

## Virtual and Remote Labs Using Windows Server and Unity 3D

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### Abstract

In the field of virtual laboratories, applications are diverse ranging from education to field of research and development, depending on the complexity and requirements of these labs, you can find them with access from web domains to use private servers or specialized software for its execution, that is why in this work was carried out the design and development of a multiplatform system with the purpose of storing and interacting with one or more laboratories, both virtual and remote, all under a web page available to the public, and using a database for control and management, achieving mass education through this tool thus decreasing the burden on laboratories physical plant, and to achieve control and manage the flow of users through of MySQL and PHP.

**Keywords:** Windows Server, Unity 3D, MySQL, PHP, HTML5, Virtual Labs, Remote Laboratory, Web server, database

### INTRODUCTION

Virtual labs are intended to amass knowledge using different remote resources that exist today, simulating different types of laboratories, which give access to a number of practical at the same time with the same resources, study, observe and investigate remotely the operation of the various components of the developed laboratory. That is why over the past years have been implemented virtual laboratories (LR) in almost all areas of knowledge, as evidenced in [1] where a new tool shown from the LR to study the relationship of humans with virtual agents, this development allowed to carry out new experiments with the possibility of implementing them in real time obtaining data with greater precision and in shorter times, among others.

On the other hand in [2] a virtual laboratory for the purpose of promoting research in university graduate students to do different types of laboratories including education in computer science, rehabilitation engineering they were developed was implemented, nanotechnology among others. All these laboratories have in common constantly interacting with a central server where the information stored and communicated constantly acquired with the directors of each laboratory, generating a communication tool in real time, adapting to the needs of students.

In a similar way in [3], where a virtual chemistry laboratory, in order to improve understanding and interaction of students with this branch of science and was implemented [4] where a virtual laboratory was designed to analyze magnetic materials at the

nanoscale because of the cost of the different teams and tests carried out to study these materials, it became clear that through the LR is possible to increase the number of studies in laboratory tests, expand the scope on the topics to develop, slow processing and data acquisition and above all provide means of study, research and development for communities and people with low income and / or limitations physical, for which as in the previous development was vital importance that these systems will be developed on a server.

In [5] a solution to the shortage at the universities of equipment and infrastructure for the needs of students and teachers is developed, which is the immersion of machine models in a virtual environment, with the aim of replacing all the previously mentioned components. Similarly, in [6] application of an immersed industrial process in a virtual laboratory, with the main focus technical design, development and operation of the laboratory in real time, in order to demonstrate educationally principles shown industrial automation, as in [7] and [8] where different LV developments are presented, each from different programming languages like Java, Matlab, among others, but in general all focused on professional education to undergraduate level.

Other of the points in favor [9] where they carried out a study of the effect of these LR in attitude and achievements that chemistry students can get to get to use them as part of their process Training, where the 16 virtual experiments were evidenced as the applications that the LR use as learning tools, generate a positive effect on the students compared with the traditional education methods. In the same way [10] A study was conducted to measure the impact or LR in the development of conceptual understanding of students and analytical skills and research in the field of science, showing that test students achieved a higher average scores especially in two cognitive levels, and that this group develop better skills analysis and research in five specific skills studied.

Furthermore in [11] a survey in order to assess the acceptability and timeliness of virtual laboratories as an alternative or complement to traditional physical laboratories in education at the graduate level at universities, where he was evident it was designed that 55.6% of respondents Their main concept is that physical laboratories are not adequate nor do they have sufficient capacity to carry out an adequate and effective education and research process, and as a main result was obtained with a 94.4% voting that the ideal education system It would be a hybrid between physical and virtual silver, taking advantage of the facilities and tools that each one possesses. As evidenced in [12] where by means of a system of data acquisition, hosting server and exchange of information, a data

server, a website and a system of interaction with (the) laboratory (s) virtual (s) "an inexpensive way for schools to have access to laboratories of all types of courses and theme through a computer lab" is obtained.

