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Development of a virtual all terrain simulation for driving a baja type vehicle and formula SAE

Desarrollo de una simulación virtual todo terreno para conducción de un vehículo tipo baja y formula SAE

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Abstract

The technological heyday aimed at virtual reality has managed to develop processes and tools never seen before that allow us to add simulation methodologies in a virtual environment for the launch of any prototype, in such a way that the first physical models are almost the final ones after having performed strict tests on them in a 3D analysis. The exploration that will be shown below focuses on analyzing the different presentations of virtual reality regarding the visualization, animation and dimensional validation of a Baja and Formula SAE type vehicle, this with the purpose of improving vehicle development processes through the application of this tool, optimizing the experience of designers, saving time and increasing operational efficiency. With the help of a VR team and special software for 3D visualization (VRED), the quality offered by the virtual environment was evaluated, as well as the different tools offered by the software to make the virtual experience as close to reality as possible. . The results obtained in this investigation will allow the reader to know the tools that were used during the process to create a virtual environment and have the ability to interact with the model and the environment created.

Baja SAE, Formula SAE, Validation, VRED, Visualization, Virtual Reality, Animation

Resumen

El apogeo tecnológico dirigido a la realidad virtual ha logrado desarrollar procesos y herramientas nunca antes vistas que nos permiten agregar metodologías de simulación en un ambiente virtual para el lanzamiento de cualquier prototipo, de tal manera que los primeros modelos físicos ya sean casi los finales después de haberles realizado pruebas estrictas en un análisis en 3D. La exploración que se mostrará a continuación se enfoca en analizar las diferentes presentaciones de la realidad virtual con respecto a la visualización, Animación y validación dimensional de un vehículo tipo Baja y Formula SAE, esto con el propósito de mejorar los procesos de desarrollo de vehículos mediante la aplicación de esta herramienta, optimizando la experiencia de los encargados del diseño, ahorrando tiempos y aumentando la eficiencia operativa. Con la ayuda de un equipo de VR y un software especial para la visualización en 3D (VRED) se evaluó la calidad que ofrece el entorno virtual, así como las distintas herramientas que ofrece el software para volver la experiencia virtual lo más cercana a la realidad. Los resultados obtenidos en esta investigación permitirán al lector conocer las herramientas que se utilizaron durante el proceso para crear un entorno virtual y tener la capacidad de interactuar con el modelo y el entorno creado.

Baja SAE, Fórmula SAE, Validación, VRED, Visualización, Realidad Virtual, Animación

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Introducction

Throughout the years technologies are changing or modified by the consumer to achieve a greater field of action as a larger development in the long run as is the use of Virtual Reality not only for large or small industrious if not for all possible fields where you manage to find an opportunity for their applications in a real environment [1]. Virtual reality in recent years has managed to take off with great force by the applications in which it has been applied previously as in which it is currently being applied to mention more practical examples of this program we see it applied in the training of surgeons [2], pilots [3] and firefighters [4] are taking advantage of the realism and flexibility offered by virtual reality. Generating that users experience their functions as real as possible as a first approach to their respective fields of action by the skills and experiences that are gradually learned and can later be reflected in real life [5].

The Baja and Formula SAE type vehicles that will be shown are designed to participate in competitions of their branches, these events are held around the world, within these they manage to expose the designs of different off-road or track vehicles, built by their teams based on the Baja SAE regulations of the competition [6], The contribution that we seek to give to this technology is that the representative teams in this case of the Universidad Popular Autónoma del Estado de Puebla is to be able to model and visualize their vehicles with the goal of recreating their movements respectively of each one in order to identify their correct route in the most realistic way and close to a scale size and can make the necessary changes to pass the different tests that encompass these competitions.

The use of virtual reality did not lead to the use of these tools in a more dynamic way by the type of vehicles being used by Baja and Formula SAE created by students of the Universidad Popular Autónoma del Estado de Puebla, in order to assess the quality of the route in the environment of the virtual prototype and evaluate the dimensional validation offered by the VRED software.

Virtual reality is currently understood as a digital experience enhanced through a vision gadget (special viewers) by means of which, before the reproduction of an environment (artificial or obtained from real events), physical and emotional sensations and reactions are achieved, just as they are experienced in real life [7].

Problem

Before being able to add a CAD model to a virtual reality software, it was necessary to investigate the features offered by such software and also to know the correct programming to use in order to make possible the animations. As part of the obstacles of this project it was found that the number of programs that will be in charge of being able to perform this type of projects is minimal at the moment and the little information released of the correct programming in Python, in addition to the fact that not all programs have student licenses. During the search process, good software was identified but with limitations, such as access to the program and its features, and the only way to use it was to purchase it.

