CGI - Technical Report

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1 Introduction

For this year's coursework within the CGI unit at University of Bristol, the theme was to design, model, texture and animate a robotic hero character asset for a functional animated feature film: "Olympoids". The term "olympoid" was given to the characters that we had to construct and represents a droid competitor instead of a human, for the Olympics in the year 2040.

Given the background concept, we had to start thinking about how our character would look, and more importantly, which sport he is going to do. There was a lot of work that had to be done, from just designing and blocking out the robot, to animating and texturing the character and lighting up the scene. Despite the workload seeming a bit overwhelming at first, the key to success was to split all the work into multiple parts and start building up the character from an early stage.

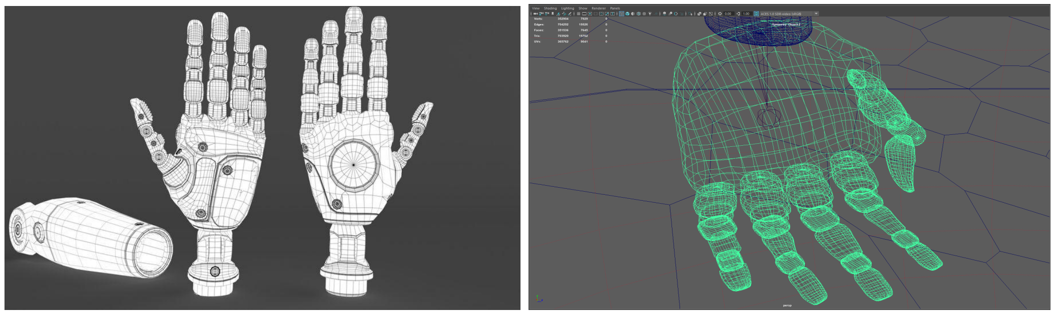
2 Modelling

From the beginning of this project, I set out to start building my robot from several pieces, better known as modular modelling. To express my modelling process as much as I can, all of the components from the scene are briefly detailed below, from the first object modelled to the last one.

2.1 Arms

2.1.1 Hands

The hand was the first part of my robot that I started modelling. I began with the fingers by creating a simple cube and then duplicating it two times. Then I created a basic cylinder shape that I duplicated two times as well, all of these forming the first finger. Afterwards, I duplicated the finger four times and then resized each of them accordingly. These were the first little steps into the world of modelling before I learnt about references. Sometimes, you can get better and faster results with modelling by a real world or a concept art reference of that object. In this case, I searched for a robot hand reference and found what I was looking for. With time, I started learning more and more functions that helped me a lot in easing my modelling efficiency, thus, with the reference set on the grid, I used a linear CV curve tool to create the half left outline of the index finger and then revolve it to create the other half. The same was done for the palm by creating the outline for the left side and then revolving it. With the palm though, it was a bit more difficult, because while the revolving tool is best suited for cylindrical objects, in my case, the left side of the palm was not the same with the right side. This issue introduced me to the vertices of the objects. Every mesh is formed of vertices, faces and edges, which can be modified for more complex modelling purposes. By slowly learning how to use this method of modelling, the hand of my robot started taking shape. Thinking that I was going to animate the fingers, I decided to use the multi-cut tool to separate the components of the fingers from the joints that were supposedly going to be used for animating the finger. Doing that, I learnt how to cut meshes with the multi-cut tool as well as separating and combining them, alongside with bevelling some parts of the objects. This part of the body served me a very good starting point in modelling the character, as it introduced me to multiple tools from an early stage, and which I was going to use in more detail for future parts from my olympoid. Below you can see the reference image on the left and the actual modelled hand on the right:

