Weblab - Microscope

A remote laboratory for experimenting with digital microscope

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***Abstract*—the use of high accuracy positioning systems provides endless possibilities for the development of remote laboratories. The remote laboratory presented in this paper allows full control of a microscope over a surface by the use of a Cartesian positioning system. The arrangement of multiple samples over the accessible surface by the lens so far as the provision of a rich graphical user interface will allow secondary school students to carry multiple experiments in biology, physics and chemistry through internet.**

Keywords— remote laboratory; positioning systems; digital mircoscope.

I. Introduction (*Heading 1*)

At the present time, most of the virtual laboratories available on the Internet that provide experimentation over mechanical systems are software-based. Experimentation provided by these systems is performed simulating real items and conditions. However, the simulation of real world conditions never fits the real behaviour. In these terms, experimentation over real equipment and samples allows the student to be closer to hands-on experimentation.

The lack of real remote laboratories is higher in those fields where manipulating items is necessary such as physics, chemistry or biology. This inconvenience can be solved through automatic or semiautomatic systems that allow users to control various elements remotely.

The remote laboratory introduced in this paper implements a software and hardware based system for performing experiments, quality reviews or material analyzing tasks remotely.

Proliferation of 3D printer has emerged very affordable mechanical systems capable of perform very precise manipulations.

II. The Scope of The Project

The scope of this work is the development of a remote multipurpose remote laboratory using an automatic positioning system. For testing purposes, the element to be accurately positioned will be digital microscope. It can be used for observing and analyzing organisms or surfaces of various materials.

The whole system consists in several parts and can be divided into various isolated subsystems:

- Development of an automated positioning system.
- Development of a firmware for controlling the mentioned machine.
- Development of the web application for remotely controlling the whole system.
- Integration with the RLMS Weblab-Deusto.

III. The Remote Lab

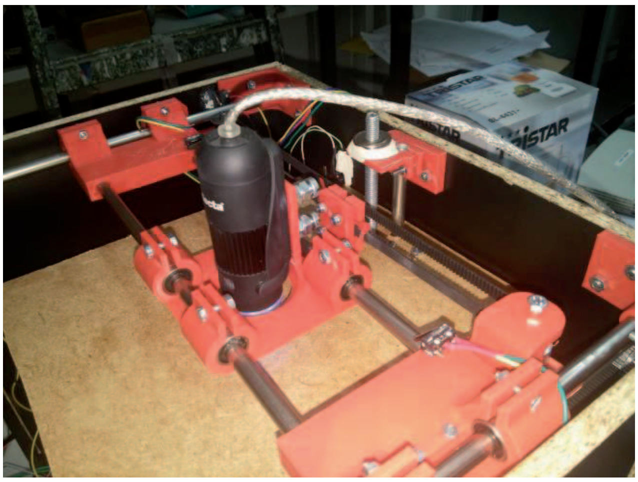
The remote laboratory presented in this paper, allows performing various tasks.

First, students will observe the evolution and behavior of organisms with a magnification up to 220X. This make possible performing some biology experiments like observation of bacteria cultures or insects.

Additionaly, the laboratory can be used for remotely perform quality inspections or diverse materials analysis.

The first prototype, shown at Fig.1 has been developed as a proof of concept previously to the definitive system that is currently in progress.

Fig. 1. First prototype of the remote laboratory.



The developed prototype performs all the main features required for remotely control the microscope system:

