Universidad nacional autónoma de México.

Faculty of Engineering.

Final Project.

Subject: Graphic computing and human-computer interaction.

Professor: Eng. Carlos Aldair Román Balbuena.

Student: 316184979.

Semester: 2022-2.

Delivery date: May 27, 2022.

Final project of CGeIHC.

Objective.

The student will perform the final project of Computer graphics and human-computer interaction, in which he will apply the concepts studied along the course, from the project realized for the laboratory of the subject.

In the laboratory the student, as a member of a team, modeled a housing complex of the real world with the purpose of making it as similar as possible to the proposal. In addition, he will add models that he will create by himself to furnish two brand new rooms inside a building.

Requirements.

- The student must create a virtual environment, which represents a residential area, conformed by buildings, houses, green areas and vehicular passages. In these virtual spaces hu must collocate cars, pedestrians, pets, etc.
- The student might use the technique of geometric modeling, hierarchical modeling, and texturing to build the elements with primitive objects or import tridimensional models.
- There must be collocated, at least, five animations made with the animation techniques which the student considers more relevant. It's forbidden to use the animations created during the laboratory classes.
- The elements of the scenery must have textures put on correctly.
- Inside the scenery, the camera may be applied correctly, due to being able to travel through space.
- The student must incorporate an audio library to add music, so the student should investigate a library compatible with OpenGL.
- The student can add elements to form a bigger and more complex scenery.
- the student will create models with the purpose to furnish two rooms inside a facade.
- The student must give an executable file.

Introduction.

For this project, we chose to model the Villa Olímpica housing unit, located in the Tlalpan mayor's office of Mexico City, specifically on the nine-hectare property between Insurgentes Sur Avenue and Periférico Avenue, very close to Ciudad Universitaria.

The complex was built by the National Bank of Works and Public Services to accommodate the Athletes of the Olympic Games of Mexico. Consists of twenty-nine buildings that bring together a total of 5,044 rooms and 2,572 bathrooms in 904 apartments, of the total of the buildings, of which 24 were destined for male competitors and 3 for female athletes, the remaining two were used for the press (Edificios de México, (s. f.)).

This place was chosen in principle because a teammate lives there, so the modeling of the objects that were placed in the project was facilitated. Taking advantage of the fact that the buildings have the same shape, it would only be necessary to design a building and duplicate it as many times as desired, in addition, this place allows us to place various elements that

allow us to cover the requirements imposed by the teacher. It should be noted that we gave ourselves the freedom to modify some objects so that it could agree with our vision, such as reducing the number of buildings, the placement of an OXXO store and a generic court.

Next, I show the design with the arrangement of the elements that we deliver in the project proposal.

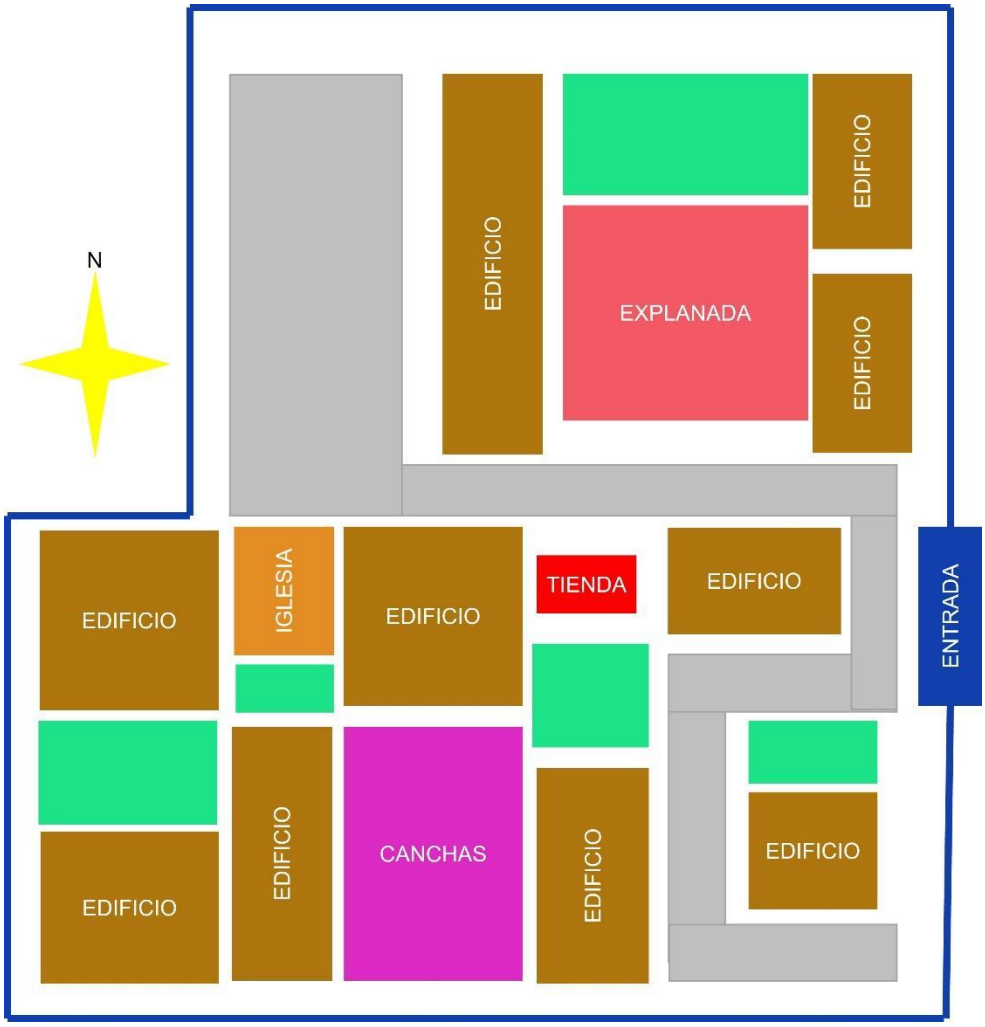

Figure 1. Map of the proposal.

Since this project is carried out as a continuation of the laboratory project with the Eng. Luis Sergio Valencia Castro, most of the work was done in conjunction with three colleagues. Finally, it would be necessary to add ten models that correspond to furniture with which the two rooms will be filled, five for each one, which correspond to the reference images delivered on the twenty-fifth of April of the current year.

Development.

For this project, various models were downloaded from the internet, and some were created to fill in the requested space.

Model information.

Next, I will show the download information of the models obtained from the internet and some details of the models made by the team for the delivery of the laboratory project. The project can be found in the next GitHub link: https://github.com/Fernando1612/Proyecto-Final-CGEIH-C.git in the branch named 316184979_PROYECTOFINAL_GPO4. The main branch was elaborated with my teammates 316054416, 419049300 y 316073934.

Downloaded from the internet:

Model: Man in standing jacket and Rigged 3D Model.

Animation. Person who drives the tricycle.

Website: open3dmodel.com.

The model has a free license for personal use to be used.

Figure 2. Man standing.

Model: Man 3D Model.

Animation. Person who rides a bicycle.

Website: archive3d.net

Within the download page was not found any kind of restriction or license of use for the model, the animations for the wheels, pedal and the man pedaling were added.

Figure 3. Man on bicycle.

Model: Pete.

Animation: Man walking towards the OXXO (Left Strafe Walking).

Website: Mixamo.

Figure 4. Man walking sideways.

Model: Samoyed Dog 3D Model

Animation. Dog walking through the unit.

Website: open3dmodel.com.

