FINAL YEAR THESIS

Modeling, UV Unwrapping, Texturing, Lighting & Rendering of
"Through the Window": A 3D Animation Short Film

BY

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Multimedia and Creative Technology

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DAFFODIL INTERNATIONAL UNIVERSITY
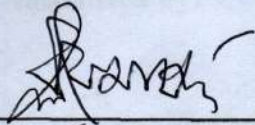
DHAKA, BANGLADESH

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APPROVAL

This Project titled **"Through the Window"**, submitted by Saurav Sarkar, to the Department of Multimedia and Creative Technology, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Multimedia and Creative Technology and approved as to its style and contents. The presentation has been held on 26th December, 2019.

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DECLARATION

We hereby declare that this project has been done by us under the supervision of **Arif Ahmed, Associate Professor, Department of MCT,** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

The way people express their thoughts is changing day by day. 3D animation is one of the new variations of these mediums. As modern technology is in its peak position right now, 3D animation process is now competent enough to express any story with the looks, colors and emotions of any real-life object or character. While our interest was in 3D animation, we also wanted to convey a message through a story relatable to our culture and society around us. So, we chose a story around child labor, which is a complex social problem in our country. It was our goal to articulate the story in a dynamic yet deep and understandable way through the whole process from story building to modeling, sculpting, texturing, rigging, animation, light setup, rendering and post processing. The final output of this project is a video footage that combine all the work that is done hopefully expresses the idea behind making it. We hope, this project will redefine the idea of 3D animation in our country.

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Introduction

1.1 Backstory:

Animation by definition is created by generating a chain of drawings or pictures taken by some sort of simulation procedure for creating movement. It creates an optical illusion through which we are able to see still images or drawings moving. 3D Animation is animating objects in a three-dimensional space, usually created via software which can be rotated and moved like real objects. A motion picture is considered one of the most common methods of presenting animation.

The story we developed titled "Through the Window" was decided to be made as a 3D animation because it was the most efficient way to convey our message. This project was heavily inspired by some animated short films by independent artists and studios like "In a Heartbeat"[1] from Ringling college, "Piston"[2] from ESMA Productions, "Coin Operated"[3] Written & Directed by Nicholas Arioli and "Mr. Indifferent" [4] from BadStache Animation Studio.

"Through the Window" is a one and a half minute long 3D animated short film which contains cartoon style characters in two different realistic environment or sequences. First sequence will be a school environment with adequate lighting and the second sequence will be a small congested old town cheap toy factory environment in dark lighting.

The story of the short film will portray the incidence of child labor in our society. In the first sequence a school boy plays with his new toy car on his way to school and on his way home from school he stumbles upon another boy of his age who was having a hard time making that very same toy car in a factory. This project will bring out the brutal reality of our socio-economic situation in front of people's eyes, about how regardless of age people have to work for minimum wages even when they are school-going age.

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1.2 Motivation:

Now-a-days child labor has become normalized in our society. In this project both realities of the lives of privileged and underprivileged children will be shown side by side for comparison. This stark comparison will effectively communicate the circumstances that cost the basic right of education for an underprivileged child to the viewers.

In our society it is not uncommon to see children working instead of going to school just to feed themselves. Some employers make them work so much as though they were adults while they would never let their own children go through the same situations. It is the hypocrisy of the people with lower morals and no ethical standards. This regular but pathetic sight was the motivation behind developing such a story and make it into a 3D animation.

1.3 Objectives:

Objectives of this project are:

1. Create different props models

2. Create 3D characters with attractive, adorable features

3. Create two different environments to portray the story appropriately

4. Texture the models to make them look as close to real objects as possible

5. Rig and skin paint the characters to make them workable models for animation

6. Animate the characters with proper body language and facial expressions

7. Light the scenes properly for the maximum resemblance with real environment

8. Render the animated frames in proper quality and format

9. Color grade and assemble the scenes

10. Add sound effects to enhance the experience

11. Portray the social situation of child labor through 3d animation

12. Create awareness about child labor in a relatable way

Although the output of this project is a 3D animation but it is not necessarily targeted towards children. The target audience of this project are people of age thirteen and up but people of any age can watch the film and enjoy it.

1.4 Literature review:

Several 3D animations have been consulted to offer an in-depth analysis of the best methodology for the film. In the film "In a Heartbeat" Beth David and Esteban Bravo used a specific pattern for the environment in their film. Everything had a "Heart" shaped feel to them. The idea of selecting a pattern and stylizing all the props and environment according to that was inspiring. Some films use semi realistic environment style such as "Piston" of ESMA productions whereas others use super realistic background environment like that of Badstache studios "Mr. Indifferent". Luke Snedecor & Sarah Heinz at Chapman University created "Preheated" [5] which portrayed a child character, which is a wonderful reference. The animated short film "Alike"[6],directed by Daniel Martínez Lara & Rafa Cano Méndez, used a minimal but stylized background environment with the unique idea of rounded edged buildings. "Watermelon A Cautionary Tale"[7] by Kefei Li & Connie Qin He had amazing animation and lighting but the background props were not much detailed and there were some noticeable mistakes where surfaces which were supposed to collide goes through each other instead. Problems like these inspired us to be looked into to eliminate in our film. 3D animated short film "The Present"[8] was based on a great little comic strip by the very talented Fabio Coala. This film has excellent texture and lighting. Most of these films had a subtle depth of field as per needed in each scene which gives us a challenge to obtain. By studying all of these films and more we have chosen the best combination of designs, textures and environments to portray our story vividly and comprehensively.

CHAPTER 2

Project Workflow

In this chapter I'll discuss about all the software and process used for this project. It includes modeling, uv, texturing, lighting and rendering. Necessary details about "Adobe Photoshop"[9],"Autodesk Maya"[10],"Substance Painter"[11] will be given as these are the software, I have used to complete the following process.

2.1 Modeling :

3D Modeling is the process of creating the faces of an object in 3-dimensional space within 3D software. There are a few types of modelling which includes Polygonal and Nurbs modeling. But for this project we chose polygonal modeling because it is more popular and more familiar to us. In this modelling process standard primitives like boxes, spheres and cylinders are used and modified to make various models. For modification, tools like extrude, bridge, combine and deformers like bend, lattice etc. are used. While modelling all the props and characters it is strictly followed that all the polygons should be in quads. Because   The description of the models I made are given below.

2.1.1 Switchboard :

The switch board is made for the factory scene. The style of this switchboard is vintage, to make the factory look more realistic. There are two different parts in the board. One is the switch and the other is the socket. For the switch, I have used pCylinder. Gave it an appropriate radius according to the real-life switch size. In the middle of the switch there is a separate Box which I took to make the on/Off button. Then I made the socket in the same way as the switch but this time I made three holes in it to make it look like a socket. The socket radius is bigger than the switch radius. The bottom part of both this switch and socket are deleted to make the polycount less. I have put supporting edge loop where it's needed before making it smooth mesh.
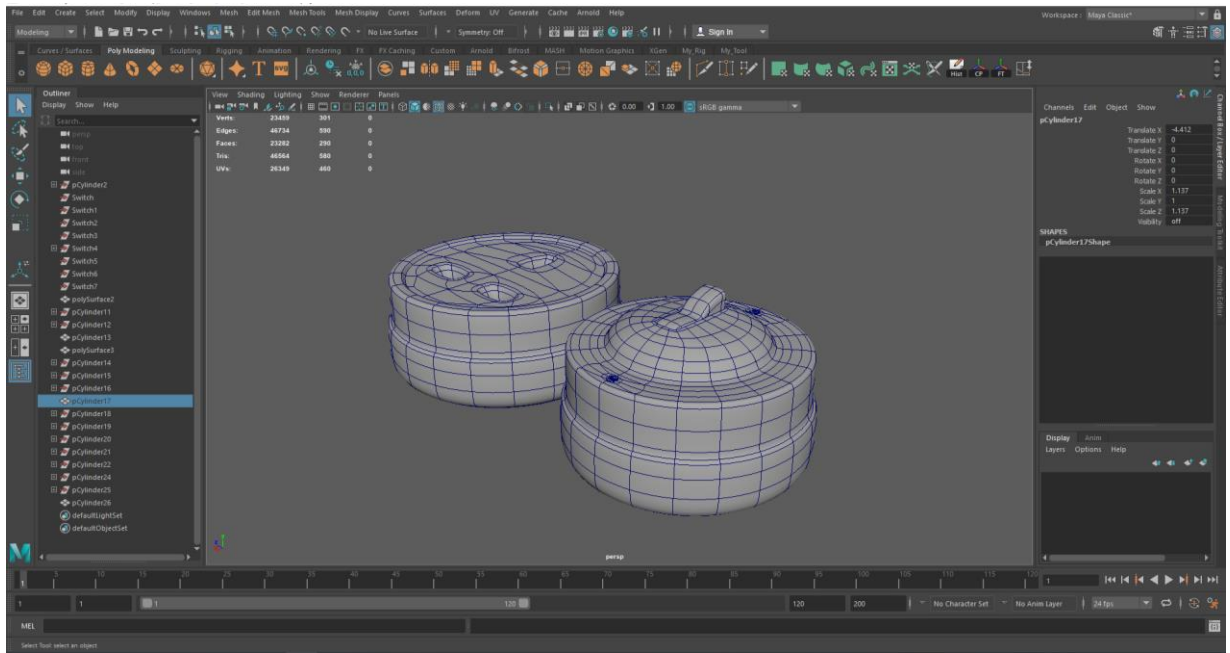
Figure 2.1 Switch and Socket Model

To hold all this switch and socket together, I created a box from six pCubes. This pCubes are modified to make it look like one single box. The edges were beveled and added support loops to smooth the mesh.
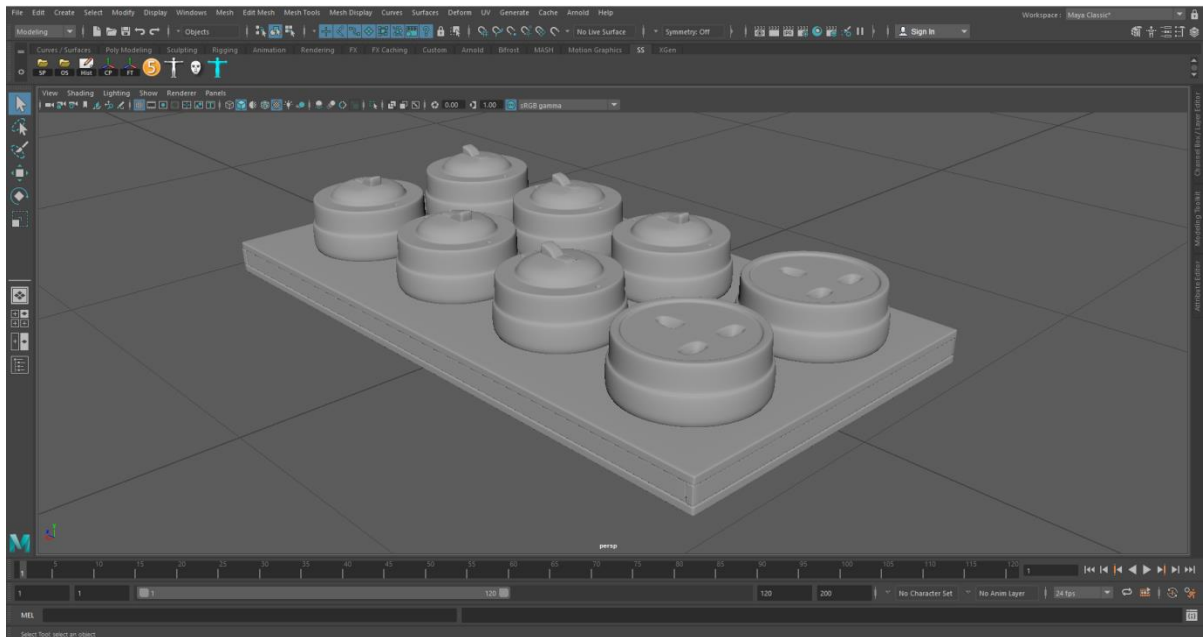
Figure 2.2 Switchboard Model

2.1.2 Water Filter :

The Water filter is also made for factory scene. For making it, first I took one pCylinder. It had 12 Subdivision axes by default and it was enough for me to manipulate it. The top and bottom polygons of the cylinder was removed in order to make the shape of water filter. To make the top of the water pot, I selected the open edge of the top part then extruded and scaled inward by pressing Shift + Drag with scale tool selected. I used this same extrude technique to make the shape of the water pot.

The water pot holder also has a water tap which I made by little modified pieces of polyCylinder.

Every piece of the water filter was made with a low subdivision first. After the final modification was done, I subdivided every piece of the filter to give it enough edge flow for the help of texturing. For the water pot holder, I again used polyCylinder with 12 Sub Axis.
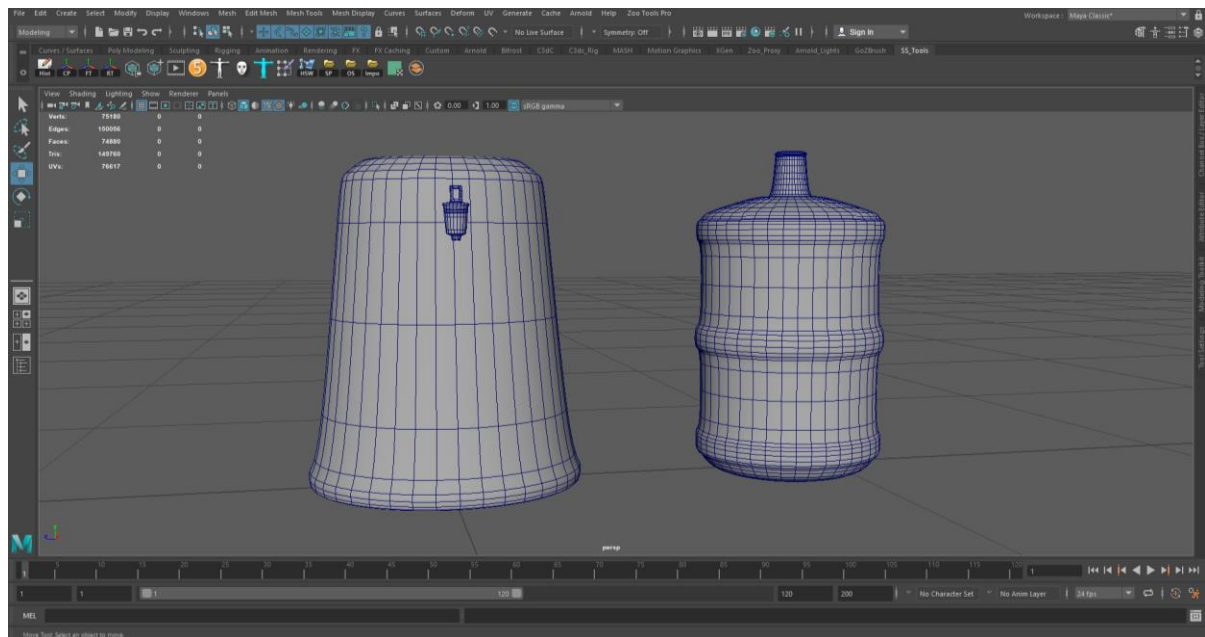
Figure 2.3 Water Pot and Pot Holder Model

The bottom polygons were deleted because they weren't going to be seen in camera. For the upper part of the pot holder, I deleted those top polygons first, then started to scale down the upper part of the cylinder to make it as the reference image was.

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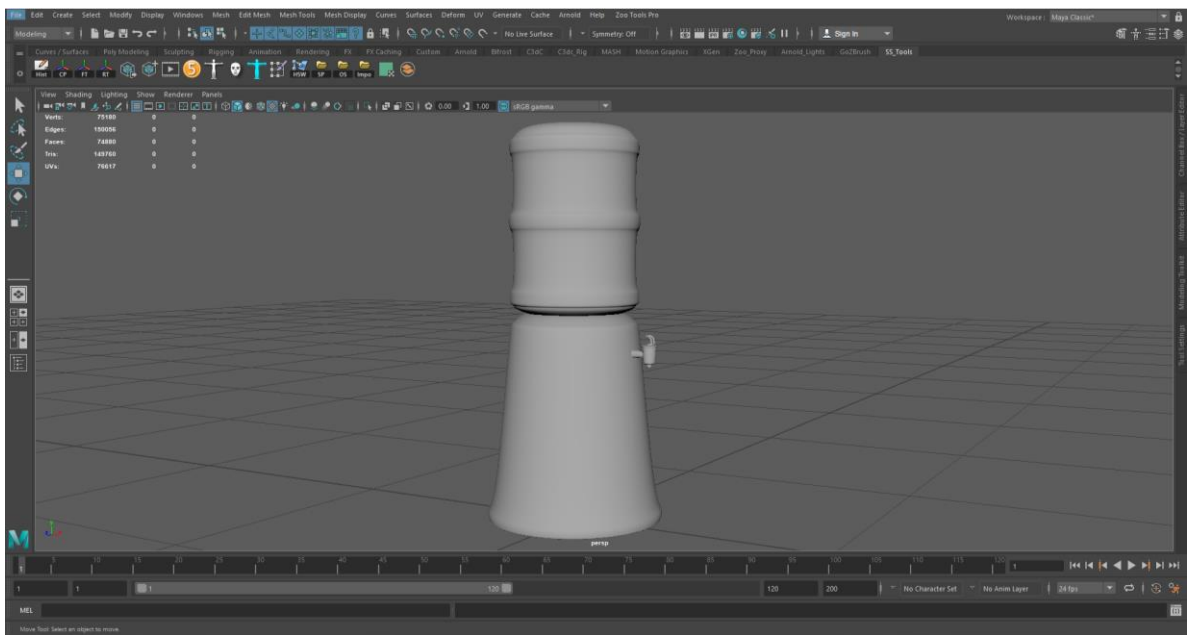
Figure 2.4 Water Filter Model

2.1.3 Exhaust Fan :

The exhaust fan was modeled for the exhaust system in the factory. This fan has two separate pieces. One is the blade and the other is the frame which holds the blade. First, I modeled the blade.
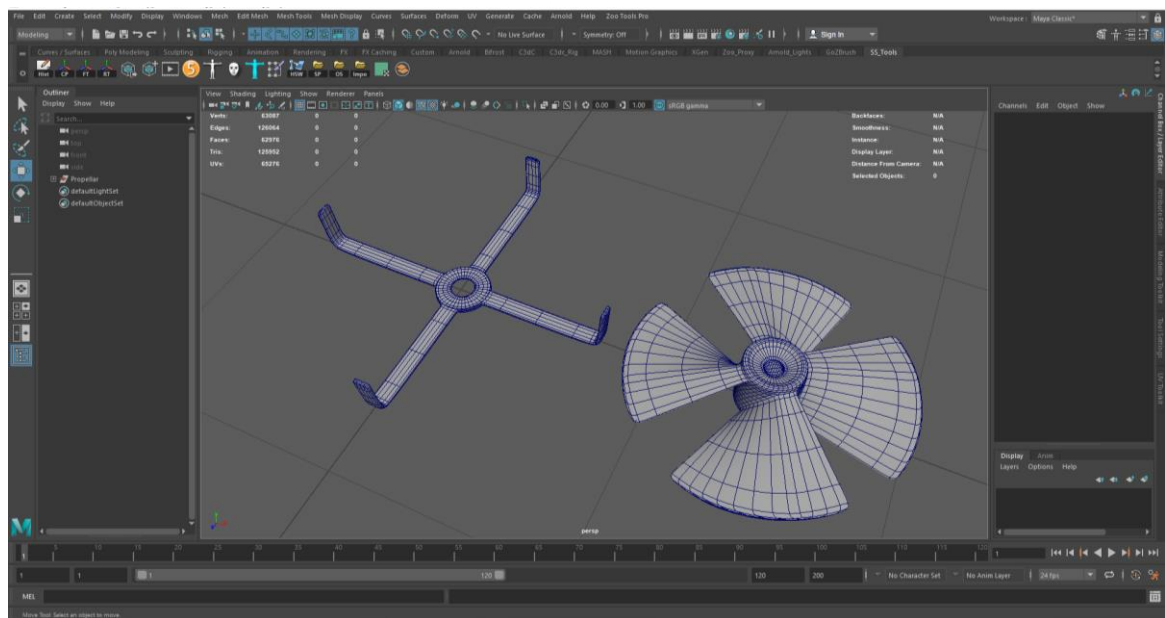
Figure 2.5 Propeller and Frame Model

I took one polyCylinder and added enough subdivision in both axis and height to do the next part. Then I selected the vertex mood in Maya by clicking the right mouse button. I had to

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rotate each subdivision height in order to make a twisted look so that I can extrude four wings from those twisted polygons. Then I selected the polygons which I needed to extrude and extruded those according to the reference.

