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Analysis of the current status of the development of virtual reality environments for teaching industrial automation systems

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Abstract– Virtual Reality (VR) can be described as a set of technologies involved in positioning the user in an environment simulated by a computer, which allows the user to interact with three-dimensional objects in the virtual environment. Within virtual environments there are several tools, the main ones being VR glasses [1], accompanied by audio devices and motion sensors that provide the user with a more immersive experience. According to the perspective developed by the authors, industries and educational centers that implement virtual environments for teaching can count on advantages in terms of personal training and in minimizing the costs of implementing physical scenarios for training. The analysis of different approaches to the use of VR in the development of industrial applications, through the selected research, will provide the ability to expand the spectrum of possibilities in the field of automation systems in the present and future. In the present work, a review of the existing literature is made from different types of perspectives and applications on the use of simulated environments and how these can be a source of learning and improvement of different activities related to control and automation systems.

Keywords: Virtual reality, prospective, automation systems, virtual environment, immersive.

I. INTRODUCTION

Currently, Virtual Reality (VR) is playing an important role in the industry, since it has allowed training and education in industrial processes to technicians who are responsible for supervising the operation of a production line within a company. Due to this, the rate of failures produced in the industrial system has been reduced, thanks to the reaction capacity of its employees to technical problems that may arise in the process [2]. These projects help the technician to reinforce the learning obtained in the academic training and practice, to avoid accidents that can be caused when performing maintenance work or damage to the equipment of the industrial process during its operation. [3].

VR allows operators to familiarize themselves with a machine or a process by virtually touring the production plant thanks to their avatar or skin and through it see exactly where the equipment or components of the machine or industrial process are located. In this way, they can observe how it works, which allows them to identify possible failures before going into operation [4]. On the other hand, the industrial revolution has forced most companies to evolve technologically and apply new digital tools to the learning and training of their staff, so that they can obtain new skills to deal with problems that may arise during an industrial process. The vast majority of companies have opted for VR, which began to spread in recent years, due to the constant technological advancement [5].

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VR technology in industry combines the design of industrial processes and computer simulation, which brings new opportunities for learning and training, as well as the speed of adaptation to new systems, customization of training requirements, cost reduction, and even the preservation of the integrity of workers [6].

Virtual reality environments for teaching industrial automation systems are of great importance nowadays, since they allow the user to immerse and be part of the simulation of an industrial process, and interact with it through the visual, auditory, and tactile senses, thus allowing to know in detail the elements of the system [7].

On the other hand, limited resources for equipment acquisition and didactic modules in educational centers have also driven the development of VR environments, which are characterized by the ability to simulate industrial equipment and processes, from the most basic to the most complex. With VR, it is possible to carry out controlled simulations such as accidents or failures in the production system. In this way, the user is allowed to perform maneuvers in the process, for a better understanding of the operation [8].

In the present work, an analysis of the existing literature about VR is carried out, taking into consideration the advances made in the last five years. Each of the documents has been selected from recognized high-impact databases to obtain verified and validated information. At the end of the present review, the possible fields of research that could be followed to make progress in this topic are analyzed.

This document is organized as follows: section I contains the introduction, section II describes the methodology used, section III the development of the research, and finally section IV the conclusions and recommendations.

II. METHODOLOGY

For the substantiation of this work, descriptive research was applied through bibliographic search methods in databases such as SpringerLink, Scopus, MDPI (Institute for Multidisciplinary Digital Publication), IEEE Xplore, and Journal conference.

The selection of the articles to be analyzed was carried out according to the following steps: (i) relationship with the research topic, (ii) search of documents according to the year of publication (2018 - 2022), and (iii) relevance according to the subject matter.

A. Research Questions

For the present work, four research questions were established. These questions are focused on covering the use of VR within the training or teaching of automation systems in industry and education. For this reason, the questions are made considering three points of view, to subsequently perform the analysis: (VP1) training or teaching in VR-based automation systems, (VP2) training in VR-based control systems and robotics, and (VP3) use of VR in industry. In Table 1, the research questions are presented.

TABLE I
RESEARCH QUESTIONS

Research Questions		Motivation
Q1	What is the use of VR in automation systems?	Identify the approaches used.
Q2	What types of technologies are used in teaching automation systems using VR?	Identify which technologies are used for the development of VR applications in teaching automation processes.
Q3	What are the benefits and advantages of using VR in teaching and training?	Identify the advantages and disadvantages of using VR in teaching.
Q4	Has VR been used in the training of technical and operational personnel?	Identify the importance of developing VR applications for the training of technicians and operators.

