2022

CGI REPORT

JINGXUAN LIU
JL17432

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JINGXUAN LIU

CGI PROGRESS REPORT 2020

1 Design and Pre-Production

1.01 Brief introduction to the project

This project is the final mini project for unit coms30058 CGI, in which the undergraduate students have been taught the skill on modelling a complex polygonal geometry in Autodesk Maya, keyframing the pose to form a set of continuous movements, constructing environment lighting, shader and UV texture mapping, and finally synthesize the previous progress outputting a 10 second animation on a given thesis.

This report reflects my whole learning process throughout the unit, including the design of the model, method of model development, character set-up, problem identifying and problem-solving, and finally, the production of the final video. Personally, I plan to work in the game industry after graduation; this unit gave me valuable experience in character production and my first taste in rendering. This project has offered me a challenging but enjoyable goal to work on because everything in this project has created a novelty environment that I had not touched before; although I had to overcome the problems while embracing the new, each solution I have found to the problem makes me feel a small step further to my career pursuit.

1.02 Understanding the background

The project was given a background of developing a Pixar-style animated film and game franchise with a working title: Olympoids. The film and the game assume a fictional future Olympic Games in 2040, where not a single human will join this fantastic global contest; all competitors will be robotic droid characters. These humanoids will compete in the same events as those in the present-day Olympic games and follow the same Olympic spirit. The project's goal is to set up my own android character and create a 10-second video clip showing the best moment of this competitor performing in its event.

1.03 Dividing goals and managing workload

The lecturer provided a manual for this unit and explained, in detail, the background of the project and expected weekly workload, which gave me an overview of the whole project and the approximate labour I should take.

The ultimate destination of this project is to build a humanoid polygon model and then render a short animation recording the character competing in an event. To gradually reach this goal, I have divided it into intermediate goals. I have also set up some milestones for each intermediate target and identified some problems I might encounter.
There are four intermediate goals: character designing, character modelling, animation keyframing, and texture and environment setup. In Chapter 1 – Design and Pre-Production, I will only focus on the first goal, character designing. I will demonstrate the rest of the intermediate goals in the following sections, where I will detailly describe my production process.

1.04 I Character Designing - Choosing the sport

I needed to focus on two distinct but intersecting areas at this stage. I needed to do some research on the Olympic games to determine the sport I wanted my humanoid to participate in and create a hand-drawing draft indicating the general appearance and structure of the robot's body. However, to make the character in harmony with the background and environment, the robot's appearance should be highly related to the actual athletics in the present-day Olympic games.

Personally speaking, I am not a fan of a particular sports. Therefore, while I was scanning the sports throughout the Olympic sports list, there were two main factors that I was concerning about: difficulty of implement and the capability of showing my skills. I wanted my final video clip to maximumly show the skills that I have learnt from this unit while at the same time keep the modelling and animation to be not over-difficult. Bringing to the background of the project, two examples to demonstrate my concern could be: a 10-second boring jogging video is not very likely to attract customers to spend time and money on my game or movie, and: as a layman in drawing and a 3-D modelling beginner, it is unpractical for me to draw a commercial grade sketch and model it out. Considering all these, I chose my sport to be weightlifting.

According to the video resources, the first reason for choosing this sport is that a weightlifting is an individual event that does not require complex equipment. During a weightlifting competition, the sportsman or sportswoman wears a weightlifting suit and a pair of sports shoes and puts their best effort into raising a barbell. In addition, a knee protector, waist protector or wrist protector may be needed to support different body parts depending on the athlete's physical condition. This equipment has straightforward and regular shapes, so it's easy to be modelled.

Another reason is that during the weightlifting process, the athlete does not have much displacement; however, their body is doing intensive movement in a very short time. The weightlifting contest in the modern Olympics includes two events, the snatch and the clean and jerk. While snatching, the athlete is expected to lift the barbell above the head at one time. In contrast, the clean and jerk allow the barbell to be held on the chest before being raised overhead. However, any pause during lifting in both events will be treated as a failure in an attempt. The whole process should happen in the designated area, on a specific size pad. Athlete steps beyond the border will also lead to a failed attempt. The result of the athlete will take the addition of both events into consideration.
All the rules introduced above would allow me to show the skills I would learn from the unit, by keyframing a set of intensive, non-repetitive body movement of my character on a size-confined weightlifting pad, in which will reduce the level of difficulty.

1.04 II Character Designing - Sketching the draft

After determining weightlifting to be my sport, the next goal is to design my character's structure and appearance. I decided to draw a rough outline of a humanoid first and then fill it in with detail and the Olympic and weightlifting elements. As shown in Figures 1.01 and 1.02, my initial drafts are just piling up triangles to form an approximate shape of a robot. Although the geometry looks simple but these drawings helped me to understand main body parts that I need to model.

As shown in figure 1.01 and 1.02, each triangle is corresponding to one body part, take as an example, in figure 1.01 you can clear distinguish there are four main parts on an arm: a shoulder, upper and lower arm, and a hand. It is also interesting to note that at beginning, I designed a battery container hanging in front of the chest (see figure 1.02). This idea came from the famous action game developed by Kojima Productions, Death Stranding, where the hero in the game has an incubator in front of his mountaineering suit and the baby inside performs as an early warning system to the enemies (see figure 1.03). Nonetheless, this design was denied when considering adding the Olympics elements into my design. As shown in Figure 1.04 and Figure 1.05, two Chinese weightlifting athletes are trying to lift a barbell in two consecutive Olympic games. Observing the two sportsmen, although 4 years has passed, the clothing has not change significantly. Both athletes were wearing a sports t-shirt and a sleeveless sports vest on the upper body, this gives me the direction of my design on the character's chest: a sports vest shape in the outer layer of a chest body.

Then, after observing several existing robot model designs, I had a basic understanding of some simple mechanical structure. I will not list all the pictures of the models that I studied because of their big amount. Instead, I will exhibit and analyse the ones that inspired me the most in the following context.
In figure 1.06 and 1.07, I had added some complex structures to the design. In the two drafts, it can be clearly seen that there are joints connecting different parts like shoulders and the chest, and legs and the hip. While I was drawing the draft, I try to do the modelling at the same time. I found some complex structure that I am not able to reflect on the canvas can be easily realised in modelling. Therefore, the problem of my poor talent on drawing can be solved on 3-D geometry space. Hence, I tried to treat my sketch as a reminder of designs and a tool of recording ratio of different body parts, this worked well for me.
There were some disagreements in figure 1.06 and 1.07 and especially on the lower body. This is due to the lack of the experience on drawing perspective drawings and reflects my struggle on the two different styles: to be more robotic or to be more humanoid. I finished the front view before the side view. At that time, I designed the legs to be complex mechanical structures that are similar to the structure in figure 1.08, which look like a joint structure with an air hydraulic damper. I chose this structure because the good effect it would show on supporting weight and shock absorbing during the robot athlete holding a heavy barbell and doing intensive movements. Nevertheless, when I was drawing the side view, I realised that this structure is so complex that my confidence of modelling this geometry was shaken. In addition, it would be hard for this structure to be connected to the Olympic and weightlifting thesis. Therefore, the legs in the side view were designed to be more similar as human's and the feet were designed to be a pair of sports shoes. In the modelling process the legs was designed to be human legs shaped armours covering the leg bone.

The design of the head came from the shape of my mouse which I always think it looks like a robot face. (See Figure 1.09 and Figure 1.10). I modified and simplified the shape to make it more like a head by giving a curving shape and evolve the mouse wheel to be a mechanical eye. While modelling, the position of the chin was lifted, and the shape of the curves were slightly modified to create a better-looking ratio of the face.

Figure 1.11 demonstrates a structure of a robots' waist and legs. This picture inspired me on my design, as my character would need a flexible and strong structure on its waist to do movement like stooping to catch the barbell. The design in this model shown in the figure 1.11 are mostly using turntable, joints and links to allow the robot to freely twist its waist. Similar structure can be found in my design shown in Figure 1.06. However, I have strengthened the structure with thicker cylinders and a supporter around the vertical pillar to allow my character's waist to support more weight. The supporter was finally replaced by a waist protector in the modelling process so that the robot could carry more weightlifting elements and has a better visual effect.

The arms were designed referenced the structure of a robot model shown in Figure 1.12. The robot in Figure 1.12 has a giant joint in the shoulder and a smaller one as an elbow. This reflects good capacities on rolling shoulders and bending arms, hence allows the character to grab the barbell and lift it up. The arms in the draft were simplified to reduce the work of drawing.

1.05 Reflection

The fundamental research and design process took me roughly a month to complete. I came up with many creative ideas at first; however, some of them were finally denied due to the unpracticality and high cost of labour. This is because the cost of making significant changes in this process is inexpensive. Although I found it challenging to produce good drawings, my 'lo-fi sketches' can help me recall my design thoughts and realise these ideas in 3-D space in Maya is more manageable than drawing. Also, I found that balancing my focus on designing a humanoid and combining the robot with Olympic games elements is more complicated than I thought. I had to study the structure of robots and then add the Olympic features to an existing structure. This caused some alterations to the design and some unnecessary, redundant labour.

2 Character Modelling

In this section I will demonstrate how the geometry of my model has been set up. The pictures of the final geometry can be found in the Appendix 2. as Figure 2.01 – 2.04. I will introduce and compare the methods I have used while developing the model. I will also demonstrate the difficulties that I have met during modelling and the problem-solving process.

2.01 Head: Curves, Loft and Planar

The design of my head was inspired by my mouse, which has a curved shape. Therefore, as shown in figure 2.05, I used CV Curve Tool to sketch the shape of the head. Then, by closing the curve and duplicate this curve, I could loft a smooth surface shown in the middle of the picture. Finally, adjusting the shape use the Fill Hole tool, I had generated the final head shape shown in the right most picture. In this stage, I had also tried another method to achieve the similar result. By Planar the original curve, I could generate a plane surface. Then I could extrude this surface to create a head shaped geometry as shown in Figure 2.06. However, the highlighted edges in the figure indicating an inconsistent surface on the face. In addition, the arrangement of the edges on the face would be not as clear as the first method.

Same strategies were also used when creating the mechanical claw, which also has a curved shape.

2.02 Chest: Bevel and Extrude

As mentioned in Chapter 1, my design of the chest would be a chest body covered by a sports vest. The nature of this design decides that I could build up a chest body first and then use the geometry on the body to create the vest shape. During the process, the Bevel tool and Extrude tool are extremely helpful. As shown in Figure 2.07, the Bevel tool allows me to give more faces to a geometry and so that smooth the edges. On the other hand, Figure 2.08 shows that the Extrude tool could duplicate or extend some parts of an existing geometry without breaking it. Then, by repositioning the vertices, a chest body was finished. Finally, I used the Multi-cut Tool to increase the edges and faces that I could manipulate on this body, extruded surfaces need, repositioned vertices and delete unnecessary faces to create a vest on the body (see Figure 2.09).

