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Journal Computational Simulation

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The works must be unpublished and refer to topics of telemetry, diffuse interval, electrical stimulation, diffuse controller, mobile application, communications network, web platform, production control, computer technology, computer electronics, control devices, programming languages and automated production systems and other topics related to Engineering and Technology.

Presentation of Content

The first article presents, *Web page of tourist attractions, history, culture and traditions of Acatlán de Osorio, Puebla, with location in google maps using augmented reality*, by ROJAS-NANDO, Julio Cesar, NIETO-ROSALES, Ana Laura, FUENTES-CORTES, Miguel and GONZALEZ-SERRET, Mónica, with a secondment at the Instituto Tecnológico Superior de Acatlán de Osorio, as the next article is *Application based on Machine Learning to obtain information on monuments and tourist areas (P-Search)*, by ARROYO-ALMAGUER, Marisol, GONZÁLEZ-MARTÍNEZ, Mary Carmen, CHÁVEZ-VIDAL, Eduardo Jesús and RODRÍGUEZ-VARGAS, María de Jesús, with a secondment at the Universidad Tecnológica del Suroeste de Guanajuato, as the next article is *Development of a virtual reality driving experience of a Formula SAE-type vehicle*, by SOLIS-ARRIAGA, Everth Rafael, CORDERO-GURIDI, José de Jesús, VELAZQUEZ-MENDEZ, Andrés and PÉREZ-REYES, Karol Josafat, on secondment to the Universidad Popular Autónoma del Estado de Puebla, as the next article is *Development of a virtual experience of evaluation of the concept of a low and SAE formula vehicle*, by CORONA-FLORES, Mario Eduardo, CUAUTLE-GUTIÉRREZ, Luis, GARCÍA-TEPOX José Domingo and ALFARO-APANGO, Miguel Ángel, on secondment to the Universidad Popular Autónoma del Estado de Puebla.

Content

Article **Journal Computational Simulation**
June 2022, Vol.6 No.15 1-5

Web page of tourist attractions, history, culture and traditions of Acatlán de Osorio, Puebla, with location in google maps using augmented reality

Página web de atractivos turísticos, historia, cultura y tradiciones de Acatlán de Osorio, Puebla, con localización en Google maps utilizando realidad aumentada

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Abstract

The present work consists of informing the result of an investigation which consisted of developing a web page of the areas considered as tourist attractions, as well as containing the history, culture and traditions of the municipality of Acatlán de Osorio; on said page this information was captured to make the municipality known to tourists who seek to visit places enriched with culture such as said municipality, the web page will show the tourist place that is of the clienct's preference, as well as the geographic location of the place, a visualization in augmented reality, with an audio description of the place, which will attract more attention, encouraging the client to visit said place, this is a way to help improve the economy of the municipality. The results reflected in this document show that the tourist places of this municipality can already be consulted in an easy and attractive way for the client.

Website, Tourism, Augmented reality

Resumen

El presente trabajo consiste en informar el resultado de una investigación la cual consistió en de desarrollar una página web de las zonas consideradas como atractivos turísticos, así mismo contiene la historia, cultura y tradiciones del municipio de Acatlán de Osorio; en dicha página se plasmó esta información para dar a conocer el municipio a los turistas que buscan visitar lugares enriquecidos de cultura como lo es dicho municipio, la página web mostrara el lugar turístico que sea de la preferencia del cliente, así mismo la ubicación geografía del lugar, una visualización en realidad aumentada, con un audio de la descripción del lugar, lo cual le llamará más la atención propiciando que el cliente visite dicho lugar, esta es una forma de ayudar a mejorar la economía del municipio. Los resultados plasmados en este documento evidencian que ya se pueden consultar los lugares turísticos de este municipio de una manera fácil y llamativa para el cliente.

Página web, Turismo, Realidad aumentada

Citation: ROJAS-NANDO, Julio Cesar, NIETO-ROSALES, Ana Laura, FUENTES-CORTES, Miguel and GONZALEZ-SERRET, Mónica. Web page of tourist attractions, history, culture and traditions of Acatlán de Osorio, Puebla, with location in google maps using augmented reality. Journal Computational Simulation. 2022. 6-15:1-5.

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Introduction

This web page is dedicated to show relevant information of the municipality of Acatlan de Osorio, as well as allows the site administrator to upload, delete and edit the information of the different tourist sites that exist in the municipality, this way it is easier to use the website, likewise the administrator has the privilege of adding more administrators or capturistas.

The role of capturer will only have the privilege of uploading tourist sites, unlike the administrator who can perform the three basic actions.

The main objective of this project is to increase the economy of the municipality by encouraging more tourists to be interested and visit the place, achieving a higher consumption by them.

Analysis

A web page was developed that could help in the publicity of the municipality of Acatlán de Osorio, which has a lot of culture and tradition, helping to increase the economy of this area.
In this section we will investigate the most important concepts used at the time of developing the system.

Survey of requirements

For the elaboration of the project, the cascade methodology was used, in which the first step is the requirements gathering of the system.

For the design of this system, requirements were determined on the programmer's side and on the client's side.

This helped our system to function correctly and fulfill the essential functions required.

Program side requirements:

- Computer hardware is required.
- Internet access.
- Windows 10 operating system.
- Domain name.
- Hosting.
- Apache Web Server.
- Web site design (Languages: html, php, css).
- Database management system: MySQL.
- Spark studio.
- Zappar Platform.

Client-side requirements:

- Computer equipment is required.
- Internet access.
- Access to a browser of choice: Google Chrome, Microsoft Edge.
- A cell phone with camera and internet.

Use case modelling

As a first step we will identify the users that will interact with our system. Once the potential users have been identified, the diagram will be drawn and the function that each user will perform and the relationship between them will be described, using the use case diagram.

Database design

The database was designed and implemented using MySQL, using 4 tables as shown in Figure 1, one of them stores the main data of the tourist sites, it is also related to the category table which determines which category each tourist site belongs to in order to show it on the web page, two more tables were used, one of them stores the personal data of the users and the second one determines what type of privilege each one of them has.

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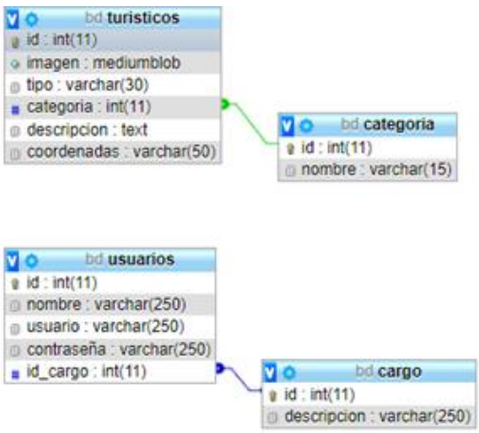

Figure 1 Database with 4 tables
Source: Own elaboration

Programming

The tools used were: MySQL database management system, Apache Web Server, PHP, CSS and HTML languages.

With the help of these tools the administrator interface was designed and programmed which consists of:

- Having access to a table where the users that can manipulate the website are shown, likewise has the privilege to register new users as desired, these can be capturers or administrators.

- You have the option to upload tourist sites to the website when required, you can also edit and delete these sites.

The captures interface was designed and programmed, which consists of the following:

- This user, unlike the administrator, can only upload tourist sites to the web site.

- The user interface was designed and programmed which consists of the following:

- The user will be able to enter the website and will have the option to choose the category of his liking, among the categories are: (hotels, restaurants, workshops, recreational places and spas), by selecting the category will be shown all the sites registered in that category, you can view their geographical location and a photograph.

- You will be able to scan a QR code which will show you the place with augmented reality, a description of the place in audio and the location.

Implementation

The web page was launched, the corresponding tests were carried out to avoid any type of error, once the corresponding tests were carried out, the page was hosted in the hosting so that any user can visit it without any problem.

Methodology to be developed

The development methodology was the cascade method, a linear methodology that requires the completion of previous activities in order to continue with the following ones, i.e. all predecessor activities must be completed before the next step can be carried out.

Results

Figure 2 shows the implementation of the tourism page where we can appreciate the home interface of the web page.

Figure 2 Implementation of the page in the domain
Source: Own elaboration

We can see in Figure 3, the main use case that was built in order to design the database.

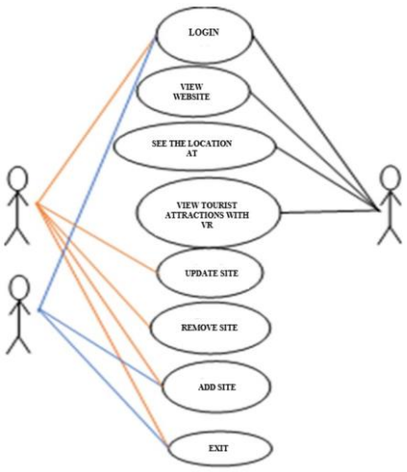

Figure 3 Main use case
Source: Own elaboration

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The following figure shows the sequence diagram that identifies the web page.

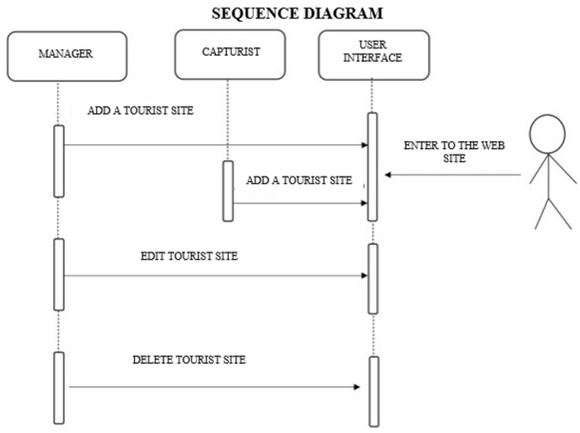

Figure 4 Sequence diagram
Source: Own elaboration

Home screen

The home screen shows the categories that can be visited by the user.

Figure 5 Home screen
Source: Own elaboration

Figures 6 and 7 show interfaces of the workshops category, in this section you can visualize in detail the information about the handicraft workshops, which is an activity that characterizes the municipality of Acatlan.