Figure 5. Dog.

Character: Shannon.

Animation: Person running in the style of Football (Running).

Website: Mixamo.

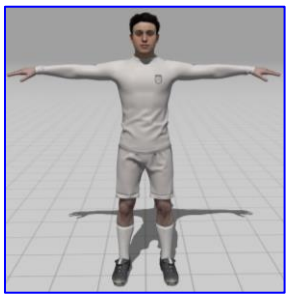

Figure 6. Sportsman.

Model: Sporty Granny.

Animation. Person walking through the unit (Female Walk).

Website: Mixamo.

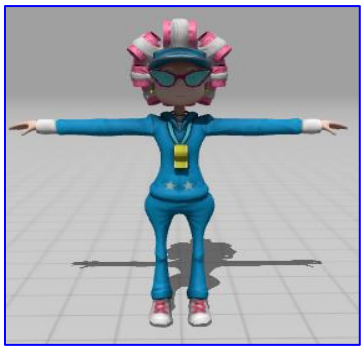

Figure 7. Sportswoman.

Model: Delivery tricycle 2.

Animation. A tricycle that simulates a tamale stand.

Website: 3dwarehouse.sketchup.com.

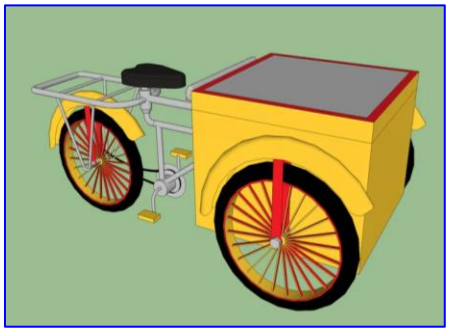

Figure 8. Tricycle.

For the model was added a texture on the front face to finish with its model. The texture used was "un mundo de Tamal" obtained from the "unmundodetamal.wordpress.com" page.

Figure 9. Image of a tamal world.

Model: Vintage Vw Volkswagen Beetle Car 3D Model.

Animation. Car that simulates driving through the unit.

Website: Open3DModel.

It was decided to change the color to the original model due to a problem with textures. The tires were exported separately so that their rotation can be properly animated.

Figure 10. Beatle.

Performed by the team:

Model: Court.

Design application: Blender.

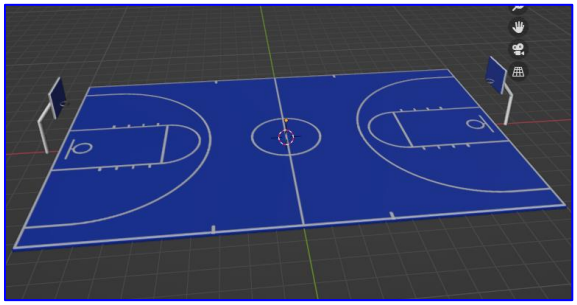

Figure 11. Court.

Model: Building.

Design application: Blender.

The model corresponds to the buildings located in the unit. To model it, planes and cubes were used. With simple transformations and extrusions, it was possible to achieve the finish like our original references. It should be noted that this is the generic building that was placed, since there is a different model which allows one to appreciate the transparency in the windows.

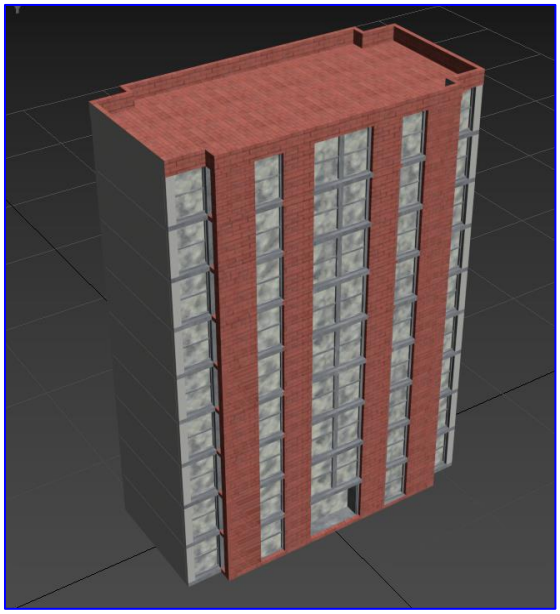

Figure 12. Building.

Model: Entrance.

Design application: Autodesk 3ds Max.

This model corresponds to the entance to the unit. Only primitive figures and a *TexPlus* were used for the numbers indicating the direction.

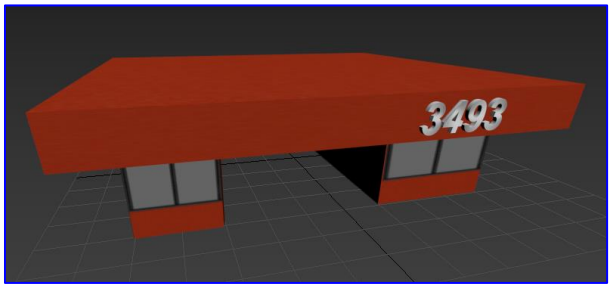

Figure 13. Entrance.

Model: Church.

Design application: Blender.

The church model was modeled using also simple figures such as cubes to which scale and translational transformations were applied. For the stained-glass window only a texture taken from a photograph taken of the physical church was placed.

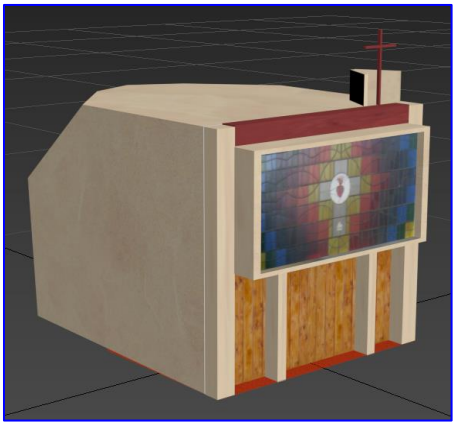

Figure 14. Church.

Model: OXXO.

Design application: Autodesk 3ds Max.

The model corresponds to a branch office of the OXXO stores within the unit. For the modeling, planes, boxes, and cylinders were used in addition to using their characteristic colors for texture.

Figure 15. OXXO.

Modelos de los muebles:

Next, I will show the occupied models to fill the two rooms; these models were created by myself, unlike the previous ones that were made together for the laboratory project. All models were created using basic figures in 3Ds Max with the purpose of being as close as possible to those that can be seen in the reference images.

In this figure you can see the five pieces of furniture I created for the first room, which are a bookcase, a table, a coffee table, an armchair and a tv. It is worth mentioning that the coffee table has a transparent texture, but for it to be appreciated in a correctly it looks green in the image and for some troubles when exporting the table, I could not place it in visual.

