UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

FACULTAD DE INGENIERÍA

Subject: Computación Gráfica e Interacción Humano Computadora

Group: 5

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Development Manual

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What is this manual?

This manual describes the realization of the project based on the resources used, the logic behind it, the programming process of this software and the rubrics requested for this project, especially for the "Elementos a incluir dentro del escenario" item.

This manual is not intended to give information about how to use the program (that can be read from the user manual) nor is it intended to help configure the build environment (that is included in the configuration manual).

Software Information

We have different items to cover within the category of "Elements to include in the scenario", which are the following:

- Geometry
- Avatar
- Route
- Lightning
- Animation
- Own element
- Audio

Below we present each rubric item with its solutions within our project.

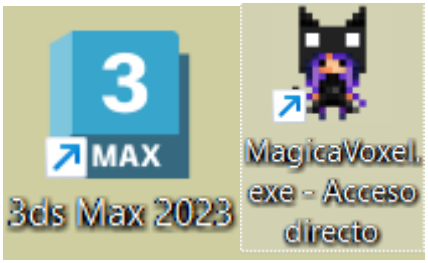
Geometry and Avatar

The Geometry category takes into account the visible models on the stage and their textures. The Avatar category considers that the proposed avatars (Morgana and Futaba, in this case) are created in a hierarchical way.

In our case, all the models (except the floor) were made by us, even the textures, with a few exceptions.

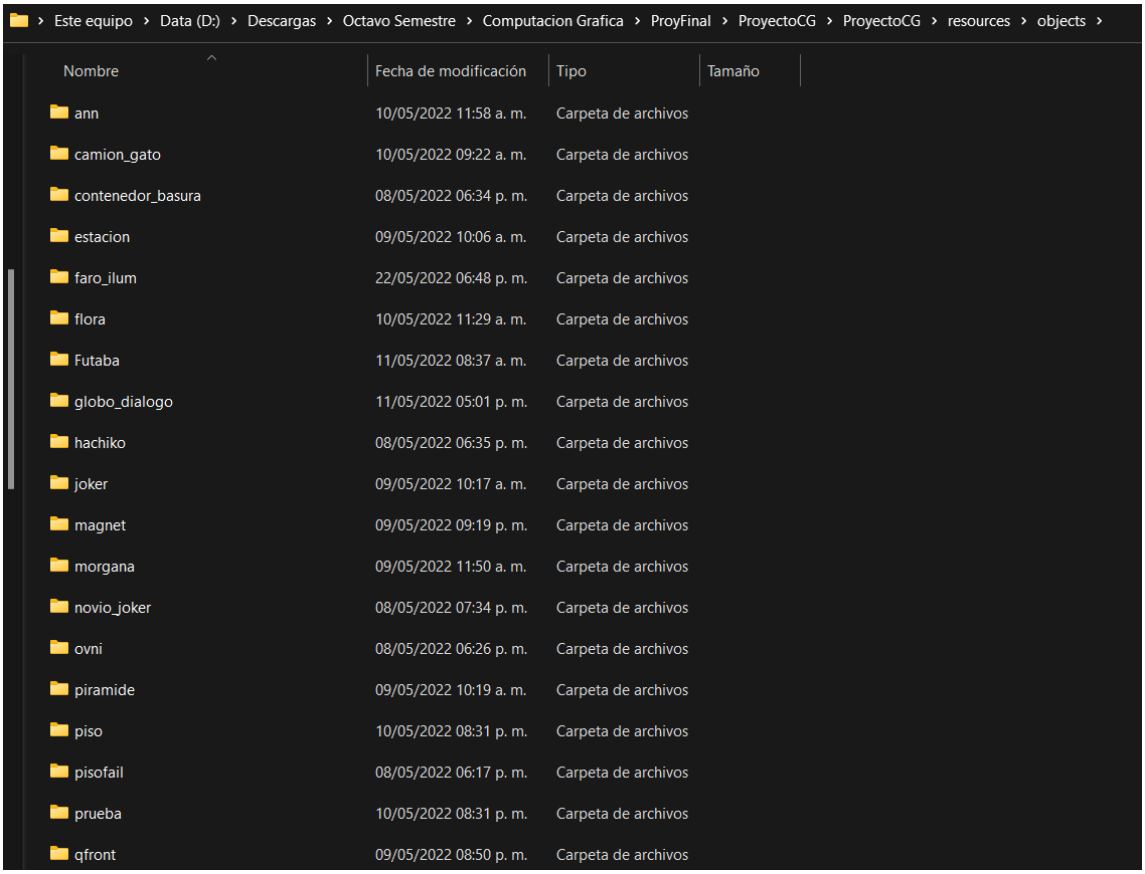
Among the exceptions, there is the blue skybox, which was given to us by Professor Sergio Valencia in the subject laboratory, but it is worth mentioning that we modified its appearance a little so that it is consistent with the voxel-art style, and the same can be said of the model of the floor, which was given to us by Professor Sergio, but we put a texture made from scratch. Likewise, the orange skybox was taken from the following link https://www.pngwing.com/es/free-png-pplmt where an author is not specified, although we also modified it to give it a more orange color tone.

All the other models are our own creation, with the help of the MagicaVoxel tool, which allows us to model in voxel-art, export our models to .obj and also obtain their materials and textures, which made this part of the development a lot easier. Unfortunately in MagicaVoxel, for small models, there are issues with the model origin, but all of these issues were solved using the 3ds Max 2023 software.



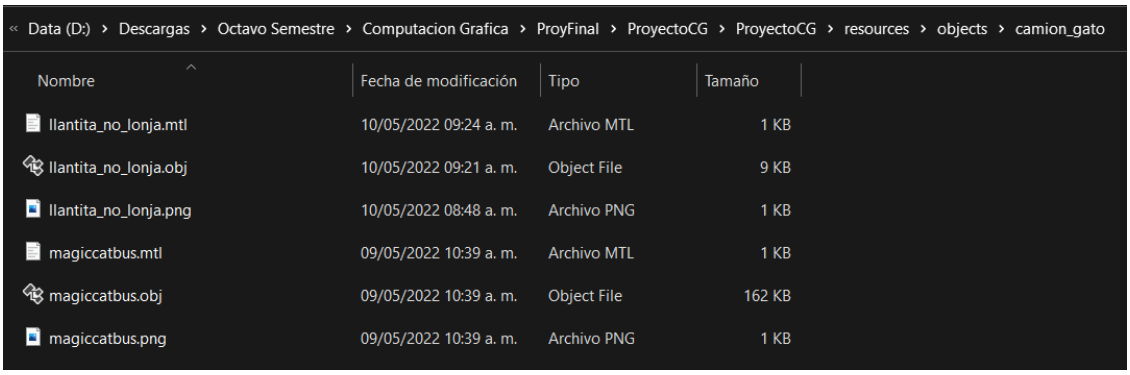
Shortcuts to MagicaVoxel and 3ds Max 2023 programs.

Once our models were exported and their origins were corrected, it was possible to incorporate them into the project. All the models are located inside the project folder “resources < objects”, although they are all in different folders.

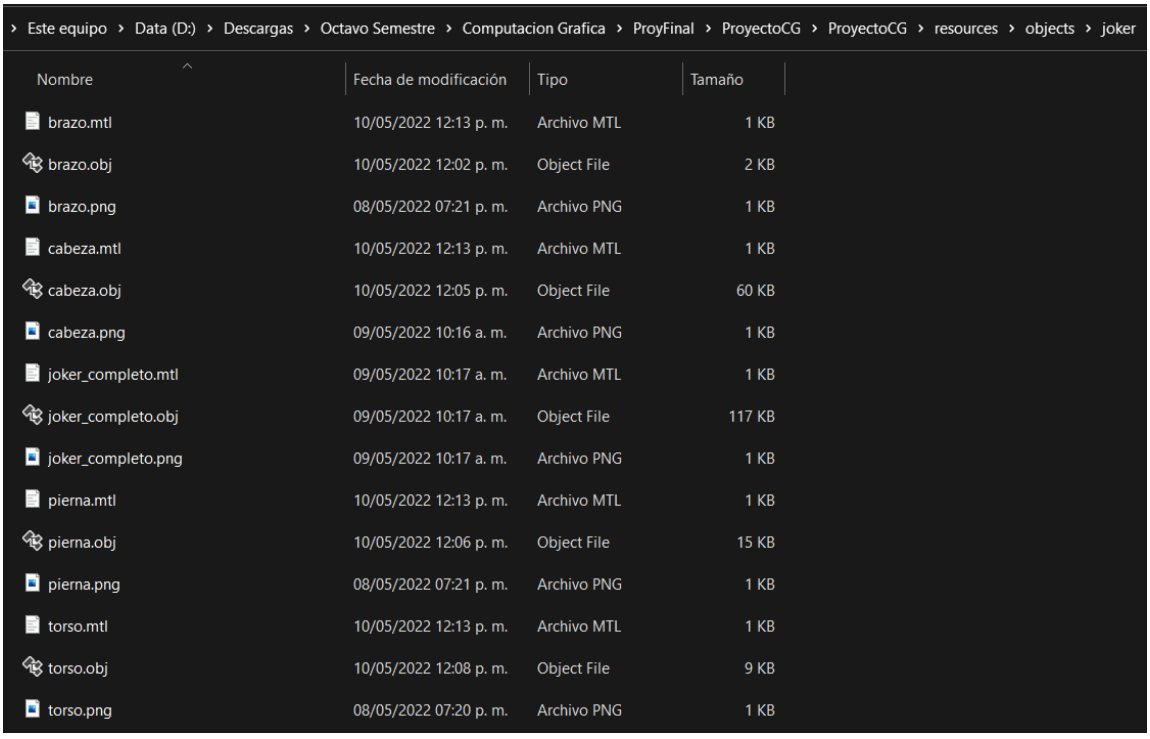


A look at the “resources < objects” folder.

Some models that make use of hierarchy are grouped together in folders. For example, the camion_gato model has the bodywork and wheels linked by hierarchy, and within its folder we can find both models (car and wheels). This also happens with all humanoid models, which have a hierarchy in arms, legs and head.



A look at the camion_gato folder, which has 2 models: Bodywork and wheels.



A look at the Joker folder, which has several models that make up the main model and are linked together by hierarchy.

The way to load the models within the project is described below.

We need to add the correct libraries, both to perform mathematical operations and to be able to use models and textures.

```
11  #include <glad/glad.h>
12  #include <glfw3.h>  //Main
13  #include <stdlib.h>
14  #include <glm/glm.hpp>  //Camara y Model
15  #include <glm/gtc/matrix_transform.hpp> //Camara y Model
16  #include <glm/gtc/type_ptr.hpp>
17  #include <time.h>
```

```
25  #include <shader_m.h>
26  #include <camera.h>
27  #include <modelAnim.h>
28  #include <model.h>
29  #include <Skybox.h>
30  #include <iostream>
```

Skyboxes make use of a shader, so it is necessary to initialize that shader.

```
1055    Shader skyboxShader("Shaders/skybox.vs", "Shaders/skybox.fs");
```

Once the shader is initialized, we proceed to load our skybox textures and create the skybox objects.

```
1059    //Se cargan recursos del skybox
1060    vector<std::string> faces
1061    {
1062        "resources/skybox/right.jpg",
1063        "resources/skybox/left.jpg",
1064        "resources/skybox/top.jpg",
1065        "resources/skybox/bottom.jpg",
1066        "resources/skybox/front.jpg",
1067        "resources/skybox/back.jpg"
1068    };
1069
1070    vector<std::string> facesalt
1071    {
1072        "resources/skybox/alt/right.png",
1073        "resources/skybox/alt/left.png",
1074        "resources/skybox/alt/top.png",
1075        "resources/skybox/alt/bottom.png",
1076        "resources/skybox/alt/front.png",
1077        "resources/skybox/alt/back.png"
1078    };
1079
1080    Skybox skybox1 = Skybox(faces);
1081    Skybox skybox2 = Skybox(facesalt);
```

Next, we proceed to use the skyboxes.

```
1086    // Shader configuration
1087    skyboxShader.use();
1088    skyboxShader.setInt("skybox1", 0);
```

Once in use, we proceed to draw the skybox.

```
2351        // Se dibuja skybox
2352        skyboxShader.use();
2353        if(skyboxtipe)
2354            skybox1.Draw(skyboxShader, view, projection, camera);
2355        else
2356            skybox2.Draw(skyboxShader, view, projection, camera);
```

If we want to change the skybox at runtime, we simply press the N key to draw the other skybox.

```
2400        //Skybox
2401        if (glfwGetKey(window, GLFW_KEY_N) == GLFW_PRESS)
2402            skyboxtipe ^= true;
```

If we close the program, we close the skyboxes so that they stop taking up memory.

```
2375    if (skyboxtipe)
2376        skybox1.Terminate();
2377    else
2378        skybox2.Terminate();
```