Figure 6 Workshops category
Source: Own elaboration

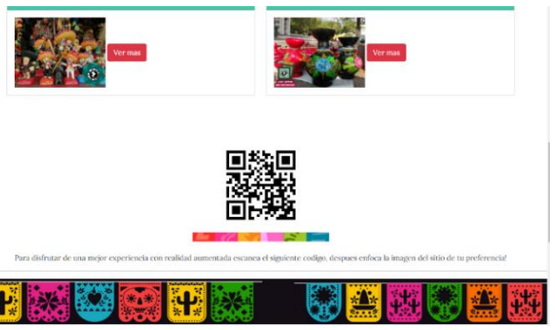

Figure 7 Workshops
Source: Own elaboration

This section shows an image of the tourist site and its geographic location.

Figure 8 Geographical location of the tourist site
Source: Own elaboration

When focusing on the image of the tourist site, an augmented reality image is displayed along with an audio description of the site and its geographic location.

Figure 9 Augmented reality image
Source: Own elaboration

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This project is the result of a research and technological development work, which was subsidized by the Instituto Tecnológico Superior de Acatlán de Osorio, the work is linked to the municipal government of that municipality.

Conclusions

This project is considered a great contribution to society and especially of great help to the municipality of Acatlan de Osorio Puebla, since it contributes to the use of technologies for the increase of tourism in the municipality, improving the economy of its inhabitants, the main objective of this project was to let tourists know the richness of Acatlan de Osorio and encourage them to visit the emblematic sites of Mexico.

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Application based on Machine Learning to obtain information on monuments and tourist areas (P-Search)

Aplicación basada en Machine Learning para obtención de información de monumentos y zonas turísticas (P-Search)

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Abstract

Guanajuato seeks to boost the tourism sector, increasing the level of satisfaction in the experiences of visitors to the state, encouraging the use of technology and promoting its accessibility (Government of the state of Guanajuato, 2021). As a result of the use of new technologies, mainly through mobile devices, users want to obtain more information about their environment with the least possible effort. In this context, the P-Search application emerges, with the aim of improving the tourist experience by obtaining information about the monuments and places that the user visits, without the need for a tourist guide. By taking a photograph of the monument and / or place, the application will do the image recognition process and the user will be able to view the corresponding information. The application uses a Machine Learning algorithm and a data repository to perform image classification and maintain a history with the preferred categories for the user. The first version of the application continues to update the classification process, expanding the number and variety of images used for training and knowledge of the database, using optimization tools.

Machine Learning, KNN Algorithm, Tourism Sector

Resumen

Guanajuato busca impulsar el sector turístico, incrementando el nivel de satisfacción en las experiencias de los visitantes al estado, propiciando el uso de la tecnología y el fomento a su accesibilidad (Gobierno del Estado de Guanajuato, 2021). Derivado del uso de nuevas tecnologías, principalmente a través de dispositivos móviles, los usuarios desean obtener mayor información de su entorno con el menor esfuerzo posible. En este contexto surge la aplicación P-Search, con el objetivo de mejorar la experiencia turística al obtener información sobre los monumentos y lugares que el usuario visite, sin necesidad de un guía de turistas. Con tomar una fotografía al monumento y/o lugar, la aplicación hará el proceso de reconocimiento de imagen y el usuario podrá visualizar la información correspondiente. La aplicación utiliza un algoritmo de Machine Learning y un repositorio de datos para realizar la clasificación de imágenes y mantener un historial con las categorías preferentes para el usuario. La primera versión de la aplicación sigue actualizando el proceso de clasificación, ampliando el número y variedad de imágenes usadas para el entrenamiento y el conocimiento de la base de datos, utilizando herramientas de optimización.

Aprendizaje automático, Algoritmo KNN, Sector turismo

Citation: ARROYO-ALMAGUER, Marisol, GONZÁLEZ-MARTÍNEZ, Mary Carmen, CHÁVEZ-VIDAL, Eduardo Jesús and RODRÍGUEZ-VARGAS, María de Jesús. Application based on Machine Learning to obtain information on monuments and tourist areas (P-Search). Journal Computational Simulation. 2022. 6-15:6-13.

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Introduction

The tourism sector is constantly seeking new proposals to improve tourist experiences, and the use of technology plays a decisive role. According to data from the State Tourism Observatory (OTEG), Guanajuato recorded the arrival of more than 18,700,000 visitors in 2021 (Carranza, 2022).

When traveling, tourists achieve a better experience when they know the detailed information of the places they visit, without the need of a tour guide.

According to the results generated by the project "The tourist's gaze: imaginary and perception of tourists visiting the city of Guanajuato" (Reales Angulo, Frías Guerrero, Ramírez Morales, Ospino De La Rosa, & Pabuena Domínguez, 2019), the attraction that most captures the attention of tourists is the architecture of a city, followed by the history of the place.

Tourism apps are of great use, not only when buying airline tickets and booking hotel accommodations, but also when receiving relevant information about tourist sites and historical monuments of interest.

Problem statement

Derived from the need expressed by the Ministry of Tourism (SECTUR) of the state of Guanajuato and the Institute of Innovation, Science and Entrepreneurship for Competitiveness (IDEA), to increase the level of satisfaction in the experiences of visitors to the state of Guanajuato, favoring the use of technology and promoting its accessibility (Government of the State of Guanajuato, 2021), the creation of an application that facilitates access to relevant information of the different monuments and/or tourist areas of the city of Guanajuato is proposed.

The problem is addressed with the following question:

How to promote and strengthen the identity of the tourist areas of Guanajuato, using Information Technologies?

Objective

Improve the user experience, obtaining information about the tourist sites of the city of Guanajuato in a simple way, through the design and implementation of a web application based on artificial intelligence.

Justification

Research and interest in the history and culture of an area or historical monument is increasingly lost because it is often perceived as a boring and tedious process. That is why, the purpose is to provide a simple and easy to use means "...the experience can be improved if some changes are achieved in the teaching of history by proposing to make it more illustrated, that is, through different technological tools useful to promote motivation, dispel doubts, arouse curiosity and share ideas that are generated at the time." (Valencia Díaz, 2018).

P-Search contributes in improving the user experience by providing information about historical monuments and tourist sites, through a photograph.

Scope

The project is aimed in the first instance at tourists in the city of Guanajuato who wish to obtain quick and simple information about the area and/or historical monument they are visiting, through a photograph. Subsequently, tourist areas and moments in other municipalities of the state will be included

Frame of reference

Artificial Intelligence (AI) and Machine Learning

AI is the intelligence carried out by machines and is developed through different disciplines, including: computer vision, natural language processing, neural networks and machine learning. Machine learning is a branch of artificial intelligence that is applied in a wide variety of fields. Its aim is to find patterns in data and develop techniques that allow machines to learn, i.e., as they are exposed to new data, they generate new learning. The different machine learning algorithms are grouped into (Embarec Riadi, 2020):

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- Supervised learning. Algorithms that work with data grouped into known variables; given the input variables, the answers are known and the output labels are assigned.

- Unsupervised learning. The modelling process is performed on a set of examples formed by inputs to the system, without having information on the categories of those examples.

- Reinforcement learning. The input information is feedback from the outside, i.e., the system learns by trial and error.

The KNN algorithm

The KNN (K-Nearest Neighbour) or k-NN algorithm is a non-parametric supervised learning model that uses proximity to make classifications or predictions about the clustering of an individual data point. The k stands for the number of neighbouring points that are close to the point of interest, in order to classify it into one of the initially labelled groups (output variables).

It is generally used as a classification algorithm, based on the assumption that similar points can be found by proximity, learned in the training stage and making guesses for new points based on that classification (IBM, 2022).

The KNN calculates the distance of the new element to each of the existing ones, and ranks these distances from smallest to largest to select the group to which it belongs. From an initial dataset, its goal is to correctly classify all new instances; therefore, learning occurs at the same time as the test data is evaluated (MERKLE, 2020).

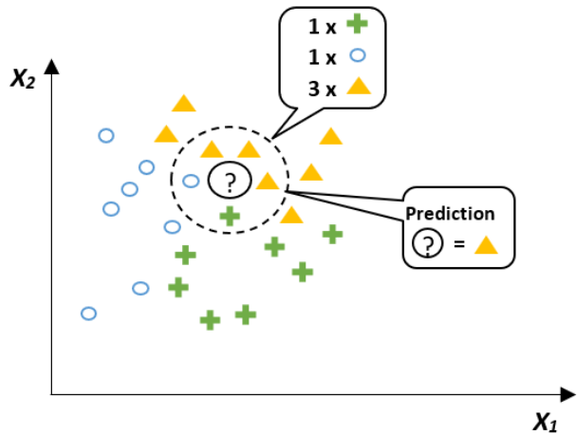
The steps to run the KNN algorithm are (Mirjalili & Raschka, 2019):

1. Choose the number of k and a distance measure.

2. Find the k-nearest neighbours of the sample to be classified.

3. Assign the class label by majority vote.

Graphic 1 shows the assignment of a new data element (?) to the class label triangle by majority vote among its five nearest neighbours.



Graphic 1 Working example of the KNN algorithm
Source: Mirjalili & Raschka, 2019

Artificial intelligence (AI) and the tourism industry

The Secretary of Tourism of the state of Guanajuato, highlights that the most innovative trends towards which the tourism sector is tending can be divided into three blocks: tourism intelligence, robotisation and artificial intelligence and augmented reality (Olvera Novoa, 2022).

According to data from the study conducted by the company SmartTravel: "AI travel agents, the future?", 64% of travellers between 30 and 40 years old want to get to know a certain destination through an Augmented Reality (AR) view before making a trip; while 50% feel encouraged to book a trip with technologies that help them personalise destination suggestions (CIO Mexico, 2021).

In this regard, Gustavo Parés, CEO of NDS Cognitive Labs, a Mexican Artificial Intelligence (AI) services company, mentions that "AI is very useful for both companies and travellers, as a pleasant travel experience is key in the tourism sector" (Hernández Villegas, 2021).

According to NDS Cognitive Labs, AI enhances the travel experience by offering personalised options that fit the tourist's wants and needs (CIO Mexico, 2021).

