VR Assignment Report

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Main Deliverable Components

Complexity and sophistication of scenes and sound

Menus

The main menu consists of buttons with the text of type TextMeshPro and images with 2D sprites as their source. All the buttons are responsive and serve a function by calling a method that has been assigned as an onclick button event in each button's properties. The main menu (Figure1) is the first element that is shown to the player, the player can:

- Press Play to enter the game and start playing.
- Press Exit to close the game.
- Press Options to adjust the sound of the game.

Figure 1: Main Menu

A display of instructions (Figure2) is shown to the player when they enter the game to ensure they understand how it works and what to keep in mind while exploring the scene. The user is instructed to view paintings and collect keys to unlock a hidden building, furthermore, they are informed of their ability to teleport, and the option to go back to the main menu.

The teleportation can be accessed when the player presses the menu button that is always available on the HUD and has a range of options such as the options to teleport to locations, view the instructions(info), close the menu, and go back to the main menu(home).

Figure 2: Teleportation Menu

The player's HUD(Figure3) consists of a menu button to access a menu and two text components that are enabled when the player collects a key and are dynamically updated for the user to keep track of the number of keys.

Figure 3: Number of Keys changes dynamically

Scene

The scene has a wide variety of assets including LOD objects to optimize performance. There are three buildings in the scene and a garden with a fountain. All the objects in this scene that can give reflections in the real world have their materials adequately edited and adjusted to have a realistic effect, Material properties such as the Metallic map, and smoothness were modified, and normal and base maps were set.

1. The first building is called "The Main Art Gallery" (Figure4) and has 16 paintings that are 2D sprites in image components and enable an information display that has their description when they are triggered. Each information display has its canvas with the render mode set to World Space to view it in VR while moving from different angles. In addition, the building has other assets to improve its realism such as a couch, 2 chairs, books, and a small sofa with a jug and a gramophone on it. Lastly, an animated character was added to greet the player by standing up(animation), bowing(animation), talking (playing audio), sitting down(animation), and going back to idle (animation) when a specified collision occurs. Lastly, keys (assets) have been placed one for each painting which serve a specific function and are enabled when a certain event occurs. The keys have two groups, there are red keys on the ground and green keys upstairs.
The first building is the starting point for the player. When the game starts, the player presses play in the menu, and they will be taken to the

Figure 4: Main Art Gallery

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game with main the art gallery presented in front of them. The user can then walk and explore the vast scene that has been enriched with information displays and collectible keys. The building has 3d sound as background music that will be less noticeable as the player walks away from it.

2. The second building is called "Da Vinci's Workshop" (Figure5) and can only be "visited" (accessed) when the user has completed a certain mission. This building has
Paintings are created in a similar manner as in the Main Art Gallery, assets that illustrate the inventions of Leonardo Da Vinci with the adequate description presented in information displays, and a small space with assets to illustrate that the artist himself is talking and working. The doors that allow the player to enter or exit this building have been animated to slide in or out depending on the user's collision state with the doors. Lastly, a 3d animated character that simulates talking while sitting with textures that resemble Leonardo Da Vinci was added. 3d sounds were added to this building, one for background music and one for the 3d character to simulate speaking.

Figure 5: Da Vincis Workshop

3. <u>A third building</u> called "big statues" was added with assets of big statues of works made by famous painters for instance "buste de femme" by Picasso. This building has stairs and two floors and allows the player to be teleported there through the teleportation menu. "The garden" is an open space with some LOD assets and has 3d sound that simulates natural and urban noises. The assets presented in the garden include a fountain, a wagon, and pillars with flowers on them.

Movement and collision detection supported

Movement is supported and can be fully executed using VR equipment such as an Oculus Quest 2 and its hand remote controllers. With the use of the locomotion system provided by the XR interaction toolkit, movement in the scene with the utilization of the left hand's controller joystick was made possible with the script ContninuousMoveProvider, and turning left or right was made possible with the script ContinuousTurnProvider. The game uses the action-based XR rig from the XR interaction toolkit to allow input from the remote controllers (Figure 6).
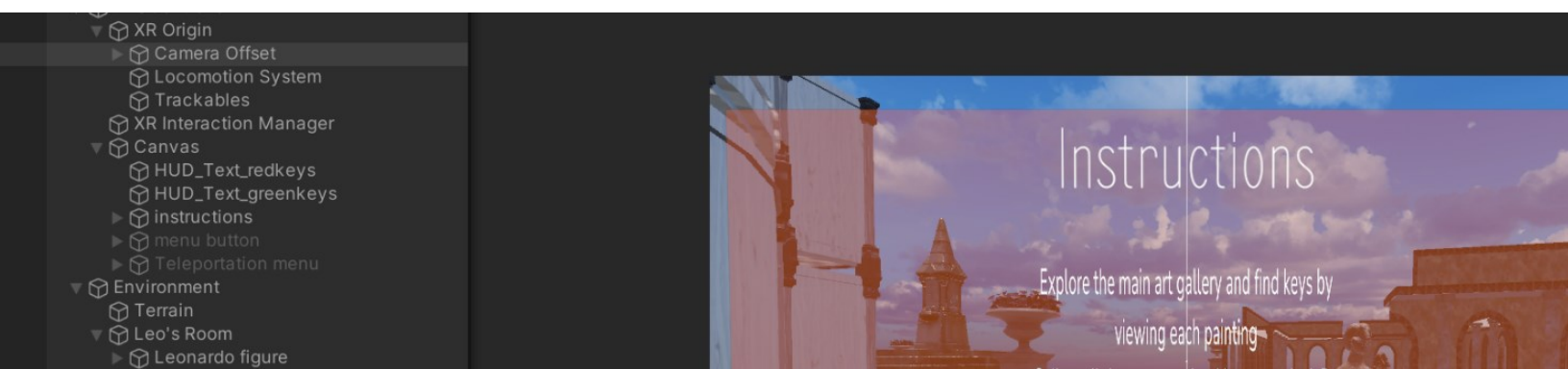
Figure 6: VR Input