For the first step, a search for articles directly related to VR, control, robotics, and industrial automation systems was carried out. Specific terms were used such as teaching, training, and training in virtual reality environments related to automation, industry 4.0, control systems, and robotics. Through this search, the articles were selected according to the year of publication, considering that it is within the range established above.

B. Scientific article selection

The information search was carried out considering specific terms related to the three points of view, before mentioned. The equations used for the collection of the information were: for VP1 was set (("training" OR "teaching" OR "education" OR "education" OR "automation systems") AND ("virtual reality")), for VP2 was set (("training" OR "training" OR "robotics" OR "automation systems") AND ("virtual reality")), finally for VP3 was set (("training" OR "training" OR "training" OR "industry" OR "control systems" OR "automation") AND ("virtual reality")). The selection of articles was made based on titles and abstracts.

According to the repository of 100 articles generated, a first review was performed for the exclusion of articles, considering the direct relationship that exists with teaching, training, and training students or technicians in automation and robotics systems. In addition, the level of visual and auditory perception that allows users during the use of the virtual environment, which can be immersive and non-immersive, was considered.

From this review, 25 articles were selected considering the following aspects: use of VR in industry, development of VR applications for teaching, training, or training related to automation systems. Finally, the language of the article and level of impact was considered. Once the information was filtered, a general review of each of the selected scientific articles was carried out to analyze and establish the results obtained in the different research studies.

III. DEVELOPMENT

VR is a dynamic experience, through which the user replaces the activities and movements performed in a physical environment with a fictitious virtual environment very similar to reality [9]. It is characterized by real-time interaction of the actions performed and whose response to operations performed by the user, the computer can interpret the actions and generate an instantaneous response in the virtual world [10], therefore, the user will feel that the actions performed were made in a real environment. The general elements that compose the architecture of a VR system, Fig. 1, are shown below.

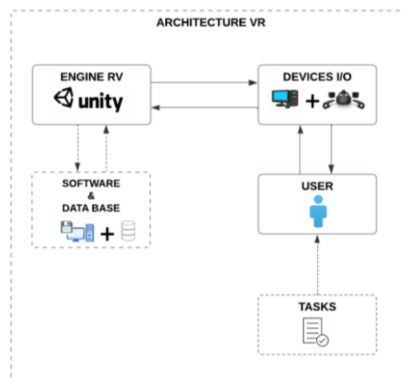

Fig. 1. General architecture of a virtual reality system.

As can be seen in Fig. 1, the elements involved in a virtual reality environment are:

- Input devices (In charge of collecting the user's actions).
- Output devices (VR goggles, audio devices, controls).
- Virtual Reality Engine (Virtual Reality Software).
- Database (Objects, properties, and processes to be designed.

For the review of articles, several aspects have been considered such as the field of application in industry, education, and training, type of user immersion in the applications developed, type of software used for the development of the project, accessories used, advantages and disadvantages. The most relevant information obtained from the selected articles is shown below.

A. Training in virtual reality-based automation systems

Virtual reality (VR) in the automation industry is currently in constant development, but it is presented as a future alternative for efficient teaching and training of students, technicians, and operators of industrial plants. This allows personnel to be trained on the architecture and manipulation of new equipment, which has made the development of VR applications increasingly common in different fields of engineering.

Harold R. et al, [11] present in their work the implementation of a virtual plant consisting of a ball-and-dish experiment in V-REP software where the emulation of the plant structure is performed. For the control, a remote API developed in Matlab is used where the programming of a discrete PID and LQR controller is performed, which are responsible for setting the position and speed of the servomotors in the process. For the implementation of the controllers in the plant, a linear model was used to describe their behavior. The results obtained in the co-simulation platform facilitate teaching and learning in process control of industrial plants.

Hakan A. et al, [12] present the development of the design of a 3D virtual laboratory created in Second Life, in which the student through an avatar can make the tour to know the structure of the process, perform the programming and simulation of the implementation of a PLC in the system. For the user to be able to program the PLC in Ladder language, the Linden Script Language (LSL) was used, which allows to stablish the logical sequence used in this language. For this case study, the automation of a conveyor belt was performed and, in the end, through a survey, it was obtained an acceptance and degree of usefulness by the students of 95.45%.