For the development of this project, applications, platforms and available tools were reviewed, aimed at facilitating the search for information on tourist areas, among which the following stand out:

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- *Google Lens* is an application that has several processing functions based on image analysis. It compares objects in photos with other images, which it classifies by their degree of similarity and relevance to the objects in the original photos. It can also copy or translate text, identify plants and animals, explore places or menus, discover products and find visually similar images (Google, 2022).

- *Photo Sherlock*, aimed at searching for people by photo. The application provides search by image taken from the camera or gallery, using Google, Yandex, Bing search engines. It can be used to search for information about a photo on the Internet, for example, to detect the real owner of the photo in a social network (Prysjazhnjuk, 2022).

- *Blippar AR*, an augmented reality application that uses computer vision and can identify different historical monuments around the world through a photo or scan of the monument (Blippar, 2022).

Development methodology

The methodology used in the development of this project is an iterative model in which five phases were defined, which are shown in Figure 2 and described below:

1. Detection of needs. 100 surveys were carried out with people between the ages of 20 and 50, with the following main results:

    - 68% of the people surveyed like to take photos when they travel; and 50% search the internet related to the tourist areas they are visiting.

    - 98% have a mobile device when travelling; and 82% would like to have an application that allows them to have information about the historical monuments and tourist areas they visit, through a photograph.

    - Finally, 80% of respondents suggested that the application should also allow them to keep a history of places visited and give their opinions so that other users can see their impressions.

2. Desk research. Exploratory research was carried out, the state of the art was reviewed and the requirements to be met by the application were determined.

3. Definition of the project. The I.T.-based proposal is presented, defining the proposal with objectives, scope and expected results.

4. Project planning. A chronogram of activities is generated, considering times and people in charge; and the architecture of the application is detailed, defining the automatic learning algorithm to be used, as well as the most suitable development tools.

5. Development and implementation. The data repository is modelled, the interfaces are designed, coded and the various preliminary tests are carried out.

The application has been built using an evolutionary development model (Figure 1), which consists of developing an initial prototype and gradually refining it through different versions that are presented to a sample of end users. This model allows the application of a technique or exploratory development that involves working with the client, starting the development of the proposal with the requirements that are most understood, and then adding new proposed attributes until the final version is reached (Sommerville, 2005).

It focuses on the gradual construction of the product, requiring constant reviews and evaluations of the different versions of the prototype, detecting timely changes in the requirements, allowing realistic results in a shorter period of time (Ramos, Noriega, Laínez, & Durango, 2017; Sommerville, 2005).

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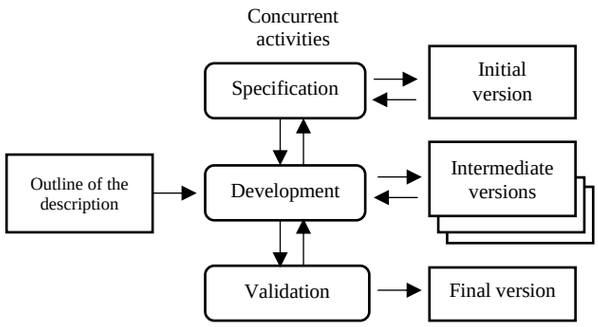

Figure 1 Evolutionary development model
Source: Sommerville, 2005

6. Testing and results. A pilot group is selected, in order to validate the software prototype, implementing changes for continuous improvement of the functionality and guaranteeing the expected results.

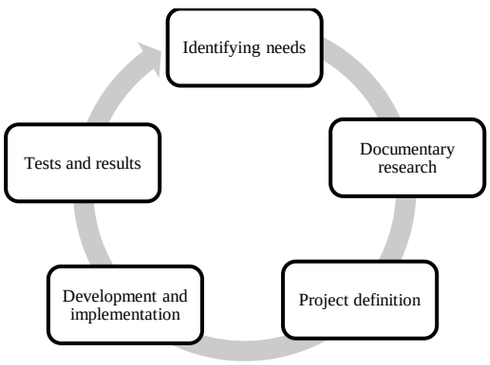

Figure 2 Project development methodology
Source: Own elaboration

Project development

P-Search is based on client-server architecture, with PHP programming language using the Model View Controller (MVC), which allows a better structure and organisation of development. The interfaces were designed implementing the *CodeIgniter framework*, being necessary the use of *HTML5*, *CSS3*, *JavaScript*, *AJAX*, *JQuery* and the ML5.js library to facilitate the use of the automatic learning algorithm. The database driver used is *MySQL*. A sample of the main interfaces is presented below.

1. Login interface. Two login profiles are considered, administrator and standard user (Figure 3).

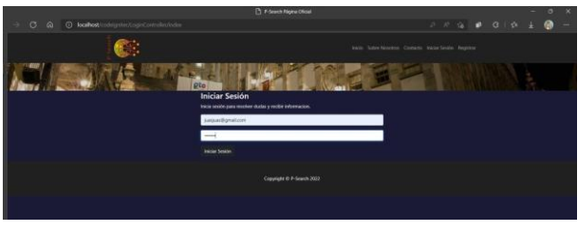

Figure 3 Login interface
Source: Own elaboration

2. Main interface. Both profiles have access to the learning module of the algorithm; the administrator profile also allows the registration of monuments and tourist areas (Figure 4).

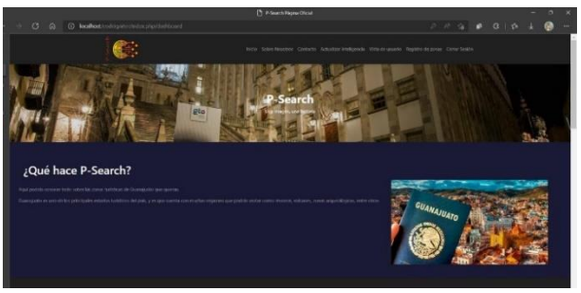

Figure 4 Main interface, administrator view.
Source: Own elaboration

3. User view interface, access to the recognition of images of monuments and tourist areas (Figure 5).

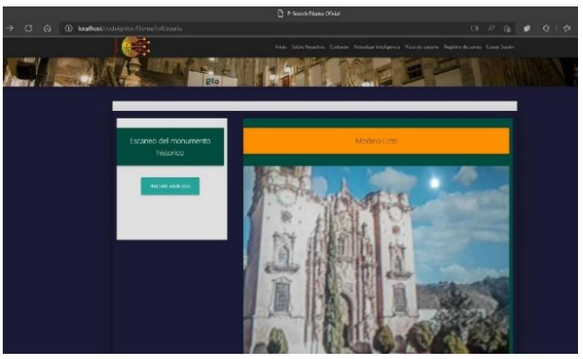

Figure 5 KNN model execution interface, user view.
Source: Own elaboration

4. Tourist zone control interface. In this section, monuments and tourist zones are registered, updated and deleted (Figure 6).

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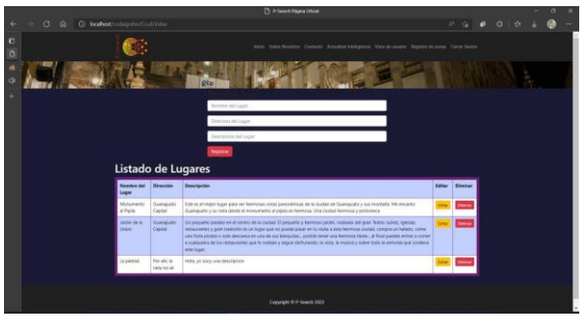

Figure 6 Tourist zone control interface.
Source: Own elaboration

The database is managed in PHPMyAdmin (Figure 7).

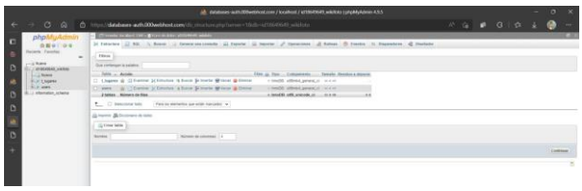

Figure 7 Database in PHPMyAdmin
Source: Own elaboration

Results and impact

P-Search is an application that displays information about tourist sites and historical monuments by means of automatic learning and image recognition through a mobile device; when a photograph is taken, the application identifies the place or monument and redirects to a customised interface that displays relevant information about it.

In the user view, access to the device's camera is automatic, but the intelligence does not start image recognition until the user presses the "Start Analysis" button (Figure 8).

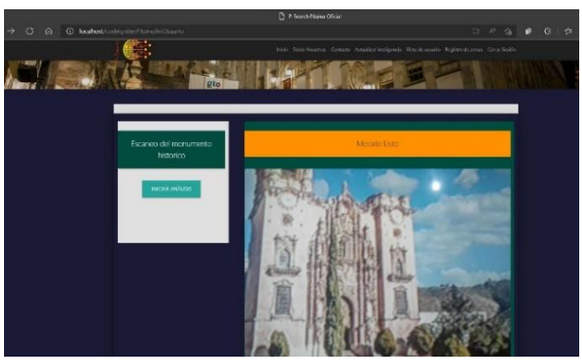

Figure 8 Standard user view
Source: Own elaboration

The supervised learning algorithm starts the image recognition process, looking for colour and shape matches, making a comparison with the images preloaded in the application. It then visualises the image with the highest percentage of coincidence (Figure 9).

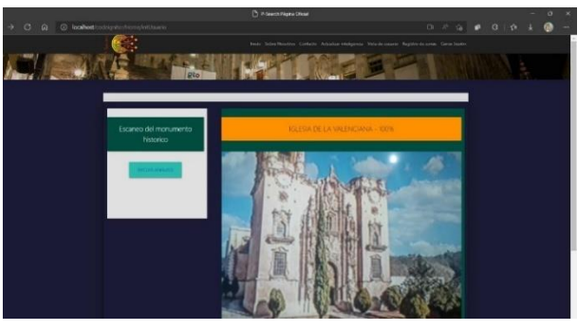

Figure 9 Image detection with supervised learning
Source: Own elaboration

To train the KNN algorithm, the button corresponding to the monument or tourist area to be added must be pressed until the coincidence is 100% (Figures 10 and 11).