To load the models, we need to load each .obj, have the texture and its material in the same folder for them to display correctly. Later, we can start the OpenGL load of models.

```
1090    // Carga de modelos
1091    // Edificios
1092    Model piso("resources/objects/piso/piso.obj");
1093    Model qfront("resources/objects/qfront/qfront_chido.obj");
1094    Model magnet("resources/objects/magnet/magnet.obj");
1095    Model torniquetes("resources/objects/estacion/torniquetes.obj");
1096    Model estacion("resources/objects/estacion/estacion.obj");
1097    Model espera("resources/objects/estacion/espera_trenes.obj");
1098    Model piramide("resources/objects/piramide/piramide.obj");
1099    Model hachiko("resources/objects/hachiko/buchiko_estatua.obj");
1100
1101    //Vehiculos
1102    Model ovni("resources/objects/ovni/ovni.obj");
1103    Model vagon("resources/objects/tren/tren.obj");
1104    Model cabina("resources/objects/tren/cabina.obj");
1105    Model camion("resources/objects/camion_gato/magiccatbus.obj");
1106    Model rueda("resources/objects/camion_gato/llantita_no_lonja.obj");
1107
1108    //Flora
1109    Model arbol("resources/objects/flora/green_tree.obj");
1110    Model arbusto("resources/objects/flora/arbusto.obj");
1111    Model circulo("resources/objects/flora/circulo-para-arbol.obj");
1112    Model planta("resources/objects/flora/planta_amarilla.obj");
1113
1114    //Reloj
1115    Model minutos("resources/objects/reloj/manecilla_minutos.obj");
1116    Model horas("resources/objects/reloj/manecilla_horas.obj");
```

In this part, the hierarchy order doesn't really matter, it only matters to load the models, although we do organize the loading in a certain order to avoid confusion.

```
1118    //Morgana
1119    Model cabezaMorgana("resources/objects/morgana/cabeza.obj");
1120    Model torsoMorgana("resources/objects/morgana/torso.obj");
1121    Model brazoMorgana("resources/objects/morgana/brazo_completo.obj");
1122    Model piernaMorgana("resources/objects/morgana/pierna.obj");
1123    Model patasCorriendoMorgana("resources/objects/morgana/patas_correr.obj");
1124
1125    //Joker
1126    Model cabezaJoker("resources/objects/joker/cabeza.obj");
1127    Model torsoJoker("resources/objects/joker/torso.obj");
1128    Model brazoJoker("resources/objects/joker/brazo.obj");
1129    Model piernaJoker("resources/objects/joker/pierna.obj");
1130
1131    //Novio Joker
1132    Model cabezaAkechi("resources/objects/novio_joker/cabeza.obj");
1133    Model torsoAkechi("resources/objects/novio_joker/torso.obj");
1134    Model brazoAkechi("resources/objects/novio_joker/brazo.obj");
1135    Model piernaAkechi("resources/objects/novio_joker/pierna.obj");
1136
1137    //Ann
1138    Model cabezaAnn("resources/objects/ann/cabeza.obj");
1139    Model torsoAnn("resources/objects/ann/torso.obj");
1140    Model brazoAnn("resources/objects/ann/brazo.obj");
1141    Model piernaAnn("resources/objects/ann/pierna1.obj");
1142    Model pierna2Ann("resources/objects/ann/pierna2.obj");
```

In the case of Futaba, since we are not using an .obj, but a .dae, we initialize an animation shader, because its default animations were obtained through Mixamo. Since there are 2 animations for Futaba, then we load the 2 models with animation.

```
1144    //Futaba 1 (Flotando)
1145    ModelAnim Futaba1("resources/objects/Futaba/Floating/Floating.dae");
1146    Futaba1.initShaders(animShader.ID);
1147
1148    //Futaba 2 (Gritando)
1149    ModelAnim Futaba2("resources/objects/Futaba/Yelling/Yelling.dae");
1150    Futaba2.initShaders(animShader.ID);
1151
1152    //Globo de dialogo
1153    Model globo("resources/objects/globo_dialogo/globo_con_dialogo.obj");
1154
1155    //Vía del tren
1156    Model via("resources/objects/via/via.obj");
1157
1158    //Faro de iluminación spotlight
1159    Model faro("resources/objects/faro_ilum/faro.obj");
```

The next step after model loading is to draw the loaded models, but for that we make use of a shader known as staticShader, while for animated models we use the animShader. We need to use them before drawing the models. The static shader is also used for lighting. Once the shaders are started, we proceed to apply geometric transformations, auxiliary matrices for hierarchy implementation

and finally draw all the models needed. Due to the constant repetition of some models, we prefer not to show all the drawing code, but parts of it.

```
1228        staticShader.use();
```

```
1304        // Personajes animados
1305        animShader.use();
1306        animShader.setMat4("projection", projection);
1307        animShader.setMat4("view", view);
1308
1309        animShader.setVec3("material.specular", glm::vec3(0.5f));
1310        animShader.setFloat("material.shininess", 32.0f);
1311        animShader.setVec3("light.ambient", ambientColor);
1312        animShader.setVec3("light.diffuse", diffuseColor);
1313        animShader.setVec3("light.specular", 1.0f, 1.0f, 1.0f);
1314        animShader.setVec3("light.direction", lightDirection);
1315        animShader.setVec3("viewPos", camera.Position);
1316
1317        // Dibujo Futaba 1
1318        model = glm::translate(glm::mat4(1.0f), glm::vec3(15.0f, movFutaba_y, 85.0f));
1319        model = glm::scale(model, glm::vec3(escalaFutaba1));
1320        animShader.setMat4("model", model);
1321        Futaba1.Draw(animShader);
1322
1323        // Dibujo Futaba 2
1324        model = glm::translate(glm::mat4(1.0f), glm::vec3(15.0f, -0.5f, 85.0f));
1325        model = glm::scale(model, glm::vec3(escalaFutaba2));
1326        animShader.setMat4("model", model);
1327        Futaba2.Draw(animShader);
```

```
1329        // Objetos estáticos
1330        staticShader.use();
1331        staticShader.setMat4("projection", projection);
1332        staticShader.setMat4("view", view);
1333
1334        // Piso
1335        model = glm::mat4(1.0f);
1336        model = glm::translate(model, glm::vec3(0.0f, -1.0f, 0.0f));
1337        model = glm::scale(model, glm::vec3(0.05f));
1338        staticShader.setMat4("model", model);
1339        piso.Draw(staticShader);
1340
1341        //Q-Front
1342        model = glm::mat4(1.0f);
1343        model = glm::translate(model, glm::vec3(-92.0f, -1.0f, 40.0f));
1344        model = glm::rotate(model, glm::radians(138.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1345        model = glm::scale(model, glm::vec3(2.5f, 2.5f, 3.1f));
1346        staticShader.setMat4("model", model);
1347        qfront.Draw(staticShader);
1348
1349        //Magnet
1350        model = glm::mat4(1.0f);
1351        model = glm::translate(model, glm::vec3(-65.0f, -0.7f, -38.0f));
1352        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1353        model = glm::scale(model, glm::vec3(2.7f));
1354        staticShader.setMat4("model", model);
1355        magnet.Draw(staticShader);
```

```
1357        //Faro iluminación
1358        model = glm::mat4(1.0f);
1359        model = glm::translate(model, glm::vec3(-30.0f, -0.8f, 0.0f));
1360        model = glm::rotate(model, glm::radians(45.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1361        model = glm::scale(model, glm::vec3(2.3f));
1362        staticShader.setMat4("model", model);
1363        faro.Draw(staticShader);
1364
1365        //Torniquetes
1366        model = glm::mat4(1.0f);
1367        model = glm::translate(model, glm::vec3(55.0f, 2.3f, -2.0f));
1368        model = glm::scale(model, glm::vec3(2.35f));
1369        staticShader.setMat4("model", model);
1370        torniquetes.Draw(staticShader);
1371
1372        //Estacion
1373        model = glm::mat4(1.0f);
1374        model = glm::translate(model, glm::vec3(55.0f, -1.0f, -37.0f));
1375        model = glm::scale(model, glm::vec3(2.35f));
1376        staticShader.setMat4("model", model);
1377        estacion.Draw(staticShader);
1378
1379        //Espera
1380        model = glm::mat4(1.0f);
1381        model = glm::translate(model, glm::vec3(55.0f, -1.0f, -72.0f));
1382        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1383        model = glm::scale(model, glm::vec3(2.35f));
1384        staticShader.setMat4("model", model);
1385        espera.Draw(staticShader);
```

```
1387        //Pirámide
1388        model = glm::mat4(1.0f);
1389        model = glm::translate(model, glm::vec3(25.0f, -0.7f, 60.0f));
1390        model = glm::scale(model, glm::vec3(3.5f));
1391        staticShader.setMat4("model", model);
1392        piramide.Draw(staticShader);
1393
1394        //Hachiko
1395        model = glm::mat4(1.0f);
1396        model = glm::translate(model, glm::vec3(20.0f, -0.9f, 0.0f));
1397        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1398        model = glm::scale(model, glm::vec3(1.2f));
1399        staticShader.setMat4("model", model);
1400        hachiko.Draw(staticShader);
1401
1402        // Circulos cerca de Hachiko
1403        model = glm::mat4(1.0f);
1404        model = glm::translate(model, glm::vec3(15.0f, -0.9f, -5.0f));
1405        model = glm::rotate(model, glm::radians(70.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1406        model = glm::scale(model, glm::vec3(1.2f));
1407        staticShader.setMat4("model", model);
1408        circulo.Draw(staticShader);
1409
1410        model = glm::mat4(1.0f);
1411        model = glm::translate(model, glm::vec3(25.0f, -0.9f, -5.0f));
1412        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1413        model = glm::scale(model, glm::vec3(1.2f));
1414        staticShader.setMat4("model", model);
1415        circulo.Draw(staticShader);
```

```
1438        //Cabina
1439        model = glm::mat4(1.0f);
1440        model = glm::translate(model, glm::vec3(movCabina_x, movCabina_y, movCabina_z));
1441        model = glm::rotate(model, glm::radians(90.0f + orientaCabina), glm::vec3(0.0f, 1.0f, 0.0f));
1442        model = glm::scale(model, glm::vec3(2.0f));
1443        staticShader.setMat4("model", model);
1444        cabina.Draw(staticShader);
1445
1446        //Vagon
1447        model = glm::mat4(1.0f);
1448        model = glm::translate(model, glm::vec3(movVagon_x, movVagon_y, movVagon_z));
1449        model = glm::rotate(model, glm::radians(90.0f + orientaVagon), glm::vec3(0.0f, 1.0f, 0.0f));
1450        model = glm::scale(model, glm::vec3(2.0f));
1451        staticShader.setMat4("model", model);
1452        vagon.Draw(staticShader);
1453
1454        //Reloj
1455        //Manecilla minutos
1456        model = glm::mat4(1.0f);
1457        model = glm::translate(model, glm::vec3(55.0f, 33.7f, -59.4f));
1458        model = glm::rotate(model, glm::radians(-giroMins), glm::vec3(0.0f, 0.0f, 1.0f));
1459        model = glm::scale(model, glm::vec3(2.35f));
1460        staticShader.setMat4("model", model);
1461        minutos.Draw(staticShader);
1462        //Manecilla horas
1463        model = glm::mat4(1.0f);
1464        model = glm::translate(model, glm::vec3(55.0f, 33.7f, -59.2f));
1465        model = glm::rotate(model, glm::radians(-giroHoras), glm::vec3(0.0f, 0.0f, 1.0f));
1466        model = glm::scale(model, glm::vec3(2.35f, 1.55f, 2.35f));
1467        staticShader.setMat4("model", model);
1468        horas.Draw(staticShader);
```

```
1470        //Ovni
1471        model = glm::mat4(1.0f);
1472        model = glm::translate(model, glm::vec3(movOvni_x, movOvni_y, movOvni_z));
1473        model = glm::rotate(model, glm::radians(orientaOvni), glm::vec3(0.0f, 1.0f, 0.0f));
1474        staticShader.setMat4("model", model);
1475        //staticShader.setVec3("dirLight.specular", glm::vec3(1.0f, 1.0f, 1.0f));
1476        ovni.Draw(staticShader);
1477
1478        //Plantitas, árboles y arbustos
1479        model = glm::mat4(1.0f);
1480        model = glm::translate(model, glm::vec3(65.0f, -0.7f, 95.0f));
1481        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1482        model = glm::scale(model, glm::vec3(1.2f));
1483        staticShader.setMat4("model", model);
1484        arbol.Draw(staticShader);
```

```
1514        model = glm::mat4(1.0f);
1515        model = glm::translate(model, glm::vec3(80.0f, -0.7f, 85.0f));
1516        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1517        model = glm::scale(model, glm::vec3(2.2f));
1518        staticShader.setMat4("model", model);
1519        arbusto.Draw(staticShader);
1520
1521        model = glm::mat4(1.0f);
1522        model = glm::translate(model, glm::vec3(80.0f, -0.7f, 95.0f));
1523        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1524        model = glm::scale(model, glm::vec3(2.4f));
1525        staticShader.setMat4("model", model);
1526        planta.Draw(staticShader);
```

```
1860        //Globos de dialogo
1861        //Globo Akechi
1862        model = glm::mat4(1.0f);
1863        model = glm::translate(model, glm::vec3(20.0f, 3.0f + mov_globoY, -30.0f + mov_globoXZ));
1864        model = glm::rotate(model, glm::radians(-90.0f), glm::vec3(0.0f, 1.0f, 0.0));
1865        model = glm::scale(model, glm::vec3(eglobo_Akechi));
1866        staticShader.setMat4("model", model);
1867        globo.Draw(staticShader);
1868        //Globo Joker
1869        model = glm::mat4(1.0f);
1870        model = glm::translate(model, glm::vec3(15.0 + mov_globoXZ, 3.0 + mov_globoY, -29.8f));
1871        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1872        model = glm::scale(model, glm::vec3(eglobo_Joker));
1873        staticShader.setMat4("model", model);
1874        globo.Draw(staticShader);
1875        //Globo Ann
1876        model = glm::mat4(1.0f);
1877        model = glm::translate(model, glm::vec3(15.0f + mov_globoXZ, 3.0f + mov_globoY, -29.0f));
1878        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0));
1879        model = glm::scale(model, glm::vec3(eglobo_Ann));
1880        staticShader.setMat4("model", model);
1881        globo.Draw(staticShader);
1882        //Globo Morgana
1883        model = glm::mat4(1.0f);
1884        model = glm::translate(model, glm::vec3(13.0f, 2.0f + mov_globoY, -30.0f + mov_globoXZ));
1885        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0));
1886        model = glm::scale(model, glm::vec3(eglobo_Morgana));
1887        staticShader.setMat4("model", model);
1888        globo.Draw(staticShader);
```

```
1890        //Vias del tren
1891
1892        model = glm::mat4(1.0f);
1893        model = glm::translate(model, glm::vec3(-114.5f, -0.5f, -72.0f));
1894        //model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1895        model = glm::scale(model, glm::vec3(3.5f));
1896        staticShader.setMat4("model", model);
1897        via.Draw(staticShader);
```

