FINAL YEAR THESIS

"Optimized 3D Modeling Process for Web-based AR"

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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APPROVAL

This Thesis titled **"Optimized 3D Modeling Process for Web-based AR"** submitted by **Md. Rahatul Akand, ID: 162 – 40 – 349** 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 was held on 08th SEPTEMBER 2019.

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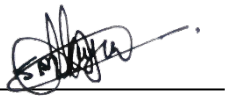

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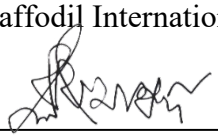

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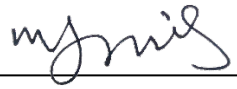

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I hereby declare that, this thesis has been done under the supervision of **Mr. Arif Ahmed, Associate Professor of the Department of MCT**, Daffodil International University. I also declare that neither this project nor any part of this project has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

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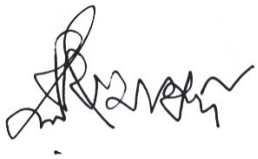

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ABSTRACT

Good representation of a product for selling is very significant for growth in business. And showing the product on a website for convincing a consumer to buy is very challenging in this modern era of online-based marketplaces. In the earlier day's web-developers would use product images or promotional videos in websites for digital marketing. They still do this now. But time and technology are changing rapidly and people want to interact with a product before they buy it. Let's say, before buying a furniture if we could measure the dimensions through putting the furniture in the room space virtually to check whether it fits or not, it would be a very smart use of technology. Now, it is really possible through only a smartphone and AR Technology. So, in that sense, we can make website-compatible 3D models and apply AR technology on them. My aim is to test a complete and proper pipeline for AR-compatible 3D model production.

There are several steps to create a website-compatible 3D model. Models can be made using Autodesk Maya, textured using Substance Painter, website-compatible GLB/ GLTF file format creation using Blender 3D. Compress and publish using online GLB packer; like (http://viewer.seekxr.com/) and (https://glb-packer.glitch.me/). We can use Marmoset Toolbag software for video renders of the products.

Web-based AR technology for product visualization is a blessing for both a seller and a customer. A seller can sell more products online and a consumer can be more confident about purchasing anything from online.

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CHAPTER 1
Introduction

There are two types of 3D models; Organic and Hard-surface. So, for understanding the procedure to build up their shapes and structure we need to choose which software is the best solution for the production. For an Organic model creation, sculpting is a better solution in case of easy production than poly-modeling. And there are dedicated sculpting software like ZBrush, Autodesk Mudbox which are industry standard and more user-friendly software. On the other hand, Hard-surface modeling requires poly-modeling technique. And for poly-modeling, there are various software like Autodesk Maya, 3DS Max, Blender 3D, Modo and so on. So, the very fast step for starting modeling, we choose the software we needed and book a monthly or yearly subscription according to our demand and sometimes we purchase them.

For a Hard-surface model, after modeling, we directly go to the texturing process in Substance painter and then we convert and compress the model. We use Blender 3D for website-compatible GLB/ GLTF file format creation and some online compressing solutions. But, for an Organic model, after sculpting we need to Retopo the model for maintaining a good topology with reasonable file size. We use the quad draw feature of Autodesk Maya for the Retopo process. After that, we go to texturing, convert and compress steps sequentially.

This production pipeline is a step by step lengthy process. Following the proper procedure will make sure a good looking and highly optimized AR-compatible 3D model.

CHAPTER 2
Literature Review

This chapter will be discussing the thesis on the different journals and books about Web-based AR technology and production pipeline. Here are lots of theories given by many researchers. Analyzing all those theories and pick up the main points from those, and finally we will take a particular theory and work on that.

2.1 Augmented Reality History

In 1968, a Harvard faculty member and computer scientist by the name of Ivan Joan Sutherland fictitious what he called the Sword of Damocles. He fictitious this as an initial form of augmented reality device along with his student, Bob Sproull.

The Sword of Damocles featured a head-mounted display that adorned from the ceiling. The users would experience computer graphics, that could make them feel as if they were in an alternate reality. This technology can be thought-about nearer to virtual reality than augmented reality.

One of succeeding massive developments was done on augmented reality in 1974 by Myron Krueger. The project was known as Videoplace, which joined a projection frame and camcorders that created the screen shadows. This arrangement could make the clients feel as though they were in an intelligent situation.

In 1990, a Boeing scientist named Tom Caudell begat the expression "Augmented Reality".

In 1992, Louis Rosenburg from the USAF Armstrong's exploration lab made the absolute first genuine operational enlarged reality framework, Virtual Fixtures. A robotic system places data on top of the workers' work environment to assist efficiently. This technique could be thought of like the early version of what most AR systems presently do these days.

In 1994, the primary theater production to utilize augmented reality that made. “Dancing in Cyberspace” bestowed acrobats dancing in and around virtual objects on stage as a bit of art and was produced by Julie Martin.

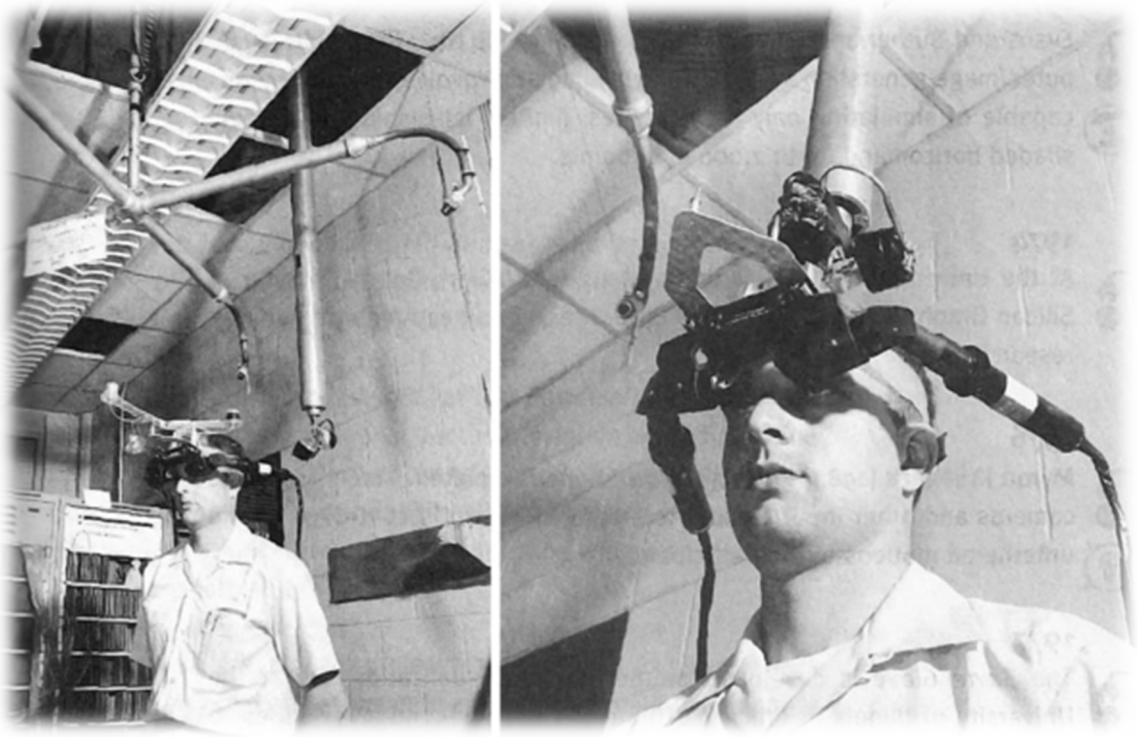

Figure 2.1.1 Ivan Sutherland with a Head-mounted 3D Display.

In 1998, Sportsvision used the first and Ten-line automatic data processing system. This technique showed the original virtual yellow first-down marker throughout a live NFL game. A variation of this virtual first-down marker is currently a norm altogether televised soccer games these days and is a massive part of augmented reality history.

In 1999, NASA used a hybrid artificial vision system that integrated augmented reality in their X-38 space vehicle. The augmented reality technology was used to facilitate improve navigation throughout their test flights.

A significant progression inside the augmented reality innovation occurred in 2000 once Hirokazu Kato from the Nara Institute of Science and Technology in Japan made a software known as ARToolKit. Through this software, one may capture real-world actions and mix it with interactions of virtual objects.

Through the utilization of a camera and therefore the web, users can experience this augmented reality. Like several of those inventions from the past, this heavily influenced what we have a tendency to experience these days altogether flash-based augmented reality apps.

In 2003, the NFL used the popular Skycam, that was used for aerial views of the sector to insert the virtual first-down marker.

In 2009, Esquire magazine, together with Robert Downey Jnr, used augmented reality in their medium. By exploitation their software on one's computer to scan the barcode on the magazine, the readers could experience augmented reality content.

In this same year, ARToolKit made augmented reality out there to web browsers.

Augmented reality has returned an extended method since its early conception, and therefore the advancements within the past 5 years are even splendid.

Figure 2.1.2 Google Glass in AR Factory.

2.2 Recent Developments on AR

In 2013, Volkswagen used augmented reality as their automobile manuals. the use of the MARTA app through the iPad would facilitate users read the internal workings of the vehicle therefore the service mechanics apprehend what they're handling.

The MARTA application can even show sequent directions to assist mechanics with the projects they're performing on. It would even facilitate with commutation components. It would even be as specific as that direction the components ought to be facing. The MARTA app would be used for a lot of cosmetic projects similarly, together with seeing how completely different color paint jobs would look on our vehicle.

In 2014, Google Glass was discovered and was been created out there for customers. The Google Glass wasn't as victorious as developers hoped it'd be, however it did show the potential of what wearable augmented reality can be. The second iteration already looks to be splendid and a lot of helpful.

Instead of victimization the Glass to scroll through social media and using apps; factory employees are using the technology to assist with their everyday work. It helps walk the employees through their daily tasks and be a lot of productive and economical.

In 2016, Microsoft introduced consequent iteration of wearable augmented reality. The HoloLens appears to be everything that the Google glass needed to be, however not at all as discreet and wearable in existence and is beyond question more expensive. The technology advancement between the two is unquestionable, however the value range of $3000 and $5000 are out of most people's budgets.

Augmented reality has conjointly infiltrated the gaming world similarly. The Nintendo 3DS comes with AR Cards that trigger integrated AR games. similar to Pokémon Go, users can see their favorite characters within the same space as them.

Figure 2.2.1 Pokémon Go Augmented Reality.

Snapchat has even created its own AR games that are engineered right into the app. The utilization of facial gestures controls all of our movements in every game.

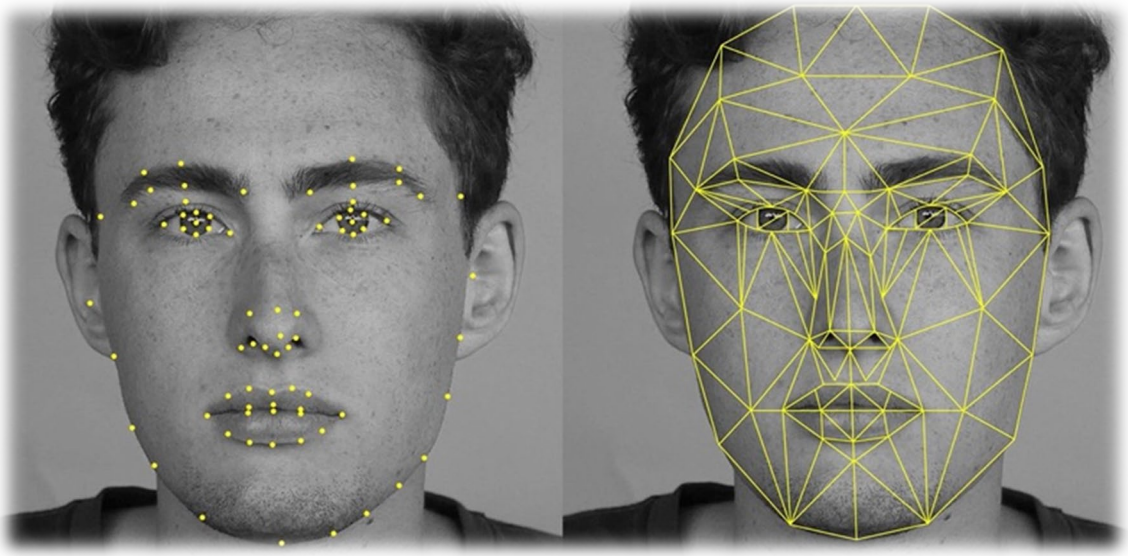

Figure 2.2.2 AI Facial Recognition.

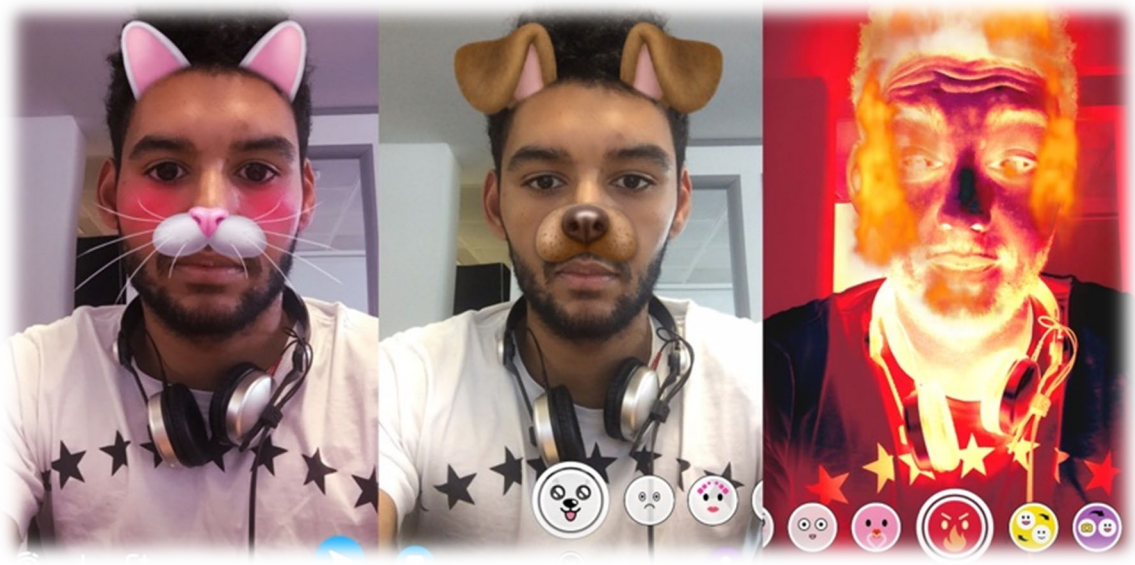

Figure 2.2.3 AR Snapchat Filter.

2.3 Web-based Augmented Reality for eCommerce

Augmented reality is all over lately. It has been around for a couple of years currently within the variety of face filters on Snapchat, Facebook, etc. and app-based experiences have popped up from IKEA, Warby Parker, and others that are before the curve in giving their customers the simplest online shopping experience attainable. many have puzzled if augmented reality would have an even bigger impact than its forerunner of virtual reality, that to several within the investment and the effect of the tech globe on living standards has been severe. Because it seems, AR has a fairly major impact, and its reach is already over and over that of VR due to the innovations in smartphones that billions of individuals have already got in their pockets.

Studies associated with the impact of AR on eCommerce are commencing to surface, and also the numbers are astounding. 30%+ increase in conversion, reduced returns, less inequality between client expectations and accrued client trust within the brand. AR is commencing to approach, in several cases, the effectiveness of getting somebody walk into a physical store, however while not all the prices and headache of maintaining a retail location that looks doomed to fail during this age of retail locations closing at the very best rate ever.

So, if AR works therefore well, how does one get started with it? it's going to seem to be

a frightening and costly task (and it will be if we approach it incorrectly), however hopefully, the subsequent ideas will act as a guide to induce us on the proper path.

2.3.1 3D Model Creation

If at any time in our AR experience, we wish customers to be ready to view our merchandise in their house, digital twins, or 3D models of our merchandise are needed. Several corporations have already been doing this for years, and that they are definitely prior the sport. Moving forward, these 3D models ought to be a typical in our product imagination process. Rather like we see unbelievable CGI in movies with models that look thus real we cannot tell the difference; it's currently doable to make unimaginable 3D models of all of our products. There are three primary ways that to create this happen: (in order of least valuable to most expensive)

1. Use the design files that were used to manufacture our product. These are probably some kind of CAD file that can be exported into several 3D formats which will be utilized in AR experiences. The best AR suppliers are going to be able to use these outputs and convert them into usable content with very little to no effort. Not all firms have access to those files, particularly if we're resellers, however there are alternative ways in which to make this happen.

2. 3D model creation is an art that some will do unbelievably well. 3D modeler like me, will inspect an image of a product and then create a model from the ground up. This option is the most popular straight away due to the associated prices. Most models can be created for $150-350, looking on the quality and complexity of the model.

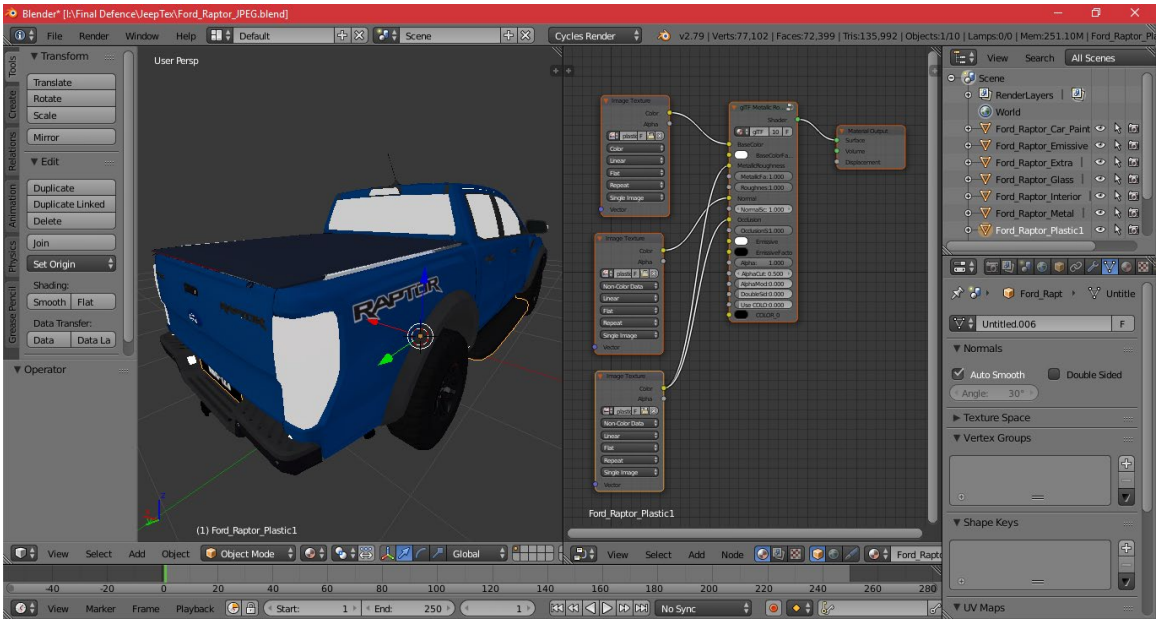

Figure 2.3.1.1 3D Model Creation for AR.

3. 3D scanning may be a newer technology that includes a long way to travel before it's cheap enough and widely obtainable enough to be used at a major scale. There are incredible scanners which can be purchased for roughly $25k each that produces nice results. They're not plug and play devices, though, and need hardware and software package training. The usual price of 3D scanning an object is $1000 (this would be for something sort of a table). Cheaper choices are out there, however they are not superb nevertheless. There are many firms out there, together with Qlone, that are specializing in building tools that enable our phone to become the scanner. They're mostly limited to small objects at now, however as phone manufacturers embrace additional depth sensors and better cameras, this may become better over time.

2.3.2 Useful Features of Augmented Reality

There are numerous things that can be done with augmented reality content, thus defining this early within the process can assist us verify wherever we'll be able to publish it, what proportion it'll cost, and what team we will need to get there. Of course, begin with the end goal in mind. What does one need the consumer to do? Does one have furniture that we need individuals to be able to see in their space? Do one need individuals to be able to try on a hat or glasses? Does one need it to merely be something fun and shareable to surprise and delight their audience? Does one need social reach? Or are we just attempting to extend

conversion rates?

Once we have got this nailed down, we'll be able to begin to differentiate what capabilities platforms have. Let’s see couple of options:

Face-scanning

Snapchat lenses are around for some time now, so most people are familiar with face filters. Since face-scanning has been around for some time, a few stages can do this past Snapchat, just as Instagram and Facebook. the web is even capable of doing this currently. This becomes very powerful as a result of it can be integrated directly onto the product page on our website, keeping the user engaged within the traditional eCommerce experience they are known to.

True-to-size and plane tracking

Cell phone cameras are presently quite strong and can detect the distance from the device between the floors and walls. Due to this measurement, product can be displayed true-to-size through the camera view. For furniture, this can be a requirement. Will the table fit? What is going to this tub look like on my deck? Without accurate plane tracking, this is not possible. AR is concerning way more than just showing a 3D model in a camera view. It must be concerning permitting the client to see what the merchandise can appear as if in their life. Thanks to ARKit and ARCore (technologies developed by Apple and Google for iOS and android respectively), apps will now track aircraft fairly well. Recently, Apple launched technology permitting iOS users to possess access to this technology directly on the web. Seek is another renowned AR solution company and they designed a cross-platform solution that brings this functionality to android on the web also.

Target or marker tracking

Target tracking ties expertise to a particular image or anchor within the real world. Snapchat, for instance, lately enabled the Lebron James Snapchat lens, which requires users to be at a footlocker place, open Snapchat and tap the camera at a mural on the wall. This could be an excellent experience if we would like users to do something in the store. Most target tracking experiences happen inside an app, however Seek's web-based AR technology will do that on the web also.

Interactivity

To play a game, spin the object, resize it, alter the color, etc., do the clients need that? To go through every detail concerning this here, would double the size of this Report, however here are the fundamentals. Web-based AR remains at the point where basic product viewing (typically one product at a time) is that the only thing possible if we would like true-to-size tracking. Of course, this may improve over time. If we ignore true-to-size, then a lot of interactions can be done on the web. If we have got a target tracking, close to something is possible from an interactivity perspective. inside a custom app, the sky is the limit. Facebook, Snapchat, and Instagram have very specific functions that we simply can utilize within experience design, and we'll be able to learn these by going to their specific studios to learn more.

Sound

Sound is an incredibly powerful tool for all media (where appropriate). Simply if we try to watch Lord of the Rings or Star Wars without sound. It would be pretty boring. Turn up the volume, and we're sucked into another universe and it tugs at our emotions. Once used properly, sound will add a further part of reality to form the user believe what their eyes are seeing. If Spiderman appears to be standing in front of us on our camera, can there be sound to add to this experience? Some AR experiences on the web may have sound. Apps actually can. Sound is not necessary for eCommerce in most cases, except for the entertainment industry and alternative related use cases, sound will take the experience to the next level.

2.3.3 Ways to Access the Contents

This, in my opinion, is that the most vital element to consider once starting with augmented reality. How are people about to get to this content? What percentage barriers are we about to place in between our audience and therefore the content or between the content and therefore the product? What demographics can see our content based on each location? are we about to place this on a social platform? A brand-specific app? Directly on our website?

The next obvious question is "where do individuals buy our merchandise from?" If we sell most of our products on walmart.com, then understand if walmart.com features a solution for AR directly on their website. or even in their app? If we sell most of our merchandise

directly on our website, then that is wherever this AR practicality should go.

Until recently, it had been only doable to make AR capabilities into an app. a really common furniture website has shared some attention-grabbing statistics with U.S.A. In their own proprietary app, this brand has spent many bucks on their augmented reality characteristics (which they need to handle for both iOS and Android) and that they see unbelievable increase in conversion from this AR. Average mobile conversion without AR is about 3.5%. With AR, it's 11%. Let's pause for an instant to digest that. 3.5%-->11% and therefore the only distinction is AR. Huge impact. However, there is a downside. Only 5-hitter of their total traffic uses their app! Many dollars and unimaginable technology engineered, however 95th of their audience is missing out.

Now, augmented reality on the web is feasible. Through, it's doable on iOS and android with true-to-size accuracy. 2 very important points are notable here:

1. Once AR is accessible directly through the website a much larger audience is reached. individuals simply don't desire to download brand apps. Some will, however most will not.
2. Once AR is accessible directly on the merchandise page, there's no major change in behavior from the customer. Customers are already conversant in clicking on an image or a video, therefore if the AR practicality may be embedded directly into an image on the website, then the client does not have to change their behavior to access this powerful product visualization.

2.3.4 Steps to Follow

Most brands haven't got the budget to take on AR by themselves. For this reason, several corporations can prefer to find a partner to deliver this service. A lot of developers around the world have access to repositories, tutorials, and comparatively straightforward tools that may be used to produce seemingly complicated AR demos. This makes it laborious to tell apart who really is aware of what they're doing and who will deliver a scalable solution. This is where the details are really important. Here are a number of points I might address once evaluating a possible solution:

Ease of Installation

How many hours can our tech team have to spend adding code to our website? Do they

need to do separate installations for each single item? distinctive installations per platform? how can it be maintained?