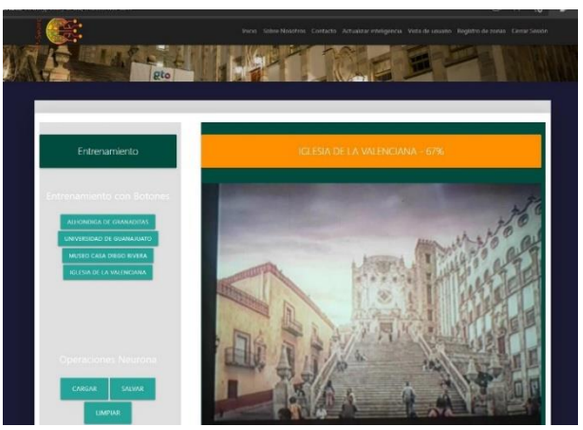

Figure 10 Demonstration of training of the KNN algorithm, at 67%.
Source: Own elaboration

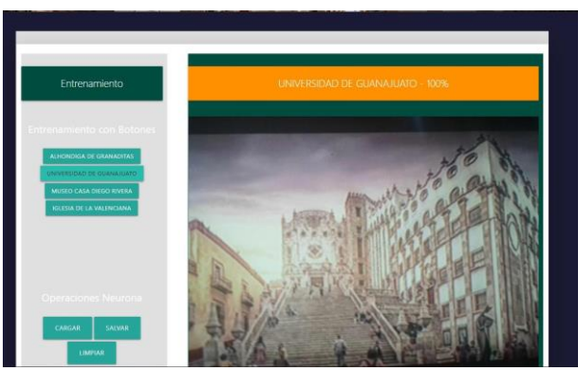

Figure 11 Training demonstration of the KNN algorithm, at 100%.
Source: Own elaboration

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The administrator has the "Save" button to download the file containing the new knowledge.

When the KNN algorithm identifies the place three times in a row and with the same percentage, it displays the information of the identified monument or tourist area (Figure 12).

Figure 12 Tourist area information.
Source: Own elaboration

The application is currently hosted on a cloud server and can be accessed from any browser and device with a camera and internet access.

Conclusions

P-Search is an application that displays information about monuments or tourist sites by means of automatic learning and image recognition, through a mobile device. It is trained to recognise images of the following monuments and tourist areas in the city of Guanajuato: Alhóndiga de Granaditas, University of Guanajuato, Diego Rivera's house and the Valenciana Church.

When a photograph is taken, the application is able to identify the area or monument with a 100% match and display the most relevant information about the monument or tourist area; if it does not recognise the image, the application currently tries to relate it and displays suggestions.

For the development of the project, open source web technology is used, so the cost is accessible, as well as being intuitive and easy to use.

This application is intended to be a technological tool that benefits the tourism sector by improving the tourist's experience when visiting the historical sites of the city of Guanajuato, providing information about the place they are visiting without the need for a tourist guide.

The project was developed through the collaboration network formed by the Academic Body of Information Technologies and students of the TSU career in Virtual Environments and Digital Business of the UTSOE.

Acknowledgements

To the Universidad Tecnológica del Suroeste de Guanajuato, for the facilities provided for the realisation of this project; especially to the Dirección de Carrera de Tecnologías de la Información for the support and trust given.

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Development of a virtual reality driving experience of a Formula SAE-type vehicle

Desarrollo de una experiencia de manejo en realidad virtual de un vehículo tipo Formula SAE

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Abstract

The objective of this work was to develop a virtual environment with the purpose of developing a driving experience in a FORMULA SAE type vehicle. The use of virtual reality has not only the purpose of entertainment, but also many more applications. From the different software tools for virtual reality, the use of the video game engine software Unity was essential. It is shown the development of a simulator that allows experiencing the movement of a Formula SAE-type vehicle through a simulated F1 track. To achieve this, we use a Formula SAE model designed by the UPAEP university. The results obtained showed different effects and sensations, including physiological effects such as dizziness depending on the variables of the simulator. However, it is a way to experience driving conditions in a Formula SAE-type vehicle. The simulator was validated by a group of engineering students and participants of the Formula SAE project, discovering results and findings from the simulation experience that allow the project to grow.

Virtual Reality, Formula SAE, Unity, Driving experience

Resumen

El objetivo de este trabajo fue desarrollar un ambiente virtual con el propósito de desarrollar una experiencia de manejo en vehículo tipo FORMULA SAE. El uso de la realidad virtual tiene no solamente el propósito de entretener si no que esta tiene muchas más aplicaciones. De las distintas herramientas de software para realidad virtual, el uso del software motor de videojuegos Unity fue fundamental. Se muestra el desarrollo de un simulador que permite experimentar el movimiento de un vehículo tipo Fórmula SAE a través de una pista simulada de F1. Para lograrlo, utilizamos un modelo de Formula SAE diseñado por la universidad UPAEP. Los resultados obtenidos mostraron diferentes efectos y sensaciones, entre ellos, efectos fisiológicos como mareos en dependencia de las variables del simulador. Sin embargo, es una manera de experimentar las condiciones de manejo en un vehículo tipo Formula SAE. El simulador fue validado por un grupo de estudiantes de ingeniería y participantes del proyecto Formula SAE, descubriendo resultados y hallazgos de la experiencia de simulación que permitan crecer el proyecto.

Realidad Virtual, Formula SAE, Unity, Experiencia de manejo

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† Researcher contributing as first author.

Introduction

The first conception of virtual reality was presented by Ivan Sutherland, who made a display that was placed on the user's head, which is considered the first virtual reality immersion, this first interaction with virtual reality had the characteristic of being able to show different images on the display, as well as knowing the position of the user's head [1]. For a system to be considered virtual reality, it must be able to digitally generate a three-dimensional environment in which the user feels present and in which they can interact intuitively and in real time with the objects they find within the system.

Technology has been constantly evolving in all aspects and the world of virtual reality has evolved in both software and hardware. A proof of that are the different applications and useful tools which satisfy current needs in different areas such as education, industry, music, medicine, architecture and virtual laboratories where it is possible to simulate the conditions of a real environment with visual content, tactile sensations and auditory stimuli, among others [3].

Currently there are different types of virtual reality hardware and software that help us to use the tools and applications in different ways such as the measurement and validation of parts, visualisation of different types of textures, providing different colours to parts, training in work simulations for company personnel and thus avoiding significant losses.

A great advantage of these softwares that allow us to develop and work with virtual reality is that different types of files can be imported from one platform to another, so that it is possible to work with different softwares at the same time and in this way work collaboratively with a work team, having as main advantage the reduction of time in the different developments of projects, works, etc.

The way in which virtual reality is transforming the way we perceive the world and how we perceive the virtual world has changed so much that sometimes it is difficult to differentiate virtual reality from reality. On the other hand, the use of virtual reality for research methods has also had a breakthrough.

Now, virtual reality is used in laboratories, research, and industrial applications that allow the operator to feel, touch and see a product or service and generate sensations very similar to those of real life.

Virtual reality has applications that have supported the development and implementation of Industry 4.0, as well as Education 4.0. On the education side, it allows the simulation of environments where participants possess exceptional characteristics without risks to their safety or the need for large investments or for participants to share the same geographical location. On the other hand, participants can have abilities such as flying, occupying an object as a virtual body or observing the environment from perspectives that would not be possible in the real world [2]. It should be noted that one of the main applications of virtual reality within the automotive area can be driving simulations, vehicle design, testing environment, among others. The environments that can be created through virtual reality allow both students and professionals to have an immersive experience when visualising models and interacting with them. Using virtual reality software and hardware which has motion sensors, wall sensors and controls for interaction.

Figure 1 shows the schematization of a virtual reality application and evaluation strategy, where Checa, D., Martínez, K., Osornio-Rios, R. A., & Bustillo, A. developed a methodology where initially the instructions were shown, where the user is shown the objective and the needs of the work. Afterwards, the interface is shown, where it is connected to the virtual reality device, to the virtual reality controls and to the sensors for the execution of the programme. Next, we had the simulation, where we could observe an environment related to the interaction work, dynamic simulations, etc. Finally, the evaluation was obtained, whereby means of surveys to different users an analysis for the work and to be able to execute an optimal evaluation was made known.

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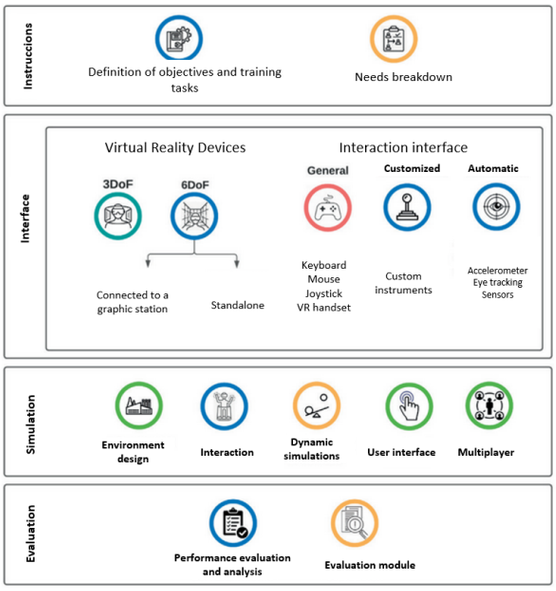

Figure 1 Proposed strategy for the design of Immersive Virtual Reality applications in the prevention of occupational hazards
Source: [5] www.revistadyna.com

Description of the method

The Society of Automotive Engineers (SAE) unveils the Formula SAE (FSAE) which is a competition where students with the help of teachers imagine, plan, manufacture and compete with their FSAE vehicle to demonstrate the creativity and engineering skills developed and put them to the test with other teams even from other countries because the FSAE competition is known around the world [4]. Drivers in FSAE as in any other competition must be subjected to different tests, in this case, driving experience can cause different physiological effects.

Figure 2 Formula SAE competition
Source: [6] https://www.avontyres.com/es-es/cuidado-de-neumaticos/fuente-de%20datos-tecnicos/aplicación-neumático-de-competicion/SAE-Formula-Student/

This work was developed as follows: the method description section focuses mainly on the conceptualisation, the rules used in the work, as well as previous actions necessary for the correct execution of the programme. Finally, the series of steps explained in detail in order to complete the work in Unity. The next section contains our results and the answers obtained by a certain number of participants. Finally, in the final section are the conclusions reached after testing the simulator.

