Web-based remote laboratory

When students log onto the system through the Internet, they are able to control both the computer and the connected equipment. A video camera can also be used to live broadcast what is happening in the laboratory. Web-based remote laboratory (WRL) experiments are created by utilizing the Web server, Hypertext Transfer Protocol (HTTP), Hypertext Markup Language (HTML), Common Gateway Interface (CGI), Web camera, and experimental equipment. The clients are IBM-compatible personal computers running MS-windows. CGI is a major tool for communication between the HTTP server and the experimental equipment. A web page is provided to enable the user to send instrument parameters to the CGI program. In order to control the interface, we use a Web server. A Visual Basic program and Active Sever Page (ASP) are used for the standard CGI program and are used to support the standard input/output streams.

The server connected to laboratory equipment manages the requests from clients and sends the parameters to the CGI program, which controls the real instruments in the WRL. Then, the CGI program returns some information collected from the server side apparatus to the client computer. After experimental data is saved on the server side, clients can download the data from the server to their own directories. After download the data they can analyze the data and prepare their reports using Microsoft Excel or other programs. Based on this general method, other remote experimental systems can be developed; we only need to develop the program to control the different instruments according to the designed procedures for the new Web-based experiment. An internet video camera can be used to live broadcast for monitoring the remote laboratory equipment. This is very important because users can feel that they are involved in controlling the real instruments remotely and not in manipulating a simulation program.

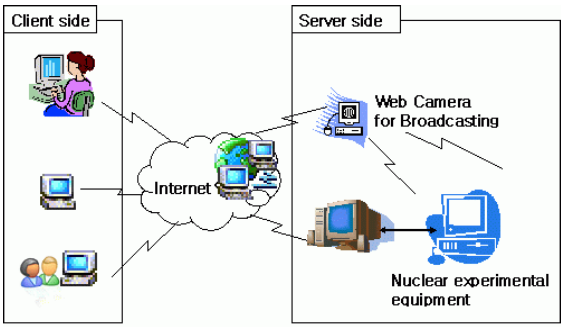

Fig. 1 The hardware structure of WRL.

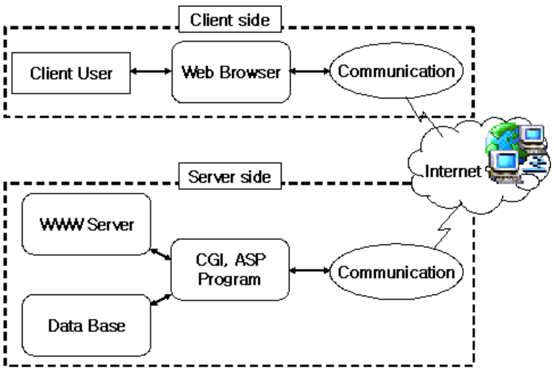

Fig. 2 The software structure of WRL.

Fig. 1 shows our hardware structure for a WRL. The list of hardware used in the WRL system is as follows:

(1) A PC computer with data acquisition cards and Ethernet card,
(2) Programmable instruments such as a data acquisition system and experimental apparatus,
(3) And an Internet-based video camera.

The software structure of the WRL for both on the server and the client is shown in Fig. 2. The clients are any Web browsers. A Web page is designed for operating the remote laboratory according to a time schedule in a series of experiments. A laboratory manager uses the timetable to set up the next WRL experiment according to the schedule. It does not matter for the experiments whether the student is in a nearby room or on the other side of the world.

3. Web based nuclear physics laboratory

As an example for the application of WRL we have constructed a remote control experiment system for nuclear experiment (WNPL). Nuclear experiments make students a little nervous because of radioactive materials. On the other hand, they are very interesting because radioactivity is a curious subject related to nuclear physics and to modern technology such as nuclear energy, medical radiotherapy, atomic bombs, etc. Also, a nuclear experiment system is expensive and is not available to every educational institute. Therefore, we have developed a remote-control nuclear experiment system to overcome such constraints.

After implementation of a remote control instrument, we can set up a remote laboratory by designing the experiment contents and a Web page for user instruction to control the remote control laboratory. The user follows the instructions to conduct the remote experiment. While one user is doing the experiment, the system does not allow any other users to initiate another experiment except sharing the experimental data. The authorized users can only do the available experiments according to the schedule and the setup determined by the lab manager.

To set up a remote experiment, we need to know how to control the remote instruments through the Internet. CGI and TCP/IP are two major tools for communications between users, local instruments, and HTTP server. A multi-channel analyzer (MCA) and electronic signal processor modules with radiation detection system are also used for nuclear experiments. The Gamma Vision (GV) software by ORTEC [6] is used for controlling the radiation detection system. Interface software can be developed to control the remote instruments. A Web page is provided to enable users to send instrument parameters. The HTTP server accepts the parameters, activates a CGI program and transmits instrument parameters to the experimental apparatus [7]. In principle, any instruments can be controlled remotely through CGI program if there is a program which can communicate with the experimental instruments (Fig. 3).