Collision detection is supported and extensively used.

 In the first building, collision is detected when the player enters it, and the audio source of the background audio is enabled through the use of the script "Audio Manager". Another collision is detected when the player enters the bounds of the 3d character that will in turn trigger the animations of it or disable it if the player is not within its bounds anymore. Furthermore, collision is present when the player collides with spinning objects (keys) that will in turn destroy them. The animation of the 3d character is disabled when the player has exited the large collider (Figure7) that covers this building.
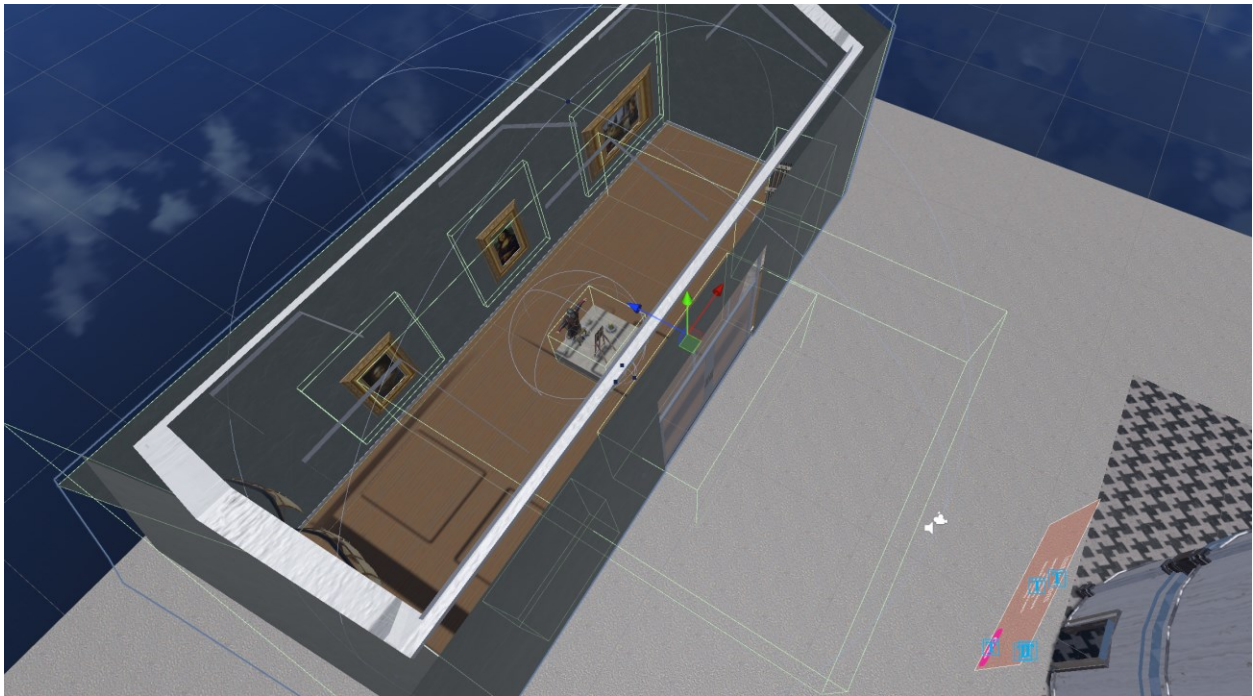
Figure 7: Building1 - Box colliders

 The second building also utilizes collision when the player comes close to the doors their animation will be triggered and when the user walks away from the door a different animation will play to simulate that the doors are closing if the user stays in bounds of the door, it will open and stay open until a new state of a collision occurs (player exits the bounds). A big box collider (Figure8) was added to the building to check if the player has left it, if the player is no longer

in the building, then the audio sources will be disabled using "Audio Manager", and animation will also be disabled using "Disable Animators", both scripts have arrays to store as many object instances as needed.

Each painting in the scene is using "LookAtObjTrigger" which triggers the information displays instantly when the player looks at a painting. A fuse was added to each painting in the scene. The fuse activates when the player looks at a painting (Ray Cast of the player), a coroutine is triggered and after 5 seconds the visibility of a GameObject is enabled.