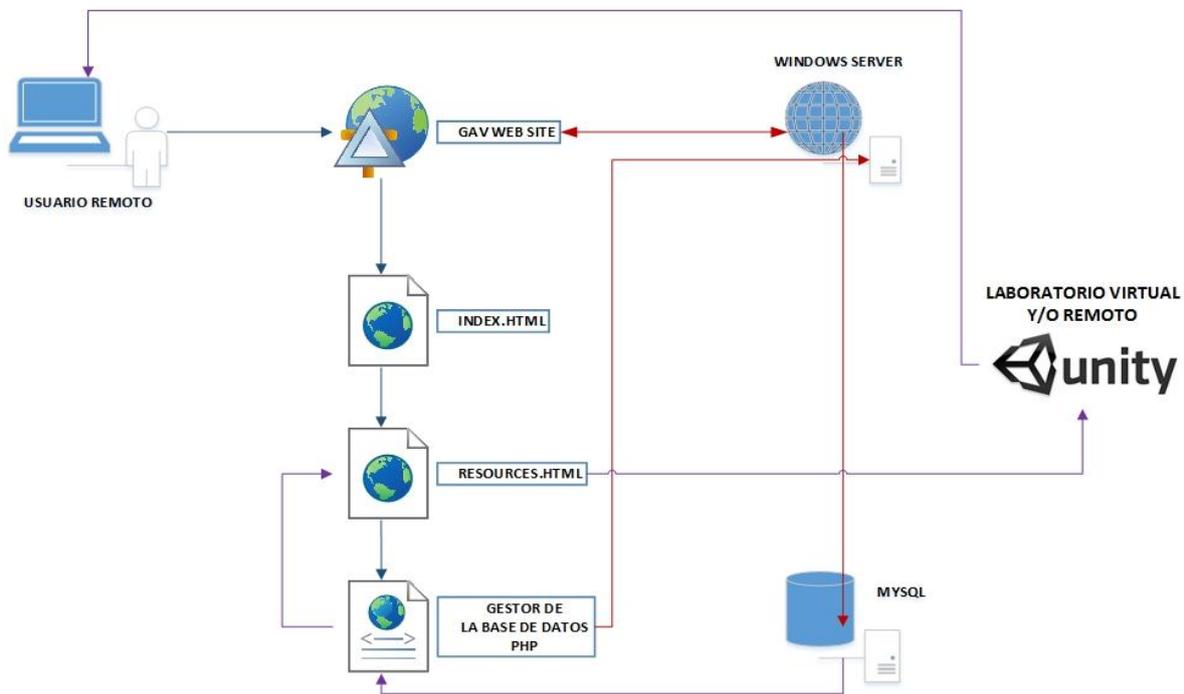
Of all the studies studied, the importance of laboratories in the educational sector and the potential they may have in the industry is evident, as well as identifying the fundamental components of these laboratories and their operation in general. It is therefore in this paper the results of the design and implementation of a platform for virtual and remote laboratories, with the primary purpose of developing an interactive tool for different needs educationally shown that through a website, and Unity 3D or Aryans us are able to explore, study and learn from the different resources available to them.

**METHODOLOGY**

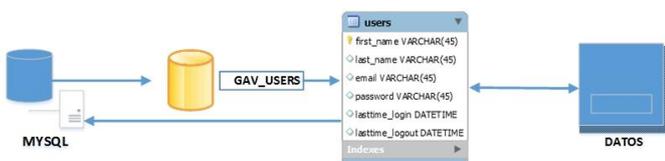
In the development of servers there are different solutions in the market which are adapted to the different needs of the people, in this design a solution was implemented that was familiarized in the educational environment of all levels, in which the interaction of tools for developing virtual environments such as UNITY with databases and web servers. Figure 1 shows the communication scheme between virtual environments and the server.

The scheme shown in figure 1 shows the form of communication that was implemented with the purpose of increasing the reach of virtual and remote laboratories, this interaction is carried out in different stages. The first stage is the connection user (s) to the website, which directly connects to the web page Resources.html, where the main connection is administered to the different virtual and / or remote laboratories, all this is done by remotely via the internet, so the ability of users depends on the application and the hardware characteristics of the server itself.

