0 – Introduction

The project was realized using the library "three.js". The goal was to make a 3D game. In the game, we will play the role of Steve a raccoon runner. The user will have the ability to move Steve through the keys A, D also balloons will appear on the screen, if we click them, they will burst and provide a speed boost to Steve. In the main scene, there are various trees on the track and a model for the finish line has been created. There is also a tribune on which there are various animals, each with a different model and a different animation, that will cheer for Steve and the other raccoons in the race. The aim of the game is very simple, we should win the race.

1—Technologies

1.1 – Three.js

Three.js is a JavaScript library and an API (Application Programming Interface) that is used to create and display animated 3D computer graphics in a web browser without relying on proprietary browser plugin: this is possible due to the advent of WebGL. Three.js runs in all browsers supported by WebGL 1.0. Some of the main features of this API are:

● Scenes: add and remove objects at run-time.

● Cameras: perspective, orthographic, cube, array and stereo.

● Geometry: planes, cubes, spheres, torus.

● Objects: meshes, particles and more.

● Materials: basic, Lambert, Phong, smooth shading, texture and more.

● Lights: ambient, directional, point, spot and shadows.

● Data loaders: binary, image, JSON and scene.

The three.js GitHub repository is full of ready to use useful examples like the loaders, so I used different loaders that will be cited.

1.2 Tween.js

"Tween.js" is a library that helps the user in the implementation of animations. A tween allows changing the values of the properties of an object in a smooth way. to do this just pass in input the properties that we want to change, for example, if we want to animate the rotation of a joint just choose the target value of the animation of the rotation, in addition, we should also choose the duration of that animation and the tweening engine will take care of finding the intermediate values from the actual to the ending point.

2 – The game

2.1 Camera and Controls

The camera used is a perspective camera. The camera is a very important component within the game in fact it has also been "animated". As soon as the game starts the camera shows all the raccoons runners from right to left and then moves to the initial position chosen for the beginning of the game, always looking at the raccoon controlled by the user (Steve). Throughout the run, the camera will always be looking at Steve. The x-coordinate is equal to Steve's x-coordinate multiplied by 1.2. With this calculation the camera will move, initially looking at Steve from behind (Steve.x = -70, camera.x = -84), in the middle of the race it will be perfectly perpendicular to Steve (Steve.x = 0, camera.x = 0) and at the end of the race, it will look at Steve from the front (Steve.x = 70, camera.x = 84). In this way, we can better admire the 3D environment of the scene. The user will have the possibility to interact through the A and D keys and the mouse. In the scene a HUD has been specially created containing: a bar that represents Steve's speed, the faster the user will be in pressing the above keys alternately, the faster the bar will load. Furthermore, depending on the difficulty chosen, it will be more difficult to reach the maximum speed. There is also a system that punishes the user if he presses the same key consecutively, in which case the accumulated speed will decrease a lot. To make the game more interactive, it was decided to introduce 5 balloons into the scene that will appear. The i-th balloon will appear if Steve reach i\*20 units of the x coordinates of the track field. The balloons will be randomly generated within a small area on the opposite side of the camera position. The balloons have two animations created with tween.js: the first one squeezes and stretches the balloon while the second one brings it upwards. These balloons can be clicked by the user with the mouse. If the user is skilled enough to click them before they disappear from the scene, he will receive a speed boost. The HUD also shows the time elapsed since the start of the race and Steve's current position. In addition, at the bottom left of the screen, there are the A and D keys, respectively inside a red and a blue box. If the user presses one of the keys, the frame becomes slightly transparent while the frame of the other key is highlighted. In this way, the user understands which of the two keys A and D must be pressed to avoid the penalty of the same key repeated several times. The HUD has been realized entirely in CSS and through the JavaScript file, its elements are updated in real-time.

2.2 Light

For the project have been used:

hemisphere light 🡪 takes a sky color and a ground color and just multiplies the material's color between those 2 colors: the sky color if the surface of the object is pointing up and the ground color if the surface of the object is pointing down.

directional light is a light that gets emitted in a specific direction. This light will behave as though it is infinitely far away, and the rays produced from it are all parallel.

point light A light that gets emitted from a single point in all directions.

In different difficulties different lights were applied

easy --> the following difficulty is set during the day. For the hemisphere light, we have used the "light blue" color.

for the sky color while for the ground color "brownish orange".

for the directional light, we have used the color "white".

medium --> the following difficulty is set during the sunset. For the hemisphere light, we have used the color "sunset orange".

for the sky color while for the ground color "brownish orange".

for the directional light, we have used the color "sunset orange".

hard --> the following difficulty is set during the night. For the hemisphere light, the colors are the same as in easy mode, but the intensity is 1/5.