Figure 8: Building 2 - Box Colliders

Interactive Features

Features that enhance the gameplay and make the game more enjoyable are an alternative means of travel – Teleportation, and a challenge – Collecting keys to unlock a hidden exhibition.

Teleportation

The player can teleport to different locations using a menu as shown in Figure 2. The current position of the transform vector changes to one of the empty Game Objects that have been placed in different locations that act as spawn points. The script "Teleport" is used to implement this ability. The script has assignable fields for the transform of each GameObject that acts as a spawn point, and the player's transform. Then methods were created one for each location to be utilized by onclick button events of the Teleportation menu.

Collectibles

Keys were used as collectibles. An asset of a key was used with two types of materials one colored red(Figure 9) and the other green(Figure10) for two groups of keys. The keys were positioned next to each painting in the Main Art Gallery, when the user looks at a painting and keeps looking at it for 5 seconds then a key's visibility that was disabled by default will be enabled on that condition. The key will then spin in 2 axes to indicate their presence combined with a sound effect to notify the player of their activation.

Figure 9:Red Key

Figure 10: Green Key

When a key is collected a sound effect is played to indicate that it has been collected and the text on the HUD is enabled if it was not already, and the text is dynamically updated as more keys are collected. When the player has collected all the keys the HUD text is disabled as keeping track of the number of keys is no longer useful since the hidden building is present in the scene on this occasion. With the successful collection of all the keys, Da Vinci's workshop is enabled and the option to teleport to that building is unlocked (Figure11) allowing the player to freely teleport to any of the given options.

Figure 11: Teleport to Da Vincis Workshop

Optimization

Decimation of models

When the player views a painting and a collectible key appears before them and they collect it the key is destroyed as there is no further use for it, this can improve the performance significantly as there are 16 keys if all of them were enabled to view before collecting them, these 16 keys would play their animation and their sound effect which could worsen the overall performance of the game.
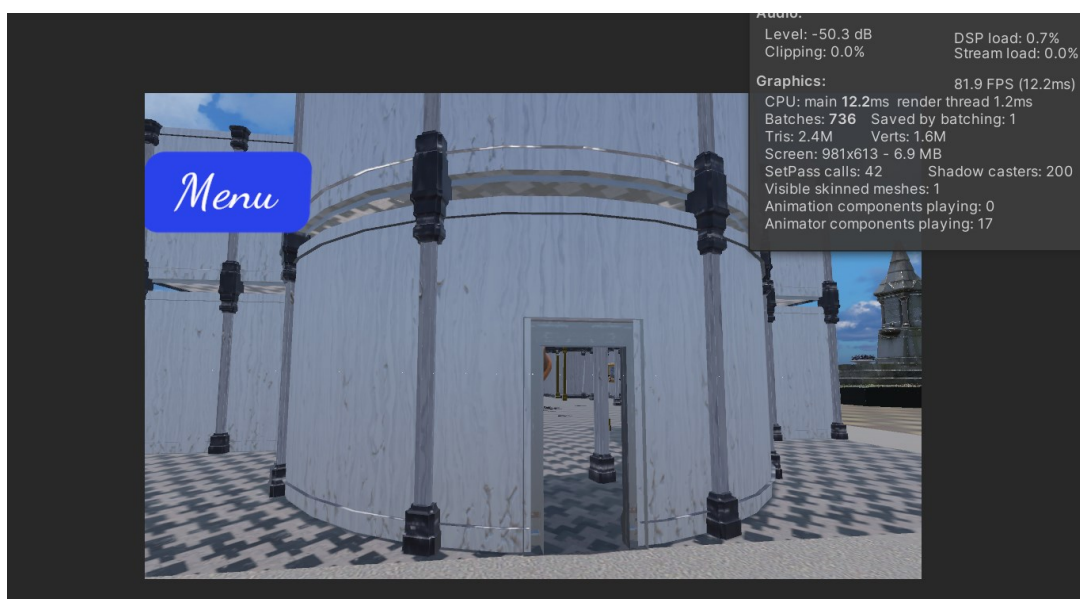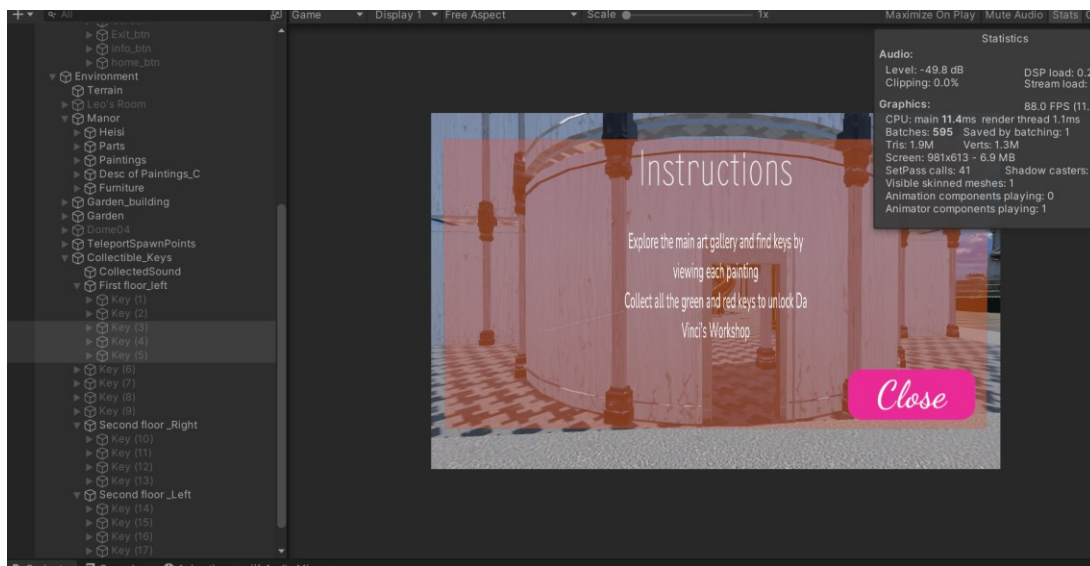
As depicted in the second picture the number of frames decreases by 7% or 6 frames when all the collectibles are enabled in a comparison with the performance displayed in the first picture.