The second stage is the connection between the user and the database, due to the fact that it is required for the use of these applications at an educational level to have a record control, and in the case of remote laboratories, a user control is limited to one user per session, this is why the database was developed in MySQL as shown in Figure 2, which has different administration tools and information exchange such as PHP, where through the TCP / IP communication protocol and using port 3306 the control and administration of this database server was performed. In order to carry out the connection between PHP and MySQL, it was necessary to host MySQL in Windows Server that through Internet Information Service (IIS) the different PHP protocols were interconnected with the database



**Figure 1.** UNITY 3D Interaction Operation Schema - User (s)



**Figure 2.** Scheme of Connection Database in MySQL

The third stage is the connection between the web page that stores the resources of the laboratories with the manager of the database in PHP and with the specific laboratory. To achieve this after user verification, an identifier is assigned to determine the type of laboratory to be used, which in the case of the virtual laboratory does not have a limit on the number of users to connect, as in the process of bottling a brewery, which is displayed in Figure 3.

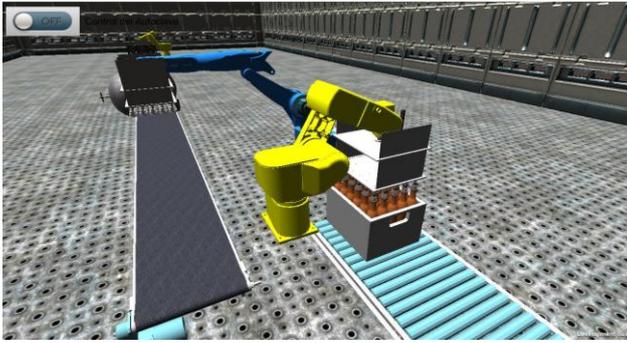


Figure 3. Virtual Environment Beer Bottling

In order to develop the virtual laboratory it is necessary to interact with the most important components, depending on the complexity and scope of the laboratory, that for the case of Beer Bottling, the autoclave (system responsible for sterilizing beer bottles) is the most important, for which a mathematical representation was obtained with the purpose of controlling it and studying its behavior, for which this is considered as an electric type furnace, for which, applying a thermodynamic analysis, we obtain equation 1 and 2.

$$C = \frac{Q}{dT/dt} \quad (1)$$

$$Q_r - (Q_c + Q_p) = Q_t \quad (2)$$

It is necessary to take into account the heat generated by the electrical resistors ( $Q_r$ ), the temperature of the object introduced into the autoclave ( $Q_c$ ) and heat losses through the walls thereof ( $Q_s$ ) in order to obtain the heat net of the system ( $Q_t$ ) of the autoclave in the operating stage. Then, using equations 1 and 2 Equation 3 is obtained, as shown below.

$$Q_r - (Q_c + Q_p) = C_r \frac{dT_r}{dt} \quad (3)$$

In order to develop the model of the autoclave it is important to determine the individual value  $Q$  thus applying equation 1 and considering the thermal conductivity of the object in the virtual laboratory (bottles), on each of the variables is produced by Equations 4, 5 and 6.

$$Q_r = \frac{V^2}{R} \quad (4)$$

$$Q_c = C_c \frac{dT_c}{dt} = \frac{T_a - T_c}{R_{tc}} \quad (5)$$

$$Q_p = C_a \frac{dT_a}{dt} \quad (6)$$

Bearing in mind that at temperatures higher than  $50^\circ\text{C}$  it is approaching  $T_r \approx T_a$  [13], where  $T_r$  temperature resistance and clearing the value  $T_a$  of equation 5, and then replacing equations 4, 5 and 6 in 2, equation 7 shown below is obtained.

$$\frac{V^2}{R} - \frac{C_c dT_c}{dt} = (C_r + C_a) \frac{d}{dt} [C_c R_{tp} \frac{dT_c}{dt} + T_c] \quad (7)$$