For models with hierarchy, such as the truck, we see code like the following, which is based on taking a model as the main model (in the case of the truck, it is the car body), a temporary matrix is made on that model and that temporary matrix is used for the drawing of the other parts (the wheels, in the case of the truck). This sets up the hierarchy.

```
1606        // Camión gato
1607        model = glm::mat4(1.0f);
1608        model = glm::translate(model, glm::vec3(movCamion_x, movCamion_y, movCamion_z));
1609        tmp = model = glm::rotate(model, glm::radians(orientaCamion), glm::vec3(0.0f, 1.0f, 0.0f));
1610        staticShader.setMat4("model", model);
1611        camion.Draw(staticShader);
1612
1613        model = glm::translate(tmp, glm::vec3(1.7f, 0.0f, 2.0f));
1614        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1615        model = glm::rotate(model, glm::radians(giroLlanta), glm::vec3(0.0f, 0.0f, 1.0f));
1616        staticShader.setMat4("model", model);
1617        rueda.Draw(staticShader);   //delantera der
1618
1619        model = glm::translate(tmp, glm::vec3(-1.7f, 0.0f, 2.0f));
1620        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1621        model = glm::rotate(model, glm::radians(giroLlanta), glm::vec3(0.0f, 0.0f, 1.0f));
1622        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1623        staticShader.setMat4("model", model);
1624        rueda.Draw(staticShader);   //delantera izq
1625
1626        model = glm::translate(tmp, glm::vec3(1.7f, 0.0f, -2.4f));
1627        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1628        model = glm::rotate(model, glm::radians(giroLlanta), glm::vec3(0.0f, 0.0f, 1.0f));
1629        staticShader.setMat4("model", model);
1630        rueda.Draw(staticShader);   //trasera der
1631
1632        model = glm::translate(tmp, glm::vec3(-1.7f, 0.0f, -2.4f));
1633        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1634        model = glm::rotate(model, glm::radians(giroLlanta), glm::vec3(0.0f, 0.0f, 1.0f));
1635        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1636        staticShader.setMat4("model", model);
1637        rueda.Draw(staticShader);   //trasera izq
```

For Morgana we have the following code.

```
1639        // Morgana
1640        //Torso
1641        model = glm::translate(glm::mat4(1.0f), glm::vec3(0.0f, 0.0f, 0.0f));
1642        model = glm::translate(model, glm::vec3(13.0f, 0.0f, -30.0f));
1643        tmp = model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 1.0f, 0.0));
1644        model = glm::scale(model, glm::vec3(0.3f));
1645        staticShader.setMat4("model", model);
1646        torsoMorgana.Draw(staticShader);
1647        //Brazo derecho
1648        model = glm::translate(tmp, glm::vec3(-0.2f, 0.2f, 0.0f));
1649        //model = glm::translate(model, glm::vec3(0.75f, 2.5f, 0));
1650        model = glm::rotate(model, glm::radians(45.0f), glm::vec3(0.0f, 0.0f, 1.0f));
1651        model = glm::scale(model, glm::vec3(0.3f));
1652        staticShader.setMat4("model", model);
1653        brazoMorgana.Draw(staticShader);
1654        //Brazo izquierdo
1655        model = glm::translate(tmp, glm::vec3(0.2f, 0.2f, 0.0f));
1656        //model = glm::translate(model, glm::vec3(0.75f, 2.5f, 0));
1657        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1658        model = glm::rotate(model, glm::radians(45.0f), glm::vec3(0.0f, 0.0f, 1.0f));
1659        model = glm::scale(model, glm::vec3(0.3f));
1660        staticShader.setMat4("model", model);
1661        brazoMorgana.Draw(staticShader);
1662        //Cabeza
1663        model = glm::translate(tmp, glm::vec3(0.0f, 0.35f, -0.05f));
1664        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1665        model = glm::translate(model, glm::vec3(0.0f, 0.0f, 0));
1666        model = glm::scale(model, glm::vec3(0.3f));
1667        staticShader.setMat4("model", model);
1668        cabezaMorgana.Draw(staticShader);
```

```
1669        //Pierna Izq
1670        model = glm::translate(tmp, glm::vec3(0.15f, -0.35f, 0.0f));
1671        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1672        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(1.0f, 0.0f, 0.0f));
1673        model = glm::scale(model, glm::vec3(0.3f));
1674        staticShader.setMat4("model", model);
1675        piernaMorgana.Draw(staticShader);
1676        //Pierna Der
1677        model = glm::translate(tmp, glm::vec3(-0.15f, -0.35f, 0.0f));
1678        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1679        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(1.0f, 0.0f, 0.0f));
1680        model = glm::scale(model, glm::vec3(0.3f));
1681        staticShader.setMat4("model", model);
1682        piernaMorgana.Draw(staticShader);
```

For the other characters, we have a fairly similar code structure:

```
1726        //Joker
1727        //Torso
1728        model = glm::translate(glm::mat4(1.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1729        model = glm::translate(model, glm::vec3(15.0f, 0.0f, -29.8f));
1730        tmp = model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1731        model = glm::scale(model, glm::vec3(0.5f));
1732        staticShader.setMat4("model", model);
1733        torsoJoker.Draw(staticShader);
1734        //Brazo derecho
1735        model = glm::translate(tmp, glm::vec3(-0.51f, 0.5f, 0.0f));
1736        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 0.0f, 1.0f));
1737        model = glm::scale(model, glm::vec3(0.5f));
1738        staticShader.setMat4("model", model);
1739        brazoJoker.Draw(staticShader);
1740        //Brazo izquierdo
1741        model = glm::translate(tmp, glm::vec3(0.51f, 0.5f, 0.0f));
1742        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1743        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 0.0f, 1.0f));
1744        model = glm::scale(model, glm::vec3(0.5f));
1745        staticShader.setMat4("model", model);
1746        brazoJoker.Draw(staticShader);
1747        //Cabeza
1748        model = glm::translate(tmp, glm::vec3(0.0f, 0.70f, 0.0f));
1749        model = glm::rotate(model, glm::radians(giroCabezaJoker_y), glm::vec3(0.0f, 1.0f, 0.0));
1750        model = glm::translate(model, glm::vec3(0.0f, 0.0f, 0));
1751        model = glm::scale(model, glm::vec3(0.5f));
1752        staticShader.setMat4("model", model);
1753        cabezaJoker.Draw(staticShader);
```

```
1754        //Pierna Der
1755        model = glm::translate(tmp, glm::vec3(-0.28f, -0.69f, 0.0f));
1756        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1757        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(1.0f, 0.0f, 0.0f));
1758        model = glm::scale(model, glm::vec3(0.5f));
1759        staticShader.setMat4("model", model);
1760        piernaJoker.Draw(staticShader);
1761        //Pierna Izq
1762        model = glm::translate(tmp, glm::vec3(0.28f, -0.69f, 0.0f));
1763        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1764        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(1.0f, 0.0f, 0.0f));
1765        model = glm::scale(model, glm::vec3(0.5f));
1766        staticShader.setMat4("model", model);
1767        piernaJoker.Draw(staticShader);
```

```
1769        // Akechi
1770        //Torso
1771        model = glm::translate(glm::mat4(1.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1772        model = glm::translate(model, glm::vec3(20.0f, 0.0f, -30.0f));
1773        tmp = model = glm::rotate(model, glm::radians(-90.0f), glm::vec3(0.0f, 1.0f, 0.0));
1774        model = glm::scale(model, glm::vec3(0.5f));
1775        staticShader.setMat4("model", model);
1776        torsoAkechi.Draw(staticShader);
1777        //Brazo derecho
1778        model = glm::translate(tmp, glm::vec3(-0.51f, 0.5f, 0.0f));
1779        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 0.0f, 1.0f));
1780        model = glm::rotate(model, glm::radians(giroBrazoAkechi_x), glm::vec3(0.0f, 1.0f, 0.0f));
1781        model = glm::scale(model, glm::vec3(0.5f));
1782        staticShader.setMat4("model", model);
1783        brazoAkechi.Draw(staticShader);
1784        //Brazo izquierdo
1785        model = glm::translate(tmp, glm::vec3(0.51f, 0.5f, 0.0f));
1786        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1787        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 0.0f, 1.0f));
1788        model = glm::rotate(model, glm::radians(-giroBrazoAkechi_x), glm::vec3(0.0f, 1.0f, 0.0f));
1789        model = glm::scale(model, glm::vec3(0.5f));
1790        staticShader.setMat4("model", model);
1791        brazoAkechi.Draw(staticShader);
1792        //Cabeza
1793        model = glm::translate(tmp, glm::vec3(0.0f, 0.71f, 0.0f));
1794        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1795        model = glm::translate(model, glm::vec3(0.0f, 0.0f, 0));
1796        model = glm::scale(model, glm::vec3(0.5f));
1797        staticShader.setMat4("model", model);
1798        cabezaAkechi.Draw(staticShader);
```

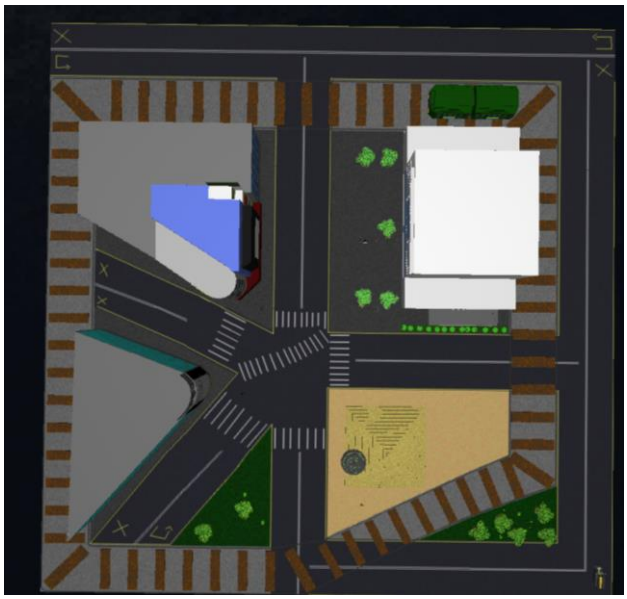
```
1799        //Pierna Der
1800        model = glm::translate(tmp, glm::vec3(-0.28f, -0.69f, 0.0f));
1801        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1802        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(1.0f, 0.0f, 0.0f));
1803        model = glm::scale(model, glm::vec3(0.5f));
1804        staticShader.setMat4("model", model);
1805        piernaAkechi.Draw(staticShader);
1806        //Pierna Izq
1807        model = glm::translate(tmp, glm::vec3(0.28f, -0.69f, 0.0f));
1808        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1809        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(1.0f, 0.0f, 0.0f));
1810        model = glm::scale(model, glm::vec3(0.5f));
1811        staticShader.setMat4("model", model);
1812        piernaAkechi.Draw(staticShader);
```

```
1814        // Ann
1815        //Torso
1816        model = glm::translate(glm::mat4(1.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1817        model = glm::translate(model, glm::vec3(15.0f, 0.0f, -29.0f));
1818        tmp = model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0));
1819        model = glm::scale(model, glm::vec3(0.5f));
1820        staticShader.setMat4("model", model);
1821        torsoAnn.Draw(staticShader);
1822        //Brazo derecho
1823        model = glm::translate(tmp, glm::vec3(-0.51f, 0.5f, 0.0f));
1824        model = glm::rotate(model, glm::radians(180.0f), glm::vec3(0.0f, 1.0f, 0.0f));
1825        model = glm::rotate(model, glm::radians(90.0f), glm::vec3(0.0f, 0.0f, 1.0f));
1826        model = glm::rotate(model, glm::radians(giroBrazoDerechoAnn_x), glm::vec3(1.0f, 0.0f, 0.0f));
1827        model = glm::rotate(model, glm::radians(giroBrazoDerechoAnn_y), glm::vec3(0.0f, 1.0f, 0.0f));
1828        model = glm::scale(model, glm::vec3(0.5f));
1829        staticShader.setMat4("model", model);
1830        brazoAnn.Draw(staticShader);
1831        //Brazo izquierdo
1832        model = glm::translate(tmp, glm::vec3(0.51f, 0.5f, 0.0f));
1833        model = glm::rotate(model, glm::radians(180.0f)                    0f, 1.0f, 0.0f));
1834        model = glm::rotate(model, glm::radians(90.0f),                    f, 0.0f, 1.0f));
1835        model = glm::scale(model, glm::vec3(0.5f));
1836        staticShader.setMat4("model", model);
1837        brazoAnn.Draw(staticShader);
1838        //Cabeza
1839        model = glm::translate(tmp, glm::vec3(0.0f, 0.70f, 0.0f));
1840        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1841        model = glm::translate(model, glm::vec3(0.0f, 0.0f, 0));
1842        model = glm::scale(model, glm::vec3(0.5f));
1843        staticShader.setMat4("model", model);
```