Content Management

If we have got 100+ product, how can we manage this content? Is there a straightforward interface that permits us to manage these files and improve upon them whenever necessary?

Content Creation

Can the corporate handle content creation? Or can we've got to search out a separate vendor for this piece? Keeping everything under one partner can make it easier for everyone involved. Content creation is an art; however, it's more than just making it look pretty. Files got to be optimized for mobile viewing and formats got to be compatible. This can be tougher than it's going to sound. Having a partner that may deliver the A to Z solution finally ends up saving time and headache.

Content Conversion

If a brand already has 3D models of their product, the chances of them being AR prepared are comparatively low. There are very specific formats that work well for mobile and a few that are simply terrible. We tend to found a solution a few month ago that presupposed to be the "best AR solution out there" and we're using a file format known as OBJ. This can be a bloated-on format that's terrible for mobile performance. Remember to the times of BMPs for pictures and compare that to these days with JPGs and PNGs. The distinction is night and day for performance. This can be a fancy issue, and since of the fast-changing AR market, there are in all probability formats we still haven't seen which will jump onto the scene and complicate more.

Content Optimization

Is that the content optimized for mobile? Several 3D models are stunning, however they're 30 MB or even 500 MB. How a user about to feel once they have to sit there waiting to transfer an oversized file in order to look at a product? Downsizing content to below 5 MB is an art as well as a complicated procedure that few have mastered.

Content Deployment

How easy is it to place new content on the website? Will the content be deployed to multiple platforms or devices? Will it be shared on Facebook? Are we going to share on Snapchat? etc.

Cross-platform/ Device Capabilities

Will this work on just iOS? Just Android? Can it work on future devices (Addressed more within the next section)?

Ease of Use for the End User

Is that the interface clean, simple, and intuitive? Will the user have to be compelled to download an app? Do they need to learn a replacement platform to check our content?

Deploy and Evaluate

Some experiences have such a big amount of specific conditions that have to be compelled to be perfectly met for the experience to show out that half the time, it simply does not work! Check what we're doing and make sure that the experience will not frustrate our client, however that it'll drive them to need to associate more along with our brand. The details matter, and if the incorrect path is chosen early on, it can be overpriced and time-consuming to fix later.

CHAPTER 3

Project Workflow

This chapter will be discussing the uses of different software and workflow of how to create a 3D product model for the web. In this part, I will be modeling and texturing few product models. I will do this in a step by step process and use Autodesk Maya, Substance Painter, Adobe Photoshop and Blender 3d for the production.

3.1 Modeling and Texturing a Leather Couch

We must follow the requirements written below to build the models.

1. Build the model with PBR materials.
2. Textures should be no larger than 2k and should be in JPG when transparency is not required, otherwise, use PNG.
3. Do not include textures that are unnecessary; for example, not all models need ambient occlusion or normal maps.
4. It is preferred that separate materials and textures be used for different parts of the model (for example, the wooden part of a chair would be a separate material than the fabric).
5. There is a polygon count limit of maximum of 30000 vertices.
6. The final model needs to use meters as the unit.
7. The models should not require double-sided rendering to look good.
8. Export the model to GLB format. The final file size (including textures) should be under 5 MB.
9. The diffuse texture needs to not tile.
10. Bake ambient occlusion for the fabric material. It should be a single-channel (black and white) jpg image.

Step 1: We need to follow the references and proper dimensions to start building the furniture base structure. For this model, the dimensions are:

Width	36 In	Arm Height	24 In
Depth	35 In	Seat Height	18 In
Height	42 In	Seat Depth	21 In
Inside Width	21 In		

And the reference images are:

Figure 3.1.1 Couch References.

Step 2: Go to Windows> Settings/Preferences> Preferences> Settings and set the Unit to Inch.

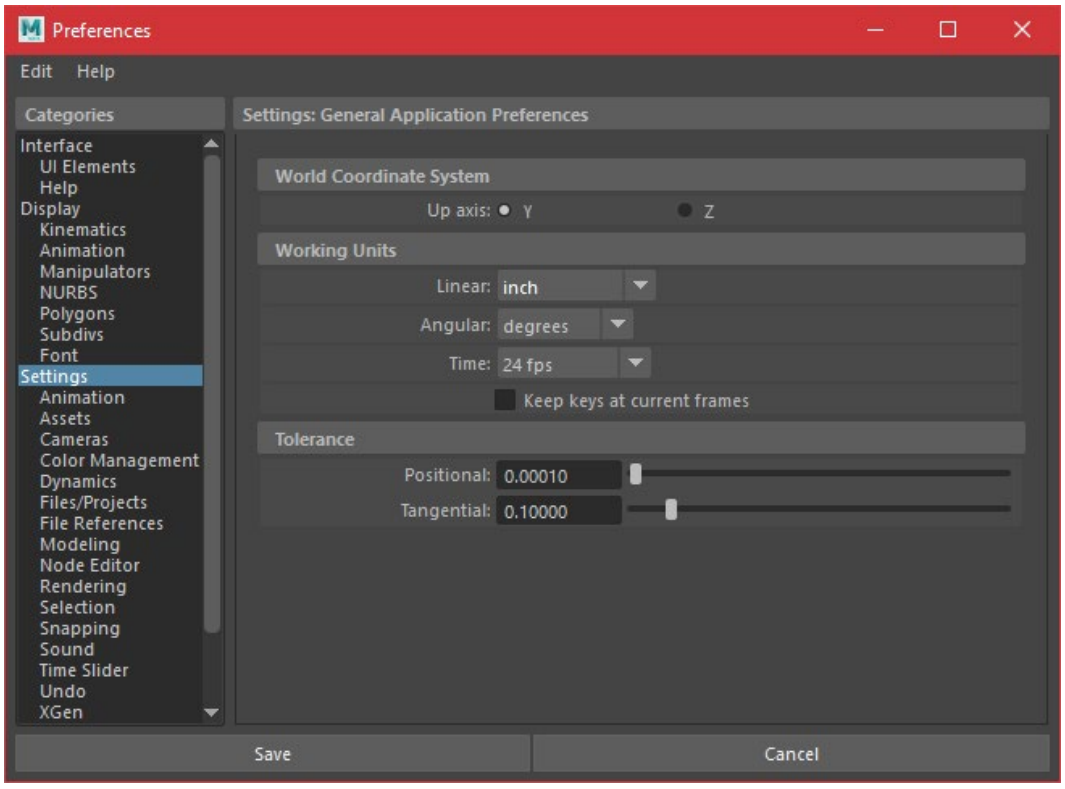

Figure 3.1.2 Unit Setup.

Step 3: Go to View> Image Plane> Import Image and import both Front and Side views reference images. Go to Create> Polygonal Primitives> Cube and create a cube with Width = 36 Inches, Height = 42 Inches and Depth = 35 Inches. Add two more cubes for defining Seat Width = 21 Inches, Seat Height = 18 Inches, Seat Depth = 21 Inches and Arm Height = 24 Inches. And add them to a layer as Templated.

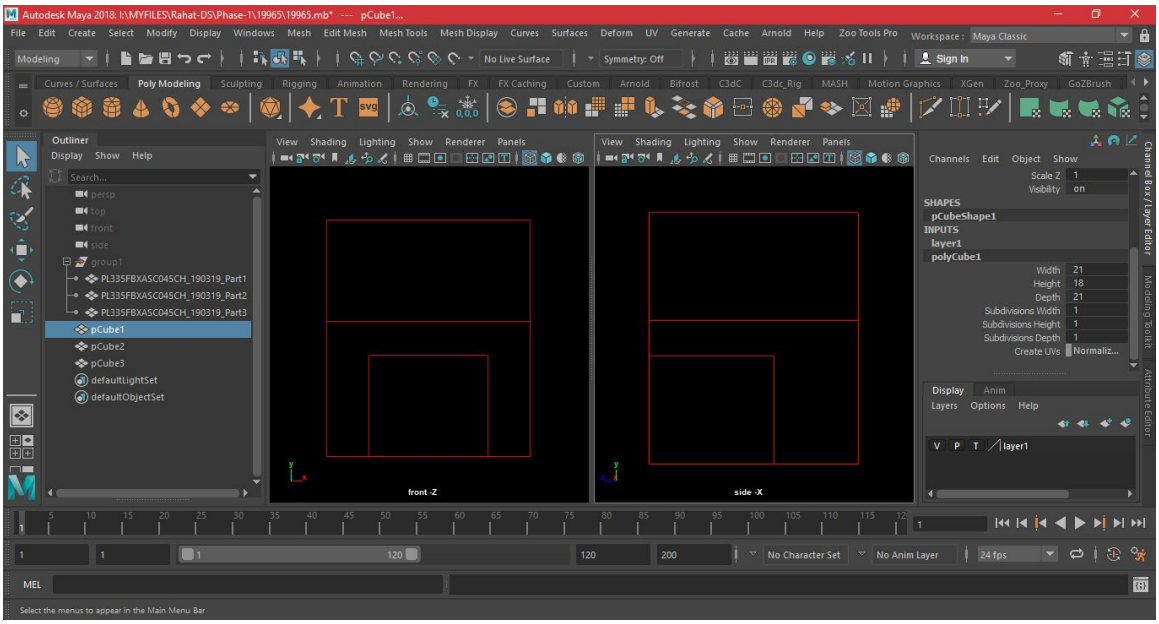

Figure 3.1.3 Reference Cube for Dimension.

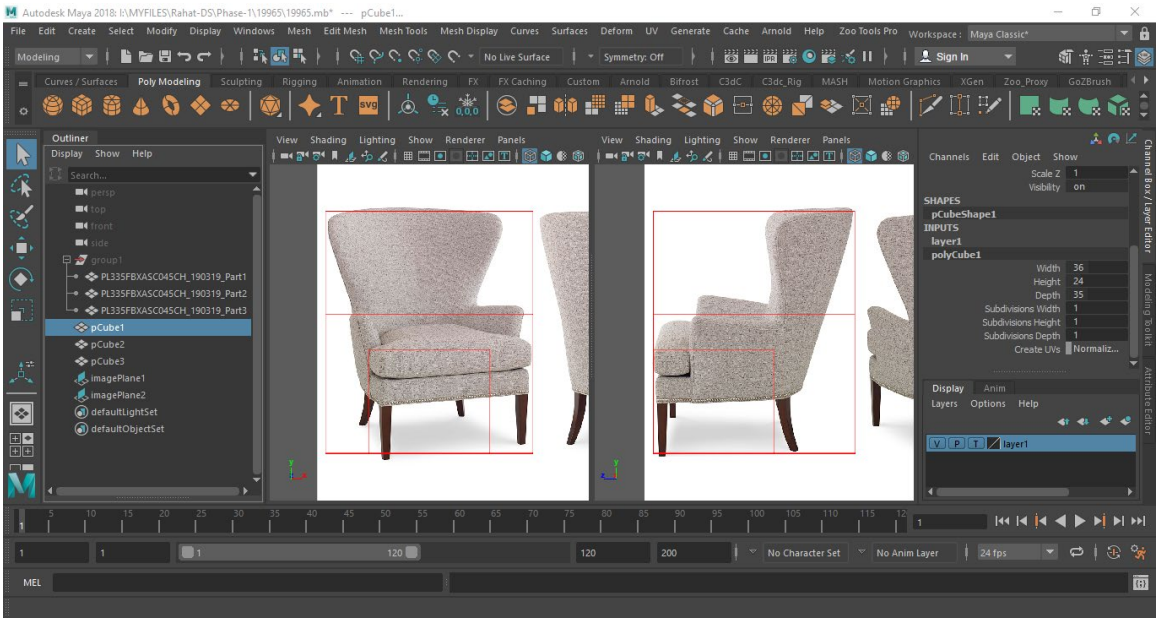

Figure 3.1.4 Image Plane Setup for Reference.

Step 4: Create all the components using poly-modeling technique one by one and Combine components according to the material count. For example, in this model there are 3 different materials would be assigned (Gloss, Leather and Wood). So, the component amount should be 3. Vertex Count should be less than 30,000. The edge seems should be created using below settings:

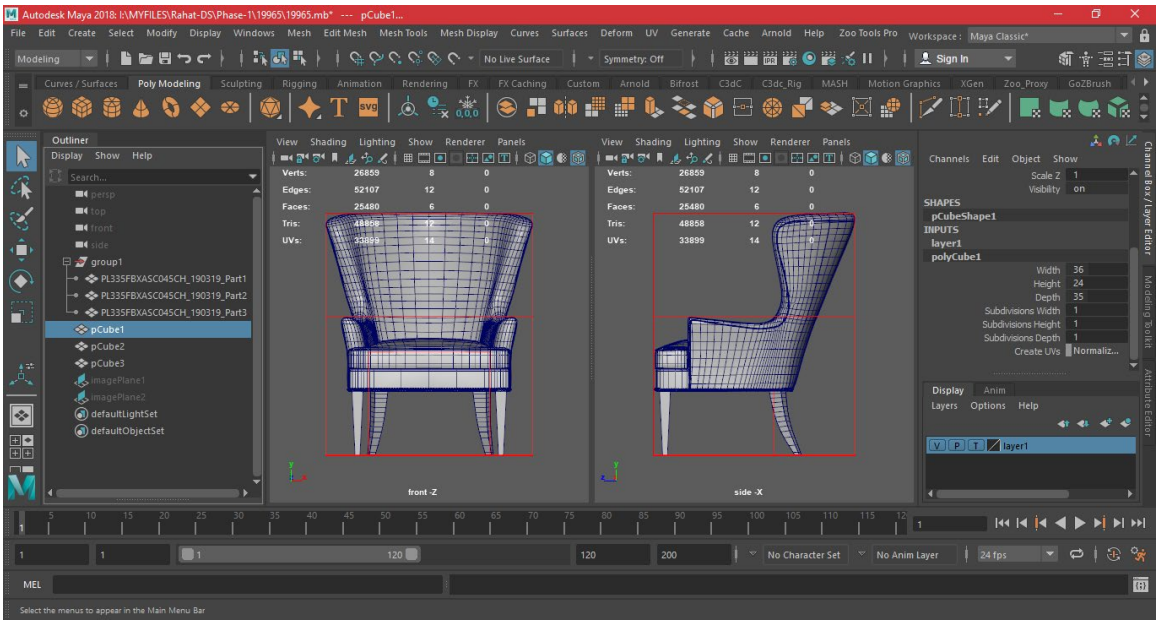

Figure 3.1.5 Structure Build-up with Poly-modeling.

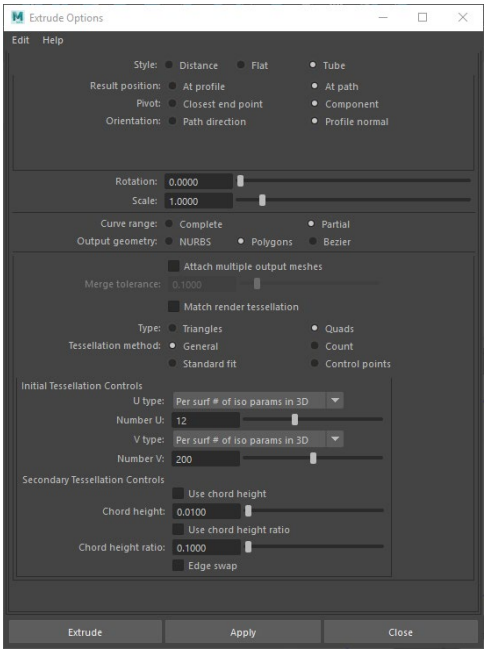

Figure 3.1.6 Seam Piping Making.

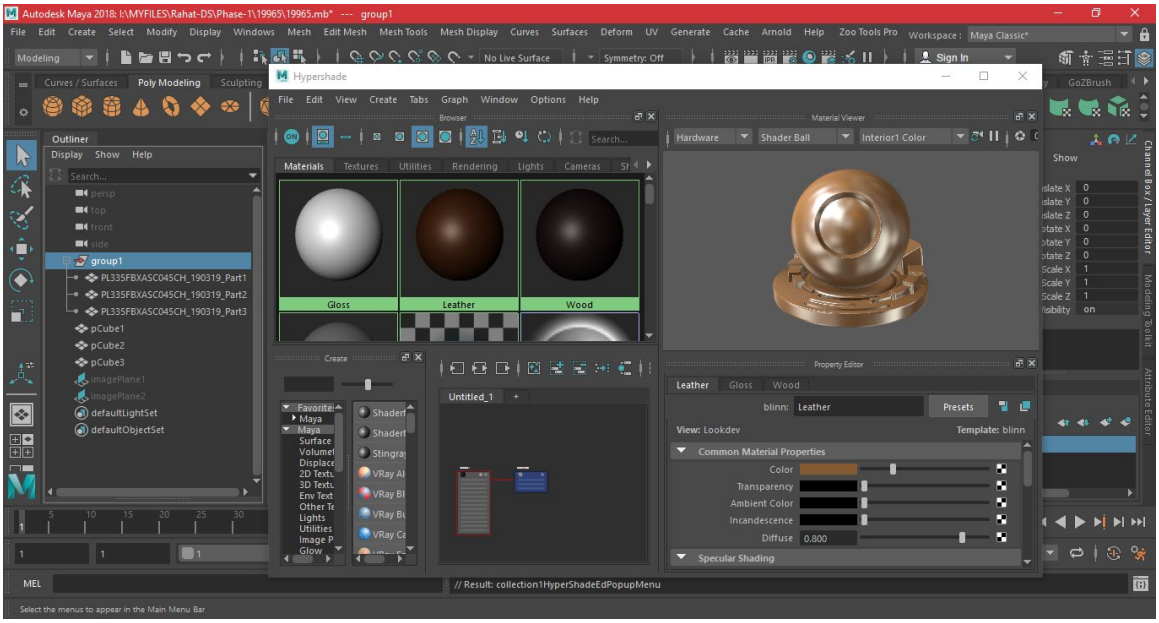

Figure 3.1.7 Material According to Mesh Count.

Step 5: Check and Delete UV Sets, if there are more than one UV Sets by going UV> UV Set Editor for every component. As well as check and Delete all the Vertex Color Sets for every component by going Mesh Display> Color Set Editor.

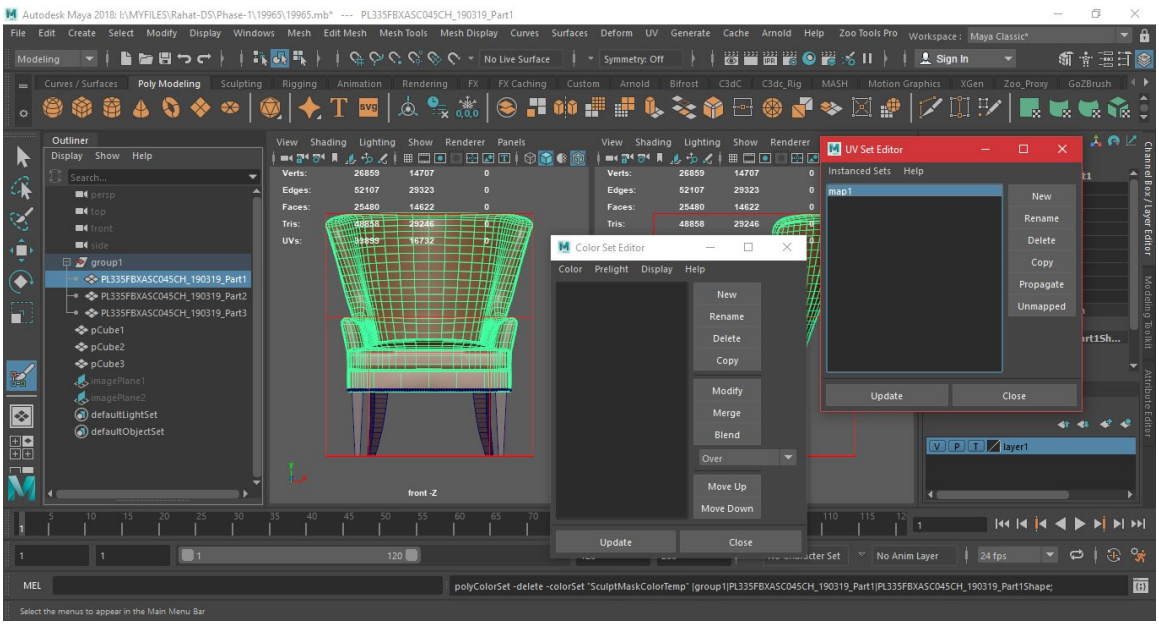

Figure 3.1.8 Checking UV Set and Vertex Color.

Step 6: UV Unwrap all components one by one. Select seem edges and press SHIFT+X on UV Editor window to cut selected edges. Select all UV Shells and press CTRL+U to unwrap and press SHIFT + RIGHT CLICK> Orient Shells. Set Shell Padding and Tile Padding to 1 pixel and press CTRL+L to Layout UVs.

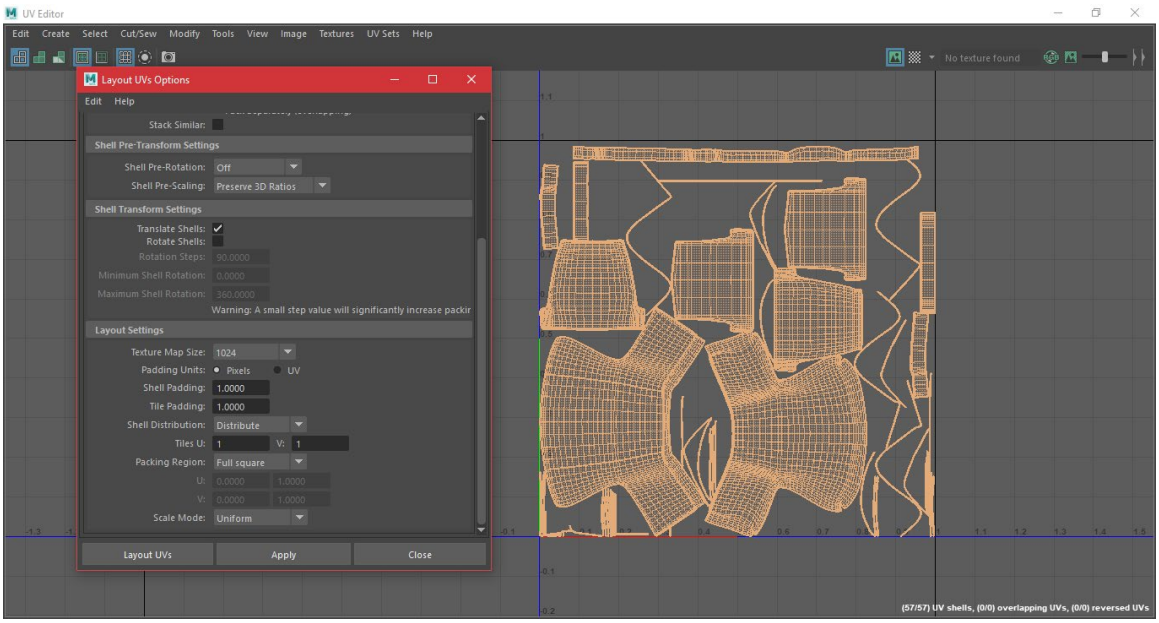

Figure 3.1.9 UV Layout Settings.

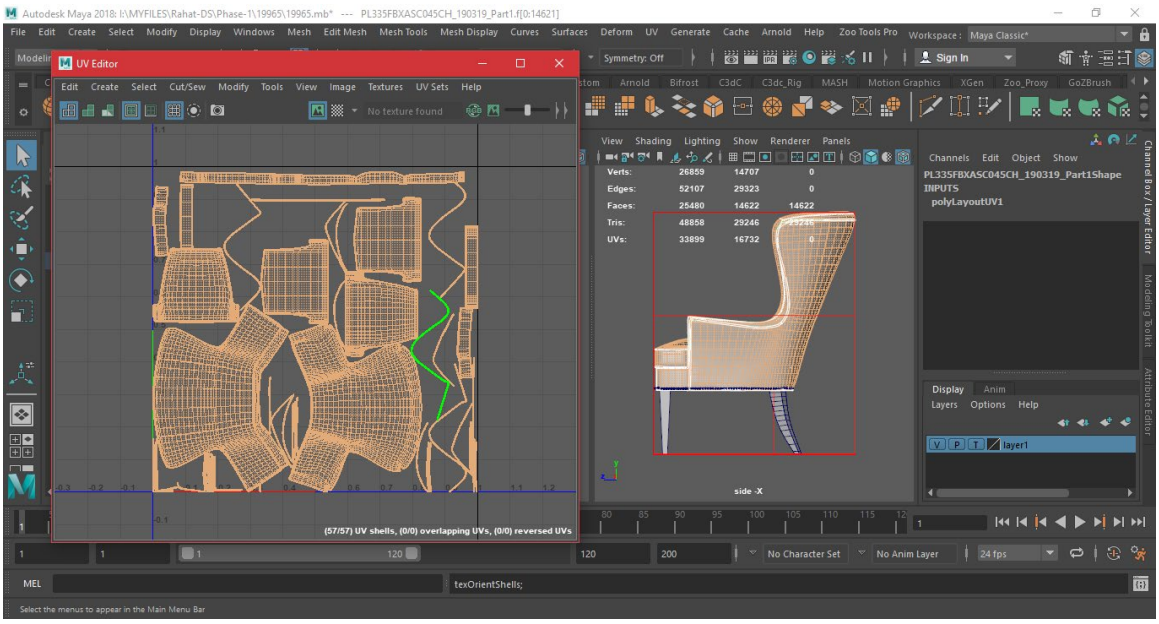

Figure 3.1.10 UV Unwrap and Layout.