Christoph A. et al, [13] develop an application in Unity 3D, which is used for the validation of automatically guided vehicles used for the distribution of materials in a production process. This application is used to perform the functional tests of the control software, through the virtual start-up of the simulated model of the machine, where the user through the use of HTC Vive glasses can interact with the virtual environment and perform the functional tests to the proposed design. This allows to perform the necessary adjustments to the control software before the construction of the real prototypes, thus saving resources.

Goga C. et al, [14] develop a virtual reality (VR) application used as an experimentation tool, which consists of three scenarios: construction and operating principles, industrial automation, and process implementation. In the first scenario, the student performs the assembly of an electric motor with the 3D parts found in the virtual environment. In this activity, the student also identifies the main parts that constitute it and observes the operation of a synchronous motor.

In the second scenario, a package sorting process is visualized, where the student can identify the constructive characteristics of an actuator and its selection process. For the implementation of the process controller, the user will be able to perform ladder programming for a PLC, which is in charge of controlling the entire sorting process. Finally, the third scenario shows a waste sorting process, where the student can identify the transfer function of sensors, actuators, and a conveyor belt.

Garcia C. et al, [15] perform a virtual reality application to simulate the operation of an Oil&Gas system for commissioning instruments, which is used for the training of technicians and operators through a virtual environment that provides the opportunity to develop skills that strengthen their knowledge. The application allows users to configure HART instruments in calibration and field installation, for the user to make the necessary mistakes during implementation, to strengthen their skills. Moreover, this development offers an alternative for training human talent in the oil and gas field without the need to purchase teaching equipment.

Hua-Jian W. et al, [5] present the development of a virtual building created in Unity 3D, which is used for the implementation of automated systems in a virtual environment through a PLC in real-time. This application allows students to identify systems that are required to be automated in the virtual building, such as an elevator. Once the system is identified, the user develops the programming in the Tia Portal software for a Siemens S7-300 PLC and to check the operation, the instructions are sent from the PLC to the building in the virtual environment through the TCP/IP communication protocol. This proposal helps the student to perform more realistic practices focused on engineering.

Leticia N. et al, [16] designed a virtual reality environment of an intelligent industrial laboratory and a laboratory practice related to Industry 4.0. Through this application, the student can interact with the devices found in the virtual world, allowing them to identify, familiarize and train with the equipment of a real laboratory through scenes created in Unity 3D.

William M. et al, [17] perform the development of a VR environment for teaching pneumatic systems to undergraduate students. This application allows the user to fully immerse in the virtual environment for interaction with the equipment and the development of control diagrams for three preset sequences. It is important to indicate that the pneumatic system in the virtual environment works synchronously with the real module and for the transmission of instructions the CoAP protocol is used employing a Raspberry Pi card.

Wanfeng C. et al, [18] propose the development of a virtual teaching simulation for industrial automation, which consists of programming using ladder language to control an elevator through a PLC in a building. The teaching platform developed in Unity 3D consists of the preparation of the experiment which consists of learning the theoretical foundation and an experimental process where programming is performed in a PLC to control an elevator in a building that has 6 to 10 floors. The development of the practice lasts 4 hours, from the theoretical review to the realization of the practice, which consists of the operation through virtual controls of the elevator, which send signals to the PLC to perform the switching on and off of the synchronous motor.

Carlos A. et al, [6] propose the development of a VR-based FESTO pneumatic laboratory, which works synchronously with the real module. This virtual environment uses the MQTT protocol on a Raspberry Pi to transmit instructions to control a real FESTO pneumatic module. This application developed in Unity 3D allows the user to fully immerse himself in the virtual world, with the help of Oculus Rift VR glasses. In this way, the user can interact with the three-dimensional elements of the virtual laboratory, where the student learns to design pneumatic circuits and make the correct connections between the cylinders, end-of-stroke sensors, and the pneumatic supply.

Rubén M. et al, [19] develop a hybrid proposal between a virtual laboratory (LV) and a remote laboratory (LR), which are focused on learning industrial networks, integrated manufacturing systems, and automation. These applications allow the student to understand the operation of a manufacturing process, and learn about automation concepts and principles of programming languages for a PLC. The experimental teaching of automation courses in the hybrid laboratory achieves greater learning in training because it allows making mistakes without causing material damage and recognizing different technologies and equipment commonly found in a manufacturing process.

