Technology Used for the Implementation of Remote Laboratories

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Abstract

Access remote laboratories, are increasingly being used nowadays, which have made it possible to democratize education by the ease that gives the user to use this technology, which in some cases physical laboratories are highly expensive, in order to have it in quantities, which allow students to practice. In this work an analysis is made of the technologies needed to implement laboratories, which can be accessed from remote locations, using client connections server. This analysis will give an overview of how the different existing technology can be used for the development of these tools of academic support.

Keywords: Education, laboratory, remote

INTRODUCTION

Los laboratories are pedagogical tools that brin-give students an education consistent with The real world by helping to consolidate theoretical concepts, through the solution of real problems, proposed in a certain context [1]. can be highlight three types prin-cipal of laboratories: traditional Laboratories (physical laboratories), virtual labs and remote labs [2].

The traditional laboratories allow the execution of experiments in the place where the physical elements. This type of laboratory has been for many years, the solution to the academic requirements of the students, however, have many limitations of time, amount of space and equipment [3].

Virtual laboratories, in contrast, are those that allow, through the simulation of experiments on a computer, users to perform any type of practice in a virtual way, i.e. are laboratories fully simulated. Virtual laboratories do not have the limitations of the traditional laboratories, but its main disadvantage is the loss of contact with reality in the realization of the experimentos[4].

Unlike the virtual labs, remote laboratories or LRs have a physical computer that can be monitored or operate remotely [5], [6]. The purpose of remote laboratories is to allow the interaction of the student with the experiment present in a physical lab [7].

The implementation of LRs, if combined with a methodology of adequate education and is a good solution to the impediments of the traditional laboratories [8]. however, they may think that they are not the solution more simple because it has as many or more requirements that a traditional laboratory and generate less impact, given that not even the experience of direct interaction with the equipment or experiments, a traditional laboratory [9], [10]. As a complement, which makes the wider the scope of the traditional laboratories, to overcome the constraints that these have [11].

The concept of LR has been implemented in a number of disarmament-rolls. One of these is shown where [12], the authors present the development of a LR e with a 'Personal Robot 2" (PR2) of Willow Garage. In [13] developed a LR for the teaching of control to engineering students of undergraduate and postgraduate education. Another implementation are the platforms-more "Micronet" and "Astronet", for the remote control of an electron microscope and a telescope located on the University of Salento, for the preparation of students for undergraduate and postgraduate degrees [10]. in Colombia, was implemented a platform of LR using the National Network of Tec-nology Advanced Renata, for the teaching of mobile robotics and manipulators, mainly, in the University of Valle and the University of Quindío [14].

For the development of the LRs, authors use different technologies. Below is a detailed review of the most widely used technologies by different authors in the implementation of LRs, by first describing the main requirements of a LR and the most common architectures.

This article is organized in the following way. In Section 2 describes the requirements that have remote laboratories. Then, in section 3, are displayed more architectures used in the implementation of the same. In Section 4 describes common architectures in the implementation of LRs. Finally, in section 5 give the conclusions of the item.

REQUIREMENTS OF THE REMOTE LAB

A LR must allow the user to interact with physical elements present in a laboratory. To ensure that this pro-cess give properly, the remote lab should have the following elements [15]:

Computer or physical plant: equipment or plant is the element with which the LR allows the user to interact with it, for the realization of the experiments. This must exist physically, otherwise it would not be a LR.

User Interface: by means of which the user accesses the LR. It is important that the interface is multiplatform, so that the user can use the LR regardless of the operating system or Web browser that has. In addition, Care must be taken to ensure that the user needs to install the minimum amount of programs or plug-ins on your computer.

Agenda for the use of the laboratory: Although the objective of the LR is having the availability that a LT has no, a user cannot access the LR at any time. You need to assign the practices in an organized manner and limit the time of the

experiments previously, in order that all users have the possibility of using the LR.

Database of experiments: It is necessary to have the registration of experiments, knowing the user who uses the LR and the hours of use. This allows you to have control over the use of the LR. In addition to this, in the BD can store information and data relevant to the LR, as the agenda.

Access Control-Control of access to the LR allows delimit the population that can use, through the identification of each user name and password per-sonal. This allows also have differentiation of users (e.g.. Teacher or student) and generate the record in the database of those who have made use of the computers in the lab.

Visual feedback: It is necessary to count with a means of visual feedback within the architecture of the LR. This not only allows the user to know the real state of the experiment, also increases the sense of reality in relation to the practice. The auditory feedback can help to increase this feeling, however it is not as popular as the visual feedback.

The existence of these elements within the laboratory re-moto allows adequately fulfill its function. For the LR give good service to their users, must be carac-terizar by be multiplatform, require a minimum amount of software installation or add-ins, efficiently use the bandwidth, provide security and generate the maximum interactivity between the experiment or physical computer and the user in real time [16].