Disabled Components

To improve performance multiple audio sources and animators are dynamically disabled or enabled during runtime as the player leaves and enters colliders that cover entire buildings. This method can reduce the number of elements that need to be rendered by the graphics renderer such as animations of 3d characters and the resources required to play audio sources of various objects.

[Before]
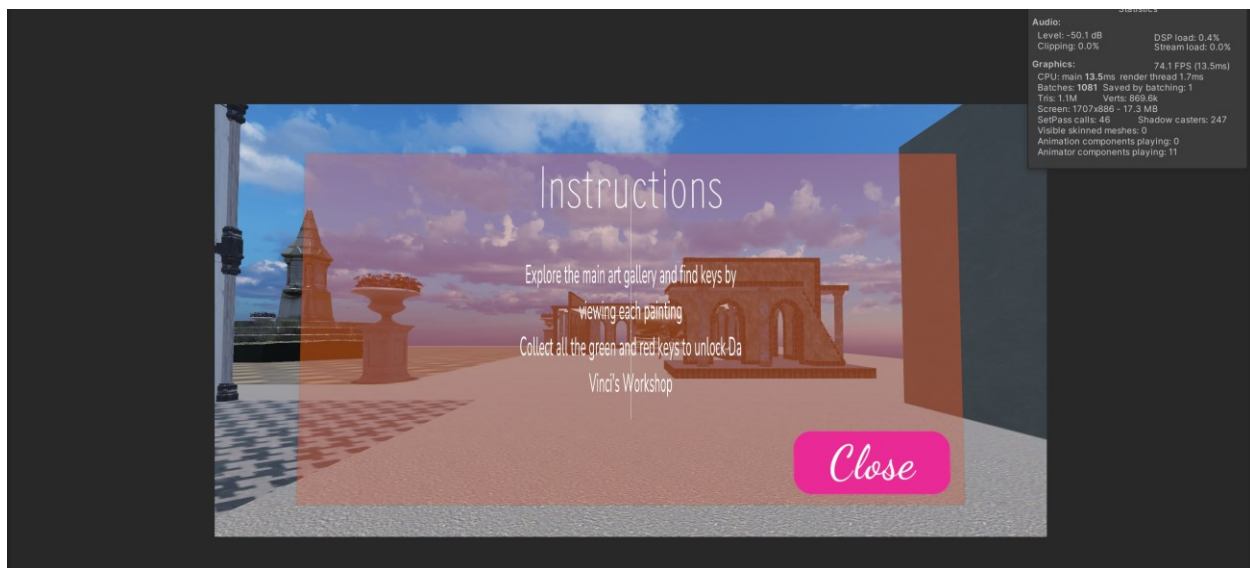
[After]
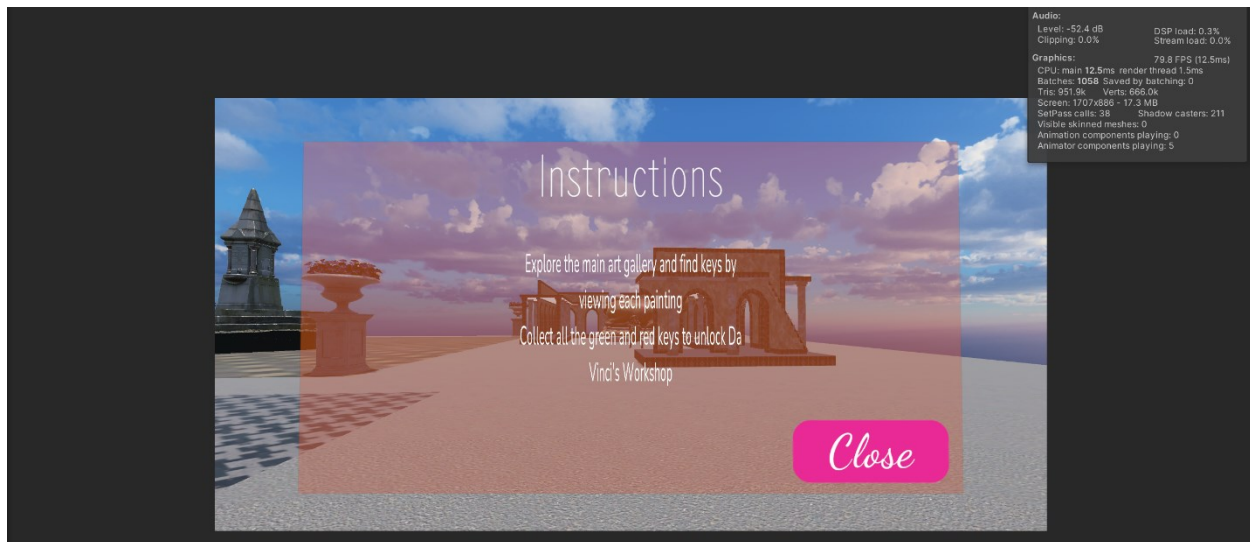
The frames increased by 8% with the use of this method. Proving that this method helps with performance.