Edwin P. et al, [2] present in their work the development of an immersive virtual environment of a didactic system created in Unity 3D and Labview, which emulates a real process of a plant, through which the user can apply cascade control techniques. The system consists of a level control plant and an HMI for monitoring and control. The TCP/IP protocol is used for the exchange of information between the two programs. On the other hand, the user through the use of Oculus Rift glasses can interact with the elements of the plant where through simulations created can see its operation and study the behavior of the different conditions of the plant in detail.

Chin S. et al, [20] present in their work the development of a logic control mechanism (LCM) with the integration of virtual reality, which consists of the following modules: conveyor, robotic arm, storage, and control. The synchronous operation between the VR scenes and the real part allows to establish the difference in the activation and deactivation time of the different modules between both parts. The data exchange is done using communication protocols, for sending data from the PLC to the virtual environment for system activation. With the offline operation model, the user can manipulate the virtual world system, so that he/she can be trained and familiarized with the operation without the need to stay in a real laboratory.

Anna A. et al, [21] present in their work the development of an immersive virtual reality (VR) application, which is used in the automotive industry for the evaluation of automated vehicle HMI designs. This tool allows researchers and designers to build virtual prototypes and immersive evaluation scenarios with less time and without the need to invest a lot of resources.

The evaluation of the VRHEAD project was carried out through two experiments. In the first experiment, the rapid iterative testing and evaluation method was applied to the group of participants interacting with the virtual environment, to gather information regarding the design of the virtual environment and to evaluate the user's experience when using the application. The second experiment was conducted with the help of researchers and designers, who were assigned tasks for the creation of the HMI. The results indicate that VRHEAD is a promising approach for the rapid implementation and evaluation of HMI design concepts in automated vehicles.

B. Training in control systems and robotics based on virtual reality.

Theodoros T. et al, [22] present the design of a VR-based teleoperation system for the design and control of robots in a production station. The developed application allows multiple users to immerse themselves in the virtual production environment and reconfigure the robotic production process. Users can program via code blocks a complete sequence for the robot to execute. This tool can also easily integrate multiple robots, programming and control is simple, because it uses the ROS libraries to give the user real-time access to robotic resources. At the end of the validation of the operation of the code created in the simulation, it can be sent to the robot controller for the actual execution of the process.

Christos C. et al, [23] present the development of a virtual/augmented reality laboratory that is used for teaching industrial automation concepts, based on IEC 61499. Open-source projects such as Eclipse 4DIAC and FORTE are used for the development of the application. The former is used to implement the programming environment of a PLC and then to execute and simulate the operation of the IEC 61499 function blocks.

The lab implemented in Unity 3D consists of five zones: the VR auditorium, the project-based learning lab, the prototyping zone, the digital factory, and the application immersion environment. Through these zones, the user is allowed to perform design reviews, perform tasks proposed in the virtual environment, validate maintenance procedures, and verify assembly and manufacturing processes. In this way, the user can detect failures and identify risks, to correct them before their implementation.

Vicente R. et al, [24] develop an immersive virtual reality pedagogical simulator of industrial robotic arms, which are used by students for better learning of the theory taught in the classroom. The robotics simulation allows the user to design, visualize, monitor, and perform safety checks, among other things. For the creation of three-dimensional models of the robot OpenGL is used and to simulate the movement, direct kinematics is used, so that the user can design their trajectories, and collision checking is done through the Open

Dynamics Engine library. This proposed learning method allows the student to develop programming skills and recognize the main parts of a robot.

Bashir S. et al, [7] present a virtual reality application of a product manufacturing system related to Industry 4.0, used for teaching students about reconfigurable manufacturing systems. The application allows one to understand the operation, design, implement and evaluate the performance of the selected model within the virtual environment. For the validation of the virtual reality system, a group of 50 students was selected who were trained for four weeks and divided into two groups of 25 (experimental and control), resulting in the experimental group performing the proposed tasks in less time than the other group, thus demonstrating the benefits of VR in education.

Shen B. et al, [25] propose the three-dimensional simulation of a robotic arm through SolidWorks 3D software and modeled it in 3DS Max to build a virtual training environment. The complexity of the implementation of this style involves knowledge of a large number of fields such as mechanics and computer science. With this simulation, tasks such as the selection of its parts in Solidworks 3D are synthesized, then introduced in Unity 3D and reproduced through scenes in an interactive way, to provide the user with a virtual reality experience on the use of robotic arms without the need to acquire a real one.

