

# Design of a Virtual Laboratory for Teaching Electric Machinery

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**Abstract**—According to the needs of Distance-learning been growing up. Network-learning service is more complicated than ever. It's a new trend of using computer-assisted technique for the teaching of experiments. By this way, we reduce the concern of safety while operation and instrument costs. Virtual Environment has reality and interaction performance. Also distributed virtual environment provides ability that multiple users could join in the same session. In our study, we determine the construction, movement and curriculum of virtual environment in the teaching of electric machinery experiments. After that we set up a virtual laboratory with reality, interaction and flexibility. In the laboratory, human-computer interaction and human-human interaction are provided for teachers and students, they could make representation, discussion and control to the machinery. As above, we approach the design of new trend of teaching experiments, also, we had established a more friendly and completely testbed.

**Keywords**—Teaching of Electric Machinery Experiment, Virtual Laboratory, Distributed Virtual Environment, Virtual Experiment Set, Human-Computer Interaction

## Introduction

Distance Interactive Learning is an important trend; not only the character based media presentation as mostly distance learning [1-4] but also the real operation. By the front-end Graphical User Interface (GUI) on Internet, it is possible to outcome remote control from distance area as really attendance. In the teaching of electric machinery, we also need to provide opportunity about hand-on experiments besides theorems learning. Because of the hazardous of operation and costly investment of machinery, students usually couldn't to have enough experiences on experimental operation. To overcome such plight, using the technology of Virtual Reality been proposed in recent years than before. [5-8]

It is the major purpose to accomplish a Virtual Laboratory with realistic, interactive and flexible character described as below.

## Realistic

Using the technology of virtual reality to setup the Virtual Laboratory. The learner could have an better-involved environment for study the operation of electric machinery.[9-13]

## Interactive

In the Virtual Laboratory environment, the system let user having many opportunities to have interactions with system, such as operation domestication after request. The system also let users to interactive each other; by the way teacher could conduct the learning process and have discussion with students. [14-17]

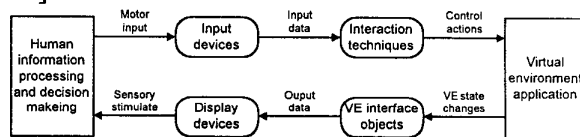


Figure 1: The Human-Machine Interaction in VR

## Flexible

Without lots limitations of computer system and let students easy to link are our determining while build an adaptable environment for teaching the experiment of electric machinery. Through Web browser on Internet, user could log in the system from every where at any time. [6,18-21]

## System Architecture

Cause of the complex while constructs the laboratory of virtual reality, the architecture of system is separated into three functional planes: Teaching Environment Layer, Network Interactive Layer, and Physical Layer (Fig.2). [22,23] Above these Layers is teaching application plane of electric machinery experiment. In the following, we will introduce the functions of each layer from the distance-learning view and their relationship.

## Teaching Environment Layer

There are three services provided in this layer, such as Teaching Web Page, Wiring Connector and Virtual Laboratory. Teaching Web Page is for the theorem learning of electric machinery. In our research, the techniques of HTML and Java are used for the formation of web pages. Wiring Connector is for the learning of machinery connection. After each connection, the Wiring Connector will appraise the wiring diagram of experiment is right or wrong, and transfer the specify connection to the control panel of the Laboratory. Virtual Laboratory is a learning environment for single or multi user to learn about simulated operation of machinery with interactive response through push buttons, switches, machine sets, and meters. In the same environment, users have their own avatars; they could interact to each other by the way of question, discussion, and conduction.

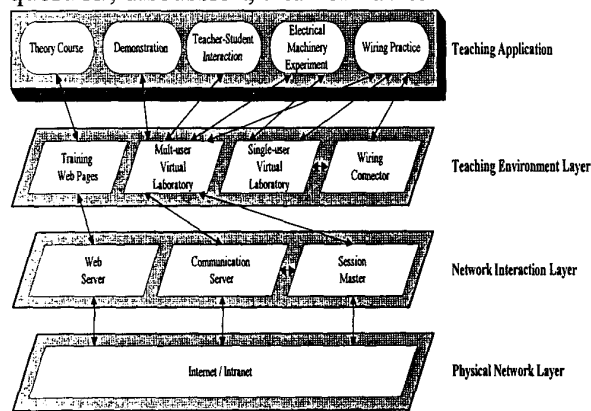


Figure 2: The system architecture in our research

### Network Interactive Layer

Based on the structure of Client/Server, the Network Interactive Layer provides Interaction function for upper layer (Teaching Environment Layer) and lower layer (Physical Layer). As the definition of user's web browser been a Client, this layer has three Servers for it, such as Web Server, Communication Server, and Session Master. The Web Server is electric machinery teaching server, it has materials of machinery theorem and operation tuition of experiment. Communication Server is created for user log in and data transmission while system works as multi user model. Session Master is designed for tracing every user's navigation and

reactions management of fictitious elements.