The program used for the visualization of the 3D models in a virtual environment was VRED. During the process it was identified the problem that the tools of this program change depending on the version, since in current versions of the software there are more complex tools with less information released, it should be clarified that not all versions handle the same interface which forced to make different tests in order to achieve the desired result even with the lack of information.

For the selection of the CAD models to be imported to the virtual reality software (VRed) it was necessary to homologate them with respect to other prototypes of vehicle design. In the case of this project, the CAD models to be used are the competition models of the UPAEP university, both the Baja and the Formula SAE.

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The tools and the different elements that will be added will be to make the virtual experience more pleasant and comfortable for those who are viewing the model with the virtual reality glasses, as part of these amenities is the interaction with the change of environment, as well as with the change of model to be displayed, the power to make a measurement point to point and in addition managing to generate a dynamic animation of the vehicles of each of the teams in their branch respectively.

When these functions are active and working, we will proceed to make a displacement of the model so that the user can observe in detail the route of a Formula or Low SAE type vehicle and also be able to see specifically how the components of each area work together to generate the movement of the vehicle.

Justification

Throughout history, the automotive industry has been updated to be able to have a relationship with its consumers, allowing access to new technologies such as virtual reality, which already has more than 50 years of trajectory, which previously focused on other areas such as video games, culture, art and entertainment. This generated an opportunity for growth in the automotive sector, which is gradually developing.

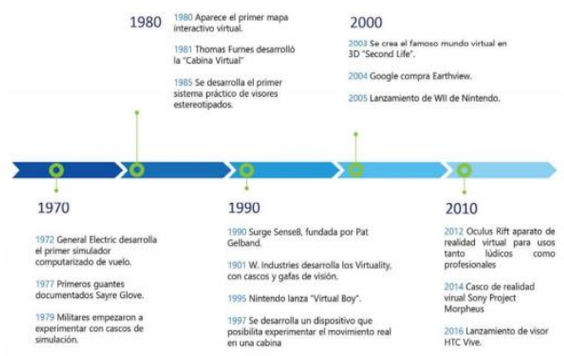

Figure 1 Development of Virtual Reality
Source: [7]

The popularity of these new technologies has increased considerably due to the multiple benefits they offer in the area of design and marketing, sources such as INSIDER Intelligence, which are dedicated to research and statistical forecasts on various topics, took on the task of forecasting the increase in the use of VR and AR. In the image number 2 is presented in a bar chart, the percentages of people using these technologies, either with headset or non headset, only for the years 2019 to 2023. Although the forecast was made exclusively for the U.S. population, this helped to have a clearer idea of the progress being made in the field of virtual reality.

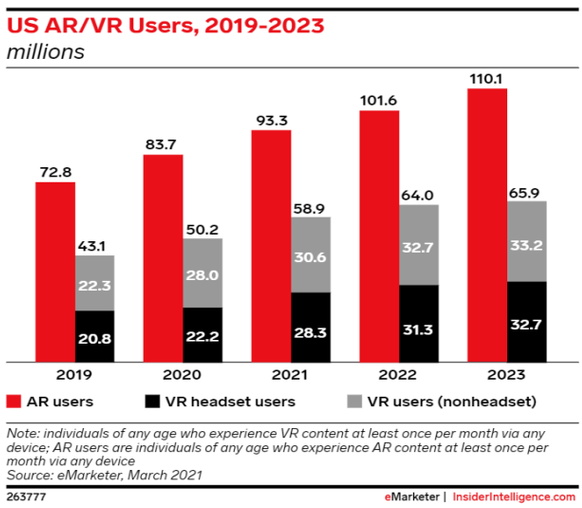

Figure 2 Table of forecasts on the increase in the use of RV and RA
Source: [8]

Conceptualization

As part of the theoretical and practical development for this work, it was essential to go deeper into the topic of the virtual environment focused on the existing standards for this type of technologies and thus be able to justify the work more clearly. Among the existing standards, ISO/IEC TR 18040:2019 Information technology- Computer graphics, image processing and environmental data representation-Live actor and entity representation in Mixed and Augmented Reality (MAR) was located; which manages to present the correct compatibility between data to share them in the correct way, since it provides a reference model for applications in MAR, in addition, it manages and controls learning, education and entertainment (LAE) in a MAR environment [9].

