Smart University
Immersive Virtual Learning

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Abstract — **This document presents the development of the proposal for the virtual headquarters of the Universidad de las Fuerzas Armadas ESPE – Sede Latacunga, highlighting the reconstruction of the university's 3D model using photometry techniques, CAD modeling and rendering optimization to achieve a photorealistic graphic level represented by reality virtual and interacting with the objects that make up the laboratories recreated virtually for the teaching of PID controllers and the formation of industrial control concepts.**

Keywords - Training, photometry, virtual reality, virtual laboratories.

I. INTRODUCTION

In recent years different technological tools have been incorporated in the field of education, in order to allow students to interact with the theoretical part taught in a classroom, obtaining a greater retention of knowledge by them, immersive technologies complement traditional education due to the constant evolution of Virtual Reality (VR), that has had an accelerated development and has shown great interest in improving methods and skills in training processes in different areas of education, such as medicine and engineering allowing students to provide new skills, training methods [1].

In engineering matters, they allow the identification, analysis and diagnosis of failures that occur between man-machine interaction, even more so in industrial processes where direct interaction with the plant's machinery and instruments is required, a scenario in which many of the operators perform the work without being previously adequately trained [2], or in turn, the insertion of recent graduates in the labor field is limited by the lack of professional skills and competences [3], therefore, it provides a tool that complements the training of engineering students in topics such as modeling and control of industrial process plants, pneumatic and hydraulic operations of pipelines, virtual laboratories in which it is possible to identify physical variables and phenomena that present a real behavior with the aim of introducing and training students in supervision, monitoring and control of industrial processes, as well as to strengthen the operator's ability to make decisions [4] by reproducing the real physical behavior applying the equations that govern the simulations [5]. The virtual reality has been a theme that has become a very marked trend in the development of technology, which as time goes by is evident a number of innovations and applications that in conjunction with other sciences such as 3D reconstruction by photometry it is possible to capture the total attention of the user by interactively interacting [6] with the elements that make up the university campus.

This article is divided into VI Sections including the Introduction. Section II presents the development of the problem and the proposal of the elaboration of virtual environments at the campus of the Universidad de las Fuerzas Armadas ESPE – Sede Latacunga; while the characteristics and design of the system are found in Section III. In Section IV, the structure of the developed system is shown; the results and the discussion of the realized virtual environments are written in Section V and finally the conclusions are detailed in Section VI.

II. DESCRIPTION OF PROBLEM

VR is a topic that has become a very marked trend in the development of technology, in which a series of innovations and applications focused on entertainment, rehabilitation and education, among others, are evident over time. For the development of the work, 3D reconstruction techniques by photogrammetry are used on the university campus of the University of the Armed Forces ESPEL, a scenario in which the user can tour its facilities and be guided by an assistant to virtual laboratories that are located in relation to the real world.

This research presents a complement to traditional education, making it possible for the physical presence of the student to be unnecessary [7], this being one of the main problems for practical education due to not having access to the machines and instruments, availability of time and even the assistance of a mentor teacher. At the same time, given the need to modernize the facilities of the industry, digital models are implemented in a virtualized environment that can serve as a basis to support engineering tasks that require simulations [8], from this point of view, the reality virtual allows the user to interact with elements of the virtual world as it did in the real world, in this sense you can develop scenarios for training operations under specific conditions [9-10].

The support of the application in virtual reality falls on the scripts that keep the instructions of the program, graphic optimization, the interactivity with the devices involved in the system, as well as the bidirectional communication of data that exists between the graphic engine and the mathematical software for share the information of the process variables and perform the control tasks in the laboratory practices. The degree of immersion sought is closely related to the visual and auditory stimuli that glasses can offer the student, as well as the apt sensations that are perceived as feedback when interacting with the stage.

III. RECONSTRUCTION BY PHOTOGRAMMETRY

The creation of the 3D model of the university begins with the capture of images taken from a drone tele-operated from ground, after an image processing is done using a dedicated software to generate the meshes of the buildings and the captured objects, then the reconstructed models are obtained and exported in .fbx format to later be used in the graphic engine that gives life to virtual reality.

Figure 1. Reconstruction by photogrammetry.