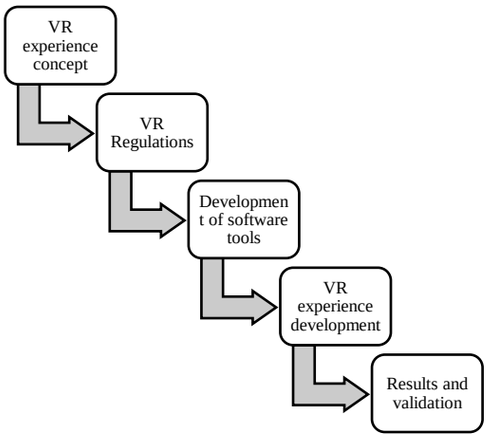

Figure 3 VR experience development method

In order to be able to carry out this work, a research of the standards related to virtual reality was carried out, so that it was possible to carry out this work, and also to have a better understanding of this virtual reality work.

Different standards were used in the development of this project:

- ISO/IEC TR 23842-1:2020 [2] Information technology for learning, education and training-Human factor guidelines for virtual reality content-Part 1: Considerations when using VR content; in this standard we see the considerations that should be taken for the appropriate and effective use of VR in different areas, such as education, learning and training.

- ISO/IEC TR 23842-2:2020 [3] Information technology for learning, education, and training-Human factor guidelines for virtual reality content-Part 2: Considerations when making VR content; where we see the considerations for making VR content in different areas such as education, entertainment and learning.

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- ISO/IEC TR 18040:2019 [4] Information technology-Computer graphics, image processing and environmental data representation-Live actor and entity representation in mixed and augmented reality (MAR); this standard provides a reference model for Mixed Augmented Reality (MAR) applications, furthermore, it manages and controls learning, education and entertainment (LAE) in a MAR environment, on the other hand, it integrates LAE in a 2D/3D visual environment in a VR environment and can provide an exchange format needed to transfer and store data between MAR applications.

The following figure shows a diagram of the process developed to generate a simulation of a driving experience.

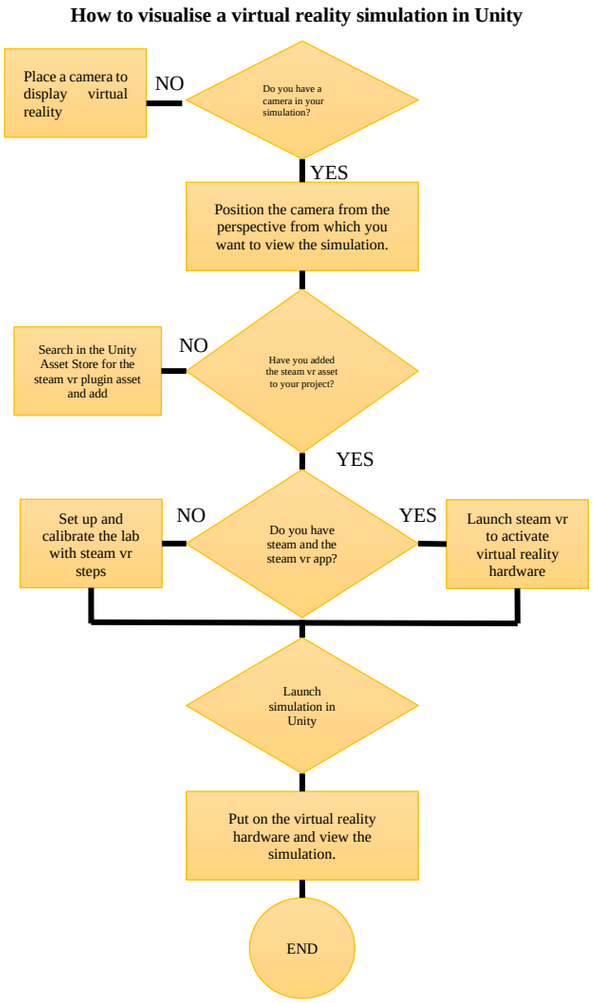

Figure 4 Unity flowchart

Model development

For this work it was of utmost importance to take into account the types of files that were going to be used, this was because not all files are compatible with the software used for this work, in this case the software used were Blender and Unity. The Blender software was used to be able to texture and colour the CAD model and Unity was used to make the simulation in virtual reality, in this scenario the type of file that these softwares have in common is ".FBX", which is ideal for 3D models.

In order to change the file type of the CAD model, i.e., the Formula SAE type vehicle model, a dedicated software was used, since the CAD model had an extension ".STP", which is not compatible with the software used in this work, this dedicated software is called CAD Exchanger, in which the CAD model was imported with the extension ".STP" (figure 5). STP" (figure 5) and then the desired file type was selected, in this case the file type ".FBX" (figure 6), once the CAD model was obtained with the desired extension the model was exported from the CAD Exchanger software and in this way it was possible to work with the CAD model correctly in the Blender and Unity programs.

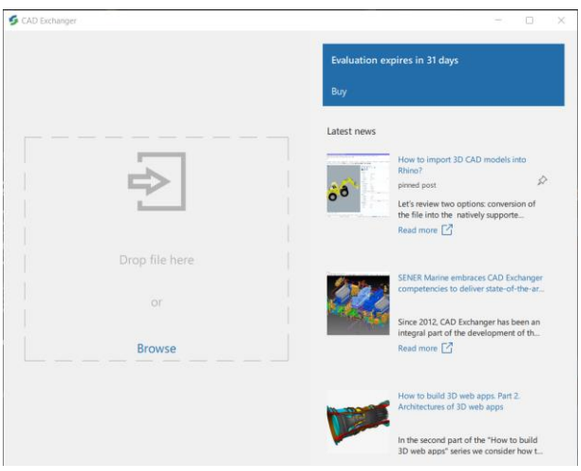

Figure 5 Import model into CAD Exchanger

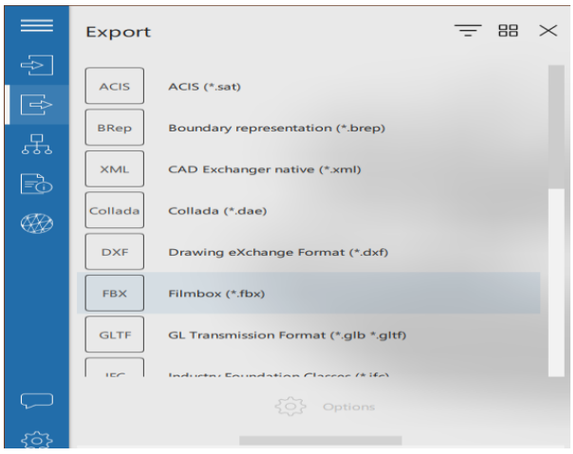

Figure 6 Select the desired file type in CAD Exchanger

Adjusting the coordinate axis

The coordinate axis is different in CAD modelling software than in software for texturing and simulation, which is why an adjustment of the coordinate system was made so that the CAD model used in the simulation would be consistent with the simulation environment. To make this adjustment, the Blender software was used, which allows us to change the coordinate system of the CAD model and in this way a correct orientation of the CAD model was obtained in Unity.

For the UP orientation in the modelling software is usually the Z coordinate, and this was changed to the Y coordinate and then in the FORWARD option was placed Z (figure 7), as it is the one that orients the model correctly.

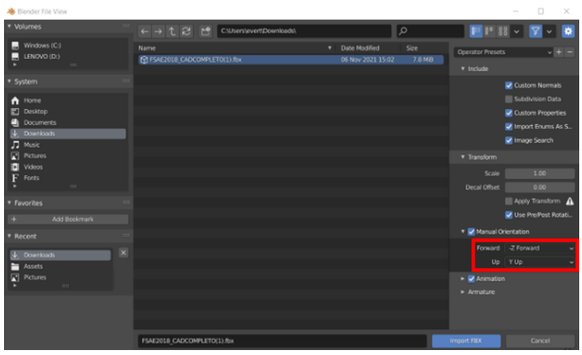

Figure 7 Coordinate adjustment

Assignment of materials and textures

Texturing is important for this work, as in this way it was possible to give greater realism to the simulation, as well as making it possible to improve the immersion experience in virtual reality, so texturing the CAD model of the SAE formula vehicle helped to improve the simulator experience.

The texturing was started by exporting the CAD model of the SAE formula vehicle in Blender software, as this software was used to select the colours of the CAD model, as well as the textures of the model.

The texturing was started in the Layout tab of Blender and within this tab the Material Properties tool was used.

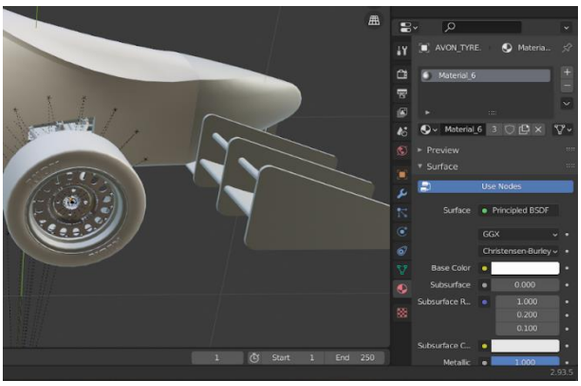

Figure 8 Material properties in blender

The surface to be textured was selected from the CAD model. In this case, the texturing began with the SAE formula vehicle tyres, as well as the rims, to which a chrome texture was assigned.

Subsequently, a wheel with colours and textures was obtained as shown in the following image, so to finish the complete texturing of the CAD model of the SAE formula vehicle, this logic was continued for the other textures.

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Figure 9 Assigning colours and textures to the Formula SAE 3D model

Import file to Unity

The CAD model of the Blender software was exported and saved with the extension ".FBX", so that Unity could support the 3D model of the vehicle type formula SAE, later in Unity the CAD model was imported in the Assets tab and then in New Asset (Figure 10), then the CAD model file with the extension of ". FBX", the file was selected and once the import of the CAD model file was finished, the 3D model was placed in the Unity scene and in this way the 3D model of the vehicle type formula SAE textured in the Unity software was obtained.