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Another standard found during the research is ISO/IEC TR 23842- 1:2020 Information technology for learning, education and training-Human factor guidelines for virtual reality content-Part 1: Considerations when using VR content [10]. This standard specifies the different considerations that designers should have for the proper and effective use of the virtual environment in different areas, such as education, learning and training as the first part, this standard has an extension of the content, subdividing the standard into two, to achieve a more dynamic content for the reader with the following nomenclature ISO/IEC TR 23842-2:2020 Information technology for learning, education, and training-Human factor guidelines for virtual reality content-Part 2: Considerations when making VR content [11]

Objetive

The joint goal of the virtual reality team and the representative team of Baja and Formula SAE is to present the vehicle in a virtual environment taking into account the needs of each team, in order to show the growth of these innovation methodologies for the construction, validation, visualization and dynamic animation of the models.

Methodology

As part of the correct construction of this project it was necessary to follow a series of initial steps in order to visualize the vehicle properly and present a final product adequate to the requirements of each competition regulation. During the design and simulation process it was inevitable to have errors in order to reach the correct manipulation and understanding of the software and thus achieve a quality virtual experience.

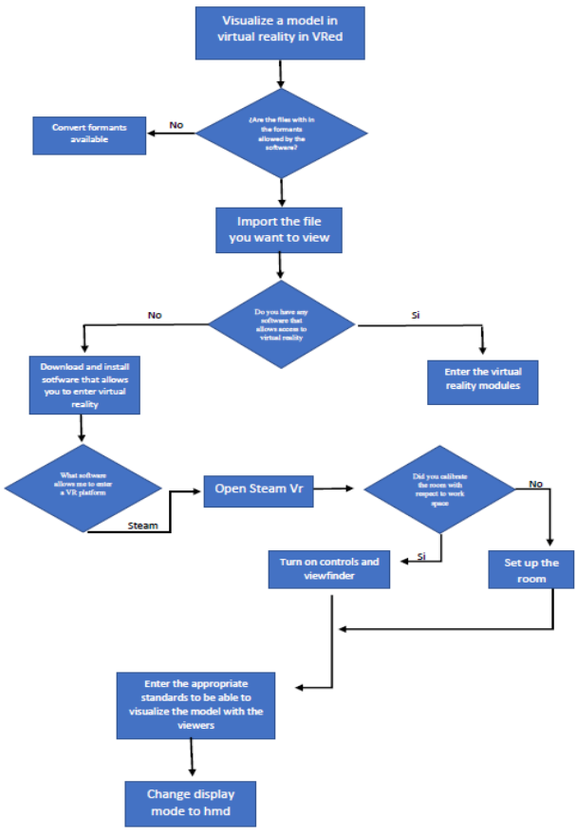

Figure 3 Flowchart for modeling a vehicle in a virtual environment

In order to start the project process it was necessary to download the VRed program through the Autodesk platform, to enter this platform it is necessary to enter student data and thus have downloaded the student license, taking into account the year of the version to use.

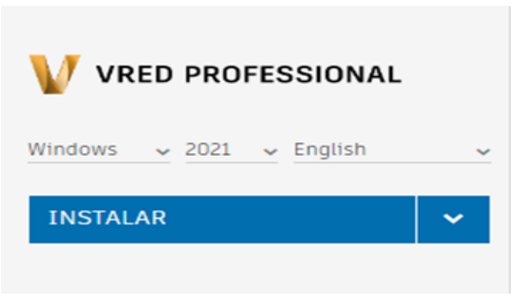

Figure 4 Software download screen

Once installed, the next step was the creation of the document (Graph). We started by importing and placing the CAD models of each branch in which the UPAEP University participates with the stp format, as well as the use of images with extension type (hdr, mtd, tif or dif) to mention a few, to be able to add in this way environments in 360 formats and to be able to visualize the desired image.

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Figure 5 Image in 360 format for Vred

Once the workspace was created and the CAD models (Formula and Low SAE) were inserted, the next step was to arrange them in their color shades and add textures to achieve a more realistic and cleaner finish.

Figure 6 Color and texture arrangement in Cad formula SAE

First of all, it is necessary to activate the menu that enables access to different settings (Scrips - VR menu - Show VR menu) because the version used this in order to use two specific functions which are teleport (to be able to move anywhere in the environment) and mesure (to check the model in the virtual reality environment).

Figure 7 Function menu of Vred version 2021

Once this was done, we looked for a work table with the extension .stp, which will serve as the basis for us to simulate, through Python programming, a set of buttons that serve as commands to activate the various tools that help us to interact with both the prototype and the environment.