(float)(0.5F)
Buscar en línea

```
1845        //Pierna Izq
1846        model = glm::translate(tmp, glm::vec3(0.27f, -0.71f, 0.02f));
1847        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1848        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(1.0f, 0.0f, 0.0f));
1849        model = glm::scale(model, glm::vec3(0.5f));
1850        staticShader.setMat4("model", model);
1851        pierna2Ann.Draw(staticShader);
1852        //Pierna Der
1853        model = glm::translate(tmp, glm::vec3(-0.27f, -0.71f, 0.07f));
1854        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(0.0f, 1.0f, 0.0));
1855        model = glm::rotate(model, glm::radians(0.0f), glm::vec3(1.0f, 0.0f, 0.0f));
1856        model = glm::scale(model, glm::vec3(0.5f));
1857        staticShader.setMat4("model", model);
1858        piernaAnn.Draw(staticShader);
```

Basically, this is the drawing method for all models. Some have slight variations in the shaders because they are animated (like Futaba). Also, some variables can be seen in geometric operations, since these variables will allow us to create animations, as described later.



Vista aérea de los modelos.

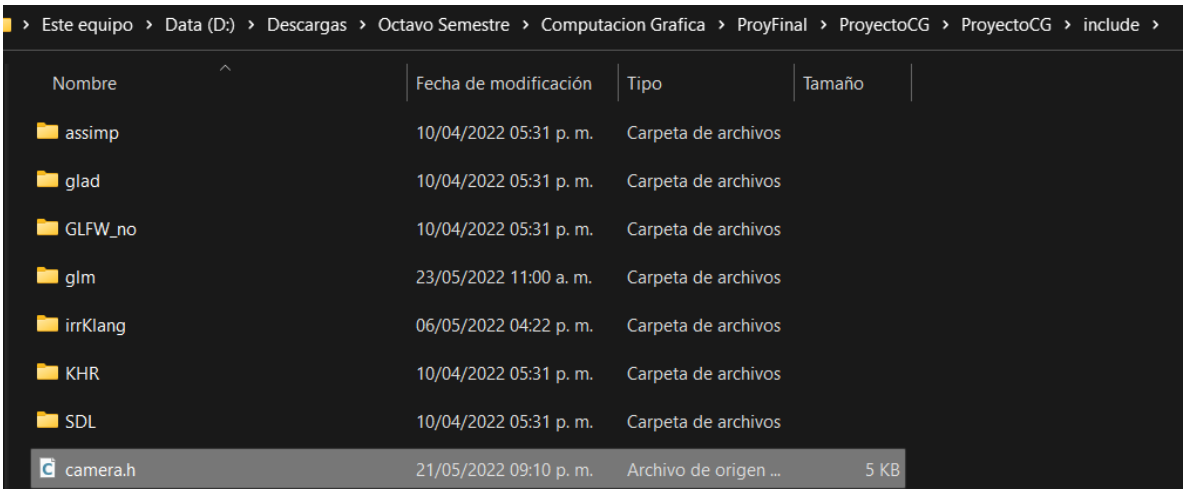
Aerial view of the models.

Traveling

For this section, the implemented cameras are taken into account (especially a camera linked to the floor). We have 3 cameras:

- Main camera, which has free movement in all axes. This allows you to move freely around the entire stage from different points of view.
- Camera linked to the XZ plane, or floor camera. This camera has a very slight elevation, near the floor, but does not allow you to move vertically across the stage.
- Aerial camera. Automatically, advances to the center of the stage, but with a great height and looking down. This allows you to observe all the elements of the stage.

The implementation of these cameras comes from the camera.h library, found in the include folder of the project.



It is included at the beginning of the project.

```
26  #include <camera.h>
```

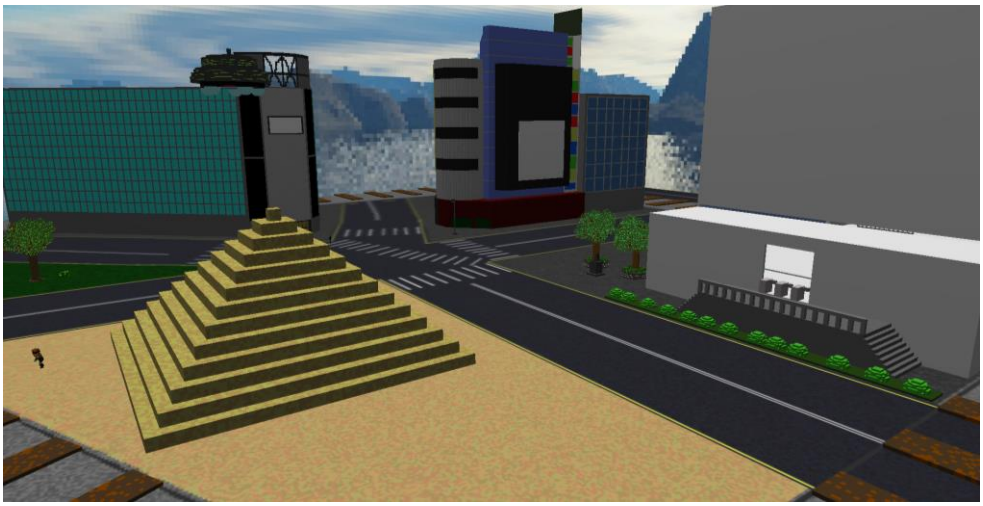
With this, we create our camera object and our variables to handle the position and angles of the camera.

```
52      // Cámara
53      float auxx = 0.0f, auxy = 10.0f, auxz = 100.0f, auxpitch=0.0f;
54      Camera camera(glm::vec3(auxx, auxy, auxz)); //Cámara libre
55      float MovementSpeed = 5.0f;
56      float lastX = SCR_WIDTH / 2.0f;
57      float lastY = SCR_HEIGHT / 2.0f;
58      bool firstMouse = true;
59      bool camaraPiso = false;
60      bool camaraAerea = false;
61      bool camaraLibre2 = false;
62      bool camaraLibre1 = false;
```

Likewise, we have our functions related to the mouse to be able to control the direction of the view and thus also modify the camera movement direction.

```
2546  void mouse_callback(GLFWwindow* window, double xpos, double ypos)
2547  {
2548      if (firstMouse)
2549      {
2550          lastX = xpos;
2551          lastY = ypos;
2552          firstMouse = false;
2553      }
2554
2555      float xoffset = xpos - lastX;
2556      float yoffset = lastY - ypos; // reversed since y-coordinates go from bottom to top
2557
2558      lastX = xpos;
2559      lastY = ypos;
2560
2561      camera.ProcessMouseMovement(xoffset, yoffset);
2562  }
2563  // glfw: whenever the mouse scroll wheel scrolls, this callback is called
2564  // ----------------------------------------------------------------------
2565  void scroll_callback(GLFWwindow* window, double xoffset, double yoffset)
2566  {
2567      camera.ProcessMouseScroll(yoffset);
2568  }
```

And so we have our main camera.



Free camera sample

For the floor camera and aerial camera, we assign the keys C and K, respectively. When one of these booleans is activated, the camera will have the behavior described above.

```
2396      //Para activar cámara en xz
2397      if (glfwGetKey(window, GLFW_KEY_C) == GLFW_PRESS)
2398          camaraPiso = !camaraPiso;
2399
2400      //Para activar cámara aerea
2401      if (glfwGetKey(window, GLFW_KEY_K) == GLFW_PRESS)
2402          camaraAerea = !camaraAerea;
```

The way these booleans affect the behavior is in the render loop of the project.

If we activate the floor camera, then the position on the Y axis will always stay at a very low height, but it is possible to move in X or Z. Instead, for the aerial camera, it stays at a very high position in Y, without the possibility of moving in X, Y or Z, and always looking down.

```
1180        //Cámara en xz:
1181        if (camaraPiso) {
1182            camera.Position.y = 1.0f;
1183            camaraLibre1 = true;
1184        }
1185        else {
1186            if (camaraLibre1) {
1187                camera.Position.y = auxy;
1188                camaraLibre1 = false;
1189            }
1190        }
1191
1192
1193        if (camaraAerea) {
1194            camera.Position.y = 325.0f;
1195            camera.Position.x = 0.0f;
1196            camera.Position.z = 0.0f;
1197            camera.Pitch=-90.0f;
1198            camera.ProcessMouseMovement(0, 0);
1199            camaraLibre2 = true;
1200        }
1201        else {
1202            if (camaraLibre2) {
1203                Camera camera2(glm::vec3(auxx, auxy, auxz));
1204                camera = camera2;
1205                camaraLibre2 = false;
1206            }
1207        }
```

The ground and aerial cameras will look like this:

Floor camera sample

Aerial camera sample

Illumination

For the illumination we make use of the staticShader. The first thing to do is to use that shader and then we put our directional light (we have 1 directional light, 2 spotlight type and 3 punctual lights).

For the directional light we set our camera as the reference point and indicate that we want the direction to be downward in Y and negative in Z (that is, that the light goes in the direction of the camera). Subsequently, we modify its ambient, diffuse and specular components.

```
71      // Iluminación
72      glm::vec3 lightPosition(0.0f, 4.0f, -10.0f);
73      glm::vec3 lightDirection(0.0f, -1.0f, -1.0f);
74      glm::vec3 lightPositionSun(0.0f, 550.0f, 0.0f);
75      glm::vec3 luzColor(0.0f, 0.0f, 0.0f);
```

```
1221        // don't forget to enable shader before setting uniforms
1222        staticShader.use();
1223        //Setup Advanced Lights
1224        // Iluminación
1225        staticShader.setVec3("viewPos", camera.Position);
1226        staticShader.setVec3("dirLight.direction", lightDirection);
1227        staticShader.setVec3("dirLight.ambient", glm::vec3(0.125f, 0.125f, 0.125f));
1228        staticShader.setVec3("dirLight.diffuse", glm::vec3(0.125f, 0.125f, 0.125f));
1229        staticShader.setVec3("dirLight.specular", glm::vec3(0.0f, 0.0f, 0.0f));
```

For the punctual lights, we have one that simulates the sun and another 2 that go in front of the truck (in its headlights). The procedure is the same for all of them: We give them a position in the environment, we modify their ambient, diffuse and specular components, as well as we modify their

constant, linear and quadratic values, so that they cover a greater distance or greater intensity in illumination.

```
1231        //Sol
1232        staticShader.setVec3("pointLight[0].position", lightPositionSun);
1233        staticShader.setVec3("pointLight[0].ambient", glm::vec3(0.0f, 0.0f, 0.0f));
1234        staticShader.setVec3("pointLight[0].diffuse", glm::vec3(1.0f, 1.0f, 1.0f));
1235        staticShader.setVec3("pointLight[0].specular", glm::vec3(0.3f, 0.3f, 0.3f));
1236        staticShader.setFloat("pointLight[0].constant", 0.08f);
1237        staticShader.setFloat("pointLight[0].linear", 0.0009f);
1238        staticShader.setFloat("pointLight[0].quadratic", 0.000004f);
```