Bevel tool and Extrude tool are the most used tool while setting up my model. Therefore, almost every part of the character has used these tools. Nonetheless, it is still worth mentioning that although these are the most frequently used tools in modelling, the strategies, and the ways of make the best use of these tools is hard to figure out. Take, as an example, the flow path of building up the structure of a fan (see Figure 2.10), where the last stage came from smoothing the previous stage. Despite I did not put this geometry in my final model, learning the process of how a complex shape this can be generated by a much simpler geometry significantly wider my experience while dissecting other complex geometries, especially on modelling the armour on the legs and the joint on the elbow.

2.03 Arms: Boolean operation and Mirroring

Previously mentioned, the structure of my character's arm was referenced to the robot model in Figure 1.12, which has outstanding designs and complex geometries. I did not save interim screenshots for modelling the arms because I was struggling on solving a problem causing the parts on the arm producing different displacement while I was moving or rotating the whole arm. My original solution was to union all the parts and form a single object and therefore I lost the geometry for each single parts shown as Figure 2.11. However, later I found that this problem might be caused by that I did not delete the history after taking a Boolean operation. Hence, I will show some screenshots on rebuilding some important structures to demonstrate which method I used.

Although the structure on Figure 1.12 looks complex, it can be seen as the combination of a number of cylinders and bevelled polyhedrons. Therefore, the main body of the upper arm shown in Figure 2.11 can be generated by take the union of a cuboid and four cylinders. The hook shaped geometry on the top of the upper arm can be got by taking the difference of two cuboids as shown in Figure 2.12 and 2.13, where the tilting cuboid has one face been bevelled. I increased the number of segments to create a smoother incision. After finishing one arm, the other one can be got by mirroring the finished work as the design of the model is perfectly symmetric. There are two ways of mirroring it, using the Mirror tool of duplicate the model and then take inverse value of the transform attributes. There is no significant difference between the two approaches.

2.04 Shoes and waist protector: Inserting Edge Loop and Non-linear Deformer

I found pictures of a sneaker and a waist protector and the models of these were done according to the pictures. I created a cube, scaled the cube to an appropriate size and then used Edge Loop tool to trim the shape of it. (See figure 2.14 to Figure 2.17). Where there is significant change in the gradient of the edge, an edge loop would be added to adjust the shape to match the reference pictures by adjust the position of the vertices. To create the bend shape of the waist protector, I used the Non-linear Deformer tool to create a bend handle as shown in Figure 2.18. I could adjust the degree of crook by changing the curvature value in the channel box on the right-hand side. At first, only the middle of the waist protect model could band and soon I realised that the strap part had very few edges for the calculation. This problem was solved by adding certain amount of edge loops. The complete model of the waist protector was achieved by mirroring the bending half model.

2.05 Reflection

The modelling process is the section where I have met the most problems compared with all other sections. This is mainly because of the unfamiliar with tools in Maya and the modelling methodology. However, as the more model I built, the more experience I gained, and the easier for me to model more complex geometry. While I was modelling a piece of geometry, I usually tried the method that I had used before, and then search some online tutorials to discover if there is other method to achieve the same results. This is considerably helpful for me to compare different tools and methods and discover new tools that I had not used before. It is tough for me to nominate which part of the model makes me the proudest because every piece of geometry made me learn a little bit more and gave me the pleasure and the confidence on continue doing modelling. Realising my design on a 2-D flat canvas come true in a 3-D space is a very enjoyable process.

3 Animation and Keyframing

3.01 Rigging the skeleton

The skeleton of my character is shown in Figures 3.01 and 3.02. All the joints were added according to the structure of the model. As the geometry is perfectly symmetric, the right half of the skeleton can be set by mirroring the left half. There is an extra joint was added just above the root, in which is the centre of the model. See Figure 3.0 The reason for adding this joint is to control the rotation of the upper and the lower body. Instead of controlling some parts of the entire model, the root itself should be responsible for all the geometries belong to this model. Moreover, two IK-handles were rigged on both legs to facilitate adjusting the pose of the character. At first, the IK-handle were causing very strange movements, for example a twisted leg. Then, after correctly setting the limitation on transform attributes and the rotate order, the leg can move within a pre-set range. Also, I found that the initial rest pose of the character should have slightly bending legs to prevent the IK-handles from calculating weird motion trails. It is also interesting to note that the two feet were not rigged to any joints because if I did, the IK-handle will control the rotation of the feet along with the legs.

I created a Point Constraint to make sure the foot should move with the leg while no rotation on the foot itself with respect to the World-Axis. In the animating stage I manually adjusted the rotation of the feet in every keyframe.

3.02 Understanding the movement

Before I keyframing the model, I needed to analyse the body movement of a weightlifting athlete and decide which set of movements I wanted my character to perform. The 10-second restriction on the length of the video is asking me to record the best and the most interesting moment would happen in my character's event. I chose the entire process of clean and jerk, because the whole process is just above 10 seconds and there are no repeating motions on the athlete. Overall, it can be divided into three main phases: picking up the barbell, lifting the barbell and holding it on the chest and finally raising it over the head. This creates three main key frames for my animation and my whole animating process followed these three stages. I had found several video clips to analyse the motion in each phase and animate my character.

3.03 Picking up the barbell

This phase occupies the first 2 seconds; the athlete needs to prepare before stooping to catch the barbell. The most important thing to do is adjust the distance between the feet to be roughly the same as the distance between the two shoulders. This will change the athlete's centre of gravity and facilitate the following motions according to Video 1 in Appendix 3. Therefore, I animated my character to separate the legs, and the head will be looking at the feet accordingly. The animation was set up by adjusting joints and setting keyframes. I set a constraint for one arm to rotate the same degree as the other arm does. Then, the character should crouch, grab the barbell, and prepare for the lifting. The camera's movement is a dolly shot, moving towards the character at a constant speed.

3.04 Lifting the barbell to the chest

This stage takes 102 frames. By analysing Video 2, the athlete in this stage first raised his waist and bounced from the floor to lift the barbell from the floor. Then, the hip of the athlete went down, and he flipped his arms so that he could position his chest low to hold the bar bell on his chest. Finally, he stood straight up in a slow-in way. These were all achieved by adjusting joints and IK-handles. To achieve the slow-in effect, I adjusted the gradient of the translate curve of the model on the graph editor. I also rotated one foot for a small degree to make the entire movement looks more natural. According to the Squash and Stretch Disney Principle, the object's shape could distort before and after the impact point. Whenever my character finishes or starts one movement, there are a few 'buffer frames' to balance the momentum of the previous movement. In these frames, the character is 'shrinking and expanding' in a small range to emphasise the impact of the movement. The same effect can be found on the barbell, where the barbell is distorted to show the effect of inertia. I had also met a problem while animating the barbell; in the previous stage, the barbell was at rest, whereas it moved along with the character's mechanical claw. My solution is to duplicate the barbell and create Expressions on both barbells to control their visibility. One will be rest on the ground at all times, but when stage two starts, it will be invisible. In contrast, the other barbell will be a constraint to one claw all the time and can only be seen after stage one.

The camera's movement is a track shot from left to right, where it will always focus on the character giving a scan of the entire character.

3.05 Lifting the barbell over head

This phase occupies 60 frames. Video 2 shows that the athlete crouched slightly to raise the barbell overhead; the tiny crouching movement matches another principle of Disney: Anticipation. Anticipation suggests that the character perform a reverse move to create momentum. Therefore, I always spent several frames animating the character to lower its body before standing up in my animation. Then, his body began to dip low because of the weight of the barbell. The legs were also more separated. Finally, the athlete closes the legs and stands still. These movements can be animated by using the same method mentioned previously. The camera in this stage moves along with the body. This will create a feeling of involvement to the audience, as if they are experiencing the same motion with the athlete.

3.06 The interesting thing

I wanted my video clip to be more than just lifting a barbell in a weightlifting contest. Therefore, I decided to add some unique movements at the end of the video. While watching Olympic weightlifting videos, I found one iconic moment in Tokyo Olympic Games, as shown in Video 3. After standing still with the barbell lifted over the head, this athlete also lifted one leg to balance his body. This challenging pose is exciting that the public believed this movement was a show-off, indicating that this athlete could hold the weight on just one leg. However, the coach and himself explained in the interview that it was a necessary motion to keep the balance at the moment. I animated this funny pose in my video, and I also created a trembling effect to show that the character is trying to keep balance.

3.07 Reflection

Animating is my favourite part of the project as it makes my model alive. Also, the rapid progress gave me a lot of confidence and self-satisfaction. At this stage, I did not encounter much trouble, and this has benefited from the complete setup in both modelling and skeleton rigging. Besides this unit, this module allows me to step into a brand-new area. I had a chance to detailly analyse one sport and the athlete's motion. I may pay more attention to the Olympic games and especially to weightlifting.

4 Texture and Environment Setup

4.01 Lighting

My lighting system consists of two sky dome lights and two directional lights. I had tried to use several panoramas pictures as the colour of the sky dome. However, the effect is strange and looks like the character is floating in the air. (See Figure 4.01). Therefore, I used the Arnold Physical Sky as my background. The other sky dome lighting provides more light in the environment, and hence it was set to be invisible to the camera. Figure 4.02 shows the two directional lights. The first directional light shines on the front side of the model to improve the brightness.

The second one shines from the top to reduce the shadow to show more detail. I did not use ambient light because this would cause local overexposure. I also do not have the demand to emphasise particular parts; therefore, point light and spotlight were not used in my scene. In fact, the combination of sky dome and directional light worked very well to enlighten the environment and the models.

4.02 Shader

Most components of the model have added a Standard Surface Shader. The combination of colours, yellow and red, came from the Chinese Olympic athlete sports suit, as shown in Figures 1.04 and 1.05. The mix of the two colours corresponds to the national flag of China. Instead of using solid red and yellow, I chose darker red and yellow to render my model. The reason for this is that I wanted my model to have a similar colour to the Iron Man, which is one of my favourite superheroes. (See Figure 4.03). I modified the shader's metalness and roughness attributes (as shown in Figure 4.04) to reflect a certain amount of light to create a mechanical and metal effect.

4.03 Texture mapping and UV space

Texture mapping was used on the shoes, the eye, and the barbell, to make the production closer to the real world. The eye and the barbell have more regular shapes compared with the shoes. Therefore, the texture could be mapped onto their UV space by Planar Mapping projected from a specific axis. The shoes, however, caused me a lot of trouble while editing UV space. As shown in Figures 4.05 and 4.06, the picture I found was the top view and the side view of the shoe. However, when mapping into 3-D space, the image could be stretched to fill up the surface around the geometry. I photoshopped the pictures and generated two texture pictures projecting from two different axes, as shown in Figures 4.07 and 4.08. The picture projecting from Y-axis has a better visual effect; it was finally mapped onto the UV space.