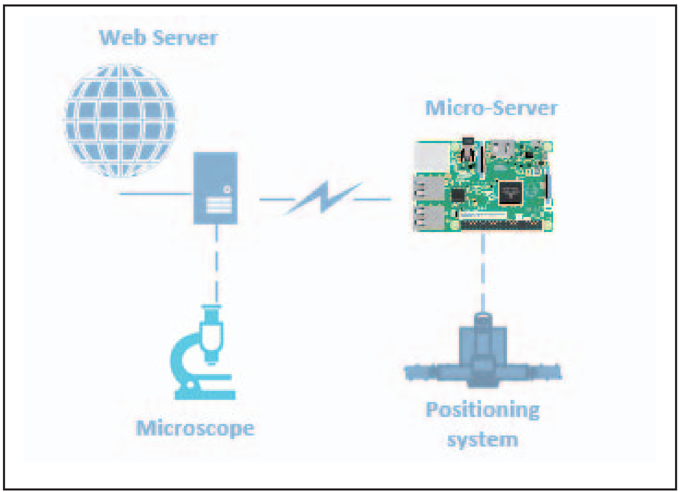
- Allows accurately controlling the position of the microscope over the surface.
- Shows the microscope captured image in real time.
- Being imntegrated in the WebLab Deusto Remote Laboratory Management System, the user session is fully registered. This feature allows cloud recording of snapshots from the microscope.

IV. System Architecture

The whole remote laboratory can be divided into various well defined subsystems that will be deeply explained during next paragraphs.

Fig. 2 shows the interconnection between the main components of the system.

Fig. 2. Architecture of the remote laboratory.



A. Positioning System

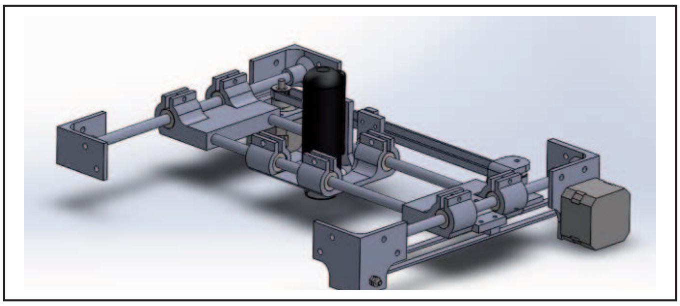
The main element of the developed remote laboratory is the Cartesian positioning system (Fig 3.). This system has three degrees of freedom, which allows controlling both the position of the microscope as the distance to the sample. Displacement over X and Y axis (position of the microscope) are conducted by two stepper motors, one per axis, and a carriage driven by two belts.

The Z axis is driven by a spindle rotating over a stepper motor. This subsytem allows controlling the distance between the microscope and the sample.

B. Electronics

The developed electro-mechanical system is powered by an embedded device. The device selected for the first prototype is a Raspberry Pi model 2 and performs two main services. First, it runs the firmware for controlling all the stepper motors and therefore, control the position of the system. The second service performed by the embedded device consists in running a lightweight web-server to enable the communication with the WebLab-Deusto Remote Laboratory Management system through a local network.

Fig. 3. Positioning system on the X and Y.



For powering the stepper motors, the Allegro's A4988 driver is used. The driver features include adjustable current limiting, overcurrent protection, and five different micro-step resolutions. It operates from 8 to 35 Volts and can deliver up to 2 Amps per coil. By correctly using the micro-stepping feature, a resolution of 0.1mm is achieved.

In order to easily connect the embedded system with the power electronics a customized PCB has been designed (Fig. 4).

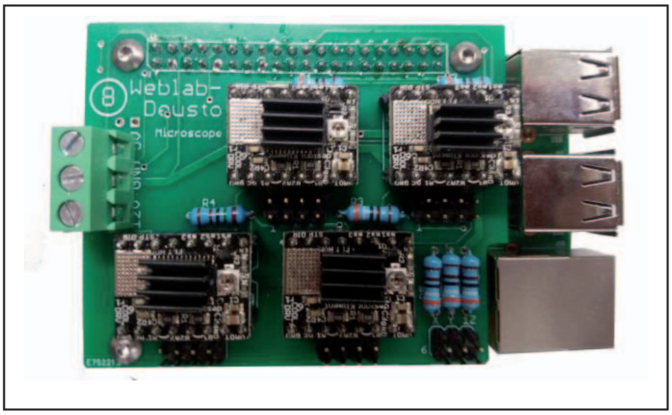
C. Firmware

The firmware hosted in the Raspberry Pi running Raspbian Wheezy Linux distro has been developed in Python, facilitating portability to different embedded devices. The firmware can be easily adapted to other Cartesian machines changing the parameters included in the configuration file.