Occlusion Culling

Occlusion culling was used to optimize the performance as it intelligently bakes the scene and takes into account all the static objects of the scene to identify what objects to render depending on where the player is looking at.
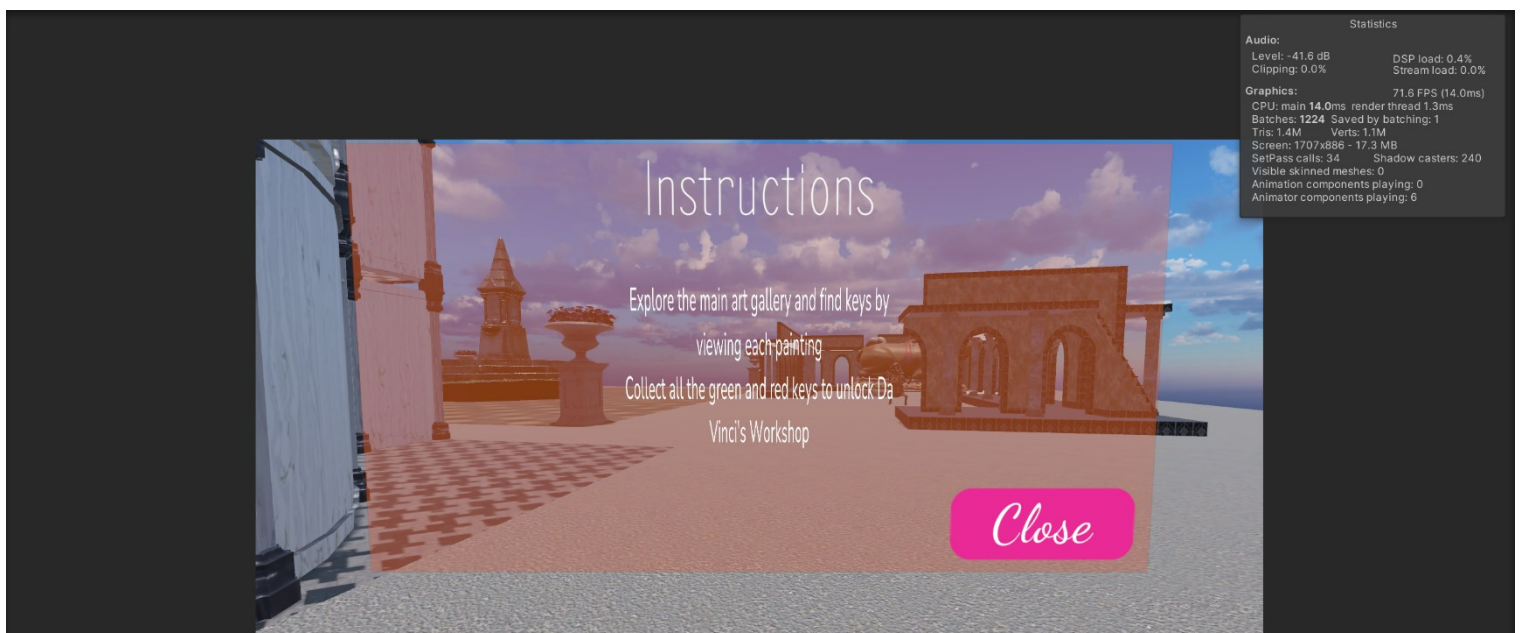
[Before]
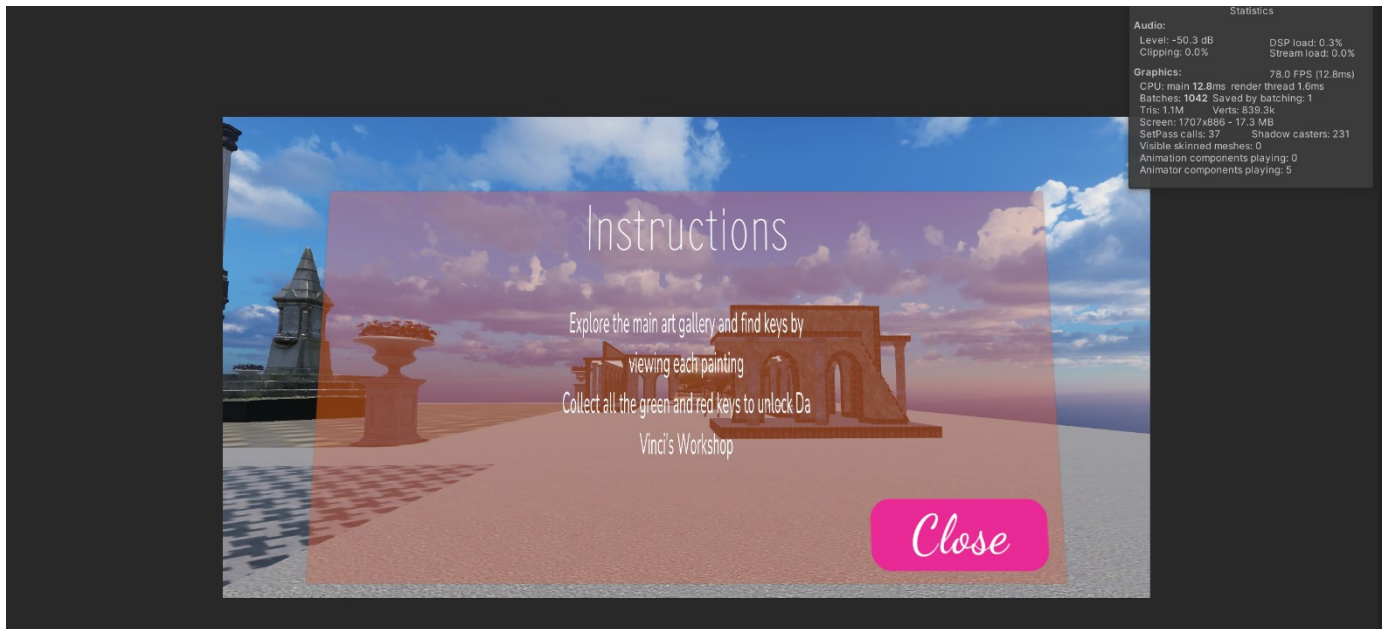
[After]