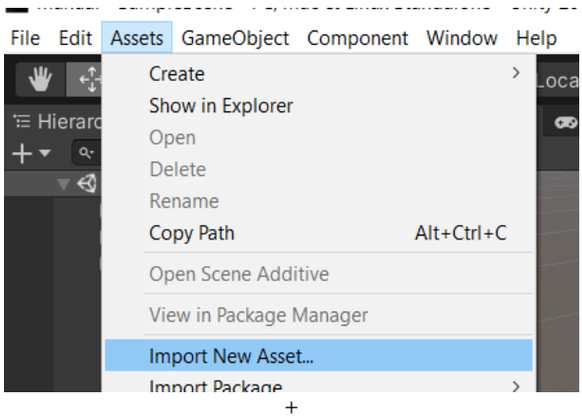

Figure 10 Insert 3D model of Formula SAE in Unity with the extension .FBX

Inserting and adjusting the camera in the 3D model

The main objective of the camera is to give a real perception inside the environment, so it was placed in a way to obtain a realistic perspective and coherent with the environment of the unity scene.

The camera with the name "Main camera" was placed inside the single-seater to obtain a realistic perspective in the simulation, to place the camera inside the single-seater in the Hierarchy tab the 3D model of the vehicle type formula SAE was looked for and it was placed inside the "Main camera" of the 3D model (figure 11), in this case the name is "fsae", once the camera was placed in the 3D model only an adjustment was made to obtain the perspective that was needed (figure 12).

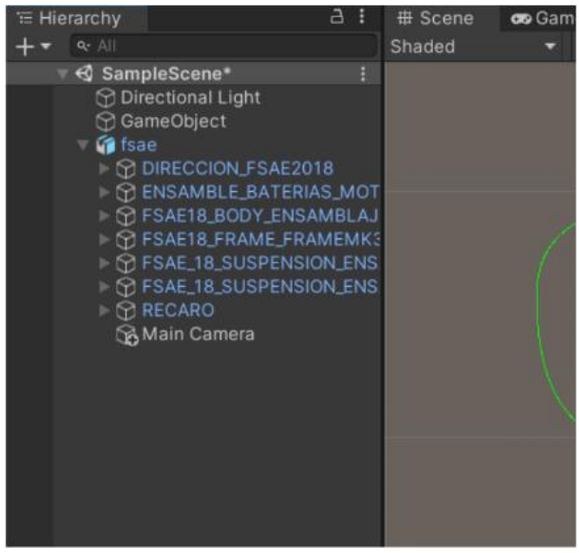

Figure 11 Insert "Main Camera" inside the "fsae" section

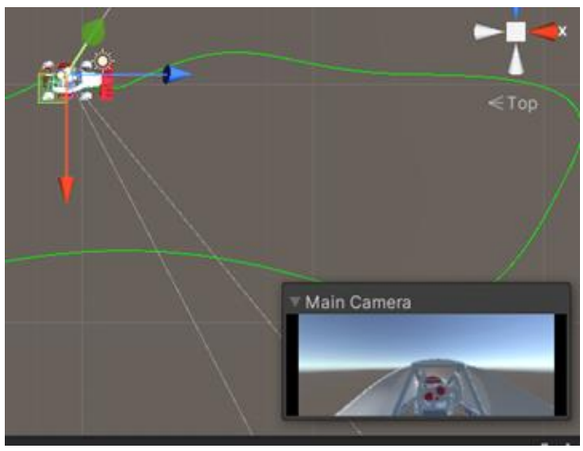

Figure 12 Camera placed inside Formula SA

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Track development in Unity

For the vehicle track, data similar to a Formula competition track was considered. Based on the choice of this vehicle category, table 1 shows the general dimensions of the track considered for the simulation.

Characteristics	Value
Track length	1.5 km
Length of track	60 Seg
Overall vehicle dimension	Length 2790 mm Height 1200 mm Width 1360 cm

Table 1 Overall dimensions of the virtual track

An asset called "Béizer Path Creator" was downloaded from the Unity Asset Store, which was necessary to create the circuit to be followed by the 3D model.

The circuit of the SAE formula vehicle was started by right clicking on the "Hierarchy" tab and then selecting the "Create Empty" option (figure 13) and then naming it "GameObject".

GameObject" was selected in order to click on the tab with the name "Add Component", then a window was displayed and "Script" was selected and then "Path Creation", finally, the option "Path Creator" was clicked (figure 14).

Subsequently, a circuit guide was displayed in the Unity scene for the SAE formula vehicle (figure 15). Then the coordinates of the displayed guide were adjusted to fit the circuit to the desired shape with the following command "Ctrl + Shift + Click". Finally, the path guide was closed with the option "close path" to have the path set (figure 16).

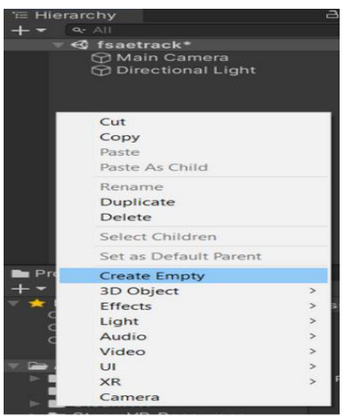

Figure 13 Create empty of "GameObject"

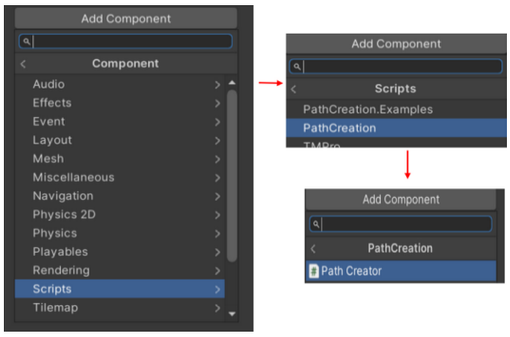

Figure 14 Script, path creation and path creator

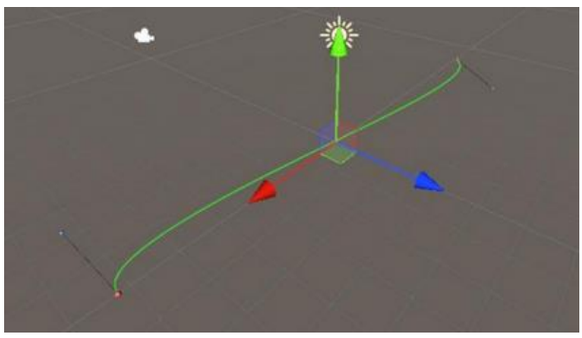

Figure 15 Path guide

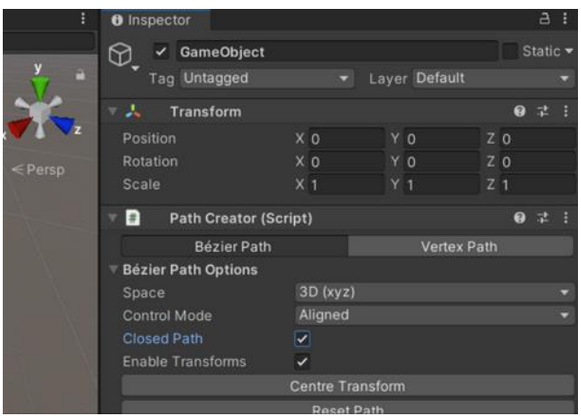

Figure 16 Close path

Development of simulation environment

Again with the help of "Unity Asset Store" an environment was downloaded for the scene according to the needs of this work, in this case a formula 1 type race track was required. In this case the most outstanding asset and similar to the dimensions proposed was "Austria Racetrack Formula 1" (Figure 17).

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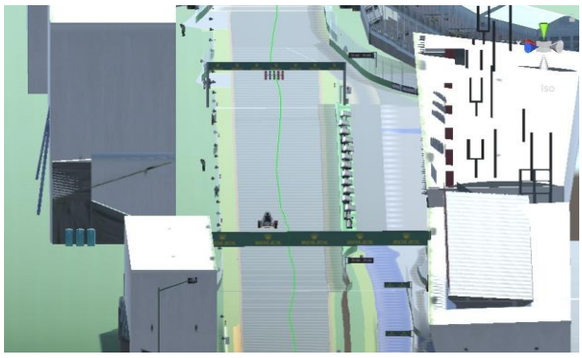

Figure 17 Environment Austria racetrack Formula 1

The content was imported into Unity, and we found it in the assets area, then clicked on "Prefabs" and finally selected "Austria" and placed it in the operations tree (figure 18).

Figure 18 Place GP Austria as environment

Adjust time and speed

A time and speed adjustment was made in order to achieve the best possible immersion in virtual reality, so the speed at which the CAD model moves in the circuit was adjusted to give the user the feeling of speed and the time was adjusted so that the user was not in prolonged sessions with the virtual reality viewer, so it was left with a time of 1'30". This was carried out in the "Follower (script)" section of the Formula Sae and finally in the "Speed" option it was modified (figure 19).

Figure 19 Speed modification

Results

At the end of the development a scenario with a circuit according to the simulation was obtained, and the experience was immersive and everything had coherence, from the scenario to the formula car.

In the following images we can see how the formula car looks in the Unity scenario in a static way (figure 20) and in movement (figure 21).

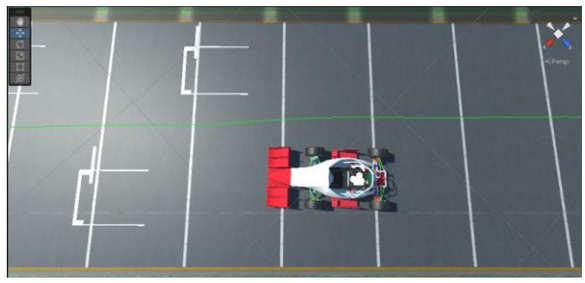

Figure 20 Formula SAE vehicle static on stage

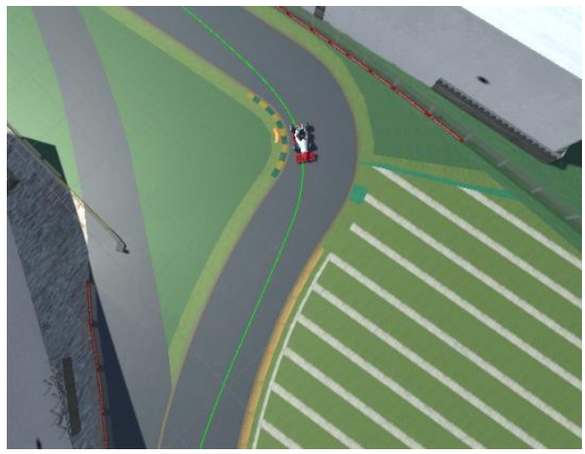

Figure 21 Formula SAE vehicle moving in the scenario

Two views were obtained from the virtual reality viewer, a static view (figure 22) and a moving view (figure 23) from the perspective inside the single-seater.