ARCHITECTURE OF A LR

The LRs enable the realization of laboratory practices remotely using a computer or real experiment, by which they are hardware and software components [17]. within your hardware components you must include the computer or experiment, with which the user can interact, together with a means of visual feedback, which allow the user to view the computer that is located in the laboratory is usually used an IP camera for this purpose. On the other hand, the software of the LR must have a structure that allows for the communication of the user, by means of the user interface, with the equipment in the laboratory, complying with the requirements of a LR, named above. A generalized architecture of the LRs shown in figure 1, composed of the experiment or computer, the camera for the visual feedback, the lab server, a web server that allows the connection of the users with the laboratory through internet, the database and the computer that is running the user interface.

The architecture of the LR can vary, on the server side, according to the tools that are used in its implementations.

Documentation [18]. can be defined three main types of lab-remote oratories, according to the method of deployment: With software intermediary, with controller web tool and with remote desktop.

The LRs that uses software broker permit the user through a user interface, can communicate with an administrator interface, which runs on the com-putador server in the LR, which in turn communicates with the driver from the computer. The communication between the server and the driver of equipment is achieved using a middleware software.

The LRs that use controller with web tool are those that use a driver software, equipment or experiment, which has tools for

the publication of the developments in the internet, with the purpose that a remote user can interact with them, as Matlab and LabVIEW.

Finally is the LRs with remote desktop. This type of LR allows the user, through a user interface, navigate to a remote desktop application that allows you to interact directly with the software driver from the computer, installed on the server computer [8].
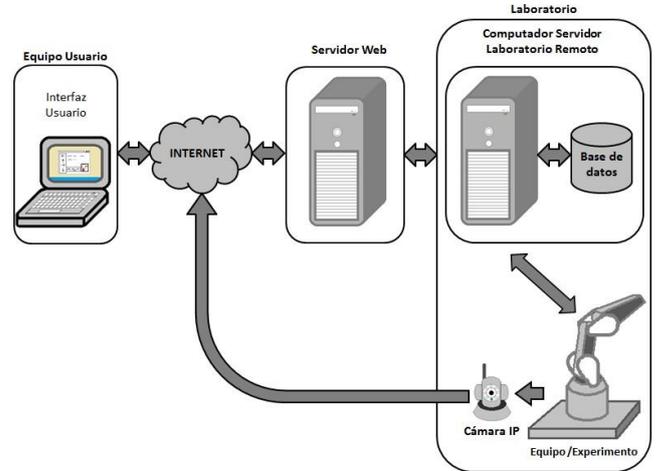
Figure 1: Generalized architecture of a LR

Technologies used in the implementation of LRS

There is a comprehensive list of technologies used in the imple-implementation of LRs. Below are shown the main technologies used for the elements that make up a LR.

USER INTERFACE

Through the user interface, the user accesses the platform of the LR This interface allows you to view and operate the equipment or experiment present in the laboratory. It can be a Web application or a downloadable application for the user to install on your computer. There are various technologies to develop the user interface of a remote laboratory, below are the most used technologies.

One of the most used for the deployment of LR is the technology of Java applet or Java Applet. It consists in an application developed in Java language, which can be run from a Web browser. For this reason and because

Allow the program to create cross-platform applications with high visual content, the Java Applets are widely used for the creation of LR. For example in [17] developed a user application using Java Applets, which allows interaction with a prototype industrial food preparation, in a LR of automation. Applications developed in java language are running in a sandbox, which prevents access to the hard disk of the computer, making it a secure application to the user. However, this can cause problems when the user needs to send information that involves access to the hard disk; in these cases it is common to combine java with another tec-nology to perform this type of actions [16]. Another disadvantage to develop applications with this technology is that for the implementation of the applications, in many cases, the user must install or update plug-ins.

Easy Java Simulation (Ejs) is a tool of open source software, which allows you to create applications in Java, with low programming requirements [19]. Ejs can be downloaded for free from http://fem.um.es/Ejs/. This tool has several elements for the creation of graphical interfaces such as buttons, faders, text fields, menu items, 2D graphics, 3D graphics, etc. In addition, allows you to view IP cameras in real time, which is very important in the development of remote labs.

EJS has been widely used in the LR for the development of user interface. For example, [20] shows the development of a LR for the teaching of control, with the experiment Ball and ARO, for which developed a user interface using Ejs. The authors selected this tool due to that allows you to create complex applications in Java, with a high degree of interactivity and display, with reduced programming skills.

This tool also finds its application in the development of virtual laboratories, because with it you can make simulations of simple way [21].