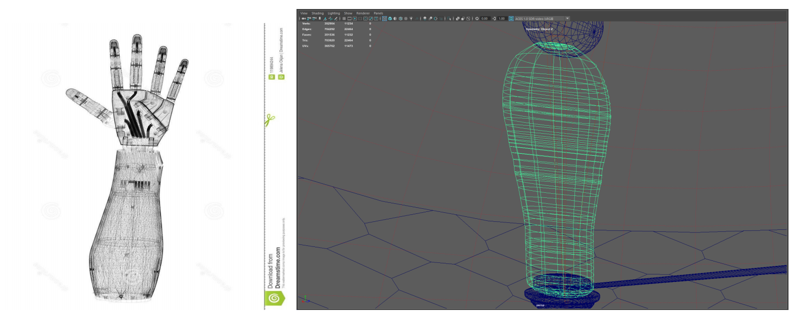


(a) reference (b) modelled hand

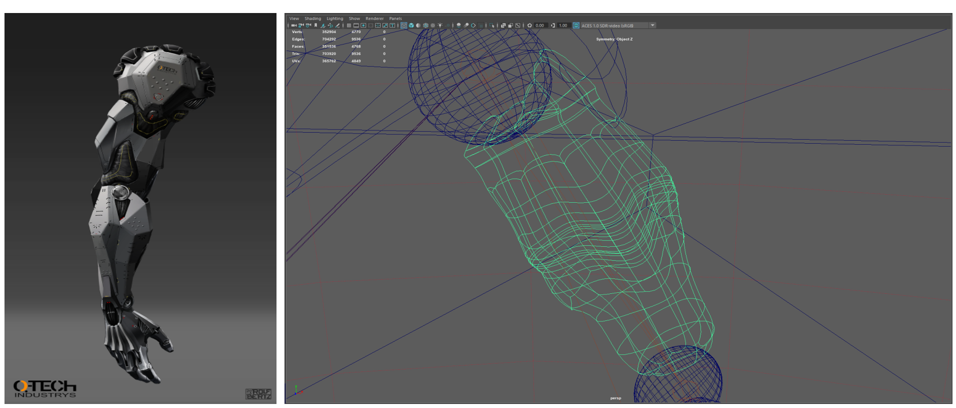
Figure 1: Comparison between the modelled hand in wireframe view and the reference image used

2.1.2 Forearm and Upper Arm

Now that I finished the hand, I needed to model the next parts that would later form the arm. After choosing a reference image for the forearm and seeing that it is almost a perfect cylinder, I decided to revolve it as well by using the curve tool. For the upper arm, I followed a similar procedure by finding a reference (figure 2 - c) and using the curve tool, but this time, the object was far from being almost perfectly cylindrical like the forearm. To get the shape that I wanted, I had to insert some edge loops and play around with the vertices. Below you have the reference images on the left and the actual modelled meshes on the right:



(a) forearm reference (b) modelled forearm



(c) upper arm reference (d) modelled upper arm

Figure 2: Comparison between the modelled forearm and upper arm in wireframe view and the reference images used

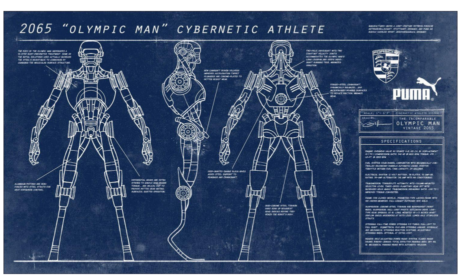
2.2 Legs

2.2.1 Thighs

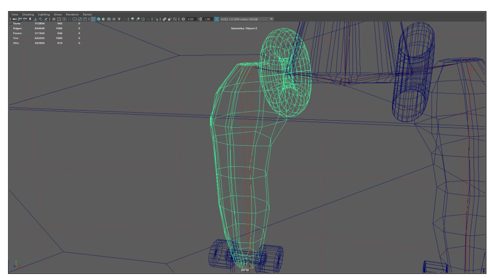
With the main components of the arms being done, it was time to think of how to model the legs. Thus, starting from the top to bottom, I decided to construct the thighs first. This is where I stopped using the revolve tool, since these were not much of a cylindrical shape either and the sides of the mesh were not symmetrical. I created a basic cylinder shape and with the help of the side and front view of my reference (figure 3 - a), I began to model my thigh by modifying the vertices and the edges. I also had a look at this tutorial which helped me gain a better understanding of how to model something based on a reference:
https://www.youtube.com/watch?v=spi4lGxnMZg&list=PL3Ue4s2WqrmWgo1RpPrFw1O1Ffw5dlWEd&index=1&t=33s