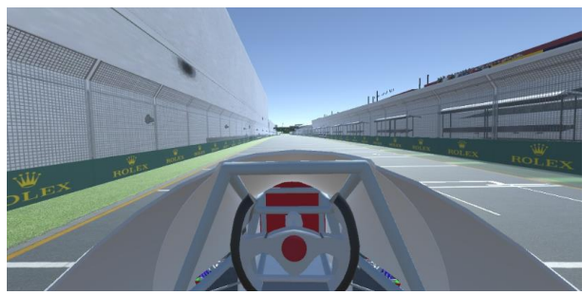

Figure 22 Perspective from inside the static single-seater

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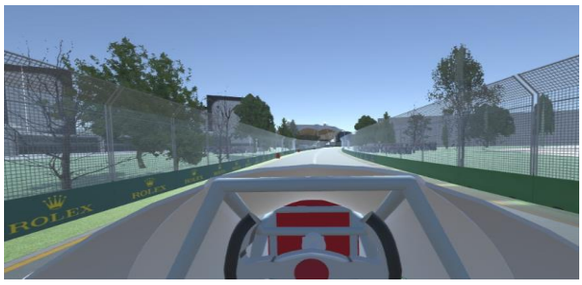

Figure 23 Perspective from inside the moving single-seater

Finally, in the real part, the simulator is shown in a simple way with only a chair for the user so that there is coherence between the virtual and real part, to match that the user is sitting in the car, and likewise a static view (Figure 24) and a moving view of the vehicle (Figure 25).

Figure 24 Real static simulator

Figure 25 Real simulator in motion

The sample consisted of 7 males and 5 females with an average age of 21.16 years. The instrument was validated by calculating Cronbach's alpha with a value equal to 0.715984. The questions related to the vehicle models, the track route and the immersive environment reported the lowest values, so future studies will consider improving the aspects of the models, the orientation of the vision in the environment and the use of sound. Table 2 shows the averages and standard deviations obtained from the sample studied.

Variable	Average	Standard Deviation
Facilities and equipment	4.9	0.34
Vehicle model	4.5	0.66
Simulation atmosphere	4.8	0.38
Simulation speed	4.6	0.58
Duration of the tour	4.8	0.41
Immersive handling experience	4.5	0.66
Physical integrity	5	0.20

Table 2 Statistics obtained from the sample

It is highlighted that the experience, the laboratory facilities and the physical integrity of the participant were the highest scoring variables, followed by the track design of the course, the driving sensation and the speed used in the simulator. There were comments on the absence of sound and the presence of dizziness when turning the head to observe elements of the environment. The latter element was important because participants indicated that as the speed of the simulator increased, the sensation of dizziness and vertigo increased, so that the exercise had to be stopped for some of the respondents. From the open-ended suggestions question, users raised opinions regarding interaction with the steering wheel, improved environmental imagery and the inclusion of sound to enhance the experience.

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Conclusions

Throughout the development of this work it was possible to conclude that virtual reality has a high impact in different fields of work, on the other hand, it was possible to know all the approaches that nowadays virtual reality is considered, because it is in constant evolution and could be optimised by creating more sophisticated hardware and software so that the industry, whatever it is, generates more quality in its work and can observe a concept of a product or service in virtual reality before executing it physically, because it can fail to meet expectations or simply give a bad service in the simulation. The work presented contains similarities to that developed by Goedicke, D [7] who presents a driving experience simulator where participants can feel the sensations of driving a vehicle, including the consideration of physiological effects such as motion sickness. Under this consideration, Nascimento, A [8] considered virtual reality systems and simulators as an important tool in the development process of future technologies such as autonomous vehicles, in the main context of risk assurance in the design and support for the research and development process. It is important to mention that the simulator caused different sensations of motion sickness according to the programming of different speeds in it, so one of the future objectives will be related to the proper control of the physiological effects that the simulator causes, as well as the inclusion of greater controls for the user, sensations such as sound and the possibility of including telemetry to give greater fidelity with a driving experience of a Formula SAE type vehicle.

Acknowledgements

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Development of a virtual experience of evaluation of the concept of a low and SAE formula vehicle

Desarrollo de una experiencia virtual de evaluación del concepto de un vehículo tipo baja y formula SAE

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Abstract

Technological growth focused on virtual reality has allowed us to develop new processes and tools that allow us to incorporate simulation methodologies in a virtual environment for the launch of any prototype, in such a way that the first physical models for testing are built after complex analysis. in 3D. The research shown below focuses on analyzing the different possibilities of virtual reality concerning the visualization and dimensional validation of a Baja and Formula SAE-type vehicle, to improve vehicle development processes through the application of this tool, optimize the experience of those in charge of design, 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 research 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 created environment.

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

Resumen

El crecimiento tecnológico enfocado a la realidad virtual ha permitido desarrollar procesos y herramientas nuevas que nos permiten incorporar metodologías de simulación en un ambiente virtual para el lanzamiento de cualquier prototipo, de tal manera que los primeros modelos físicos para las pruebas se construyen luego de complejos análisis en 3D. La investigación que se mostrará a continuación se enfoca en analizar las diferentes posibilidades de la realidad virtual con respecto a la visualización 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

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† Researcher contributing as first author.

Introduction

The beginning of the evolutionary history of virtual reality is marked in the nineties; however, it has an origin with experiences in cinematographic sectors in 1950, when the "sensorama" appeared as a pioneer experience in the development of virtual reality [1]. The development of virtual reality programs is more frequent and more popular, in recent years, Virtual Reality (VR) applications have become widely available [2], since there is a wide variety of software that facilitate tasks ranging from manufacturing 3D models, control of a graphics engine that is mainly responsible for 2D and 3D digital content. Through extensions of the same software, Virtual Reality is a medium that is composed of interactive simulations by means of a computer, which sensitize the position and actions of a user, generating the sensation that the user is immersed or present in the simulation (virtual world) [3]. Software such as Solid Works, Unity 3D and Catia V5, to mention a few in their free versions, have the necessary tools to visualize the models adequately even with their limitations.

The Baja and Formula SAE vehicles that will be shown are designed to participate in competitions of their branches, these events are held around the world, within these are achieved to expose the designs of different off-road or track vehicles, built by their teams based on the Baja SAE regulations of the competition [4], our contribution to this project will be to model in a virtual environment for both vehicles in order to show the prototype designed by the team in each of the branches, to a scale size and can make the necessary changes to pass the various tests that encompass these competitions.

Taking into account the development of these new technologies, it was decided to venture into the development of a virtual reality prototype with respect to the Baja and Formula SAE created by the students of the Universidad Popular Autónoma del Estado de Puebla, with the aim of assessing the quality of 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 [5].

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. As part of the obstacles of this project, it was found that the number of programs that will be able to perform this type of projects is minimal at the moment, 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.

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 point to point measurement, among others.

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When these functions are active and working, a displacement of the model will be performed so that the user can observe in detail the path 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.

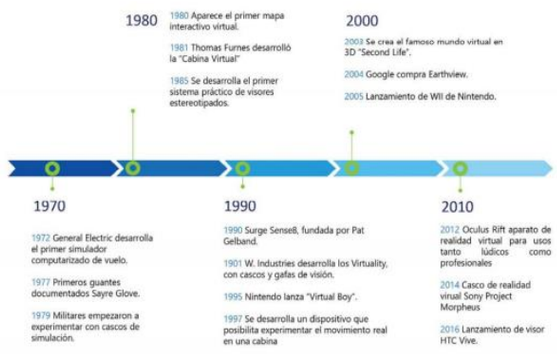

Figure 1 Development of virtual reality
Source: [6]

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.

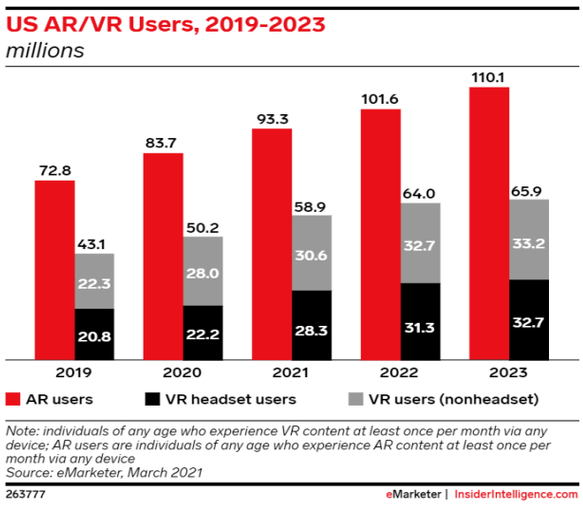

Figure 2 Chart of forecasts of increased use of VR and AR
Source: [7]

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 [8]. 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 [9].

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 [10].

Objective

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, with the purpose of showing the new innovation methodologies for the construction, validation and visualization acquired by the VRED software.

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 suitable to the requirements of each competition regulation. Within 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.