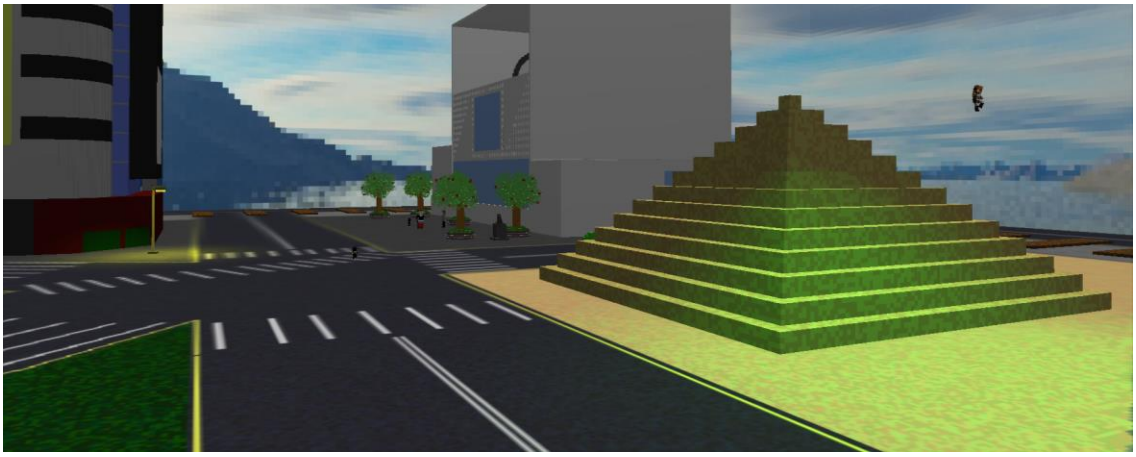
```
1240    //Luz para el gato camion 1
1241    //staticShader.setVec3("pointLight[1].position", glm::vec3(movCamion_x - 3, movCamion_y + 3, movCamion_z - 6));
1242    staticShader.setVec3("pointLight[1].position", glm::vec3(movCamion_x + movCamionLuz_x, movCamion_y + movCamionLuz_y, movCamion_z + movCamionLuz_z));
1243    staticShader.setVec3("pointLight[1].ambient", glm::vec3(ilumCamionR, ilumCamionG, ilumCamionB));
1244    staticShader.setVec3("pointLight[1].diffuse", glm::vec3(ilumCamionR, ilumCamionG, ilumCamionB));
1245    staticShader.setVec3("pointLight[1].specular", glm::vec3(ilumCamionR, ilumCamionG, ilumCamionB));
1246    staticShader.setFloat("pointLight[1].constant", 0.08f);
1247    staticShader.setFloat("pointLight[1].linear", 0.009f);
1248    staticShader.setFloat("pointLight[1].quadratic", 0.5f);
1249
1250    //Luz para el gato camion 2
1251    //staticShader.setVec3("pointLight[2].position", glm::vec3(movCamion_x + 3, movCamion_y + 3, movCamion_z - 6));
1252    staticShader.setVec3("pointLight[2].position", glm::vec3(movCamion_x + movCamionLuz2_x, movCamion_y + movCamionLuz_y, movCamion_z + movCamionLuz_z));
1253    staticShader.setVec3("pointLight[2].ambient", glm::vec3(ilumCamionR, ilumCamionG, ilumCamionB));
1254    staticShader.setVec3("pointLight[2].diffuse", glm::vec3(ilumCamionR, ilumCamionG, ilumCamionB));
1255    staticShader.setVec3("pointLight[2].specular", glm::vec3(ilumCamionR, ilumCamionG, ilumCamionB));
1256    staticShader.setFloat("pointLight[2].constant", 0.08f);
1257    staticShader.setFloat("pointLight[2].linear", 0.009f);
1258    staticShader.setFloat("pointLight[2].quadratic", 0.5f);
```

The punctual lights are appreciated like this in the truck, although it is difficult to appreciate the light of the Sun in an image:

For our spotlights, the procedure is quite similar to that of punctual lights, but with some extra parameters, such as the cutoff and outer cutoff. Also, we assign a direction to them (in this case, the two spotlights point downwards).

```
1260        //Luz de ovni
1261        staticShader.setVec3("spotLight[0].position", glm::vec3(movOvni_x, movOvni_y+5.0f, movOvni_z));
1262        staticShader.setVec3("spotLight[0].direction", glm::vec3(0.0f, -1.0f, 0.0f));
1263        staticShader.setVec3("spotLight[0].ambient", glm::vec3(0.0f, ilumOvni, 0.0f));
1264        staticShader.setVec3("spotLight[0].diffuse", glm::vec3(0.0f, ilumOvni, 0.0f));
1265        staticShader.setVec3("spotLight[0].specular", glm::vec3(0.0f, ilumOvni, 0.0f));
1266        staticShader.setFloat("spotLight[0].cutOff", glm::cos(glm::radians(20.0f)));
1267        staticShader.setFloat("spotLight[0].outerCutOff", glm::cos(glm::radians(40.0f)));
1268        staticShader.setFloat("spotLight[0].constant", 1.0f);
1269        staticShader.setFloat("spotLight[0].linear", 0.009f);
1270        staticShader.setFloat("spotLight[0].quadratic", 0.005f);
1271
1272        //Luz del faro
1273        staticShader.setVec3("spotLight[1].position", glm::vec3(-29.0f, 9.0f, 0.5f));
1274        staticShader.setVec3("spotLight[1].direction", glm::vec3(0.0f, -1.0f, -0.0f));
1275        staticShader.setVec3("spotLight[1].ambient", glm::vec3(0.0f, 0.0f, 0.0f));
1276        staticShader.setVec3("spotLight[1].diffuse", glm::vec3(ilumFaro, ilumFaro, 0.0f));
1277        staticShader.setVec3("spotLight[1].specular", glm::vec3(ilumFaro, ilumFaro, 0.0f));
1278        staticShader.setFloat("spotLight[1].cutOff", glm::cos(glm::radians(20.0f)));
1279        staticShader.setFloat("spotLight[1].outerCutOff", glm::cos(glm::radians(60.0f)));
1280        staticShader.setFloat("spotLight[1].constant", 1.0f);
1281        staticShader.setFloat("spotLight[1].linear", 0.0009f);
1282        staticShader.setFloat("spotLight[1].quadratic", 0.005f);
```

The spotlights will look like this:



As seen in previous screenshots, the lights have values inside some variables, and the truck's spotlights are "turned off" (values of 0). These lights will light up when triggering animations and reaching certain states. Though the beacon light will be turned on/off by pressing the F key.

```
2399    //Activar luz
2400    if (key == GLFW_KEY_F && action == GLFW_PRESS) {
2401        faroOn ^= true;
2402        if (faroOn)
2403            ilumFaro = 1.0f;
2404        else
2405            ilumFaro = 0.0f;
2406    }
```

For the truck, the lights will turn on in most states:

```
437     // Para gato camion (Animación 3)
438     if (animacion_camion) {
439         giroLlanta += 0.2f;
440         switch (estado_camion) {
441         case 1:
442             if (movCamion_z >= 70.0f) {
443                 giroLlanta += 1.0f;
444                 movCamion_z -= 1.0f;
445                 movCamionLuz_z = -6.0f;
446                 movCamionLuz2_z = -6.0f;
447                 ilumCamionR = 1.0f;
448                 ilumCamionG = 1.0f;
449                 ilumCamionB = 1.0f;
450             }
451             else {
452                 estado_camion++;
453             }
454             break;
```

For the UFO, the spotlight will turn green when it abducts and returns Futaba.

```
653             case 1:
654                 //Desaparece Futaba 2 y aparece Futaba 1
655                 escalaFutaba2 = 0.0f;
656                 escalaFutaba1 = 0.35f;
657                 estado_Ovni = 2;
658                 ilumOvni = 1.0f; //Encendemos luz de ovni
659                 break;
660             case 2:
661                 //Futaba 1 viaja hacia arriba con escala, rotación y traslación en Y
662                 if (escalaFutaba1 >= 0) {
663                     //Movimiento y decremeneto
664                     escalaFutaba1 -= 0.001;
665                     movFutaba_y += 0.1;
666                 }
667                 else {
668                     estado_Ovni = 3;
669                 }
670                 break;
671             case 3:
672                 //Pequeño delay xD
673                 if (contOvni <= 120) {
674                     contOvni++;
675                     ilumOvni = 0.0f; //Apagamos luz de ovni
676                 }
677                 else {
678                     ilumOvni = 1.0f; //Encendemos luz de ovni
679                     estado_Ovni = 4;
680                     contOvni = 0;
681                 }
682                 break;
```

And the sun will move when its animation is activated:

```
307     //Animación del sol (Animación 0)
308     if (animacion_sol) {
309         lightPositionSun.x = 500.0f * cos(movSol);
310         lightPositionSun.y = 500.0f * sin(movSol);
311         if (lightPositionSun.y < 0 || lightPositionSun.x < 0) {
312             movSol += 0.005f;
313         }
314         else {
315             movSol += 0.0025f;
316         }
317     }
```

Animation

In this section, we have 8 animations, of which 1 uses the keyframe method, most of these animations are basic animations (based on transformations and flags) and a few others are complex or advanced. For more information on what can be observed from them, read the user manual.

Starting with animation 0, according to its assigned key, it is the movement of the point light that acts as the sun. Pressing the 0 key activates the boolean that allows the execution of the animation in our animations function (animate) that is executed in the execution loop.

```
2408    //Animación 0: Luz del sol
2409    if (key == GLFW_KEY_0 && action == GLFW_PRESS) {
2410        animacion_sol ^= true;
2411    }
```

```
1214        animate();
```

This animation consists of the sun traveling, by means of a formula, in a circular path in the X and Y axes, along the stage. When the sun is above the stage then it will go slower, but if it goes below the stage it will move twice as fast.

```
305 void animate(void)
306 {
307     //Animación del sol (Animación 0)
308     if (animacion_sol) {
309         lightPositionSun.x = 500.0f * cos(movSol);
310         lightPositionSun.y = 500.0f * sin(movSol);
311         if (lightPositionSun.y < 0 || lightPositionSun.x < 0) {
312             movSol += 0.005f;
313         }
314         else {
315             movSol += 0.0025f;
316         }
317     }
```

For animation 1, we have clock hands at the train station. The minutes hand moves at one speed and the hours hand moves at 1/12 of that speed. It is activated by pressing the key 1. Pressing this key also resets the start values.

```
2413    //Animacion 1: Manecillas del reloj
2414    if (key == GLFW_KEY_1 && action == GLFW_PRESS) {
2415        animacion_reloj ^= true;
2416        giroHoras = 0;
2417        giroMins = 0;
2418    }
```

```
319     //Para reloj: (Animación 1)
320     if (animacion_reloj) {
321         giroMins += 0.3f;
322         giroHoras += 0.025f;
323     }
```

For animation 2, we activate it by pressing the 2 key. Likewise, we put the initial values.

```
2420    //Animación 2: Movimiento del tren
2421    if (key == GLFW_KEY_2 && action == GLFW_PRESS) {
2422        animacion_tren ^= true;
2423        estadoCabina = 0;
2424        estadoVagon = 0;
2425        orientaCabina = 0.0f;
2426        movCabina_x = 51.0f;
2427        movCabina_z = -90.0f;
2428        orientaVagon = 0.0f;
2429        movVagon_x = 70.0f;
2430        movVagon_y = 0.2f;
2431        movVagon_z = -90.0f;
2432    }
```