As a last step it is stable  $C_c R_{tp} = \tau$  [13], the thermal resistivity  $R_{tp}$  being generated between the walls of the autoclave with the outside environment and  $\tau$  as the exposure

time in hours of quantized object, so that replacing and simplifying the result, equation 8 is obtained [13], [14].

$$\tau \frac{d^2 T_c}{dt^2} + \frac{(C_c + C_r + C_a)}{(C_r + C_a)} \frac{dT_c}{dt} = \frac{V^2}{R} \frac{1}{(C_r + C_a)} \quad (8)$$

This equation obtained is the mathematical representation of the autoclave, so that by using real data that can develop control system, which for this laboratory was designed under a PD controlled, with predesigned values  $K_p = 87,207$  and  $K_d = 0.401$  but the possibility of modifying them, thus modifying the time of establishment and the response of the system, as can be seen in figure 4.

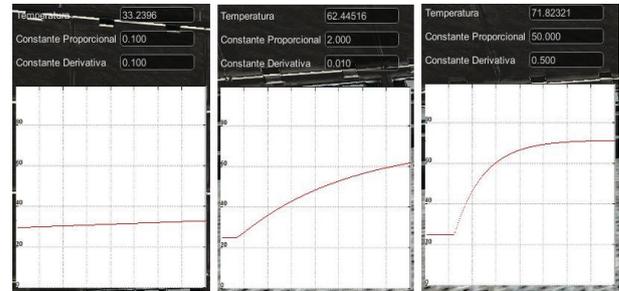


Figure 4. Plant response to different controller values

## RESULTS

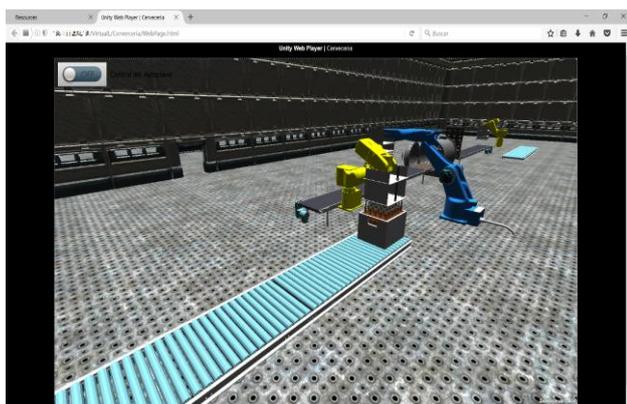
Once the server and configured launched was achieved stably maintain a connection with equipment 48 while virtual laboratory for dispensing beer as can be shown in Figure 5.



Figure 5. Serve features or through MySQL

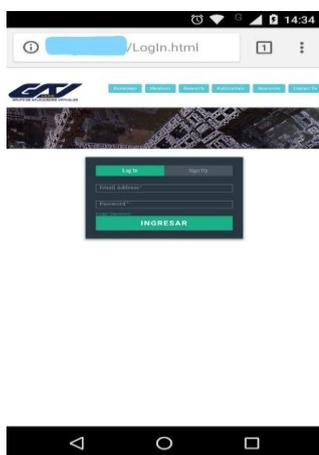
Figure 5 shows 48 connections with a data traffic of 2.69 KB / s, which means that the virtual laboratory developed does not require a massive data traffic to work. Additionally, it has a key efficiency of 86.7%, demonstrating the speed in the identification and transfer of data between the server (Windows Server), the database (MySQL) and the web page. On the other hand it was possible to obtain optimum performance and response Virtual Laboratory from different devices at the same

time and in Figure 6 the connection to the laboratory remotely from a laptop is evident.



**Figure 6.** Remote access to the virtual laboratory through Windows Server, MySQL and Unity 3D

In the same way the system is multiplatform, therefore, with the correct configuration it can be accessed from an Android cell phone as shown in Figure 7.