The results show an 8% increase in frames which indicates a benefit of using occlusion culling.

LOD Group
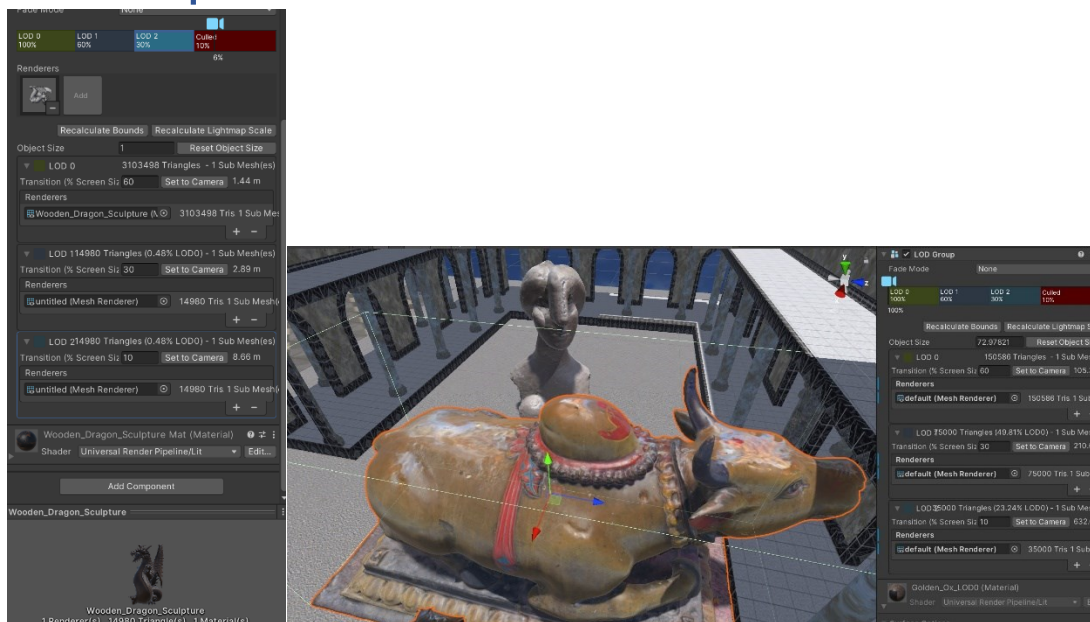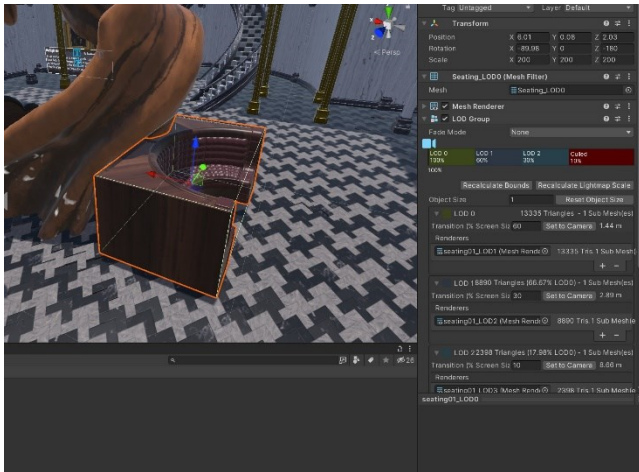
Instances of models that are game ready are shown, they are optimized with three groups of objects to intelligently switch the version of an asset to a worse one as the player walks further away from the optimized asset.

