



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 13, April 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

9940 572 462

6381 907 438

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# The Virtual Laboratory for School Education System

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**ABSTRACT** : The Laboratory activities are playing a substantial role in supporting scientific learning fields by enabling students to obtain practical skills through experiments and by giving them the chance to have a more profound understanding of the content. Although laboratory activities are expensive and time-consuming, virtual laboratory activities can save money, time, and effort. The Virtual Science Lab (VSL) is a web-based platform designed to improve learning approaches by introducing a safe and interactive lab environment for students in schools. VSL was found to be an exciting, useful, and enjoyable learning environment during user trials. It allowed users to conduct experiments individually and to repeat them multiple times if needed.

## I. INTRODUCTION

Control engineering education should combine theory and practice. Students should achieve knowledge and skills in control systems modeling to develop controllers that enforce performance requirements. After a controller is designed and implemented, observation of the resulting dynamics gives valuable insight into design concepts. Students can observe dynamic phenomena that are often difficult to explain in writing. Furthermore, interactive experimentation on real-world plants improves the motivation of the students and also develops an engineering approach to solving list ictic problems. Simulation is a proper way to complement control education but in general, it cannot replace experiments on real plants. Since simulation is only as good as the model, experimentation has the advantage of making the user aware of phenomena that are hard or impossible to simulate. With remote experimentation, unique or expensive equipment can be shared between different universities. Because a wider range of laboratory resources can be made accessible, students have the choice of a variety of experiments. They can use the Virtual Lab at any time and at any place saving travel time and cost.

## II. SYSTEM DESIGN

The main design idea of the system is to use the World Wide Web as a communication structure and a Web browser the as the user interface. The Web browser provides a platform for transmitting information as well as an environment to run Java applets. The Web itself provides the infrastructure to exchange nice information.



### 1.1 Requirements

Computer-based controller implementation for the experiment is necessary for remote experimentation. Another important aspect is to transport the feeling of a real experiment to the remote user. A video and audio broadcast provides the remote user with the feeling of being present at the experiment location. With the visual feedback, the user can supervise the experiment and check whether everything runs as expected. For system identification and performance evaluation, it is necessary to collect the relevant data on one process. The data should be stored on the server side for later download and additional processing by the students. As only one student at a time receives access to an individual experiment, schedules, and exclusive access procedures to the experiment are necessary. The main requirement of the server is the security of the experimentation plant and of the server computer. The plant has to be protected against any action that can damage or destroy it. For this reason, all commands to the controller of the plant must be analyzed and dangerous controller parameters must be avoided. If the controller algorithms can be defined by the user without any restrictions, controller instability is hard to detect. From the user's point of view, other important must be fulfilled. Students may not have the choice of which computer to use on their site. They usually do not want to install specific software they can start the experiments. Therefore, cross-platform client software is an important user demand. Since students do not want to pay for additional software, free client software is a large advantage too.

### 1.2 Procedure of Remote

Experimentation After a student has requested particular experiments his user ID and password. With that identification, he can log into the server and make an appointment for the chosen experiment. Appointments are stored in a database and are used for access control. The student can download the instructions and tools for offline simulation and preparation of the experiment. At the date of the experiment, the student connects to the server with the help of a Web browser. He uploads his prepared data onto the plant and starts the experiment. A live video and audio stream help to provide the student with a laboratory feel. The output data of the experiment are stored on the server, the user can download them to analyze the results of his efforts.

### 1.3 Communication Structure

Figure 1 shows the communication structure of the system. The communication structure is based on a client/server architecture written mainly in Java. The student may work on any platform that supports a Web browser with a Java runtime. The local Web browser is the only user interface for the experiment. The browser loads the client software as Java applets from the server and starts them. Due to the modular structure of the system, extensions with new features are easy to implement. The communication server runs on a PC with the operating system Linux. The HTTP server Apache provides the HTML documents and the Java applets. The server contains a video capture card and a sound card for video and audio transmission. The real-time controller of the experiment itself usually runs on different computer hardware with a real-time operating system. The connection between the server and the real-time controller could for example be a serial link or an Ethernet. If the real-time operating system RT-Linux [3] is used, the controller can be run directly on the server. The communication structure is generic therefore, it can be used in different experiments. Java applets on the client side, allow the continuous improvement of the software since the applets are loaded when they are needed. Applets are always up-to-date so no software upgrading is necessary when the software changes.