2.2.2 Shins and Feet

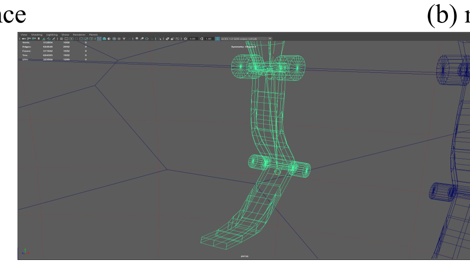
When the moment came to model the rest of the leg, I started thinking a bit ahead about the sport that my olympoid is going to do and what is going to be the main movement of the character. I haven't decided on the final olympic test, but the main requirement for the robot in my case was to run fast and jump very high. Consequently, I realised that the shins and the feet from my thigh reference were more than a perfect fit for what I had in mind. Since the shin and the foot of the robot's leg were similar to the form of some skis, I proceeded to model them using the loft tool. I started by firstly creating a curve of the left side of the shin, then duplicating it and lofting between them. The same was done for the right side of the shin and after that, a final loft was done between the two pieces that would form the lower leg. Now that the shin was done, I decided to use the cut tool again to cut the shin where I thought that the knee joint would come into place and below it, the continuation of the shin would actually be the foot. With that in mind, I started to cut the mesh and then separate the two meshes, one being the shin and the other being the foot of the leg. Now that I had the main components of the arms and legs for my robot, there was only one right arm and one right leg, so to have the left ones as well, I used the mirror function to mirror the meshes on the X axis. Below you can see the modelled parts of the leg together with their reference image:



(a) leg reference



(b) modelled thigh



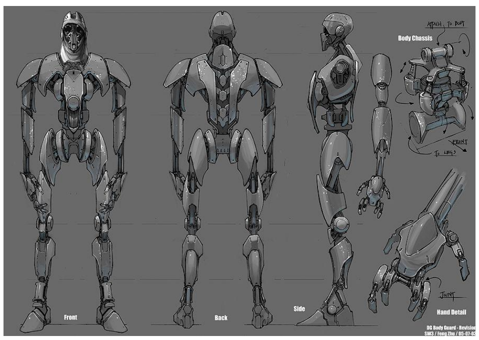
(c) modelled shin and foot

Figure 3: Comparison between the modelled shin, foot and thigh in wireframe view and the reference image used

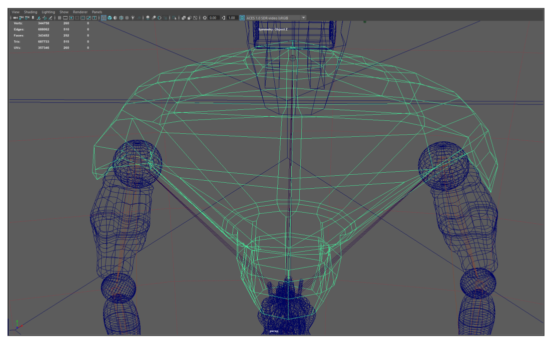
2.3 Torso and Waist

For the torso, I was not very happy with the reference from figure 3, hence, I started looking for something that suited what I was thinking. After finding what I needed, I began to model it similarly to how I did the thigh object. I created a basic cube shape and tried to roughly match the torso in the reference by modifying the vertices and edges in respect to the side and front view of the torso. At this stage I also began to add vertices separately and edge loops more efficiently through the multi cut tool and experimented a lot with modelling the vertices and edges as well as the faces of the mesh.

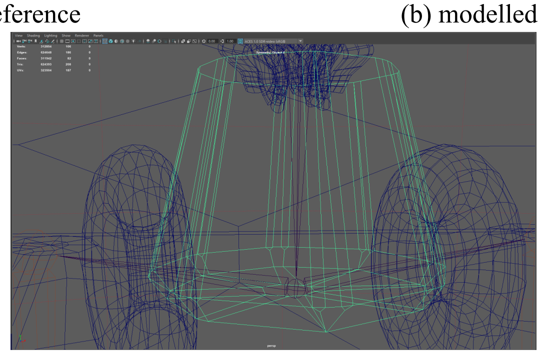
For the waist, it was the moment when I didn't use a reference anymore and modelled it from a cylinder with less edge loops. In this way, it was easier to modify it by using the bevel tool on some edges on the bottom and on some edges on the side. Below you have the images containing the reference and the modelled torso and waist:



(a) torso reference



(b) modelled torso



(c) modelled waist

Figure 4: Comparison between the modelled torso and waist in wireframe view and the reference image used

2.4 Joint Meshes

2.4.1 Wrists, Elbows and Shoulders

With the arms, legs, torso and waist ready for assembly, what was left was to create the joints that would connect all of these components and would make the parenting and the rigging a lot easier. That being said, this was a rather simple objective since for the elbows and the shoulders, all I did was to create two spheres, one bigger for the shoulder and one a little smaller for the elbow. I modelled the wrist (figure 5) using the curve too by creating the left outline of the reference from figure 1 and then revolving it. The revolve function on this one suited perfectly since both the left side and the right side are symmetrical.