The middle part of the blade was extruded down according to the design of the fan. After making the basic form of the blade I gave it enough resolution by subdividing it. The frame of the fan was made from a pipe. I increased the subdivision height and width according to my need. Then extruded some polygons of that pipe according to the reference image.
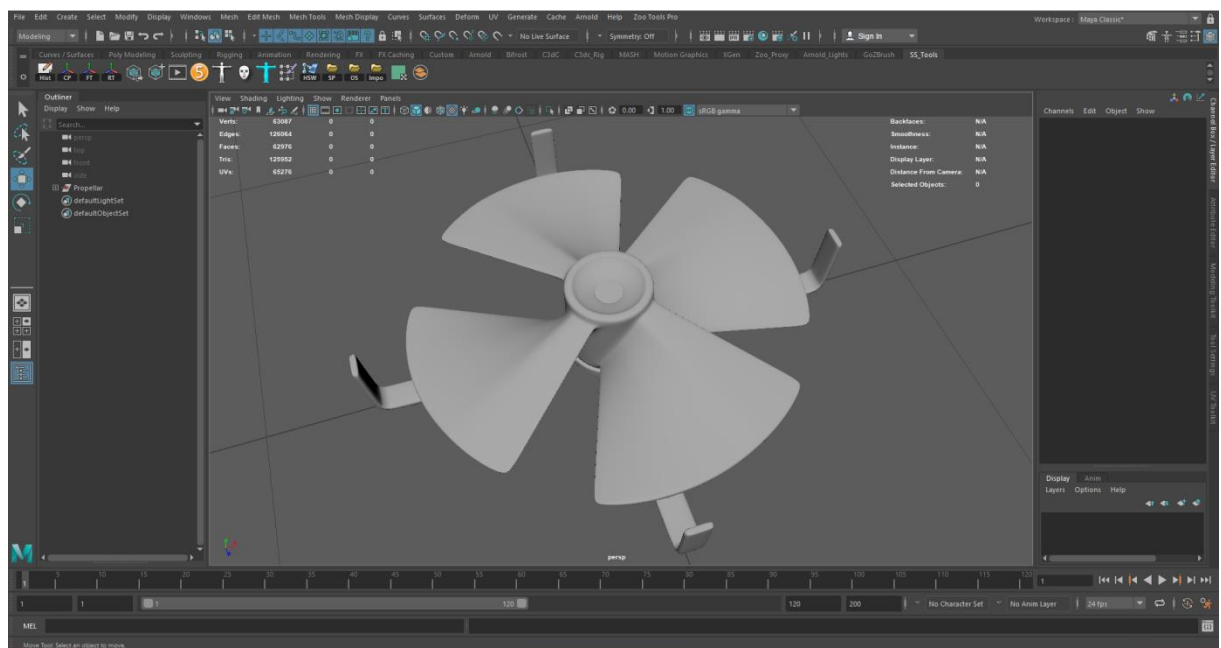
Figure 2.6 Exhaust Fan Model

2.1.4 Hammer :

The hammer was designed as a tool in the factory. It's a simple hammer which have two different parts in the final model. One is the hammer head and another is the handle.

Figure 2.7 Hammer Model

The modeling part of the handle was easy because it was made out of a single box which was then manipulated with some edge loop. Although making the hole in the handle was a little bit difficult.

The head of the hammer was difficult to make because it is a combination of three different primitives(Box, Sphere, Cylinder).I took those three primitives and make them look like the head by manipulating them in vertex and edge mood. Some polygons were deleted in order to combine those three primitives. For combining those I used merge vertices operation by Shift + Right mouse button >Merge Vertices >Merge Vertices. It was mandatory to stay in vertex mood in order to use merge vertices operation.

2.1.5 School Bench :

These benches were made for the classroom scene. It has 2 different parts which have Metal and Wood part. The wood part was quite simple to make. It has only a box which was subdivided to make enough edge. Sharp corners of the box were chamfered to make it realistic because in the real world no object have blade sharp edge. To chamfer/bevel, select the edge, Shift + Right mouse button>Bevel Edge. There are three parts of wood in one bench. One is the table top, the second one is for sitting and the last one for resting your back.

The second part of the bench was the steel part which has lots of bending going on. So, to bend the frame according to the design, I used the bend option from Menu→ Deform→ Nonlinear →Bend. I also made some screws to make the joints more realistic. That screw was made out of sphere which was cut in half and extruded to match the shape of a screw.
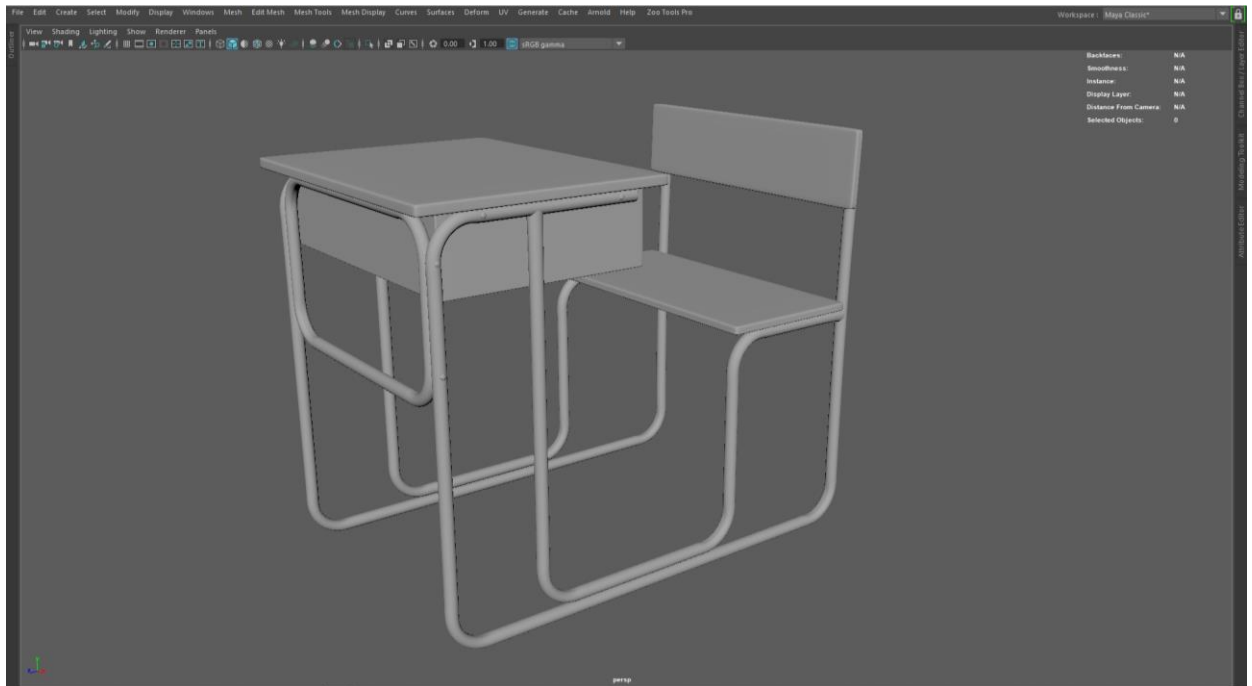
Figure 2.8 Classroom Bench Model

2.1.6 Sidewalk & Walls:

These things were made from the reference of our everyday lives. The tiles of the sidewalk were modeled one by one with the dimensions of 10 inch by 10 inches. There are two different types of tiles with two different design.

Although the same result could have been achieved by using texture and bump maps.

The walls were pretty simple to make. It's just a box with the top portion extruded a little bit. To do this, first insert an edge loop(Shift + Right Mouse Button →Insert edge loop tool)in the top portion of the wall then select the right face and extrude (Ctrl + E) it outward. In the end, smooth the mesh by pressing 3 in your keyboard.
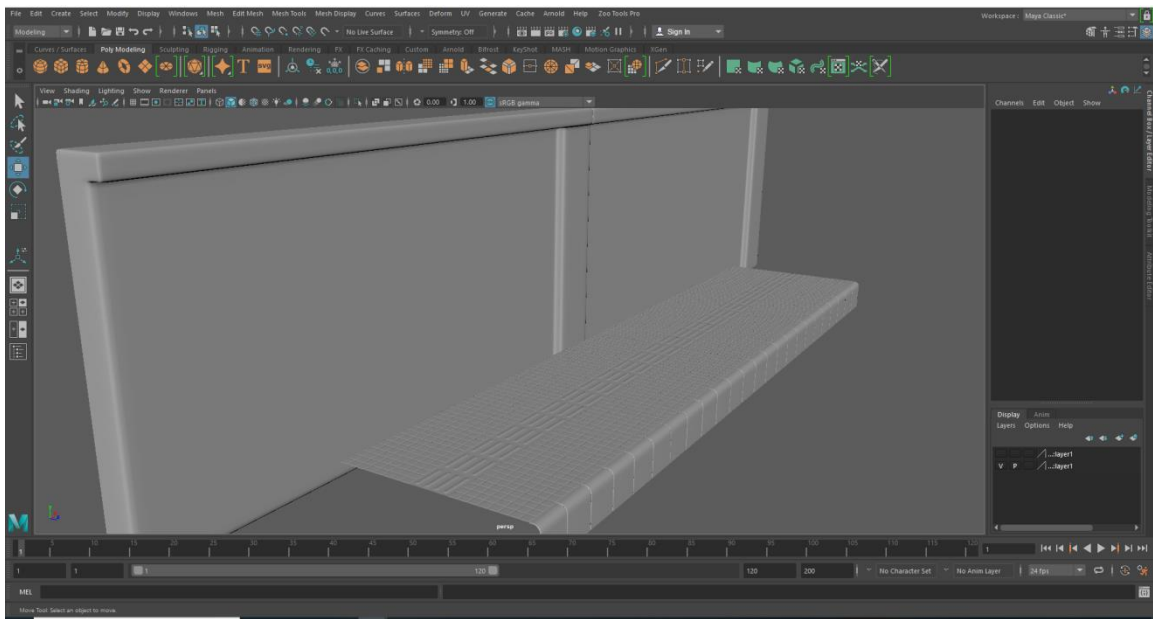
Figure 2.9 Sidewalk and Walls Model

2.1.7 Mold Machine :

This model is one of the key models because our story is related to it. So, this model took a lot of time to make with so many small details. There are many different parts of this mold machine. In fact, it was made to perform an animation of its own.
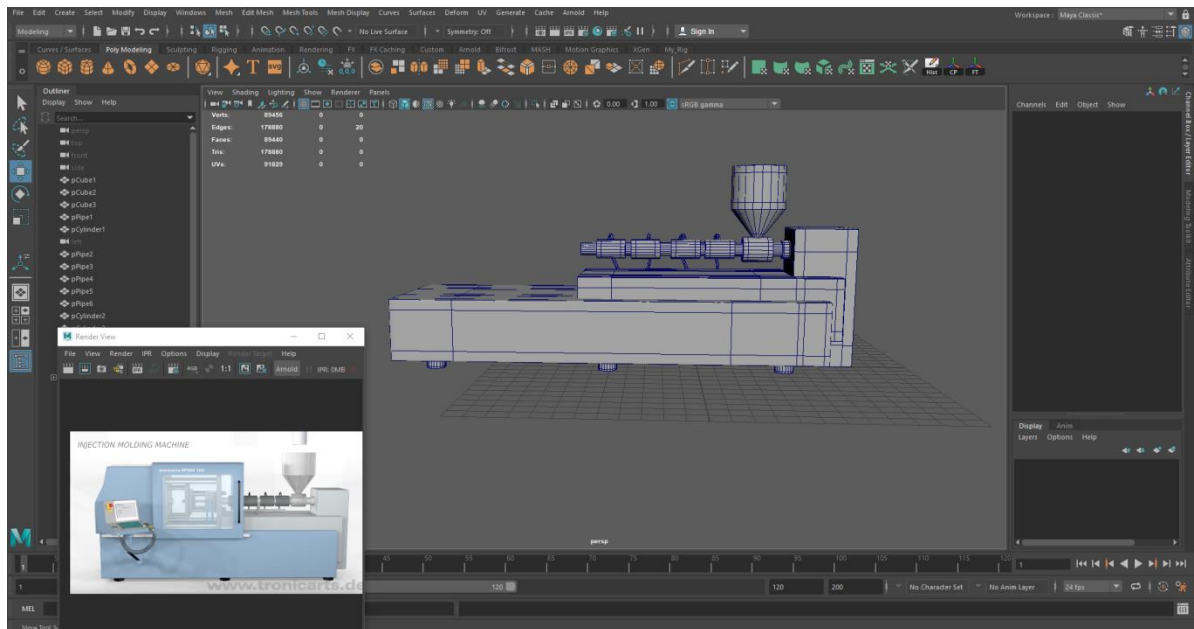
Figure 2.10 Base part of Mold Machine

To complete this model, I have used so many basic shapes like box, cylinder, torus, pipe etc. As you can see in the picture, first I created the base of the mold machine which are just some boxes. Basically, I beveled the side edge and make each box smooth by pressing 3 on my keyboard. After the base part, I made those cylinders according to the reference. After these base and cylinder parts, there are some technical parts which I have modeled to do some animation. According to the design there were some holes. To make those holes I have used the Bridge command. For each and every part of the mold machine, maintaining the topology was the main thing because without a good topology I wouldn't be able to perform the smooth mesh command. And without smoothing the mesh, the model would look so unrealistic.

In mold of the mold machine from which the plastic cars come out is in the middle of the mold machine. For creating the mold part, I have used the model of the plastic car which I made for our short film. I combined and merged that car model with a box which together made the mold.
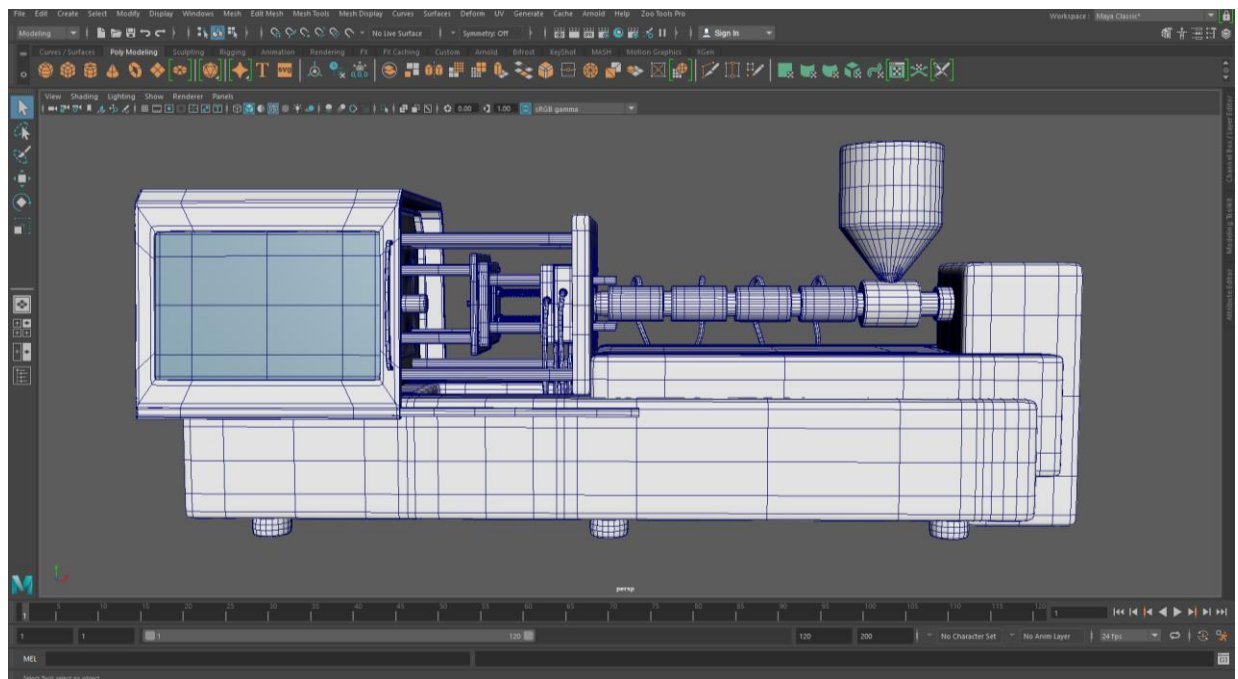
Figure 2.11 Complete Mold Machine Model

To combine any object with another object, first select those objects you want to combine, then under the Modeling Set >Mesh >Combine. And to perform the merge operation, select

the vertices you want to merge together and Shift + Right Mouse Button > Merge vertices > Merge vertices.

2.1.8 Toy and Real Cars :

There are two different cars which I modeled for this project. One is for our main character Shanto and another is for our side character Milli. Both cars have different designs and pattern.
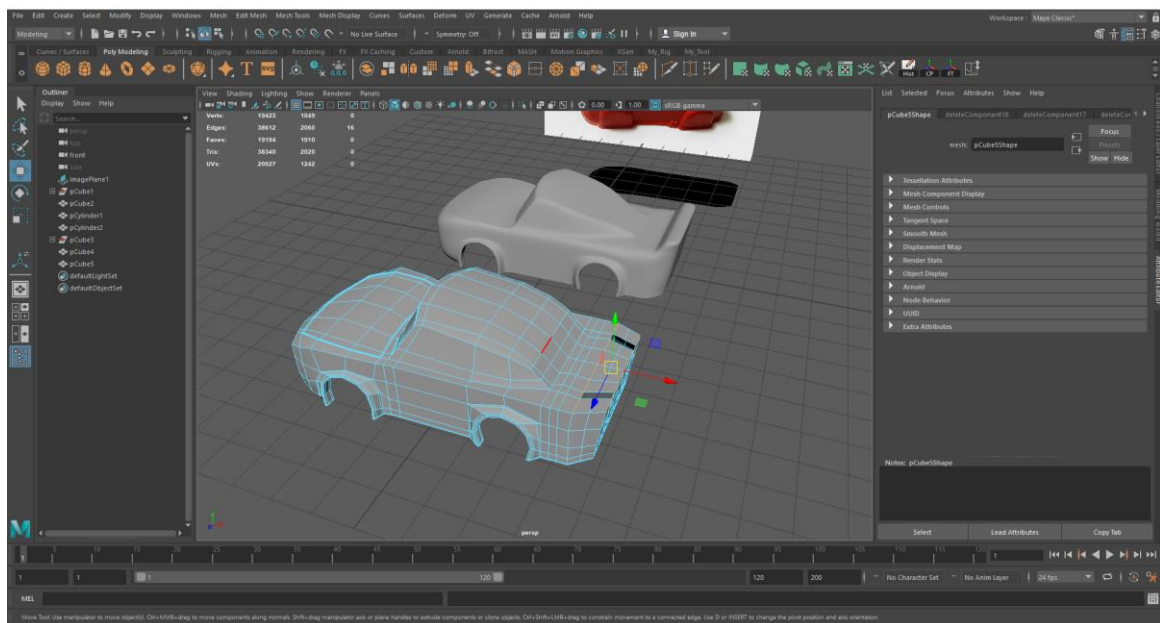
Figure 2.12 Basic Shape of Toy Car