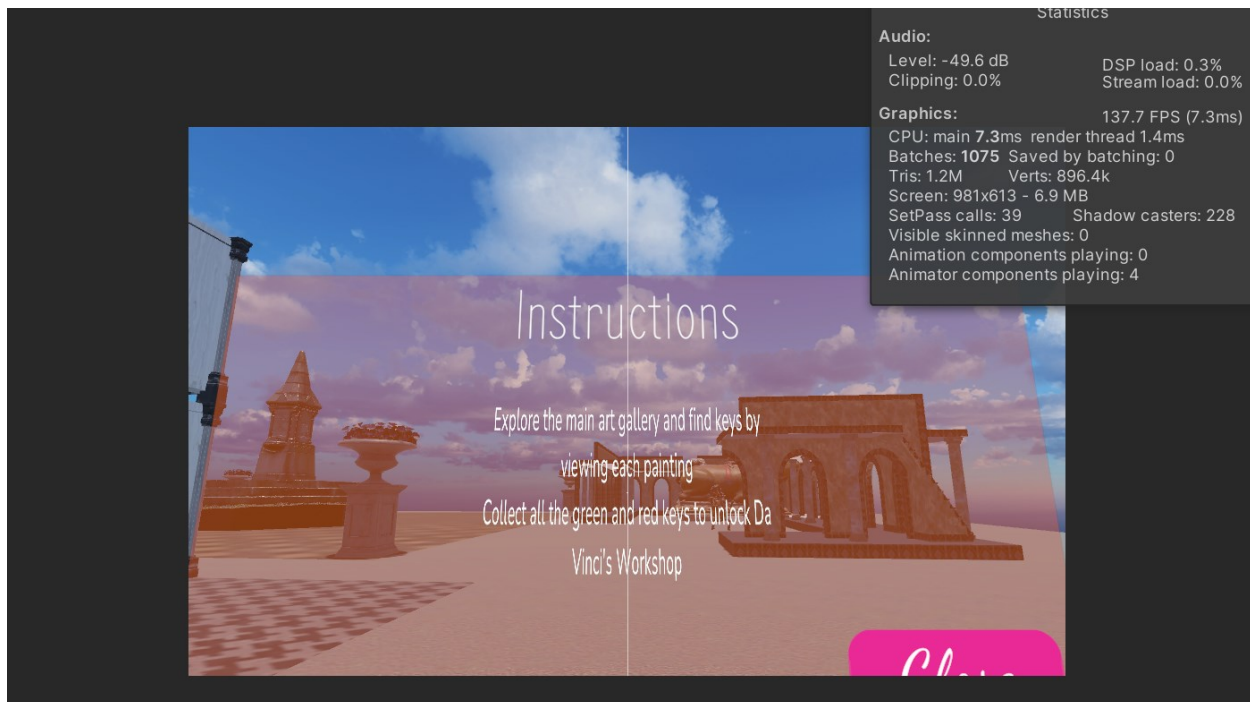## Use of Models with a low number of Tris and Verts