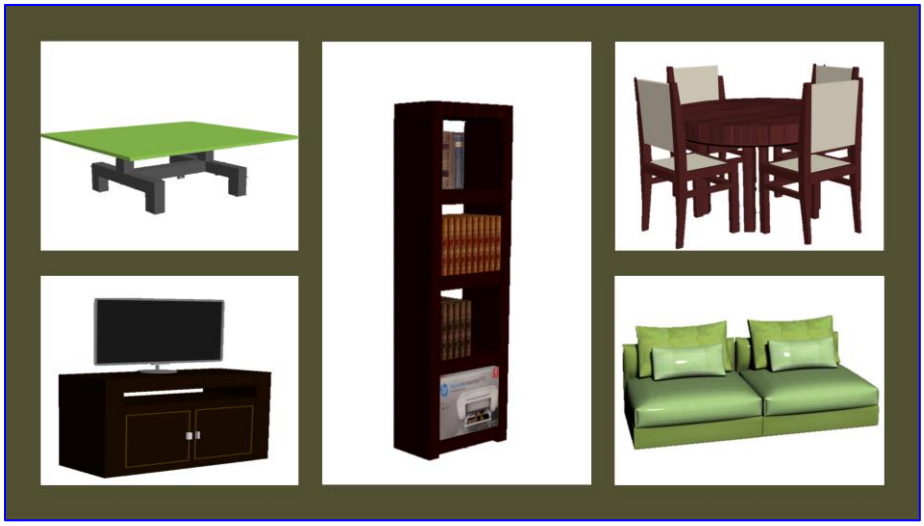

Figure 16. Models of the furniture of the first room.

The furniture in the second room is a chest of drawers, a bed, a desk, an empty bookcase, and a wardrobe. These five objects are in Visual.

Figure 17. Models of the furniture of the second room.

Schedule of activities.

Activities:	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Project proposal.						
Shop (OXXO). Tricycle-Person. Person on a bicycle.						
Entrance.						
Cars. Person-Court.						
Building (11).						
Esplanade, paths and green area.						
Church.						
Court.						
Person-Dog.						
Person walking.						
Furniture						
Execution manual.						
User manual.						
Credits.						
Documentation						

Animation information.

Animation of man on bicycle:

The animation is divided into several objects:

- Man pedaling.
- Bicycle frame.
- Two pedals.
- Two wheels.

The animation of the man pedaling, shown in Figure 3, was created with 3ds Max using the Auto key tool. At the time of drawing the man in the program, we assign the variables of movement in X and Z of the bicycle and rotation so that when the bicycle moves, the man also does it.

For the animation of the bike a route was assigned within the map where six states from zero to five will be used using the Switch/Case control structure, the bike will change its position on the X axis and the Z axis. This animation is repeated infinitely since when it reaches state five the bicycle is in the coordinates of origin and returns to the zero state. You do not need to press a key to start, the animation starts together with the program.

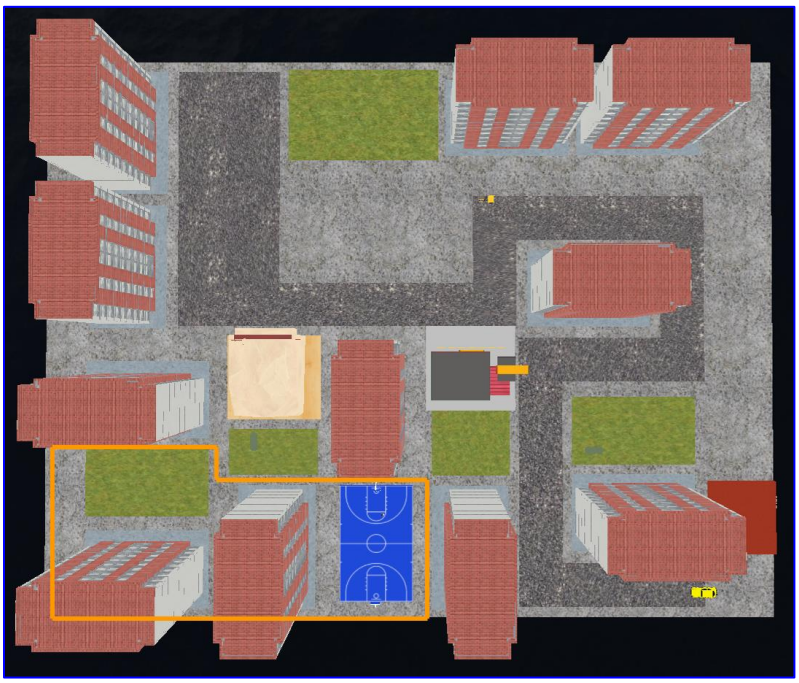

Figure 18. Bicycle animation route.

Animation of man selling tamales:

The animation is divided into several objects:

- Man pedaling.
- Tricycle frame.
- Two pedals.
- Three wheels.

The animation of the man pedaling, (figures 2 and 8), was created with 3ds Max using the Auto key tool as in the previous animation. At the time of drawing the man in the program we assign the variables of movement in X and Z of the tricycle and rotation so that when the bicycle moves, the man also does it. At the time of loading the model had an incorrect rotation so two rotations were made, one at the beginning to accommodate it in the tricycle and the second that will change as the tricycle advances.

For the animation of the tricycle, a route was assigned within the map where the entire housing complex is traveled using sixteen states from zero to fifteen, using the Switch/Case control structure for changes in the X and Z axis. This animation is repeated infinitely since when it reaches the fifteenth state the tricycle is in the origin coordinates and returns to the

zero state, nor do you need to press a key to start, the animation starts together with the program.

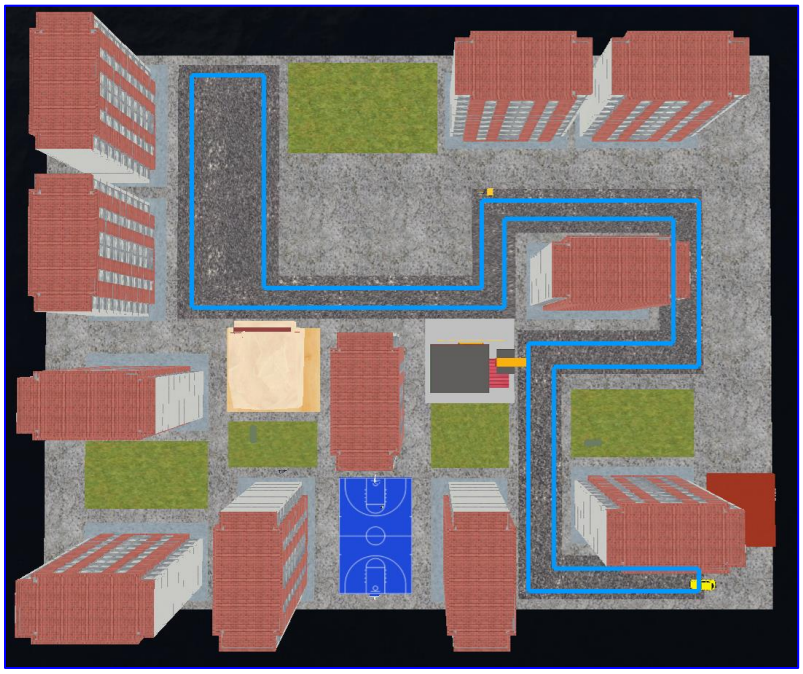

Figure 19. Route of the lord of the tamales.

Animation of man doing sports on the court:

The animation consists of a single object, the character Shannon with the animation Running (Figure 6), downloaded from the Mixamo page. At the time of downloading, it was indicated that the animation should be in one place, so that based on code the displacement will be generated. To be able to draw the object, the variable that will allow it to move on the Z axis had to be placed, this taking advantage of the fact that it will not move on the X and Y axes; in conjunction with a variable that allows its rotation on the Y axis to simulate its change of direction.

Occupying a SWITCH which chooses between the five states, which represent how far from the court the object must reach, within each CASE there is an IF statement that verifies whether the object is advancing (towards larger values) or returning (towards smaller values). In case the condition that it reaches a certain distance is activated, the object will make a turn of one hundred and eighty degrees and will perform the next movement changing state.