The basic shape needed to be so low poly which make the modeling tough to manipulate the shape. But its needed because after making the mesh smooth, the subdivided mesh will have a lot of polygons.
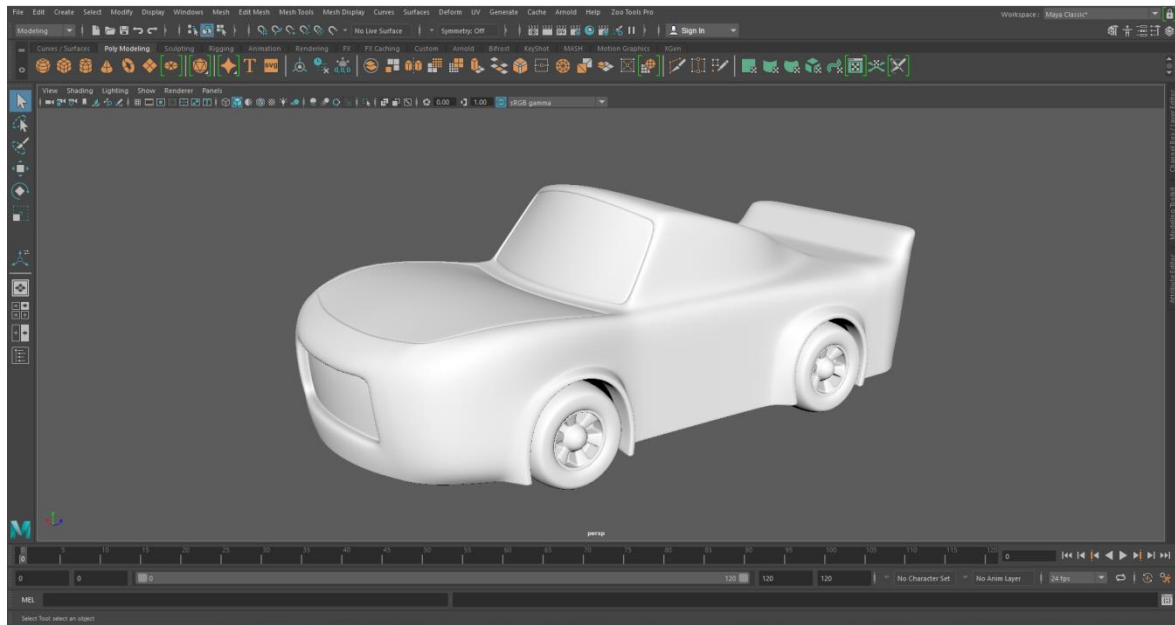
Figure 2.13 Complete Shape of the Toy Car

First, I downloaded a good reference then started to make the shape of the car from a simple primitive box. I have used Insert Edge Loop Tool to manipulate the box as the design needed. Select any object, press Shift + Right Mouse Button >Insert Edge Loop Tool.
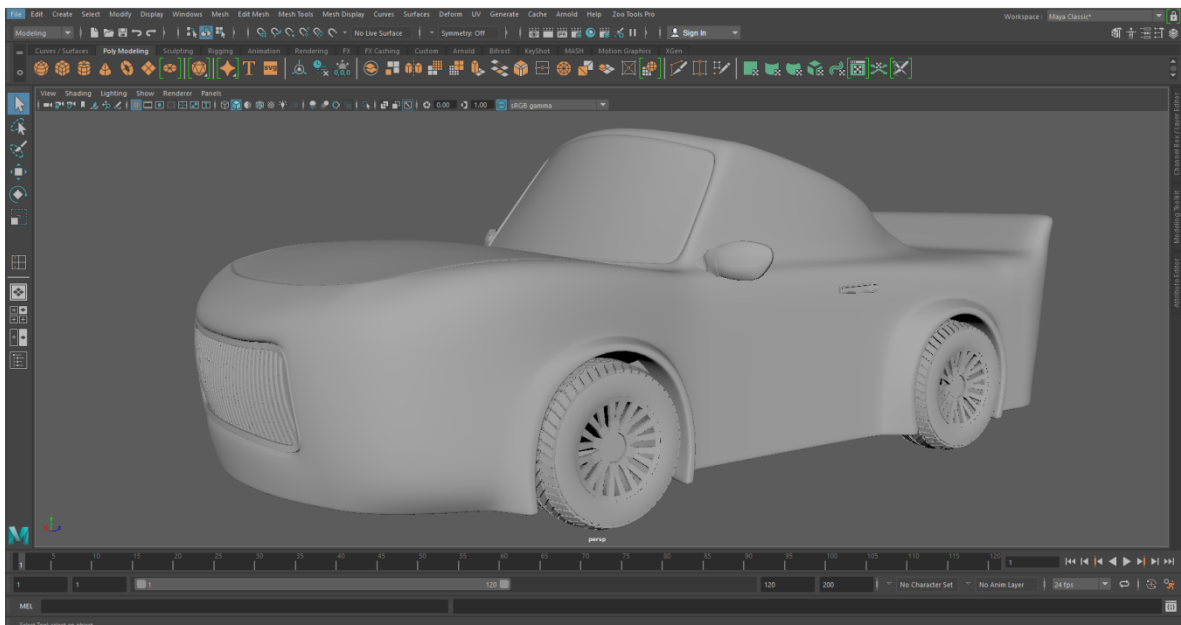
Figure 2.14 Complete Real Car Model

I have also used the Multi-Cut tool to cut the geometry where it's needed to be cut. For example, the round space for the wheels to rotate in the car body.

2.1.9 School Gate :

Modeling the school gate comes with some challenges. These two pillars were made out from a box which have the same height and width of a real gate. For design purpose I added some edge in middle and extruded some faces inward to make it look good. Then I added some support edge loop to smooth the mesh. The lights were made out from sphere and the base from cylinder. SCHOOL letters were created in Maya with the help of polygonal text. Shelf >Poly Modeling >Polygon Type: Create polygonal text on the grid .Then type in attribute editor what you want to right.
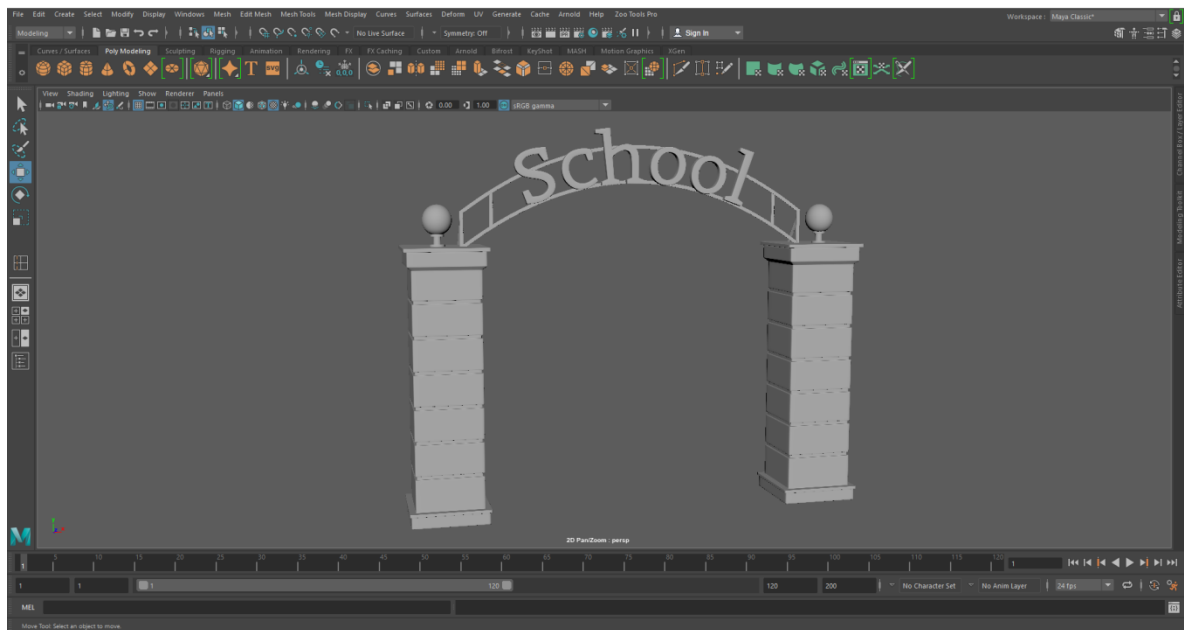
Figure 2.15 School Gate Model

2.1.10 Character Modeling :

There is a total of four characters in our 3d animation film. One of them is our main character Shanto who is a boy. A character model is separated into different parts - Head, Torso, Legs, Arms, Feet and Hands.

The torso is made out of a pCylinder with 8 subdivisions, head was made of a pSphere with 12 subdivisions, arms and legs were created with pCylinders with 8 subdivisions. Hands are made of pCubes.

Character building process starts with the torso part. First the cylinder is shaped to match with the reference picture by adding edge loops wherever it is necessary. This process includes the transform and scale commands mostly with "object x" selected in the symmetry menu from the menu bar. When modeling the character, it should be kept in mind that the model needs to match with only one side of the reference image. Because after one side is perfectly matched the faces of the other side are deleted from the middle. Then selecting the faces of the other side, the pivot point is moved and snapped to the center of the grid by pressing d and x on the keyboard. Then from the dropdown edit menu duplicate special option is selected and value of scale x is set to -1 and applied. This duplicate and mirrors all the faces and positions them to 0 point on the grid as the pivot point was previously set there.

After doing the duplicate operation, the middle vertices must be merged because otherwise the smooth mesh will show odd results.
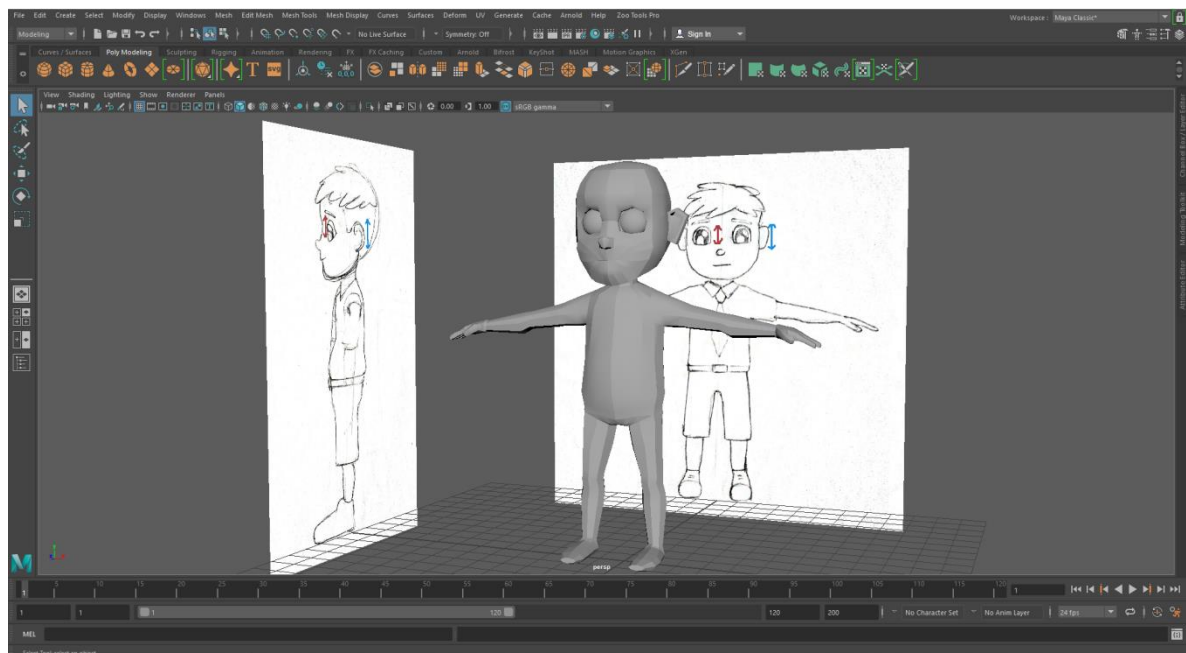
Figure 2.16 Character Basic Shape

To merge any vertex with other vertex, select those and press Shift +Right Mouse Button >Merge vertices >Merge vertices. After this the history of the object must be deleted. To delete

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history, go to Menus >Edit >Delete by type >History. After doing the base shape it was just a matter of time to move and adjust every vertex and edge loop according to the reference image.

For the face I used a sphere with 12 subdivisions and merge it with the body. Then modified it by deleting and creating holes for the eyes. Nose and mouth.
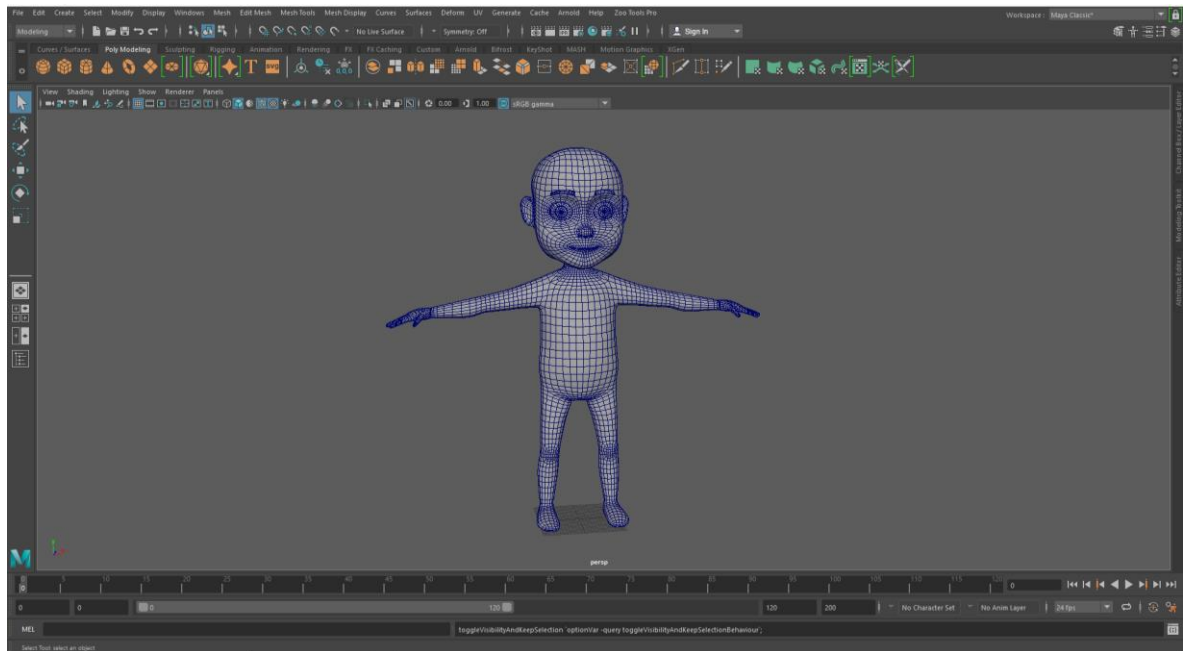
Figure 2.17 Smooth Mesh Preview of Character's Body

To create the dress, first the character body is duplicated on place. Then it is extruded to make it bigger than the body and all the unnecessary faces are deleted. It gives a primary shape of a garment. For each piece of garment, the body needs to be duplicated separately. This process provides enough polygons to model the garments perfectly.
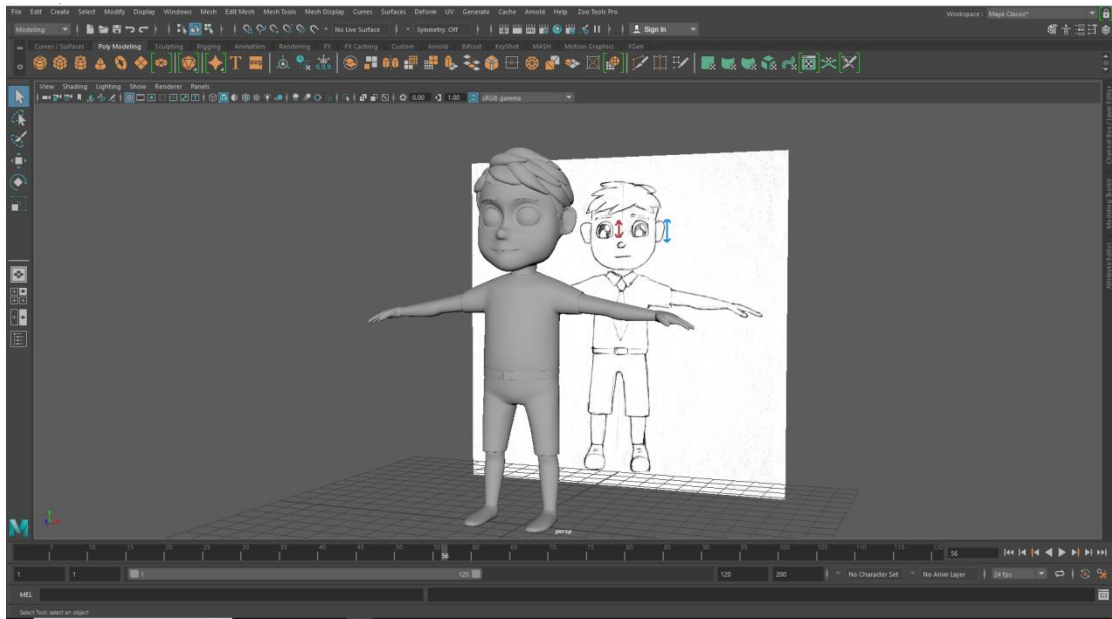
Figure 2.18 Complete Character Model

2.1.11 Shelf :

The shelf is made out of some basic primitives. I have used simple boxes to make all the shapes of the shelf. I have used the Insert Edge Loop tool to put edge loop where it's necessary. Then extruded some parts to match the reference image.
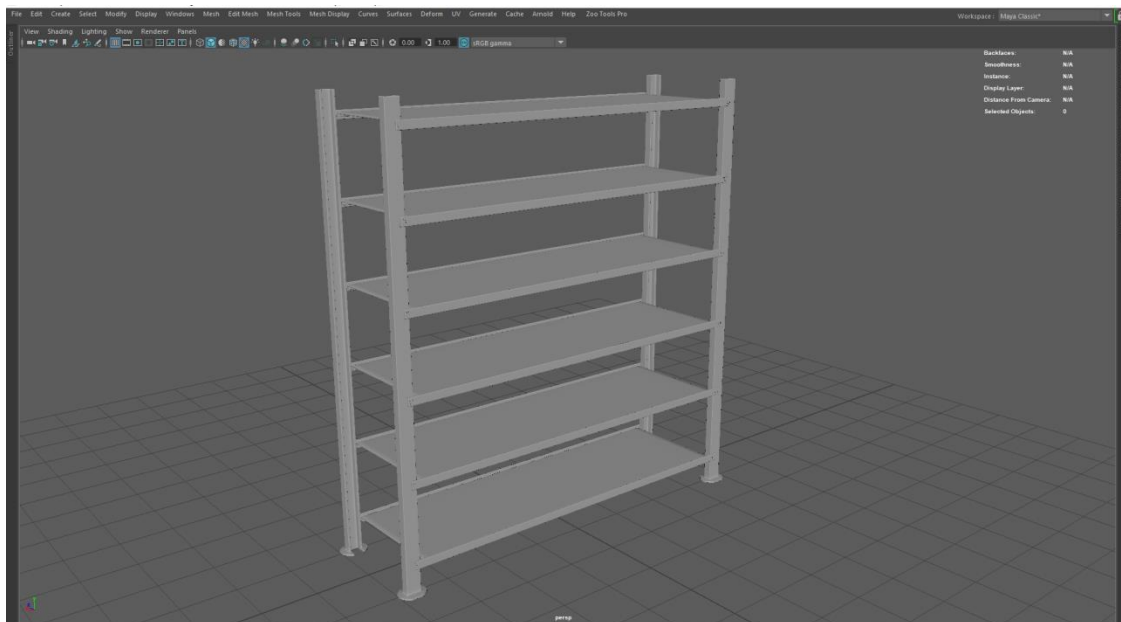
Figure 2.19 Steel Shelf Model