Every effort was made to find assets of adequate quality with a reasonable or very low number of triangles and vertices in order to achieve the most optimal performance.
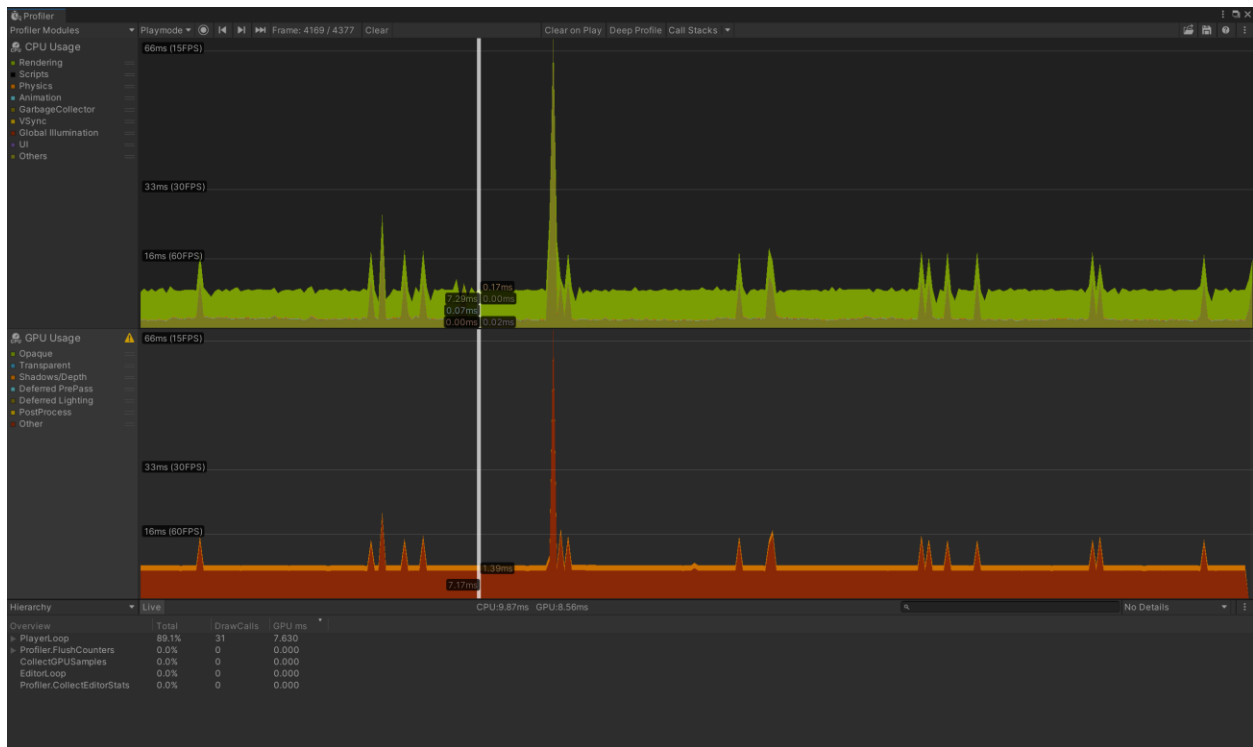
Results
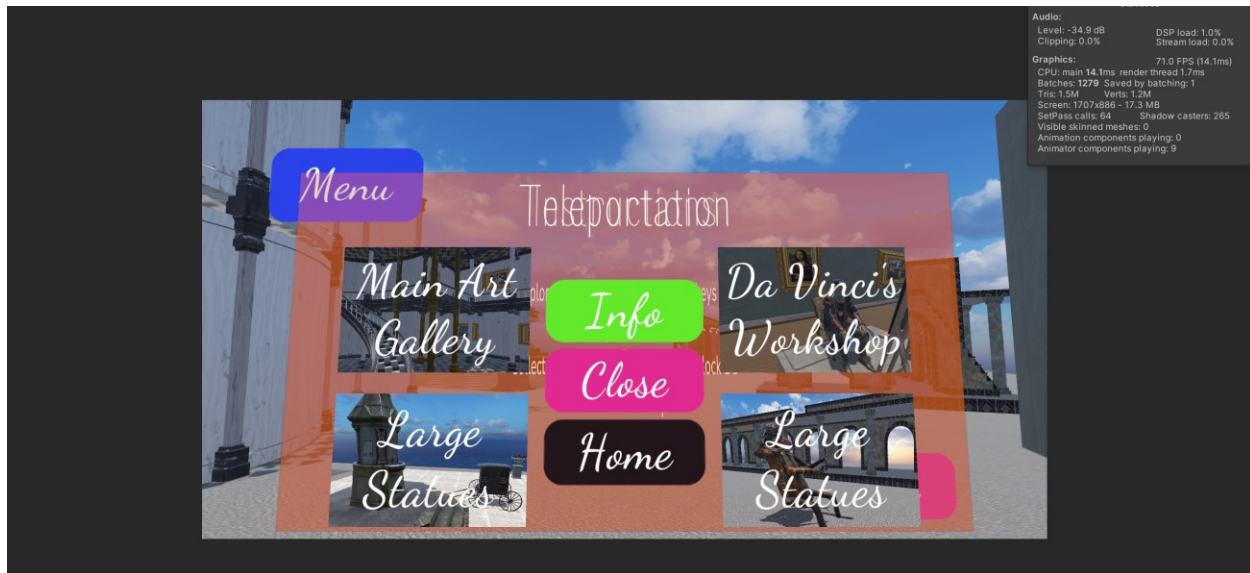
The game without any optimizations or smart design choices is limited to approximately 70 fps.

The game when fully optimized achieves up to 140 frames per second.

When fully optimized the shadows take 1.39 ms to render while other GPU processes take 7.17ms on average.

For the CPU usage, the rendering takes the most time 7ms while other CPU tasks are 0.02 ms on average.