To result in the animation of the character running to each mark and returning to the origin again and again, since the animation was not conditioned to a user input when pressing a key.

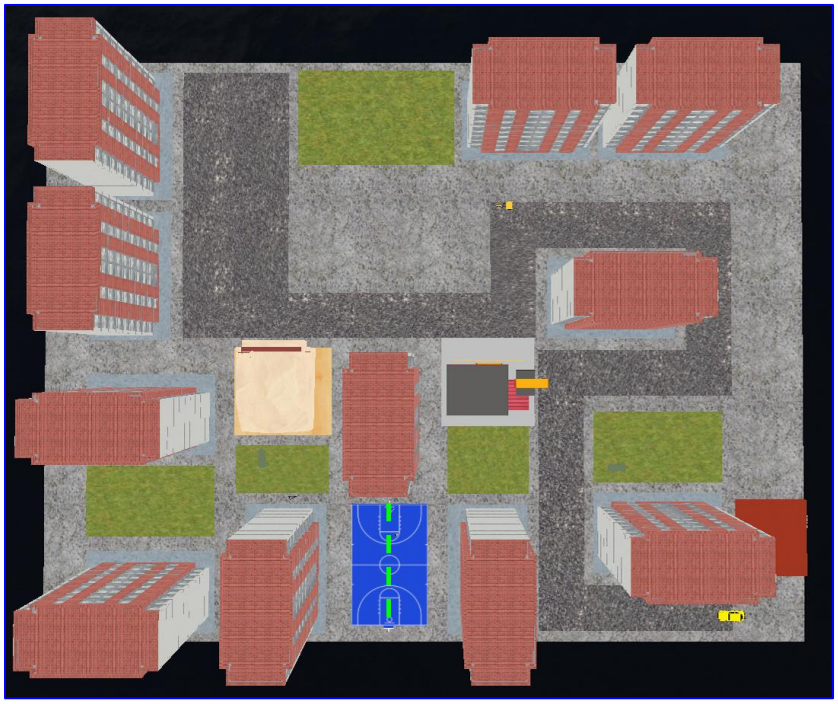

Figure 20. Court showing distances that the character travels.

Car animation:

The animation consists of five objects:

- The bodywork.
- Four wheels,

I think the most complicated thing about placing the objects was the proportions and placing the wheels in the right position so that they don't look bigger than they should. In the body (figure 10) the variables that allow its movement in X and Z were placed and one to make the turn on Y; for the wheels only one variable is occupied for its rotation on X.

For the car to perform its movements, the user needs to press the SPACE key to move forward or stop. For the tour it was decided that it starts next to the entrance object and ends parked. The first thing to do is to check what state the car is in so that it advances and turns the tires in one direction, then it is asked if I have already reached a position that we selected so that it makes a turn, changes state and continues to advance; the positions depend on the distribution of the asphalt. I think that the most complicated thing about animation was to see how far it should rotate and not go through objects that we don't want.

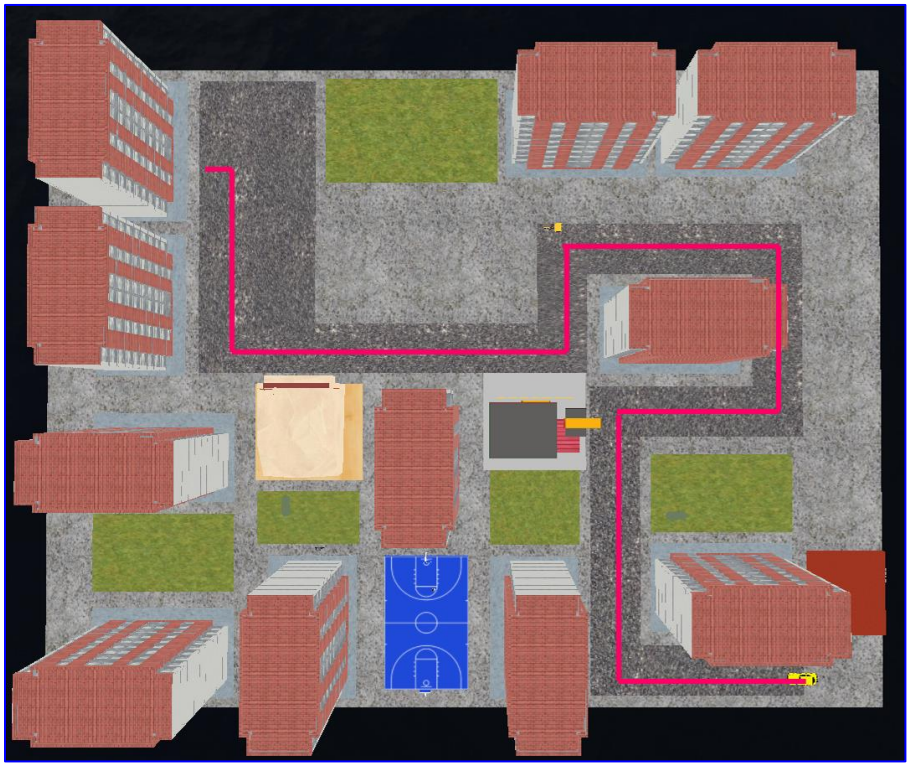

Figure 21. Route of the animation of the car.

Animation of the walking man:

For this animation, only one object downloaded from Mixamo was used (Figure 4). The character was placed under the input and with two variables for its movement in X and Z will move until it reaches the OXXO and with a variable in its rotation will rotate on the Y axis.

Within the *animate* function, an IF was placed so that the user presses the C key and thus the character begins his journey. Later it is verified in what state it is so that it advances in the correct direction and when it reaches a certain location, it changes orientation and state. It should be clarified that in state five, the character will not advance if the car is going to cross the same place, this verifying that the state of the car is different from two; in turn the character only crosses the OXXO object, the doors are not opened for him to enter.

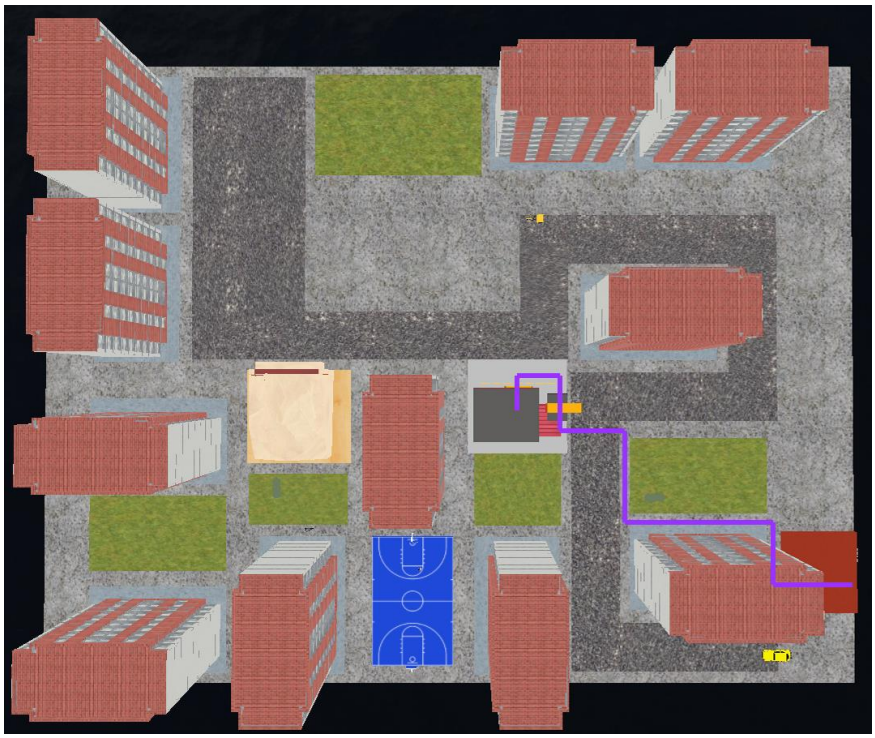

Figure 22. Route of the animation of the person walking.