As evidenced in Fig. 1 the reconstructed model presents a single unusable mesh of the whole set of buildings and objects that make up the scenario, besides the quality of textures is not at the level of the immersion that is sought, is then that, based on the model obtained, a modeling software is used to reconstruct the buildings one by one, and the process is to generate materials that provide a photorealistic texture that, together with an adequate illumination of the objects in the scene, is obtained a 3D reconstruction of the high-quality university as shown in Fig. 2.

Figure 2. Modeling of the ESPE - Latacunga.

IV. UI USER INTERFACE

The user interface panels are shown in Fig. 3 and 4. These are designed in the Illustrator software and then exported to the graphic engine to be a visual introduction of the student upon entering the virtual campus. Through the development of a laser pointer system using the haptic controls of the HTC Vive glasses it is possible to interact with the user interface (UI).

Figure 3. Cover of the application.

In addition, an event system is implemented that detects through the collision between a "Collider" of the controller and the UI interface to activate the functionality of the buttons that guide the student to the place of the laboratories through the use of a compass and a signal visual in the form of a portal that indicates that it has arrived

Figure 4. Laboratory selection panel.

V. RECREATION OF VIRTUAL LABORATORIES

Based on the P&ID diagram of the practice drawn in AutoCAD P&ID, all the elements that make up the control system laboratory are modeled using the AutoCad Plant 3D software that allows designing piping systems for industrial processes, after importing the graphic engine to equip physical properties to objects such as position, rotation, scale, mass and collision detection as show in Fig. 5. It also adds lighting and sound effects linked to events that are performed with the interaction of the laboratory elements.

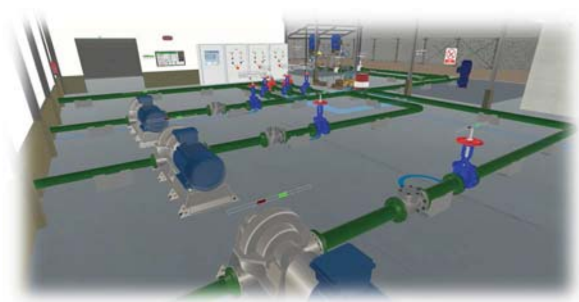
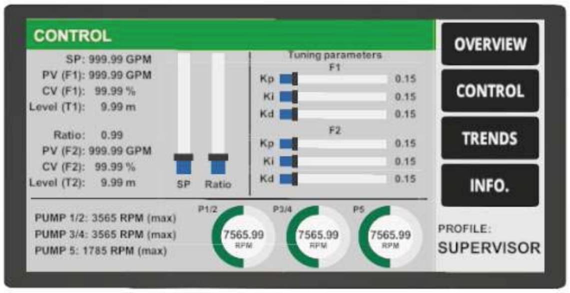


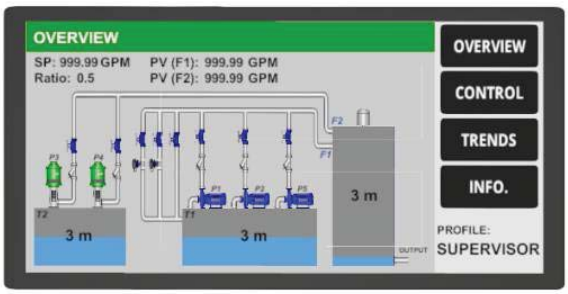
Figure 5. Laboratory control systems.

At this point, a client-server TCP connection is made between Matlab and Unity3D, the first performs the PID control of the tank filling while the second receives and sends the data to generate the measurement variable curve (PV) in response to the desired value (SP) observed simultaneously in the two realities.

The Fig. 6 show how the students can interact with the valves of the pipes as if he did in real life to make changes in the plant's functioning, as well as interacting with other objects, in addition, that he can modify the PID parameters of the process both from Matlab and from the user interface panels within the virtual environment.



a) Control board



b) Monitoring board

Figure 6. PID user interface.

In a similar process to the previous one, based on the pipeline and instrumentation diagram shown in Fig. 7, the elements that make up the instrumentation laboratory are modeled, which once finished are imported into the graphic engine to implement an interactivity to the process and a series of instructions in the simulated HDI as a guide to practice.