D. Capture System

The microscope chosen for the sample capture is a Dino-Lite Edge AM4515ZT. This device provides a resolution of 1280x1024 pixels with a magnification range between 15x and 220x. It includes its own controller Dino-Lite MSKM01 allowing direct control from the client provided by the RLMS.

Fig. 4. Printed Circuit Board designed to facilitate the connection of the electronic systems with the embedded platform.



The firmware has been developed using object-oriented paradigm and contains three main classes:

- The “Axis” class contains methods for controlling engine’s speed or direction. This class can be used for different lineal positioning systems by configuring some attributes.
- The “Machine” class contains three axis objects properly configured for the designed positioning system.
- Finally, the third defined class consists in a light weight web-server which interacts with the machine class based on the requests received from the client.

Adopted design facilitate the reusability and extensibility of the firmware. It can be extended adding new parts to the positioning system or increasing the number of machines with their own parts. This feature making allows the control of different positioning machines with the same embedded platform.

E. Web Development

Finally the last subsistem of the remote laboratory consists in the web-server which hosts the web application used for accessing the lab. The application has been developed using Flask. Flask is a micro web application framework written in Python and based on the Werkzeug toolkit and Jinja2 template engine. The selection of the framework has been taken out due to the next features provided:

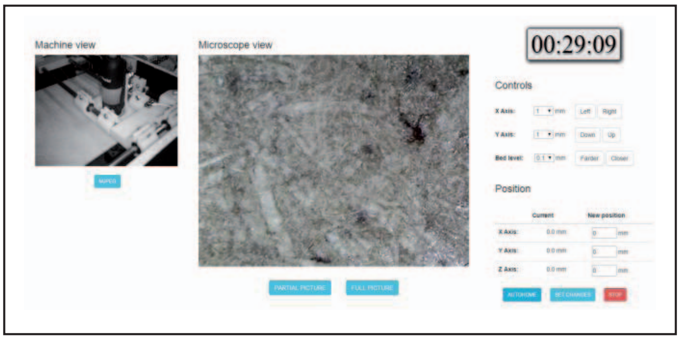
- Contains development server and debugger.
- RESTful request dispatching.
- Support for secure cookies (client side sessions).
- 100% WSGI 1.0 compliant.
- Google App Engine compatibility.
- Extensions available to enhance features desired.

The developed Flask application serves the required templates to the user including all the data shown in the Graphical User Interface and manages the http requests, establishing communication with the micro-server hosted on the embedded device and updating data shown over the front-end (Fig. 5).

As client-side code is written in HTML5, the lab can be used without installing any special software or interpreter.

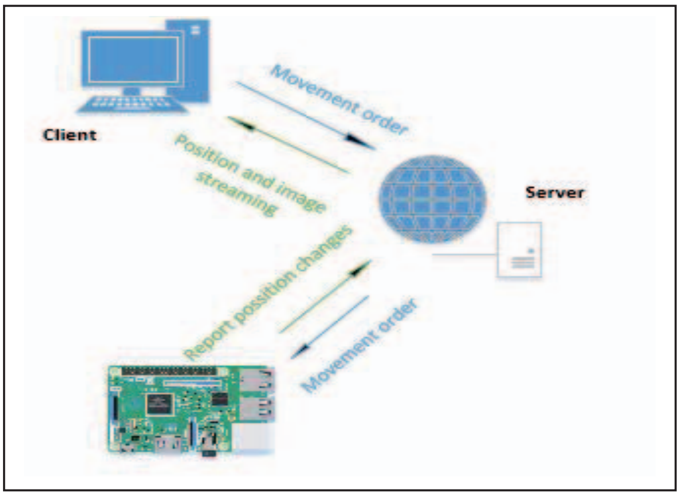
Fig. 6 shows how the user movement requests are conducted to the main web-server. Then, firmware translates these requests to the positioning system’s micro-server. Since the client is receiving both position and image streaming from the server, when the movement is done, the micro-server sends a request to the main server for updating to the new position and once the position is updated on the server, the user can monitor the new position instantly.