2.1.12 Plastic Basket :

The basket was pretty simple to make. To make this basket first take a box and select the face in the top. Press Ctrl + E to enable extrude mood then press any or the colored square in the gimbal to enable inset mood. Inset a little bit then extrude it down to make the belly of the basket. After that to make the design in the body of the basket just insert some edge loop as you want and extrude some faces according to the design. At last give some supporting loops to the existing edge loop so that after performing the smooth mesh operation, it can hold its original shape. Then press 3 on your keyboard to smooth it.
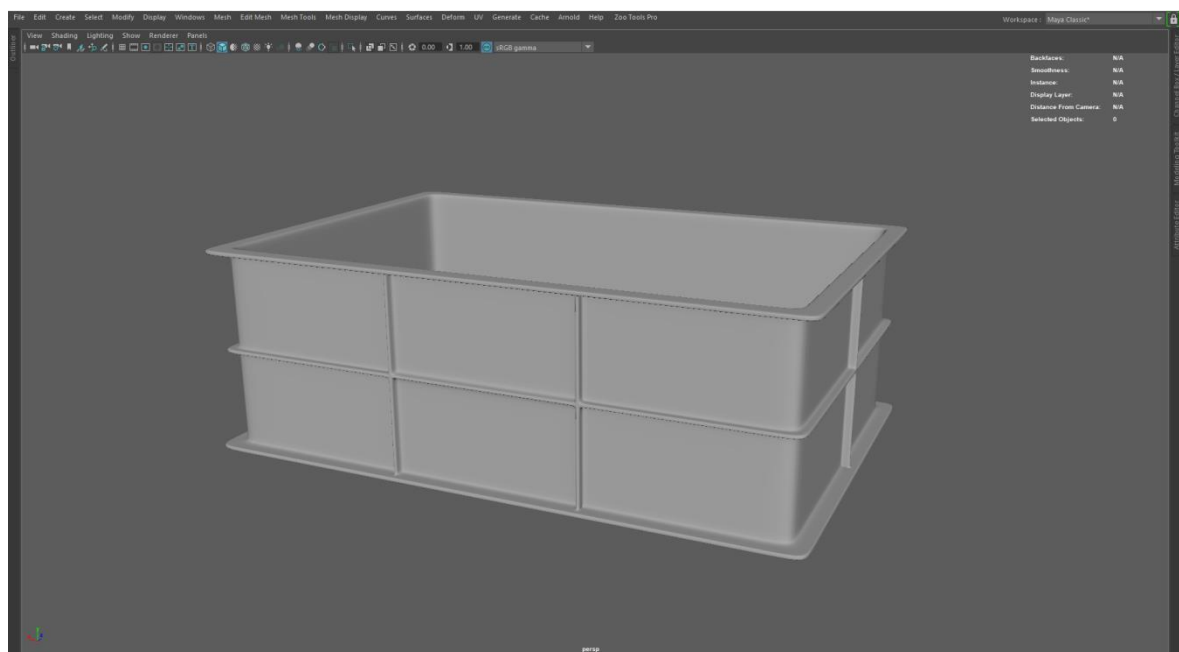

Figure 2.20 Plastic Basket Model

2.1.13 Electric Pole :

The electric pole was created for the outdoor scene. It's a combination of a cylinder, some boxes and some small pipes which was modified to make those small parts in top. The height of the pole is around 25 feet. First, I took one cylinder with a subdivision of 12.The top and bottom part of the cylinder was deleted to reduce the file size. Then I selected the vertex mood and scaled down the top vertices a little bit according to the design. The wires were made out of cylinders too. I inserted some edge loops in one long cylinder around 40 feet long and

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selected the middle vertices. Then turn on the soft selection by double clicking on the selection tool.
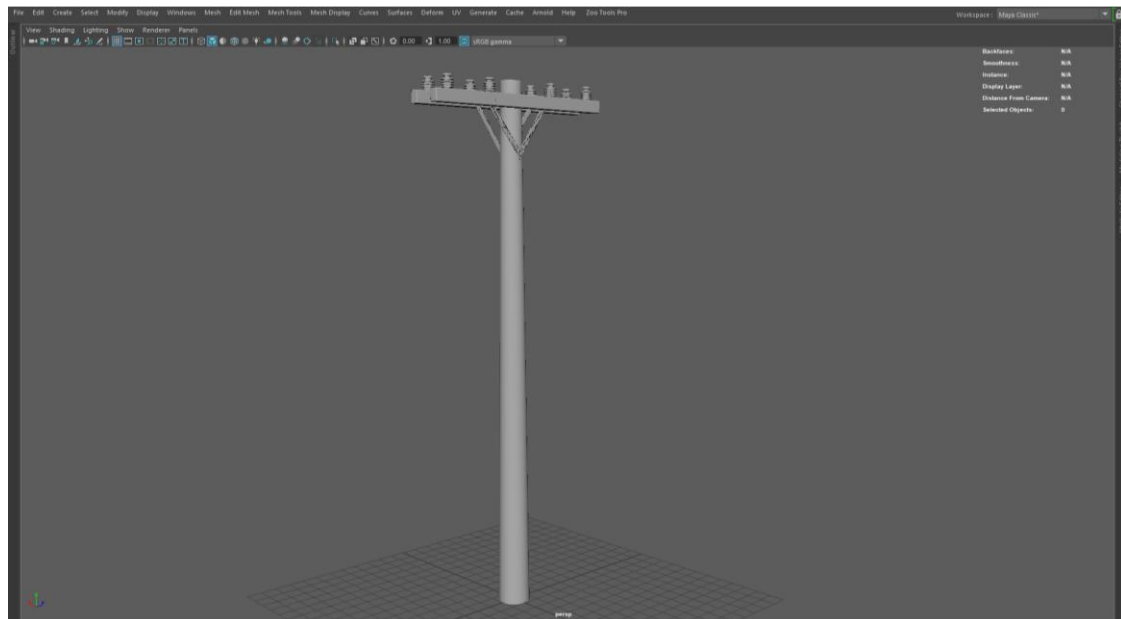
Figure 2.21 Electric Pole Model

Adjust the soft selection level according to the need. After that I pulled those vertices to make them carved from middle to look like wires. In top of the pole, there are two wood bars. To make those I just used one box and beveled the edges to look realistic.
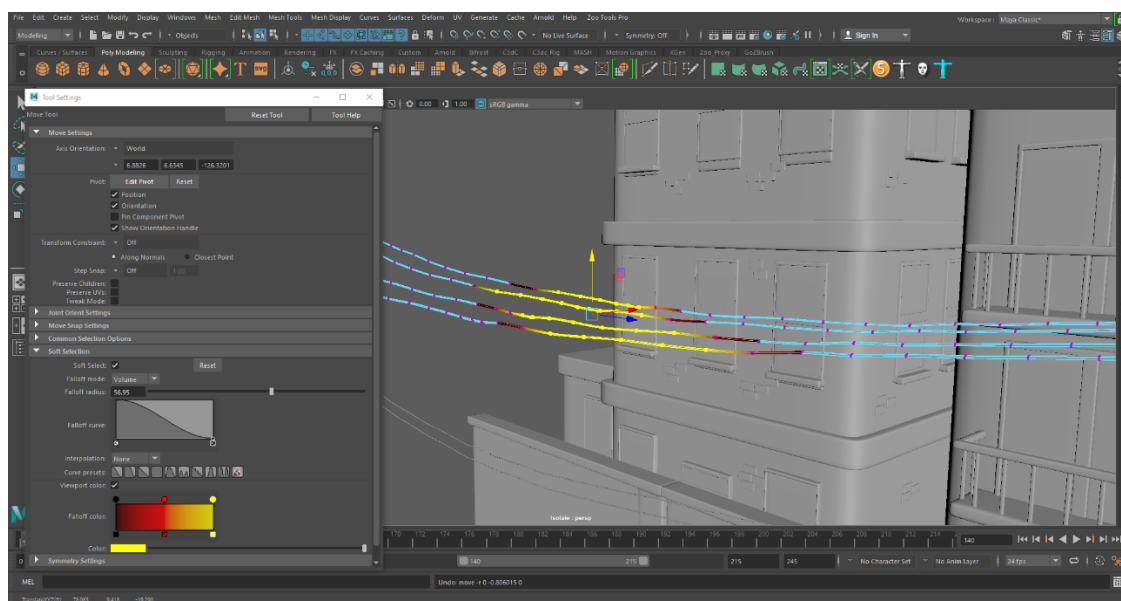
Figure 2.22 Electric Pole Wire Model

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2.2 UV Unwrap

Unwarp is one of the popular methods for doing UV of any 3d object. UV means representing a 3d object's surface with a flat 2d surface. It's used to texture 3d objects easily. This process of creating a uv map is called UV unwrapping.

Here the U and V represent two axes of the 2d space. And in the 3d space there are three(X,Y,Z) axes which represent 3 different directions.

2.2.1 Switchboard :

Each and every component in switch board was unwrapped for the texturing purpose. First selected the switch, then choose the right edge which needed to be cut for making the seam. To make the cut, open the UV editor from Windows > Modeling Editors> UV Editor. Then with the right edge selected, press SHIFT + X to make the cut. After cutting all the necessary edge to unfold the switch, press CTRL + U while shell mood is selected in the UV Editor. That unfolded the switch properly but sometimes it needed to be optimized in order to unfold perfectly. Optimize tool will be found in the UV Toolkit > Unfold > Optimize. To orient the shells, Select the shells you want to orient >Open up the UV Toolkit >Arrange and Layout >Orient Shells. This will make all the shells oriented which will make the texturing process easier.
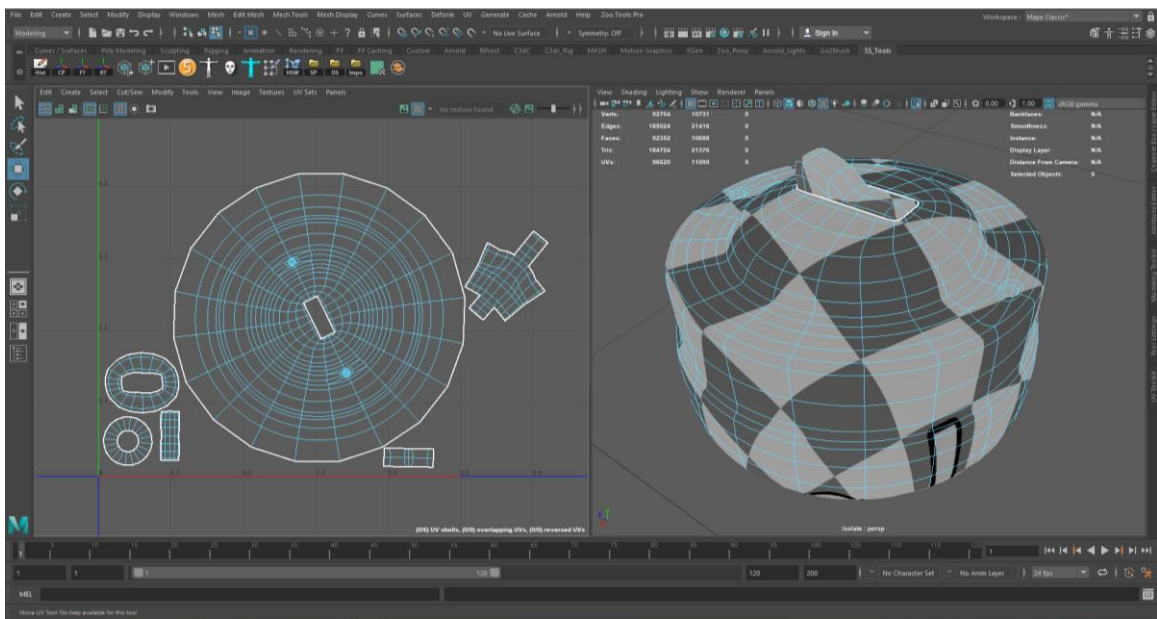
Figure 2.23 Switch UV Unwrapping

As some of the switches are identical, so in order to save space in 0 to 1 space I used Stack and Orient Operation to stack those same unfolded uv shells. It's located in UV Toolkit >Arrange and Layout >Stack and Orient.
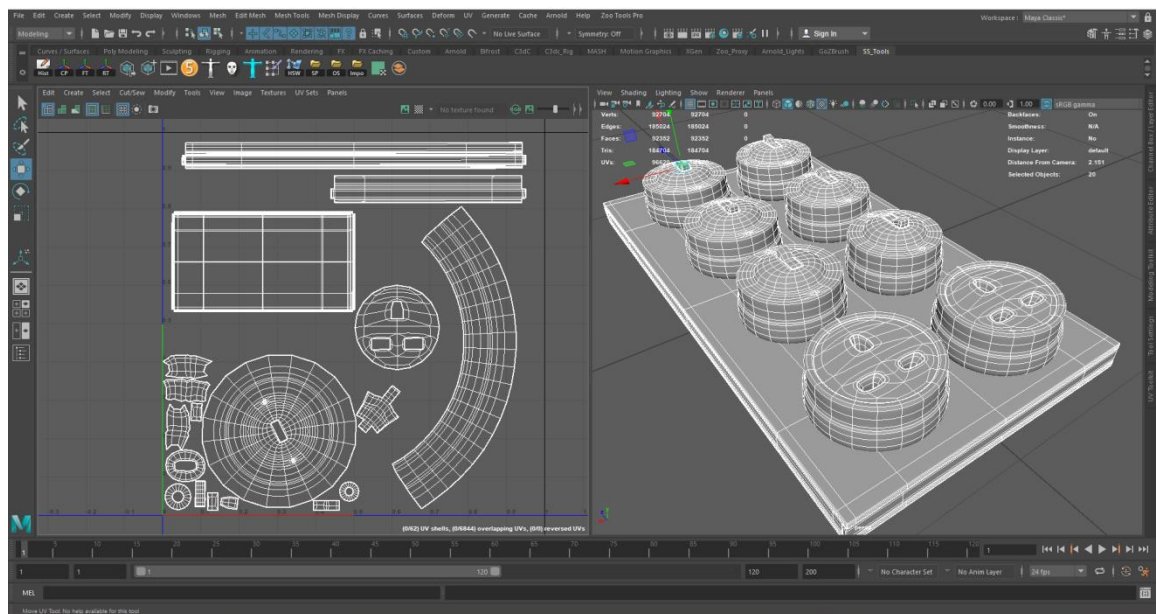
Figure 2.24 Switchboard UV Unwrapping

2.2.2 Water Filter :

Water filter have around five to seven part including some small pieces. So, each piece needed to be cut according to the need of texturing and unfolding. After selecting the edge, you want to cut, Open UV Editor and press Shift +X and press Ctrl + U to unfold the object properly in 2d surface.
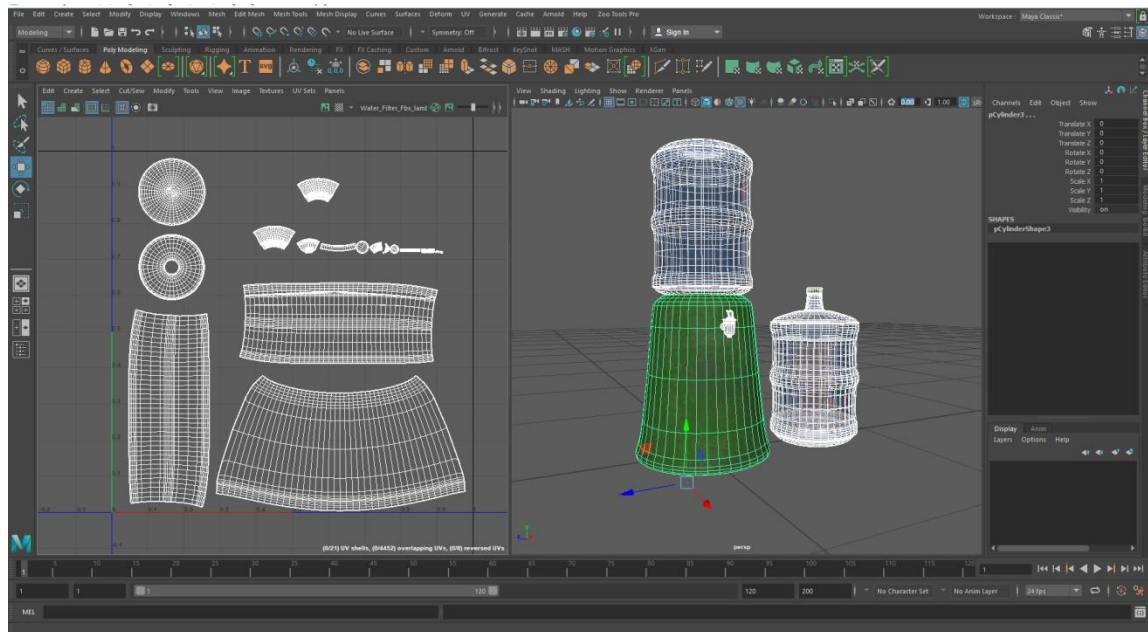
Figure 2.25 Water Filter UV Unwrapping

Sometimes the unfold may not be perfect, so to fix that use the Optimize tool from UV Toolkit >Optimize. This will fix any odd stretched unfolding problem and make the cut shells perfectly flat.

2.2.3 Exhaust Fan :

The unwrap process is almost the same for every model, the difference is to find the perfect seam spot where the cut will be less visible. For the exhaust fan, all components were cut and unwrapped one by one. By selecting the seam edge press Shift + X on the UV Editor window to cut the selected edges. Select all the UV Shells and press Ctrl + U to unwrap and press Shift + Right Mouse Button > Orient Shells. At last press Ctrl + L to lay out all the shells.

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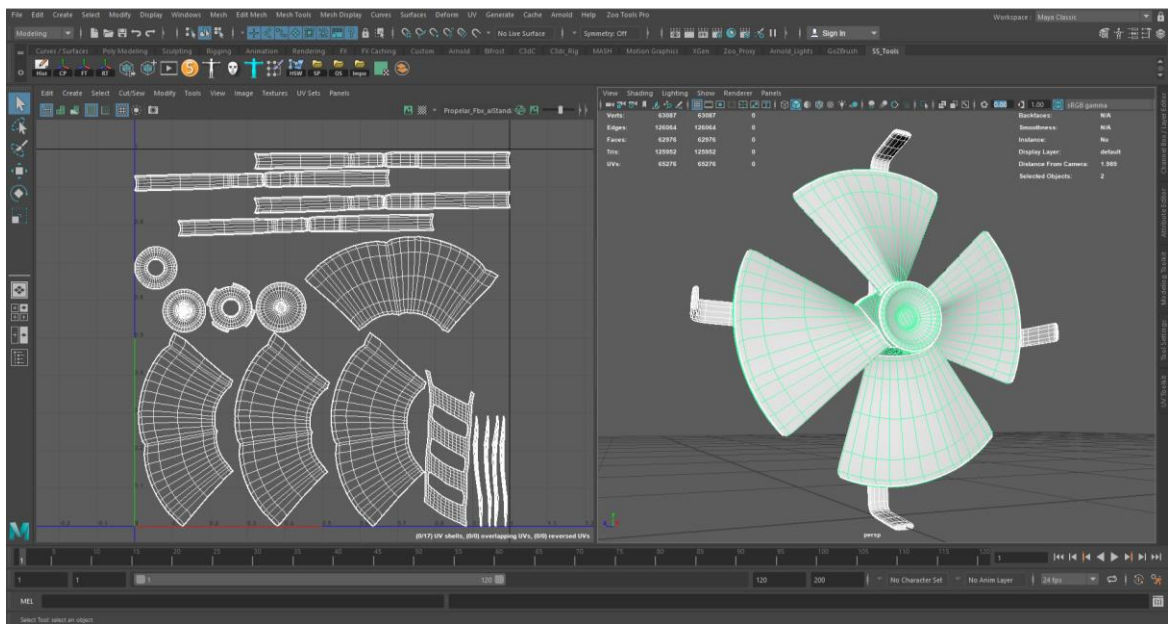
Figure 2.26 Exhaust Fan Unwrapping