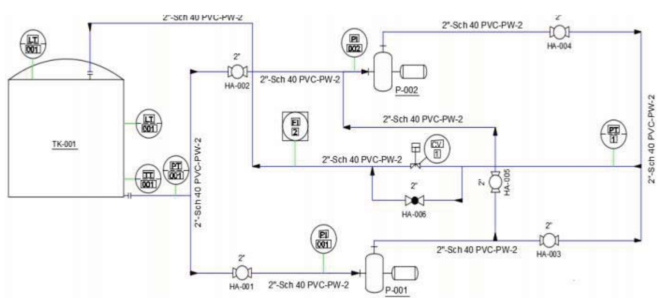


Figure 7. Diagram P&ID hydraulic laboratory.

Finally, a system of shared memories is implemented that allows the bi-directional communication of data between Matlab and Unity 3D in order to graph the process variables once the student finishes the virtual laboratory practice.

Figure 8. Hydraulic laboratory.

VI. System structure

The communication process between the flows of data for the operation of the application is presented in Fig. 9. The process begins with the verification of the device between HTC Vive and the computer that runs the program, this gives all the support for the application to receive the signals from the wireless controllers, as well as the tracking of the location of the glasses.

Within the scene is the assembly of 3D modeling that forms the virtual campus and its facilities, it is in this layer where the optimizations of rendering are made in which a better performance is obtained by frames per second (FPS) both in lighting using Shaders, which are microprograms that calculate the incidence of light on objects, as in high contrast textures [11] to achieve the photorealistic effect that is sought.

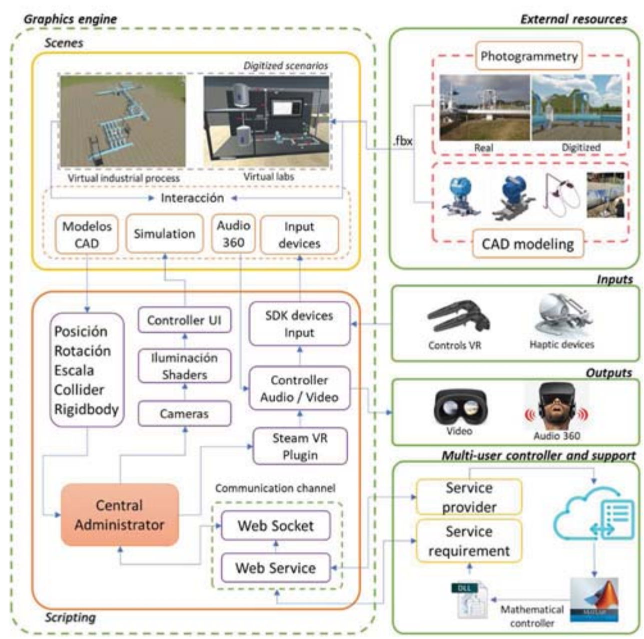


Figure 9. Diagram of relationship of layers.

Afterwards, the components that perform the immersion in virtual reality are represented through scripts that contain the instructions of the program, in this phase it is endowed with interactivity between the student and the environment with its elements, enabling the ability to move across the campus and interact with the user interface and the objects of the virtual laboratories. During the execution of the application there is a feedback of the process variables between the graphic engine and the mathematical software to process them and perform the control tasks.

Finally, all the information of the process is visualized in virtual reality through the HCT Vive glasses, which allows changing the viewing angle around a single point of view, that is, looking around the virtual environment favoring the immersion experience [12], haptic and auditory stimuli are also generated on the scene based on the events that are performed by interactivity with the laboratory components.

VII. RESULTS AND DISCUSSION

This section shows the results obtained in the proposal of the virtual headquarters of the Armed Forces University ESPEL as a complement to the training and capacitation in tasks of supervision, monitoring and control of industrial processes. Initially, the workspace that the user will occupy in the course is configured, this with the purpose of guaranteeing an optimal tracking of the components of the virtual reality headset and the integrity of the devices and the person, starting from here, the student is introduced to the simulated scenario.

The virtual application induces the student and the new workers in the industrial safety thematic, this as part of the INEN-ISO 3864-1 standard [13] when strategically locating the signage in the areas of interest of the laboratory, in addition, you can find several elements such as valves, tools and personal safety implements that can interact directly with them (Fig. 10).

Figure 10. Signage and interactive tools.

A series of legends are shown on the controls to indicate the actions that can be performed with the buttons, following this guide you will initially learn how to move through the facilities using wireless controls to later learn how to deploy the laboratory selection panel that will guide you to the access portal through the assistance of a compass and the distance measurement to the selected laboratory.