Animation of the person walking a dog:

The animation is divided into two objects:

- Person.
- Dog.

So that the objects can make the animation, it is important that where we draw these same (figures 5 and 7), we add the corresponding variables in the translation, where these will be added with their defined position, so that the initial position will not be modified. Similarly, so that objects can perform a rotation, the corresponding variable is added to it.

To perform the states of the animation, the Switch-Case control structure is used, so that when the expected result is met, move on to another case and continue the animation.

For each case there is an if-else which will check that the movement in a certain axis does not exceed that determined by the developer, which consequently the objects will increase or decrease their position to this limit in addition to rotating the established degrees. Finally, once the condition is not met, the dog will increase or decrease its position so that it achieves that the dog is on the left side of the person and moves to the next case (state of the animation with a maximum of five states).

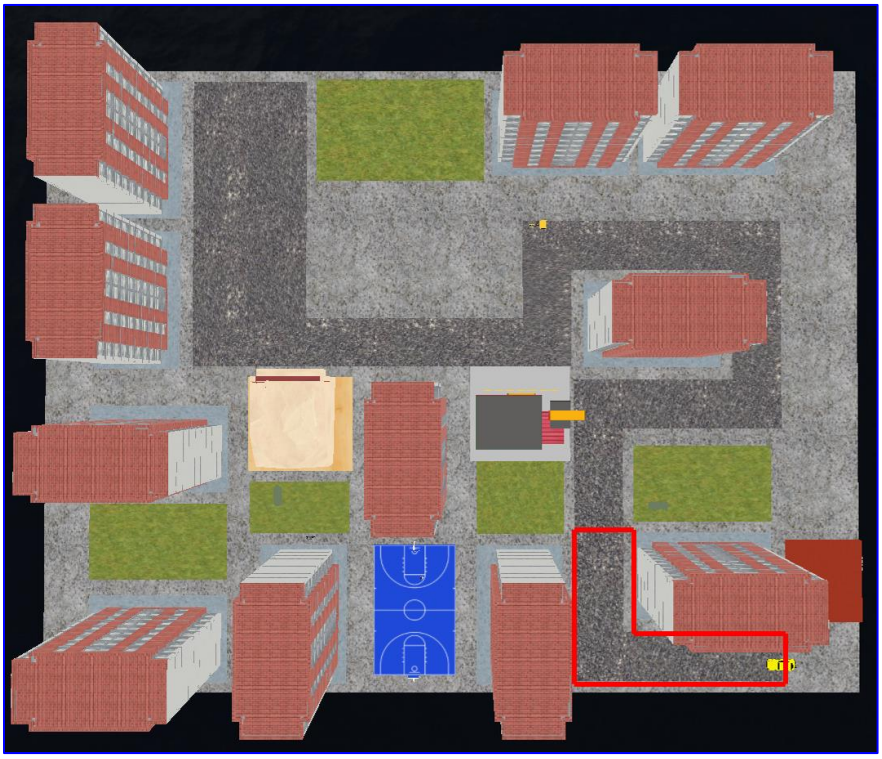

Figure 21. Route of the person walking a dog.

Technical study for the determination of the cost of the project:

For the cost of this project, the procedure learned in the subject of Finance in computer engineering located in the seventh semester of the curriculum of the career was carried out. There it was reviewed that the cost of the project is divided into two main items, the direct cost that is based on the total duration of the project and the indirect cost that depends on all the expenses associated with the project. For the calculation, the work of the four members of the team for the realization of the laboratory project is considered.

the calculations are shown in the following tables:

Final project of CGeIHC										
Direct cost	**Quantity**	**Personnel**	**Role**	**# Projects of works on**	**Rate/h**	**Disposal**	**Hours/Month**	**Hours/Project**	**Salary/Month**	**Salary/Project**
	1	Project Leader	X	5	$700.00	0.2	32	40	$22,400.00	$28,000.00
	3	Developer	Jr	5	$350.00	0.2	32	40	$11,200.00	$14,000.00
				6		0.16666667	26.6666667	40	$9,333.33	$14,000.00
				7		0.14285714	22.8571429	28.5714286	$8,000.00	$10,000.00
							Total	148.571429		$66,000.00

	Quantity	**Concept**	**Unit dollar cost**	**Cost unit pesos**	**Total cost per concept**
Indirect cost	1	Car model	$0.00	$0.00	$0.00
	5	Person model	$0.00	$0.00	$0.00
	1	Dog model	$0.00	$0.00	$0.00
	1	Bicycle model	$0.00	$0.00	$0.00
	0	Server	$0.00	$0.00	$0.00
	0	Storage system	$0.00	$0.00	$0.00
	0	Licenses	$0.00	$0.00	$0.00
	1	Rent of premises/Month	X	$15,000.00	$4,500.00
	X	Payment of services/Month	X	$10,000.00	$3,000.00
				Total	$7,500.00

Direct cost:

For the calculation of the direct cost, an 8-hour working day five days a week was considered, resulting in 40 working hours of work; considering that the project lasted 6 weeks, equivalent to 240 hours.

Duration	hours
1 day	8
1 week	40
1 month	160
Project (6S)	240

Since we are four members of the team, one member was appointed as the project leader and the rest with the role of Jr. developer; it should be clarified that the rates reflected in the tables were recovered from a case study in the field of finance. In turn, as all the members of the team carry more than one subject, their availability would not be one hundred percent, so the item of "number of projects in which they participate" is equivalent to "number of subjects that are studying", therefore, the provision is a simple division of time between that value. In addition, since only five weeks were worked in a team and an extra week individually, three members are considered only in a part, only one member of the team is contemplated in the entire project.

The following columns are multiplications up to the calculation of the total man hours worked approximately 148, implying a direct cost of $66,000.00.

Indirect cost:

In the indirect cost must be considered all the elements used throughout the project, such as the models downloaded from the internet, which fortunately did not cost anything, there we consider the item of its price in US dollars since in the download platforms its value is in this type of currency.

You should also consider all the implicit expenses, such as the rent of a premises and the payment of the services that are needed (internet, electricity, water, etc.). These expenses in the same way should be distributed among all the projects that are carried out by the team members as shown below, it should be clarified that it multiplied among the disposition of a larger member.

$$\$15{,}000.00 \cdot 0.2 = \$4{,}500.00$$

$$\$10{,}000.00 \cdot 0.2 = \$3{,}000.00$$

Resulting in a total indirect cost of $7,500.00.

Total cost:

The total cost of the project corresponds to the sum of both total values, that of the direct cost and that of the indirect, therefore, it is concluded that the total cost of the project is equal to $73,500.00.

Navigation map:

Requirements:

For execution with Visual Studio 2019 with C++ installation or with the executable:

1. Windows 7 (Last updated), Windows 8 (2919355), Windows 10 (version 1703 or higher).
2. Processor: 1.8 GHz (4 cores or more recommended)
3. 2.5 GB RAM minimum, 8 GB recommended.
4. 20 GB on disk, recommended.
5. Graphics chip of minimum 720p resolution.