In this animation we will see the train moving around the stage. It consists of 5 states, although it should be noted that this occurs for both the wagon and the cabin.

```
325     //Para tren (Animación 2)
326     if (animacion_tren) {
327         switch (estadoCabina) {
328         case 0: //Estado inicial hacia izquierda
329             orientaCabina = 0.0f;
330             if (movCabina_x >= -115.0f) {
331                 movCabina_x -= 1.0f;
332             }
333             else {
334                 estadoCabina = 1;
335                 orientaCabina = 45.0f;
336             }
337             break;
338         case 1: //Hacia abajo
339             orientaCabina = 90.0f;
340             if (movCabina_z <= 115.0f) {
341                 movCabina_z += 1.0f;
342             }
343             else {
344                 estadoCabina = 2;
345                 orientaCabina = 135.0f;
346             }
347             break;
348         case 2: //Hacia la derecha
349             orientaCabina = 180.0f;
350             if (movCabina_x <= -15.0f) {
351                 movCabina_x += 1.0f;
352             }
353             else {
```

```
            estadoCabina = 3;
            orientaCabina = 192.615f;
        }
        break;
    case 3: //Giro raro
        orientaCabina = 205.23f;
        if (movCabina_x <= 90.0f) {
            movCabina_x += 1.0;
            movCabina_z -= 0.47116f;
        }
        else {
            movCabina_z = 65.0f;
            estadoCabina = 4;
            orientaCabina = 237.615;
        }
        break;
    case 4: //Hacia arriba
        orientaCabina = 270.0f;
        if (movCabina_z >= -90.0f) {
            movCabina_z -= 1.0f;
        }
        else {
            estadoCabina = 0;
            orientaCabina = 305.0f;
        }
        break;
    }
    switch (estadoVagon) {
    case 0: //Hacia la izquierdaa
        orientaVagon = 0.0f;
        if (movVagon_x >= -115.0f) {
            movVagon_x -= 1.0f;
        }
        else {
            estadoVagon = 1;
            orientaVagon = 45.0f;
        }
        break;
    case 1: //Hacia abajo
        orientaVagon = 90.0f;
        if (movVagon_z <= 115.0f) {
            movVagon_z += 1.0f;
        }
        else {
            estadoVagon = 2;
            orientaVagon = 135.0f;
        }
        break;
    case 2: //Hacia la derecha
        orientaVagon = 180.0f;
        if (movVagon_x <= -15.0f) {
            movVagon_x += 1.0f;
        }
        else {
            estadoVagon = 3;
            orientaVagon = 192.615f;
        }
        break;
    case 3: //Giro raro
        orientaVagon = 205.23f;
        if (movVagon_x <= 90.0f) {
            movVagon_x += 1.0;
            movVagon_z -= 0.47116f;
        }
        else {
            movVagon_z = 65.0f;
            estadoVagon = 4;
            orientaVagon = 237.615;
        }
        break;
    case 4: //Hacia arriba
        orientaVagon = 270.0f;
        if (movVagon_z >= -90.0f) {
            movVagon_z -= 1.0f;
        }
        else {
            estadoVagon = 0;
            orientaVagon = 305.0f;
        }
        break;
    }
}
```

For animation 3, we activate it by pressing the key 3. As with the previous ones, we have a reset of the variables each time we press this key.

```
2434        //Animación 3: Camión
2435        if (key == GLFW_KEY_3 && action == GLFW_PRESS) {
2436            animacion_camion ^= true;
2437            giroLlanta = 0.0f;
2438            movCamion_x = 118.0f;
2439            movCamion_y = 0.0f;
2440            movCamion_z = 115.0f;
2441
2442            movCamionLuz_x = -3.0f;
2443            movCamionLuz2_x = 3.0f;
2444            movCamionLuz_z = -6.0f;
2445            movCamionLuz2_z = -6.0f;
2446
2447            movCamionLuz_z = movCamion_z - 6.0f;
2448            orientaCamion = 180.0f;
2449            estado_camion = 1;
2450        }
```

Once the key is pressed, we proceed to start the animation, which consists of 12 states. In those states, except the ones which involve jumps, we see that there is a point light in the truck's headlights.

```
437         // Para gato camion (Animación 3)
438         if (animacion_camion) {
439             giroLlanta += 0.2f;
440             switch (estado_camion) {
441             case 1:
442                 if (movCamion_z >= 70.0f) {
443                     giroLlanta += 1.0f;
444                     movCamion_z -= 1.0f;
445                     movCamionLuz_z = -6.0f;
446                     movCamionLuz2_z = -6.0f;
447                     ilumCamionR = 1.0f;
448                     ilumCamionG = 1.0f;
449                     ilumCamionB = 1.0f;
450                 }
451                 else {
452                     estado_camion++;
453                 }
454                 break;
455             case 2: //Salto 1
456                 if (movCamion_z >= 60.0f) {
457                     giroLlanta += 0.1f;
458                     movCamion_z -= 1.3;
459                     movCamion_y += 0.3f;
460                     ilumCamionR = 0.0f;
461                     ilumCamionG = 0.0f;
462                     ilumCamionB = 0.0f;
463                 }
464                 else {
465                     estado_camion++;
466                 }
467                 break;
```

```
467                 break;
468             case 3:
469                 if (movCamion_z >= -60.0f) {
470                     giroLlanta += 1.0f;
471                     movCamion_z -= 1.0f;
472                     ilumCamionR = 1.0f;
473                     ilumCamionG = 1.0f;
474                     ilumCamionB = 1.0f;
475                     if (movCamion_y > 0.0f)
476                         movCamion_y -= 0.3f;
477                     else
478                         movCamion_y = 0.0f;
479                 }
480                 else {
481                     estado_camion++;
482                     movCamion_y = 0.0f;
483                 }
484                 break;
485             case 4: //Salto 2
486                 if (movCamion_z >= -70.0f) {
487                     giroLlanta += 0.1f;
488                     movCamion_z -= 1.3;
489                     movCamion_y += 0.3f;
490                     ilumCamionR = 0.0f;
491                     ilumCamionG = 0.0f;
492                     ilumCamionB = 0.0f;
493                 }
494                 else {
495                     estado_camion++;
496                 }
497                 break;
```

```
498             case 5:
499                 if (movCamion_z >= -107.0f) {
500                     giroLlanta += 1.0f;
501                     movCamion_z -= 1.0f;
502                     movCamionLuz_z = -6.0f;
503                     ilumCamionR = 1.0f;
504                     ilumCamionG = 1.0f;
505                     ilumCamionB = 1.0f;
506                     if (movCamion_y > 0.0f)
507                         movCamion_y -= 0.3f;
508                     else
509                         movCamion_y = 0.0f;
510                 }
511                 else {
512                     estado_camion++;
513                     movCamion_y = 0.0f;
514                     orientaCamion = -90.0f;
515                     movCamion_z = -107.0f;
516                 }
517                 break;
518             case 6: //Arriba de estación
519                 if (movCamion_x >= -7.0f) {
520                     giroLlanta += 1.0f;
521                     movCamion_x -= 1.0f;
522                     movCamionLuz_x = -6.0f;
523                     movCamionLuz2_x = -6.0f;
524                     movCamionLuz_z = -3.0f;
525                     movCamionLuz2_z = 3.0f;
526                     ilumCamionR = 1.0f;
527                     ilumCamionG = 1.0f;
528                     ilumCamionB = 1.0f;
529                 }
530                 else {
531                     estado_camion++;
532                     orientaCamion = 0.0f;
533                     movCamion_x = -7.0f;
534                     movCamionLuz_x = -3.0f;
535                     movCamionLuz2_x = 3.0f;
536                 }
537                 break;
538             case 7:
539                 if (movCamion_z <= -70.0f) {
540                     giroLlanta += 1.0f;
541                     movCamion_z += 1.0f;
542                     movCamionLuz_z = 6.0f;
543                     movCamionLuz2_z = 6.0f;
544                     ilumCamionR = 1.0f;
545                     ilumCamionG = 1.0f;
546                     ilumCamionB = 1.0f;
547                 }
548                 else {
549                     estado_camion++;
550                 }
551                 break;
552             case 8: //Salto 3
553                 if (movCamion_z <= -60.0f) {
554                     giroLlanta += 0.1f;
555                     movCamion_z += 1.3;
556                     movCamion_y += 0.3f;
557                     ilumCamionR = 0.0f;
558                     ilumCamionG = 0.0f;
559                     ilumCamionB = 0.0f;
560                 }
561                 else {
562                     estado_camion++;
563                 }
564                 break;
565             case 9:
566                 if (movCamion_z <= 60.0f) {
567                     giroLlanta += 1.0f;
568                     movCamion_z += 1.0f;
569                     movCamionLuz_z = 6.0f;
570                     movCamionLuz2_z = 6.0f;
571                     ilumCamionR = 1.0f;
572                     ilumCamionG = 1.0f;
573                     ilumCamionB = 1.0f;
574                     if (movCamion_y > 0.0f)
575                         movCamion_y -= 0.3f;
576                     else
577                         movCamion_y = 0.0f;
578                 }
579                 else {
580                     estado_camion++;
581                     movCamion_y = 0.0f;
582                 }
583                 break;
584             case 10: //Salto 4
585                 if (movCamion_z <= 70.0f) {
586                     giroLlanta += 0.1f;
587                     movCamion_z += 1.3;
588                     movCamion_y += 0.3f;
589                     ilumCamionR = 0.0f;
590                     ilumCamionG = 0.0f;
591                     ilumCamionB = 0.0f;
592                 }
593                 else {
594                     estado_camion++;
595                 }
596                 break;
597             case 11:
598                 if (movCamion_z <= 115.0f) {
599                     giroLlanta += 1.0f;
600                     movCamion_z += 1.0f;
601                     movCamionLuz_z = 6.0f;
602                     movCamionLuz2_z = 6.0f;
603                     ilumCamionR = 1.0f;
604                     ilumCamionG = 1.0f;
605                     ilumCamionB = 1.0f;
606                     if (movCamion_y > 0.0f)
607                         movCamion_y -= 0.3f;
608                     else
609                         movCamion_y = 0.0f;
610                 }
611                 else {
612                     estado_camion++;
613                     movCamion_y = 0.0f;
614                     orientaCamion = 90.0f;
615                 }
616                 break;
617             case 12: //Hacia la derecha
618                 if (movCamion_x <= 118.0f) {
619                     giroLlanta += 1.0f;
620                     movCamion_x += 1.0f;
621                     movCamionLuz_z = -3.0f;
```

```
622                 movCamionLuz2_z = 3.0f;
623                 movCamionLuz_x = 6.0f;
624                 movCamionLuz2_x = 6.0f;
625                 ilumCamionR = 1.0f;
626                 ilumCamionG = 1.0f;
627                 ilumCamionB = 1.0f;
628             }
629             else {
630                 estado_camion = 1;
631                 orientaCamion = 180.0f;
632                 movCamion_x = 118.0f;
633                 movCamionLuz_x = -3.0f;
634                 movCamionLuz2_x = 3.0f;
635             }
636             break;
637         }
638     }
```

For animation 4, the UFO anmation, we have a total of 7 states. This animation involves a spotlight. It is turned on with the key 4 and restarted with the O key. In any case, the UFO will always be rotating.

```
2452     //Animación 4: Secuestro de Futaba
2453     if (key == GLFW_KEY_4 && action == GLFW_PRESS) {
2454         animacion_ovni ^= true;
2455     }
```

```
2456     //Uso una tecla diferente para reiniciarlo
2457     if (key == GLFW_KEY_O && action == GLFW_PRESS) {
2458         animacion_ovni = false;
2459         orientaOvni = 0.0f;
2460         movOvni_x = 10.0f;
2461         movOvni_y = 30.0f;
2462         movOvni_z = 60.0f;
2463         estado_Ovni = 0;
2464         escalaFutaba1 = 0.0f;
2465         escalaFutaba2 = 0.35f;
2466         movFutaba_y = -0.5;
2467         contOvni = 0;
2468         ilumOvni = 0.0f;
2469     }
```

```
640     // Para ovni (Animación 4)
641     if (animacion_ovni) {
642         orientaOvni -= 1.0f;
643         switch (estado_Ovni) {
644         case 0:
645             if (movOvni_z >= 85) {
646                 estado_Ovni = 1;
647             }
648             else {
649                 movOvni_x += 0.02;
650                 movOvni_z += 0.1;
651             }
652             break;
653         case 1:
654             //Desaparece Futaba 2 y aparece Futaba 1
655             escalaFutaba2 = 0.0f;
656             escalaFutaba1 = 0.35f;
657             estado_Ovni = 2;
658             ilumOvni = 1.0f; //Encendemos luz de ovni
659             break;
660         case 2:
661             //Futaba 1 viaja hacia arriba con escala, rotación y traslación en Y
662             if (escalaFutaba1 >= 0) {
663                 //Movimiento y decremeneto
664                 escalaFutaba1 -= 0.001;
665                 movFutaba_y += 0.1;
666             }
667             else {
668                 estado_Ovni = 3;
```

```
669             }
670             break;
671         case 3:
672             //Pequeño delay xD
673             if (contOvni <= 120) {
674                 contOvni++;
675                 ilumOvni = 0.0f; //Apagamos luz de ovni
676             }
677             else {
678                 ilumOvni = 1.0f; //Encendemos luz de ovni
679                 estado_Ovni = 4;
680                 contOvni = 0;
681             }
682             break;
683         case 4:
684             //Futaba hacia abajo con escala, rotación y traslación en Y
685             if (escalaFutaba1 < 0.35) {
686                 //Movimiento y decremeneto
687                 escalaFutaba1 += 0.001;
688                 movFutaba_y -= 0.1;
689             }
690             else {
691                 estado_Ovni = 5;
692             }
693             break;
694         case 5:
695             //Futaba 1 desaparece y aparece Futaba 1
696             escalaFutaba2 = 0.35f;
697             escalaFutaba1 = 0.0f;
698             estado_Ovni = 6;
```

```
699             ilumOvni = 0.0f; //Apagamos luz
700             break;
701         case 6:
702             //Ovni regresa a posición de inicio
703             if (movOvni_z <= 60) {
704                 estado_Ovni = 7;
705             }
706             else {
707                 movOvni_x -= 0.02;
708                 movOvni_z -= 0.1;
709             }
710             break;
711
712         }
713     }
714     else {
715         orientaOvni -= 0.2f; //Garantiza que el ovni siempre esté en movimiento
716     }
```