### Physical Layer

Physical Layer is the network connection subject of Client and server. In our research, Internet and Intranet are used for the teaching system.

### Design Procedure of VR Lab.

There are six processions during the design of Virtual Laboratory.

**Plan:** First of all, figure out all the elements and stages needs of Virtual Laboratory.

**Sense:** Using simple cube to confirm the size, positions of elements, and compose them for scenery.

**Shape:** Then finish the detail prospect and function one by one. Geometric point and relative point are used during facet formation.

**Attribute:** It is important to set adapted attribute to each element. While element have action, system will check with its' function to avoid error behavior.

**Behavior:** Design the interactions of elements for making interact between user and system.

**Optimize:** The final step of construction is to optimize the entire virtual environment. For the purpose of faster process, reduce the facet of elements always been used.

### Operating Process of Learning

We create five ladders of processes for the design of Distance Learning in the VR Lab. (shown as Fig.3). They are Login, Navigation, Interaction, Evaluation, and Logout.

**Login:** Whoever login the learning system, the Virtual Laboratory will record about his identity (Who) and time (When) at first. After that, user has to select an avatar as him self for navigation.

**Navigation:** Avatars could go anywhere in the VR Lab. The VR laboratory (Where) likes a learning group consists of four experimental sets (Which) for users' choice.

**Interaction:** There are three types of interactions in our system; first of all is the discussion (What) of student and teacher. The human-machine interaction while the

operations (What) of experiment sets being progressed is the other one. And the demonstration (What) by teacher is also an interaction in our system.

**Evaluation:** When the learning process been completed, the system will leave his records to teacher for evaluate (How) student's achievement.

**Logout:** As the user logout the system, all data (Who, When) about this learning will be stored for assessment.

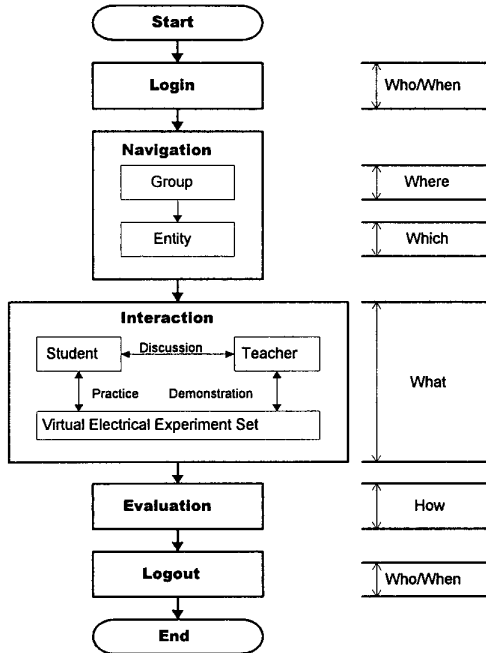


Figure3: The Operation Process of VR Lab.

## Implementation

### Environment

We had built up a Web Server for the teaching of Electric Machinery Experiment. Through the Web Browser, students succeed their Distance Learning in the Teaching Environment, without limitations of time, region and equipment. The environment of single user is shown as figure 4. We provide a private zone for personal learning, but still under the monitor of teacher. Users just need to click mouse to enter the learning environment to achieve the human-machine interaction, as he has no adapted hardware like 3D mouse, VR glove and etc.

Because of budge and time limitations, we realize series experiments of DC Machine and

test their performance critically.

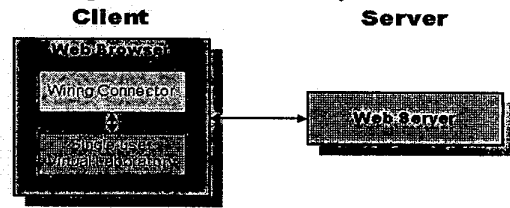


Figure4: The Teaching Environment of Single User

For the needs of more interactions such as discussion and demonstration, the environment of multi user is adapted shown as figure 5. The Communication Server set up for receive the data of every client and transmit to the specified client. The Session Master traces and records the clients' behavior, also provide a super-client service for the management of environment such as log, security, file, fault, performance and accounting.