Unlike the other modes, there is no directional light but there are 7 point lights positioned in correspondence of the same number of flashlights. The color of the light is "orange fire".

2.3 Track field and Grass

For the grass and track field were used:

THREE.PlaneGeometry

THREE.MeshBasicMaterial

THREE.MeshLambertMaterial

THREE.MeshPhongMaterial

Special textures have been chosen for both track field and grass. To facilitate the positioning and to correctly apply the textures to the geometries, a special function was created: myPlane() which takes in input :

sizeX, sizeY, texture, x, y, z, line, repeat, endLine = false, grass = false

sizeX, sizeY --> represent the size of the plane.

texture --> corresponds to the path of the textures to be applied to the plane.

x, y, z --> represent the x, y, z position in the scene.

line --> is used to correctly calculate the value to assign to the texture. This was done because the white lines in the track field have a different thickness than the lanes, so it was necessary to modify the y coordinate of the texture that was wrapped with clampToEdgeWrapping. This technique allows us to stretch a texture beyond the end of the plane to show on the lines a texture with dimensions equal to that of the lane. To correctly determine the size of the texture to be applied, a special calculation was performed:

1/1 = 1 if it is a lane. In this way, the displayed texture will be normal without the wrap.

1/ (lane thickness/line thickness) if it is a line. In this way, it will be wrapped in proportion to the lane and line thicknesses.

repeat --> represents the number of times the texture is repeated.

endline --> a Boolean that tells us if we are working with the white vertical line at the beginning and the end of the track. The base value is false.

grass --> a Boolean that lets us know if we are working with the grass (in which case the value will be true) or with the track field, the base value is false.

To optimize, the MeshBasicMaterial is always used if shadows are disabled. This choice was made because shadows are not cast on this type of material, and it is much lighter from a computational point of view. The MeshLambertianMaterial is used in day mode [] because it allows casting shadows and is lighter than the MeshPhongMaterial. In the night mode [] it was necessary to use the MeshPhongMaterial since it still allows to cast shadows and in addition, it allows to show the light effects given by the point lights.

2.4 Animals

Other animals were also introduced in the scene 5 different types of chicken were included, a seal, a giraffe, an elephant, a pigeon, and a dinosaur. All the animals were animated with Tween.js and each animal has a different animation. The models are glTF models that were loaded through a special loader. Were also loaded through a special loader of the audio that represents the sound of the animal, each animal has an associated audio in this way the cheer of the animals on the stand is more realistic. Since the project was designed to run on Chrome, to try to circumvent the browser's policies on audio (Chrome does not allow audio to start on a page unless there has been an interaction from the user) the audio is played after the user clicks the play button on the loading screen. In this way, thanks to this interaction, it is possible to start the audio within the game.

2.5 Raccoons

The same glTF model was used for raccoons. The models are placed in the scene at the beginning of the track field, one per lane. The closest one is Steve[]. Each raccoon has the following hierarchical structure:

image

Exploiting this structure, the joints of the raccoon have been moved to make it stand upright and obtain its initial position.

The animations were done by creating a distance given from the starting point to the ending point. This distance was then divided by the number of frames needed to complete it thus obtaining the step of moving to be added. Some of these animations have been structured in phases. You start from an initial state and reach other states depending on the condition. Each state has a different animation. The sequence of all states performs an animation that uses the same number of frames as non-phase animations, this is because the individual phases use only a percentage of these frames, and the sum of all percentages is 100. To give the effect of a real run, the joints are moved back and forth thanks to the use of a multiplier that assumes values between 1 and -1 by changing the sign of the step of the movement. The change of the value 1 and -1 occurs according to the rotation of the X-axis of the left shoulder (shoulder\_L\_014).

The raccoon runs from left to right. Each raccoon's goal is to run 3 units in an entire animation. So the distance traveled is calculated as follows: 3/(number of frames needed to complete an entire animation). Depending on the difficulty the raccoons will need a different number of frames. Steve, unlike the other raccoons, will need about twice as many frames to complete the animation, because he has the maximum bar speed as a multiplier, which is 2. The following formulas indicate how the number of frames needed changes over time to simulate a real race:

Steve

frame \* (barSpeed + baseSpeed +boostBalloon)

barSpeed --> current value of bar speed.

baseSpeed --> the base movement value.

boostBalloon --> cumulative value given by exploding balloons.