2.2.4 Hammer :

Unwrapping the hammer was not so difficult because it doesn't have a lot of components. It has two components. The head and the body. First select the edge which will be the seam and cut it by pressing Shift + X in UV Editor and then Unfold it by pressing Ctrl +U.
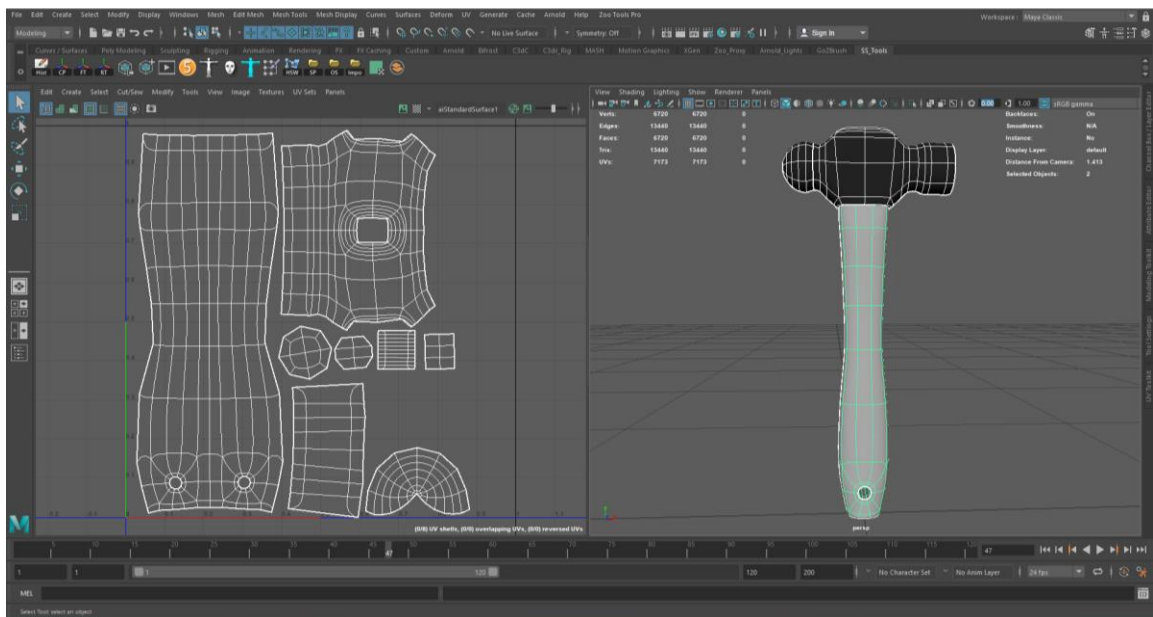
Figure 2.27 Hammer Model Unwrapping

2.2.5 School Bench :
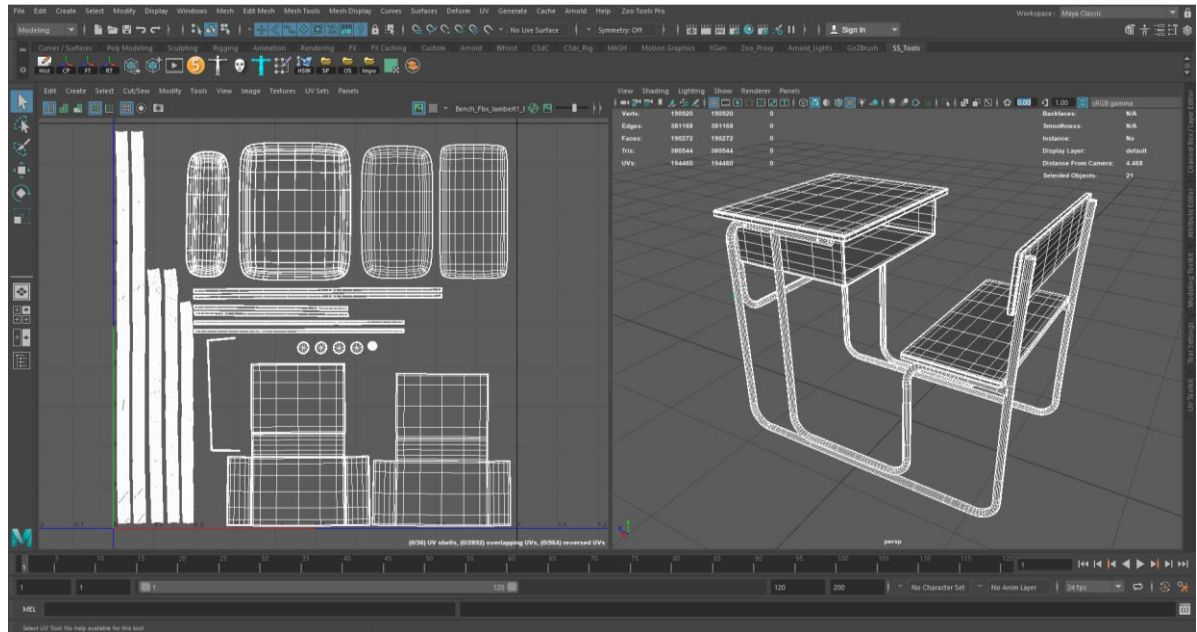
Figure 2.28 School Bench Unwrapping

The school bench had two different parts to unwrap. One is the steel parts and the other one is the wood part. Both of these things were cut and unfolded as the previously mentioned process.

2.2.6 Sidewalk & Walls:

Sidewalk has three components to unfold which were basically two types of tiles and one cement block. These things were already almost flat so it didn't need to be cut. Only by pressing Ctrl +U it was unfolded properly.
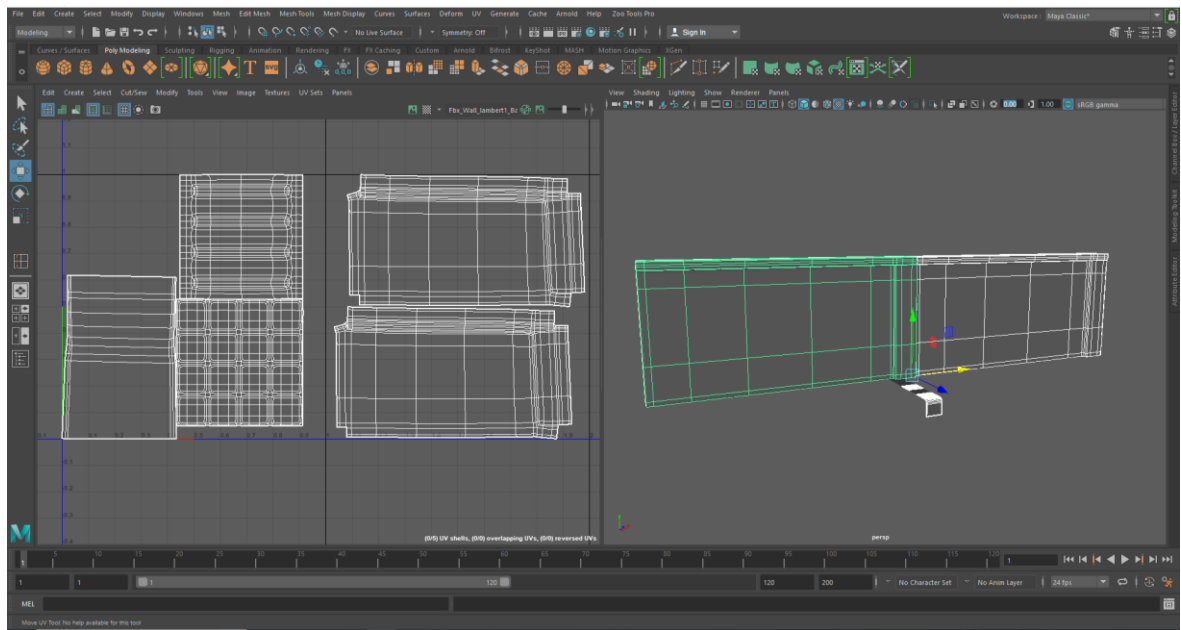
Figure 2.29 Sidewalk and Walls Unwrapping

The walls have also almost same geometry because the back faces were deleted to make the scene optimized. It was pretty flat already so just pressing the Ctrl +U it unfolded automatically.

2.2.7 Mold Machine :

Unwrapping the mold machine was not easy because it has a lot of components in it . And in uv editor there needs to be some space management because texture resolution depends on it. For normal small models the preferred space is 0 to 1 space. It means all the parts of the models needs to be fit in the shown space below.

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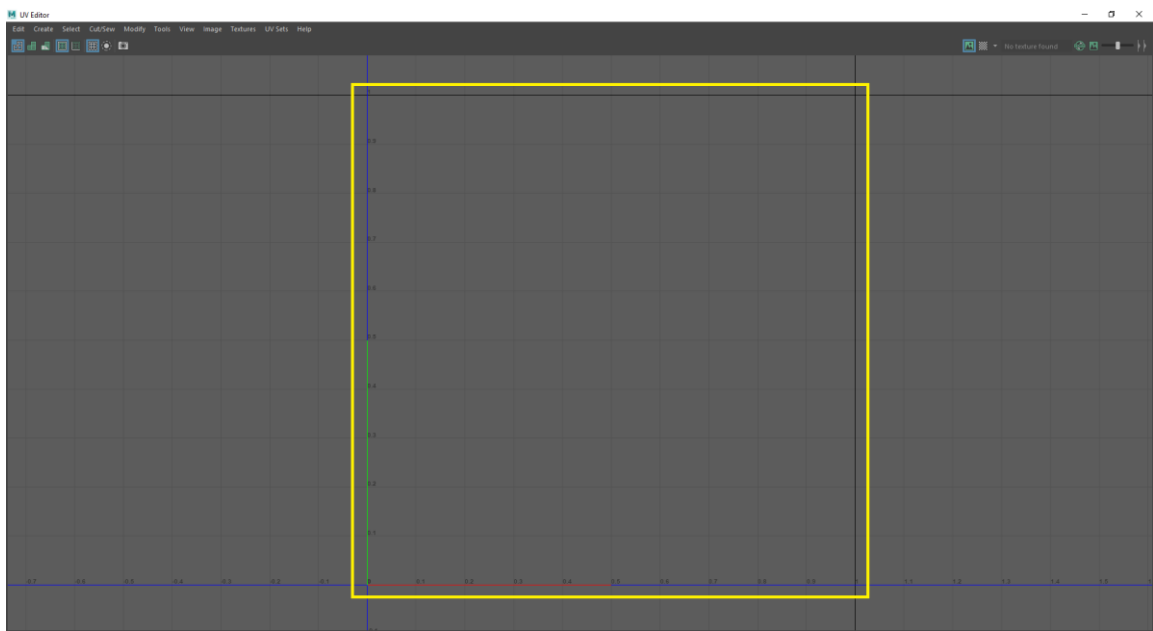
Figure 2.30 : 0 to 1 Space for Layout All UV Shells

But as the mold machine has a lot of parts, it was difficult to fit all those parts in 0 to 1 space. So, I used some more space to fit those all. This type of texture set is called UDIM Texture "**UDIM** was invented by Richard Addison-Wood and came from Weta Digital (circa 2002). The term UDIM comes from **U-Dimension** and design **UV ranges**. The UV range 0-1 being 1001, the range 1-2 being 1002, and so on. We designate by **UDIM Tile** a specific range, the tile 1001 being the range 0-1 of a given mesh. The goal of having multiple UV ranges it to **increase the texture resolution** of a given mesh. Instead or working with very big textures (16K, or even 32K) which are hard to optimize it is instead better to split a mesh into sub-parts. Because of the UDIM naming convention, parsing files is easy as the ID of a tile is embedded into the filename, which make them convenient to use in external rendering software such as **V-ray** or **Arnold**."[12] .UDIM uses more than one tile of UV Editor to lay out every part of any model. For cutting every necessary edge to make the seam, select the object then select the edge.

Go to Menu >Windows >Modeling Editors >UV Editor. Press Shift + X to make the cut and Ctrl +U to unfold the part properly. This same process was repeated for every part of the mold machine. Each and every piece needs to be unfolded properly otherwise the texture will give some odd results. I needed three UDMI tiles to fit all those parts of the mold machine.

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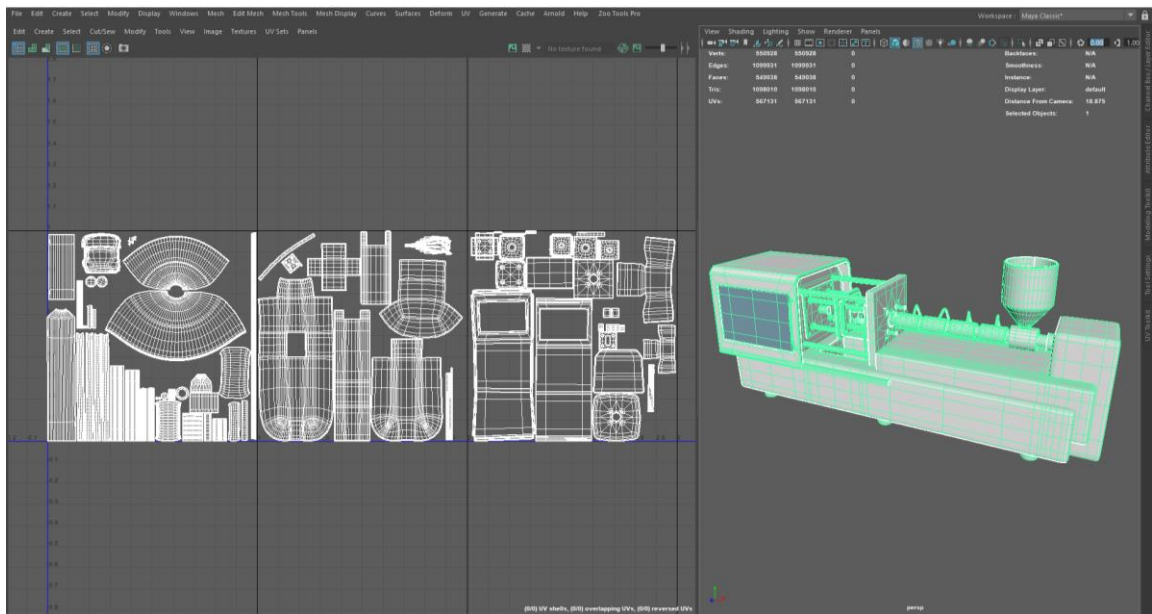
Figure 2.31 Mold Machine Unwrapping with 3 UDIM Tiles

2.2.8 Toy and Real Cars :

As the toy car needed to have stickers in its body, so it was important to unfold it in one single piece so that no seam can be seen in stickers. To do this I had to cut some of the edge according to the need by pressing Ctrl + U and then gave it some optimization with the optimize tool from the UV Toolkit.
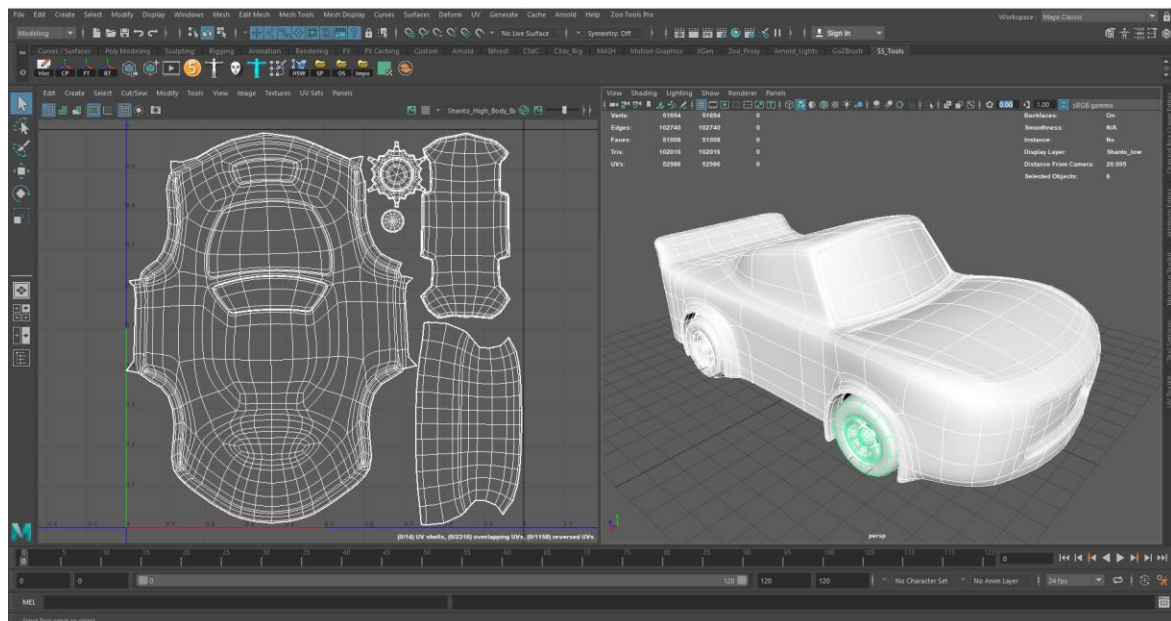
Figure 2.32 Toy Car Model Unwrapping

The real car model was also modified from this toy car so the UV Unwrapping has the same process described in for the toy car.

2.2.9 School Gate :

The school gate has some small and big components in it including some words. So, the columns in two side was unwrapped just like a box. The different words have different ways to cut for unwrap.
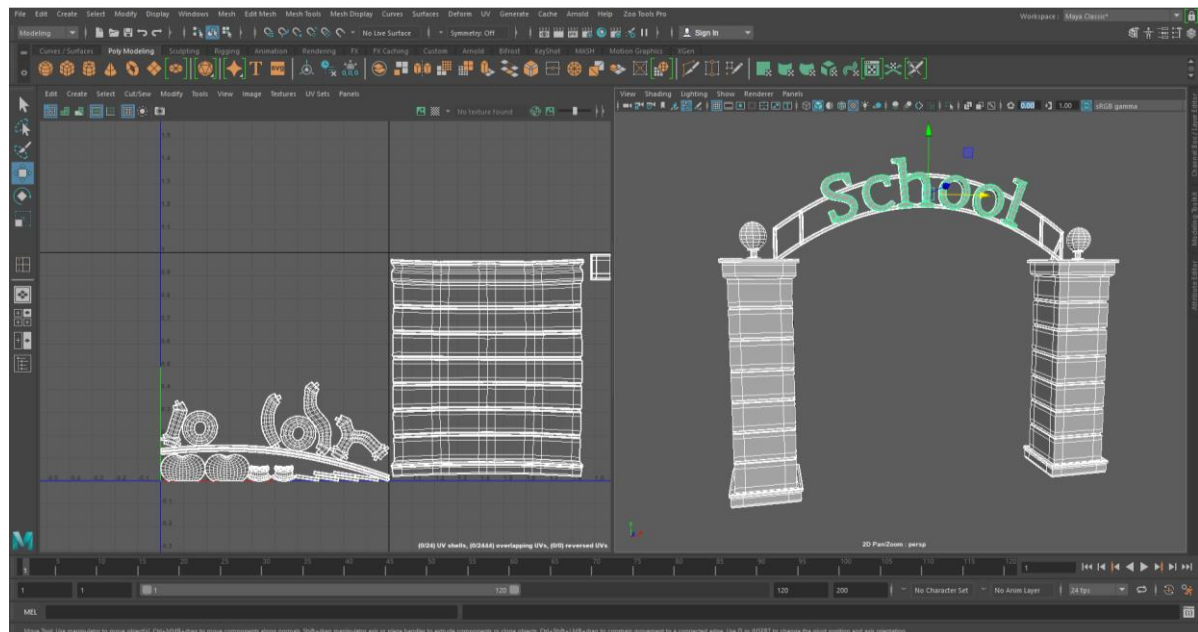
Figure 2.33 School Gate Model UV Unwrapping

2.2.10 Character Unwrap :

Character unwrapping is not that much tough how its look like. It has some simple ways to do. You just need to understand where to cut and where not. Every piece of the body can be unwrapped by cutting the following edges shown below. First there needs to be cut made in every single joint. Started by cutting the edge around the thighs where the thigh joins with the torso. Then the arms are cut along the edge that joins them with shoulders.
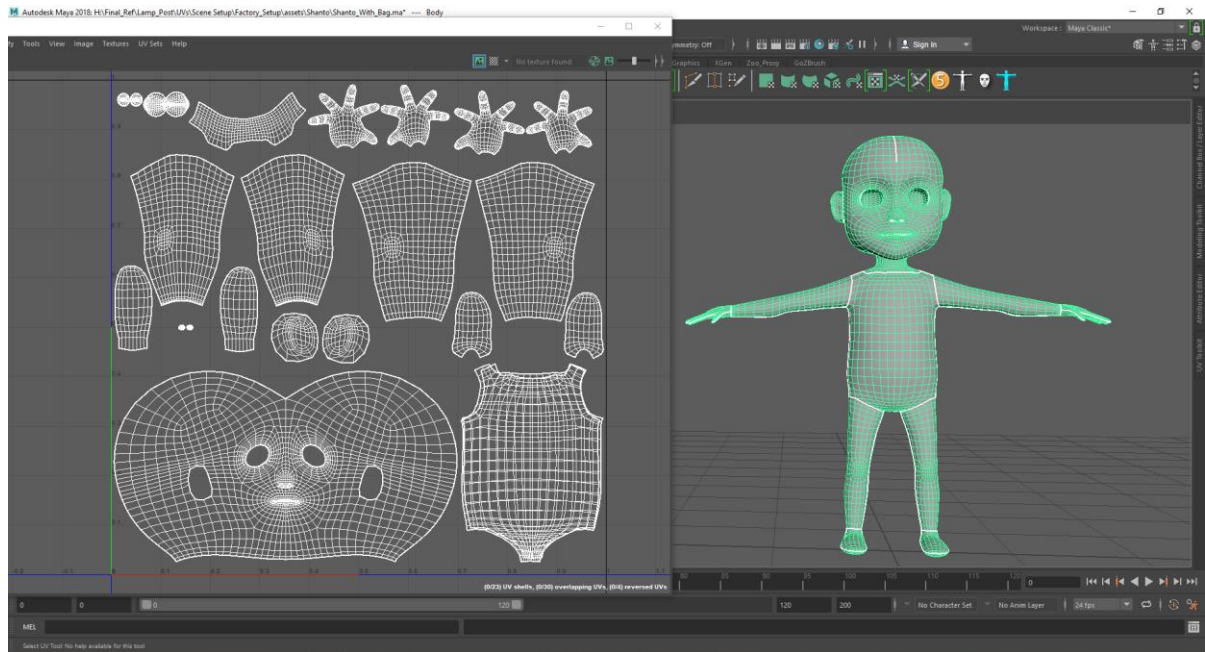
Figure 2.34 Character Body UV Unwrapping

After that the head is separated by cutting around the neckline. Hands are cut along the wrist and the feet are cut along the ankles. For flattening the head, a cut is made behind the head starting from the hairline.