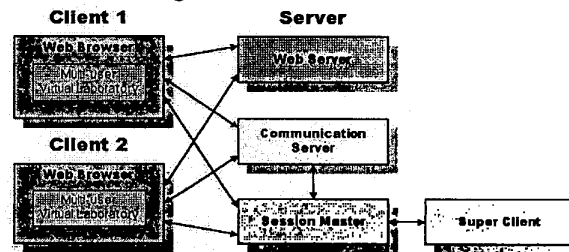


Figure5: The Teaching Environment of Multi User

### Wiring Connector Module

The Wiring Connector Module that we proposed consists of three compartments. They are Wiring Block, Wiring Diagram, and Wiring Rule-base. Wiring block has three categories: Circuit, Machine, and Instrument (Table 1).

Table 1: Wiring Block

Category	Icon
Circuit Block	
Machine Block	
Instrument Block	

Learner selects a block and arranges it to the

Wiring Diagram (Fig. 6). We also provide series samples for student by clicking menu bar. After complete wiring diagram, click the icon “ok” to check the result under the appraise of Wiring Rule-base (Fig. 7), besides the system also report the corresponding type of experiment. For more detail about each Node, click “Show Connection” icon will get the connection status list table. For example, Node-P connected by P<sub>+</sub>, V<sub>1P</sub>, and A<sub>1N</sub>.

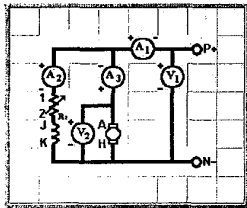


Figure6: The Wiring Diagram

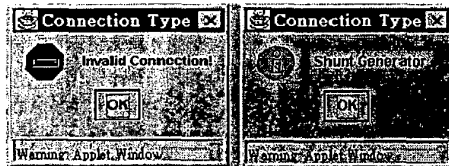


Figure7: The Wiring Rule-base

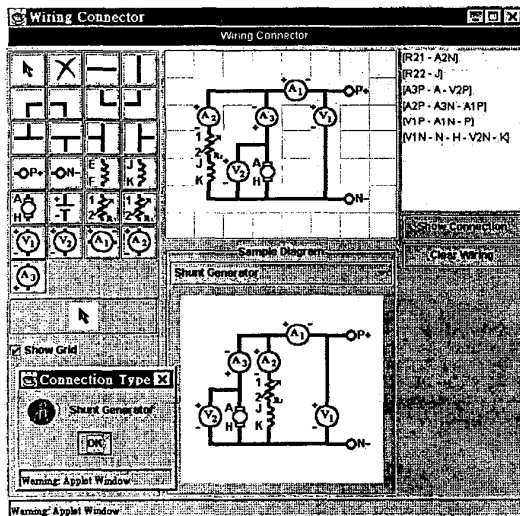


Figure8: The Wiring Connector Module

### Electric Machinery Set Module

We built four Modules of Electric Machinery Set in the VR laboratory for the usage of Single-user and Multi-user. Each machine set includes Induction Machine, Eddy Current Machine, Synchronous Machine, and DC

machine (Fig. 9).

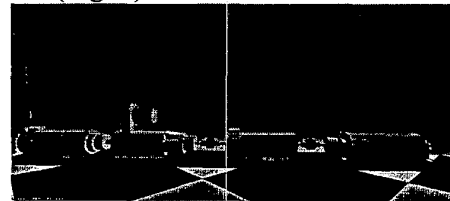


Figure9: The Electric Machinery Set

### Control Panel Module

The Control Panel Module (Fig. 10) consists of Power-switch, Instruments, Variable-resistance for the regulation of exciting field and armature. Student could regulate variable-resistance to get every situation and record data of experiment for analysis. The specified physical-wiring figure shown in the panel is transferred from Wiring Connector automatically. On the panel of figure 10, there are 6 instruments such as voltage, ampere, and rpm meters. Besides the analog display function, the digital data is synchronous displayed here.