Fig. 5. Graphic User Interface.



The microscope is connected directly to the web server avoiding the embedded platform used for controlling the position. That is done for reducing latency and increasing the number of frames received from the client.

Fig. 6. System Data Flow.



V. INTEGRATION WITH WEBLAB-DEUSTO RLMS

The platform Weblab-Deusto is a RLMS (Remote laboratories management system) that provides all administration tasks and facilitate the laboratory consumption from learning platforms such as Moodle or Sakai.

There are two major approaches for developing a remote labs within Weblab-Deusto, managed and unmanaged laboratories. Managed laboratories are those developed with the Weblab-Deusto API. In the other hand, unmanaged laboratories are those where the communication is not sent through WebLab-Deusto, but directly to the final server.

This lab has been developed as unmanaged. A typical unmanaged environment works as follows:

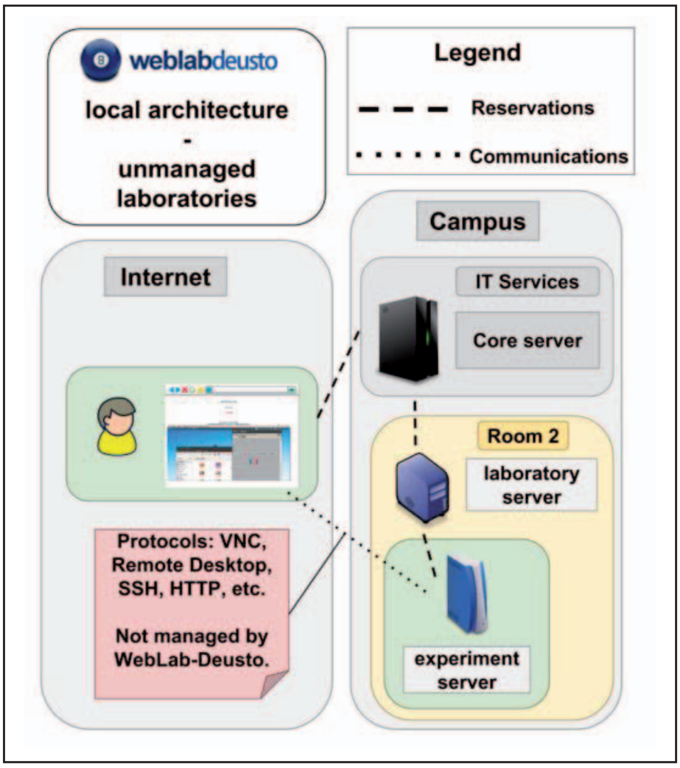
- The user selects a laboratory in WebLab-Deusto.
- Then, when the user attempts to use a laboratory, WebLab-Deusto contacts the laboratory. Some secret

is exchanged between both WebLab-Deusto and the laboratory, and WebLab-Deusto provides the user with a URL which contains a secret so the laboratory can identify the user [6].

- Finally, the user is redirected to that URL and he interacts directly with the laboratory.

This way, Weblab-Deusto manages all the reservation process (Fig. 7).

Fig. 7. System Data Flow.



VI. Conclusion

The use of automatic systems on remote labs allows to carry out experiments where different items must be precisely moved. Using the developed remote lab, students can observe real organisms and study their behavior without the need of having a microscope or maintaining the organisms themselves. The lab can be used for remotely perform quality inspections too.

All the firmware code can be reused for the developing of other positioning systems maintaining the same communication mechanisms.

In addition, thanks to the Weblab-Deusto remote laboratory management system sharing the laboratory with other educational platforms is possible.

Acknowledgment

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