Figure 8 Work table

We proceeded to the creation of the commands in the work area to perform the interaction activities subdivided into 4 sub menus (Environment, Variants, Tools, Antialiasing), which were grouped and developed the panels of each of these tools in order to interact with the environment and CAD models, in this case the Formula SAE and Baja SAE.

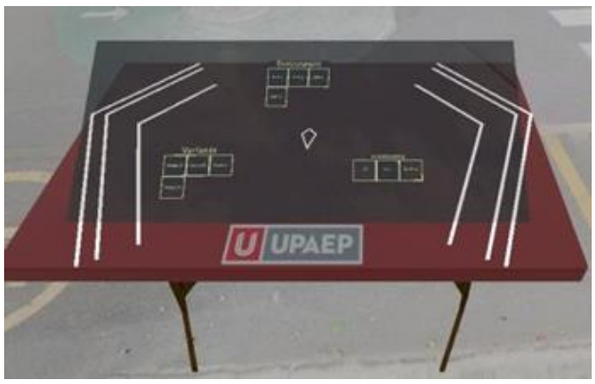

Figure 9 Work table with added submenus.

Once all the programming was done, we continued with the development of the animation of the models (Baja and Formula SAE) and thus achieve that the vehicle within the virtual environment has a cyclic path in the environment of the selection.

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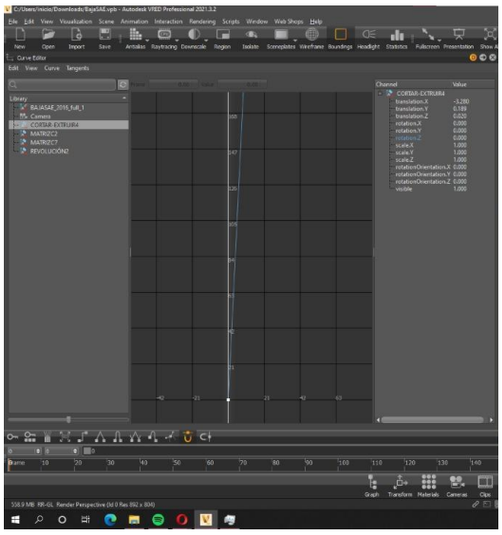

Figure 10 Cyclic animation graphic

Subsequently, the environment was modified. To create a virtual environment it is necessary to take into account the extensions to have an image that meets the format requirements of the software, in order to have an environment as close as possible to the real one.

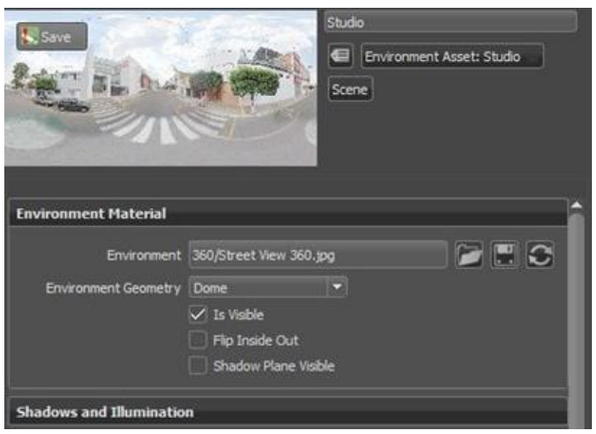

Figure 11 Environment change panel

To conclude this work, the vehicles were visualized by applying the above procedures for each one of them and thus have a quality and presentable product.

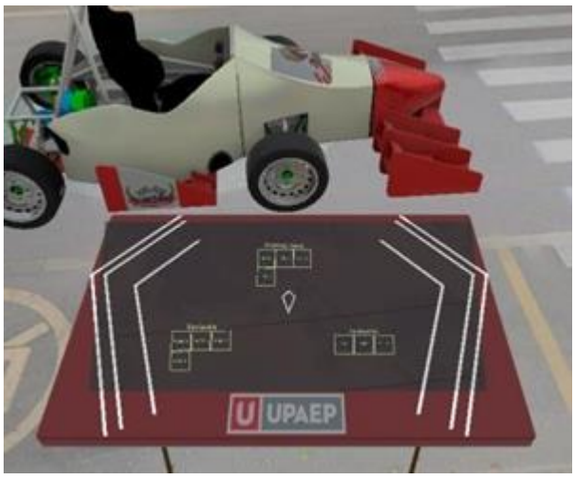

Figure 12 Final model of the project

Animation

In this work we developed the animations of the models with which we are working, generating a better perspective of how the models can move in a real way, in the same way we can adjust certain parameters of the models so that they are in the best way and can meet the general and specific objectives of the project, the final animations were as follows, in the image 13 we can visualize the cars of the UPAEP university of both branches, in which we can see that it is in an unpaved environment, since it is the environment where the competitions for this type of vehicles are performed.