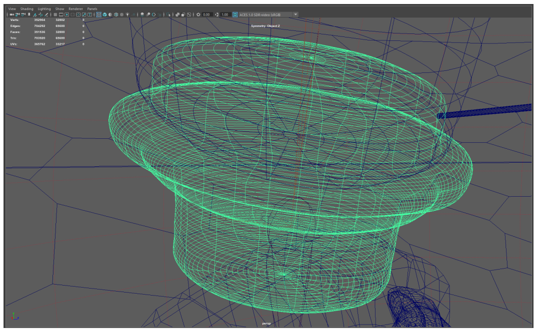


Figure 5: The modelled wrist

2.4.2 Hips, Knees and Ankles

After finishing up the joints in the arms, I began the modelling on the rest of the joints for the legs. The procedure was very similar with the creation of the joints from the arm, because for the hips I just created a torus shape and for the knees and ankles, I created three basic cylinder shapes which I combined them into a single mesh. One cylinder would be in the middle horizontally and the other two would be on the side vertically. You can see the hips as well as the knees and ankles in figure 3.

2.4.3 Middle Wires

After finishing the other parts of the body, I had nothing between the torso and the waist. Knowing that it is good practice to have a middle part which will be the middle joint used for rigging later, I decided to create some improvised wires that make the connection between the torso and the waist. What I did was to create a curve based on the front and the side of the grid and then extrude a cylinder alongside the created curve. This would create the intended wire that I duplicated multiple times, alongside some other curve variations to have more different wires. After I finished creating all the wires, I combined them into a single mesh and that was going to be the middle of the character. Below you can see the modelled middle wires:

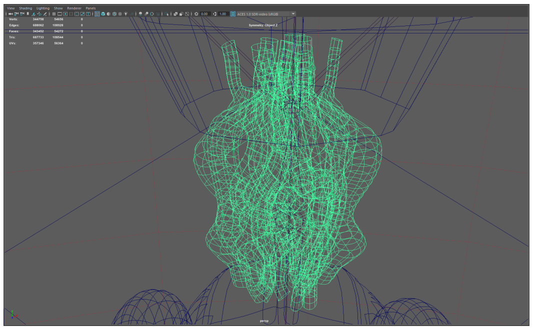


Figure 6: Modelled middle wires

2.5 Head

With all the components of my robot's arms, body and legs done, there was one last piece missing from the puzzle in terms of character modelling, and that was the head. There was not much time for a very detailed head and since, in general, the head modelling is the hardest part in a character creation process, I opted for a basic robot head instead of just a simple sphere. I started by creating a basic cube shape, then adding multiple edge loops vertically. I deleted the face at the bottom and started to move the bottom edges until the desired shape of the head was formed. I extruded the bottom front edge to form the face and the edge in the back to form the back of the head. I also created one cylinder and extruded the side faces to be a little more aesthetic and deleted two faces in the front of the head to create the appearance of the eyes. Below you can see the final version of the head:

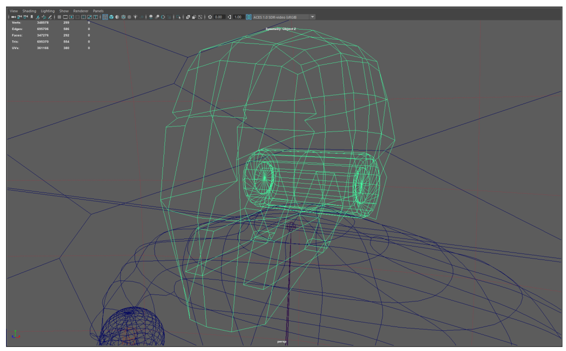


Figure 7: The head

2.6 Environment

At this moment I pretty much decided what was the olympic test that my robot was going to do. For that to be as accurate as possible for the future animation, I had to create a pole, a vault obstacle and a basic stadium. There is still room for a lot of improvement but given the time and the scope of this project focusing on character modelling, I resumed to creating a sphere and cut it in half for the stadium, and for the pole and the vault obstacle, I created multiple cylinders which I made them longer and combined them accordingly. For the sake of page limit, you can see them in the final render animation.