In the case of animation 5, we have more complexity, since it is made with the keyframes method. For this, several functions are needed. The first thing we show is how it works: When we press the key 5, the animation starts, starting with the first frame, we interpolate and advance from frame to frame.

```
2471     //Animación 5: Cachetadas a Joker (Keyframes)
2472     if (key == GLFW_KEY_5 && action == GLFW_PRESS)
2473     {
2474         if (play == false && (FrameIndex > 1))
2475         {
2476             std::cout << "Play animation" << std::endl;
2477             resetElements();
2478             //First Interpolation
2479             interpolation();
2480
2481             play = true;
2482             playIndex = 0;
2483             i_curr_steps = 0;
2484         }
2485         else
2486         {
2487             play = false;
2488             std::cout << "Not enough Key Frames" << std::endl;
2489         }
2490     }
```

What we do here is to define the structure of our frames, we create an array of frames that will save the values that we think are convenient and then we create a function to save frames.

```
178     // Definición de frames
179     #define MAX_FRAMES 9
180     int i_max_steps = 60;
181     int i_curr_steps = 0;
182   typedef struct _frame
183     {
184       //Para cachetadas
185       //Joker
186       float giroCabezaJoker_y;
187       //Akechi
188       float giroBrazoAkechi_x;
189       //Ann
190       float giroBrazoDerechoAnn_x;
191       float giroBrazoDerechoAnn_y;
192
193     }FRAME;
194
195     //Arreglo de frames
196     FRAME KeyFrame[MAX_FRAMES];
197     int FrameIndex = 0;
198     bool play = false;
199     int playIndex = 0;
200
201     bool skyboxtipe = true;
202
203   void saveFrame(void)
204     {
205       KeyFrame[FrameIndex].giroCabezaJoker_y = giroCabezaJoker_y;
206       KeyFrame[FrameIndex].giroBrazoAkechi_x = giroBrazoAkechi_x;
207       KeyFrame[FrameIndex].giroBrazoDerechoAnn_x = giroBrazoDerechoAnn_x;
208       KeyFrame[FrameIndex].giroBrazoDerechoAnn_y = giroBrazoDerechoAnn_y;
209       FrameIndex++;
210     }
```

Likewise, we have our function to assign values already obtained to each frame:

```
//Valores para nuestra animación por KeyFrames
void insertarFrames(void) {
    //Frame 0:
    giroCabezaJoker_y = 0.0f;
    giroBrazoAkechi_x = 0.0f;
    giroBrazoDerechoAnn_x = 0.0f;
    giroBrazoDerechoAnn_y = 0.0f;
    if (FrameIndex < MAX_FRAMES)
    {
        saveFrame();
    }
    //Frame 1
    giroCabezaJoker_y = 0.0f;
    giroBrazoAkechi_x = 0.0f;
    giroBrazoDerechoAnn_x = -18.6f;
    giroBrazoDerechoAnn_y = -107.7f;
    if (FrameIndex < MAX_FRAMES)
    {
        saveFrame();
    }
    //Frame 2
    giroCabezaJoker_y = -24.6f;
    giroBrazoAkechi_x = 0.0f;
    giroBrazoDerechoAnn_x = 17.1f;
    giroBrazoDerechoAnn_y = -115.2f;
    if (FrameIndex < MAX_FRAMES)
    {
        saveFrame();
    }
    //Frame 3
    giroCabezaJoker_y = 0.600001f;
    giroBrazoAkechi_x = 0.0f;
    giroBrazoDerechoAnn_x = 59.6999f;
    giroBrazoDerechoAnn_y = -115.2f;
    if (FrameIndex < MAX_FRAMES)
    {
        saveFrame();
    }
    //Frame 4
    giroCabezaJoker_y = 44.9999f;
    giroBrazoAkechi_x = 0.0f;
    giroBrazoDerechoAnn_x = 26.1f;
    giroBrazoDerechoAnn_y = -115.2f;
    if (FrameIndex < MAX_FRAMES)
    {
        saveFrame();
    }
    //Frame 5
    giroCabezaJoker_y = 4.5f;
    giroBrazoAkechi_x = 0.0f;
    giroBrazoDerechoAnn_x = -68.6999f;
    giroBrazoDerechoAnn_y = -47.0999f;
    if (FrameIndex < MAX_FRAMES)
    {
        saveFrame();
    }
    //Frame 6
    giroCabezaJoker_y = 4.49999f;
    giroBrazoAkechi_x = 172.801f;
    giroBrazoDerechoAnn_x = -68.6998f;
    giroBrazoDerechoAnn_y = -5.99983f;
    if (FrameIndex < MAX_FRAMES)
    {
        saveFrame();
    }
    //Frame 7
    giroCabezaJoker_y = 0.0f;
    giroBrazoAkechi_x = 0.0f;
    giroBrazoDerechoAnn_x = 0.0f;
    giroBrazoDerechoAnn_y = 0.0f;
    if (FrameIndex < MAX_FRAMES)
    {
        saveFrame();
    }
}
```

Once we have these values, we simply have to interpolate and play them.

```
void interpolation(void)
{
    incGiroCabezaJoker_y = (KeyFrame[playIndex + 1].giroCabezaJoker_y - KeyFrame[playIndex].giroCabezaJoker_y) / i_max_steps;
    incGiroBrazoAkechi_x = (KeyFrame[playIndex + 1].giroBrazoAkechi_x - KeyFrame[playIndex].giroBrazoAkechi_x) / i_max_steps;
    incGiroBrazoDerechoAnn_x = (KeyFrame[playIndex + 1].giroBrazoDerechoAnn_x - KeyFrame[playIndex].giroBrazoDerechoAnn_x) / i_max_steps;
    incGiroBrazoDerechoAnn_y = (KeyFrame[playIndex + 1].giroBrazoDerechoAnn_y - KeyFrame[playIndex].giroBrazoDerechoAnn_y) / i_max_steps;
}
```

```
930     //Para cachetadas con keyframes (animación 5)
931     if (play)
932     {
933         if (i_curr_steps >= i_max_steps)
934         {
935             playIndex++;
936             if (playIndex == 3) {
937                 //Reproducir sonido 3d
938                 morgana->play3D("resources\\sounds\\efectos\\looking-cool-joker.mp3", irrklang::vec3df(13.0f, 1.0f, -30.0f), false, false, false);
939             }
940             if (playIndex > FrameIndex - 2)
941             {
942                 playIndex = 0;
943                 play = false;
944             }
945             else
946             {
947                 i_curr_steps = 0;
948                 interpolation();
949             }
950         }
951         else
952         {
953             giroCabezaJoker_y += incGiroCabezaJoker_y;
954             giroBrazoAkechi_x += incGiroBrazoAkechi_x;
955             giroBrazoDerechoAnn_x += incGiroBrazoDerechoAnn_x;
956             giroBrazoDerechoAnn_y += incGiroBrazoDerechoAnn_y;
957             i_curr_steps++;
958         }
959     }
```

Likewise, as seen in the last image, we see that there is a 3D sound. This is played upon reaching the 3rd frame.

For animation 6, activated with the key 6, we have speech bubbles that appear above the characters. Speech balloons essentially change their scale and rise on the Y axis. Also, the animation can be restarted with the P key.

```
2491    //Animacón de globos
2492    if (key == GLFW_KEY_6 && action == GLFW_PRESS) {
2493        animacion_globos ^= true;
2494        //Reproducir sonido 3d
2495        morgana->play3D("resources\\sounds\\efectos\\looking-cool-joker.mp3", irrklang::vec3df(13.0f, 1.0f, -30.0f), false, false, false);
2496    }
2497
2498    //Uso una tecla diferente para reiniciarlo
2499    if (key == GLFW_KEY_P && action == GLFW_PRESS) {
2500        animacion_globos = false;
2501        eglobo_Joker = 0.0f;
2502        eglobo_Ann = 0.0f;
2503        eglobo_Akechi = 0.0f;
2504        eglobo_Morgana = 0.0f;
2505        estado_globos = 0;
2506        mov_globoY = 0.0f;
2507        mov_globoXZ = 0.0f;
2508    }
```

```
// Para globos de dialogo (Animación 6)
if (animacion_globos) {
    switch (estado_globos) {
    case 0:
        if (eglobo_Akechi < 1.5f) {
            eglobo_Akechi += 0.05;
            mov_globoY += 0.01;
            mov_globoXZ += 0.01;
        }
        else {
            estado_globos = 1;
        }
        break;
    case 1:
        if (eglobo_Akechi > 0.0f) {
            eglobo_Akechi -= 0.05;
        }
        else {
            estado_globos = 2;
            mov_globoY = 0.0f;
            mov_globoXZ = 0.0f;
        }
        break;
    case 2:
        if (eglobo_Joker < 1.5f) {
            eglobo_Joker += 0.05;
            eglobo_Morgana += 0.05;
            mov_globoY += 0.01;
            mov_globoXZ += 0.01;
        }
        else {
            estado_globos = 3;
        }
        break;
    case 3:
        if (eglobo_Joker > 0.0f) {
            eglobo_Joker -= 0.05;
            eglobo_Morgana -= 0.05;
        }
        else {
            estado_globos = 4;
            mov_globoY = 0.0f;
            mov_globoXZ = 0.0f;
        }
        break;
    case 4:
        if (eglobo_Ann < 1.5f) {
            eglobo_Ann += 0.05;
            mov_globoY += 0.01;
            mov_globoXZ += 0.01;
        }
        else {
            estado_globos = 5;
        }
        break;
    case 5:
        if (eglobo_Ann > 0.0f) {
            eglobo_Ann -= 0.05;
        }
        else {
            estado_globos = 6;
            mov_globoY = 0.0f;
            mov_globoXZ = 0.0f;
        }
        break;
    case 6:
        if (eglobo_Morgana < 1.5f) {
            eglobo_Akechi += 0.05;
            eglobo_Morgana += 0.05;
            mov_globoY += 0.01;
            mov_globoXZ += 0.01;
        }
        else {
            estado_globos = 7;
        }
        break;
    case 7:
        if (eglobo_Morgana > 0.0f) {
            eglobo_Morgana -= 0.05;
            eglobo_Akechi -= 0.05;
        }
        else {
            estado_globos = 8;
            mov_globoY = 0.0f;
            mov_globoXZ = 0.0f;
        }
        break;
    case 8:
        if (eglobo_Ann < 1.5f) {
            eglobo_Ann += 0.05;
            mov_globoY += 0.01;
            mov_globoXZ += 0.01;
        }
        else {
            estado_globos = 9;
        }
        break;
    case 9:
        if (eglobo_Ann > 0.0f) {
            eglobo_Ann -= 0.05;
        }
        else {
            estado_globos = 10;
            mov_globoY = 0.0f;
            mov_globoXZ = 0.0f;
        }
        break;
    case 10:
        if (eglobo_Akechi < 1.5f) {
            eglobo_Akechi += 0.05;
            mov_globoY += 0.01;
            mov_globoXZ += 0.01;
        }
        else {
            estado_globos = 11;
        }
        break;
    case 11:
        if (eglobo_Akechi > 0.0f) {
            eglobo_Akechi -= 0.05;
        }
        else {
            estado_globos = 12;
            mov_globoY = 0.0f;
            mov_globoXZ = 0.0f;
        }
        break;
    case 12:
        if (eglobo_Joker < 1.5f) {
            eglobo_Joker += 0.05;
            mov_globoY += 0.01;
            mov_globoXZ += 0.01;
        }
        else {
            estado_globos = 13;
        }
```

```
854             break;
855         case 13:
856             if (eglobo_Joker > 0.0f) {
857                 eglobo_Joker -= 0.05;
858             }
859             else {
860                 estado_globos = 14;
861                 mov_globoY = 0.0f;
862                 mov_globoXZ = 0.0f;
863             }
864             break;
865         case 14:
866             if (eglobo_Ann < 1.5f) {
867                 eglobo_Morgana += 0.05;
868                 eglobo_Ann += 0.05;
869                 mov_globoY += 0.01;
870                 mov_globoXZ += 0.01;
871             }
872             else {
873                 estado_globos = 15;
874             }
875             break;
876         case 15:
877             if (eglobo_Ann > 0.0f) {
878                 eglobo_Morgana -= 0.05;
879                 eglobo_Ann -= 0.05;
880             }
881             else {
882                 estado_globos = 16;
883                 mov_globoY = 0.0f;
884                 mov_globoXZ = 0.0f;
885             }
886             break;
887         case 16:
```

```
888             if (eglobo_Akechi < 1.5f) {
889                 eglobo_Akechi += 0.05;
890                 mov_globoY += 0.01;
891                 mov_globoXZ += 0.01;
892             }
893             else {
894                 estado_globos = 17;
895             }
896             break;
897         case 17:
898             if (eglobo_Akechi > 0.0f) {
899                 eglobo_Akechi -= 0.05;
900             }
901             else {
902                 estado_globos = 18;
903                 mov_globoY = 0.0f;
904                 mov_globoXZ = 0.0f;
905             }
906             break;
907         case 18:
908             if (eglobo_Morgana < 1.5f) {
909                 eglobo_Morgana += 0.05;
910                 mov_globoY += 0.01;
911                 mov_globoXZ += 0.01;
912             }
913             else {
914                 estado_globos = 19;
915             }
916             break;
917         case 19:
918             if (eglobo_Morgana > 0.0f) {
919                 eglobo_Morgana -= 0.05;
920             }
921             else {
```

```
922                 estado_globos = 0;
923                 mov_globoY = 0.0f;
924                 mov_globoXZ = 0.0f;
925             }
926             break;
927         }
928     }
```