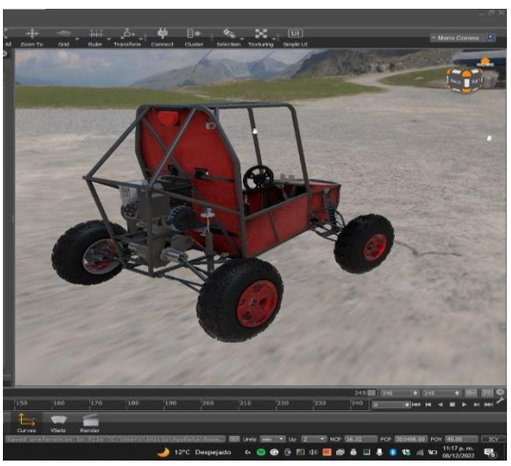

Figure 13 Animation of the SAE Lower Model

In order to achieve the dynamic animation of these vehicles, a series of graphs were created as shown in image 14, which determine through manipulation the type and degree of movement of the selected part within the assembly.

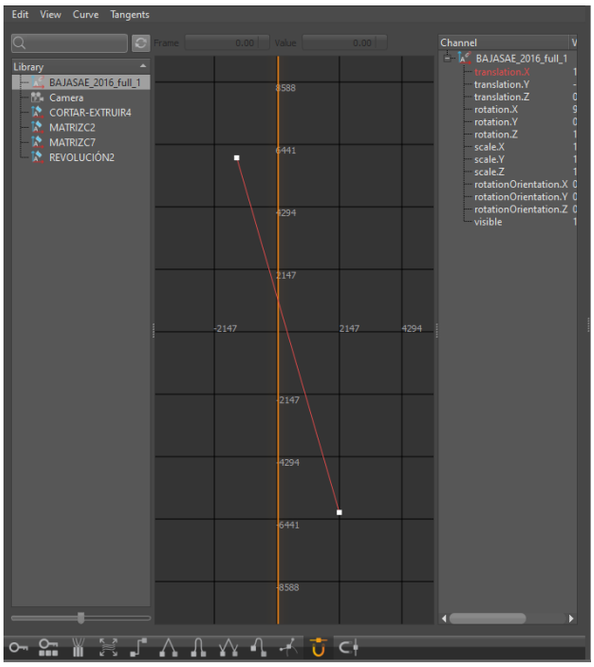

Figure 14 Graphic used for the animation of the Baja SAE

Through the ehremiante curves is how you can recreate this type of movements, along with the ability to create nodes that help the interaction with the subject that is immersed in the virtual environment.

Figure 15 Graphic used for the animation of the Baja SAE.

Results

To evaluate the final experience of the virtual environment, the evaluation was subdivided into 3 categories: the animation of the vehicles, the visual detail of the model and the ability to interact with the environment and the model, with the purpose of taking into account all the fundamental aspects of the virtual environment. On the animation side, we were able to add a series of different routes in which the prototype of the Baja and Formula SAE vehicles could be presented in different ways, within these animations we were able to modify the speed and cycles. In order to make the experience more real, a scenario known by the team members was added, so it was decided to capture one of the streets of the city of Puebla (Av. 11 poniente, between C. 23 and 25 sur).

Figure 16 Scenario selected by the team. Av. 11 poniente, between C. 23 and 25 sur

Regarding the visual detail of the models in the virtual environment, we came to the conclusion that all the parts, accessories and components that make up the Baja and Formula SAE vehicles have a very high visualization quality. In this way we were able to see both vehicles in detail and thus present to each team the proposals of the design models in a real size.