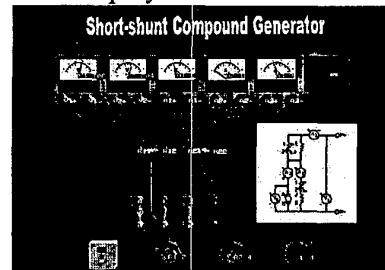


Figure10: The Control Panel Module

### Avatar

In the virtual environment, everyone needs an Avatar as a physical user while navigates in the Virtual Laboratory, not only in single-user but also in multi-user status. The system provides four different kinds Avatars for choice (Fig.11).

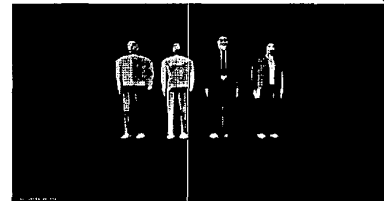


Figure11: Four kinds of Avatar

### Discussion Dialogue

Using the technology of VRT Paraworld Communication, students have much more

interactions in the virtual environment, such as make discussion to each other, and teacher [24]. Through the dialogue, teacher demonstrate and instruct to students more interactively and friendly.

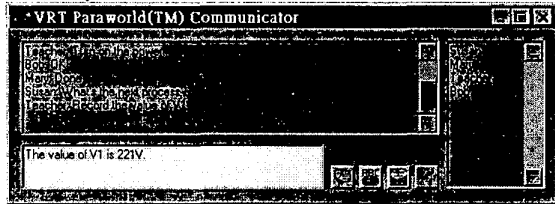


Figure12: The discussion Dialogue

### Web Pages

After login the system by Internet, user will have the homepage of greeting and catalog. He could select Training (Theory Courses) pages, Single-user Virtual Laboratory, or Multi-user Virtual Laboratory pages for learning (Fig. 13).

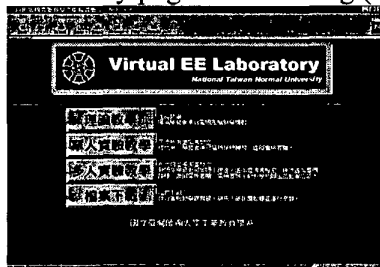


Figure12: The Homepage

As user's selection, the entrance of Virtual Laboratory will display to him (Fig. 13).

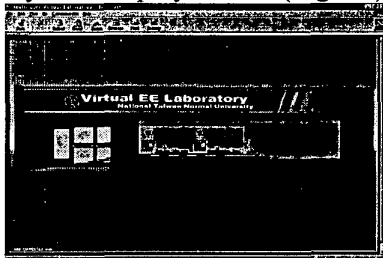


Figure13: The Virtual Laboratory

A Multi-user experiment environment is shown as below (Fig. 14).

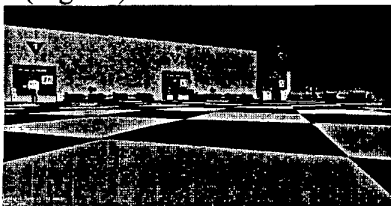


Figure14: The Multi-user Experiment

An interaction example of teacher and student shown as below (Fig. 15), by the way of VRT Paraworld, they communicate to each other and operate on the Control Panel alternately.

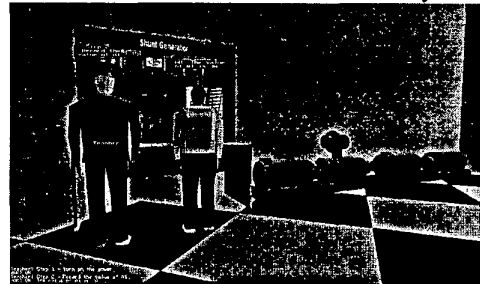


Figure15: The Interaction of Teacher and Student

### Conclusion

In this paper, we describe a Distance Learning system, designed to give engineering students an enhanced study of the theories and operation experiences of electric-machinery experiments. The Virtual Laboratory we completed, has highly reality, flexibility, and interactively. It is not only for individual learning but also suitable for Team-education and Team-training. In our research, using the technology of VRT Paraworld Communication for Communication Server and Session Master. Also, the JAVA technology is used for the modules of Wiring Connector, and Control Panel. VRT technology is used for the construction of Virtual Laboratory. These experiences provided here for future works.

The system we proposed is setup in the Electric Engineering Laboratory of *National Taiwan Normal University* (NTNU) as a teaching aid for undergraduate while take the course of electric-machinery experiment.

### Acknowledgement

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