Step 7: Go to Windows> Settings/Preferences> Preferences> Settings and set the Unit to meter. (i.e.: Substance Painter only supports meter as unit.) Select all the components and Export the model as (.fbx) format.

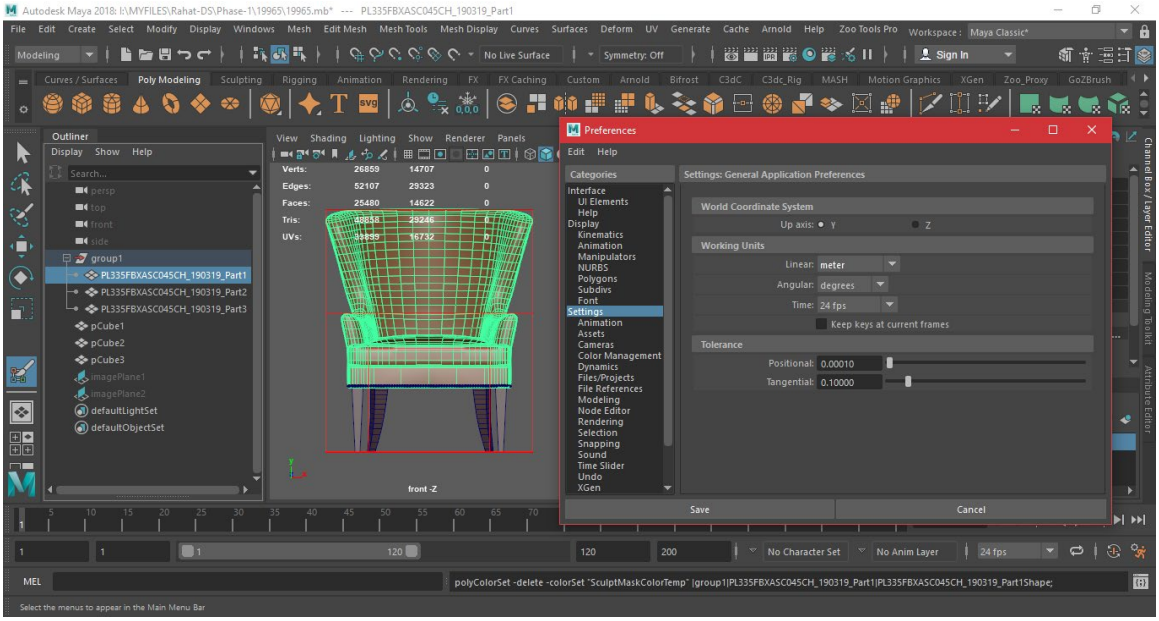

Figure 3.1.11 Export Unit Setup.

Step 8: Open the (.fbx) File on Substance Painter. Go to Texture Set Settings and Bake Mesh Maps at 2048 resolution and Bake all texture sets.

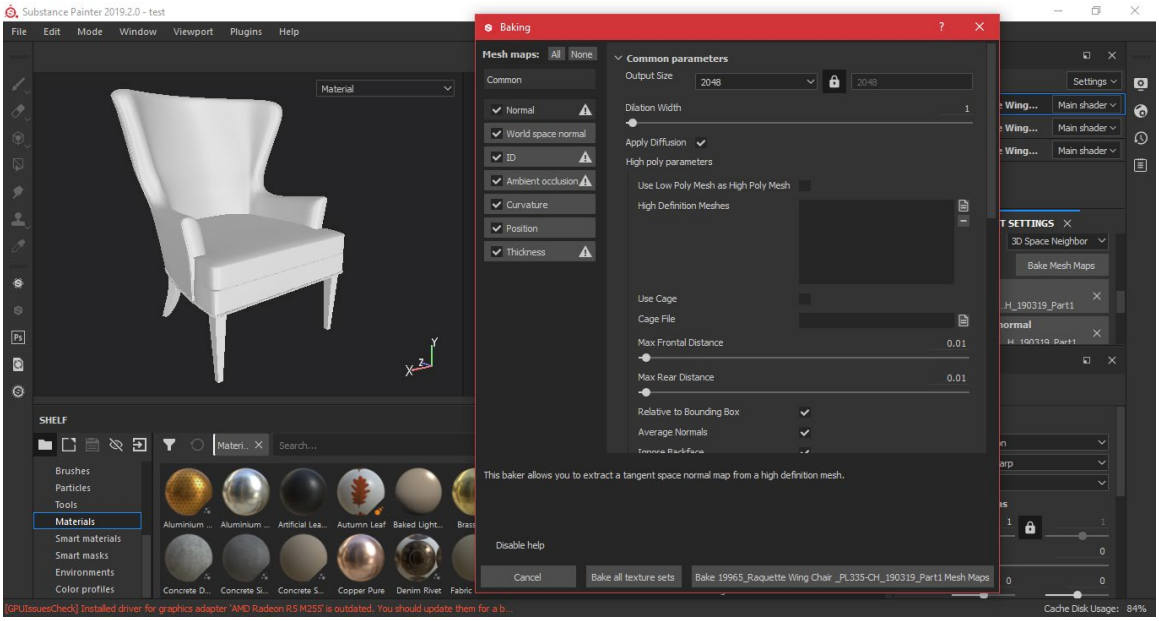

Figure 3.1.12 Texture Set Bake.

Step 9: Apply Leather Stylized smart material to the Part1, Aluminium Anodized Red smart material to Part2 and Wood Walnut material to Part3 Layer stack.

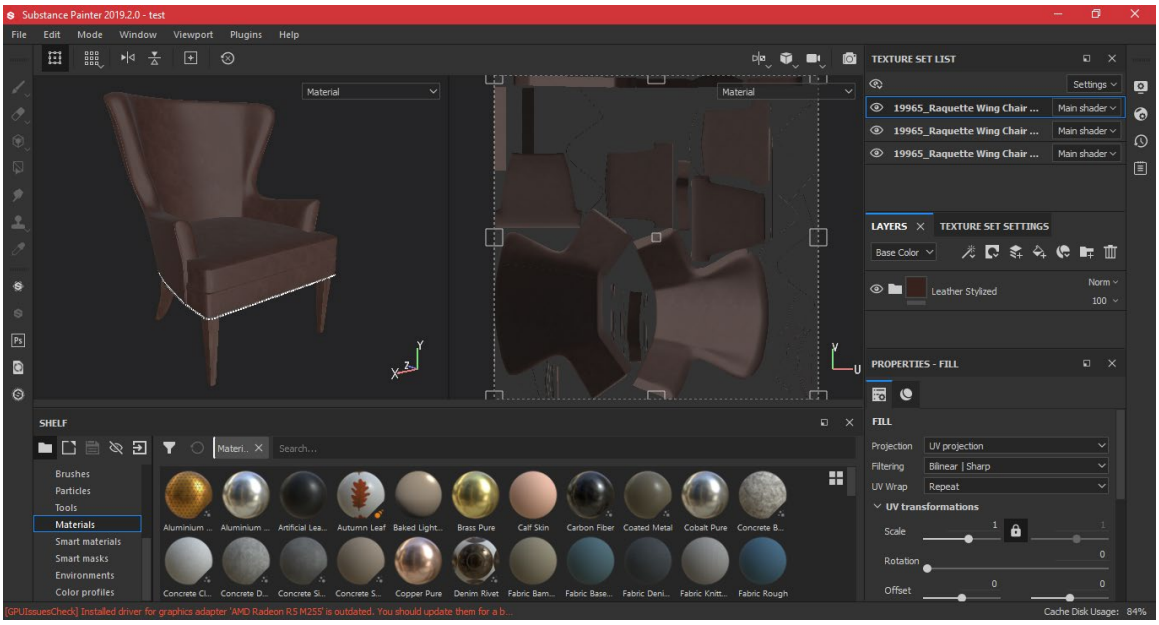

Figure 3.1.13 Texturing in Substance Painter.

Step 10: Go to File> Export Textures> Configuration and create a new preset for Blender 3D Export and Export textures in (.jpeg) file format using this preset.

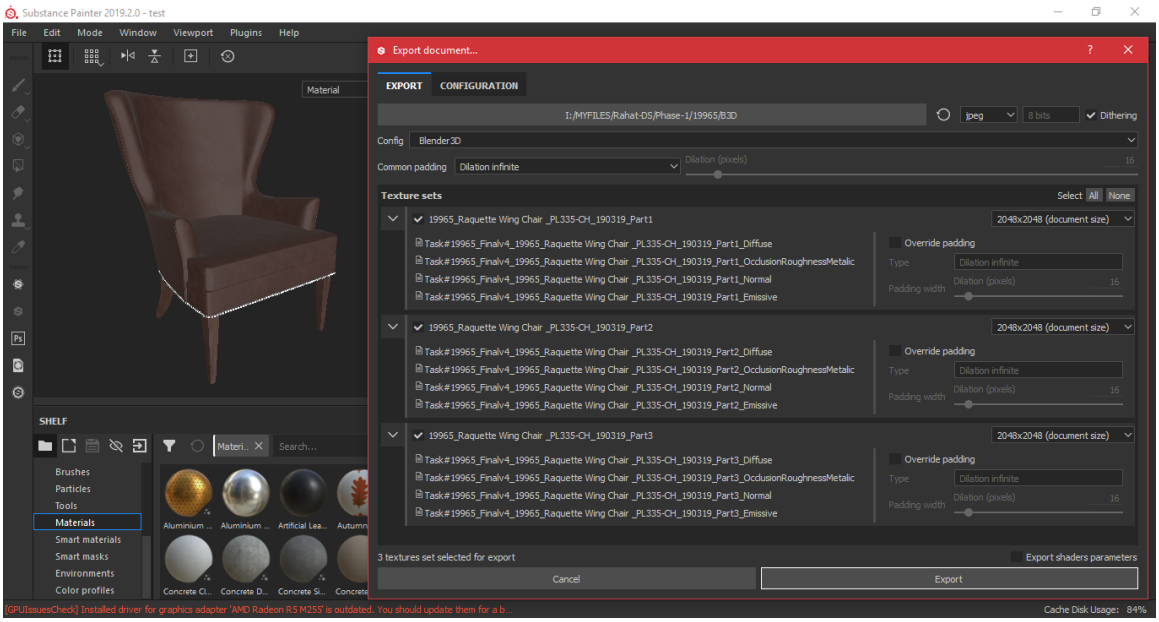

Figure 3.1.14 Export Textures Settings.

Step 11: Import (.fbx) file on Blender 3D and assign all the textures correctly and export as (.glb) file format.

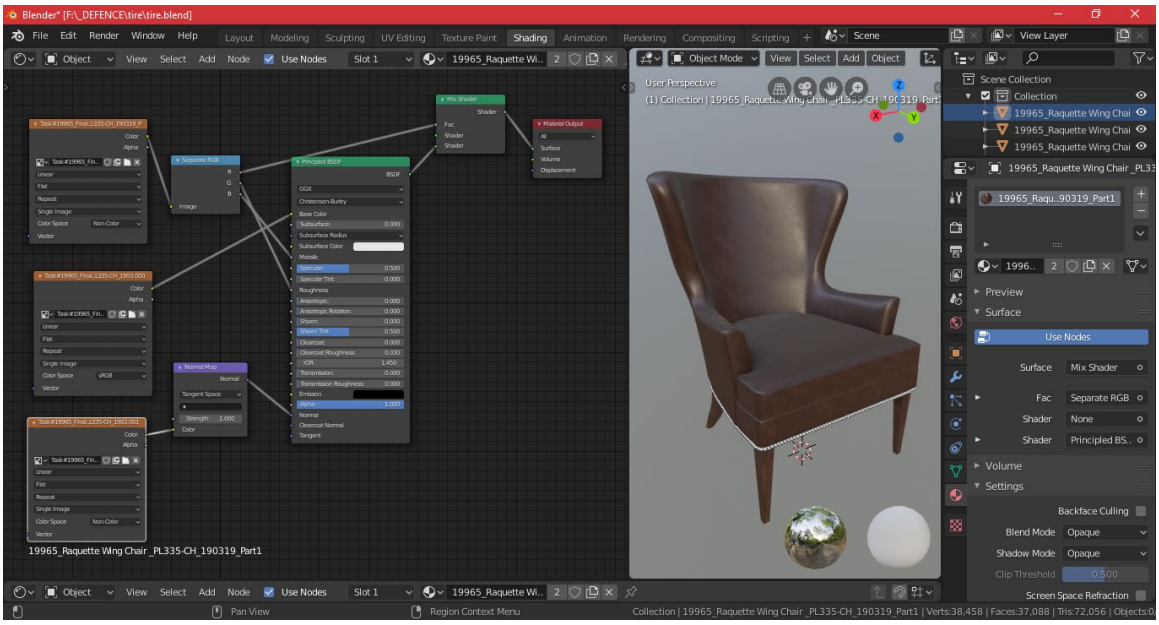

Figure 3.1.15 Texture Node Setup in Blender3D.

Finally, we get a website-compatible Leather Couch model in GLB file format that we can upload and view online without any problem.

3.2 Modeling and Texturing a Smart TV

Step 1: Change the measurement unit into Meter. I will go to Windows> Settings/Preferences> Preferences> Settings and change the unit.

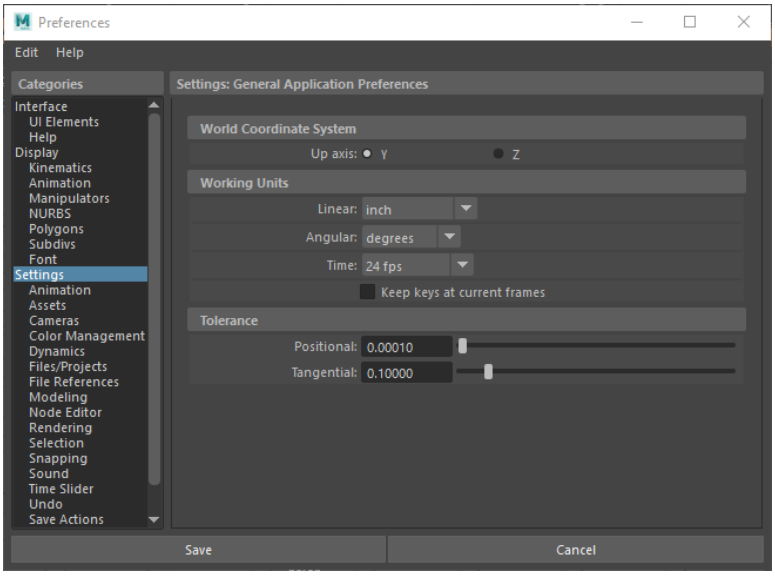

Figure 3.2.1 Unit Setup.

Step 2: Go to View> Image Plane> Import Image and import Front, Side, Top and Back views reference images. Go to Create> Polygonal Primitives> Cube and create a cube with Width = 57.0625 Inches, Height = 35.5625 Inches and Depth = 0.172 Inches.

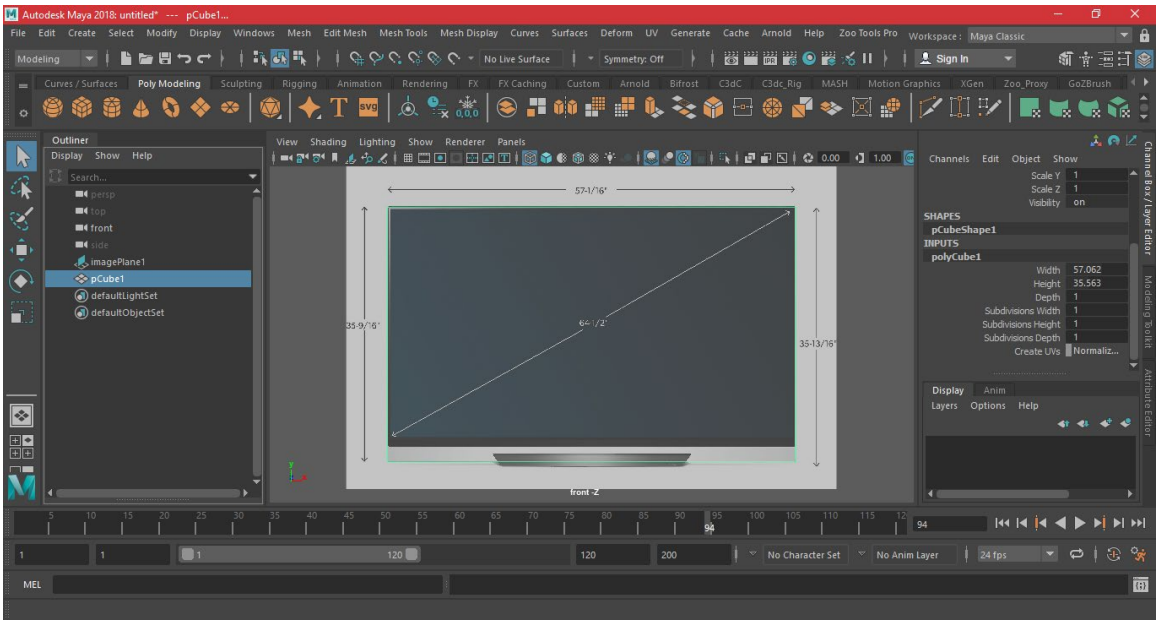

Figure 3.2.2 Image Plane Setup.

Step 3: Go to Attribute Editor and change image plane display property for all image planes as looking through camera instead of in all views.

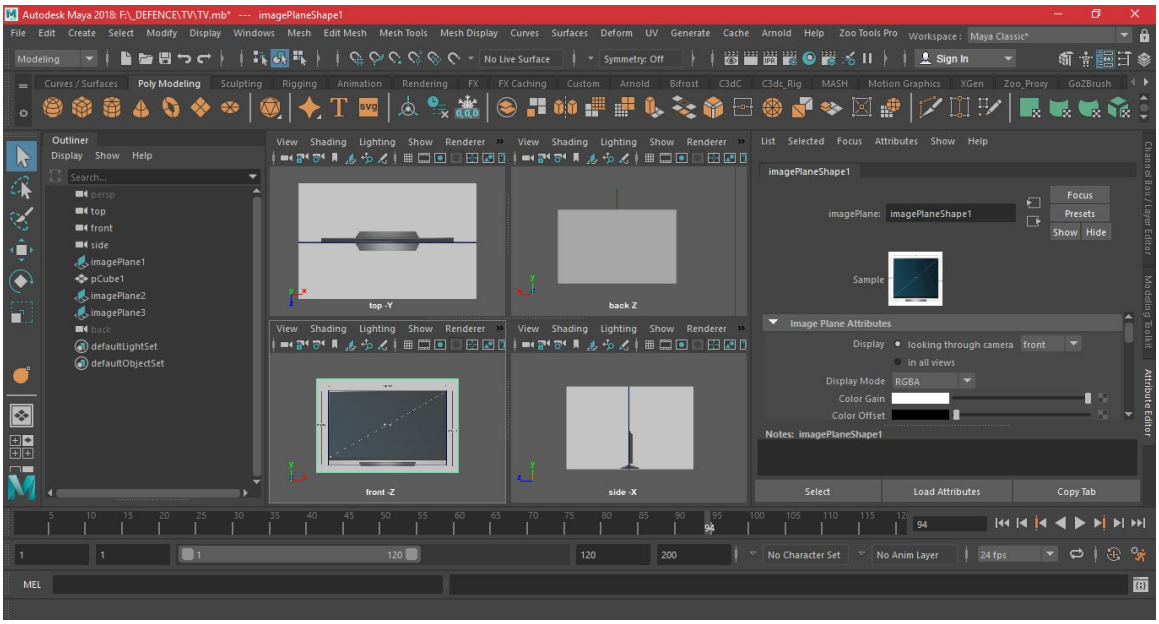

Figure 3.2.3 Looking Through Specific Camera Setup.

Step 4: Create corner edges smooth and try to match the curve using Bevel Edge (Ctrl + B).

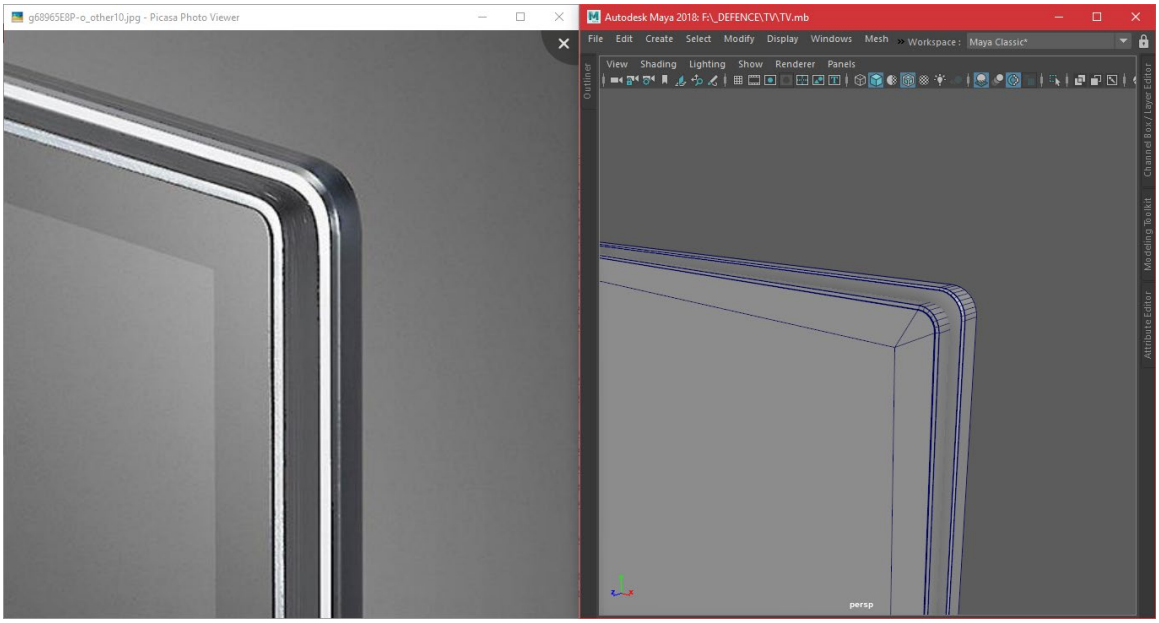

Figure 3.2.4 Matching the Model with the Reference.

Step 5: Create a Poly Cube and make the back-panel structure.

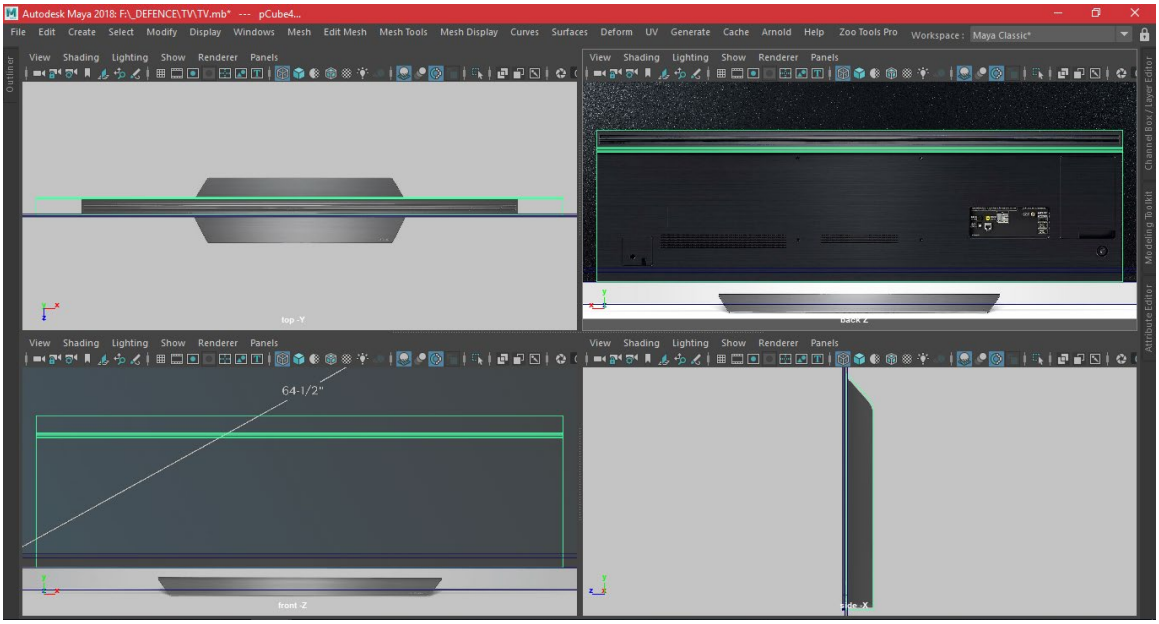

Figure 3.2.5 Modeling Looking at the References.

Step 6: Create a Poly Cube and resize to the back details, which we'll use for Deference Boolean later.