### 1.4 Video and Audio Transmission

A live video stream for viewing the experiment and an optional audio stream helps to provide a laboratory feel. Early Web implementations could not handle video streams. Netscape introduced the server-push mechanism which sends images in equidistant intervals to form a video stream. Server-push technology has the disadvantage that it takes a long time to transmit images to the client. Therefore, the maximum possible frame rates are too slow for high dynamic systems. The throughput of this mechanism is far too high to be used in wide areas or modem connections. Video compression standards mainly used over the Internet (H.261 and MPEG) use motion detection and differential encoding to reduce the throughput of the video stream [4]. MPEG uses a better compression algorithm than H.261 but was designed for stored videos. H.261 was designed for video conferences over ISDN lines and allows encoding of the video stream in real time. Without the help of plug-ins or Java applets, Web browsers cannot handle audio streams. Plug-ins are dynamically loaded modules that are usually written in the native programming language of the computer. Compared to Java applets, plug-ins are capable of using all of the local computer resources. A software failure in a plug-in can damage the student's local computer. Furthermore, plug-ins are not



platformindependent and must be installed on the client’s side. For user convenience and client computer security, a Java applet solution was chosen. To employ a different software product on the server’s side, standard protocols are used. The Real-Time Transport Protocol (RTP) [10] allows the transmission of realtime video and audio via the Internet. It does not standardize any audio or video formats. Therefore, RTP can be used for transmitting standardized video and audio formats [11] as well as for transmitting proprietary formats.

2.4.1Client: The Java Media Framework (JMF) [5] was chosen to display the media streams in the browser. JMF is an application programming ininterface (API) for incorporating media data types into Java applications and applets. The JMF API is a cross-platform solution written entirely in the Java programming language. JMF supports RTP receiving in video and audio streams via the Internet. For realtime video decoding, there is a performance pack that must be installed on the client’s side. The performance pack includes native code in dynamically loaded libraries. In the currently used JMF 1.1, this performance pack is only available for Windows and Solaris platforms. For real-time audio encoding, a

version in pure Java is available. It enables the installation of JMF 1.1 on Web servers to facilitate Web deployment of the necessary JMF library classes. In this case, there is no need for the user to install JMF software on his computer. Because we need the video stream too, the inconvenient software

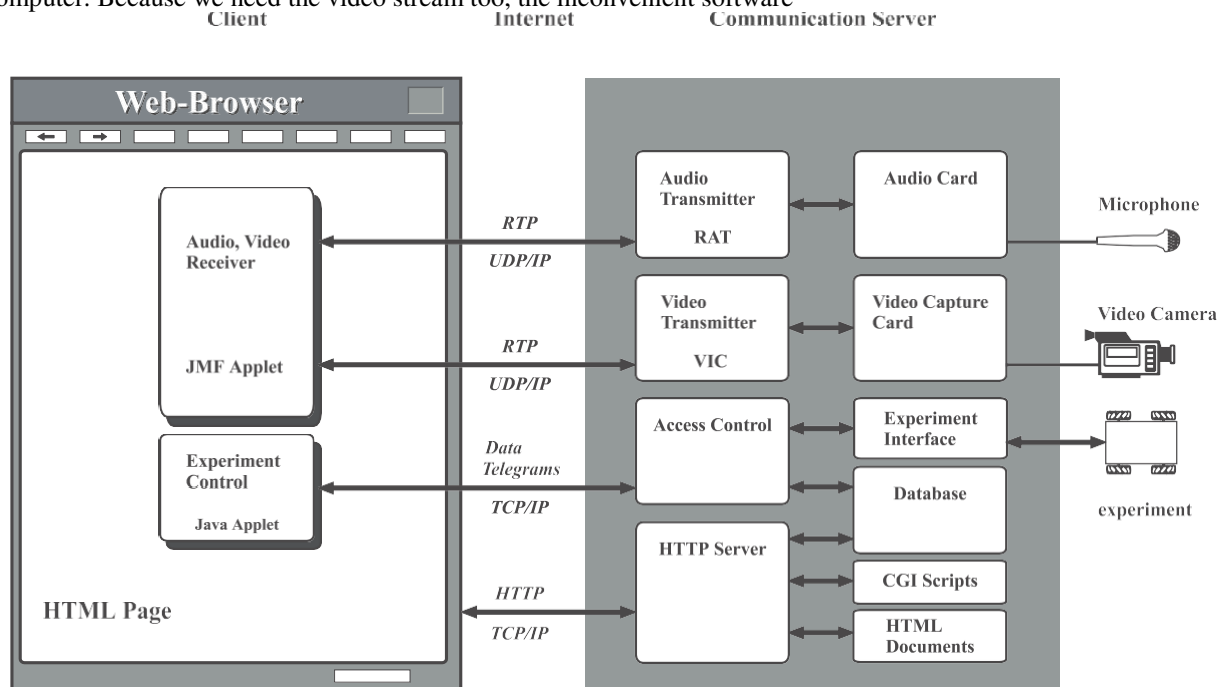


Figure 1: Communication Structure

installation on the client’s side is necessary. Just one single applet is needed to receive the video and audio stream from the server. This applet is stored on the server eliminating the need to install it for the clients. For platforms other than Windows or Solaris, the use of plug-ins to display the media streams is necessary.