After making the cuts were done it was time to unfold the UVs. It was unfolded following the steps previously mentioned. Then the layout was done manually to make it easier for texturing later.
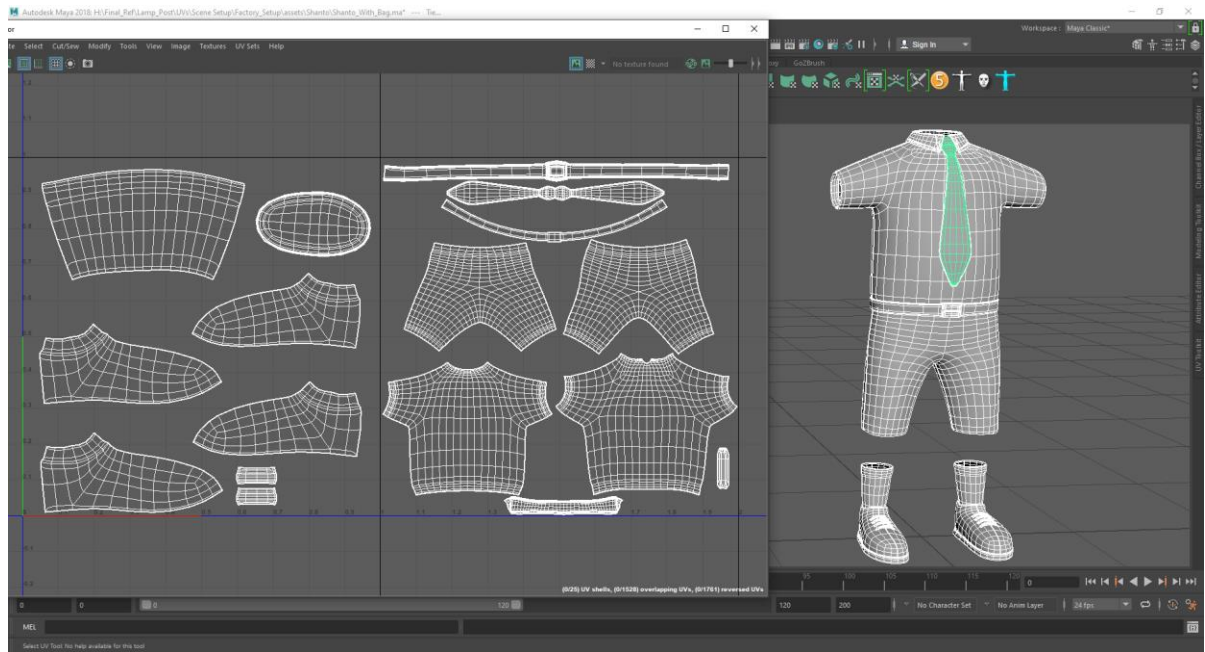
Figure 2.35 Character Dress UV Unwrapping

For unwrapping the dress, it was done one by one. First the shirt was selected and edges along the sides were cut. When unfolded , it easily split into two equal symmetric halves. Similarly, the pants were unfolded. In this case all the clothes were kept in the same 0-10 space in the uv editor to save some space.

2.3 Texturing

Texturing is a method of creating high quality detail, surface texture or color information on a computer generated 3d model or graphic. For our project we have used "Adobe Substance Painter"[13] to texture most of our models. It works layer by layer and makes texture easy. Adobe Substance Share website helped a lot because it had a lot of free materials in it.

2.3.1 Switchboard :

The texturing part was done in Substance Painter in order to have more control over the materials and textures. I needed to export the whole switchboard in fbx format from Autodesk Maya to Substance Painter. There were two different kinds of materials needed in the switch board. One is the wood texture and the other is the plastic material.

Figure 2.36 Switch Board Texturing in Substance Painter

In order to import the fbx switchboard in Substance Painter, go to File> New> Select the fbx switchboard file and give it an appropriate resolution then press OK. First, we need to bake mesh maps for the model. For creating new materials in Substance Painter, go to Layers tab > Add a fill layer> Material. There I can modify base color, metalness, roughness, normal and

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height. After creating the materials properly according to the need, I exported those texture maps for Autodesk Maya. For Export textures; File> Export Textures. A new tab will be opened and there some options needs to be changed according to the requirements. Like format, size etc. of those exported textures.
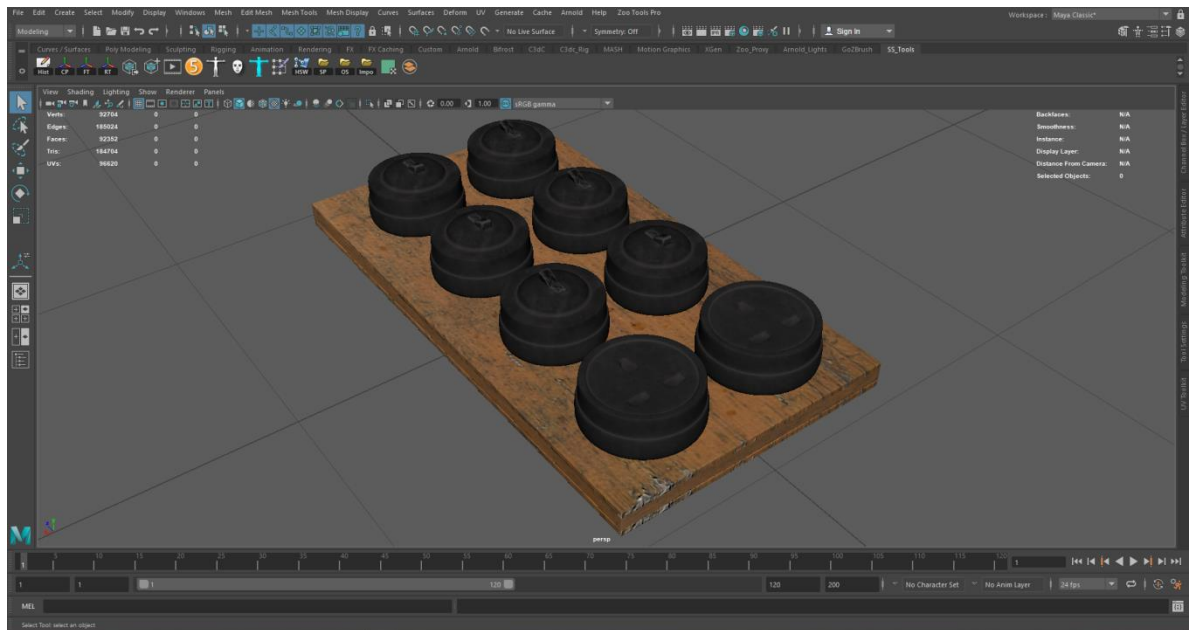
Figure 2.37 Switch Board Assigned Texture in Maya

The switchboard at the top have all the png textures assigned in Maya which was created in Substance painter. In Maya I used aiStandardSurface Material for rendering every model. The picture below shows the fully rendered image of the switchboard with Arnold Renderer.

Figure 2.38 Switch Board Rendered Image in Autodesk Maya

2.3.2 Water Filter :

In order to import the fbx switchboard in Substance Painter, go to File> New> Select the fbx switchboard file and give it an appropriate resolution then press OK.
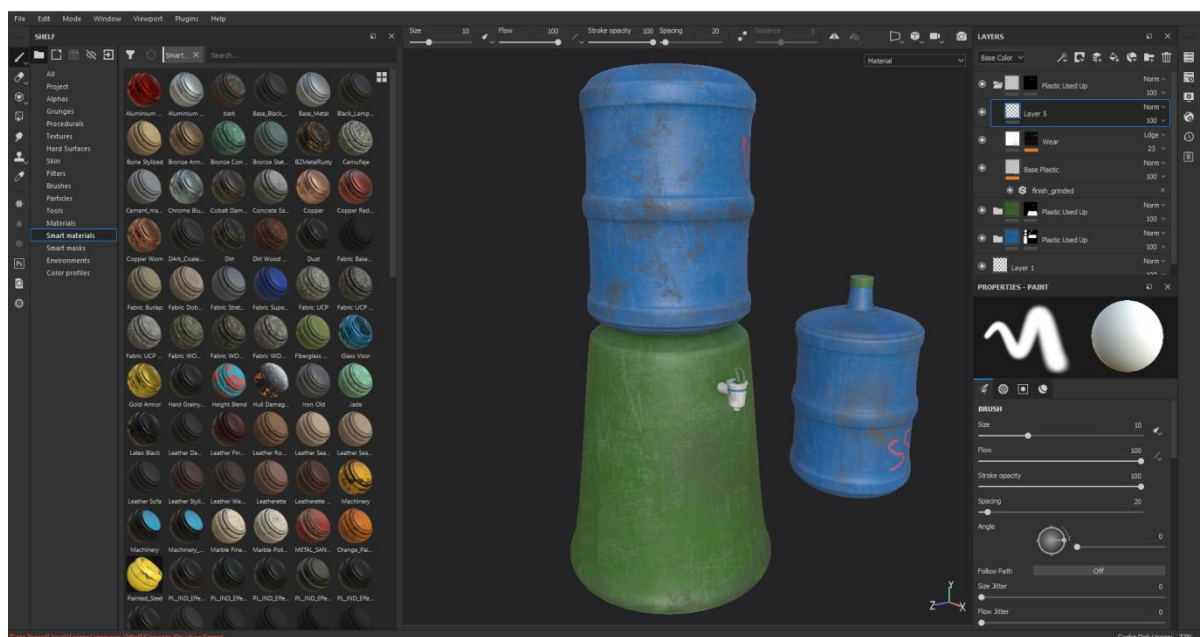
Figure 2.39 Water Filter Texturing in Substance Painter

First, we need to bake mesh maps for the model. For creating new materials in Substance Painter, go to Layers tab > Add a fill layer> Material.

Figure 2.40 Water Filter Rendered Image in Autodesk Maya

2.3.3 Exhaust Fan :

First the fbx format file of the exhaust fan was exported from Maya then imported into substance painter with the UV information. To import the fbx file in Substance Painter , go to File > New > From the Template select the file you want to import >give it a resolution >Ok. After importing it with one resolution it can be changed anytime.

Then we need to bake mesh maps for the model. For creating new materials in Substance Painter, go to Layers tab > Add a fill layer> Material.
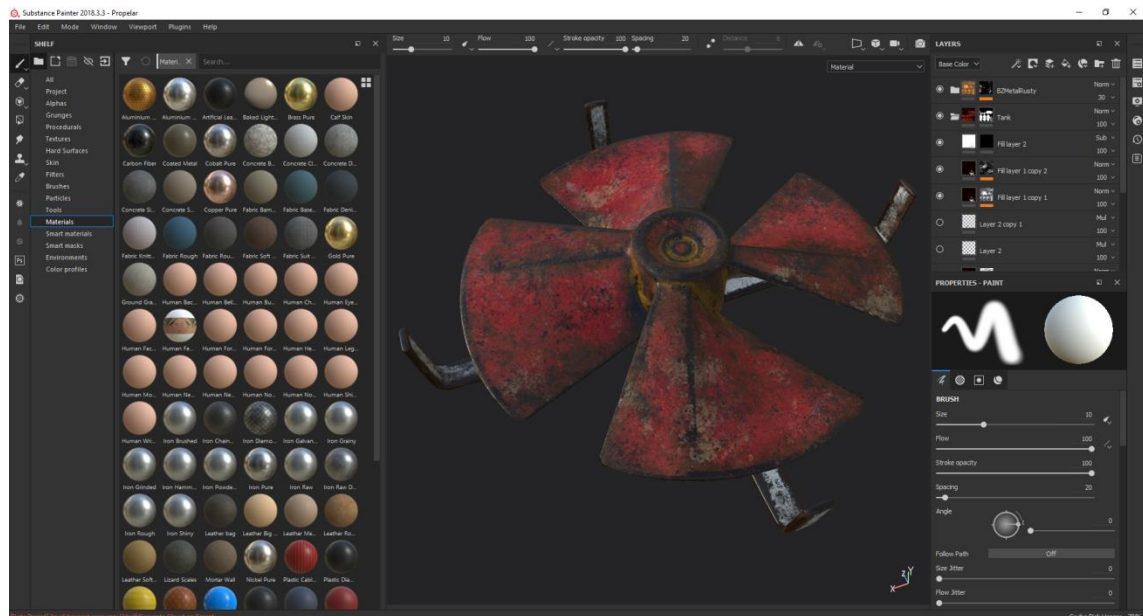
Figure 2.41 Exhaust Fan Texturing in Substance Painter

Smart materials were used because it stays contained in layers and it can be modified easily.

Figure 2.42 Exhaust Fan Rendered Image in Autodesk Maya

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2.3.4 Class Bench :

The importing and baking techniques are the same as the previous models. But for this school bench I have used two UDIM sets to export textures from Maya. So, when importing fbx
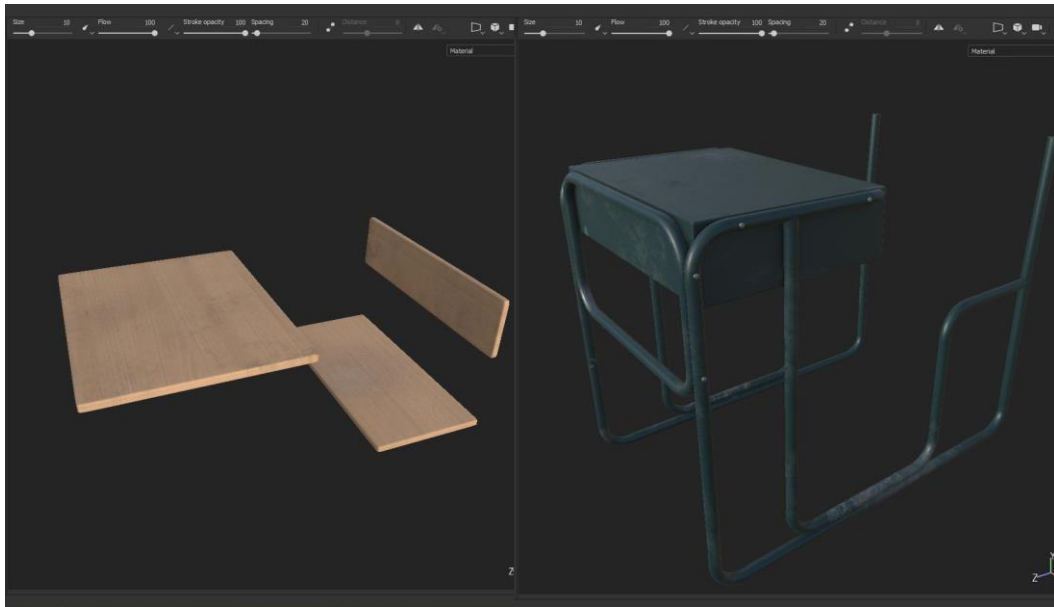
Figure 2.43 Class Bench Texturing in Substance Painter

file in Substance painter, you need to click on "Create a texture set per UDIM tile".

Figure 2.44 Class Bench Rendered Image in Autodesk Maya

2.3.5 Sidewalk and Walls :

These textures were done in Substance painter with multiple layers. It's needed to look a little bit old so some dirt layers were applied on top of the clean materials.
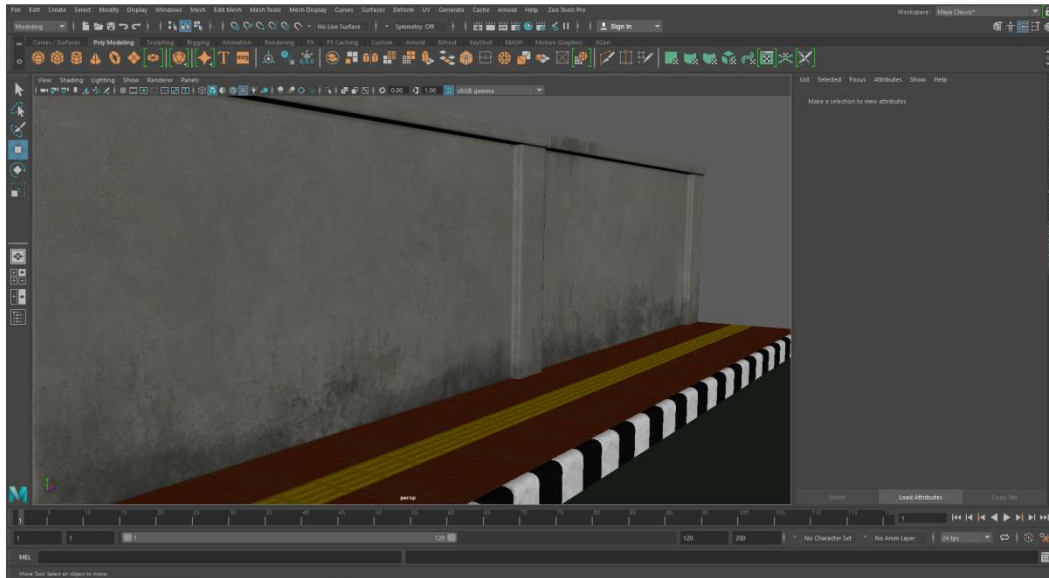
Figure 2.45 Sidewalk and Walls Texture Assigned Image in Autodesk Maya

As it has four different components, so four different types of materials needed to be created for them. As you can see down below, the red tiles have 4 different layers in total.
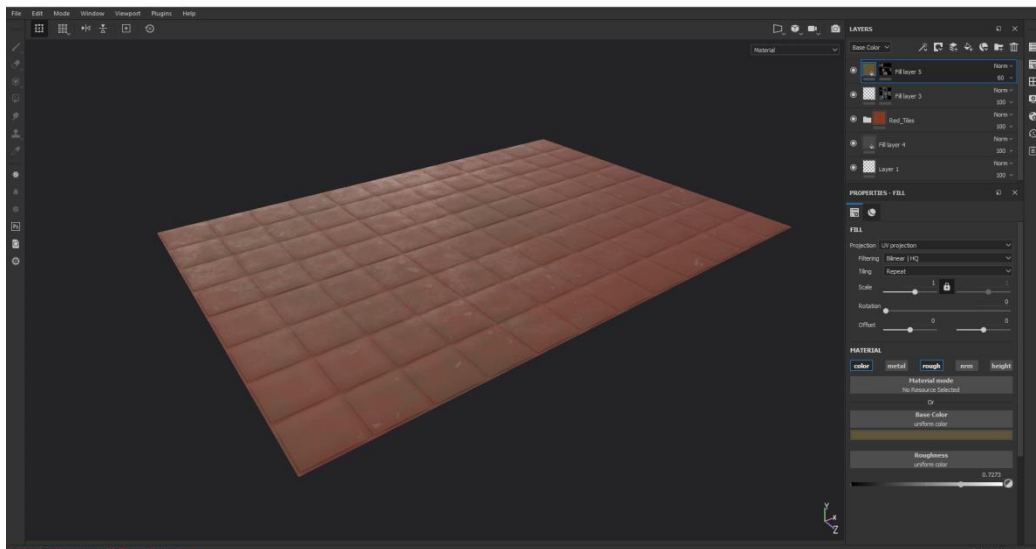
Figure 2.46 Sidewalks Tiles Texturing in Substance Painter