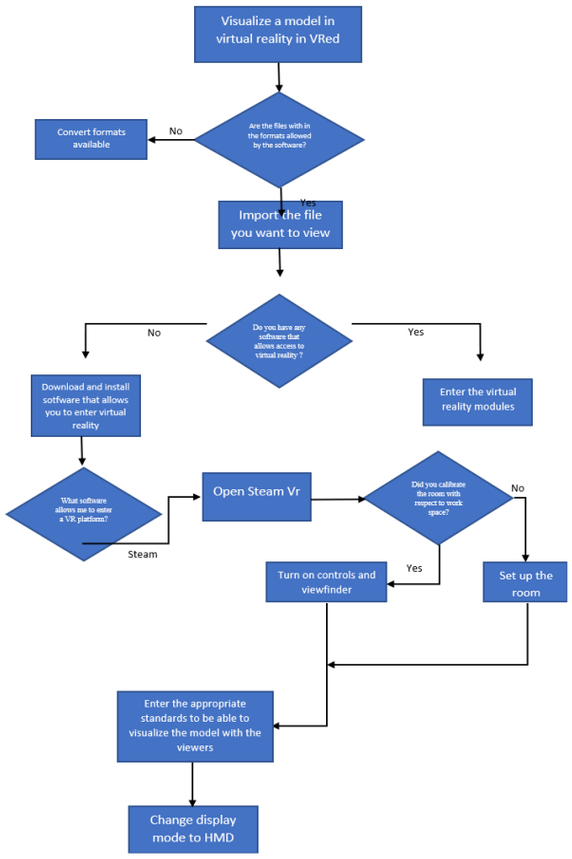

Figure 3 Flowchart to model a vehicle in a virtual environment

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.

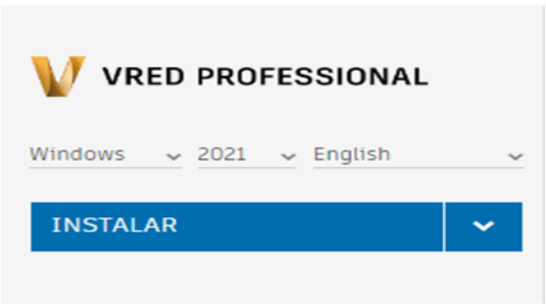

Figure 4 Software download screen

Once the software was 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 Baja SAE) were inserted, we continued to arrange their colors 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 configurations (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 verify the model in the virtual reality environment).

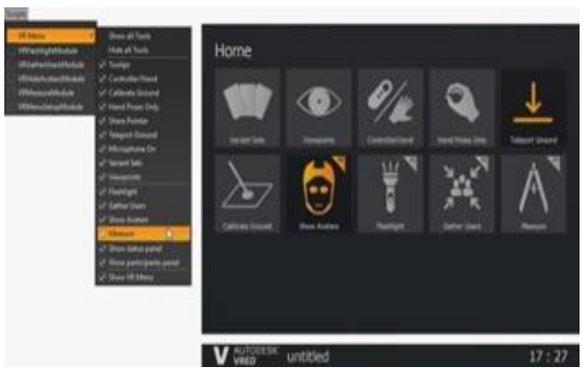

Figure 7 Function menu of Vred version 2021

Once this was done, we looked for a worktable with the .stp extension, 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 developing 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.

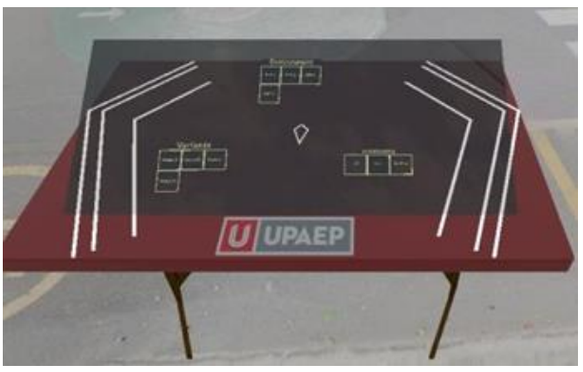

Figure 9 Work table with added sub menus

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

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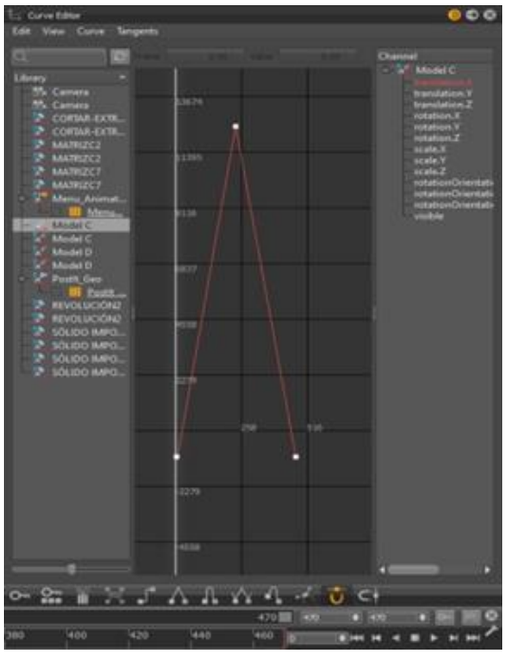

Figure 10 Cyclic animation graph

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 thing.

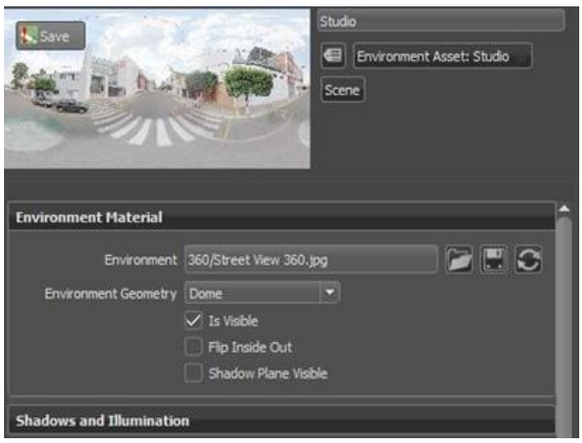

Figure 11 Environment change panel

To conclude this work, the next step was the visualization of the vehicles, applying the previous procedures for each one of them, in order to have a quality and presentable product.

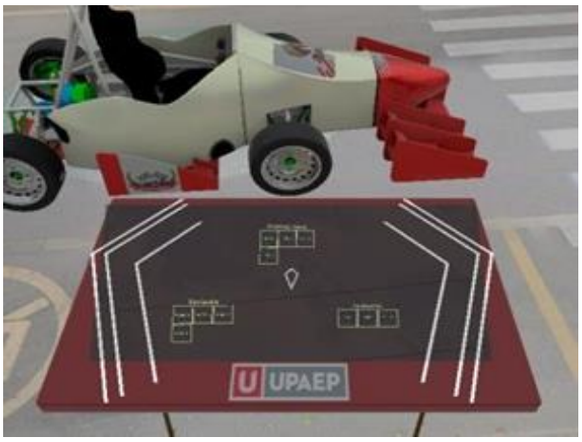

Figure 12 Final model of the project

Rendering

In this work were developed renderings of the models with which they are working, generating a better perspective of how the models can be displayed in a real way, in the same way you 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 renderings were as follows, in the image 13 and 14 we can visualize the cars of the UPAEP university of both branches, in which we can see that it is in a track type environment, and in the second rendering which is the image 14 we can observe a Baja SAE type car, which is in an unpaved environment, since it is the environment where the competitions for this type of vehicles take place.

Figure 13 Rendering Formula SAE

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Figure 14 Rendering Low SAE

Results

To evaluate the final experience of the virtual environment, the evaluation was subdivided into 3 categories: the environment, the visual detail of the model and the ability to interact with the environment and the model, in order to take into account all the fundamental aspects of the virtual environment.

In terms of ambience, we were able to add a series of different scenarios in which the prototype of the Baja and Formula SAE vehicles could be presented in different ways, within these scenarios we were able to modify the dimensions and scale. 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 15 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 concluded that all parts, accessories and components that make up the Baja and Formula SAE vehicles have a fairly 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 real size.

Figure 16 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 the change of scenario and model.

Figure 17 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.

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For the data analysis a non-probabilistic sampling by convenience was carried out, resulting in a population of 17 males and 1 female, 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 of 0.7091. 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 in advance. Table 1 shows the averages and variances obtained from the sample studied.

Question	Average	Variance
The quality of the models is adequate to distinguish the subsystems that make up the vehicle.	4.6	0.38
The quality of the scenery is adequate.	4.6	0.25
The animation of the vehicles is adequate.	4.7	0.35
Understanding how to use the tools turns out to be easy.	4.6	.35
The equipment (scopes) affected your experience.	3.2	2.15
The components of each vehicle resemble the real thing.	4.5	0.38
Hand controls are easy to use	4.7	0.21
The use of the tool panel was adequate.	4.7	0.49

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 quality of the models is adequate to distinguish the subsystems that make up the vehicle. 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 experience for the evaluation of the concept of a low and SAE formula vehicle was born from the need to have a prototype of the cars designed by the members of both teams, with the aim of having the possibility of redesigning the model if it has a design error 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, Other limitations worth mentioning were the selection of the 3D visualization software to be used for the creation of the virtual environment, since most of the companies that create these programs ask for money to use the software, without having a few days to test and evaluate 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 [11]. 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.

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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 highlights 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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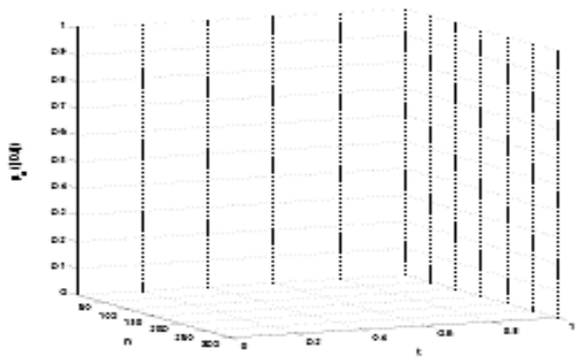

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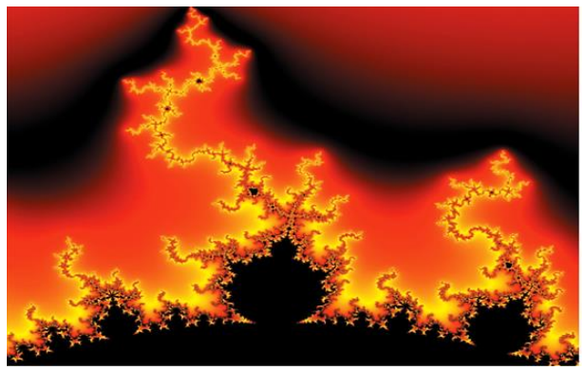

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