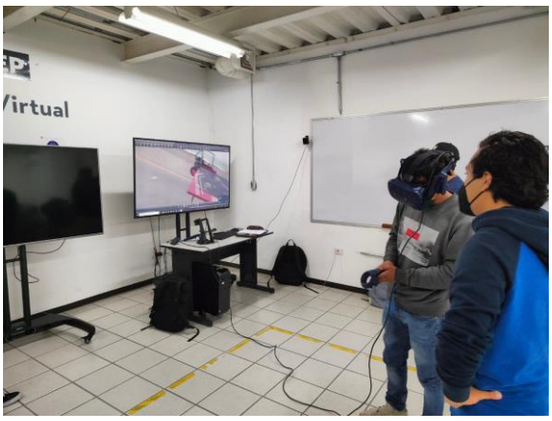

Figure 17 Presentation of the Baja SAE model in simulator

As a result of the last criterion about being able to interact with the model and the virtual environment, they were mostly enriching for the creation of a more real and interactive environment with the user and is that within the virtual environment was added a panel of tools that allows you to make the change of scenario and model.

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Figure 18 Presentation of the Formula SAE model in simulator

To finalize this work, a questionnaire was developed with the purpose of generating a more accurate opinion of the quality of the work done for the creation of the virtual reality models presented.

For the data analysis a non-probabilistic sampling by convenience was carried out, resulting in a population of 11 males and 9 females, this instrument was based in the facilities of the Universidad Popular Autónoma del Estado de Puebla, in the summer academic period, it can be highlighted that the student population in this period is of low demand as it is a private institution. The instrument was validated by calculating Cronbach's alpha with a value equal to 0.7382. The questions related to the equipment (viewers) affected your experience reported the lowest values, so that future studies will consider improving the experience and raising awareness of the use of the equipment beforehand. Table 1 shows the averages and variances obtained from the sample studied.

Ask	Average	Variance
The quality of the models is adequate to distinguish the subsystems that make up the vehicle.	4.22	1.59
The quality of the stage is adequate.	4.61	0.25
The animation of the vehicles is adequate.	4.89	0.10
Understanding how to use the tools turns out to be easy.	4.5	0.38
The equipment (scopes) affected your experience.	3.17	3.09
The components of each vehicle are similar to the real thing.	4.61	0.25
Hand controls are easy to use	4.72	0.21
The use of the tool panel was adequate.	4.72	0.33

Table 1 Statistics obtained from the simple

It is also noted that the animations of the vehicles are adequate, the hand controls are easy to use and the use of the tools panel was adequate. Something that is of interest was that some users reported the absence of an environment accompanied by sound to achieve a more impacting effect in the experience, on the other hand, the presence of dizziness when turning the viewers was detected precisely because it was the first time using the equipment and the lack of awareness in the correct handling of the equipment.

The details in the scenarios were very well qualified, generating a reality that makes you have an immersion in your environment. The open questions identified areas of opportunity to evaluate other scenarios, such as the validation of prototypes at real scales and thus save response times in modifications of a design before building it, achieving an impact in different areas of study.

Conclusions

The work previously presented on the development of a Virtual Simulation for the Driving Evaluation of a Baja and Formula SAE Type Vehicle was born from the need to have a prototype of the cars designed by the members of both teams, with the objective of having the possibility of redesigning the model if any design error were to occur or if it is required to create another proposal to change the order of the subsystems within the vehicle. Within the development of this virtual experience, the process that was carried out during all the work that goes from the conceptualization to the modeling of the virtual environment is exposed, it is necessary to emphasize the limited information that is available with respect to these new technologies, since it was one of the biggest limitations that were found during the conceptualization process.

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Also one of the problems that we came to have in mind was the correct application and development of the codes used in Python to achieve the correct animation of the vehicles since it was stated that if it was not well done the animation was not generated or simply did a different thing than expected since Python is a more specialized software for the use of commands and codes needed to generate movement since most companies that create these programs ask for money to use the software, without having a few days of testing and evaluating whether the software has the necessary tools to achieve the objectives. On the other hand, the experience that was had as a team is something unique, having the possibility to study, use and test these new technologies opens the mind to new possibilities and new ways in which these tools can be used by the new generations. It is a fact that virtual reality is one of the technologies with the highest growth projection, according to the latest IDC Research forecasts (2020), investment in VR and AR will multiply by 21 in the next four years, reaching 72.8 billion euros in 2022 [12]. It is worth noting that both technologies will take an important part for the digital transformation plans of companies, therefore it is expected that by 2024 more than 50% of large European companies have a VR and AR strategy.

Finally, it is essential to mention how important were both the results and the comments made by the participants of the sampling, within this feedback the great experience they had within the virtual environment and the great detail of the models, in the same way they commented on the proposals to use these tools and software within their projects, but in different areas. The authors are in favor of the idea that this technology is being known by many more people, this will help that in the future every day there will be more innovations in the field and thus to know all the possibilities that exist for these technologies.

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