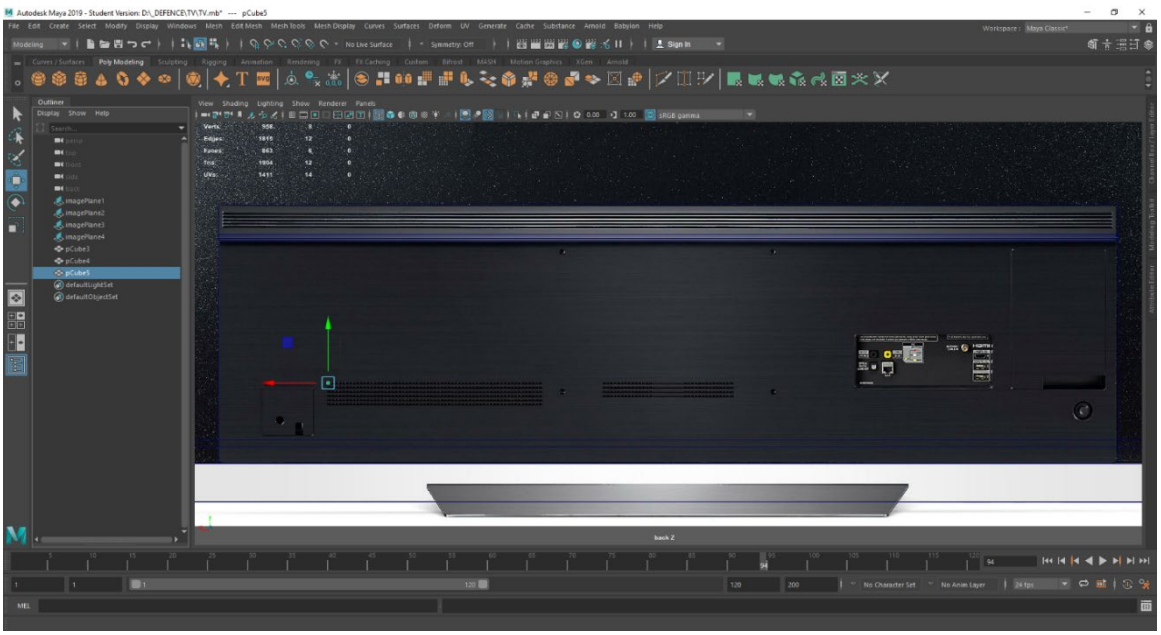

Figure 3.2.6 Modeling Looking at the References.

Step 7: Create an array of Poly Cubes by using Duplicate with Transform command (Shift + D).

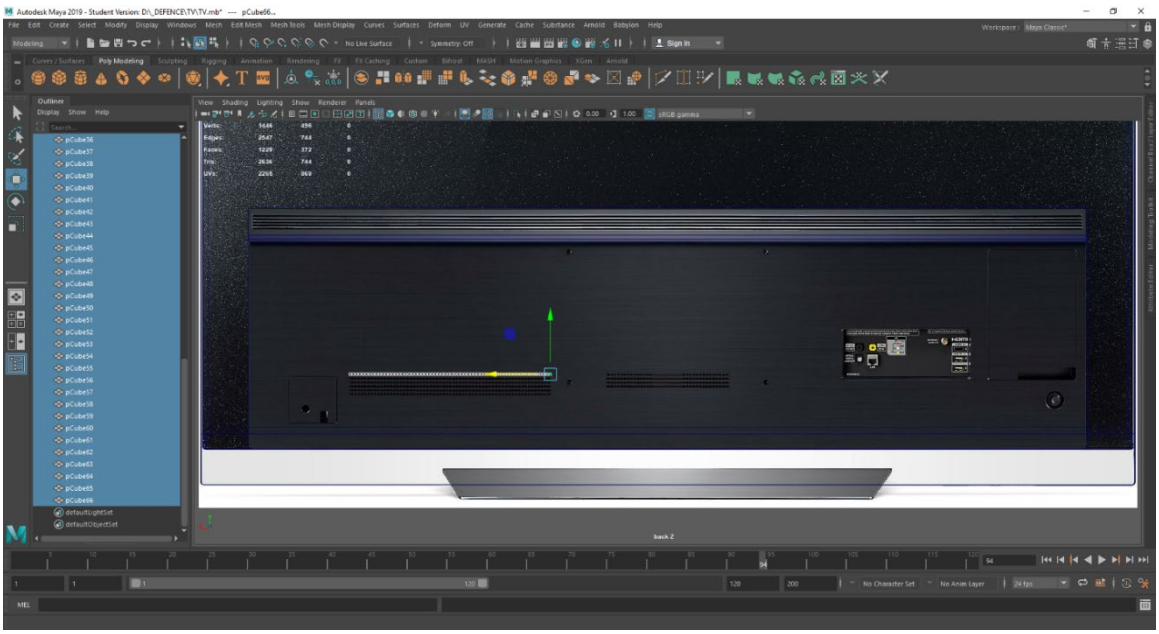

Figure 3.2.7 Duplicating Array of Cubes for Boolean.

Step 8: Create all the details of the back-panel for Deference Boolean process and Combine them.

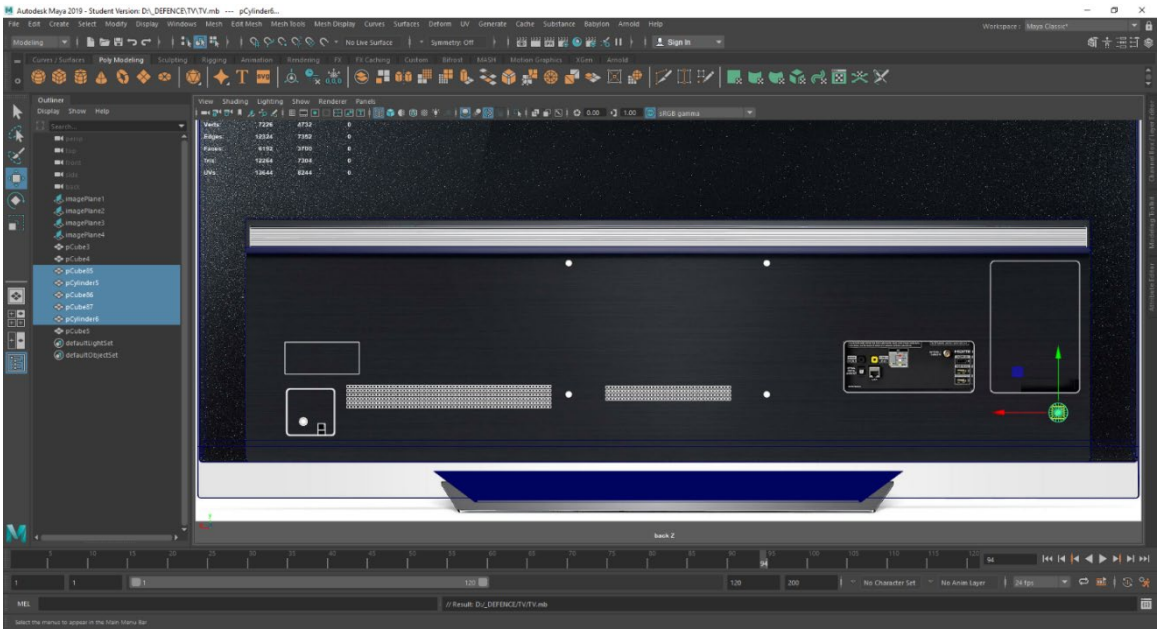

Figure 3.2.8 Preparing all the Details for Boolean.

Step 9: Selecting the back-panel mesh and mesh created for Boolean in order go to Mesh> Booleans> Deference.

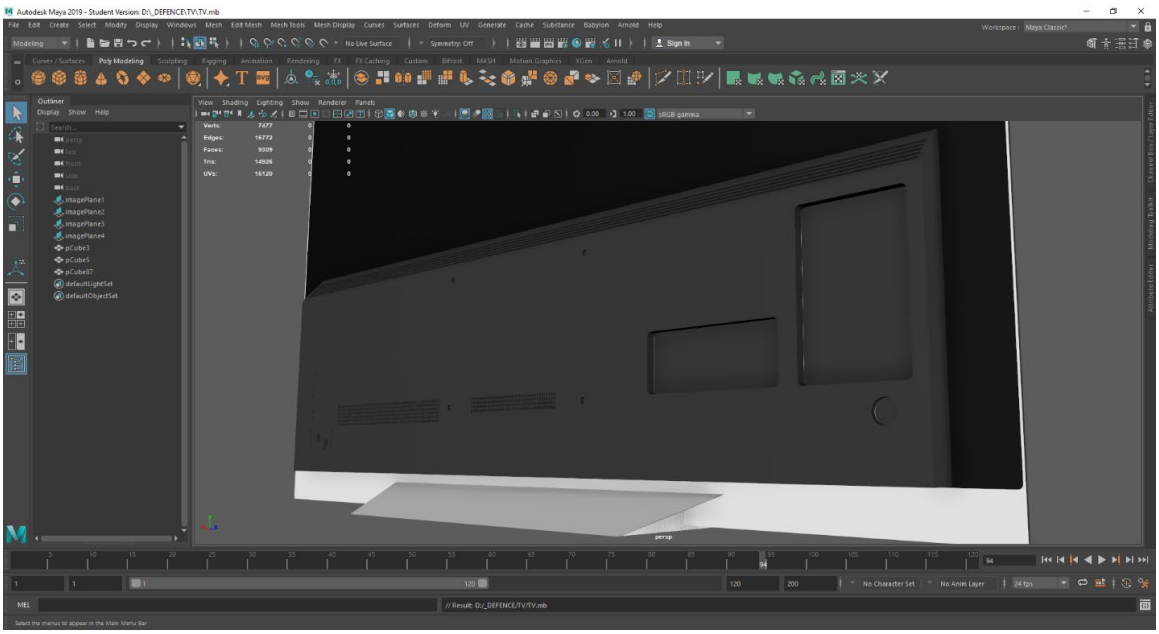

Figure 3.2.9 After Appling Boolean as Deference.

Step 10: Go to Mesh> Cleanup an select Faces with more than 4 sides to cleanup n-gons of the back-panel. Create cavities for ports by using Mesh Tools> Multi-Cut and Extrude the faces inside.

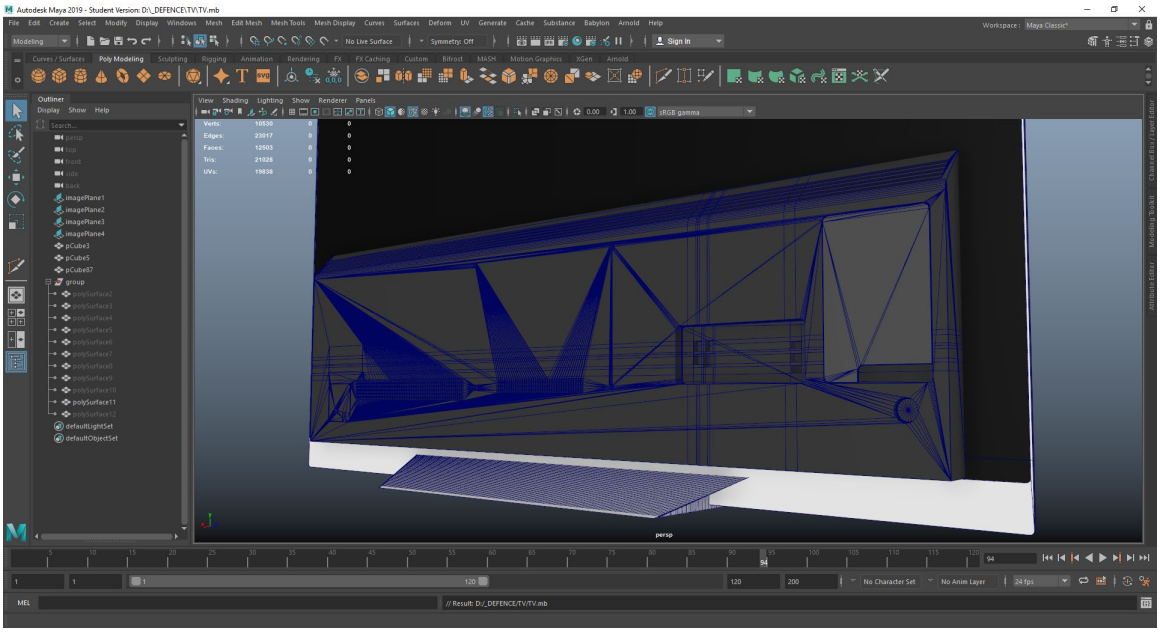

Figure 3.2.10 Mesh Cleanup After Appling Boolean.

Step 11: Create all the ports and buttons.

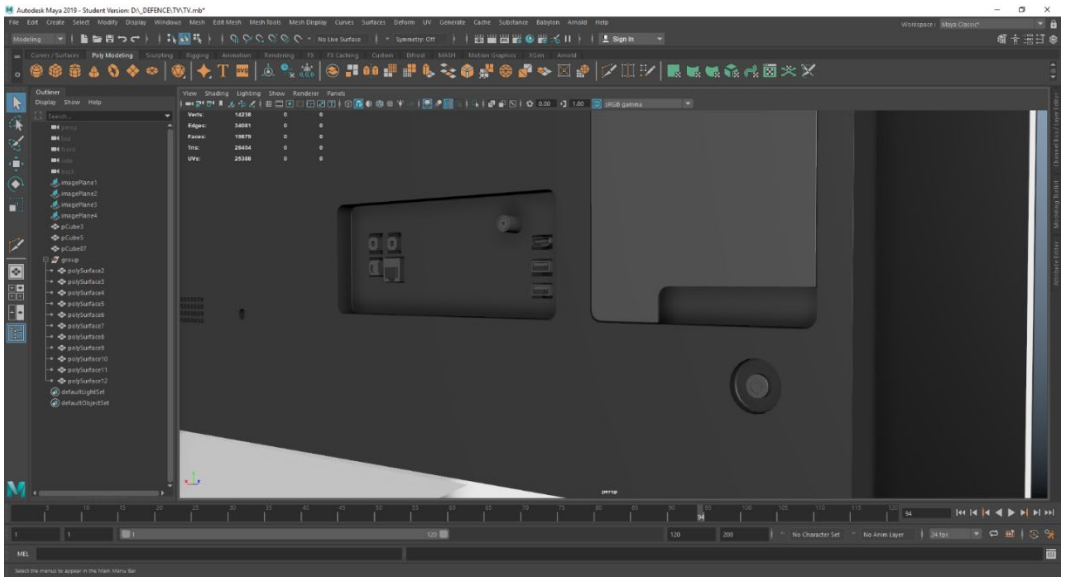

Figure 3.2.11 Creating Ports and Buttons.

Step 12: Try to stick with minimal mesh count and apply one material for one mesh. UV Unwrap all the meshes (Ctrl + U), Shift + Right Click on UV Editor and select Orient Shells. Layout UVs (Ctrl + L) keeping Shell Padding and Tile Padding 2 Pixels. Check for multiple texture set and any unwanted vertex color and File> Export Selection at Meters as Unit in FBX file format.

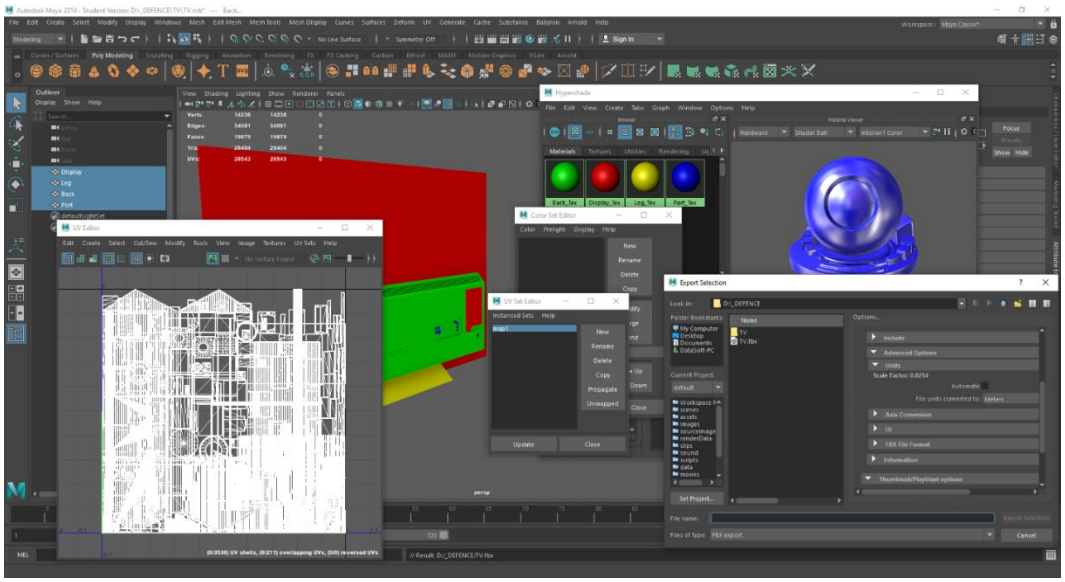

Figure 3.2.12 UV Unwrap, Layout, Checking Texture Sets, Vertex Color and Material Count.

Step 13: Import FBX to Blender3D and selecting meshes one by one apply Object Data> Normals> Auto Smooth and Export FBX again.

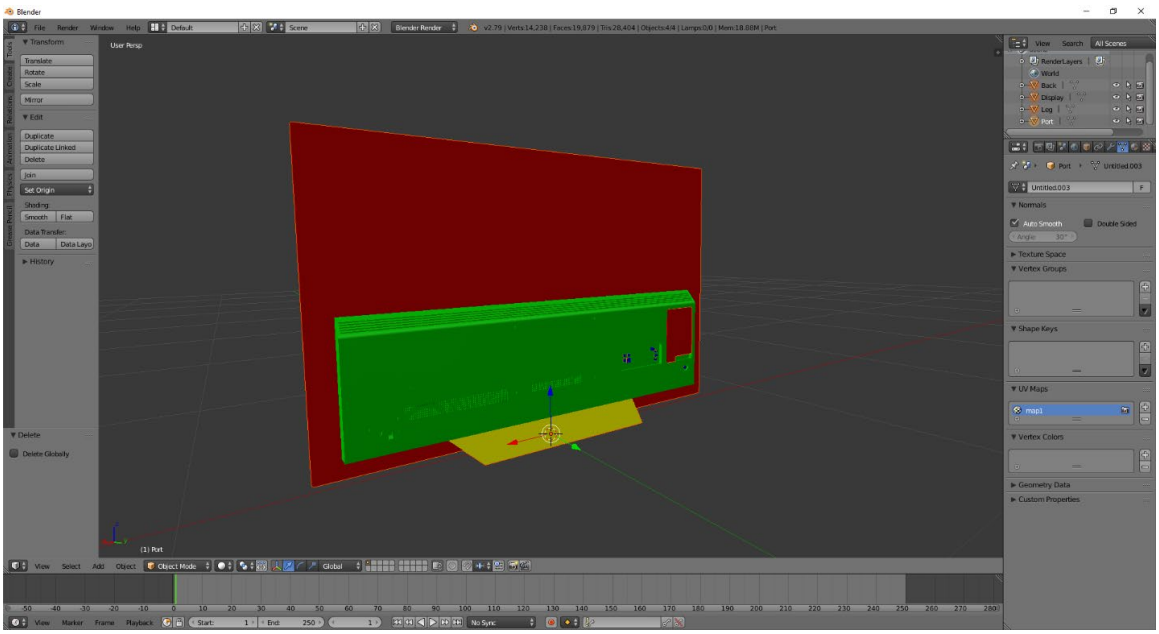

Figure 3.2.13 Apply Auto Smooth in Blender3D.

Step 14: Create new Substance file using the TV_B3D.fbx file and Bake Mesh Maps for Back_Tex and Display_Tex at 1024 and Leg_Tex and Port_Tex at 512 resolution. Apply materials and textures according to the references.

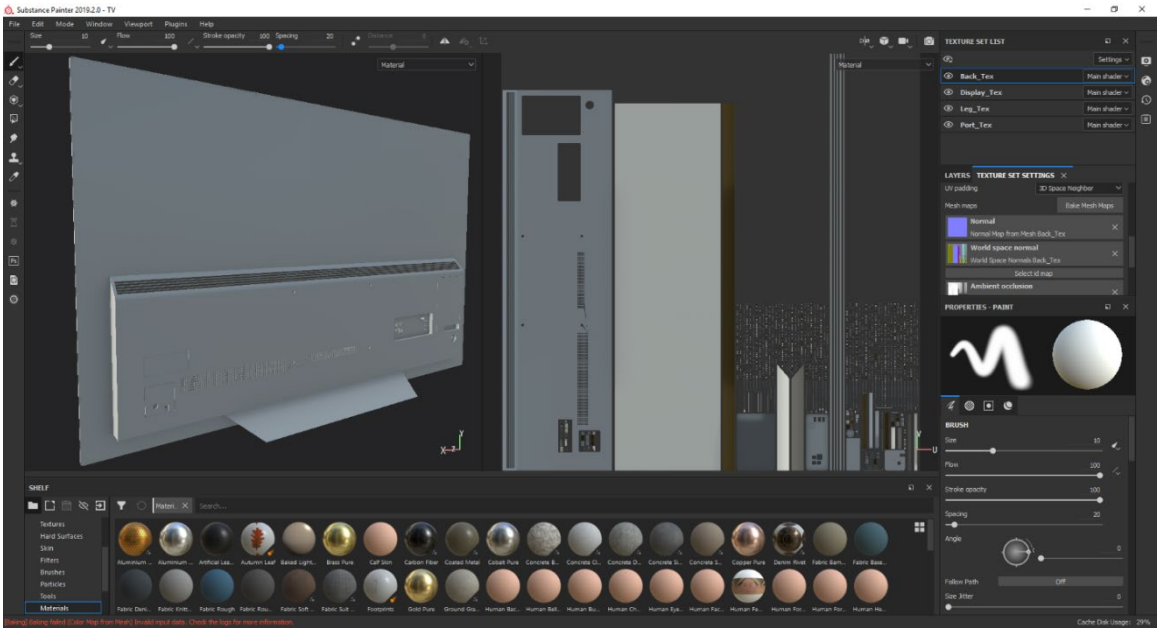

Figure 3.2.14 Baking and Texturing in Substance Painter.

Step 15: Export as GLB file according to the settings below.

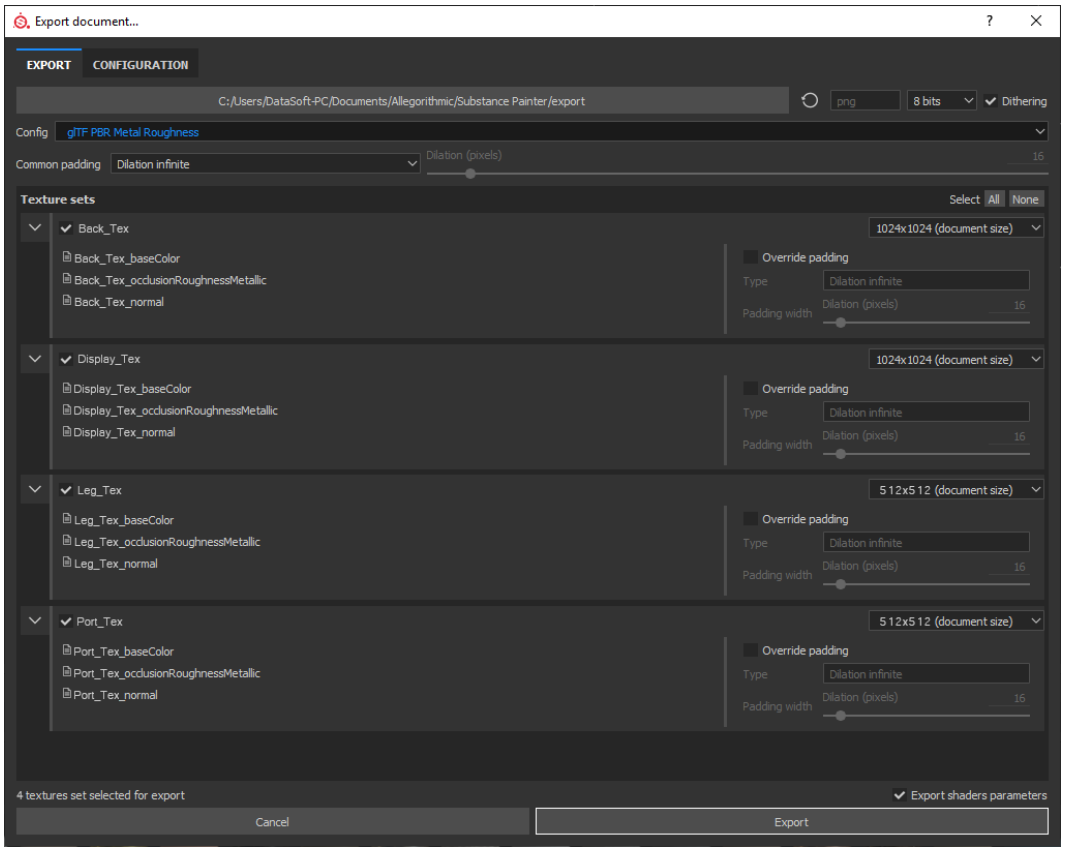

Figure 3.2.15 Texture Export Settings.