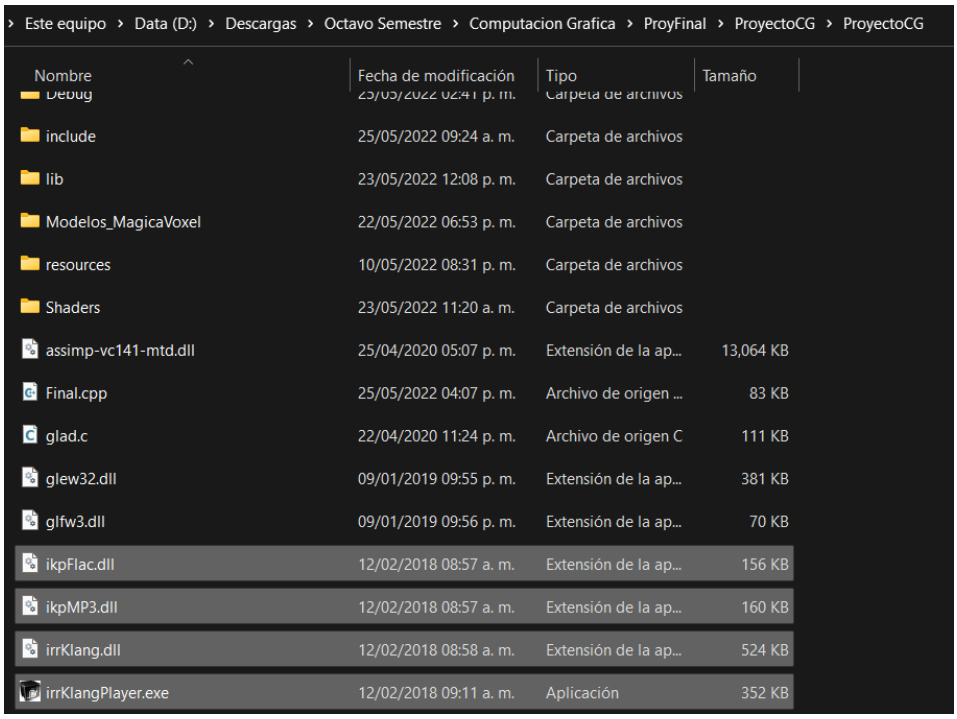
Finally, for animation 7, activated with the key 7 and restarted with the L key, we have Shadow Morgana running in circles around the crossing. It also raises and lowers its arms to simulate the shock of running fast and always looks in the direction where it is running. This animation relies on mathematical formulas.

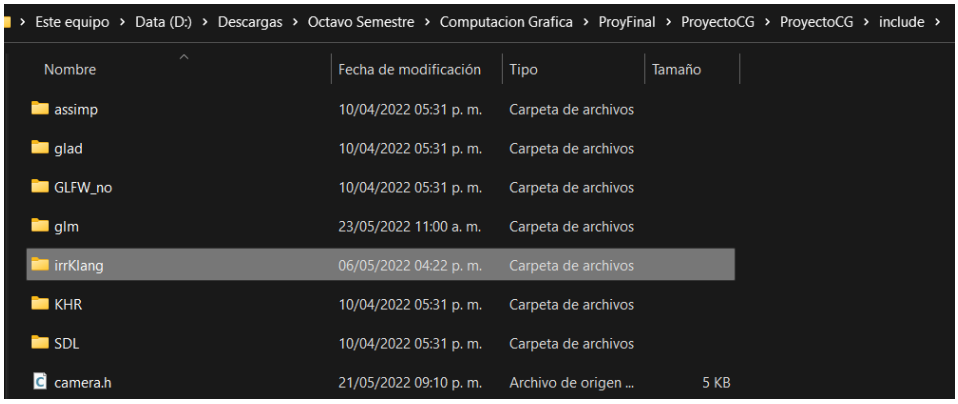
```
2510    //Pausa de animación de morgana corriendo
2511    if (key == GLFW_KEY_7 && action == GLFW_PRESS) {
2512        animacion_morgana_corriendo = !animacion_morgana_corriendo;
2513    }
2514
2515    //Usamos L para reiniciar la animación
2516    if (key == GLFW_KEY_L && action == GLFW_PRESS) {
2517        animacion_morgana_corriendo = false;
2518        posMorgana_x = 0.0f;
2519        posMorgana_y = 0.0f;
2520        posMorgana_z = 0.0f;
2521        escMorgana = 1.0f;
2522        giroTorso_y = 0.0f;
2523        giroBrazoMorgana_x = 30.0f;
2524        giroBrazoMorgana_z = 45.0f;
2525        giroBrazoMorganaPositivo = true;
2526    }
2527 }
```

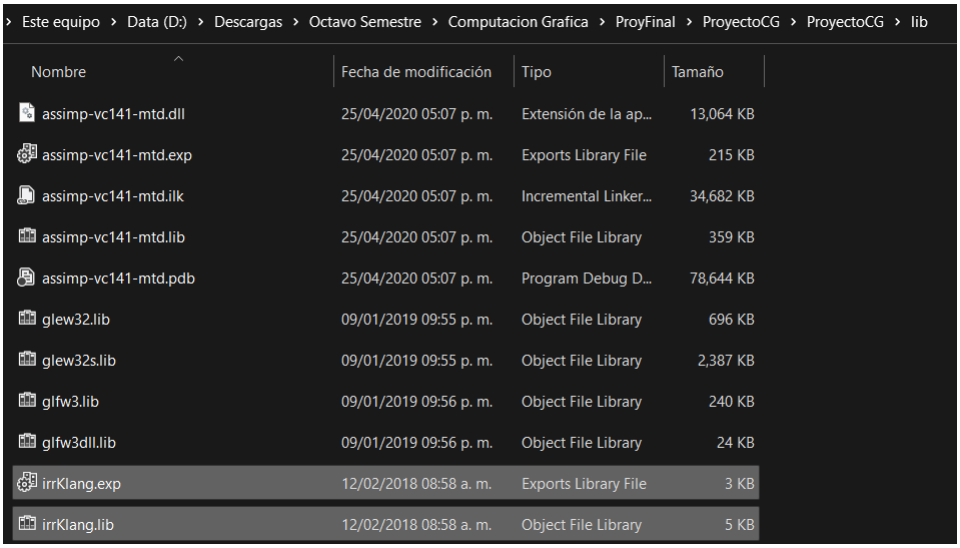
```
961     //Animación de morgana corriendo (Animación 7)
962     if (animacion_morgana_corriendo) {
963         posMorgana_x = 20.0f * cos(glm::radians(giroTorso_y));
964         posMorgana_z = 20.0f * sin(glm::radians(giroTorso_y));
965         giroTorso_y += 1.0f;
966
967         if (giroBrazoMorganaPositivo) {
968             giroBrazoMorgana_z += 3.0f;
969             if (giroBrazoMorgana_z >= 90.0f)
970                 giroBrazoMorganaPositivo = false;
971         }
972         else {
973             giroBrazoMorgana_z -= 3.0f;
974             if (giroBrazoMorgana_z <= 45.0f)
975                 giroBrazoMorganaPositivo = true;
976         }
977
978     }
979 }
```

Audio

In the case of audio, the irrKlang library was used. The first thing was to download the necessary files and add them inside the project folders.


Este equipo › Data (D:) › Descargas › Octavo Semestre › Computacion Grafica › ProyFinal › ProyectoCG › ProyectoCG
Nombre
Fecha de modificación
Tipo
Tamaño
Debug
include 25/05/2022 09:24 a. m. Carpeta de archivos
lib 23/05/2022 12:08 p. m. Carpeta de archivos
Modelos_MagicaVoxel 22/05/2022 06:53 p. m. Carpeta de archivos
resources 10/05/2022 08:31 p. m. Carpeta de archivos
Shaders 23/05/2022 11:20 a. m. Carpeta de archivos
assimp-vc141-mtd.dll 25/04/2020 05:07 p. m. Extensión de la ap... 13,064 KB
Final.cpp 25/05/2022 04:07 p. m. Archivo de origen ... 83 KB
glad.c 22/04/2020 11:24 p. m. Archivo de origen C 111 KB
glew32.dll 09/01/2019 09:55 p. m. Extensión de la ap... 381 KB
glfw3.dll 09/01/2019 09:56 p. m. Extensión de la ap... 70 KB
ikpFlac.dll 12/02/2018 08:57 a. m. Extensión de la ap... 156 KB
ikpMP3.dll 12/02/2018 08:57 a. m. Extensión de la ap... 160 KB
irrKlang.dll 12/02/2018 08:58 a. m. Extensión de la ap... 524 KB
irrKlangPlayer.exe 12/02/2018 09:11 a. m. Aplicación 352 KB


Este equipo › Data (D:) › Descargas › Octavo Semestre › Computacion Grafica › ProyFinal › ProyectoCG › ProyectoCG › include ›
Nombre
Fecha de modificación
Tipo
Tamaño
assimp 10/04/2022 05:31 p. m. Carpeta de archivos
glad 10/04/2022 05:31 p. m. Carpeta de archivos
GLFW_no 10/04/2022 05:31 p. m. Carpeta de archivos
glm 23/05/2022 11:00 a. m. Carpeta de archivos
irrKlang 06/05/2022 04:22 p. m. Carpeta de archivos
KHR 10/04/2022 05:31 p. m. Carpeta de archivos
SDL 10/04/2022 05:31 p. m. Carpeta de archivos
camera.h 21/05/2022 09:10 p. m. Archivo de origen ... 5 KB


Este equipo › Data (D:) › Descargas › Octavo Semestre › Computacion Grafica › ProyFinal › ProyectoCG › ProyectoCG › lib
Nombre
Fecha de modificación
Tipo
Tamaño
assimp-vc141-mtd.dll 25/04/2020 05:07 p. m. Extensión de la ap... 13,064 KB
assimp-vc141-mtd.exp 25/04/2020 05:07 p. m. Exports Library File 215 KB
assimp-vc141-mtd.ilk 25/04/2020 05:07 p. m. Incremental Linker... 34,682 KB
assimp-vc141-mtd.lib 25/04/2020 05:07 p. m. Object File Library 359 KB
assimp-vc141-mtd.pdb 25/04/2020 05:07 p. m. Program Debug D... 78,644 KB
glew32.lib 09/01/2019 09:55 p. m. Object File Library 696 KB
glew32s.lib 09/01/2019 09:55 p. m. Object File Library 2,387 KB
glfw3.lib 09/01/2019 09:56 p. m. Object File Library 240 KB
glfw3dll.lib 09/01/2019 09:56 p. m. Object File Library 24 KB
irrKlang.exp 12/02/2018 08:58 a. m. Exports Library File 3 KB
irrKlang.lib 12/02/2018 08:58 a. m. Object File Library 5 KB

Next, we add the library to our code:

```
32      //Librería de audio:
33      #if defined(WIN32)
34      #include <conio.h>
35      #endif
36      #include <irrKlang/irrKlang.h>
37      #pragma comment(lib, "irrKlang.lib") // link with irrKlang.dll
```

We start the audio engines, one being dedicated for background music and the other for sound effects, and if one engine fails, we send an error:

```
159     //Inicio de audio morgana
160     irrklang::ISoundEngine* morgana = irrklang::createIrrKlangDevice();
```

```
1008        //Inicio de música de fondo
1009        irrklang::ISoundEngine* bg_music = irrklang::createIrrKlangDevice();
1010
1011        if (!bg_music)
1012            return 0; //Error con la música de fondo
1013        if (!morgana)
1014            return 0; //Error con morgana
```

In the case of background music, it is played when the rendering starts. Meanwhile, Morgana's voice effect plays on certain events (such as animations or pressing the 6 key).

```
1076        //Reproducir música de fondo
1077        bg_music->play2D("resources\\sounds\\bg_music\\The_Whims_of_Fate.mp3", true);
```

Since Morgana's sound is in 3D, you need to constantly update the hearing position for the sound to be heard correctly:

```
1203        morgana->setListenerPosition(irrklang::vec3df(camera.Position.x, camera.Position.y, camera.Position.z), irrklang::vec3df(0, 0, 1));
```

Once we end the program, we free the memory of the audio engines.

```
2358        bg_music->drop(); //Borrar música de fondo
2359        morgana->drop(); //Borrar efecto de sonido de morgana
```