3 Rigging

3.1 Parenting and Skeleton

With all the main components and joints modelled, it was time to begin the rigging process of my character. I would say that it is rather tedious work when it comes to rigging, but I thought early in the process about it and I was determined to keep a parenting hierarchy as I modelled more parts for my robot. In this way, I found it a lot easier when it was time to create the skeleton. As you can see in the figure 8 below, after the base parenting was done with just the meshes of the robot, I started the rigging process by placing the skeleton joints. As it is good practice, I placed the first joint in the middle wires, which is the middle and the main joint of the character and thus, named it “middle”. The following two joint vertices were at the base of the torso and at the base of the waist. To keep it clean and not mess up the parenting that I created, I decided to finish putting the joint vertices on the children of the waist and then on the children of the torso. Thus, the next joint was at the top of the right thigh, followed by its child joint in the knee and consequently, the last joint in the ankle. After mirroring the right leg skeleton to have both legs rigged, I continued with the children joints of the torso. In my case, I created a joint in the right shoulder, then one in the elbow, one in the wrist and one in the middle of the palm. After mirroring the skeleton to have it on the left arm as well, I created the last joint which was for the head. A better picture of the overall parenting of the skeleton can be seen in the figure 8 below:

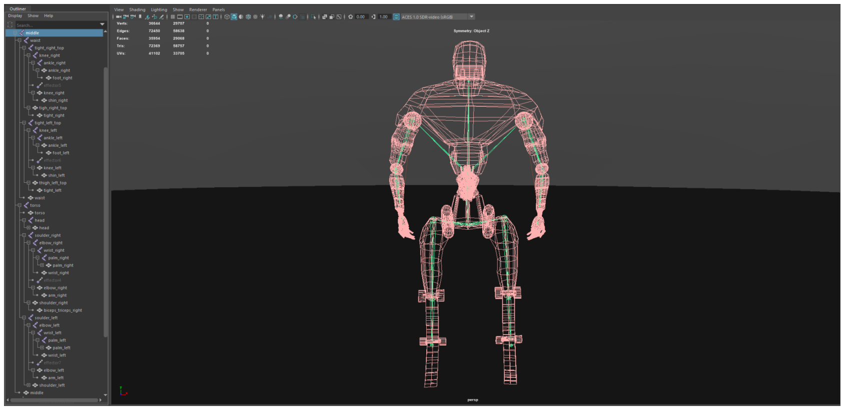


Figure 8: The parenting and skeleton of the character in the templated view

3.2 Creating IK Handles

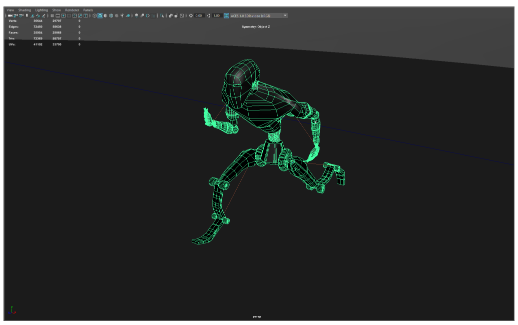
After I finished placing the skeleton joints around the robot's body, all that remained regarding the rigging process was to create some inverse kinematics, also known as IK handles. It is often easier for computer-based designers and animators to define the spatial configuration of an assembly by moving parts, arms or legs, rather than directly manipulating joint angles. In that regard, rather than animating each joint for even a slight movement, I decided to put some IK handles on arms and legs. For each arm I created an IK handle, the first joint being the one in the shoulder and the third joint being the one in the wrist. Same was done for each leg, the first joint being in the hip and the third one in the ankle. During the creation of the IK handles, I constantly tested their movement to make sure that each arm and leg is moving as intended for the future animation, hence, I had to move around the joints (by pressing "d" and moving their origin) until I got the motion I wanted. That is also why you can see in the figure 8 that the skeleton joints for the hips are actually a little bit to the side of them.