4.04 Reflection

This chapter makes my production more vivid and closer to the real world. I enjoyed reflecting on my own thoughts and creativity in setting up texture and environment. I would say this is the most charming part of CGI. One might build the most incredible model and animate it by dancing the best movement by referencing the existing design. Still, in my opinion, the model will be ensouled only when he empowers geometry with his unique thinking.

5 Appendix

Appendix 1

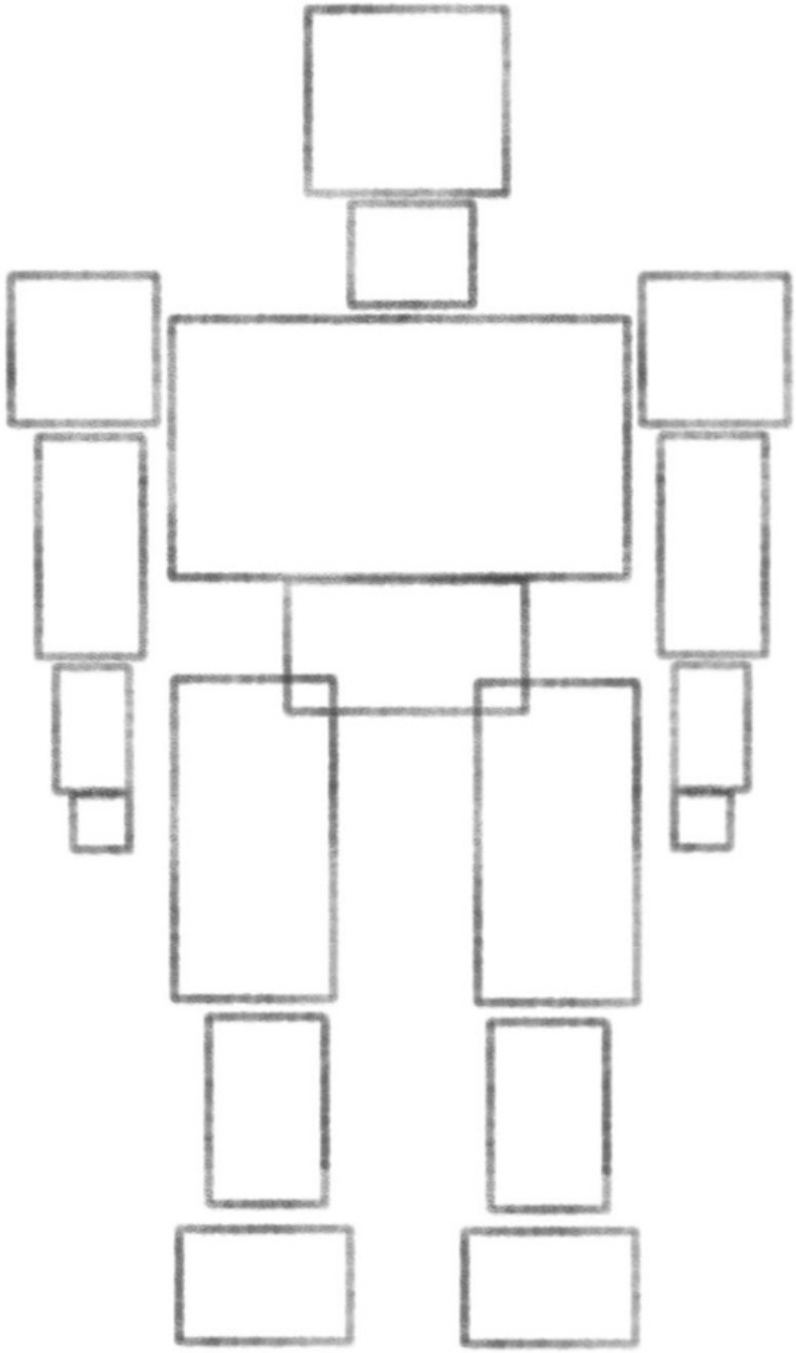

Figure 1.01

Appendix 1

Figure 1.02

Appendix 1

Figure 1.03

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Figure 1.05

Appendix 1

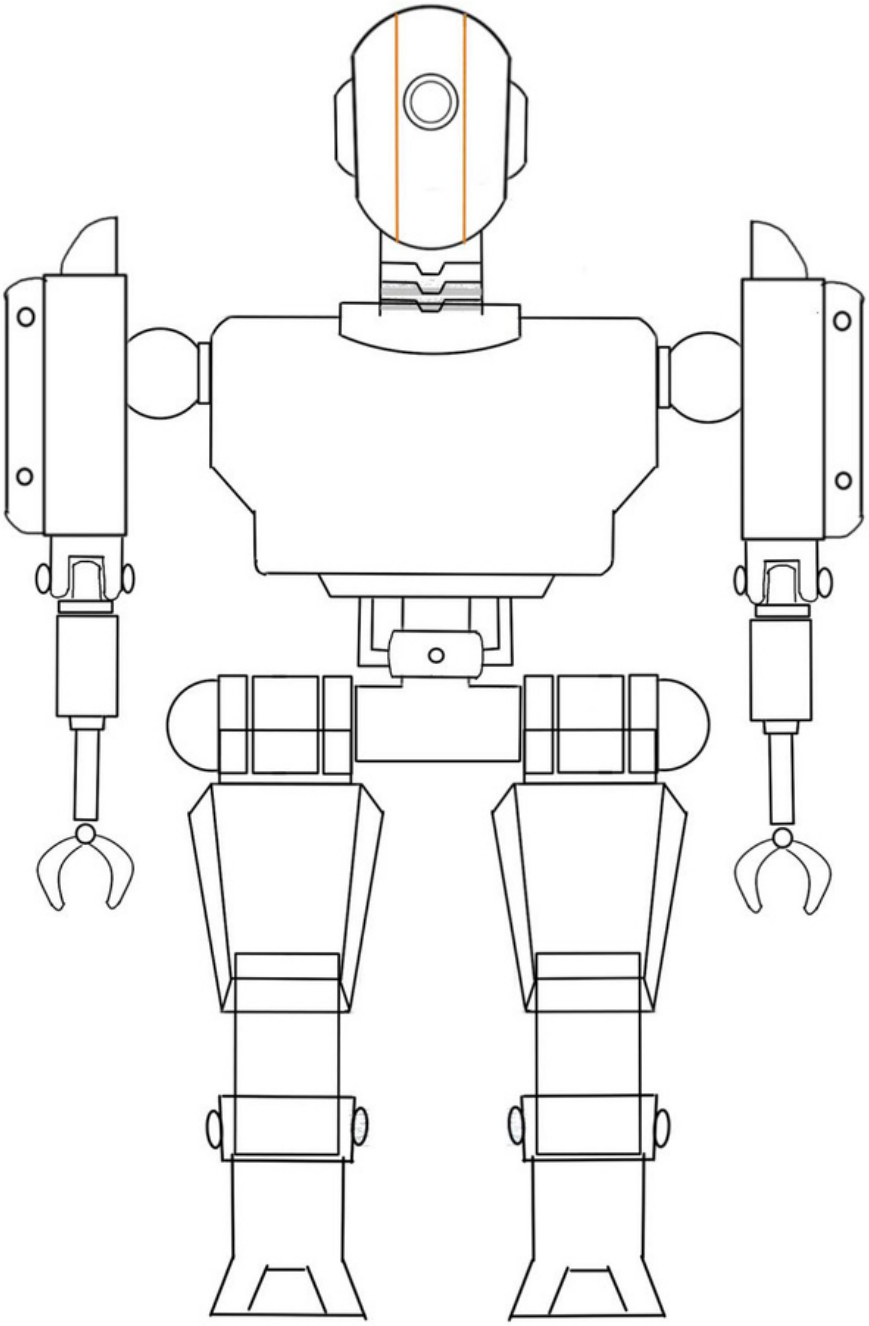


Figure 1.06

Appendix 1

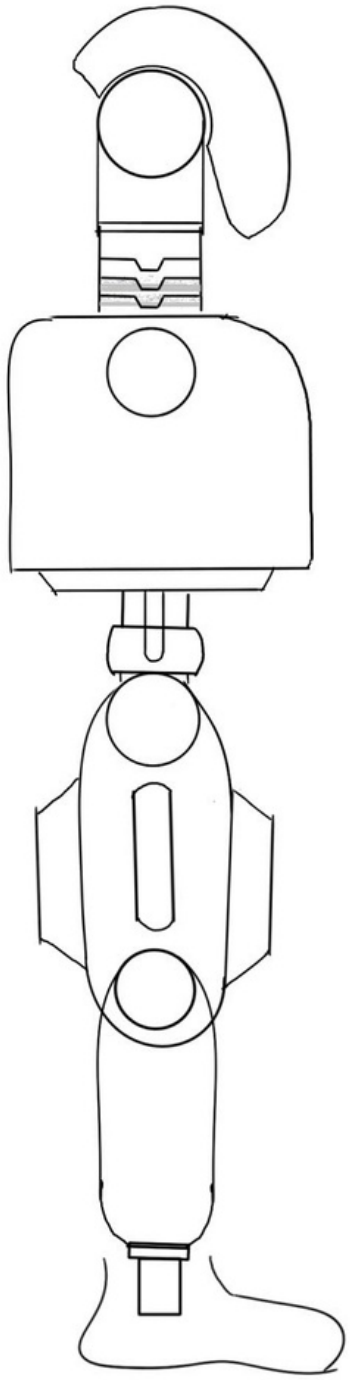


Figure 1.07

Appendix 1

Figure 1.08

Appendix 1

Figure 1.09

Figure 1.10

Appendix 1

Figure 1.11

Appendix 1

Figure 1.12

Appendix 2

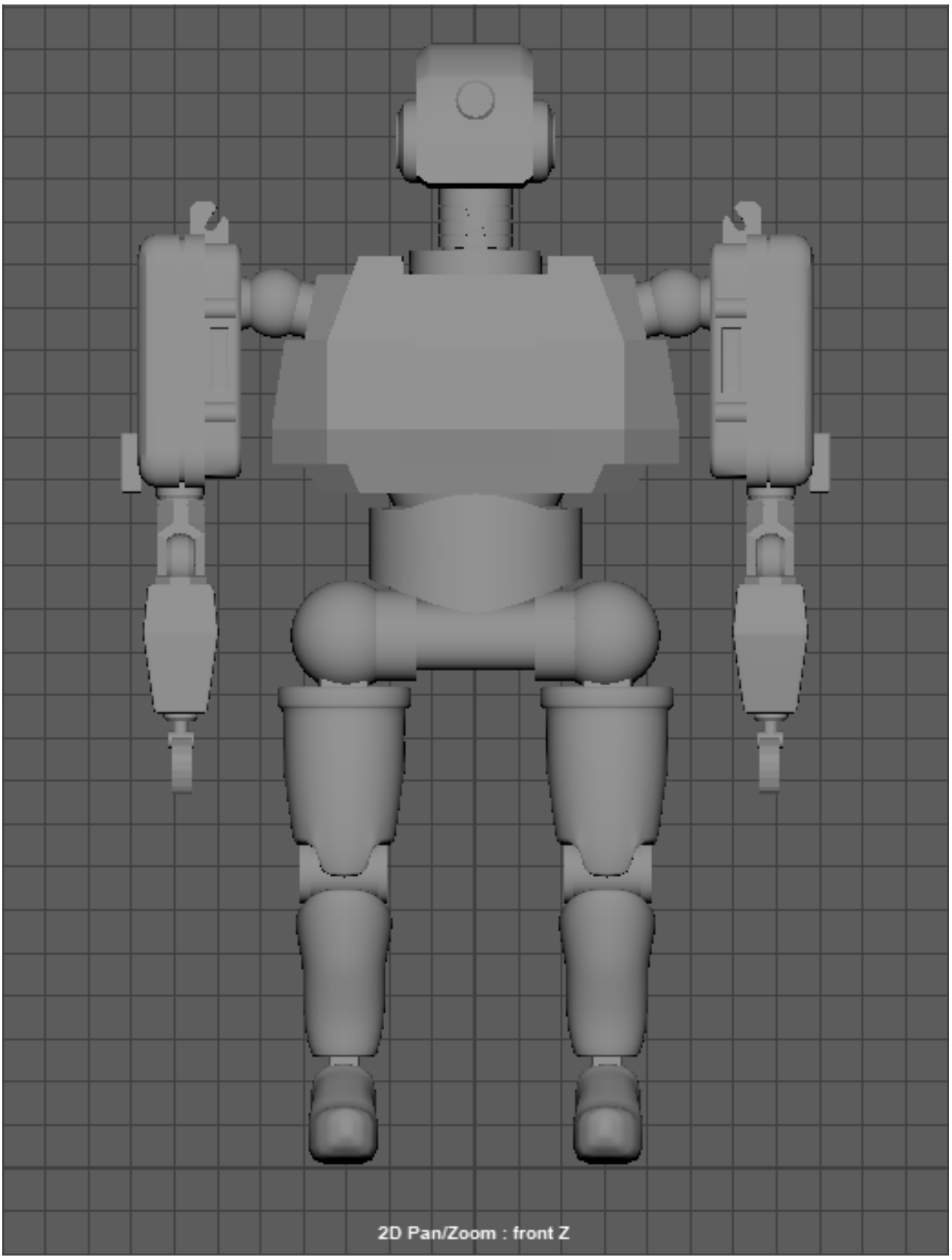


Figure 2.01

Appendix 2

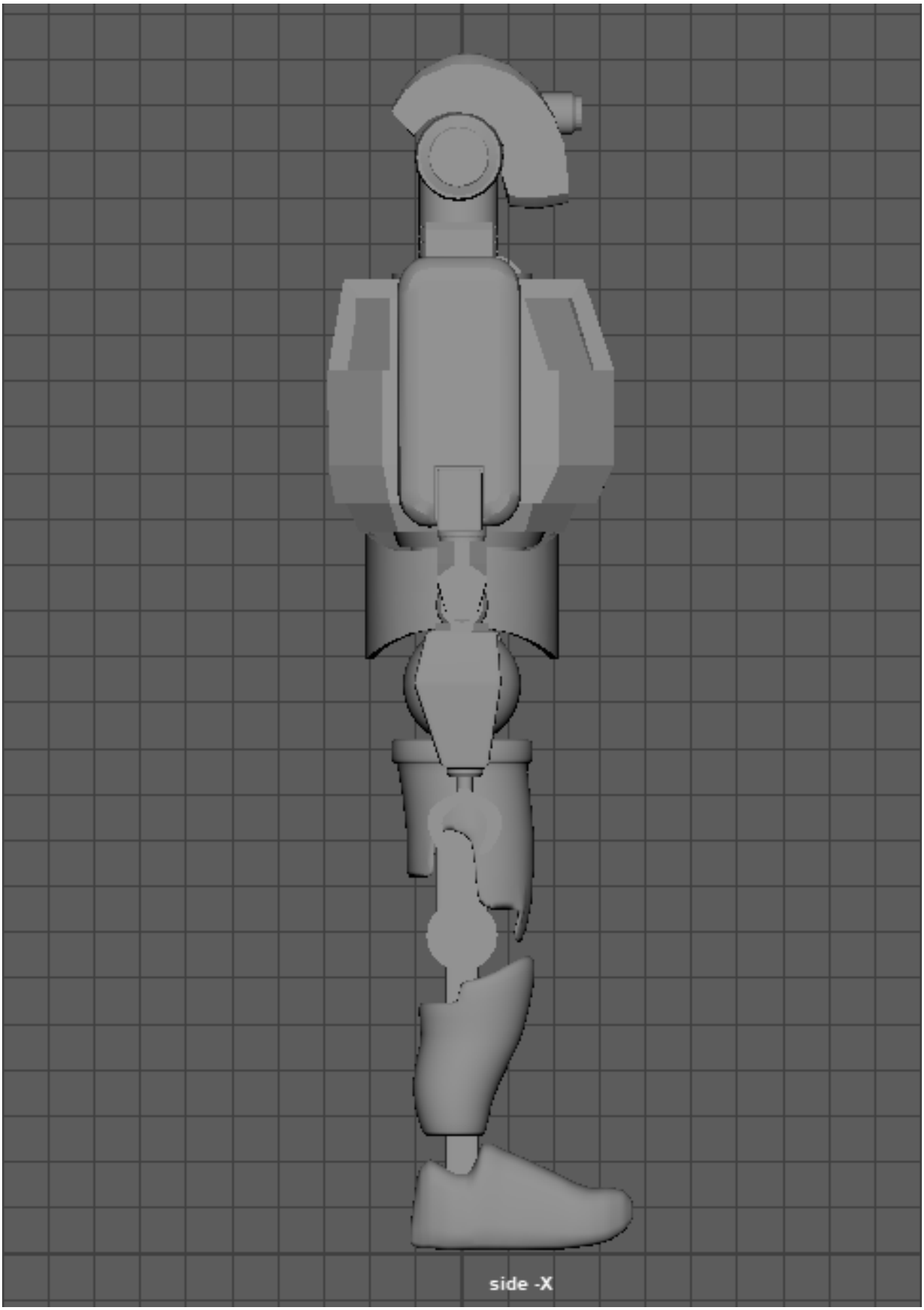