Download and run the code:

Download the project from GitHub by clicking the green "Code" button and selecting one of the options.

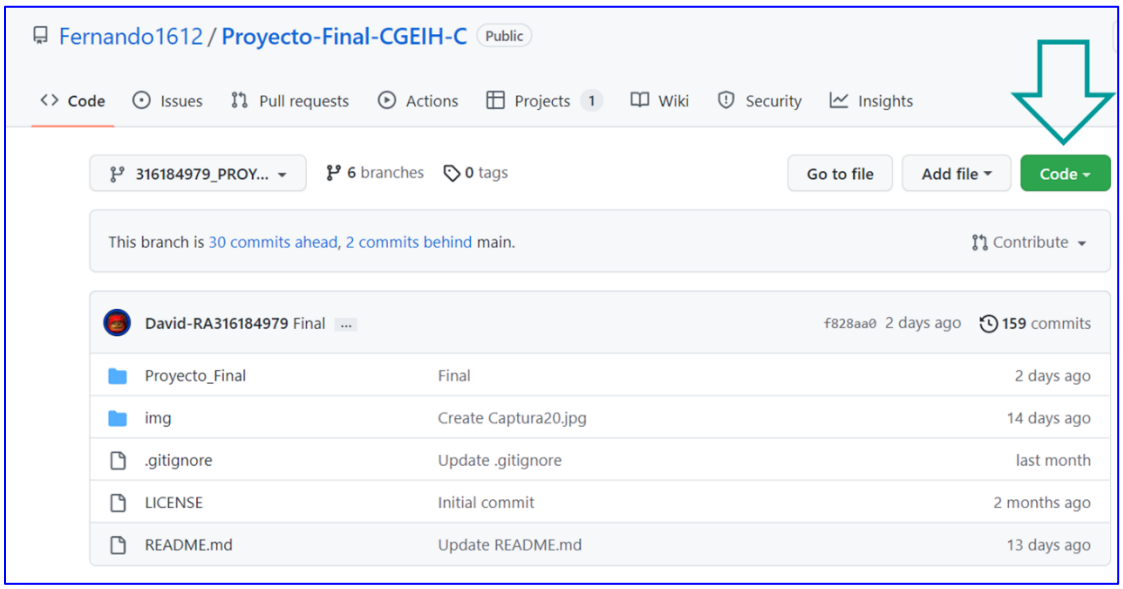

Figure 22. Screenshot showing the button for download.

If you select "Open with GitHub Desktop" you need to have this application installed on your computer and follow the steps to clone the repository locally, once cloned jump to "Run the file .exe".

The selection "Download ZIP" will download a file .zip of the project, you will have to unzip it on your computer, return to this manual and skip to "Run the file .exe".

Running with Visual Studio:

If desired and you have the Visual Studio IDE installed, you can run the application by following these steps. Have downloaded the project from GitHub and have unzipped the zip folder. Once you have this open Visual Studio and select the option "Open a project or a solution".

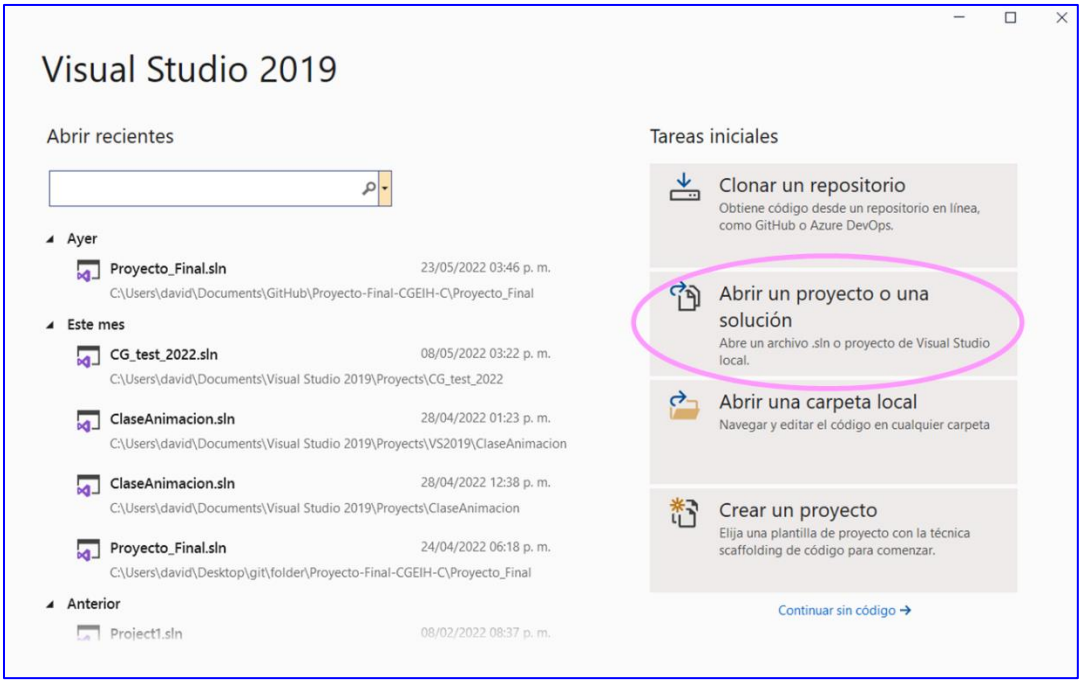

Figure 23. Screenshot showing how to open the project in Visual.

Find the "Proyecto_Final.sln" file inside the unzipped folder and hit the open button.

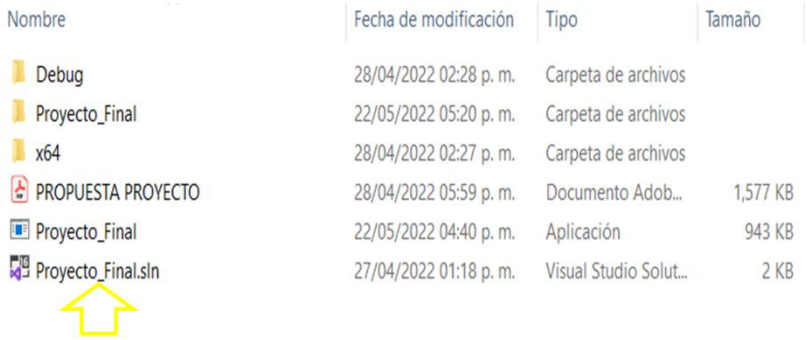

Figure 24. Screenshot showing the location of the project in the folder.

Before running the program, we check that all libraries and settings are loaded correctly. We go to the solution explorer, right-click on the project name and select the properties option.

In the "General" section we verify that the Platform Toolset is one that we have downloaded can be v142 or v143.

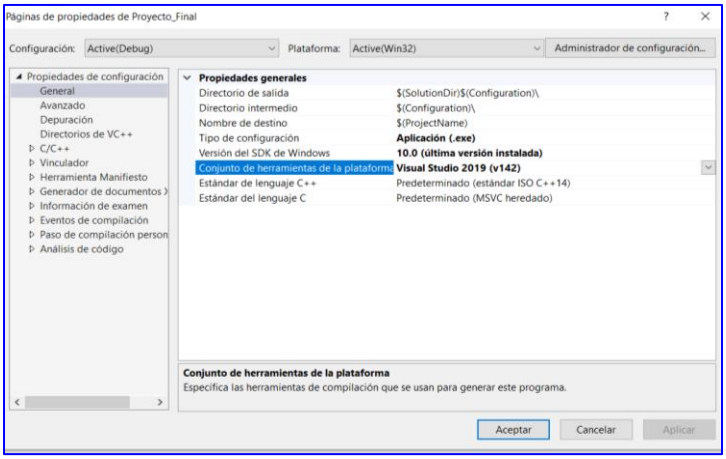

Figure 25. Screenshot showing the set of tools to select in Visual.