Other raccoons

difference = (speedCenter - frame);

percentage = (100\*difference)/range;

frame += (Math.random() - 0.5) + (percentage/100)/2;

speedCenter --> number around which the frames should be.

difference --> difference between actual frames and speedCenter.

range --> maximum value added to or subtracted from speedCenter.

percentage --> value between -100 and 100. When the difference is equal to -range the value will be -100, +100 when difference = range. Intermediate values are interpolated.

result --> a random value ranging from -0.5 to 0.5 is added or subtracted 0.5 obtained by dividing the percentage obtained previously by 200. If the percentage is -100, we get as result a value ranging from -1 to 0 if the percentage is 100 the value will range from 0 to 1.

To make the race between the other raccoons competitive and unpredictable, this random value is added to the number of frames.

2.5 Trees, Finish line, Tribune, Balloons, Fog

Inside the scene, there are also trees, which contribute to the setting, a tribune on which are placed the animals that cheer, and a finish line that was created specifically through the Maya program also the texture applied to the model was done using photoshop. The trees, the tribune, the finish line and balloons are all glTF models. Different models have been used for the trees in order to give diversity to the environment. Inside the environment a fog has also been inserted, to avoid that the sides of the plane representing the terrain were visible making it look like it does not end. To do this, a special fog() function was created. This is done through Three.fog. This class contains the parameters that define linear fog. After that, a light blue color was set as the background value to simulate the sky. The fog in the different difficulties will have different colors to simulate the day, the sunset, and the night.

2.6 cursor

Since all raccoons have the same pattern to identify Steve a cursor was used. This cursor will follow Steve throughout the race and was created as a cone with three sides to simulate a pyramid through a THREE.js primitive. This pyramid is rotated backward and has been animated with an animation that goes up and down and rotates slightly around its z-axis.

2.7 Html

HTML is a formatting language that describes how the textual and non-textual content of a web page is laid out or displayed graphically (layout) using formatting tags. We used Html for the start page, the loading screen, the countdown, the end game screen, and the main menu page that will be used to choose the difficulty and enter the game.

2.7.1 Index.Html

This page is opened from Github pages. Inside it a button that allows you to reach the main menu. A note advising the user to enable hardware acceleration has also been added. This page also serves the purpose of allowing the background music in the main menu to start [].

2.7.2 Main Menu

In the main menu, there is a description of the game, instructions, and a choice of difficulties. Also, for those who have a high-performance computer, the possibility of enabling shadows has been added.

2.7.3 Loading Screen

During the loading of the various game elements, the user is shown a loading screen. At the end of the loading process, the loading screen is replaced by a button that, if clicked, will start the game. Since loading may take several seconds, the user is warned of this through a message. There are 3 loading pages, graphically equal, that allow starting the different difficulties.

2.7.4 countdown, end game screen

In order to give the user, the possibility to prepare for the race, a countdown has been inserted with appropriate audio. The countdown is done by updating from time to time a div inserted inside the HUD and positioned in the center of the screen. It has been made also animation for the countdown in fact that allows enlarging the writing that appears inside the div. Every time a second passes the value inside this div changes from "3", then to "2", then to "1". At the moment of the starting, the value inside the div changes from 1 to "GO!". For the "GO!" text a fading style effect has been done. Then the value inside this div is deleted to avoid the appearance of text during the game. As soon as any raccoon wins the race all animations are stopped, the sounds of the animals cheering are stopped, as well as the music that accompanies the race, the camera is moved in such a way as to simulate a photo finish and starts new music. In order to make the whole thing more pleasant, a semi-transparent end-game screen has been inserted with summary information such as:

Time spent (this value will be shown only if Steve will arrive first otherwise will be shown the value "N/A").

Position obtained.

The number of balloons popped.

A button that will allow the user to reach again the main menu (since the user makes the click action, we can insert the background music in the main menu, since the Chrome browser policies are respected)

2.8 Audios

Various audio files were used to make the game. Each animal, as mentioned above, has associated audio with its own verse. While for the raccoons, audio was taken that represents the noise its paws make when they touch the track field. It has also taken 3 different background music, one for the main menu, one that will last from the start to the end of the race, and another that will be played at the end of the race. Also, audio has been taken for the countdown. All the audios except for the explosion of the balloon are loaded at the beginning of the game, thanks to the loadingManager together with all the other elements and then they are started. This was done because during the design we noticed that if the audios were loaded and started on the moment, they could give delay problems. All audios are stored as a pair: (Three.Audio, id audio) in the sounds array. We have also created a special function play() that facilitates everything in fact this function takes in input: audio, volume, loop, preload, idValue, delay

audio--> represents the path of the audio file we want to load.

volume --> value needed to set the audio volume.

loop --> if the value is true then the audio will loop otherwise not.

preload --> if the value is true the audio must be loaded and started on the moment, otherwise it is just loaded.

idValue --> a string representing the id we want to give to a certain sound.

delay--> a value in milliseconds that represents the waiting time before the sound starts. It was inserted to make the audios of the cheering animals asynchronous.