In [22] implemented an integrated laboratory, virtual and remote, for the teaching of control with a system of three tanks, whose user interface is an Applet developed with Ejs. This interface allows them to view and interact with the physical experiments, in real time.

In the development of the user interface is also used Adobe Flash [10], software to create multimedia content, audio and video, with which you can interact with the user. Adobe Flash is a multiplatform technology, with a great performance in graphics and animations, whose applications can run from a web browser, which makes it a suitable technology for the implementation of LRs [16]. similarly to what happens with the Java Applets, one of the disadvantages of Adobe Flash is that in the best of cases it requires the installation of add-ons, or updating the same, for the implementation of the applications developed with this technology.

DATABASE

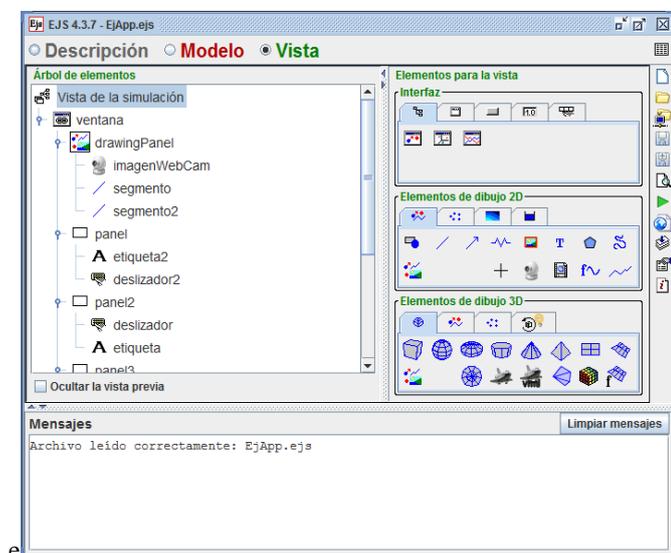The LRs require a database (BDs) where you can store the schedule of practices and relevant data

Figure 2: "View" window EJS

Of the experiments as a user, time of use, results and comments. This information enables you to give order to the available times for the use of the LR (agenda), detailed knowledge of who is responsible for the practices and receive feedback from users on the operations of the LR. There are different administrators of BDs that can be used in the implementation of a LR, one of the most used is MySQL [11], [23]. MySQL is an administrator of BDs that is characterized by be multiplatform, compatible with various programming languages and scalable [24]. this BD Manager provides the following tools [25]:

SQL Server, which allows access to the database

Programs for customers, through which the user interacts with the database

Bookshop: For the user to develop their own pro-grammes in different languagesTeam Driver Software.

The software driver enables the interaction the computer or experiment in the lab. Is responsible for sending and receiving information from the hardware. In many cases the driver is own of the computer or the experiment. When the computer is not equipped with a driver of their own or is an experiment that designed for the practices of the remote lab requires a software that enables the communication with the hardware, i.e. read sensors, active actuators, among other functions. In these cases, for the implementation of LR, common is the use of Matlab/Simulink and LabVIEW as drivers, usually through the use of a card of acquisition or DAQ card. In this section reflect on these two tools, because it is difficult to name each of the drivers used in LR. Matlab is a tool with a high-level programming language that offers the programr to an integrated development environment (IDE) [26]. Simulink is a programming environment in block diagrams that is integrated with Matlab [27]. and Simulink are widely used as soft-ware driver, in the development of LR [28]. for use as a controller, a toolbox of acquisition of data that allows to connect the software with a data acquisition hardware or DAQ card [29].

The main advantage of using Matlab or Simulink is that you can integrate with Java environments, C, C++ and.NET with which you can use the tools of Matlab remotely from a computer that does not have the license [30].

For example in [31] shows the implementation a lab-Oratory for remote mobile robots based on Ejs and Matlab. In this development use the library JMatlink which allows you to connect the application of Ejs and Matlab. To make the remote connection use the Java server Internet Matlab (JIM Server), which is an open source software developed in Java, which allows an application developed in EJS that runs on a computer, use Matlab remotely from another computer that is licensed.

As previously was appointed, another tool used in the implementation of LRs is the development software LabVIEW. Allows you to create systems graphically, with in-terfaces of user that can contain elements of procurement-tion, analysis, viewing and storage of information. The programs developed with LabVieware called virtual strumentos-or virtual instruments (VIs), because they have a similar appearance to the physical instruments [32]. like Matlab,

LabVIEW is very used in the deployment of LR as driver, because it is designed to communicate with hardware tools as acquisition cards.

Labview account with a tool called Web Publishin Tool. This allows the user to publish the Vis in a web page, with which you can remotely monitor and control [33].