Figure 3.2.16 Final Output (Front).

Figure 3.2.17 Final Output (Back).

And This is the final output of the Smart TV Model.

3.3 Re-Modeling and Texturing a Coffee Machine

Inspection 1: This is an unoptimized coffee machine model which is 10.3 MB in size.

Figure 3.3.1 Unoptimized Model.

Inspection 2: The coffee beans on top of the model are made with poly mesh which is a major cause for its oversizing and if we use texture and normal map instead of poly mesh, we can reduce its size a lot.

Figure 3.3.2 Coffee Bean Made in Mesh.

Inspection 3: There are interior details inside of the model which is unnecessary. So, we can get rid of that.

Figure 3.3.3 Unnecessary Inner Details.

Step 1: As it is a GLB format file; we can import it to Blender3D (Version: 2.8) and export as FBX file format.

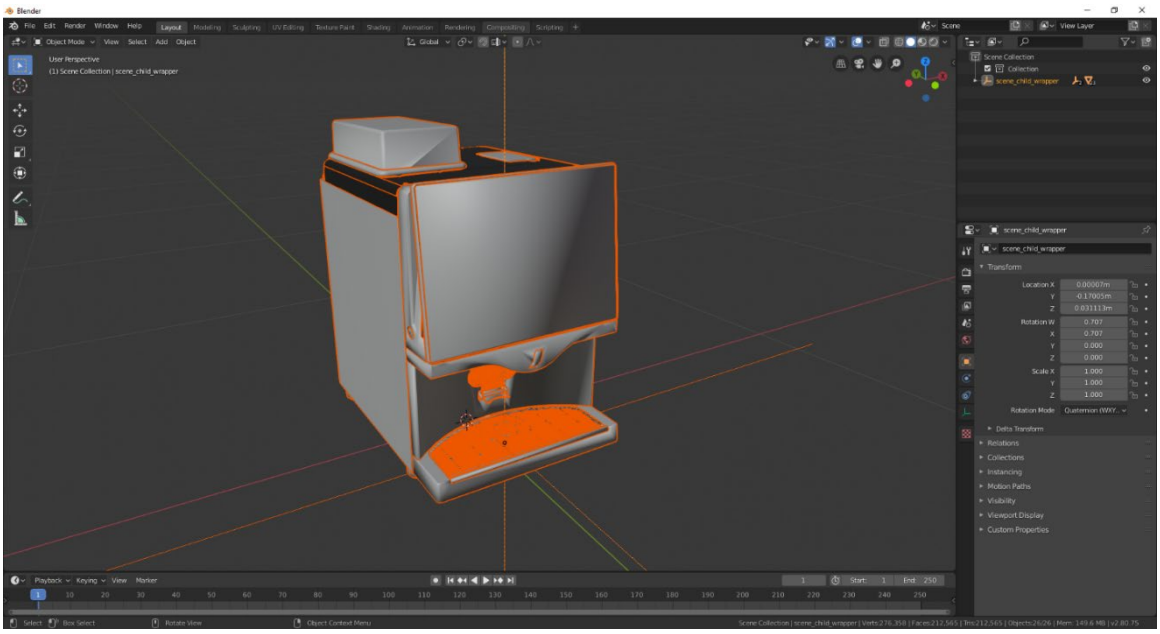

Figure 3.3.4 Converting GLB to FBX in Blender3D.

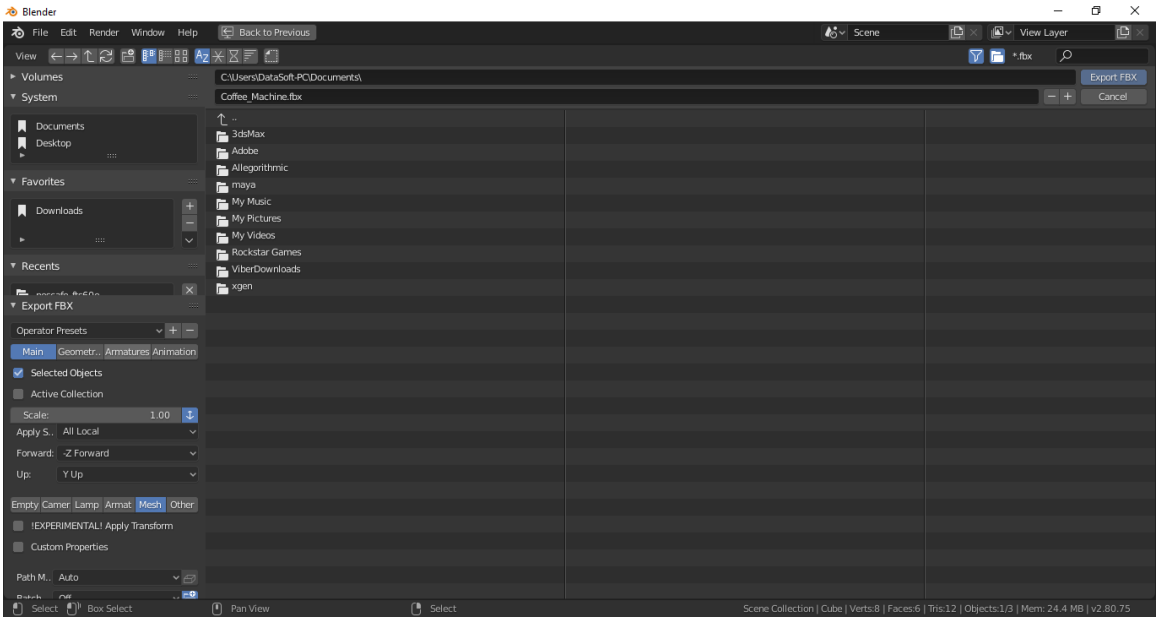

Figure 3.3.5 FBX Export Settings.

Step 2: Import the FBX file to Maya, set up the unit to Meters. Try to modify the meshes, Delete the unnecessary component. If the mesh is unusable, start to re-model it and always try to keep the poly count low. Use the given model as size reference.

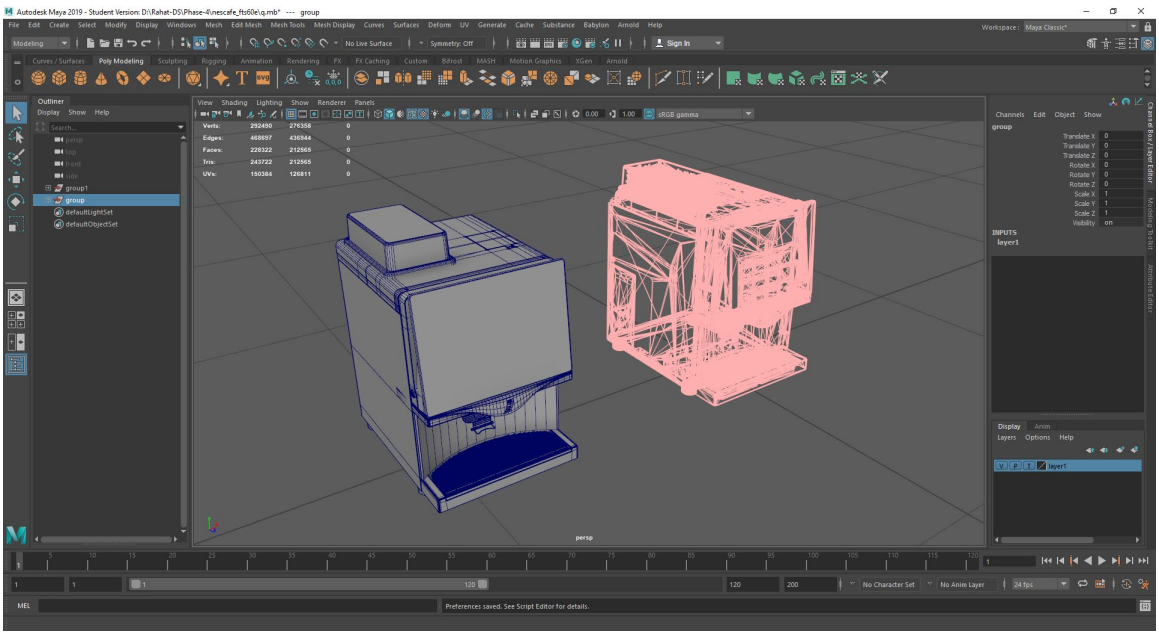

Figure 3.3.6 Import FBX for Size Reference.

Step 3: Try to stick with minimal mesh count and apply one material for one mesh. UV Unwrap all the meshes (Ctrl + U), Shift + Right Click on UV Editor and select Orient Shells. Layout UVs (Ctrl + L) keeping Shell Padding and Tile Padding 2 Pixels. Check for multiple texture set and any unwanted vertex color and File> Export Selection at Meters as Unit in FBX file format.

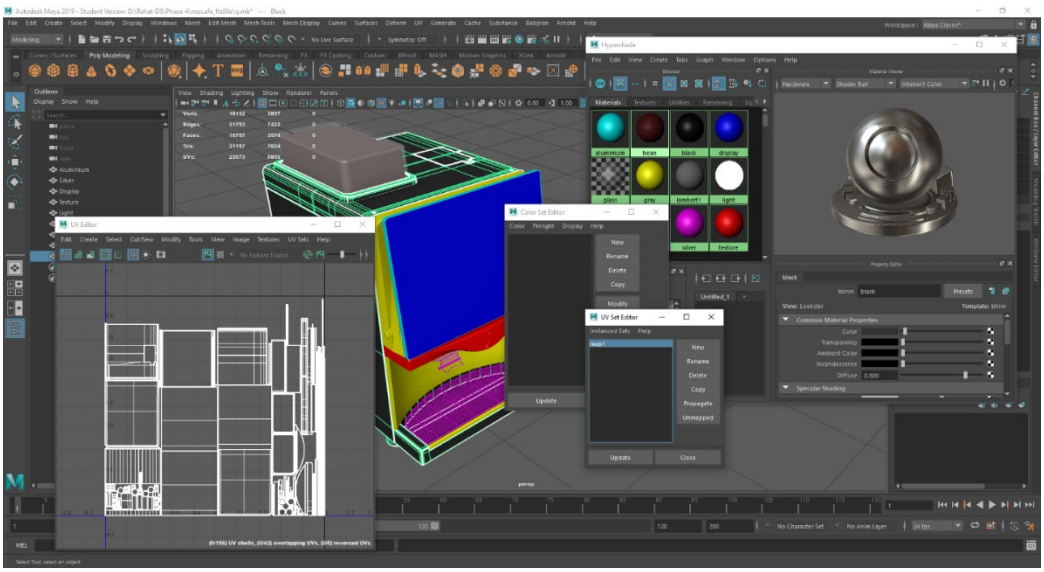

Figure 3.3.7 UV Unwrap, Layout, Checking Texture Sets, Vertex Color and Material Count.

Step 4: Create new Substance file using the FBX file and Bake Mesh Maps for all texture sets at minimum 256x256 and maximum 1024x1024 resolution.

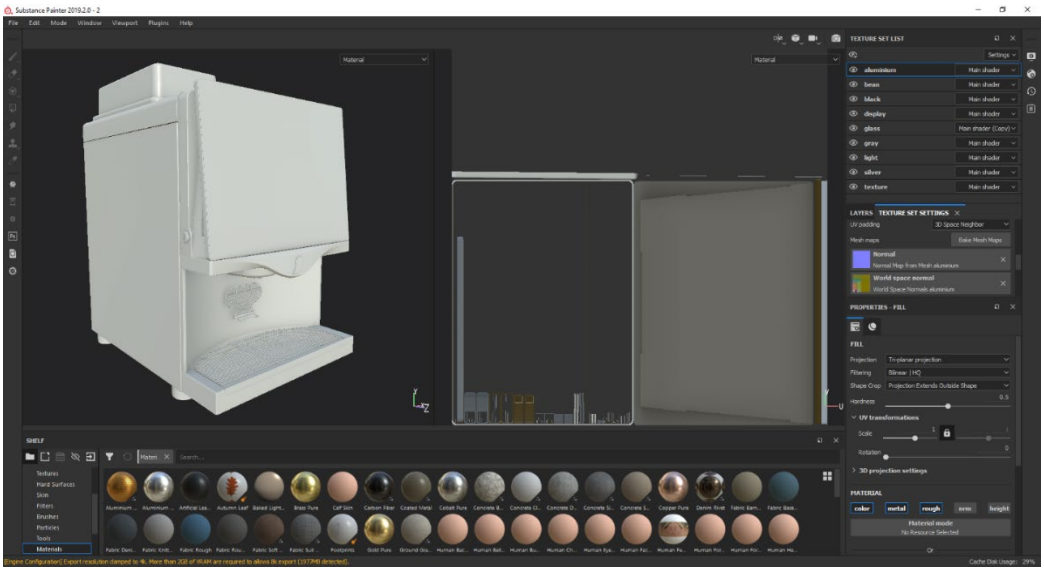

Figure 3.3.8 Baking Texture Sets in Substance Painter.

Step 5: For glass create a New Shader Instance and going to Shader Settings, select pbr-metal-rough-with-alpha-blending. Create Opacity channel from Texture Set Settings by pressing the + icon. And for light and display Create Emissive channel.

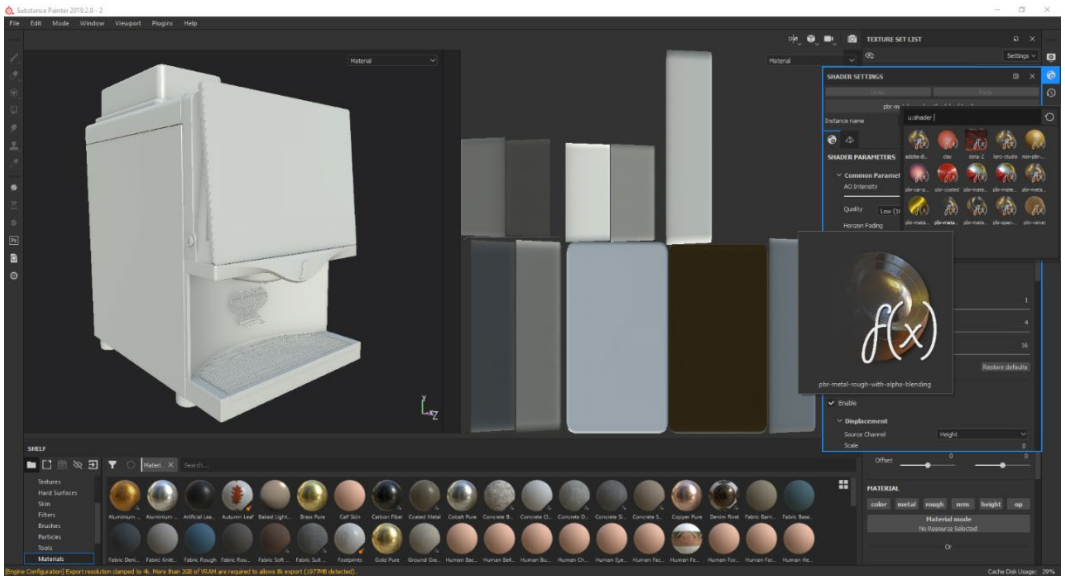

Figure 3.3.9 pbr-metal-rough-with-alpha-blending for Glass.

Step 6: Apply materials and textures according to the references. For coffee bean texturing create a fill layer and disabling all the channels except color, rough and height apply the seamless bean texture to both color and height and set the roughness to 0.55.

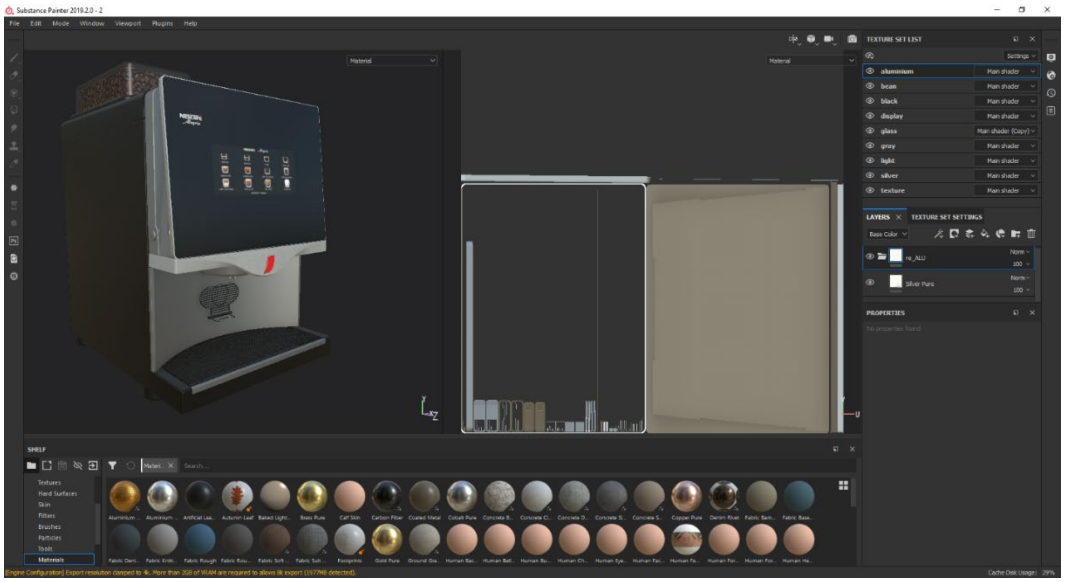

Figure 3.3.10 Texturing in Substance Painter.

Step 7: Export as GLB file according to the settings below.

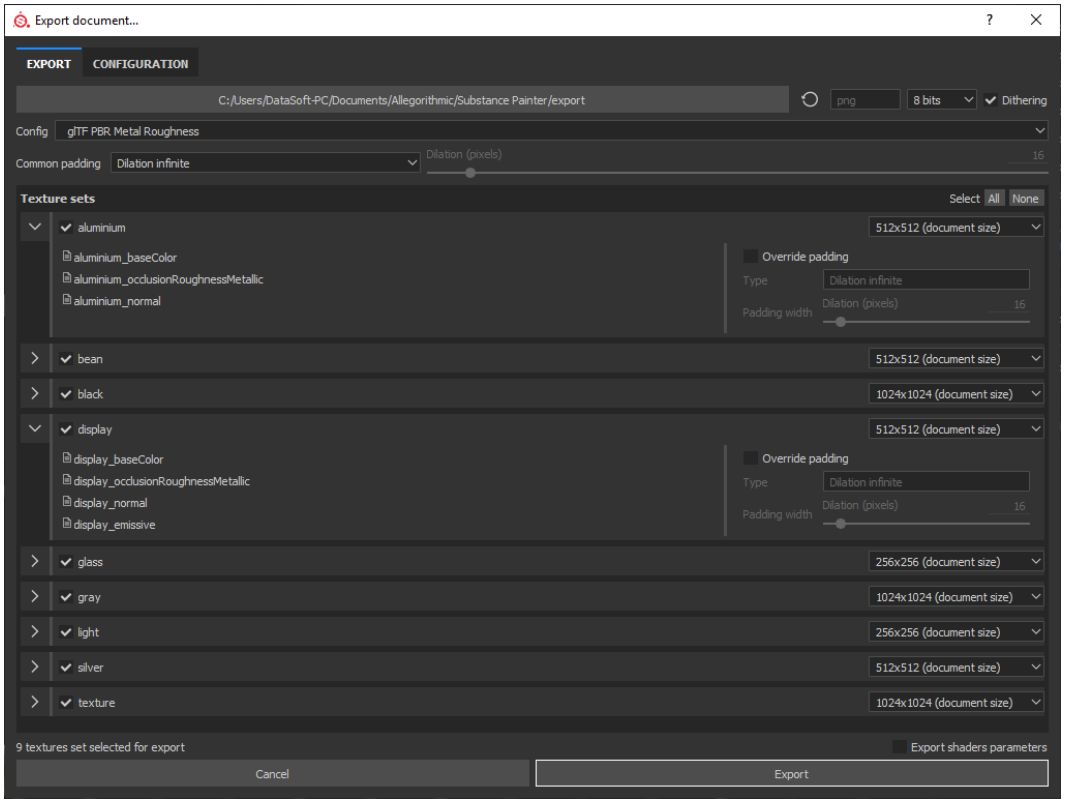

Figure 3.3.11 GLB Export Setup.

Figure 3.3.12 Final Output.

CHAPTER 4

3D Model Optimization

This chapter will be discussing 3D model optimization techniques. In this part, I will be making a car tire with high-poly mesh. Then, I will turn the high-poly details into depth-map and apply it on to a low-poly model. I will do this in a step by step process and use Autodesk Maya, Substance Painter, Adobe Photoshop and Blender 3d for the production and also point out some online compressing solution.

4.1 Baking High-poly Details on a Low-poly Mesh

Step 1: Change the measurement unit into Meter. I will go to Windows> Settings/Preferences> Preferences> Settings and change the unit.

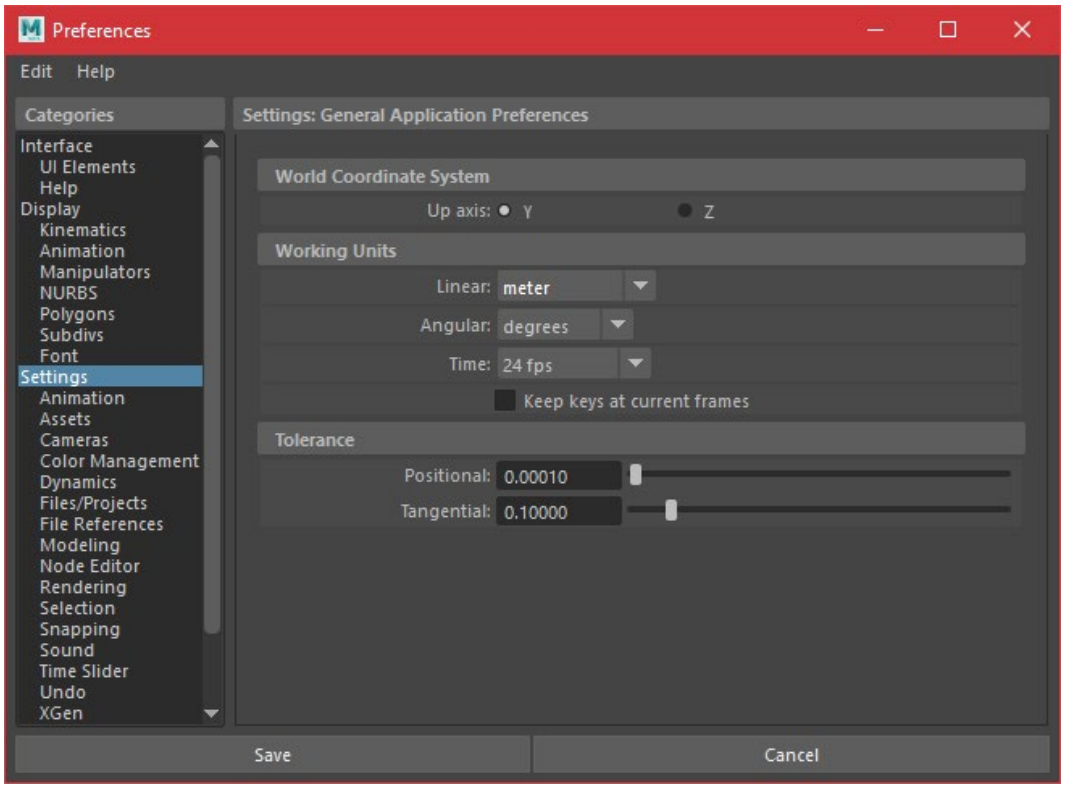

Figure 4.1.1 Unit Setup.

Step 2: Go to View> Image Plane> Import Image and import tire pattern image on front view.

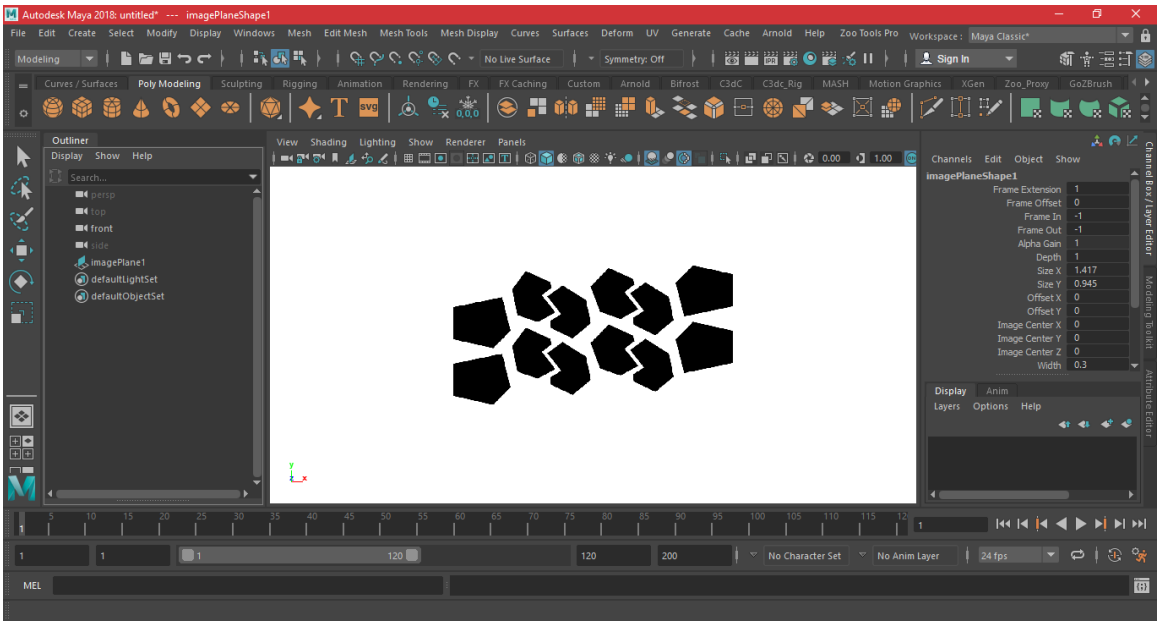

Figure 4.1.2 Use Image Plane for Reference.