Figure 2.02

Appendix 2

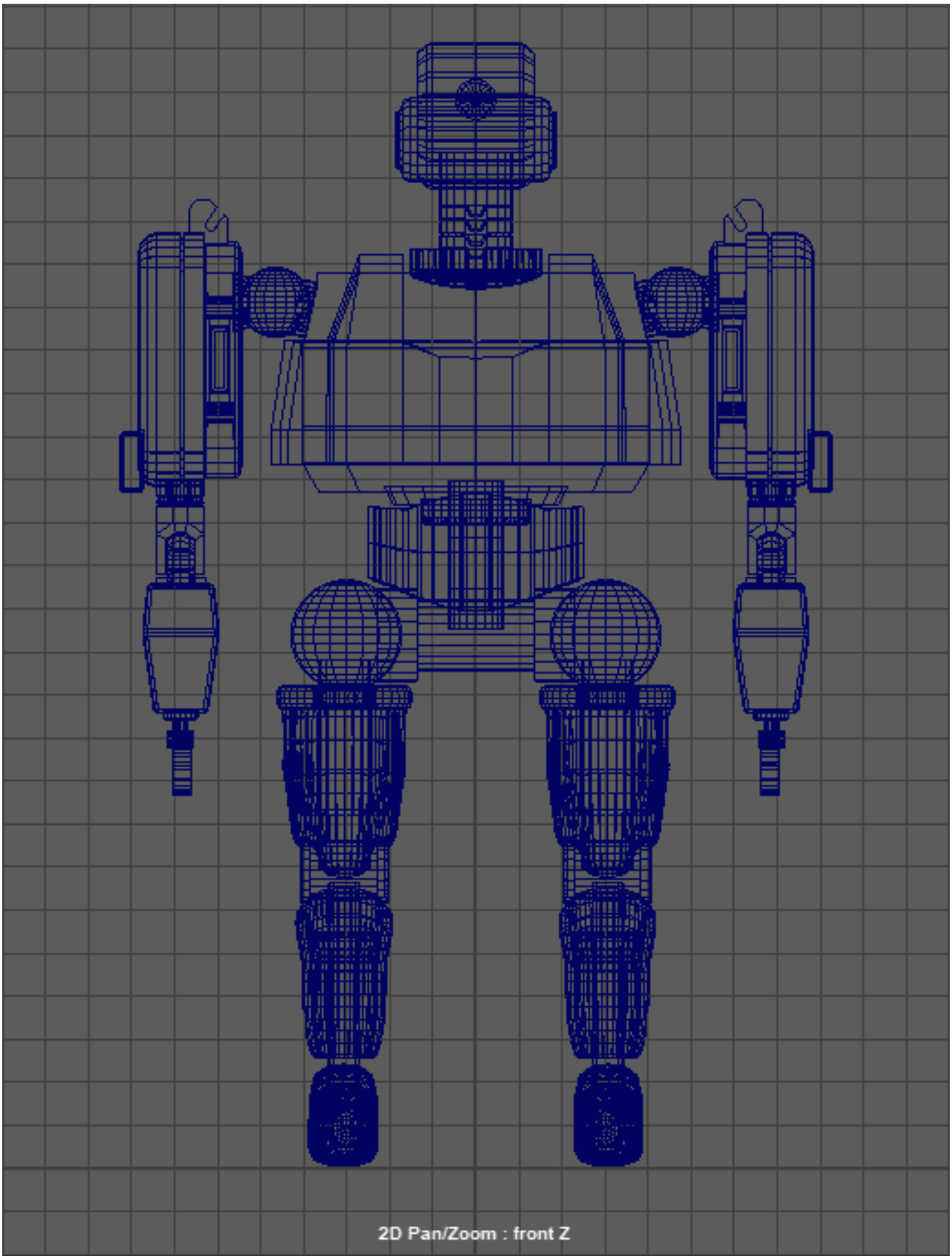


Figure 2.03

Appendix 2

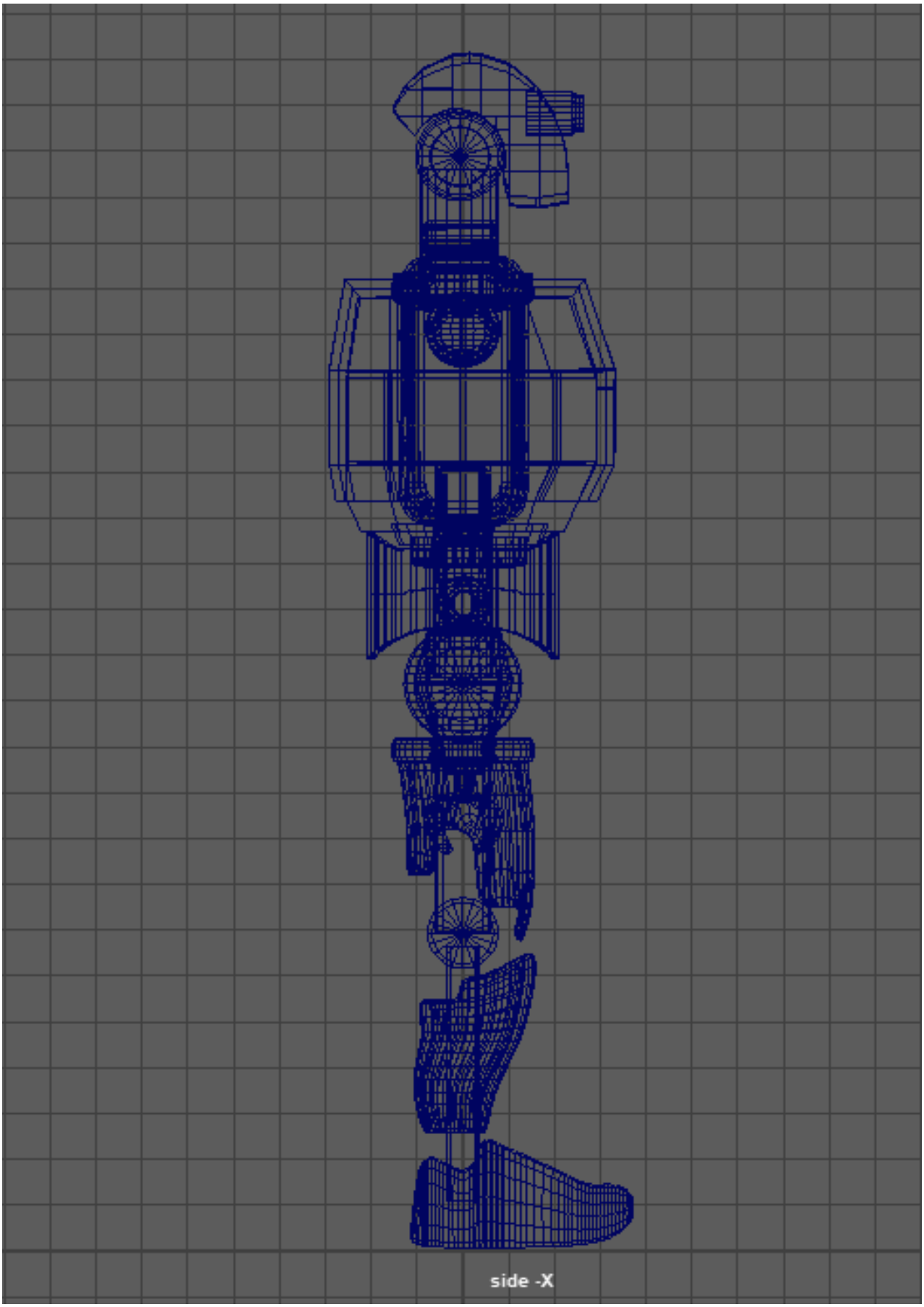
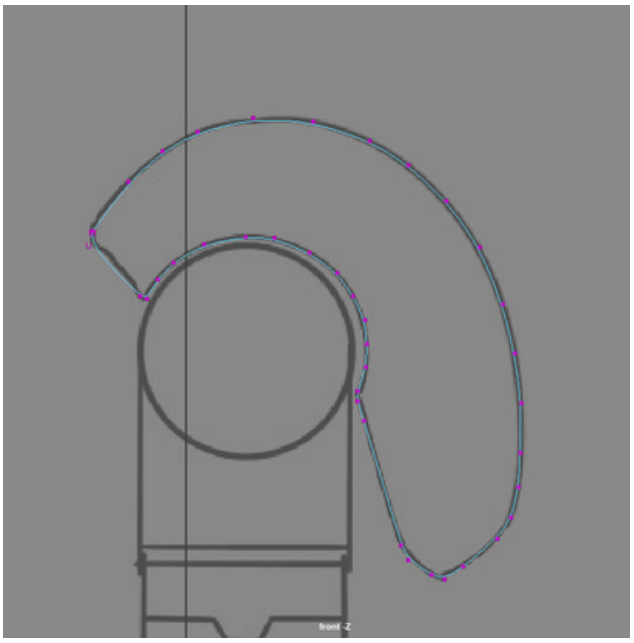


Figure 2.04

Appendix 2



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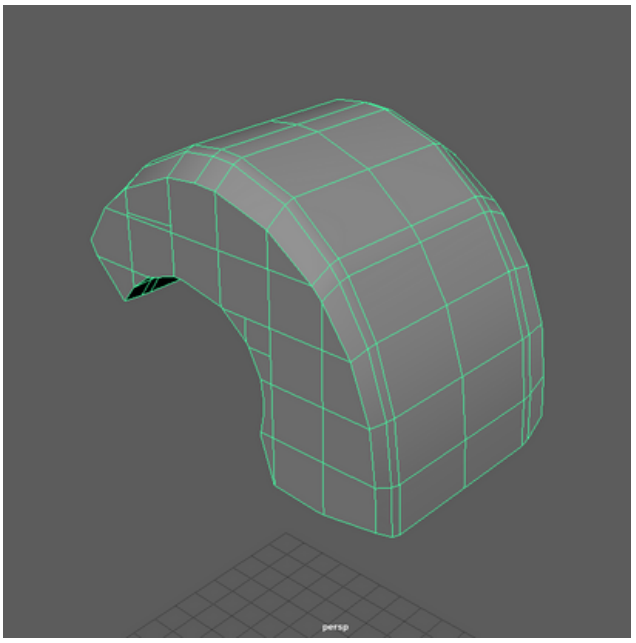

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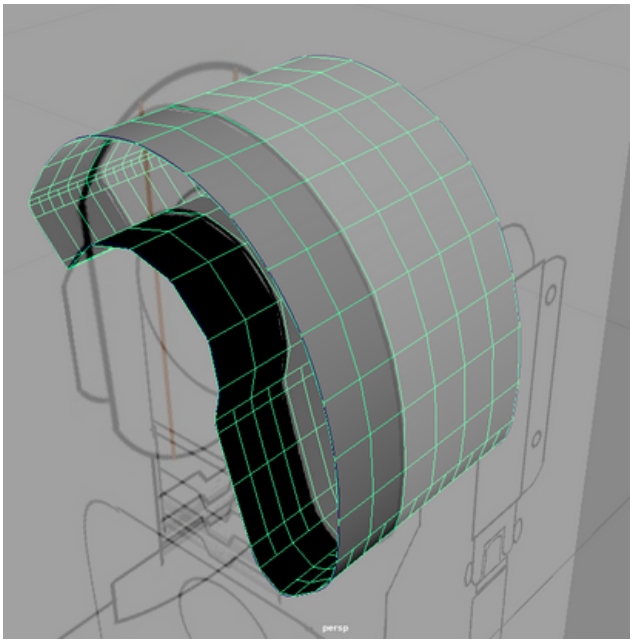

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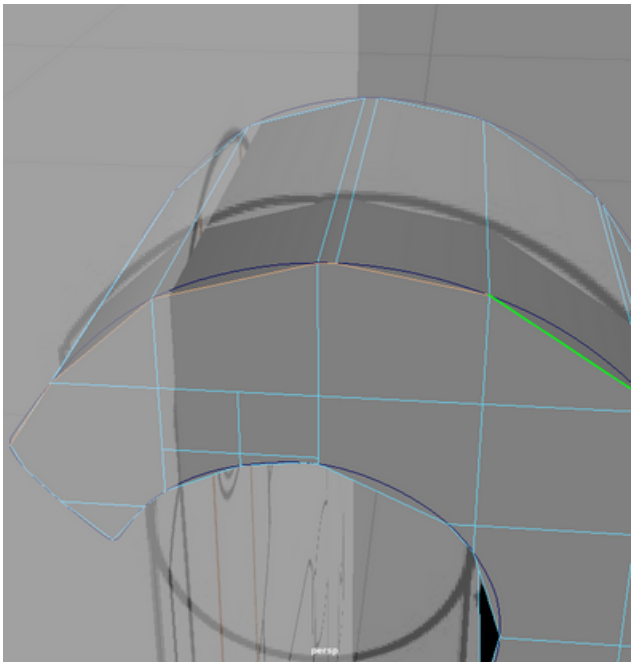