2.4.2Server: The used JMF 1.1 is not able to transmit multimedia streams but the upcoming JMF 2.0 will support video and audio capture capability. As this new version is not yet available, Bone tools [6] were chosen to transmit the media streams. These tools are publicly available and run on most Unix systems and Windows. They are specially developed for multicast transmission of the data streams but they support cast transmission too. If transmissions are used, only one client can watch the media streams. To support teamwork multicast transmission is unnecessary modem connections usually are not able to receive multicast streams and multicast to unicast translators to connect the server to several unicast clients. For this task, the Translator [7] has been successfully tested. VIC (Video Conferencing Tool) [8] is used to produce the video stream. VIC supports different video encodings but only the H.261 encoding is supported by both the used Linux release and the JMF 1.1. The throughput of the video stream depends on the frame rate, the frame size, and the image quality. The Common Intermediate Format (CIF) is often



used for video conferencing. CIF produces 352 x 288 pixels at 15 frames per second. To reduce the throughput of the video stream, smaller sizes or fewer frame rates are possible. A quad of CIF (QCIF 176 x 144) or a subquad (SQCIF 128 x 96) is usual. When using VIC with a modem connection and CIF only a few frames per second (1-3) are feasible. When using VIC with a unicast stream it is necessary to know the IP- Address of the client. This is done with the Common Gateway Interface (CGI) of the Web server. After the client is connected to the server, the Web server starts VIC. This is done with a shell script that uses the IP- Address of the client as a parameter for the destination address of VIC. Since the connection to the user may differ, he can choose the frame rate and the maximum throughput of VIC.

RAT (Robust Audio Tool) [9] was chosen for the audio stream. Table 1 shows the different encodings one can use with RAT. The throughput and the sound quality differ very much between the encodings. Not all encodings are supported by JMF. In Local Area Networks (LAN), PCMU encoding is used. This encoding produces a good sound quality and doesn't need too much processing power for compression and decompression. For modem connections, PCMU is not usable because

Table 1: RAT Encodings

Name	Bit rate	JMF	RTP payload type
L16	128.0 kbit/s	-	11
PCMU	64.0 kbit/s	+	0
DVI	32.0 kbit/s	+	5
GSM	13.2 kbit/s	+	3
LPC	5.8 kbit/s	-	7

of the high requirement of bandwidth. In that case, GSM encoding is a good choice. It was specially designed for voice signals and it needs a lot of processing power. If it is used in experiments with technical noise, the sound is not as good as the PCM encoding but works well over a modem connection. DVI is a good compromise between processing requirements and bandwidth. All encodings of RAT use a fixed 8kHz sampling rate.

### 2.5 User Interface

The user interface for controlling the experiment is realized as a Java applet. After the web page is loaded, the applet starts and an authentication dialogue and a control window pop up. The student must enter a valid login name and password to be able to access the server. When the login process is completed, the applet opens a TCP/IP connection to the access control module of the server. This server module is also implemented in Java. The communication between the client and server is executed as data telegrams over the previously opened TCP/IP connection. These telegrams contain commands and optionally, additional parameters. Every command is stored in a database with its valid range of parameters. The access control verifies the telegrams and if the command and its parameters are valid, the experiment interface transforms it and sends it to the experimental plant. The server acknowledges every command with a status telegram. This telegram contains status information of the experimentation plant which is shown in the Java applet on the client side. The control applet and the plant interface depend on individual experiments and have to be adapted to every additional experiment. The access control and the telegram structure are generic and can be used in all cases.

### 2.6 Data Acquisition

While the experiment is running, the input and output data of the experimentation plant are measured and stored as an ASCII file on the server. The students can download the files with the help of their browsers. The files include the input and output values of the plant and controller. Since the values are stored in ASCII format, they are independent of the used platform. A Java application has been developed for the analysis of the controller performance. The program runs as an applet in a browser or as an application in a Java Runtime Environment. To identify the model parameters of the plant, the tool can estimate them using several methods.



