VIRTUAL JOINT LABORATORY – E LABORATORY SOLUTION

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Abstract: This paper presents a remote virtual laboratory, which can be accessed via Internet. This infrastructure provides remote access to virtual labs for programming robots. Virtual Lab is a new way of advanced e-learning concept, where the student was a participant at the same time real and virtual remote control process. Need for life-long learning has increased. Therefore, virtual classrooms and virtual laboratories for common individual and collective learning. These new learning places integrate many technologies and improve its use of net-based communication between student learning and actual connected devices. Robotics animation and visualization can help students to complex robot programming in the virtual and the real world. Distributed learning environments that support learning spaces allow students to access a wide range of resources and rapid economic and facilitate their active participation in the community. So far, many experiments were made with student access to robotic laboratory equipment through internet communication. In the last decade, this area has been expanded education iSPACE Laboratory Network

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1. Introduction

Effective learning in engineering education can only be achieved by these approaches witches combining theoretical courses with laboratory work that could be repeated as many times as the students want. In conventional methods, laboratory training can have many restrictions on foreign providers and learn. This requires more staff (assistant and / or technicians, teachers), the high cost of establishing and maintaining the equipment...

Today's educators and curriculum developers are able to incorporate new technologies to provide a wide range of educational alternatives for learners. [1]. Remote and virtual laboratories provide alternative approaches for solving many educational problems. However, few studies in the literature discuss the requirements of these laboratories or the instructional design issues that need to be considered when building them. Web-based distance-learning technologies are based on interface design elements such as usability, visualization, functionality, and accessibility, all of which play an important role in learning. This system then culminates in high machine utilization, especially for small-sized production manufacturers.

2. System Description

The system consists of a robotic manipulator, Web cameras and servers, acting as a web server, video conferencing and a manipulator controller. Figure 1 shows the system. The client is a remote computer science student. Since the system is equipped with a video conferencing system, the student is able to see what is running on the robot, in real time. In this way students can get the entire course through WWW, without losing the ability to interact, such as asking questions and getting professional help to solve the problem.[2] The Main Server is a PC which includes the web site from where the user can download the Java application to simulate and to teleoperate the robot. The Tele-operation Server validates the commands that the robot receives from a user’s computer, translates them to the appropriate language, and sends them to the robot controller. The IP camera allows users to receive video streams by means of the HTTP protocol as feedback during the teleportation processes. Finally, a PLC permits remote power control of the laboratory [4]:

The system development was divided in three separate parts:

1. The local control of the robotic manipulator;
2. The teleoperation of the manipulator and;
3. The videoconference and visual feedback system

Fig. 1 Hardware components

The local control of the robotic manipulator. This cell is based on an ABB IRB 2000 robot. Some of the most important features of this robot are presented below:

- Degree of freedom - 6
- Loading capacity - 10 Kg
- Repeatability - ± 0.1 mm
- Reach length - 800 mm
- Operating area
  - Axis 1 - ±179°
  - Axis 2 - +100° to - 110°
  - Axis 3 - ± 60°
  - Axis 4 - ±200°
  - Axis 5 - ±120°
  - Axis 6 - ±200°
- Speeds
  - Axis 1 - max. 115°/sec
  - Axis 2 - max. 115°/sec
  - Axis 3 - max. 115°/sec
  - Axis 4 - max. 280°/sec
  - Axis 5 - max. 300°/sec
  - Axis 6 - max. 300°/sec
- Drive - DC servomotor
- Pressure range - 4 to 8 bar
- Digital Outputs - 16 (0.2A;24VDC)
- Digital Inputs - 16 (24VDC)
3. The teleoperation of the manipulator

An important part of any computational architecture is the software. In this system, the software provides system modeling, planning, sensing and acting.[7] The architecture of the systems functional modules is shown in Fig. 2

The goals of the software modules were to provide

- A flexible and friendly environment for coding, debugging, and running programs
- A friendly simulation environment for generating necessary background data for proper system performance,
- Different library modules to be combined for various applications

![Fig. 2: System functional modules](image)

The system functional modules, shown in Figure 2, include:
- Model Data was developed to simulate the camera and robot work cell operations [6] and in this way allows you to display 2D perspective gray image that is very similar to that of real cameras.
- Communication among subsystems:
  - a) CommTools that allows PC to access files on any NFS server
  - b) Image processing system and robot control system
  - c) 3D F/T sensor and robot control system
  - d) Common database

Off-line programming is, by definition, the technique of generating a robot program without using a real machine. It presents several advantages over the on-line method:

- a) programs are prepared without interruptions of robot operation, resulting in reduction of robot down time;
- b) removal of the programmer from the potentially dangerous environment, as most of the program development is executed away from the robot;
- c) new programs can include previously developed routines;
- d) program changes can be incorporated quickly by substituting only the necessary part of the program;
- e) signals from sensors can be incorporated into programs;
- f) information from the environment (CAD/CAM systems) can be incorporated into programs;

It permits verification of the robot behavior through graphical simulation and allows for the correction of any error in the program. The virtual lab developed implements a large amount of options suitable for robotic e-learning. Students will be able to learn complex robotic concepts by means of a VR environment in an easy way.

4. Conclusion

In this paper, we presented the development of a Virtual and remote controlled laboratory for industrial robotic arm. Our system is mainly focused on training and e-learning robotic concepts. The application is developed using open-source tool for creating interactive simulations. In this way, the process for conversion of robotic systems in an interactive virtual lab's easier to make than most programs available.

With a virtual laboratory, students can learn robotic concepts such as direct / inverse kinematics, path planning and dynamic programming. The user interface is very user-friendly, graphic and very realistic simulation. The remote possibility of application allows users to experiment with the right equipment on the Internet. This kind of virtual laboratory allows the teacher and the students of an on-line course through the Internet to use shared simulations in order to experiment practical concepts in a coordinated way [5]. Also, if we built Virtual Joint Laboratory, then we are the part of ISPACE. The iSpace Laboratory Network is a worldwide scientific non-profit network of professors, researchers and laboratories engaging in active research in the intelligent space-related

5. Reference