Andrzej B. et al, [3] develop in their project a method for robot programming, using virtual reality and digital twins through CAD models of existing station elements. The development is focused on virtual reality simulations and using Oculus Rift glasses. The user can observe the robot replicating human movements in the cleaning of ceramic molds used for casting. The system works with the help of elements such as VR goggles, handheld controllers, and sensors, the devices track the movements of the wrist which is transferred to the fingers to simulate grasping objects in the 3D environment.

Ali Ahmad M. et al, [26] explore the technological development in virtual reality for the design of industrial production systems based on integration with simulated human-robot environments through the AWS Sumerian environment. The virtual model is created through a CAD environment called Siemens NX, with the help of passive and active elements in which such programming is saved in the virtual production system Jupiter Tessellation which is a lightweight 3D format. This data is exported to a simulation tool with tools such as HTC VIVE to have a virtual environment suitable for simulating production processes.

Ivan K. et al, [27] present WareVR, which is a human-robot interface based on the application of virtual reality to interact with a robotic system in automated inventory management. WareVR provides visualization of the robotic system in a virtual environment of a warehouse, which is accompanied by real-time video streaming of the real environment through a camera on an unmanned aerial vehicle (UAV). Using the WareVR interface, the operator can perform different levels of inventory, monitor the inventory process remotely, and remotely operate the drone for a more detailed inspection, through HTC VIVE controllers to track the user's positioning in the Unity 3D virtual environment. The proposed interface allows warehouse workers with no VR experience to control the robotic system consisting of an unmanned ground vehicle (UGV), which determines the relative coordinates of surrounding objects and calculates the position of the pallet.

C. Virtual reality-based industry training

Erik K. et al, [28] present in their project called KEGA the creation of interactive educational applications, virtual/mixed reality for students and professionals in the area of mechatronics who are doing their studies and for those who are in constant training. In this project, they develop educational videos, interactive 3D applications such as a solar system (interactive through a web browser), an electric kart showroom (it is an interactive and VR application), a hangar with electric vehicles (interactive application for PC), electric vehicle showroom (application for PC and VR) and electric car (mixed reality application). These applications allow the user to have a better understanding of the operation of electric vehicles.

Ziyue G. et al, [29] present the development of a cost-effective, fast, and accurate method to improve the maintenance process in the initial stages of maintenance by establishing the IMVES (immersive maintainability verification and evaluation system) system. This system allows interaction with maintenance objects and uses immersive simulation, monitoring and management, and evaluation modules. For the supervision module, a virtual environment is used through VR glasses and a joystick that allows the user to interact with maintenance objects including activities such as disassembly and navigation. In the supervision module according to the requirements in real-time, you can adjust the simulation scene or interact with the virtual environment in collaboration with the simulator staff. And the evaluation module establishes the effectiveness of the equipment maintenance process. This is supported by DELMIA software for virtual environment execution.

Wei-Kai L. et al, [30] perform the integration of immersive virtual reality in teaching chemical experiments by interacting with the virtual environment through buttons. The user can manipulate chemical elements during the development of the experiment and the teacher through the screen can explain to all students synchronously the procedure of the experiment. The developed application has a high acceptance among students due to its performance and interactivity.

D. Discussion

Research conducted in the field of VR is key to the improvement of teaching and learning processes, taking the methodologies used so far to the next, more technological level. This makes these processes more secure, reliable, and accessible. Therefore, it is necessary to analyze the applications of this type of development that are novel and that allow facing future challenges in the field of teaching, breaking barriers of presentiality, until now necessary for teaching processes based on experimentation or applications in a real environment.

Previously, VR appeared as a way to give the person a scenario that simulated a specific environment, initially used for video games. Subsequently, advances have been made, not only in the simulation of a scenario but also, in the possibility of interacting with elements of the scenario, which has made it possible to use these VR models for remote teaching and learning processes.

In the research developed, plants and laboratories are modeled for use in virtual and/or mixed experimentation employing VR elements. The developed models can be applied in different areas. VR turns out to be the most used for automation and control applications, especially in the transportation, assembly, and classification processes of a product or equipment through electromechanical and/or pneumatic processes. Additionally, within this same field, there are applications oriented to Industry 4.0 and robotics processes. There are also applications for training in vehicles with automatic guidance that allow validating their operation in certain tasks that can then be applied in real environments.

In the educational field, VR has been applied mainly for the staging of laboratories that allow interaction with the user to carry out some experimentation practice through elements generated with VR. This allows students to have an immersive and practical experience in laboratory experimentation either with virtual and/or mixed elements. VR environments not only allow a student to see the results of an experiment but also what happens if the experiment is performed incorrectly.