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2.3.6 Mold Machine :

As the mold machine has three UDIM tiles, it was difficult to texture because every set of UDIM needs to be textured separately. It's because every UDIM will be in different layers which can be found under Texture Set List tab.
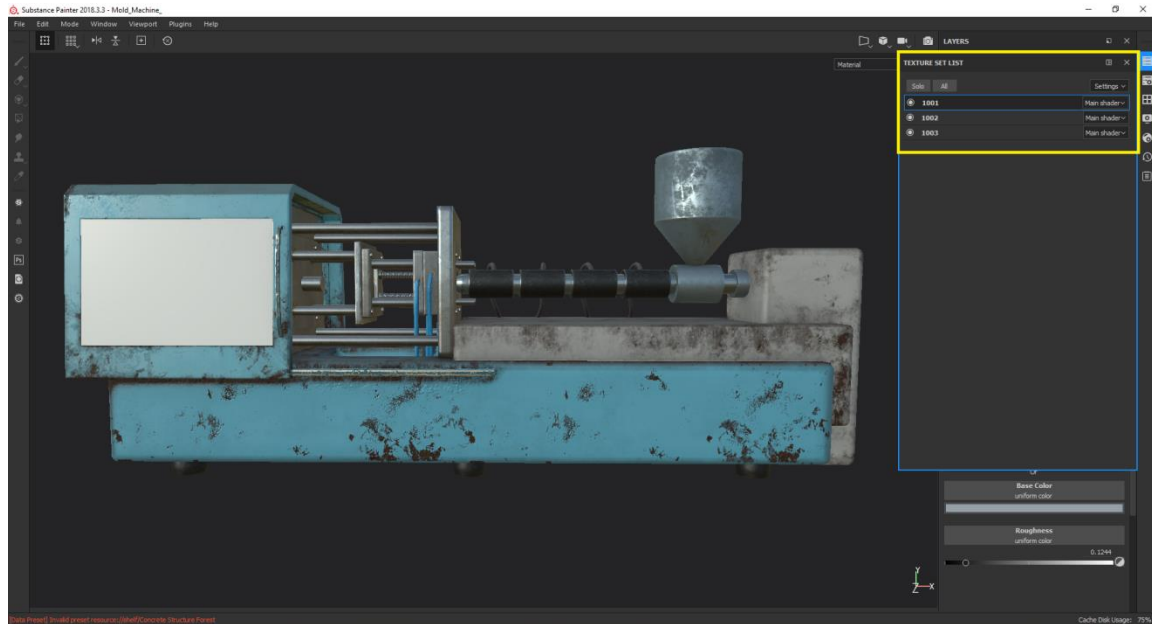
Figure 2.47 Three Different UDIM Texture Set of Mold Machine
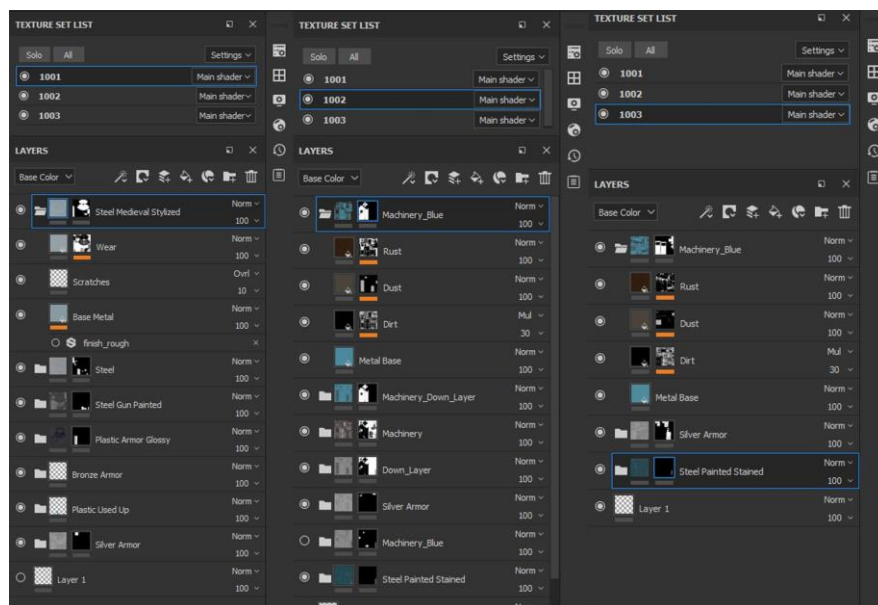
Figure 2.48 Layers of Three Different Texture Set List of Mold Machine

There you can turn on/off any of the UDIM tiles for the help of the texturing.

I have given screenshots of three different UDIM tiles for understand how the texturing work in substance painter if you import any model with multiple UDIM tiles.

2.3.7 Toy Cars :

Texturing process of the car was a little difficult because as it is the main prop for the story so it's needed to be perfect. It was difficult to find the solution for creating different reflection maps for the body of the car and the stickers on the body. It was exported from Maya with single UDIM tiles so I used the polygon texture method sometimes to texture small parts of the car.

Figure 2.49 Toy Car Texturing in Substance Painter

2.3.8 Pliers :

At first the .fbx format file of pliers was imported in Substance Painter. Press File > New >Select the fbx file >then press ok. It will import the smooth mesh of pliers exported from Autodesk Maya .

After this I baked all the texture sets with a resolution of 2k.I baked the world space normal map, ambient occlusion map, curvature map and the position map. All these maps will make the texture process easier.

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Figure 2.50 Pliers Texturing in Substance Painter

As you can see, I have used some smart material from the material shelf and also created some fill layers to add more details in the models. That logo of "VISE-GRIP" was first created in photoshop then used as e height map in substance painter for making the bump.

Figure 2.51 Pliers Render Image with Texture in Autodesk Maya

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2.3.9 School Building :

The school model was so big that taking its UV as UDIM texture set was tough. So I textured it with photoshop with a seamless brick texture. I had to create a bump map from that texture so that I can give some bump in my school walls.
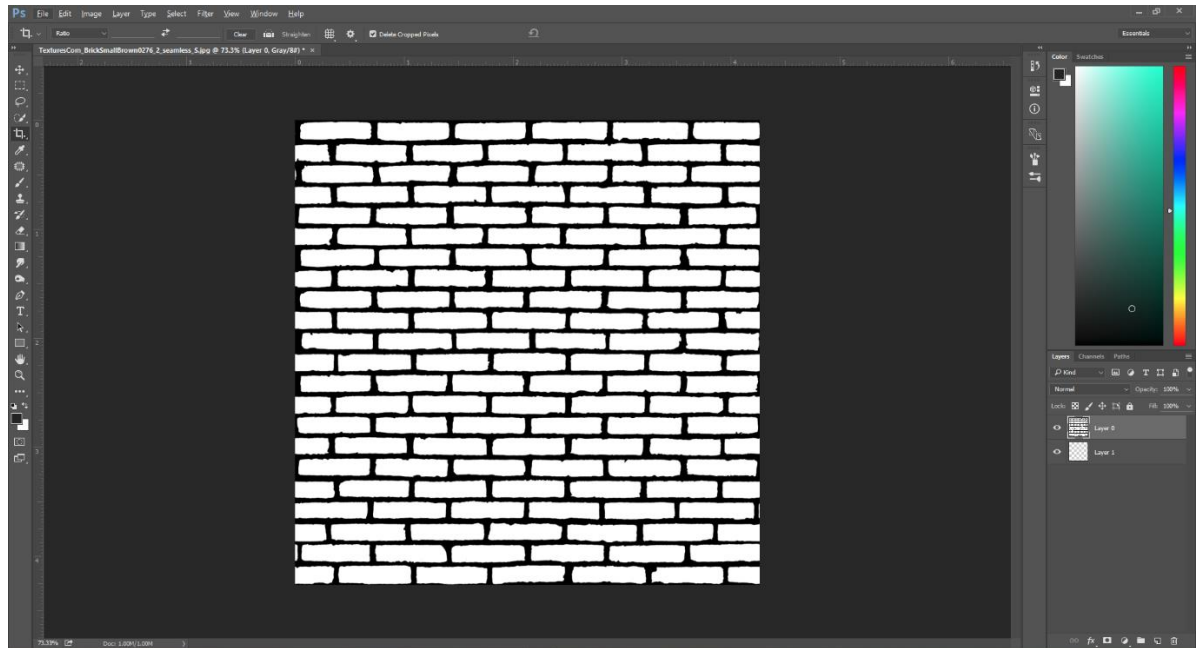
Figure 2.52 Bump Map Creating for Bricks in Adobe Photoshop

Figure 2.53 School Building Rendered Image in Autodesk Maya

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2.4 Lighting

The lighting of all the scenes in this project was done with both default Autodesk Maya Lights and Arnold Lights. Solid Angle's "Arnold Render"[14] was the render engine which we used for our whole project. For specific scenes we used different kinds of lights according to the mood needed for the story. From Arnold we used Sky dome Light, Area Light, Mesh Light and from Maya, we used Directional Light and Spot Light. I'll describe the parameters of light for every scene in our project.

In the first scene, there are three shots. One is the extreme close shot of the toy car; the second shot is the long shot and the last one is the mid shot of our main character Shanto. As it was a day time shot, so I have used a Maya default Directional Light and an Arnold Sky dome Light. You can find the Maya Directional Light under Menus >Create >Lights >Directional Light. It's a default Maya light which is available in every version of Autodesk Maya.
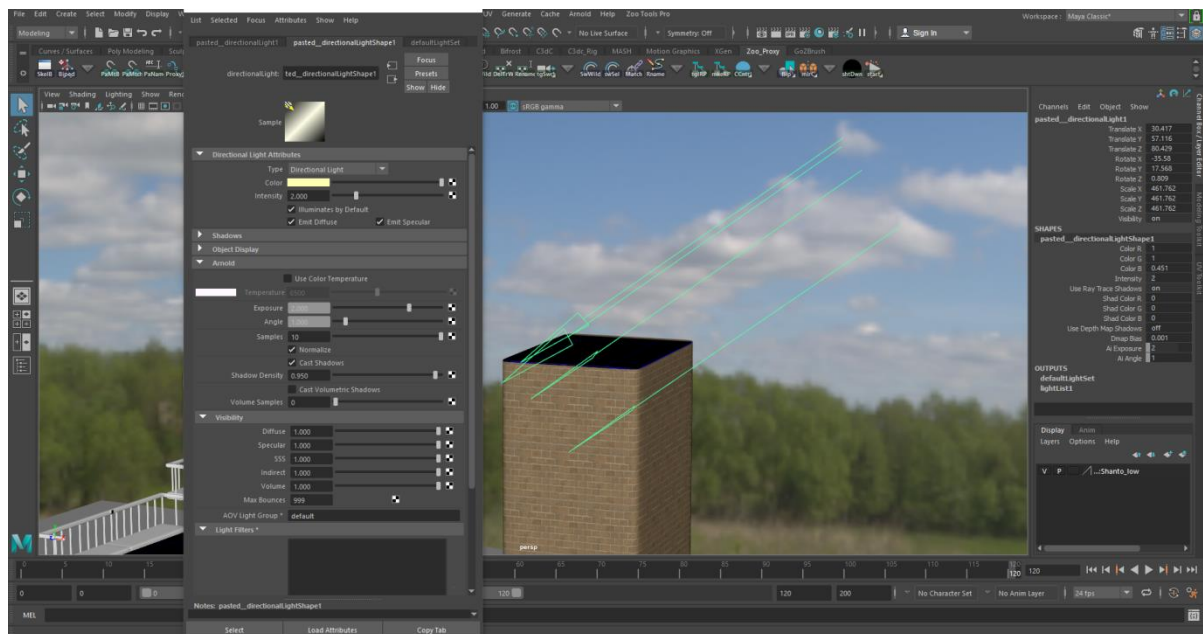
Figure 2.54 Directional Light Parameters of First Scene

The time of the shot was around 9 a.m., so I needed to create a light with a yellow tone. To change the color of the light, go to attribute editor by pressing Ctrl + E. Then go to directional light shape tab and change the color of the light to a bright yellow. The parameters of the

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directional light for this scene is given below. The second source of light in the scene was the Arnold Sky dome Light. Which can be found under Menus >Arnold >Lights >Sky dome Light. This light has worked as a fill light for the scene. In the color attribute of the dome light, I have used a HDRI map of a bright day. To do this, you need to press Ctrl +E to open up attribute editor then go to aiSkydomeLightShape tab . Find the color option there and press the icon on the right side of color. Then select your HDRI map. The parameters of the sky dome light for the first scene is given below.
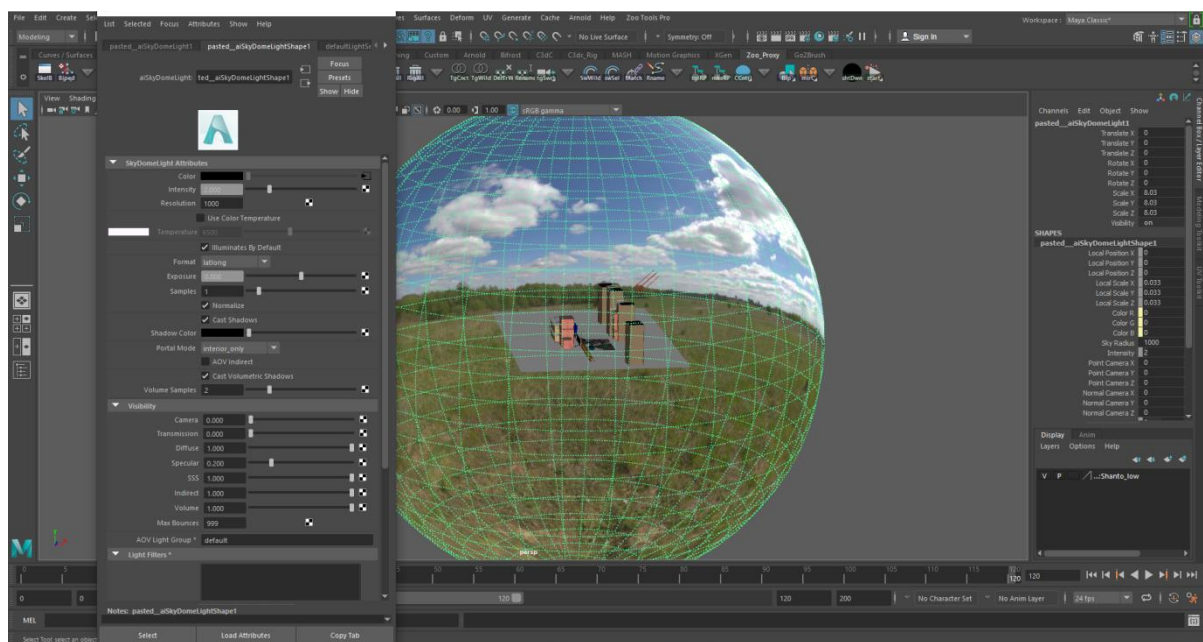
Figure 2.55 Sky Dome Light Parameters of First Scene

In the second scene, there was only one shot. It was also an outdoor shot so the light I have used was the same as the previous scene.

The third scene was an indoor scene with three different shot so the lights were different from the last two scenes. One close shot and two mid shots. As it was an indoor shot with the windows so I needed to create both outdoor and indoor lights to make the scene realistic.
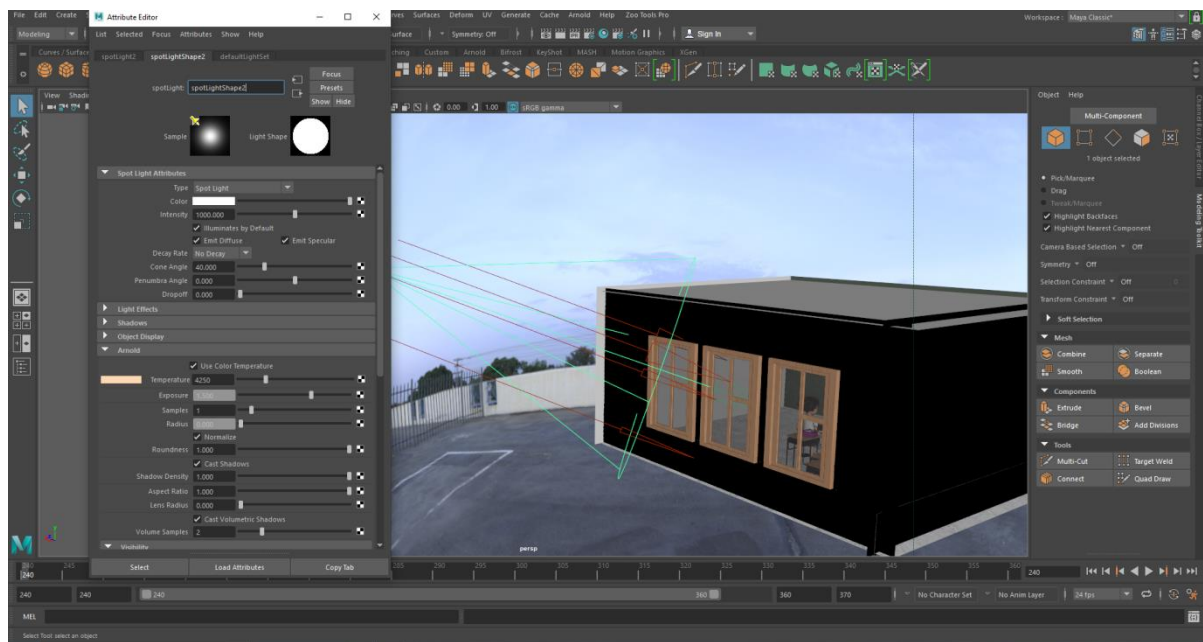
Figure 2.56 Spot Light Parameters of Classroom Scene (Outdoor)

There are total five lights in this scene. One directional light, one spot light, one sky dome light and two area light. I have already discussed about Maya default Directional Light and Sky dome light. The Spotlight is also a Maya default which can be found in Menus> Create> Lights> Spot Light.