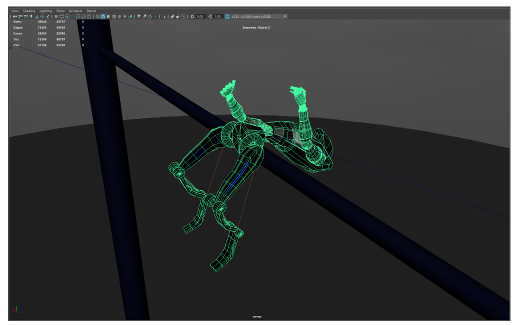
4 Animation

4.1 Story and Character animation

Since we learnt about the theme of our scene, it was clear that our robot needed to perform a typical movement based on the olympic sport that he was going to do. At the beginning of the development of my robot character, I was thinking about making him perform the long jump but after some time I thought that maybe it would be better if he would do the pole jump. This way I had the chance to make something a bit more complex and maybe more eye-catching.

With all the rigging done and after testing out some basic movements for the IK handles to see that everything moves as intended, my olympoid was ready to be animated. After finally deciding on the olympic sport, I had to think about the movements of my character necessary for this. Thus, the scene starts with the robot looking down at the pole that supposedly is given to all the participants at this test to help them to get over the vault obstacle. Taking into account that the year is 2040 and the Olympics wouldn't really be the same, with robots participating instead of humans as well, my robot throws the pole after looking at it and then proceeds to run towards the obstacle. Right before the vault obstacle, my character jumps very high while rotating 180 degrees in the air over the obstacle. Then, it recovers in the air by hitting the ground on its feet. The animation itself was no easy task, as I had to think ahead about multiple positions that the robot is going to have and based on those, to move its parts of the body accordingly. Moreover, after animating a certain movement, I had to test it out by playbacking the animation. There were a lot of imperfections, especially with the IK handles, which at many times during the animation they started to rotate in a strange way. This was solved by putting more keyframes between the main frames of the animation. Also, something important to mention is that I have never rotated the skeleton root of the character, but only the mesh itself for aesthetic purposes as you can better see in figure 9 - b. Below you can visualise a snapshot of the main movements of the character, the running part and the vaulting part:



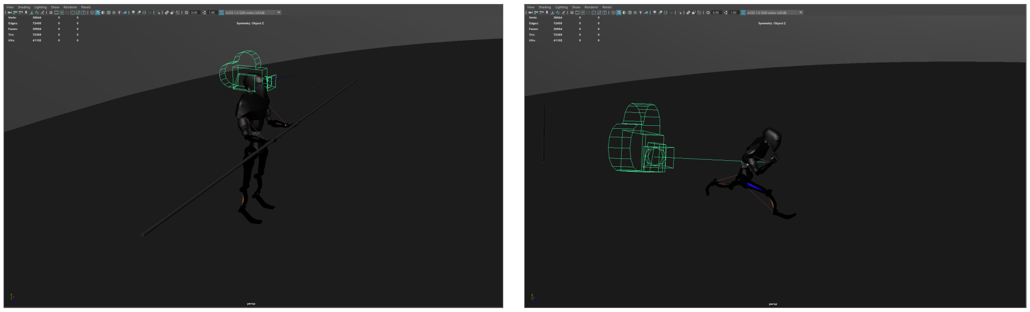


(a) running (b) vaulting

Figure 9: Images showing the running and vaulting instances of the robot

4.2 Camera animation

The second main component in the scene that had to be animated was the camera. During the development, I have been using the default perspective camera, but when you need to render a scene with different settings, it is good practice to create a new one. There are multiple ways of animating a camera, the most basic way would be to just create a new basic camera and control it from a perspective point of view and keyframe the camera in different positions. Another way would be to create the same basic camera, but this time, creating a custom curve as well that with the use of the "attach to motion path" function in Maya, it attaches the camera to the curve, in this way creating a defined path for it. In the end, I chose to create a camera with an aim. It is the same basic camera but with a spring arm attached to it that has a pointer. Based on where that pointer is located or moved, the camera rotates accordingly, thus, I found it being the easiest way to follow something while it was moving, in my case, the character as a whole and different parts of the body. That being said, in the first few seconds of the scene the camera is in the head of the robot (figure 10 - a), creating a first person perspective while he throws the pole and after that, the camera cuts to a different location, following the olympoid for the rest of the scene. I also tried to make the movement of the camera a bit more dynamic by moving it around the robot during the running animation and at the end, closing up to his head after the landing.