For the integration with other applications, Labview has the technology Data Socket, which simplifies the exchange of information between computers and applications. This technology is specially developed for applications that require integrating hardware and software and the LRs, since it allows the interaction with the hardware and the transmission of data in real time [34]. to interact with a VI remotely, there is also Java Internet LabVIEW (JIL server) that, as Jim, enables the user to interact with the VI from a java application remotely [35].

The disadvantage of implementing LRs with Matlab/Simulink or LabVIEW, is that for the use of these tools are you must purchase a license. This implies that functions, such as Web Publishing Tool in LabVIEW, vary depending on the version of the license purchased, limiting the developer [18].

MIDDLEWARE

In the LRs, the middleware allow communication with the controller, to achieve interaction with the computer or physical experiments. A Middlewares is a software that enables the exchange of information between two applications, allowing them to interact. Put another way, a middle-ware is the intermediate layer between two technologies [36].

Main characteristics that must have a middleware are [37]:

Interoperability, which is the ability to exchange information between two or more components.

Transparency, which makes reference to hide information that does not need to know, like the location and form of distribution on both the server and the user.

Scalability, that could be adapted according to the size of the problem.

Abstraction, to facilitate the programr to the creation of applications.

There may be many middleware as drivers of computers. An example is the Common Object Request Broker Architecture (CORBA), used in [38], is an object-oriented architecture proposed by Object Management Group (OMG), which allows the interaction between different software programming languages, executed in different computes-ing. CORBA applications are composed of objects. An object is a single unit of software. Each object can be a client or server, the client invokes objects that the server creates and makes provision [39], [40].

Other middleware used in the deployment of LR is Robot Operating System or ROS [12], a open source middleware for robots, developed by Willow Garage in the Artificial Intelligence Laboratory of Stanford (SAIL). ROS is a mechanism of communication that works with the topology peer-to-peer (P2P), that is to say that consists of a series of nodes interconnected, which communicate between themselves with structures of data types. The nodes have two types of communication: Service and Topic. The first is a

synchronous communication, in which sent messages and is waiting for a response between the nodes. The second is asynchronous, in it a node publishes a message and other nodes signed can access it, but cannot respond to the node publisher [41].

Oracle also offers technologies, for java platforms, which provide functions of middleware. In [14] use a middleware based on Java Servlets, in the implementation of a LR for the teaching of robotics, which achieve the user interaction, from a java applet, with robots present in physical laboratories.

JIM and Jil you can also consider Middleware, as they act as intermediaries between Java applications and Matlab or Labview respectively [42], [43].

REMOTE DESKTOP

A Remote Desktop is a technology which allows a user to work from a computer on the desktop of another computer, remotely. The LRs with remote desktops are common, due to the use of this tool prevents the use of Middlewares or inter-mediariossoftwares, since the user accessed through a web application to the desktop of the server computer of the LR or to the part of him that is authorized.

There are various tools for implementing LR with remote desktops [35]. a it is Virtual Network Computing (VNC), an open source software multi-platform for remote desktop. Some variables of VNC

Are used in LRs as Tight VNC and Ultra VNC [44], [8]. VNC these variables are supported in their majority among them, some are free and others require acquire license according to the use that you give.

Other technologies of remote desktops are remote desk-top Connection, Screen Sharing, go to my pc, LogMeIn and Team Veiwer [1].

CONCLUSIONS

In education is important to the completion of laboratory practice for the consolidation of theoretical knowledge. Traditionally, the practices are carried out in the LTs, however, the LTs have limitations related to the availability of time, space and equipment. For this reason, to overcome these limitations, the LRs are a complement to the LTs.

In the implementation of a LR must ensure that it is multiplatform, as far as possible does not require software installation or add-ins, use efficiently the bandwidth, be sure and generate greater interaction between the user and the computer or experiment. Considering these features, the LR must count with visual feedback, user interface, database, and access control, ensuring that the LR adequately fulfill its purpose.

At present there are many technologies that help the developer to comply with the requirements of the LRs, in this article were shown some of the most widely used technologies by different authors in recent years in the development of the most relevant elements of a LR. For example, in the implementation of the user interface, a technology very used in the LRs is Ejs, a tool that allows you to create java applications without the need for many programming skills.

With regard to the administrator of the database, the most used is My SQL. On the other hand, the software drivers can be as varied as the same equipment or experiments, however they may say that Matlab and Labview software are very well known, commonly used as drivers in the LRs. In the same way there are many Middlewares, which although not always required in the implementation of a LR, are of great importance because they can generate the exchange of information that allows the interaction between the user and the experiment or computer.

The technologies are very varied and constantly change with the passage of time, which allows each time it is easier to find one that fits the requirements of the LR, but it is necessary to select them properly making a detailed study of them.

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