**Figure 7.** Remote access to the server through an Android device

Therefore, once the laboratory in a multiplatform system with different users connected simultaneously tested, it was possible to demonstrate the stability of the server being possible to use it at all levels of education, be possible under different modifications using it as an industrial tool.

## CONCLUSIONS

From the work developed in this article it was possible to implement a multiplatform system under the Windows Server standard and Internet Information Service (IIS), capable of hosting different virtual laboratories developed in Unity 3D, which are managed by a database server through MySQL, able to manage more than 48 users at the same time making it possible to implement education for the development of practices in different races.

By using 3D Unity is able to implement an affordable virtual laboratory from any web browser via JavaScript, so laboratories

implemented do not require higher technical specifications, so with minimal configuration and internet access can access this type of resource.

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## REFERENCES

- [1] T. Bickmore and D. Schulman, "A virtual laboratory for studying long-term relationships between humans and virtual agents," in *Proceedings of The 8th International Conference on Autonomous Agents and Multiagent Systems-Volume 1*, 2009, pp. 297–304.
- [2] T. P. Way, "A virtual laboratory model for encouraging undergraduate research," in *ACM SIGCSE Bulletin*, 2006, vol. 38, pp. 203–207.
- [3] N. R. HERGA, M. I. GRMEK, and D. Dinevski, "Virtual laboratory as an element of visualization when teaching chemical contents in science class," *TOJET Turk. Online J. Educ. Technol.*, vol. 13, no. 4, 2014.
- [4] W. Tarnq, Y.-H. Cheng, C.-M. Lin, C.-Y. Lee, and H.-H. Liou, "Design of a Virtual Laboratory for Analyzing Nanoscale Magnetic Materials," *Int. J. Multimed. Its Appl.*, vol. 6, no. 1, pp. 17–32, Feb. 2014.
- [5] E. A. Salazar and M. E. Macias, "Virtual 3D controllable machine models for implementation of automations laboratories," in *2009 39th IEEE Frontiers in Education Conference*, 2009, pp. 1–5.
- [6] P. Skočik and P. Neumann, "Industrial process in laboratory environment," in *2013 International Conference on Process Control (PC)*, 2013, pp. 320–323.
- [7] W. Guo, Y. Gao, and Y. Wang, "Design and realization of the interactive virtual laboratory based on VRML," in *2012 2nd International Conference on Consumer Electronics, Communications and Networks (CECNet)*, 2012, pp. 2510–2513.
- [8] Z. Zeng, M. Hu, D. Li, and Y. Liu, "Distributed Virtual Laboratory System Based on Java/Corba," in *2011 Third Pacific-Asia Conference on Circuits, Communications and System (PACCS)*, 2011, pp. 1–4.
- [9] C. Tüysüz, "The effect of the virtual laboratory on students' achievement and attitude in chemistry," *Int. Online J. Educ. Sci.*, vol. 2, no. 1, pp. 37–53, 2010.
- [10] H. A. El-Sabagh, "The Impact of a Web-Based Virtual Lab on the Development of Students' Conceptual Understanding and Science Process Skills," 2010.
- [11] C. Pearson, and C. Kudzai, "Virtual Laboratories A Solution for Tertiary Science Education in Botswana," *Eur. Cent. Res. Train. Dev. UK*, vol. 3, no. 1, pp. 29–43, Mar. 2015.
- [12] A. Alexiou, C. Bouras, and E. Giannaka, "Virtual laboratories in education," *Technol. Enhanc. Learn.*, pp. 19–28, 2005.
- [13] C. E. M. Navarrete, "Estudio Dinamico De Un Horno De Resistencias Electricas Convertido A Gas System Dynamic of an electrical oven and a gas oven retrofit," Oct. 2009.
- [14] P. F. Monaghan, M. T. Brogan, and P. H. Oosthuizen, "Heat transfer in an autoclave for processing thermoplastic composites," *Compos. Manuf.*, vol. 2, no. 3, pp. 233–242, Jan. 1991.