The articles analyzed show a clear trend towards the use of virtual environments for teaching and learning processes as a safe, efficient, accessible, and immersive alternative for the training or virtual or semi-virtual experimentation of a student or group of students who can have an experience very close to the real one with all the variants that can be presented in it. The new trends aim to improve these VR methods in such a way as to have environments as close to reality as possible and with most of the characteristics taken from a real environment. This allows not only to verify the results of an experiment or process performed but also what happens when they are performed incorrectly, which makes it a more controlled and safer environment for experimentation as part of a training process.

E. Selected scientific papers analysis

After analyzing the articles, it can be observed that most of the researches develop applications focused on improving the learning and skills of users in the industrial sector, mainly in the field of control and automation. In general, the researches show the different types of interaction that can occur between the virtual environment and the user, taking into greater consideration the researches that allow the user to be completely immersed in the virtual world.

Through the literature review, the importance of the development of applications related to teaching automation, robot control and industrial maintenance can be evidenced. In general, it can be understood that the training of technicians and operators in the industry is essential to keep the industrial plant in proper operation. Most of the articles reviewed present innovative ideas that are still in the development stage, but show encouraging experimental results in teaching and training.

F. Challenges of virtual reality in the industry

The development of VR applications is increasingly common in research conducted for education and training. However, it has aspects to improve in terms of hardware, mainly computers and the high cost of VR goggles makes it impossible for users to have free access, despite the reduction in the cost of electronic devices due to technological progress. On the other hand, the development of customized environments in a specific subject makes it difficult to integrate other areas into the virtual reality environment. For this reason, it is required that the software where the design of these applications is made is more user-friendly and allows the modification of their three-dimensional virtual environments.

Virtual reality is not very well known in the field of education and training, due to its high cost of implementation and lack of knowledge of its operation, since it requires trained people for its use. For this reason, the companies dedicated to the development of these VR applications for teaching do not stand out and this makes their growth impossible, despite not having much competition in the market. Most of the applications in the different researches have been developed only for testing and there are only a few applications that have been commercialized related to engineering areas; however, there is no data on their efficiency in teaching.

The information technology infrastructure requires constant updating since the large number of users on the network can cause connection failures. Another important aspect to take into account is cybersecurity, due to the exposure of personal data, the user can be vulnerable to hacking attacks, causing the loss of personal data.

Digital transformation is important in industry and educational centers, as it allows lower costs in the implementation of spaces for training technicians and operators in maintenance, industrial safety, automation systems, and design validation. In addition, this will make it possible to offer quality customized products to consumers, manufactured in less time and adjusted to their needs, since through VR technological tools the consumer will be able to visualize the product in detail and easily modify it if required before its manufacture. Finally, it can be indicated that virtual reality is emerging as a potential alternative tool for teaching, training, and coaching in engineering areas.

IV. Conclusions and Recommendations

The development of VR applications related to automation systems has allowed for solving latent problems in the industrial field. For example, the lack of resources in the training of technical and operational personnel is of great importance, since it helps prevent accidents and improve productivity times within a company. On the other hand, the use of VR learning environments in teaching in secondary and higher education centers has also allowed students to have a space where they can reinforce the theoretical basis and develop their skills in the practical part.

Virtual reality also allows the validation of the operation of mechanical designs, control systems, and automation, among others, without the need to build or implement the system. In this way, the presence of faults in the designed designs or prototypes can be corrected in time.

The insertion of Industry 4.0 in the different industrial processes together with the Internet of Things (IoT) and robotics, has encouraged the implementation of new ways of teaching, due to the high cost in the construction of a laboratory where the user can perform his training in the aforementioned topics. Virtual reality training environments have been developed, using software that is commonly used in the creation of video games such as Unity 3D, and Unreal Engine, among others.

The main advantages offered by VR for teaching and training to different users can be indicated as follows: (i) commitment, the methodology currently used in different teaching centers is conventional, which causes boredom and lack of attention. By inserting VR applications in teaching, the user focuses his attention during the development of the task, because of the novelty involved in the method of developing it. (ii) Operation, the application allows the user to interact with the virtual environment, for a better understanding of the system being used, the user can retain information about the operation of the system. (iii) Reduction of accidents, virtual environments provide a safer space for practices and does not expose the physical integrity of the user during its use. (iv) Reduction of costs, as an application developed in a video game engine, it does not require much investment compared to the implementation of a real laboratory.

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