Within C/C++ ->general verify that the word include is in additional include directories. In the Linker ->General the word lib. In Additional library directories and finally, in Linker -> Entry verify the following dependencies ***Winmm.lib;SDL2.lib;SDL2main.lib;assimp-vc141-mtd.lib;opengl32.lib;glfw3.lib;kernel32.lib;user32.lib;gdi32.lib;winspool.lib;comdlg32.lib;advapi32.lib;shell32.lib;ole32.lib;oleaut32.lib;uuid.lib;odbc32.lib;odbccp32.lib;%(AdditionalDependencies)*** must be included in Additional dependencies.

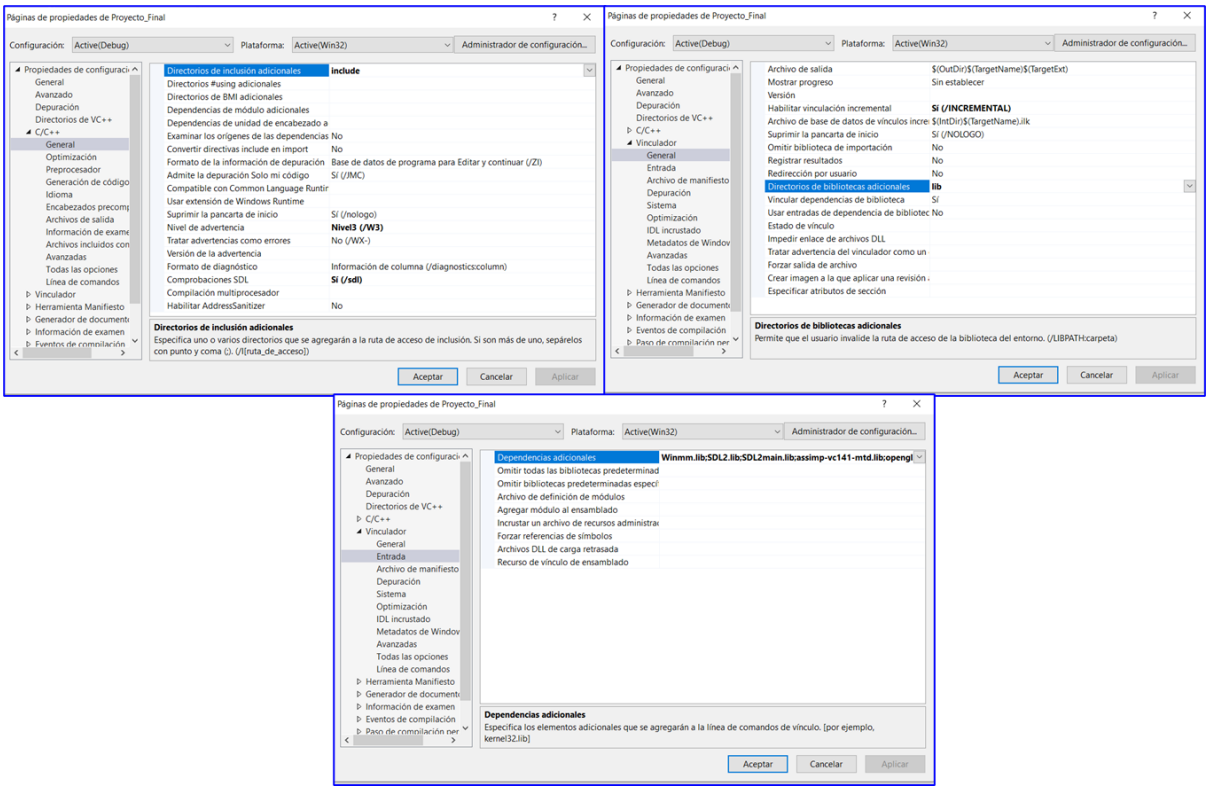

Figure 26. Screenshot showing the project settings in Visual.

To run the project, you must select the "x86" option in the top bar and verify that the "Debug" option is selected as shown in the following image.

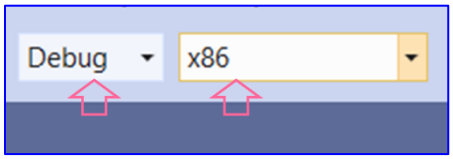

Figure 27. Screenshot showing the Debug option in Visual.

You can now run the project by clicking on the "Windows Local Debugger" button, this will open the program window.

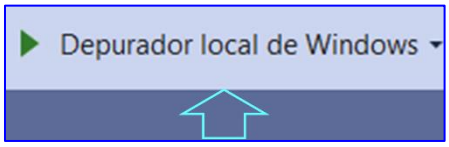

Figura 28. Captura de pantalla que muestra el depurador de Windows en Visual.

Execution with .exe file:

Once the project has been cloned or the ZIP has been unzipped: open the generated folder or repository location on your computer and go to ".\Proyecto_Final\Proyecto_Final", locate the "Proyecto_Final.exe" file and double-click to open. The above will open a window with the virtual space running.

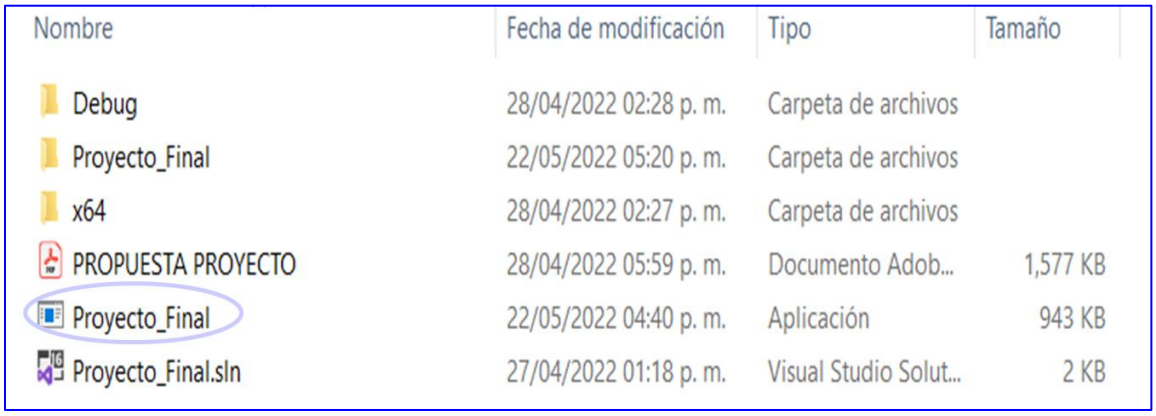

Figure 29. Screenshot showing the executable in the folder.

Interaction with the environment:

Once the window is opened; being inside the virtual space the mouse is captured to work only within it, so the course is not observed, and the movement of the mouse only works inside the window. The interaction takes place through the keyboard and mouse of the computer. The distribution of the models can be seen in Figure 1.