Figure 2.06

Appendix 2

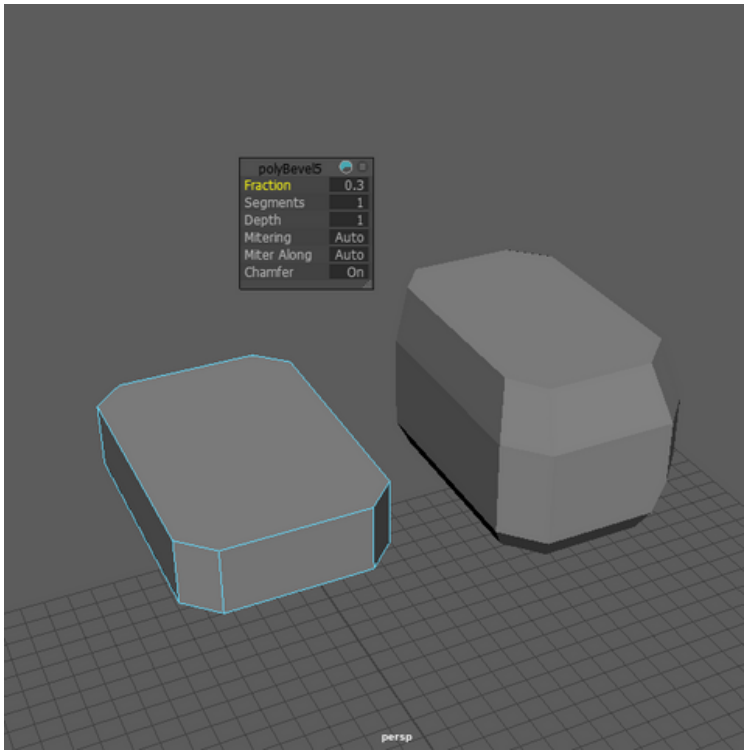


Figure 2.07

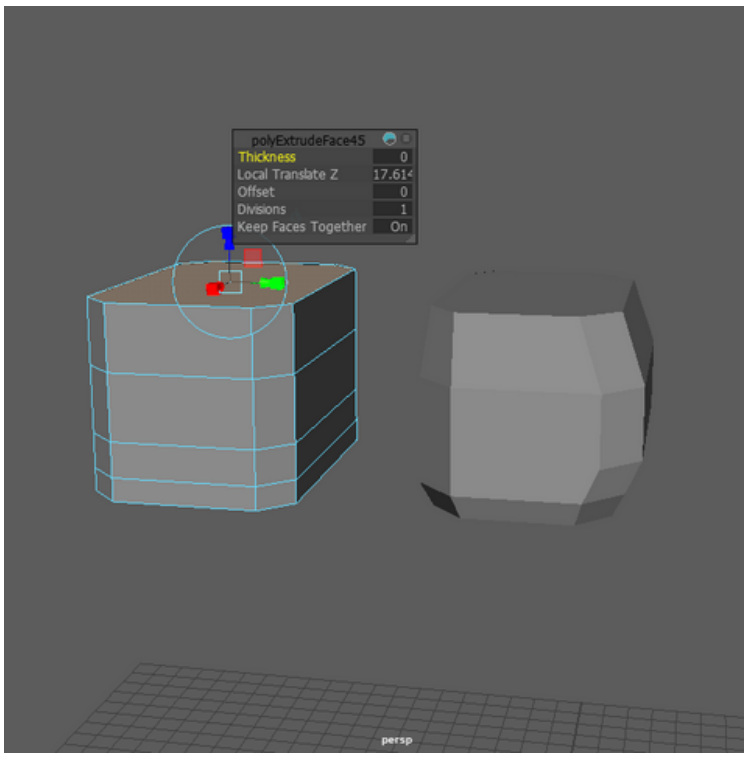


Figure 2.08

Appendix 2

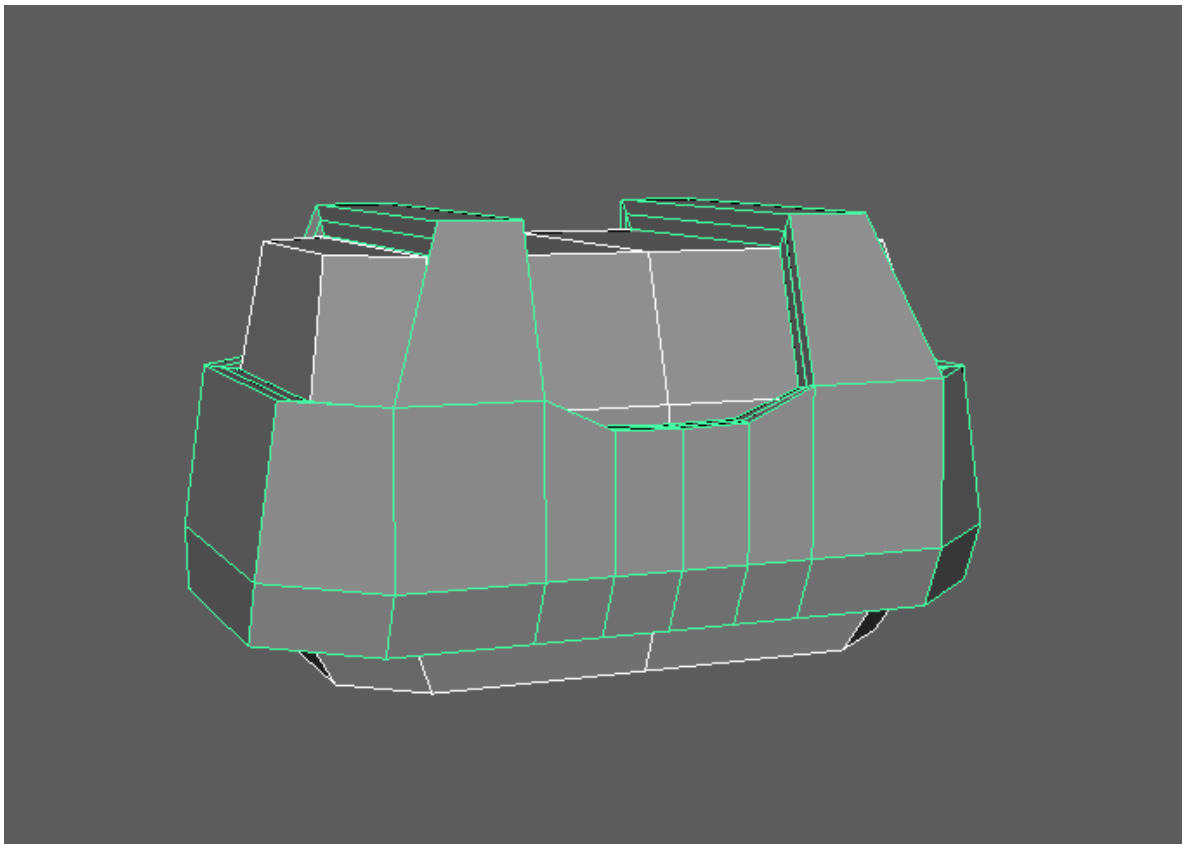


Figure 2.09

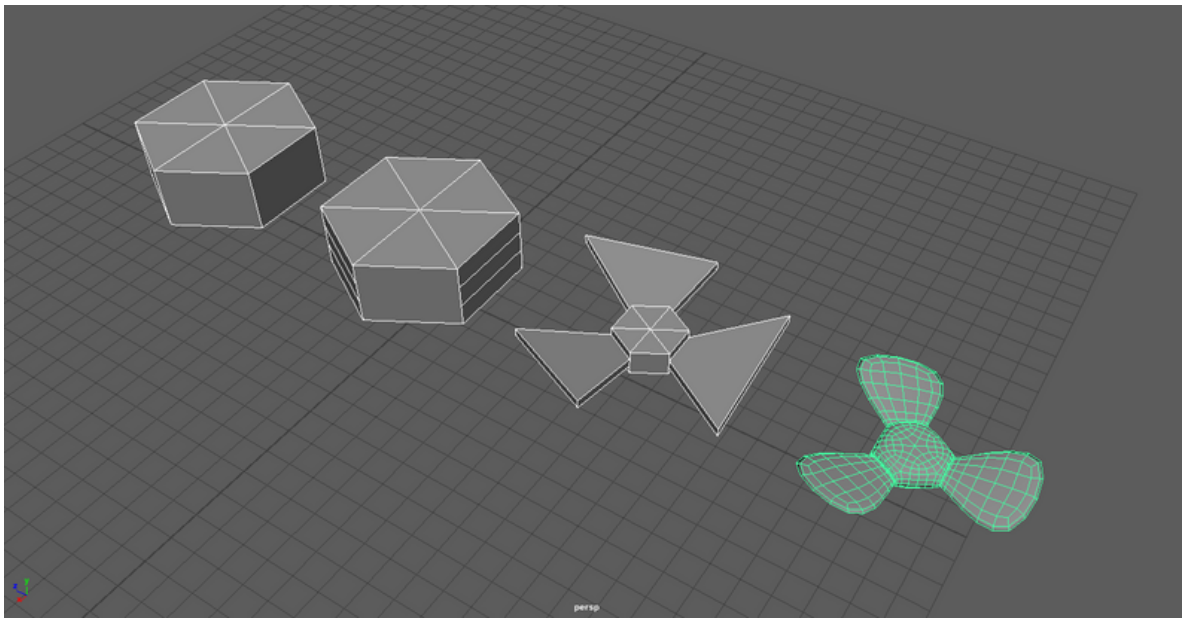


Figure 2.10

Appendix 2

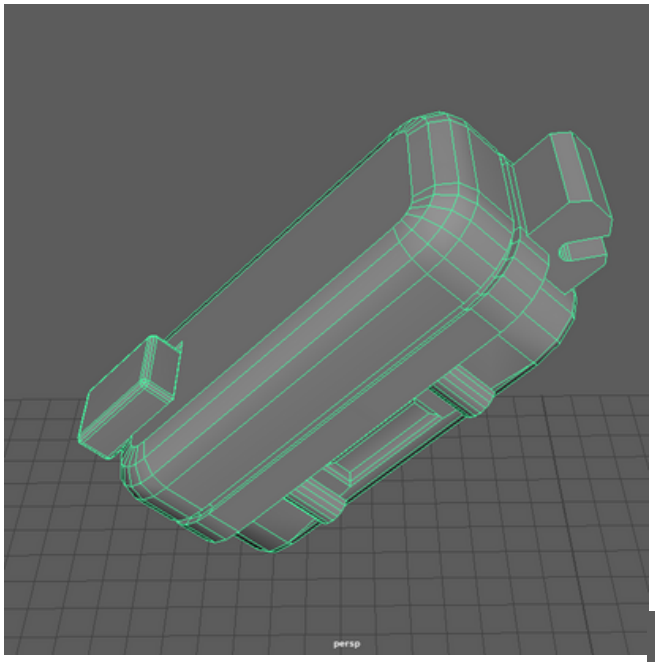
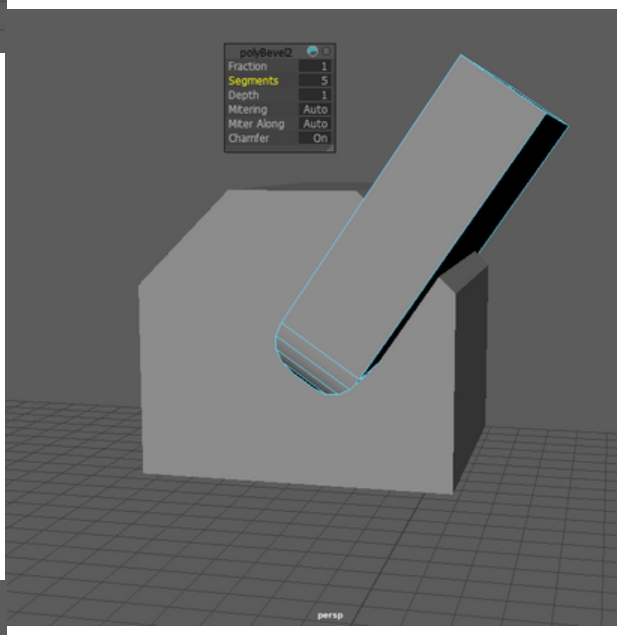