Step 3: Go to Create> Polygon Primitives> Plane to create a plane, rotate it 90 degrees to X-axis and adjust its vertices to match the pattern.

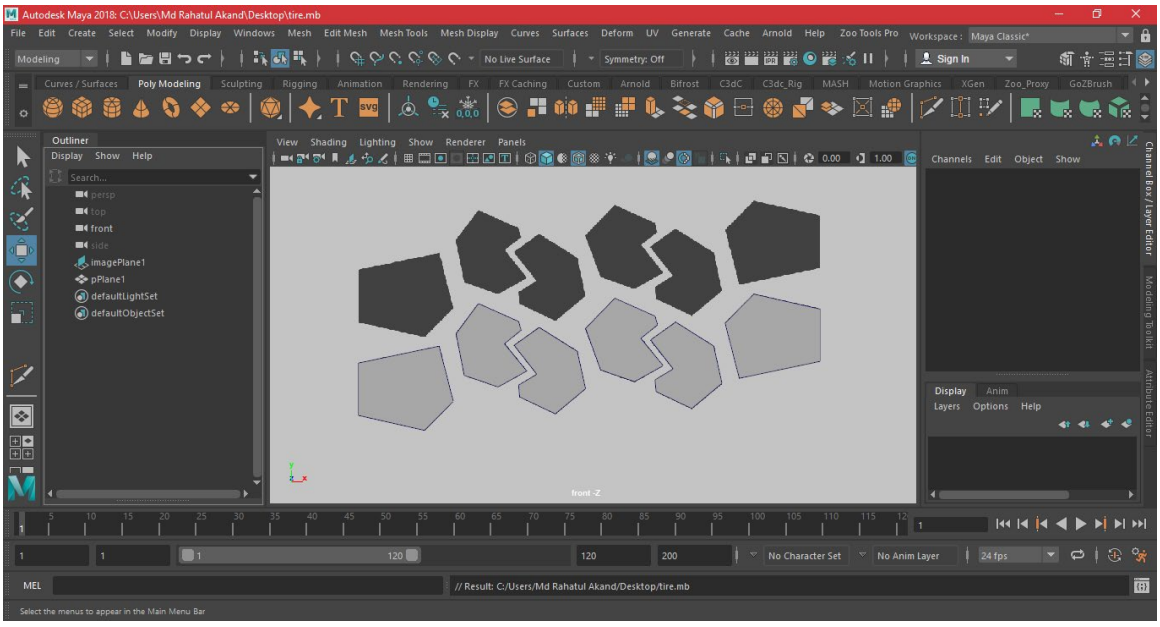

Figure 4.1.3 Pattern Creation Using Plane.

Step 4: Bridge all the edges, Extrude and make a repeatable pattern.

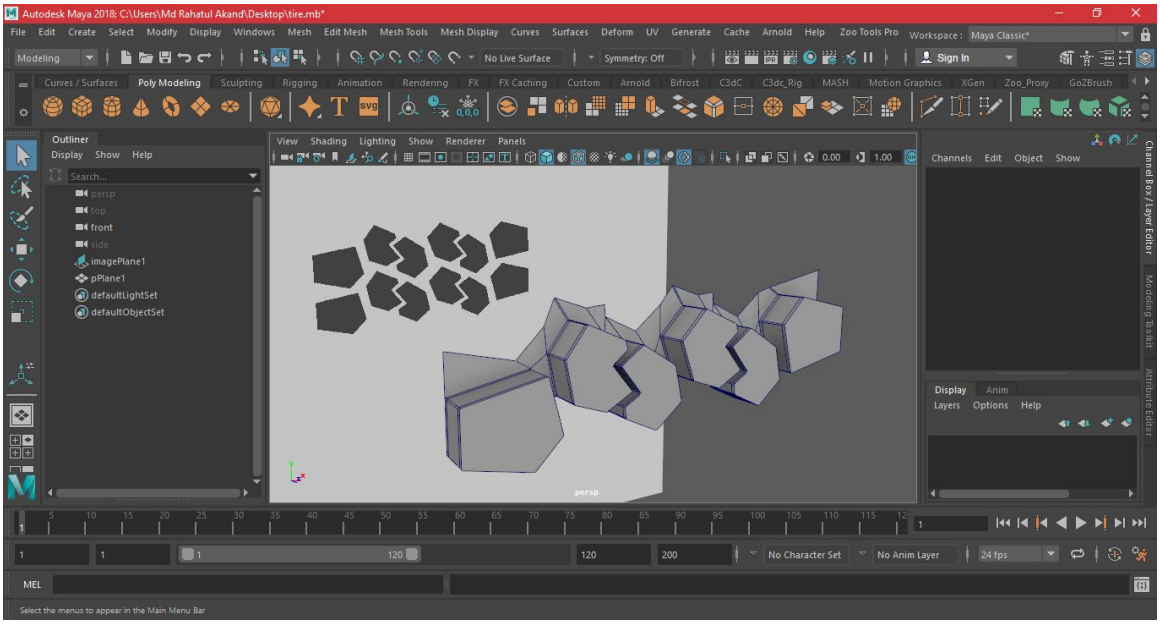

Figure 4.1.4 Extrude from Pattern.

Step 5: Go to Edit> Duplicate Special (Option box) and Instance 50 copies of the pattern along Y-axis at 0.022 unit.

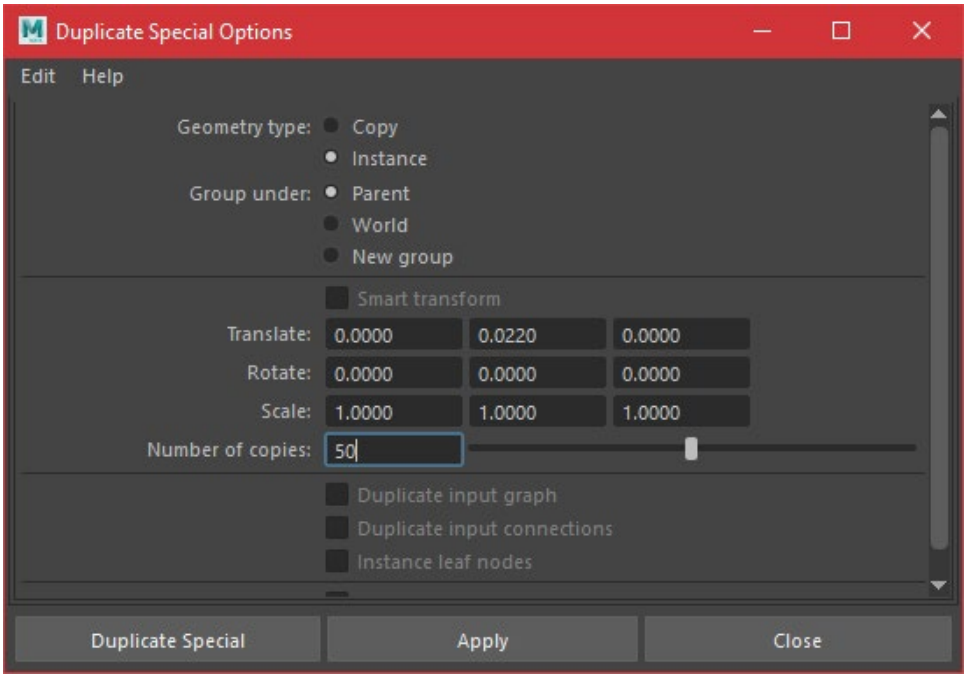

Figure 4.1.5 Duplicate Special Settings.

Step 6: Selecting all 50 patterns go to Mesh> Combine and selecting bottom vertices go to Edit Mesh> Merge and input 0.001 value.

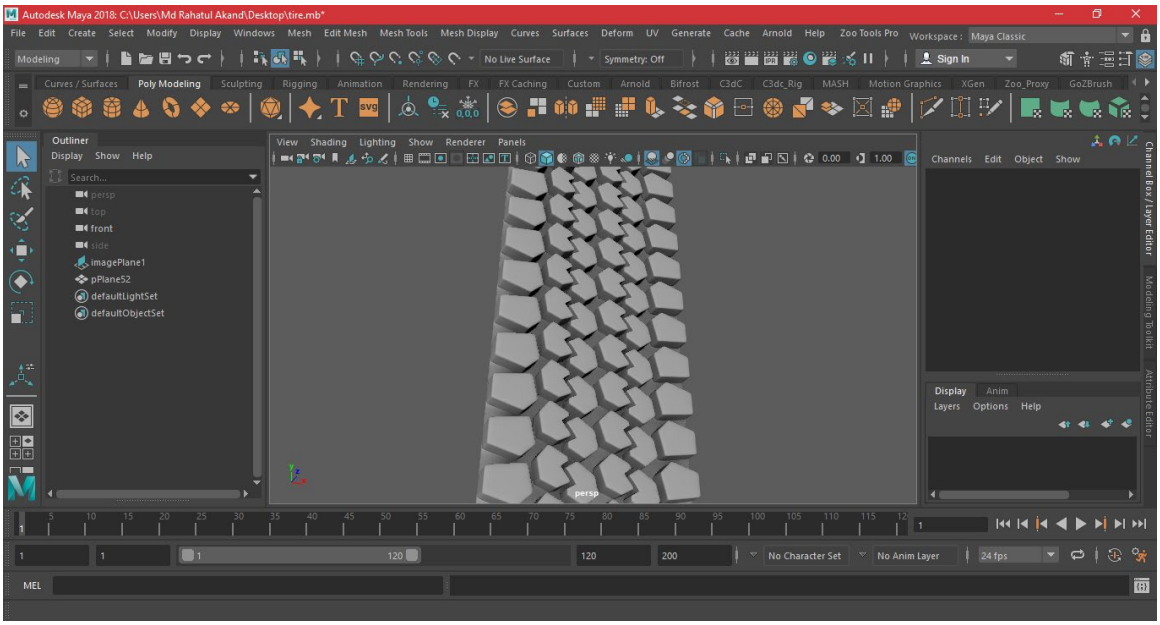

Figure 4.1.6 Array of Pattern.

Step 7: Selecting the mesh apply Deform> Nonlinear> Bend and rotate the bend handle 90 degrees to Y-axis and set the curvature to 182.64. Merge the vertices to make a complete circle.

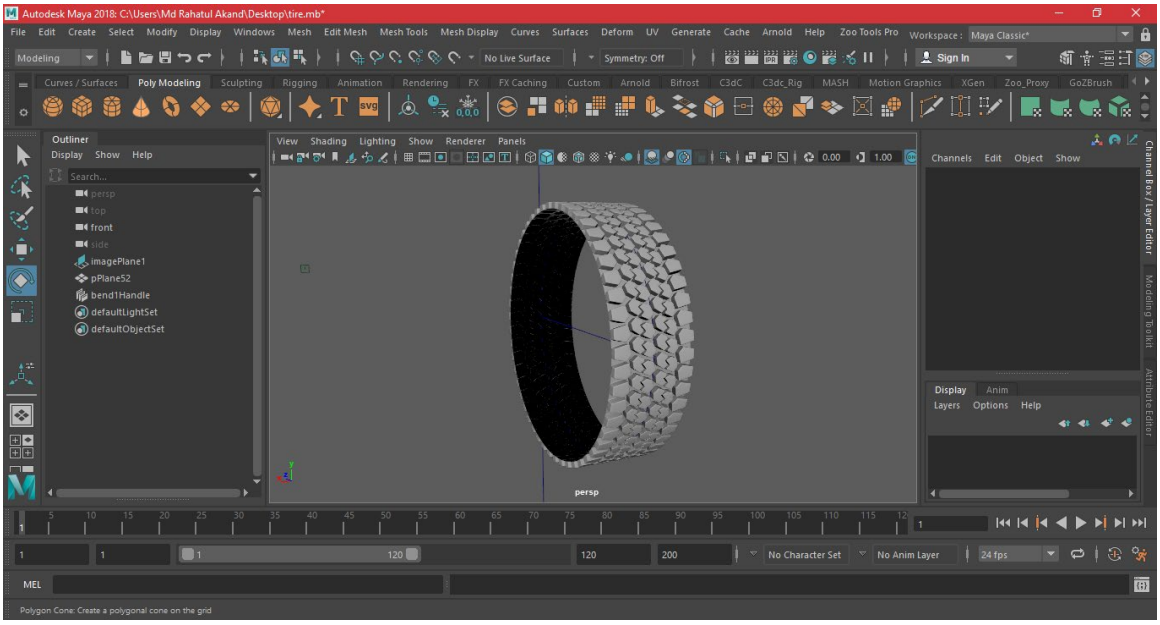

Figure 4.1.6 Using Bend Deformer.

Step 8: Complete the tire model by Extruding border edges to center.

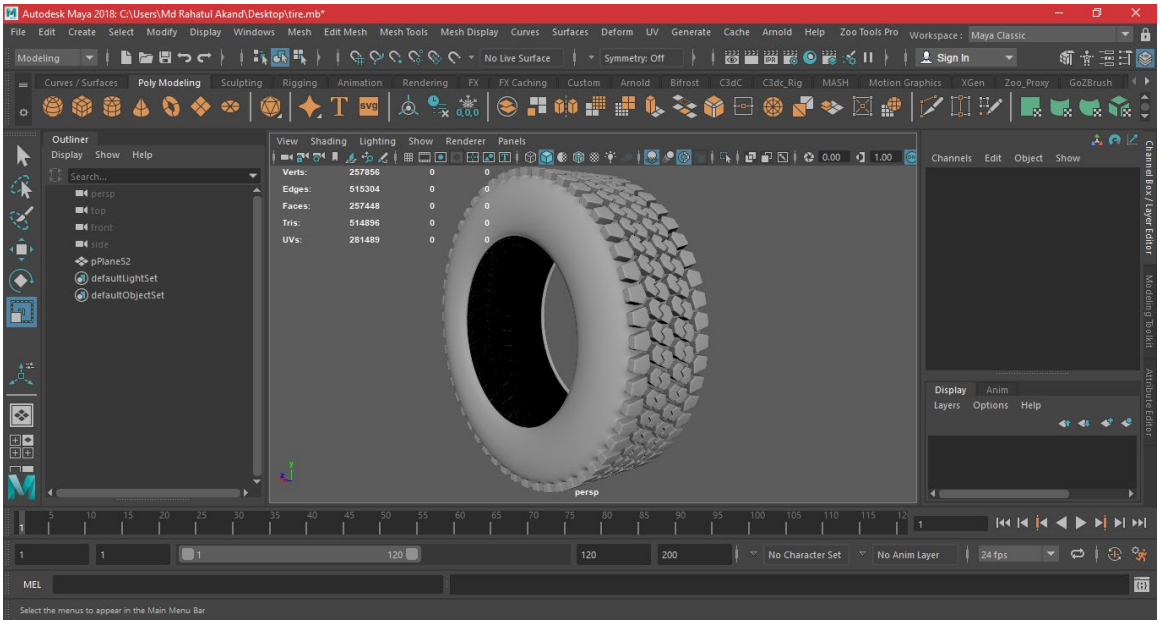

Figure 4.1.7 Making the Tire Shape.

Step 9: Correct the curvature of the tire using Lattice.

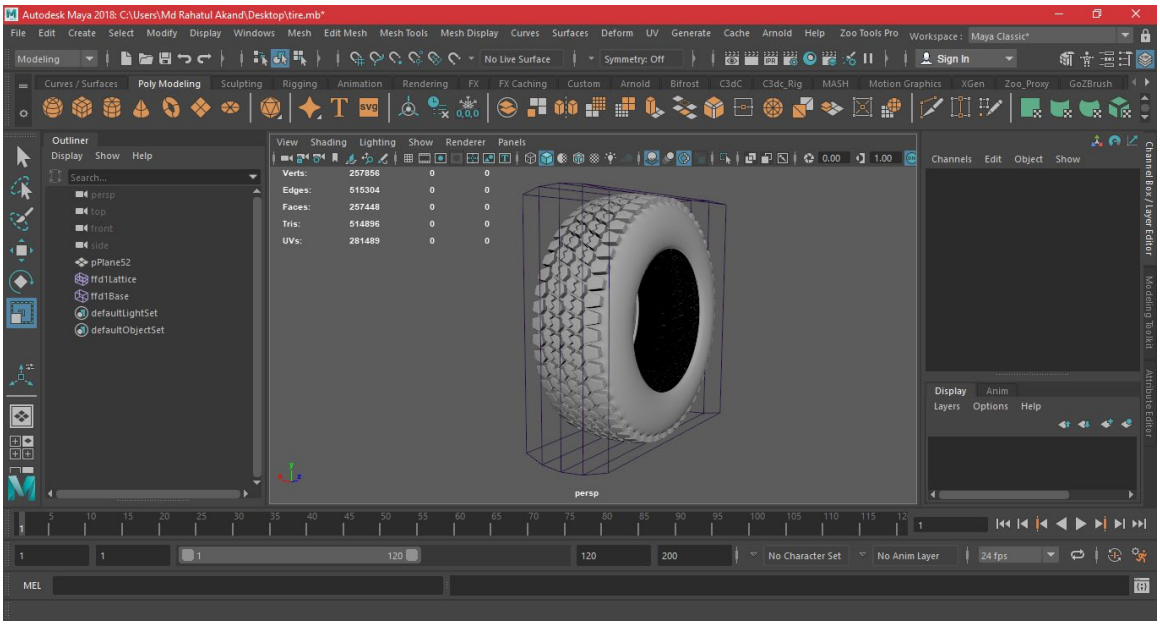

Figure 4.1.8 Using Lattice Deformer.

Step 10: Go to Modify> Convert> Smooth mesh preview to polygon and create a high-poly tire. We can see the verts count by going to Display> Heads up display> Poly count and the verts count of the high-poly mesh is around 257856, which is a lot for a website-compatibility.

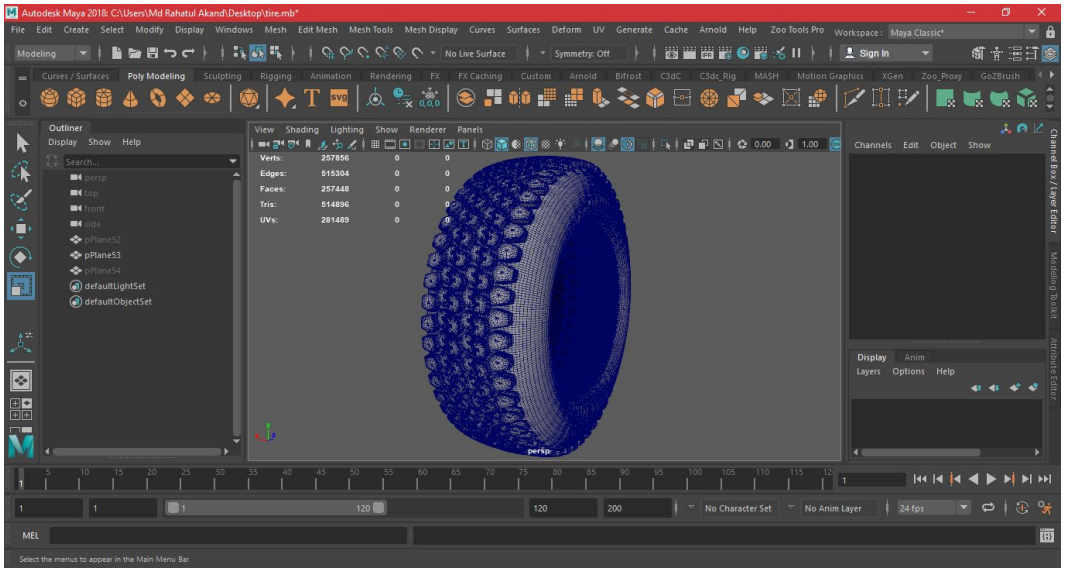

Figure 4.1.9 Convert Smooth Mesh Preview to Polygon.

Step 11: Let's make a very low-poly tire with same measurement and ignoring pattern details. The verts count of this model is 816, which is very efficient for the web.

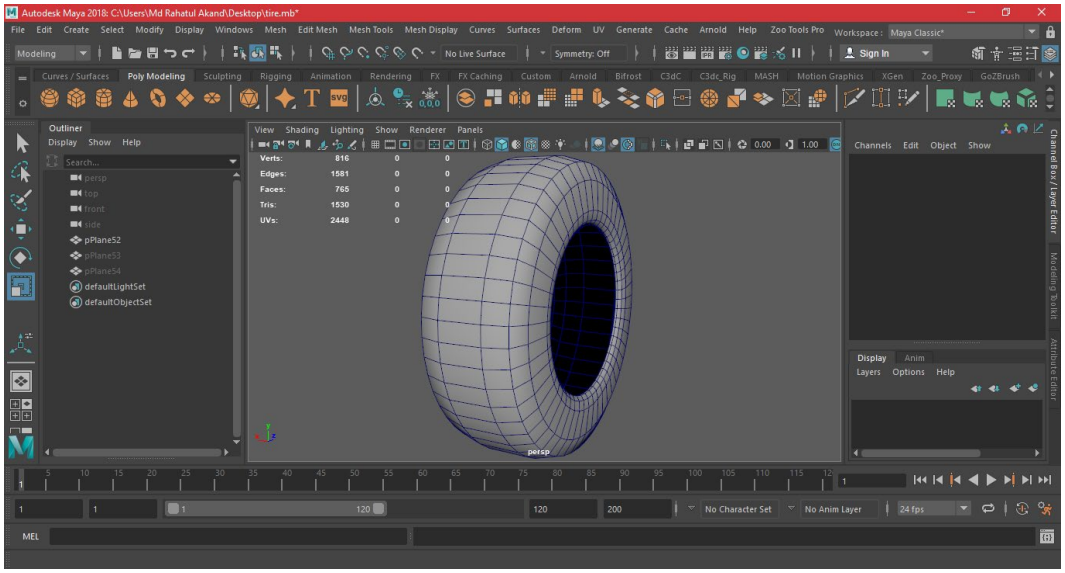

Figure 4.1.10 Creating Low-poly Tire Model.

Step 12: Let's UV unwrap both of them and rename them to Tire_high and Tire_low accordingly. Export them as (.fbx) format.

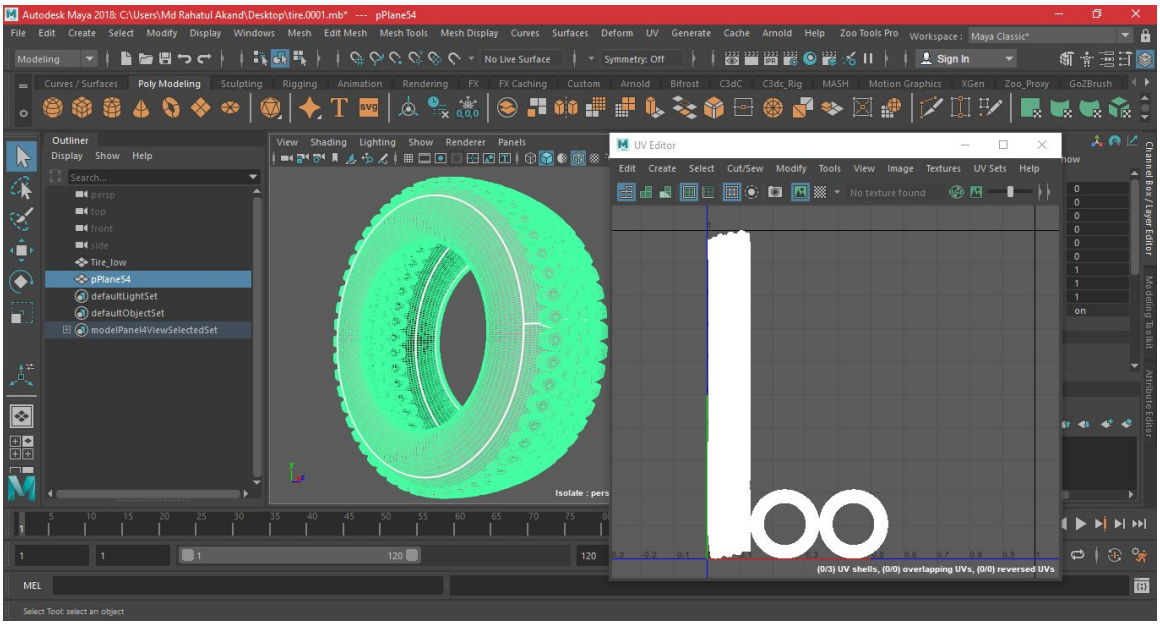

Figure 4.1.11 UV Unwrap and Layout (High-poly Version).