### III. CONTROLLER DESIGN FOR AN OMNIDIRECTIONAL VEHICLE

In one of our experiments, students have to design a speed controller for an omnidirectional vehicle with Mecanum wheels that provides three degrees of freedom in Cartesian space. The vehicle is controlled by a VME-Bus computer with the operating system pSOS+. The connection to the communication server is built with a radio Ethernet bridge. The communication is based on the TCP/IP protocol and is similar to the communication between the client applet and the communication server. Students can generate a trajectory to learn the kinematic behavior of the vehicle. The trajectories are created with a CAD tool that supports paths with linear and circular shapes. In the first, step we enhance the existing CAD tool with communication facilities for remote experimentation [2]. The communication module was implemented in the programming language Java and is in the actual software release, used as Java Applet in the browser. After path generation, students can simulate the corresponding motion of the vehicle. If the behavior is satisfactory, students can download the path on the control computer of the - vehicle itself and restart the motion. The audio feedback shows the student the different noise emissions of the vehicle depending on speed and direction.

The first part of the experiment is to model the plant and to identify the parameters of the plant with the help of a step response signal. The measured values of the step response are stored on the server. The student analyses them with the help of the analyzer applet. The analyzer applet can identify the vehicle’s model parameters through several methods. After modeling the plant, the student has to design the parameters of the speed controllers of the wheels. He can adjust the controller parameters with sliders in the control applet. He has the choice of different paths before he starts the motion of the vehicle. Figure 3 shows the Web browser with the audio, video, and control applet. While the vehicle is moving, the desired and actual velocities of the four wheels are measured and stored as an ASCII file on the server. The student analyses the data with the analyzer applet. Figure 4 shows the Web browser with two analyzer windows. The controller can be modified interactively until the expected performance is achieved.

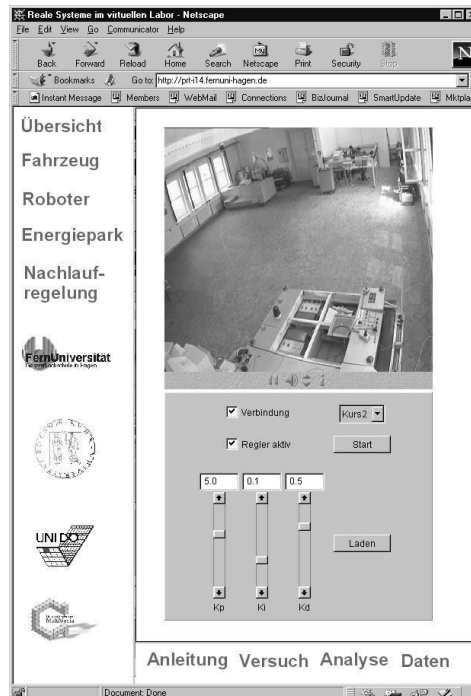


Figure 2: Web Browser with JMF and Control Applet

### IV. CONCLUSION

The paper shows that distance education can be applied to laboratory experiments. On the client part, there are only some minor requirements. A student can use the Virtual Lab with a Web browser and Java runtime environment. On



the part of the laboratory, the experiment must be adapted to the requirements of remote control. The Communication server contains only software that is freely available. Since open standard protocols for the video/audio transmission are used, different software products on the client's side are applicable. The developed software has been implemented in the programming language Java. Therefore, it can be easily adapted to other platforms. The Virtual Lab can be extended with video conferencing tools to support teamwork. In this case, only one student at a time has access to the experiment. At different stages of the experiment, various students can and should have access to the experiment. The other students can observe the experiment and discuss the results to modify the controller interactively.

#### REFERENCES

- [1] Project Page <http://prt.fernni-hagen.de/vitlab>
- [2] Rohrig, C.; Jochheim, A.: Remote Control of Laboratory Experiments, Proc. of the 19th ICDE World Conference on Open Learning and Distance Education Vienna, June 99
- [3] Real-Time-Linux: <http://www.rtlinux.org>
- [4] Bolot, J.; Hoschka, P.: Sound and Video on the Web, <http://www.inria.fr/rodeo/personnel/hoschka/WWW5tutorial.ps.gz>
- [5] Sun Microsystems: Java Multimedia Framework, <http://www.java.sun.com/products/java-media/jmf/index.html>
- [6] UCL Networked Multimedia Research Group: MBone Conferencing Applications, <http://www-mice.cs.ucl.ac.uk/multimedia/software/>
- [7] Parnes, P.: translator <http://www.cdt.luth.se/~peppar/progs/translator/>
- [8] Network Research Group at the Lawrence Berkeley National Laboratory: <http://www-nrg.ee.lbl.gov/vic/>
- [9] UCL Networked Multimedia Research Group: <http://www-mice.cs.ucl.ac.uk/multimedia/projects/rat/>
- [10] RFC 1889 RTP: A Transport Protocol for RealTime Applications <http://www.normos.org/rfc/rfc1889.txt>
- [11] RFC 1890 RTP: Profile for Audio and Video Conferences with Minimal Control <http://www.normos.org/rfc/rfc1890.txt>



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