Figure 2.11



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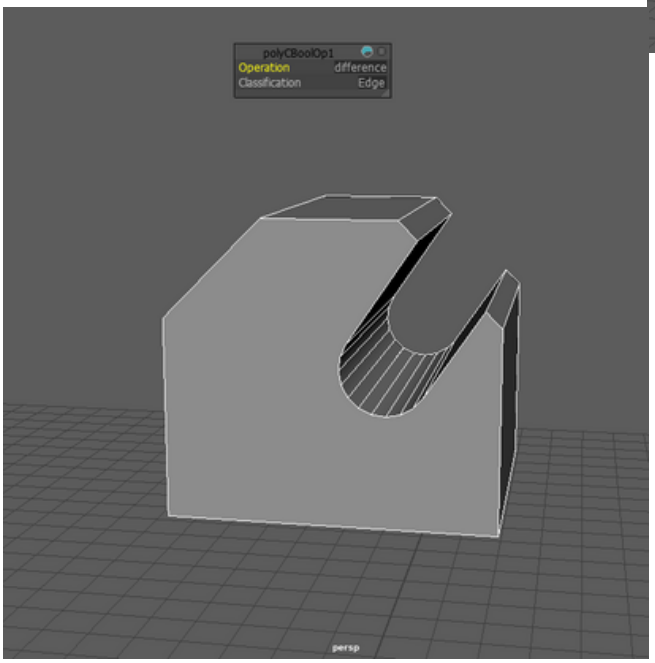


Figure 2.13

Appendix 2

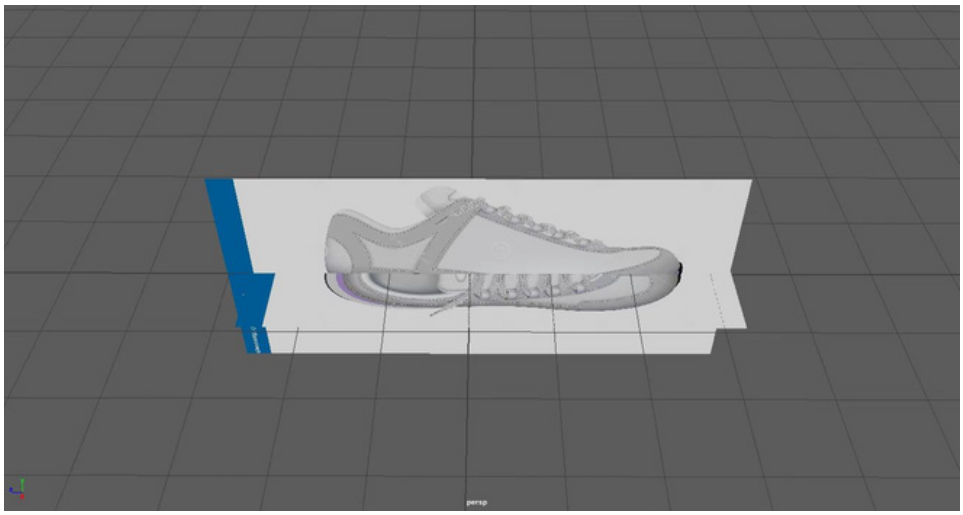
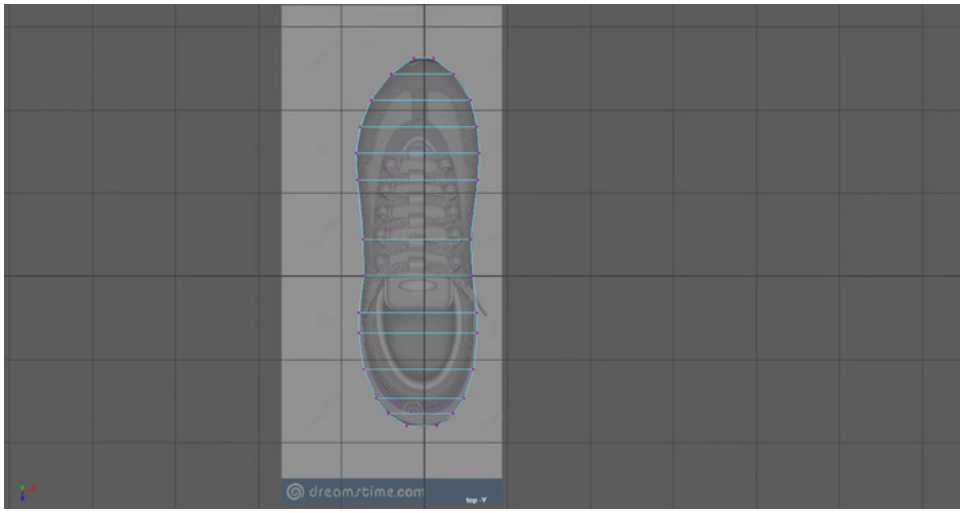