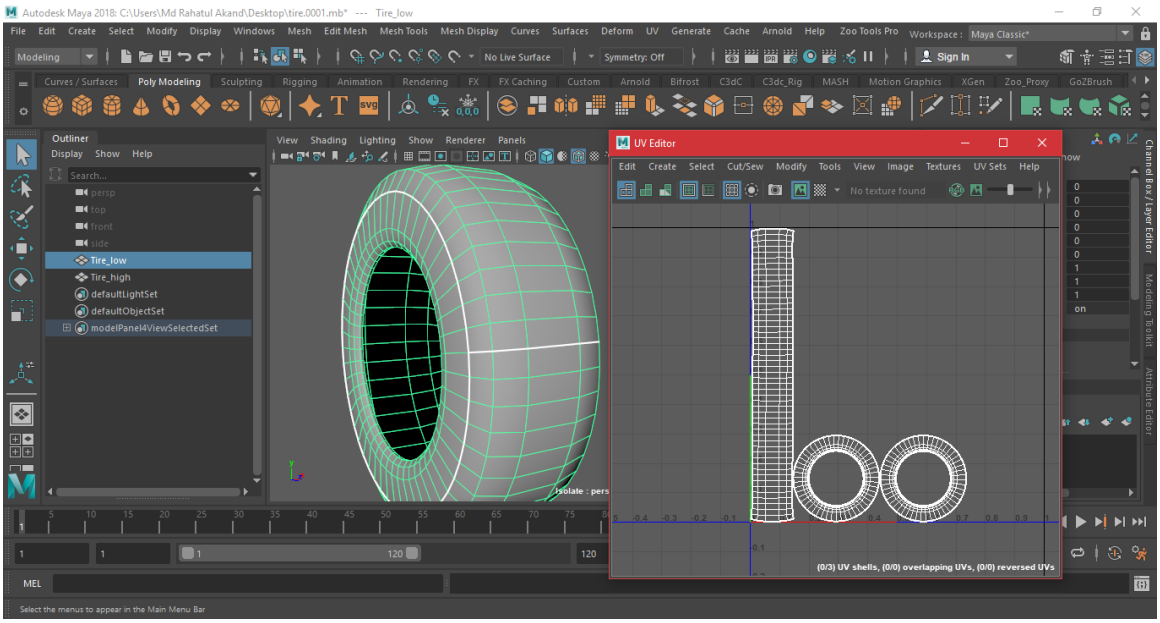

Figure 4.1.11 UV Unwrap and Layout (Low-poly Version).

Step 13: Open the (Tire_low.fbx) File on Substance Painter. Go to Texture Set Settings and Bake Mesh Maps at 2048 resolution. Select the (Tire_high.fbx) file for High Definition Meshes slot; Match by Mesh Name; Antialiasing Subsampling 4x4 and Bake lambert1 Mesh Maps.

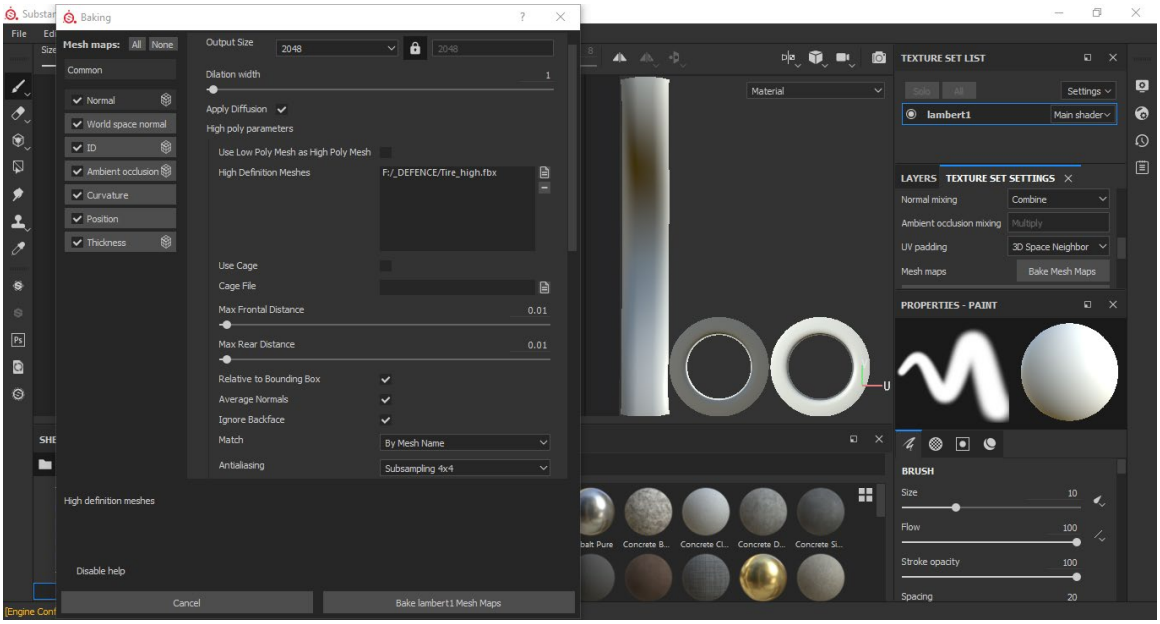

Figure 4.1.12 Bake High-poly Normal Map to Low-poly Mesh.

Step 14: Apply Rubber Tire smart material to the lambert1 Layer stack.

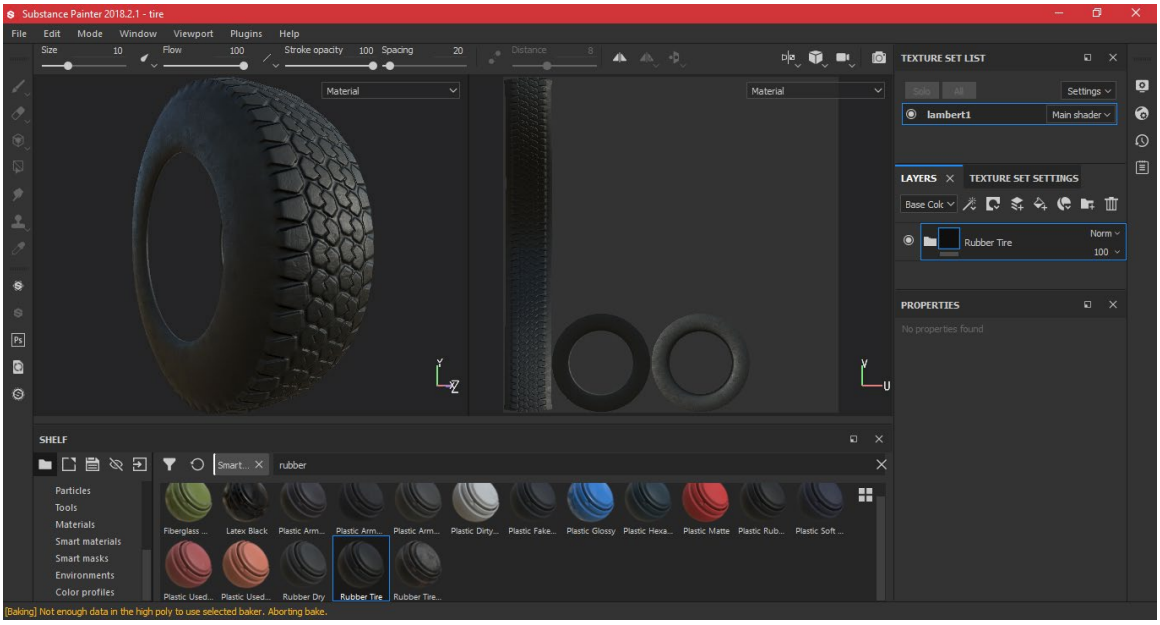

Figure 4.1.13 Texturing in Substance Painter.

Step 15: Take UV Snapshot of Tire_low from Autodesk Maya and UV Map the text on the tire using Adobe Photoshop.

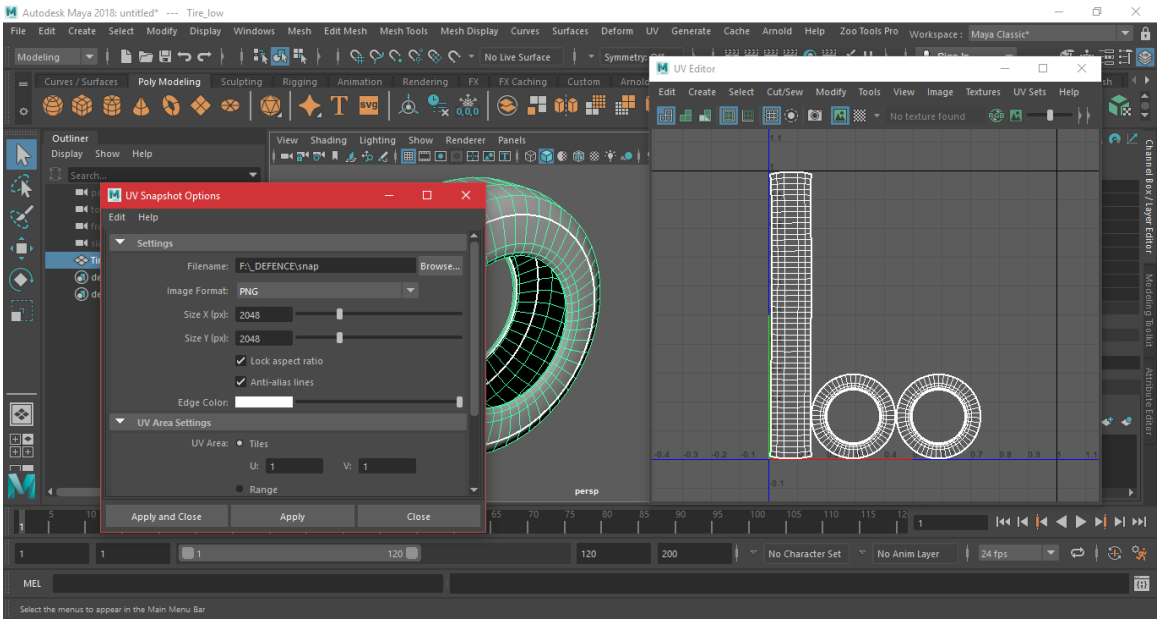

Figure 4.1.14 UV Snapshot.

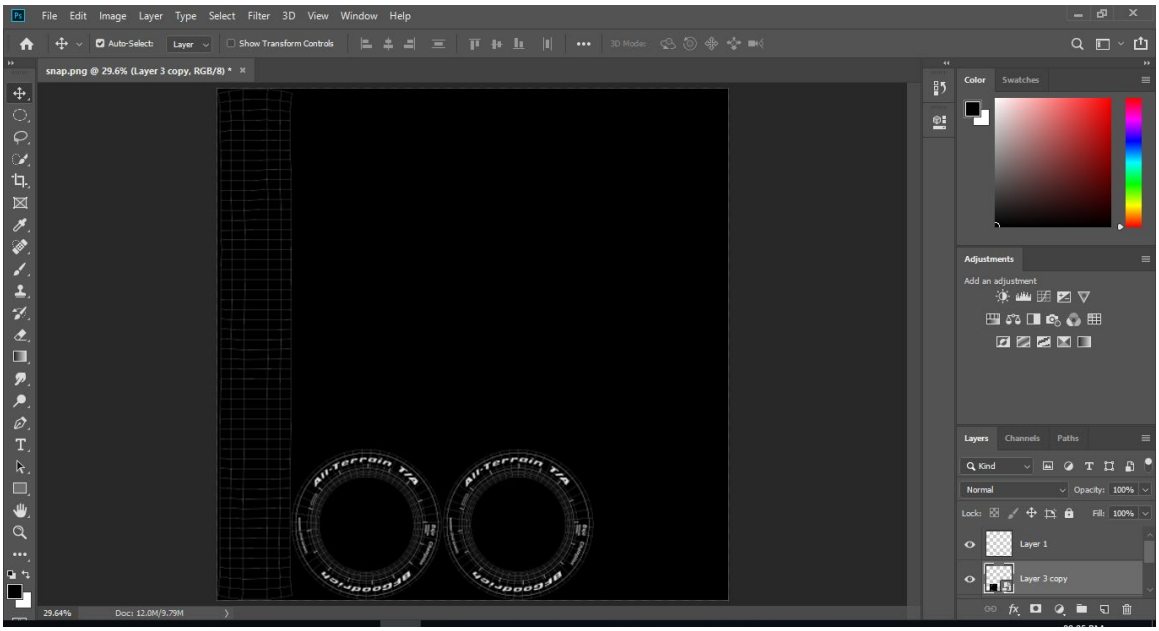

Figure 4.1.15 Texturing in Photoshop.

Step 16: Import the image into Substance Painter as Alpha, add a fill layer, turn off everything except height and put the image as height map. Adjust the height by using add levels to the fill layer targeting Height as Affected Channel.

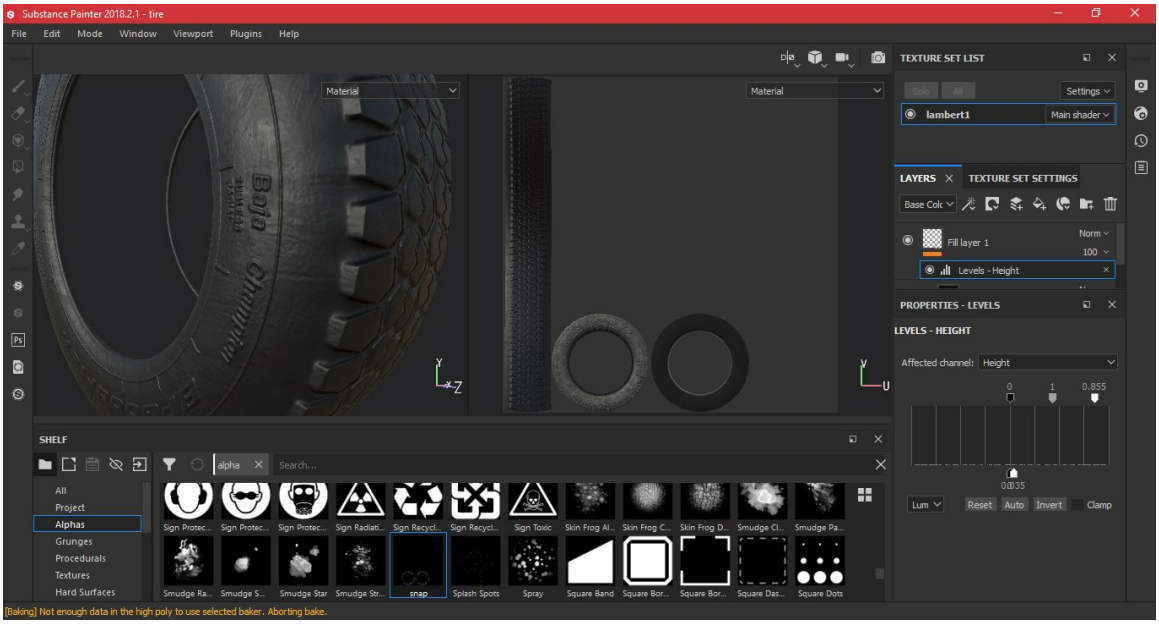

Figure 4.1.16 Texturing in Substance Painter.

Step 17: Go to File> Export Textures> Configuration and create a new preset for Blender 3D Export and Export textures in (.jpeg) file format using this preset.

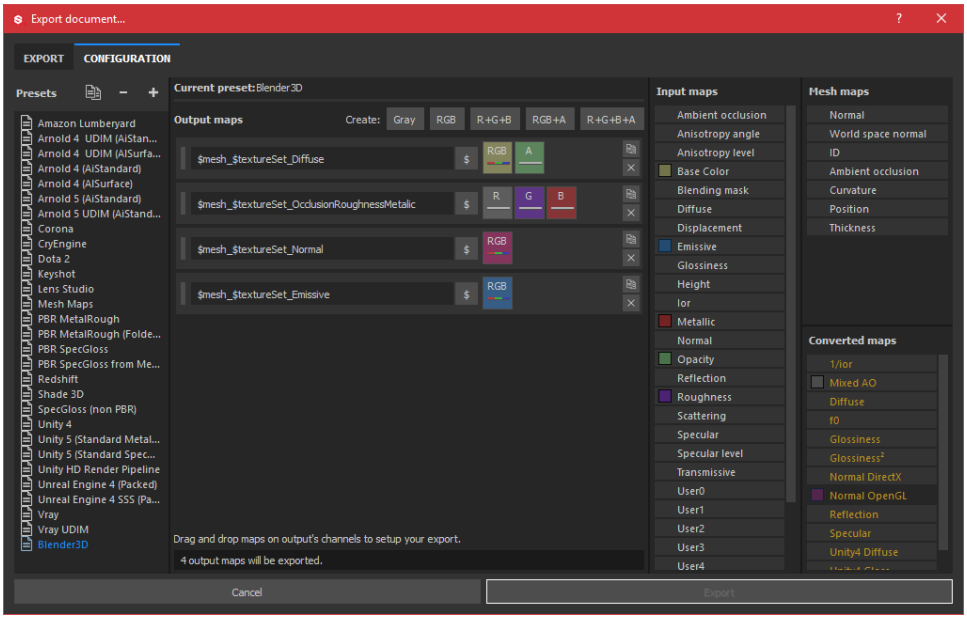

Figure 4.1.17 Export Textures Preset.

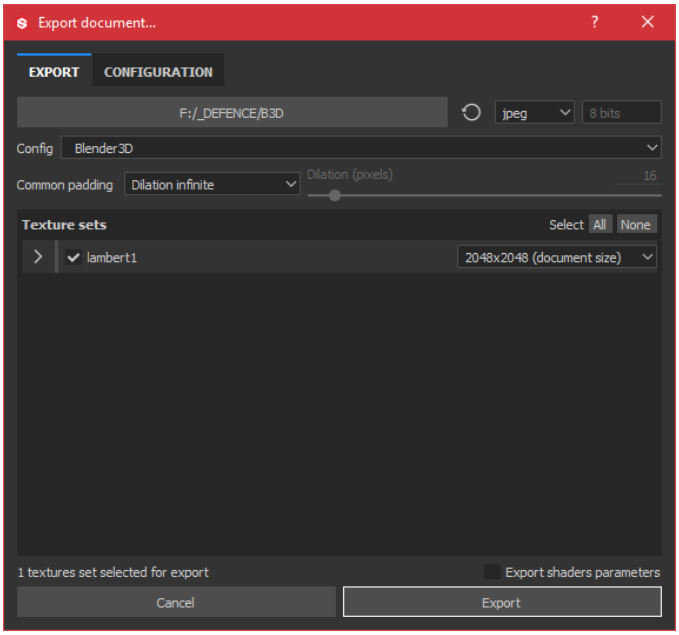

Figure 4.1.18 Export Textures Settings.

Step 18: Import (Tire_low.fbx) file on Blender 3D and assign all the textures correctly and export as (.glb) file format.

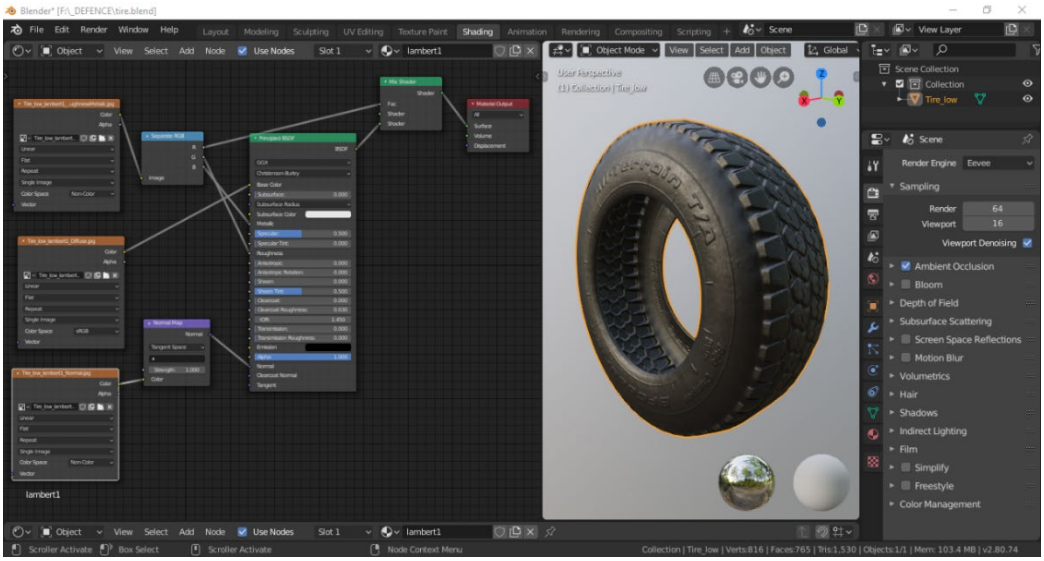

Figure 4.1.19 Texture Node Setup in Blender3D.

Now, finally, we can compare the file size of both the high-poly and the low-poly mesh. High-poly mesh without texture file size about 12 MB. On the other hand, low-poly mesh with details and texture file size exactly 977 KB which is a huge difference. So, this is the process of optimization for web.

4.2 Online Compressing Solution

Step 1: Export as GLB file according to the settings below along with textures from Substance Painter to a folder and make sure to check Export shaders parameters which will create a (.json) file.

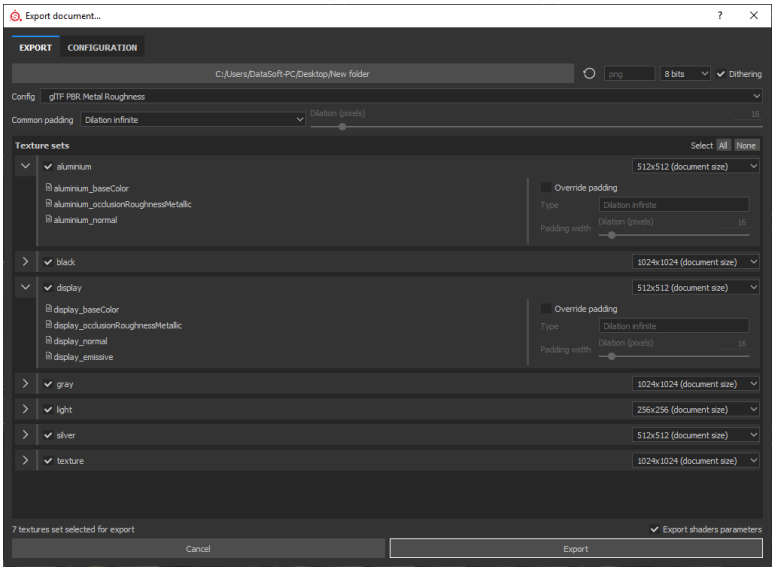

Figure 4.2.1 Export Textures Settings for Web.

Step 2: Go to https://glb-packer.glitch.me/ web address and check Convert PNG to JPEG (beta). Select all the texture file, GLB, GLTF along with (.json) file from the folder. Drag and drop them to the browser window and the compressed file will be downloaded automatically.

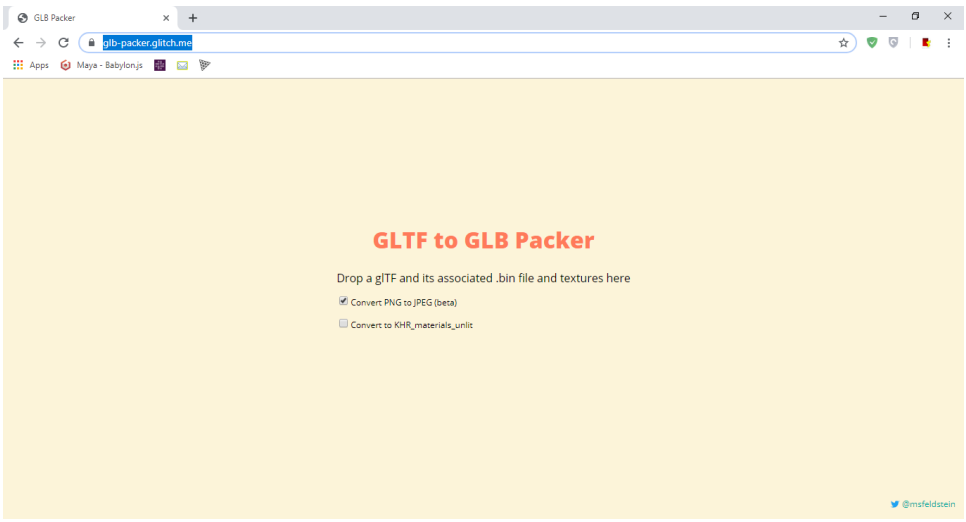

Figure 4.2.2 GLB Packer Website.