Figure 11. Testing the application.

During the realization of the lab practices that are guided by means of pop-up windows containing the instructions to be performed, the student has the freedom to interact with the elements of the scenario as it were in the real world with the advantage that the process of learning becomes somewhat fun and entertaining while doing the practice, in addition, you can see how changing the parameters in the process variables affect the phenomena that are controlled, so that both for the PID control and for the laboratory practice can be experimented with different situations and verify the expected result.

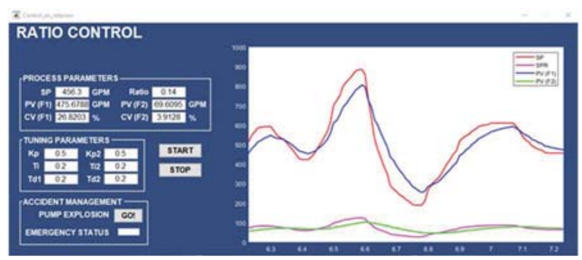


Figure 12. PID control interest curves in Matlab.

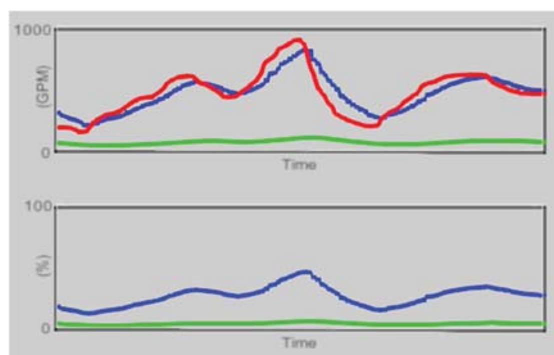


Figure 13. PID control interest curves in Unity3D.

Finally, the curves of interest are plotted both in Matlab and in the virtual environment with the possibility that the parameters of the PID control can be modified in the two realities to be able to study the response curve of the plant (view Fig. 12,13).

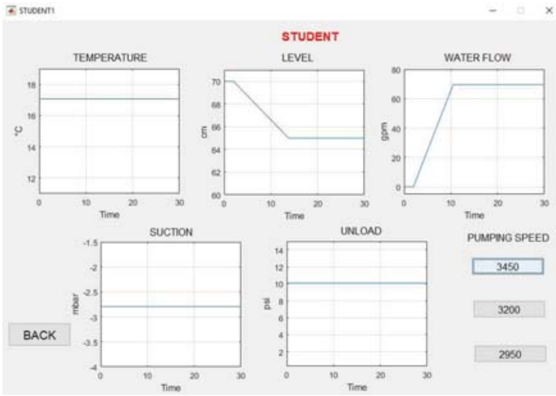


Figure 14. Efficiency curves of the process variables.

Similarly, as show in Fig. 14, the second laboratory it throws results how the efficiency curves of the process variables are plotted in a series and parallel configuration, showing that the first configuration maintains the flow rate while the second one increases the flow rate due to the change in suction pressure and discharge of each pump. These representations give rise to the possibility that the theory behind the phenomenon can be taught, taught and trained.

VIII. Conclusions

The development of the virtual application as a complement to the learning process of new professionals shows a remarkable acceptance when interacting with simulated elements that are known in the real world. The level of immersion satisfies a degree of realism that is sought both in visual, auditory and tactile stimuli, this thanks to the reconstruction and modeling techniques of the stage, devices and components that make up the virtual campus, as well as interactivity with them. In addition, because the parameters of the processes that simulate the laboratories can be modified in the two realities, it is possible to make a previous explanation of the phenomena studied, on the other hand, the development of the application gives free rein so that it can continue to be integrated more laboratories that involve the teaching of engineering concepts.

Acknowledgment

The authors would like to thank the Coorporación Ecuatoriana para el Desarrollo de la Investigación y Academia- CEDIA for their contribution in innovation, through the CEPRA projects, especially the project CEPRA-XIV-2020-08-RVA *"Tecnologías Inmersivas Multi-Usuario Orientadas a Sistemas Sinérgicos de Enseñanza-Aprendizaje "*; also the Universidad de las Fuerzas Armadas ESPE and the Research Group ARSI, for the support for the development of this work.

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