Figure 2.14



Fugure 2.15

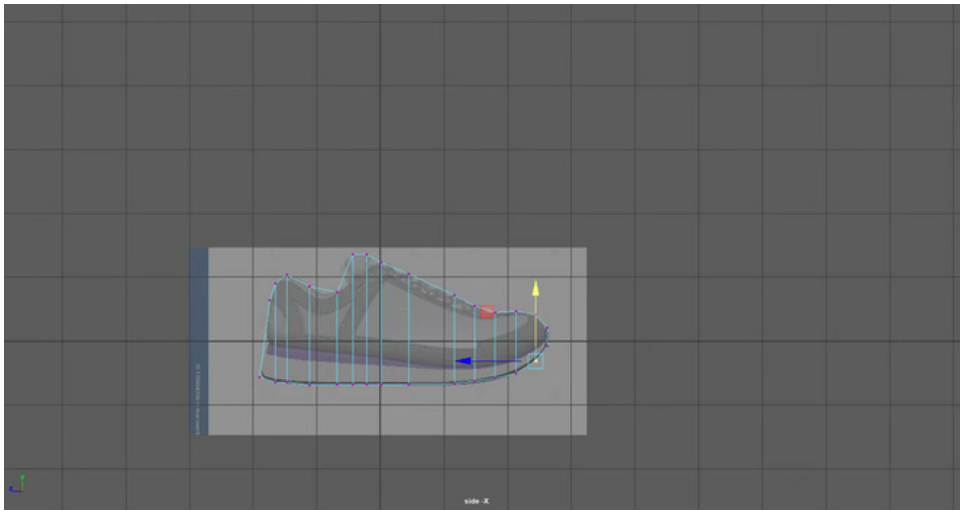


Figure 2.16

Appendix 2

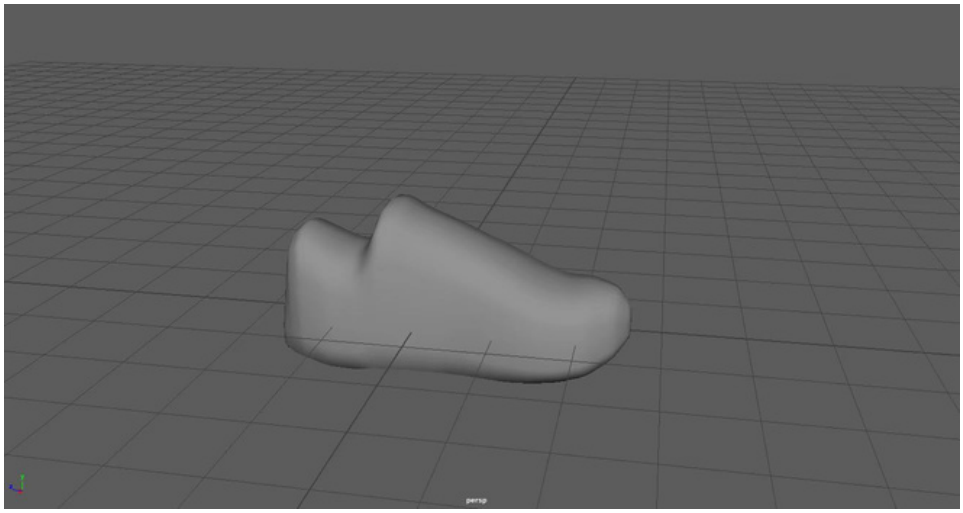


Figure 2.17

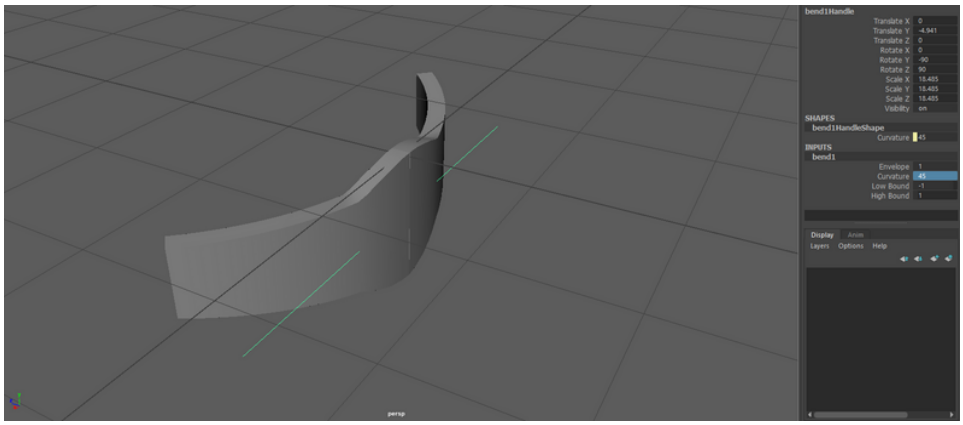


Figure 2.18

Appendix 3

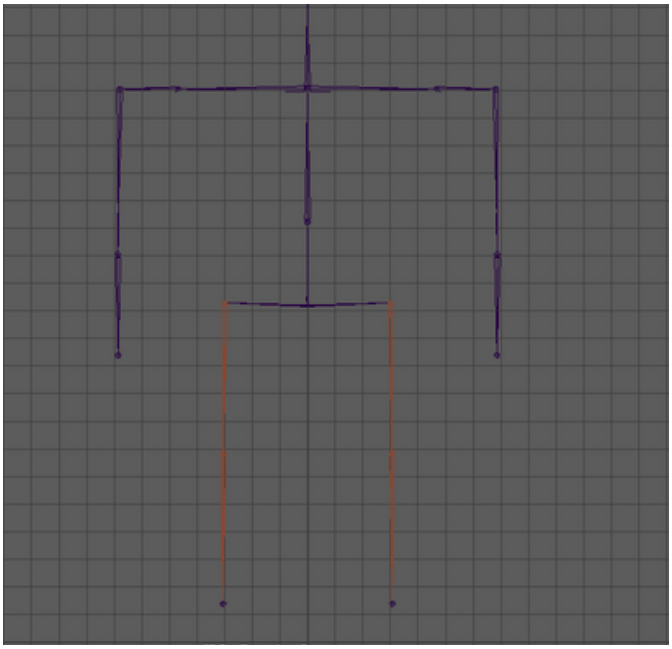


Figure 3.01

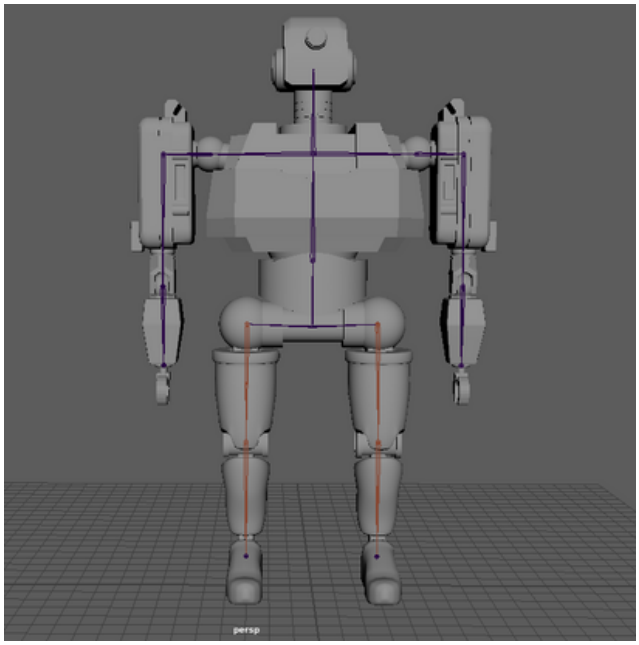


Figure 3.02

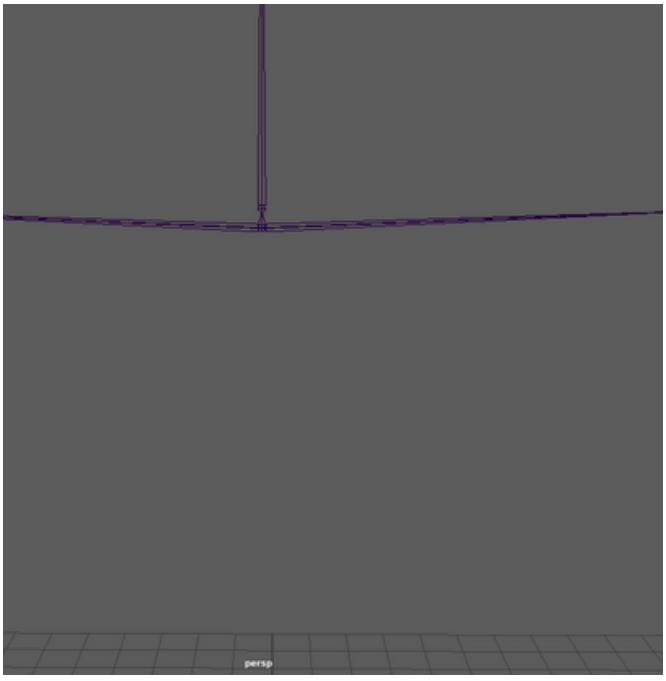


Figure 3.03

Appendix 3

Video 1.Weightlifting tutorial

https://www.bilibili.com/video/BV1Zt411777z?spm_id_from=333.999.0.0

Video 2.Weightlifting athlete in 2020 Tokyo Olympics

https://www.bilibili.com/video/BV13T4y1f7dw?spm_id_from=333.999.0.0

Video 2.The funny pose on Tokyo Olympics

https://www.bilibili.com/video/BV1564y167Sx?spm_id_from=333.999.0.0

Appendix 4

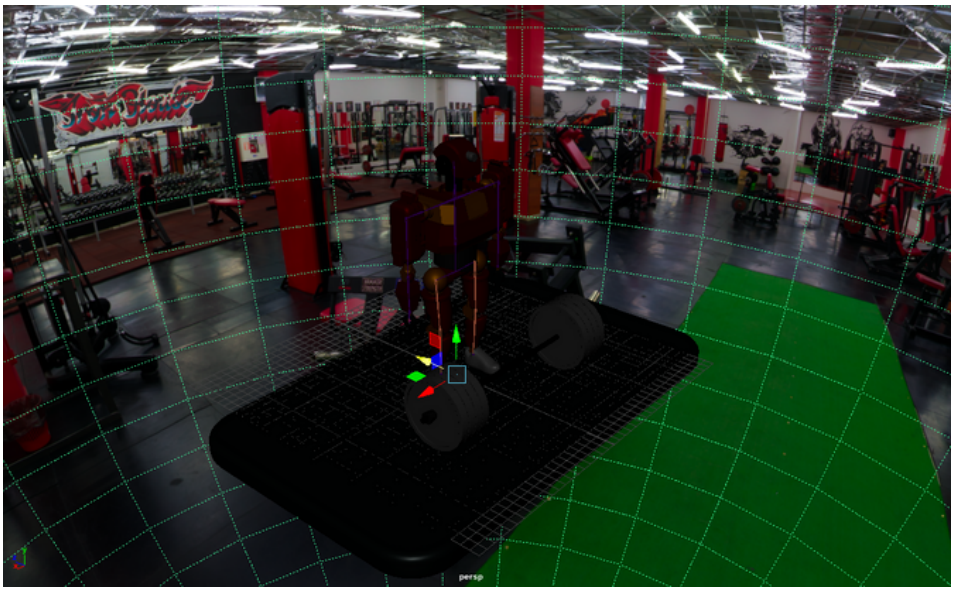


Figure 4.01

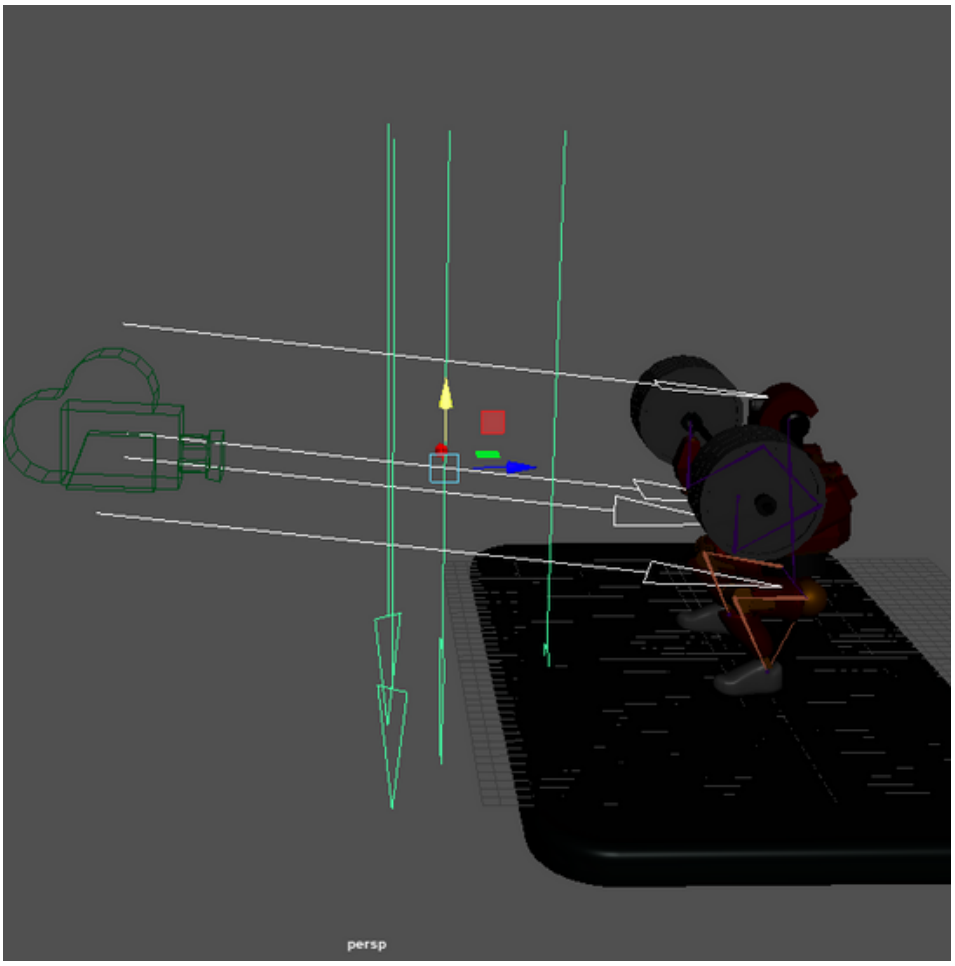


Figure 4.02

Appendix 4

Figure 4.03

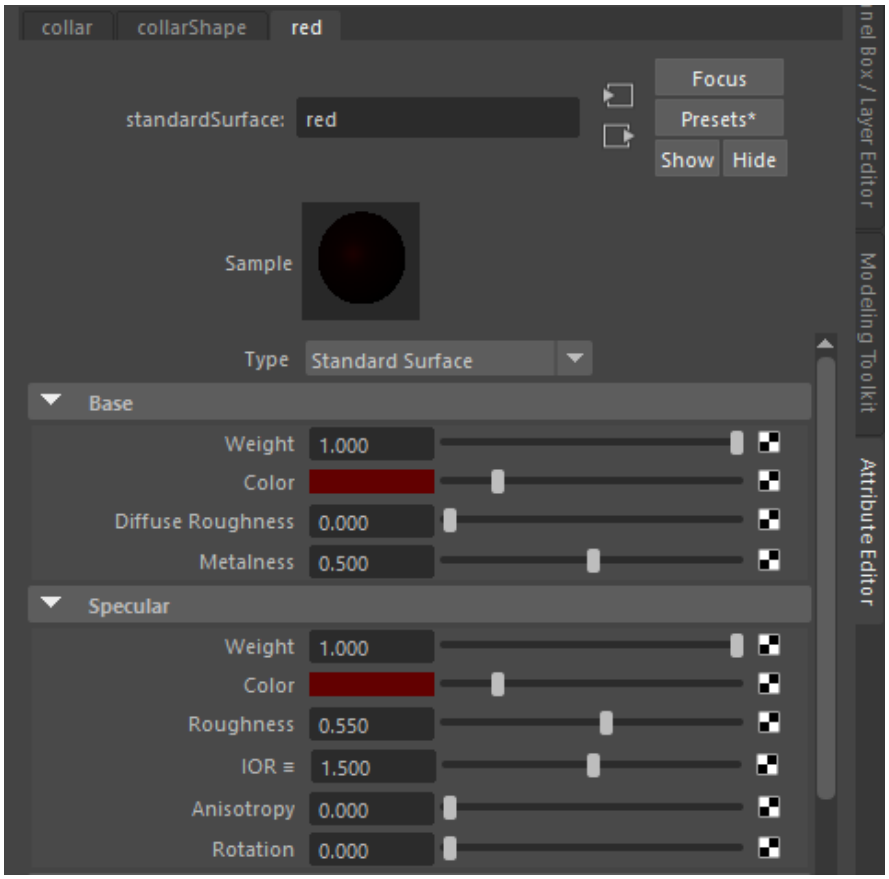


Figure 4.04

Appendix 4

Figure 4.05

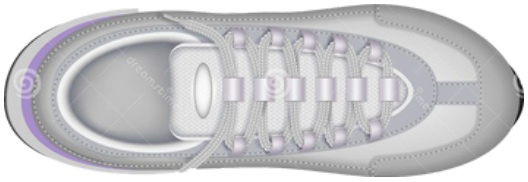


Figure 4.06

Figure 4.07

Figure 4.08