Next, it was necessary to activate the audios that were stored in the sounds array and that were not played immediately. To do this, a special function was created: findSound() which, given a string as input, returns the element in sounds that has the string given as id. On the value obtained, then, the command play() is used to start the audio and stop() to stop it. As for the audio elements having the empty string as id, since they represent only the audio of the animals on the stand, a stopSoundAnimals() function has been created which searches in sounds all the elements having the empty string and executes the stop() command.

3 Global Aspects

3.1 Technical details and problems encountered.

The scene takes a while to load so a loading screen has been added. The time taken varies depending on the connection and the specifications of the computer used, all this is reported to the user on the loading page. A loadingManager has been used for the loading, in fact as soon as the loading of all the elements of the scene is completed, the onLoad function of the loadingManager will be entered, and after this, instead of the loading message, a button with the word "play" appears. If the user clicks on it the game will start.

Initially, the game was thought of in a more detailed way, using a larger stand and inserting many more animals on the stand to cheer, also the number of trees was much higher than the current ones. The game has been designed on powerful computers and during the development of the project no problems have been noticed, however in the testing phase other users have found some performance problems, the game did not run well, it was jerky, and the animations of the raccoons and the camera were very slow especially for those who did not have high-performance computers because of the methodology used for these animations []. On less-performing computers, fewer frames translate into a slower animation. To overcome this problem, taking as speed to simulate that obtained with 144 fps, the number of frames of each animation has been reduced using the following formula:

the number of frames needed for the animation \* 144/ (actual frames generated by the running pc). This way if a computer generates less than 144 frames, the number of frames needed for the animation is multiplied to a number smaller than 1 thus reducing the number of frames needed for the animation and making it faster. Another trick used to optimize performance was to remove certain elements from the scene. One of the elements that weighed most on the performance was the presence of shadows. However, it has been decided to give the possibility to the user to activate or not the shadows (in the case in which it possesses a performing computer) through a checkbox in the main menu, because the game is much more pleasant with the shadows activated.

As mentioned above, due to the policies of the Chrome browser, it is not possible to play audio within an Html page without the user having made interaction. For this reason, a special Html page has been created with a button in the middle of the screen that says, "Click to enter the menu". Clicking it will take you to the main menu with background music playing. This happens because we have shown the page following the click of the button by the user which represents the necessary interaction.

An array of pairs contains the raccoon management information. Each pair is associated with a raccoon. This pair has as a first element the root of the object useful for moving it, as second an object that has as attributes the raccoon's bones, this to facilitate their modification.

By clicking on the screen thanks to Three.Raycaster a ray starts. If this ray intersects a balloon, it explodes, playing a random sound among 3 audio files. The balloons were created immediately in a position not visible from the camera to facilitate the code. Later, when the balloon should spawn, it is moved.

4 Levels

There are three difficulties:

Easy 🡪 Other raccoons are much slower than Steve’s maximum speed.

Medium 🡪 Other raccoons might be a bit faster than Steve’s maximum speed. You will have to pop balloons to win. Also, it will be more difficult to reach the maximum speed.

Hard 🡪 Other raccoons will be faster than Steve’s maximum speed. The race will take place at night and balloons will give a lower boost. It will be more difficult to click on balloons.

|  |  |  |  |
| --- | --- | --- | --- |
| Difficulty | Easy | Medium | Hard |
| Initial speed of other raccons | 80 | 80 | 73 |
| Bar speed increase\*\* | 5% + (0-15)% | 1% + (0-6) % | 1% + (0 - 6) % |
| Bar speed decrease | 0.001 per frame | 0.00115 per frames | 0.00115 per frames |
| Balloon boost | 0.2 | 0.2 | 0.17 |
| Balloon speed\*\*\* | 50/17 | 50/17 | 50/10 |
| Range of speed [] | 70 - 90 | 60 - 80 | 60 -80 |

\* Speed is the number of frames needed to complete the animation. The higher it is, the longer the time taken.

\*\* range from one value to another. The higher the bar percentage is, the lower the bar speed increase percentage will be.

\*\*\* speed expressed as distance covered / time spent.

5 Conclusion

The aim of the project was to make a browser game that meets the requirements. The project contains a lot of hierarchical models. All models have been animated in different ways, some of them in a more thorough way, e.g. the dinosaur. However, only the raccoon model has been fully exploited for its animation. Torches and balloons were also animated. Not all aspects of the code have been covered due to their breadth. However, the code is well annotated. If you look at it, you will understand aspects that have not been covered. the game has a lot of potentials, and new game elements could be added. For example, new character racers could be added with their characteristics and abilities, different, longer routes with different obstacles.