Then comes the Area Lights which is an Arnold Light. It was needed for the indoor environment. This light can be found in Menus> Arnold> Lights>Area Light.
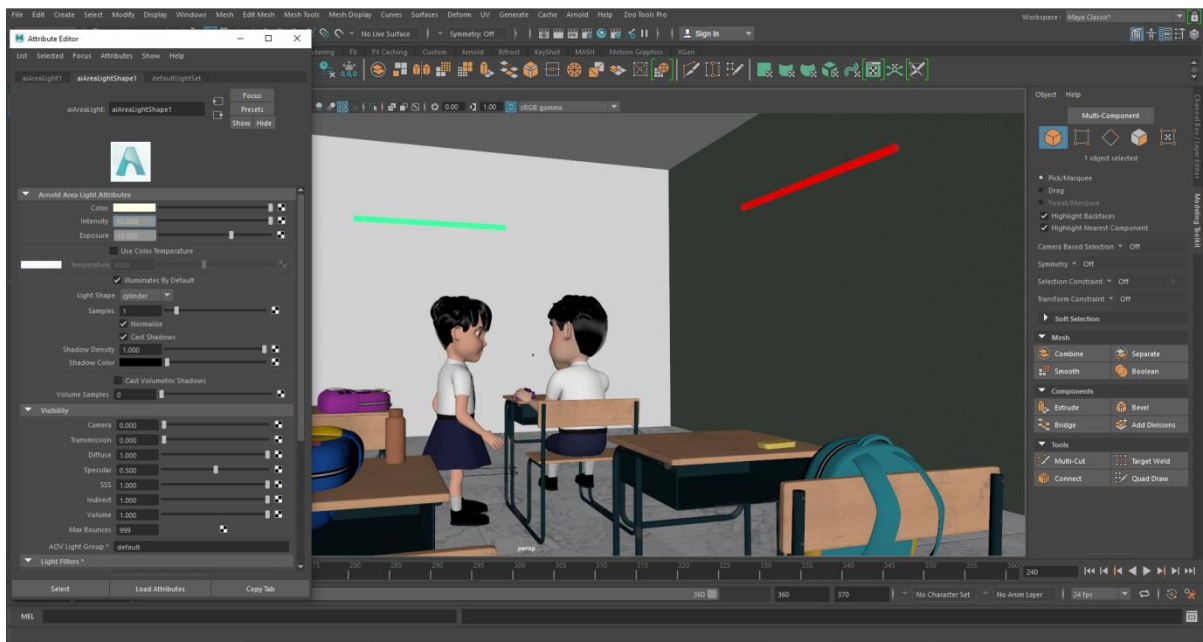
Figure 2.57 Area Light Parameters of Classroom Scene (Indoor)

The fourth scene was the starting of the factory scene which also have a lot of lights. In total there are six lights for the main factory scene. One Spot Light, four Area Lights and one Sky dome light. Different Area Lights were needed because there were four spots for lights to come in .One window, one door and two transparent roof spots.
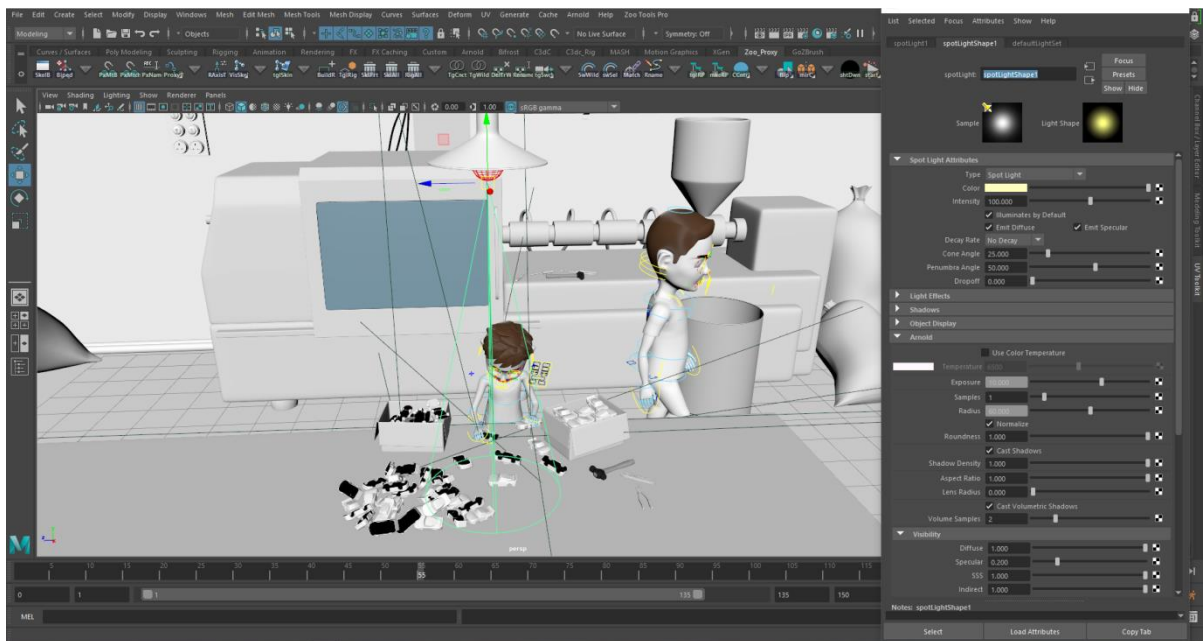
Figure 2.58 Spot Light Parameters of Factory Scene (Indoor)

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As the demand of the story this scene needed to have a yellow tone because the bulb you see is an old-fashioned yellow bulb. The four other area light had all different parameters according to the needs of the scene.
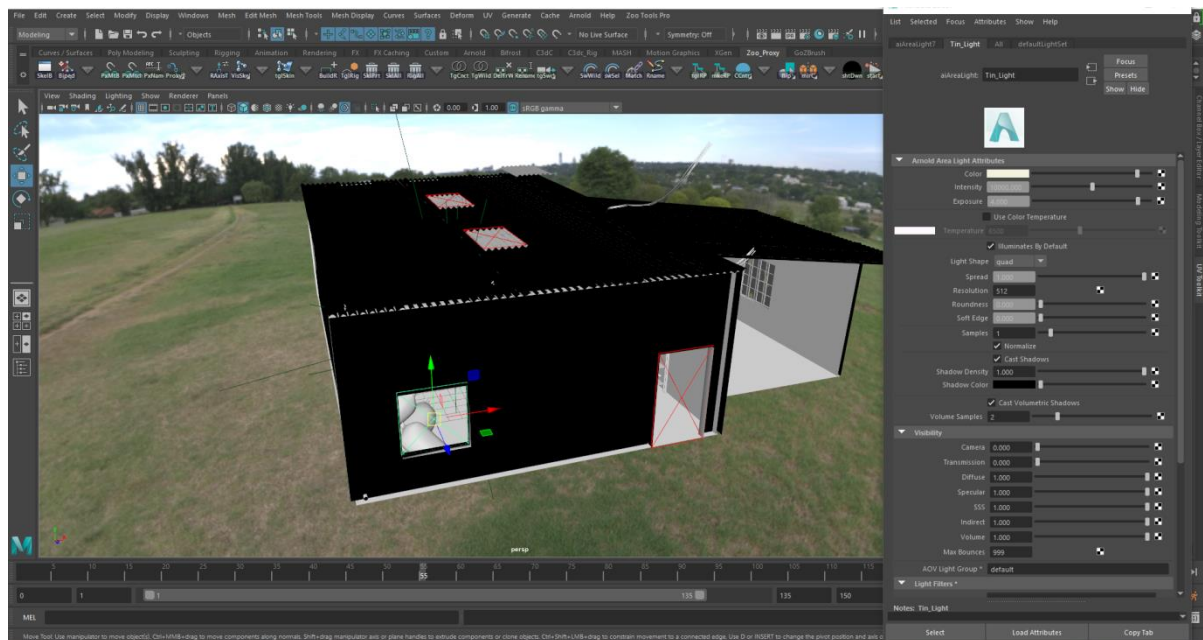
Figure 2.59 Area Light Parameters of Factory Scene

The last scene is in the store room of the factory. The lighting was almost the same as the previous scene but there were some changes. As in the last scene the camera had a window in view, so I had to create a direction light to mimic the sun light. It was not easy to combine the low light of the factory indoor and the sun light of outdoor.
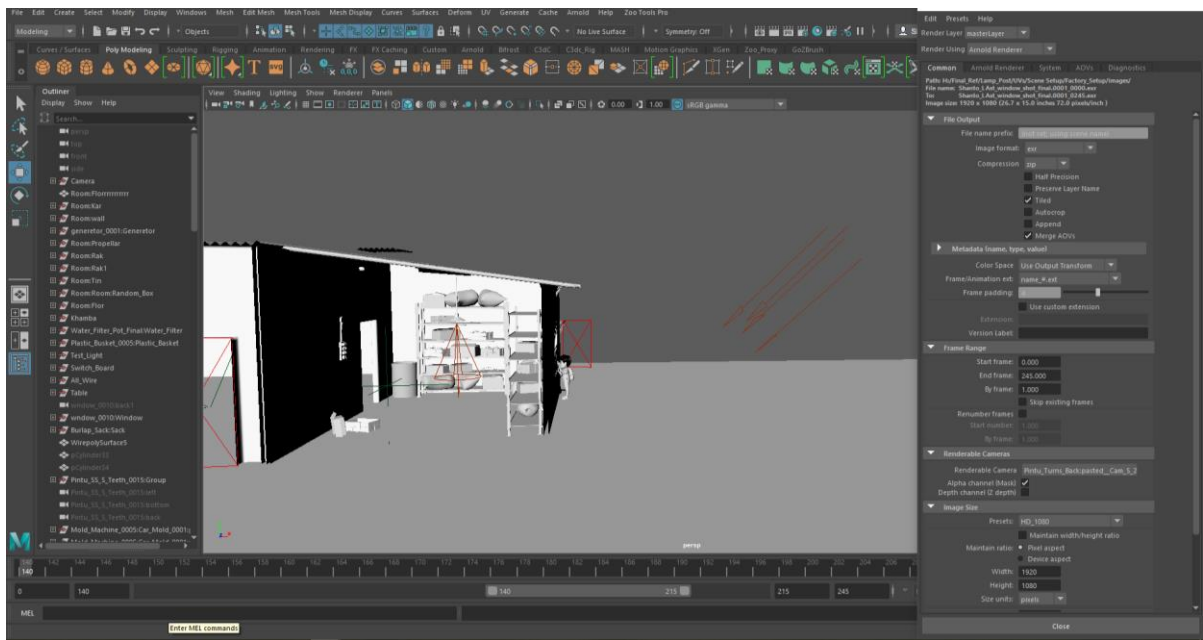
Figure 2.60 Combination of Indoor and Outdoor Lights

At the end of the lighting part I would like to show the final results of the lights I have described earlier. These are the final rendered file in Autodesk Maya with Arnold Renderer. All the images given below have the raw color produced by the Renderer.

Figure 2.61 First Scene Final Rendered Image

This is the raw render output of the long shot from the first scene and second scene. I have used one Maya Directional Light and one Sky dome Light for these two scenes.

Figure 2.62 Second Scene Final Rendered Image

Volumetric fog was added in the rendered image below from Maya's default Environment.

Figure 2.63 Classroom Final Rendered Image

This picture in the figure 2.63 was the shot from third scene which is in the classroom. There are total five light sources to illuminate the scene. And the picture below is from the factory scene. It has a total of six lights which I have already described.

Figure 2.64 Main Factory Final Rendered Image

Figure 2.65 Factory Storage Room Final Rendered Image

This picture in the top is the shot from the storage room of the factory. It has three light sources. And the picture below is from the last shot of our animation short film. This have the combination of indoor and outdoor light set up.

Figure 2.66 Last Scene Final Rendered Image

2.5 Render Settings :

We have used Arnold Render Engine to render our short film. This is a render engine developed by the company "Solid Angle". According to Wikipedia "Arnold is based on Monte Carlo Ray Tracing. Its engine is optimized to send billions of spatially incoherent rays throughout a scene. It often uses one level of diffuse interreflection so that light can bounce off of a wall or other object and indirectly illuminate a subject. For complex scenes such as the space station in Elysium, it makes heavy use of instancing. It uses the Open Shading Language to define the materials and textures."[15]

To control the rendered resolution the "Arnold Sampling"[16] must be controlled precisely. For each of our scene we used different sample rate according to our need.
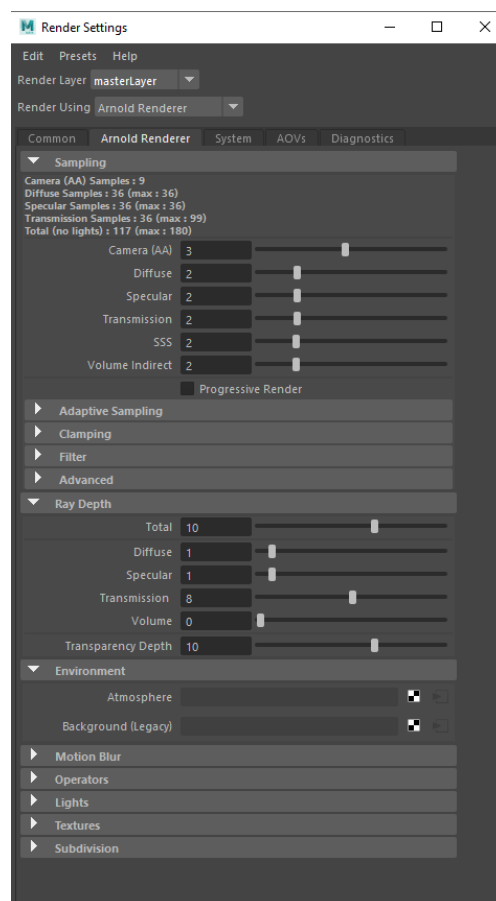
Figure 2.67 Default Arnold Sampling Parameters

For our first scene to render we used our customized render sampling according to our need and available time because render time depends on render sampling.

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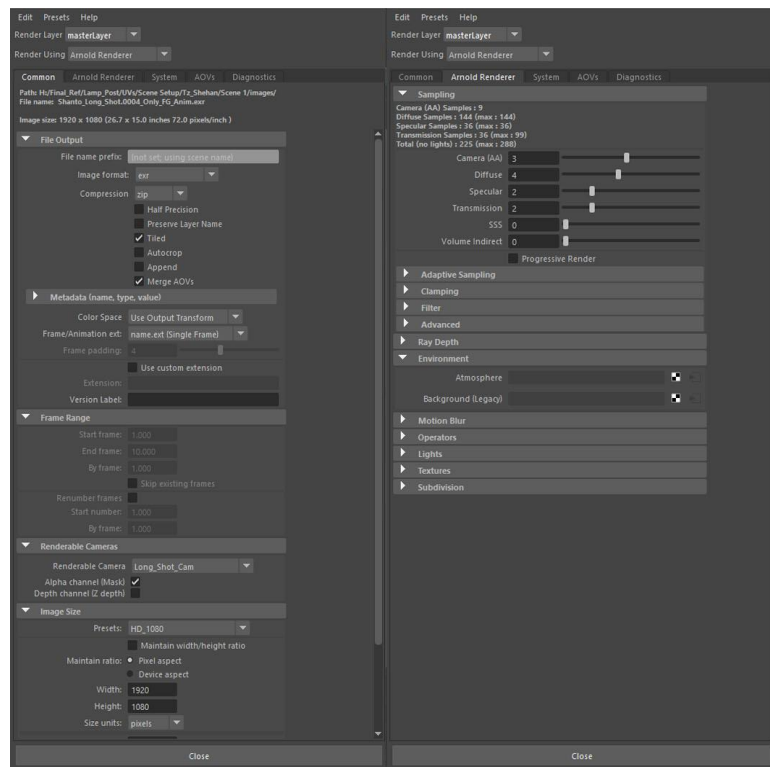
Figure 2.68 Final Render Setup and Sampling Parameters

The export format for our render output was set to exr (.exr) in order to preserve the best quality and information. We have used total 7 "AOVs" [17] for control in the post production.
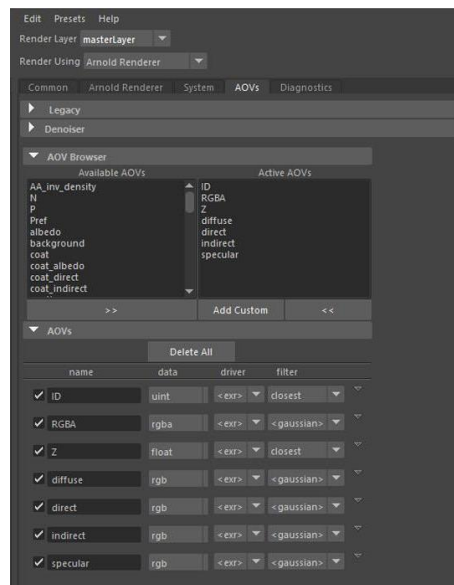
Figure 2.69 Final AOVs for all Scenes

These AOVs means there will be different 7 different passes, all together will make the beauty layer.

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CHAPTER 3

Limitations and Challenges

3.1 Limitations:

A lot of intangible limitations were faced while working on this project. These limitations affected the output of our project in one way or another. Some of these are discussed below.

The most intangible limitation was the lack of experience. There were some experiences in all the steps in this process but the proper pipeline was never followed. Also, the scope of skill implementation was also limited. When it came to such a big project with a proper pipeline was to be followed, we fell short on experience we fell short on experience which affected time management and finding solutions to problems faced.

3D animation is a form of art which combines a lot of other forms of art. For initiating a project like this a lot of things from the artistic angle needs to be considered. Such as the color palette of the film, the looks of the characters, forms of different models, postures sense, perspective sense, a sense of composition etc. For this reason, a strong hold on fine arts category is much needed. Unfortunately, this skill is inadequate. Being a student work there were no fixed budget for this project.

3.2 Challenges:

As this is a group project it was important that all the members work together with close proximity so that whenever any member faces a problem they can reach out to other members. This makes problem solving much easier and obtaining approval faster. Living in different homes at first there were no fixed spot where all four members could work together but eventually a room was rented and the challenge was met.

All the software used for 3D animation and rendering require high configuration computers. In this case the higher the configuration the better the quality. But for our average quality computers we faced a lot of challenges to work with. The software kept crashing or getting stuck. Sometimes they became slow and could not read the commands and execute them properly. Sometimes files would take several minutes to even open up. These kinds of problems wasted a lot of time which would not have been an issue if there were better quality computers available.

Computers with higher configuration can decrease render time exponentially. Render time a big factor when it comes to producing any computer graphics. Keeping computer limitation on mind sufficient time slot needed to be allocated for the rendering segment.

In order to create the desired outputs a few new software and commands from known software were needed to be learnt in a very short time. As the knowledge of these software were limited so problem solving became a big issue.

CHAPTER 4

Some Problems and Solutions

UV Unfolding : The default unfold option sometimes does not work properly while unfolding the shells. For eliminating this problem sometimes, the default unfold method needed to set to legacy in the options box beside unfold in the UV toolkit.

Rigging : As the project was done mainly in Maya 2018.6, the plug in we were using for rigging did not work properly. The skeleton build process could not be completed. To solve this problem the rigging was done Maya 2017[14].

Maya Mash : The trees in this film were made with Maya Mash. While doing this sometimes the leaves were not attached to the surface of the mesh they were input on. They would scatter by offsetting around the mesh. It was then figured out that if the main leaf was freeze transformed at 0, 0, 0 point of the gridline then it would work properly.

Leaf Texturing : The leaves were made with a PNG file on a plane to make the trees low poly. But the leaves were not rendering transparent. By assigning maps in the parameters of the plane this problem was fixed.

Arnold Stand Ins : Some heavy objects were made proxy by the Arnold Stand In options to the scenes would be less heavy. But these Stand Ins did not receive texture files when transferred to a different computer. Several methods were tried but the result was the same. We couldn't solve this problem entirely but it was decided the scene with Stand Ins will only be rendered with computer they were made in.

Source Image : While rendering the files were distributed to a number of computers. But some of the models did not receive textures directly from source image. So, they rendered without texture. This caused us system loss and a lot of rendered files were discarded. So, every file needed to be checked thoroughly before rendering in every single computer. This added to the total time allotted for rendering and created a time crunch.

Texture loading failed : As there were a lot of heavy models in most of the scenes and all of them had high resolution textures, the GPUs in our computer failed to load them eventually

causing software crash sometimes. So, texture mode was turned off while working on heavy scenes.

Viewport loading failed : Some of the scenes were so heavy that the computers with lower amount of RAM failed to load them on the viewport. To temporarily fix this problem extra RAM was borrowed and added to the computers.

Storage problem : The entire project was approximately 1.5 TB in size. Some of the files also needed back up. To meet this challenge portable hard drives were managed.

Render time optimization : Each frame required 20 minutes to render on average. In this rate the total rendering time would exceed 2 months. We could not afford this much time so rendering was distributed to 29 Computers in total. This reduced render time exponentially leading us to finishing our project in time. Some of the scenes were also rendered in alpha channel where background could be a still image. This also reduce render time.

Manual Subdivision causes PC freeze : For giving a high poly look to the character hairs more subdivision was needed to be added. But by adding more subdivision the file size increasing a lot causing software crash. So instead of increasing subdivisions physically on the model, the iterations were increased in rendering within the Arnold tab which gave the model the desired high poly look without actually adding more subdivisions.

CHAPTER 5

Conclusion

Due to the weakness of the law and mass poverty, the number of child laborers are increasing day by day in our society. These children are subjected to harsh and dangerous working conditions, even in some cases physical abuse and sexual harassment.

This animated short film is a small attempt to expose all these inconsistencies of society with child labor.

While doing this project we had some unique experiences. We learned a lot of in-depth knowledge about 3D animation pipeline. This project gave us the opportunity to learn a few new software and more about the software's we were already familiar with.

We faced various issues while working on this project but solved most of them by consulting and researching together. Although there are some problems, we were unable to solve but we are keen to learn about them in the future.

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