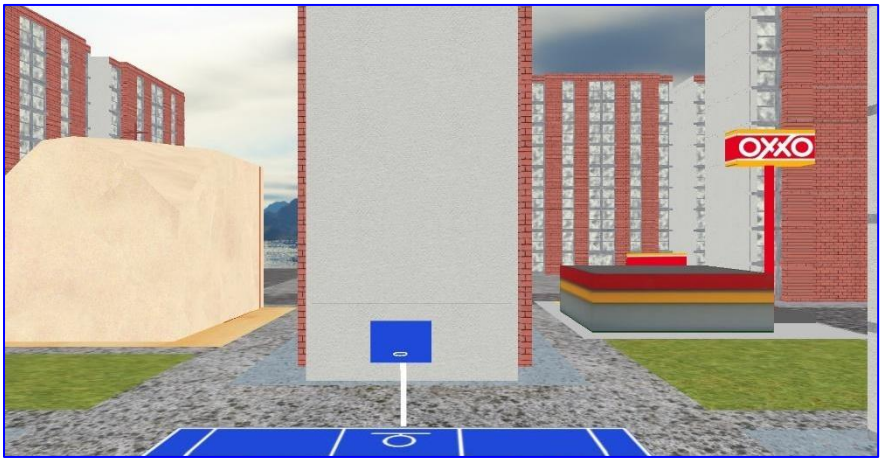

Figure 30. Captures with what is shown when opening when running the program.

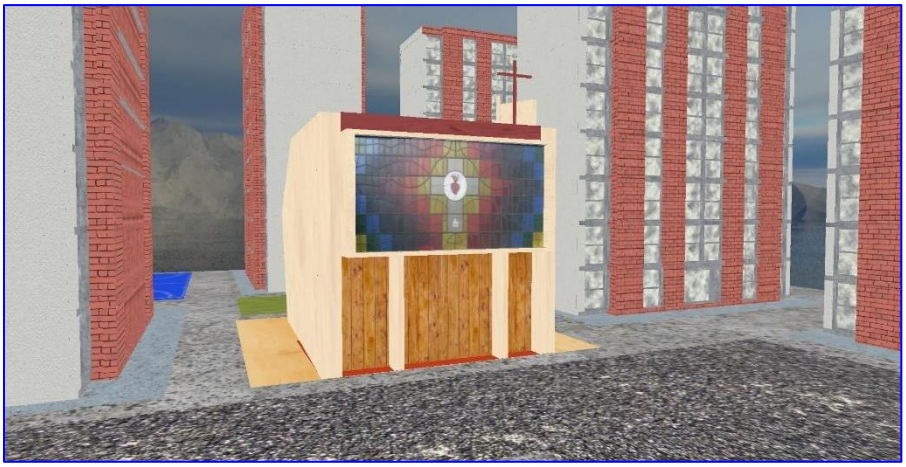

Figure 31. Model of the Church and its location.

Figure 32. Model of the OXXO store and its location.

Figure 33. Model of the entrance and its location.

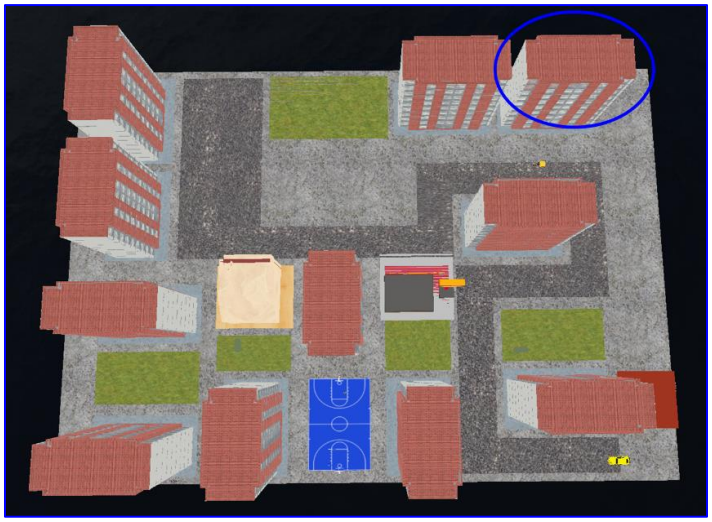

Figure 34. Location of the furnished building.

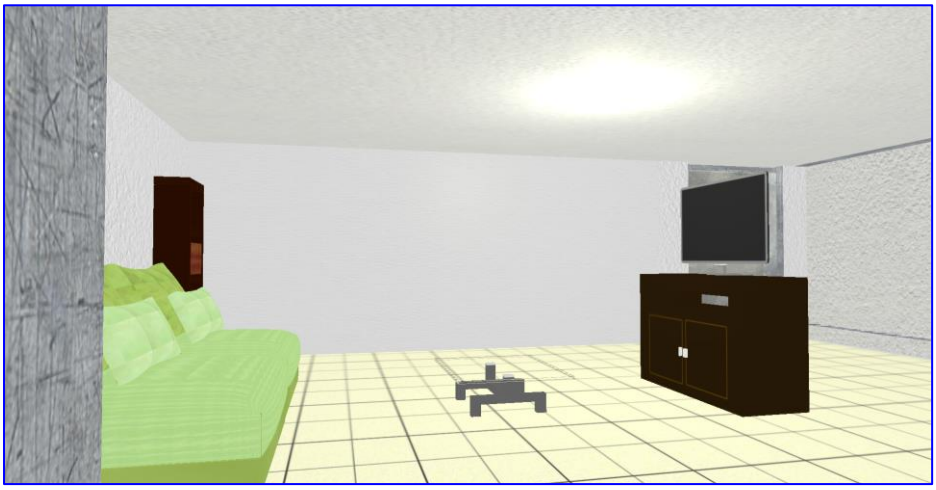

Figure 35. Room 1.

Figure 36. Room 2.

Functions:

Next, it is indicated with which keys the animations are activated or that it can be performed.

- Keyboard:
  - ESC: to exit the window / end the program.
  - W: Move the camera forward.
  - S: Move the camera back.
  - A: Move the camera to the left.
  - D: Move the camera to the right.
- Music:
  - Z: Turn on the sound.
- Animations:
  - SPACE: activate or deactivate the animation of the vehicle.
  - C: activate the animation of the walking person.
  - Tricycle animation does not need user input.
  - The animation of the bicycle does not need a user input.
  - The animation of the person walking does not need a user input.
  - The athlete's animation does not need a user input.
- Lamps:
  - 1: Turn on or off the focus of room 1.
  - 2: Turn the focus on or off in room 2.
- Mouse movements:
  - Sliding the mouse to the left or right, up or down makes the turn of the camera in that sliding direction, the *field of view* moves as it happens with the cursor of the computer.
  - Mouse scroll zooms + moving it forward and zooms - back.

Conclusions.

My first impression of the project was that it was extremely big, it was a lot of work to do; but I think that something that helped us was the fact that we divided very well the tasks to accomplish and I'm so grateful with my partners because they did what they had to do in time and showing a huge disposition. I had some troubles during the project, errors when I exported the models, some difficulties to locate the objects and give them the correct size and specially to make an animation which fulfilled the objectives. Finally, I consider that we satisfied the goal of the project, we put in practice the topics which were studied along the course.

References.

- Edificios de México (s.f.). Villa Olímpica Miguel Hidalgo [mensaje en un blog]. Recuperado de https://www.edemx.com/site/villa-olimpica-miguel-hidalgo/
- MIXAMO. (2022). Recuperado de https://www.mixamo.com/#/
- Open3DModel. (2022). Recuperado de https://open3dmodel.com/es/