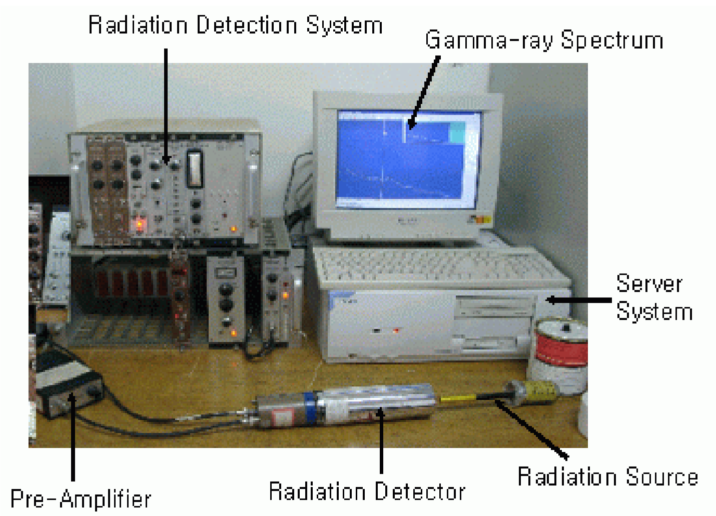

Fig. 3 The Web based nuclear physics laboratory (WNPL)

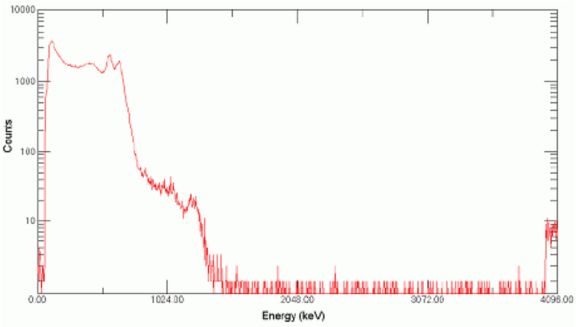

Fig. 4 A sample spectrum for gamma-ray.

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<%
Set objFs2=CeratObject("Scripting.FileSystemObject")
Set objFile2=objFs2.OpenTextFile("c:₩inetpub₩scripts₩remote.job",2,True)

objFile2.Write "Set Detector 1" & vbCrLf
objFile2.Write "Set Preset Clear" & vbCrLf
objFile2.Write "Set Preset Real" & Ctime & vbCrLf
objFile2.Write "Clear" & vbCrLf
objFile2.Write "Start" & vbCrLf
objFile2.Write "Wait" & vbCrLf
objFile2.Write "Fill Buffer" & vbCrLf
objFile2.Write "Set Detector 0" & vbCrLf
objFile2.Write "Save" & "c:₩inetpub₩scripts₩data₩" & Fname & ".chn" & vbCrLf
objFile2.Write "Set Detector 1" & vbCrLf
objFile2.Write "Quit" & vbCrLf

objFile2.Close
%>
```

Fig. 5 The ASP code for JCF.

In our experiment, the CGI program activates the local instrument and executes the GV program. The GV program uses a job control file (JCF) which includes many experimental parameters, such as selection of the detector, the measuring time, the data filename, sequential number of looping, control procedures, etc. Therefore, the CGI program was used to create the JCF before executing the GV program. When the experiment is finished, a user can download the data from the server with the given filename in the JCF. Clients can also see the spectrum data by using Win-Plot software which can be downloaded from the server. Fig. 4 is a sample spectrum from measured gamma ray spectrum data. We have used an ASP code for CGI program to create the JCF as shown in Fig. 5. "Set Preset Real" in the ASP program represents the real measurement time. If one wants to change the measurement command from real time to live time, "Set Preset Live" can be used instead.

The procedure for remote experiments can be changed, depending upon the experimental subject. The Web server program, the radiation detection program, and the Web camera server program are integrated into one computer system.

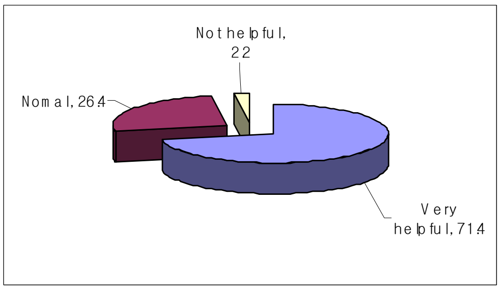

Fig. 6. The response of students for the WNPL system.

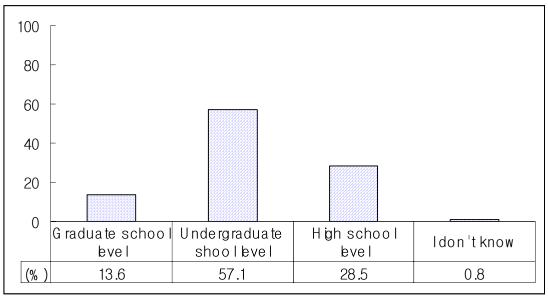

Fig. 7. The proper level for the WNPL system.

4. Pilot Test

We tested our WNPL system on an undergraduate class. Twenty-four students participated in this pilot test. Most of them were positive to the use of such system in the distance learner class. 71.4 % replied that this WNPL system was very helpful for learning the subject. However, some students replied that the contents of the Web page for the experiment seemed to be difficult to understand. 57.1 % of the students answered that this system would be proper for the undergraduate level, 28.5 % for the high school level, and 13.6% for the graduate level. The students pointed out several inconveniences: 1) two or more user could not operate the remote control system simultaneously; 2) it was very difficult to understand the whole process without knowing the theoretical background and having prior knowledge of the radiation experiment.

5. Conclusion

In this paper, we proposed a WNPL system for distance learners and regular school students. The following reasons are why the radiation measurement system is useful as a WRL: (1) the laboratory equipment is too expensive and is not usually available to local schools, and (2) the experimental procedure is too dangerous. The system can be adapted to Geiger counting, alpha-ray, beta-ray, gamma-ray spectroscopy, Compton scattering, coincidence technique, nuclear lifetime measurements, radiation biology, environment radiation, etc., in the field of nuclear physics.

We have used HTTP, HTML, and a CGI program to construct the remote control laboratory system. The CGI program is a major tool for communication between the HTTP server and experimental radiation equipment. Distance learners can control the real equipment and observe the experimental process in real time. They can also download their experimental results from the server via the Internet. It would be of practically interest to apply the system to regular school education, distance learning, radiation measurement education for employee working in the field, radiation monitoring near nuclear power plants, etc.

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