(a) Render camera in first person perspective (b) Render camera following the robot

Figure 10: Images showing the start position and the following position of the render camera

5 Lighting and Textures

5.1 Lights

With the animation being done and edited to fix small imperfections, it was time to light up the scene. Firstly, I experimented with the spotlight, thinking that I would put one of these on the robot in the beginning and after that I would put some directional lights along the path of the running sequence, to mimic the rays of the sun. Ultimately, I decided to search for an HDRI skydome that I could insert into my scene and have all the light I need. The idea was to have the proper lighting but also the background of the skydome had to blend into the scene created, thus, after multiple tries with different types of skydome I decided on the "yellow field" HDRI from Poly Haven. It is a perfect fit for my scene as I have put it in a way so that only the sky and some treetops can be seen during the render sequence (figure 11).

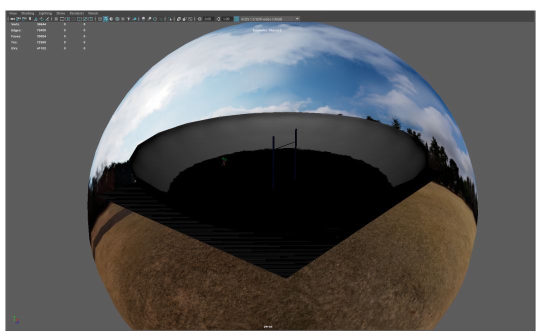


Figure 11: The skydome used in the scene

5.2 Shaders and Textures

After I lit up my scene, it was time to put some textures on my character. I started searching for texture images and downloaded different files from sites such as WallpapersMug, Pixabay and Peakpx. Then I tried every texture file on different parts of the body until I found a good fit for the arms, torso, head, waist, middle wires and leg joints. For the thighs, shins and feet, I opted for a custom shade of blue that looks pretty good in the light. For texturing, I chose the planar method of mapping the UVs of the texture onto the 3D models of my robot as you can see in the figure 12 below. To see how the textures actually would look like in the scene, I frequently opened the Arnold Render View and moved the camera around my robot to see if the textures look as intended and if there are any distortions. I also made sure to make the binary decision between 0 and 1 for the metallic property of the shaders.

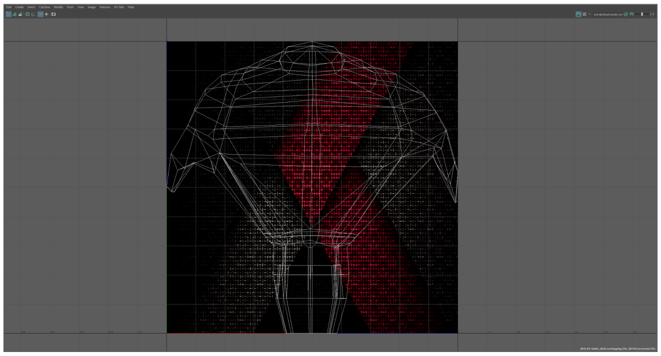


Figure 12: Planar mapping of a texture onto the torso

6 Rendering

Once I was happy with the textures and the lighting in my scene, I proceeded to the render part. Firstly, I had to check the render settings and ended up with a jpeg image format. I set the quality of the image to 100, the frame padding to 2, the renderable camera being the new camera with the aim that I created and animated, and changed the image size from 720p to 1080p. After that, I chose Render Sequence and Arnold began to render the scene frame by frame. I have 250 frames in total with 10 seconds of animation, thus, there are 250 images in total. The last thing left to do was to combine all of these images and create an mp4 out of them and to make that possible, I used a software called ffmpeg.

7 Conclusion

With the render also done, my whole scene was now complete. I went through almost all the practices of modelling, animation, and rendering with the correct light and textures. From just bevelling and extruding a simple cube shape, I got to learn how to model complex shapes using image references, as well as modelling through vertices, edges and faces using multiple important and efficient functions such as the multi-cut tool, loft or revolve. On the animation side, I learnt how to rig and correctly parent the components of a character, as well as key framing and experimenting with the graph editor. I also learnt how to map textures on a 3D mesh and how to place different types of lights in the scene such that the textures and shaders on the objects look as intended. Lastly, if I was to start the same project again, I would clearly save a lot of time knowing what tools to use and when, for modelling, and the animation would be a lot more refined, knowing how to place the key frames a lot better. There are multiple moments when you tend to say that the animation is sped up. Also, for the textures, I would try to experiment a little more by connecting the Maya software with Quixel Megascans and map some high resolution scanned textures from there, to some objects from my scene. That being said, I am confident that I have got to use all the tools and concepts presented in this unit and successfully created a scene with them.