- Important thing to note that, the model size before compression was 5.29 MB and afterward it was downsized to 1.89 MB. Now, this model will load quicker in the website than before.

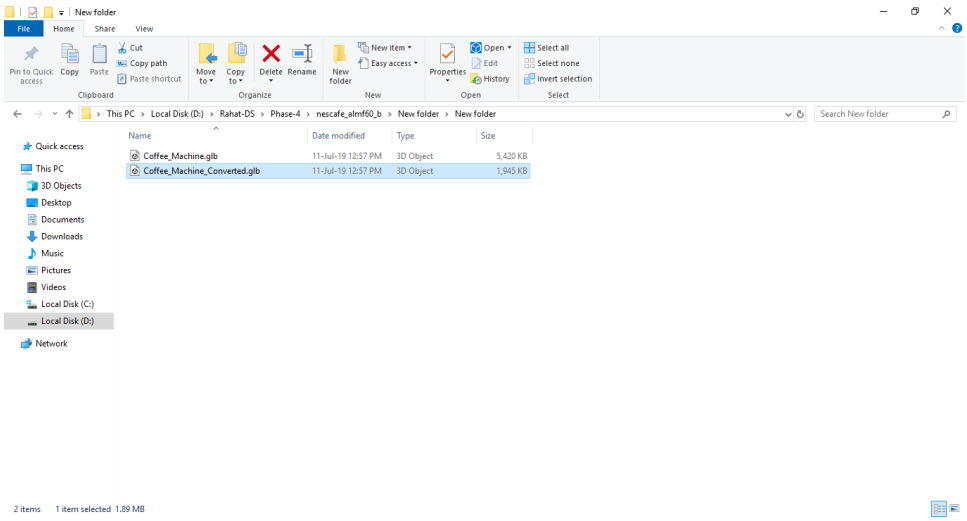

Figure 4.2.3 GLB Size Comparison.

- But we can use this process only with fully opaque models. Converting PNG to JPG will lose the transparency of the model. In that case we need to go to https://viewer.seekxr.com/ web address and we can delete some texture maps like ambient occlusion of flat meshes or normal map where there are no details.

Figure 4.2.4 Modify GLB on seekxr Website.

CHAPTER 5

Creating Video Representation

This chapter will be discussing about the software uses and workflow for creating video representation of the 3D models.

5.1 Video Rendering in Marmoset Toolbag

Step 1: Export Textures with Diffuse, Normal, Roughness, Metallic, Ambient Occlusion and Emissive map from Substance Painter. We can export with 2K resolution and PNG format.

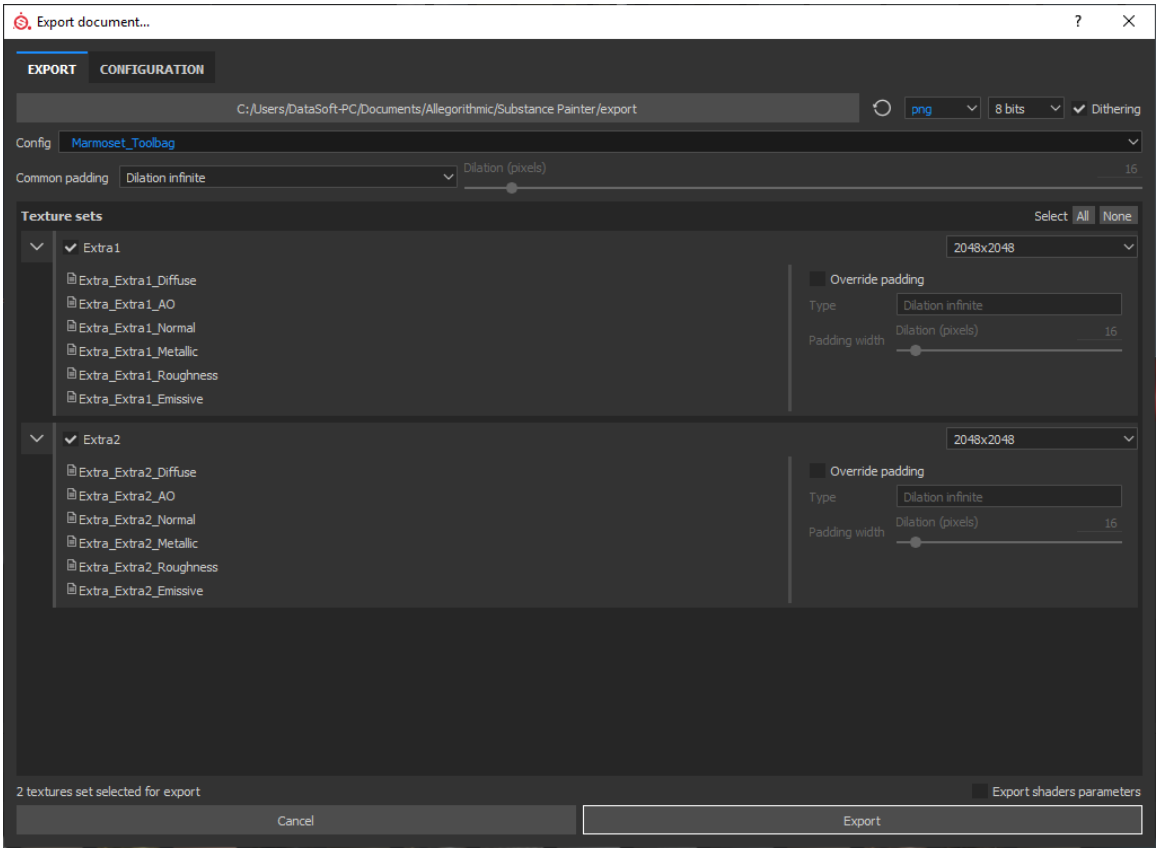

Figure 5.1.1 Export Textures Settings for Marmoset Toolbag.

Step 2: Open Marmoset Toolbag and go to File> Import Model and import FBX file.

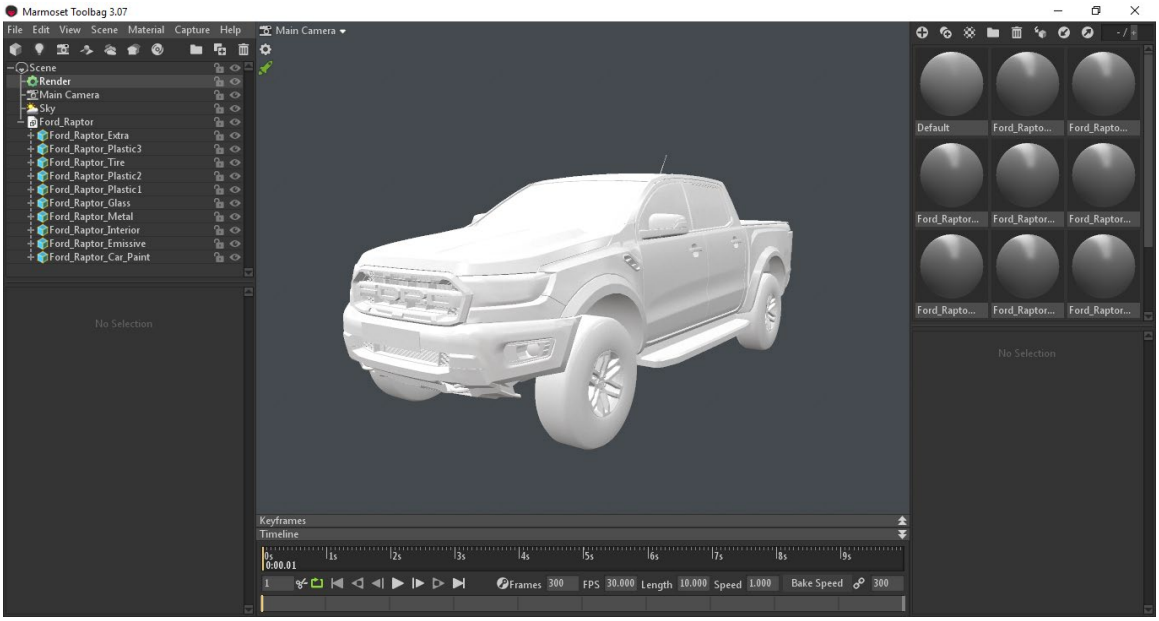

Figure 5.1.2 Import Model to Marmoset Toolbag.

Step 3: Apply all the textures, use light, backdrop, change HDR and build atmosphere.

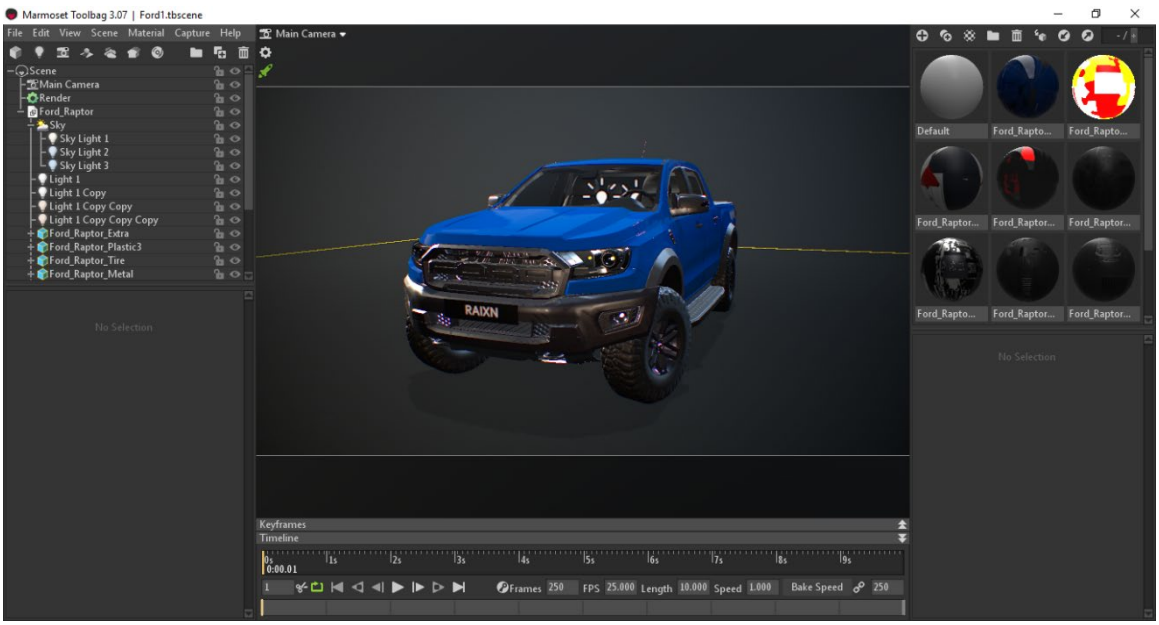

Figure 5.1.3 Applying Textures.

Step 4: Selecting Main Camera we can change Depth of Field, Flare, Distortion. We can add Post Effects. Selecting Render we can turn on Global Illumination, Ambient Occlusion and change the resolution. We can add manual keyframes to the model or containing folder in the timeline and also use automatic Turntable.

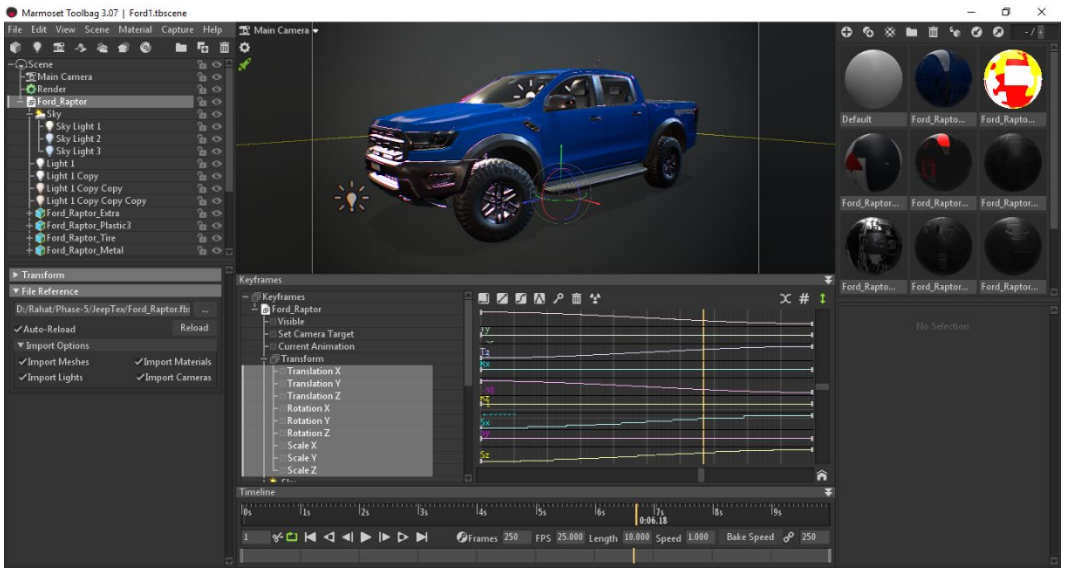

Figure 5.1.4 Adding Keyframe for Animation.

Step 5: Go to Capture> Settings and set the Aspect Ratio, Sampling and file format to render to. Press F5 to start video rendering.

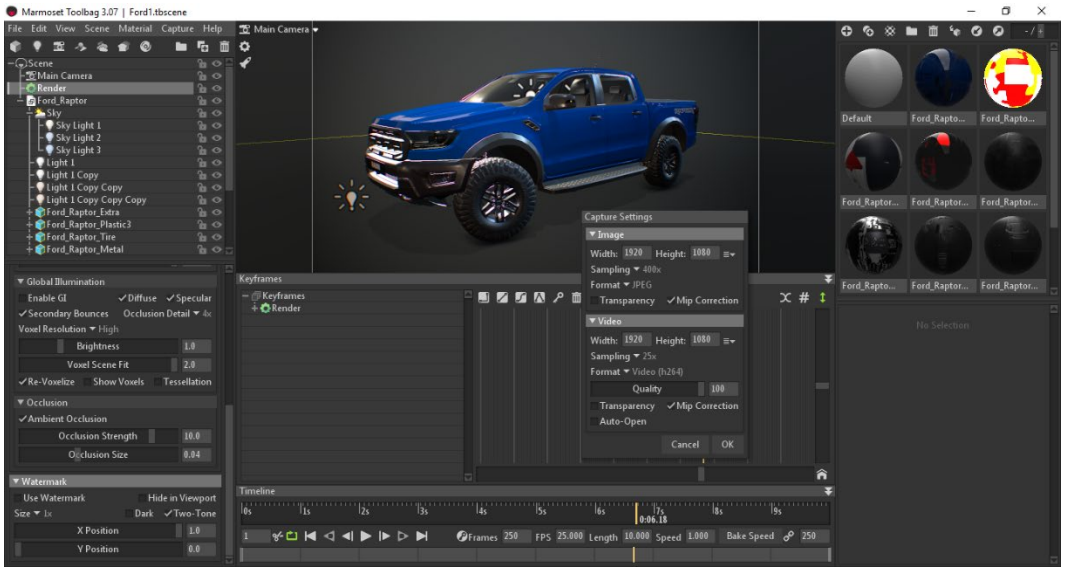

Figure 5.1.5 Render Setup.

CHAPTER 6

Some Common Problems and Their Solutions

This chapter will be discussing about some common problems during 3d model production process and how to fix them.

6.1 Unit Mismatch Issue

If we export FBX format from Maya in any unit other than meter; Substance Painter won't support it and there will be a unit mismatch. Substance Painter is mainly a texturing software for game engines like Unreal Engine, where the compatible unit is meter. So, we must export FBX in meter from Maya.

6.2 Vertex Color Issue

Sometimes we accidentally press the hotkey for adding vertex color to a mesh and in the viewport, we see the colorful textures without any issues. But, when we export the GLB file, the texture comes out grayscale. The solution to this problem is, go to Mesh Display> Color Set Editor and Delete all Vertex Colors.

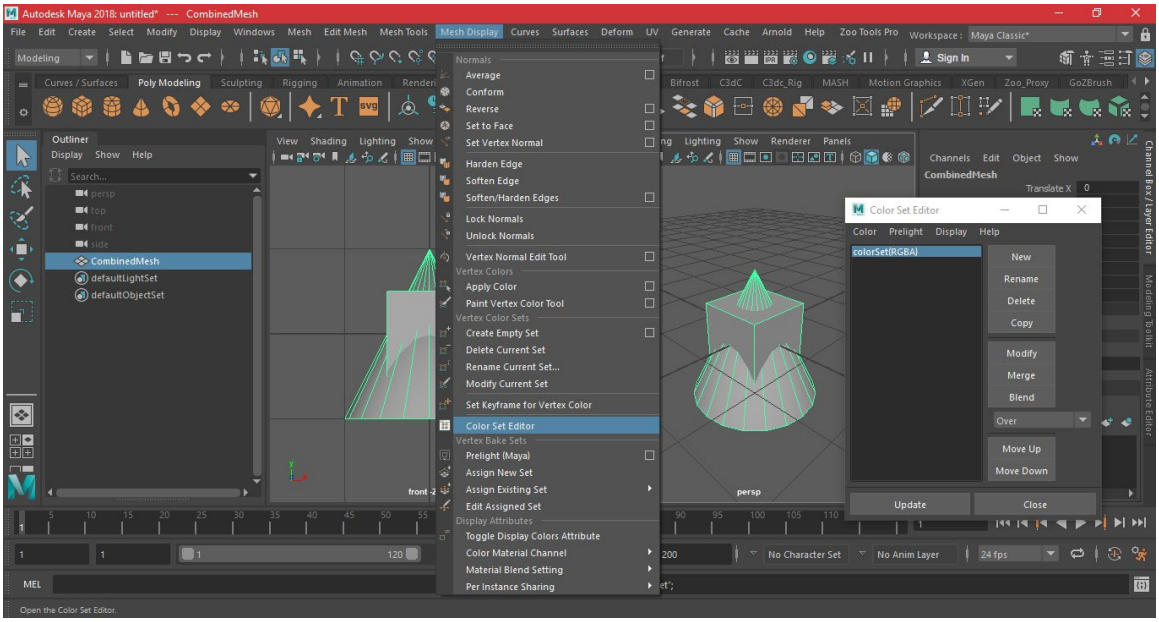

Figure 6.2.1 Check for the Vertex Color.

6.3 Multiple Texture Set Issue

Sometimes we import multiple meshes from different files which can have different texture sets and combine them. For this reason, we get missing or mismatched UV Layout. The solution for this problem is, go to UV> UV Editor> UV Sets> Copy UVs to UV Set> map1

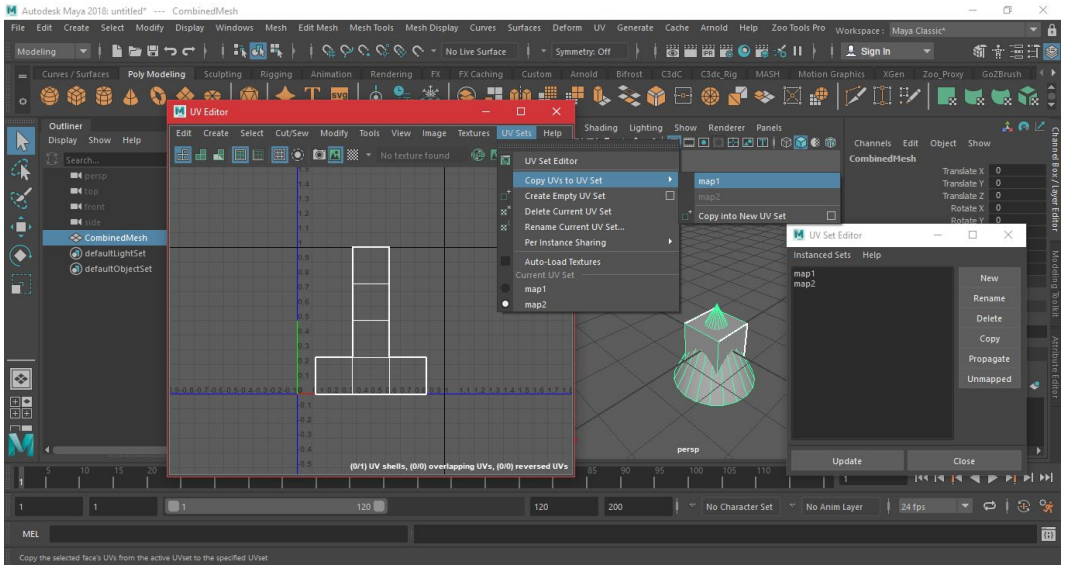

Figure 6.3.1 Check Texture Sets.

6.4 Boolean and Combine Issue

This mesh is made using Deference Boolean and multiple meshes Combine.

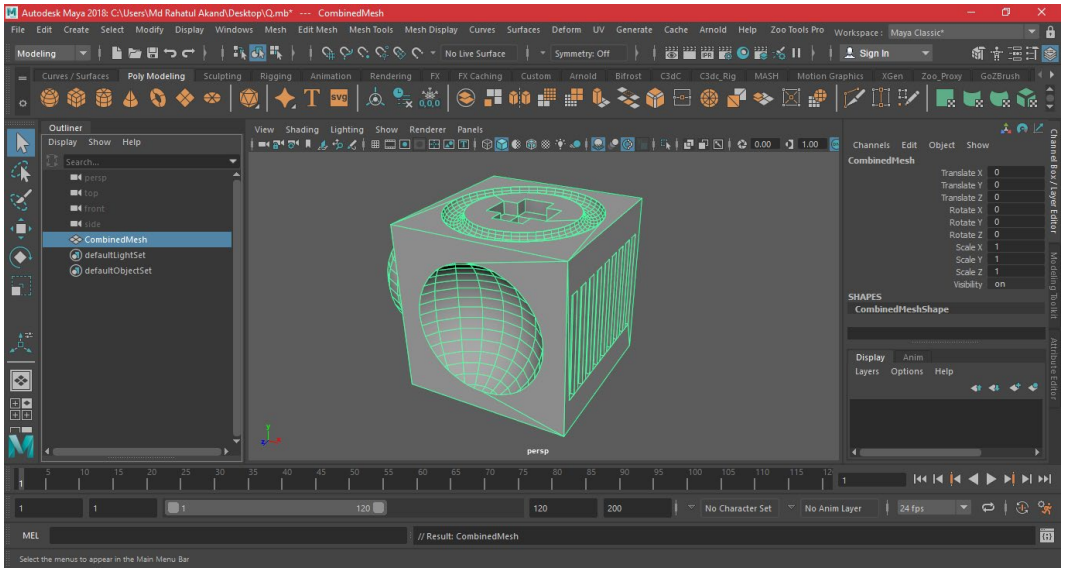

Figure 6.4.1 Boolean.

In Substance Painter, when we Bake Mesh Maps, the model structure breaks.

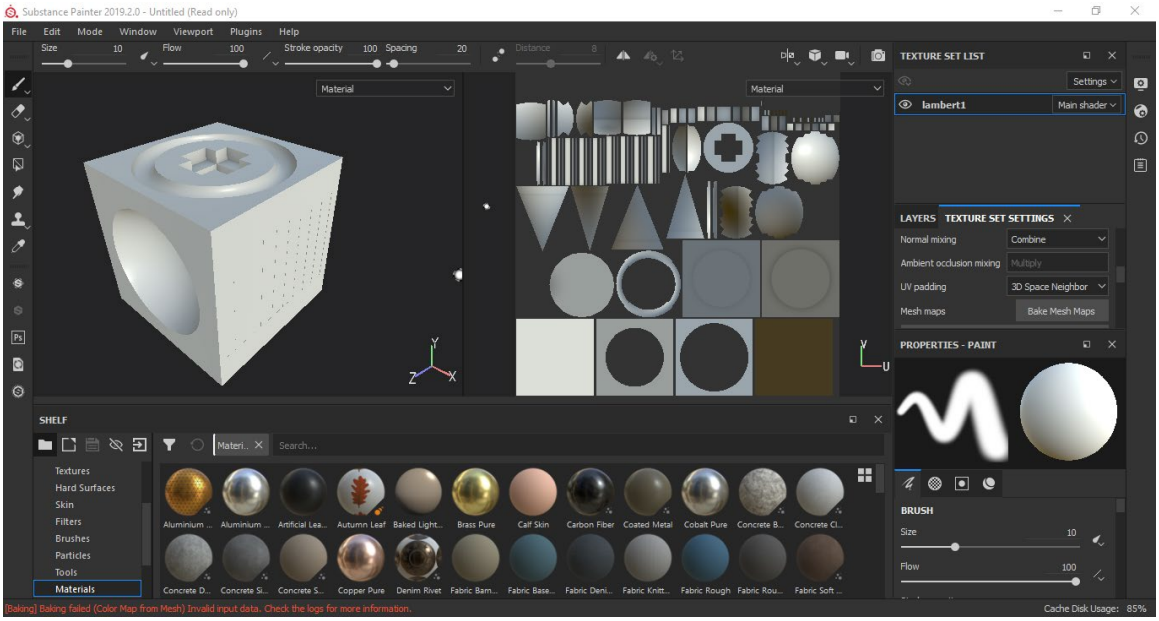

Figure 6.4.2 Incorrect Baking.

Solution

In Maya, go to Mesh> Separate

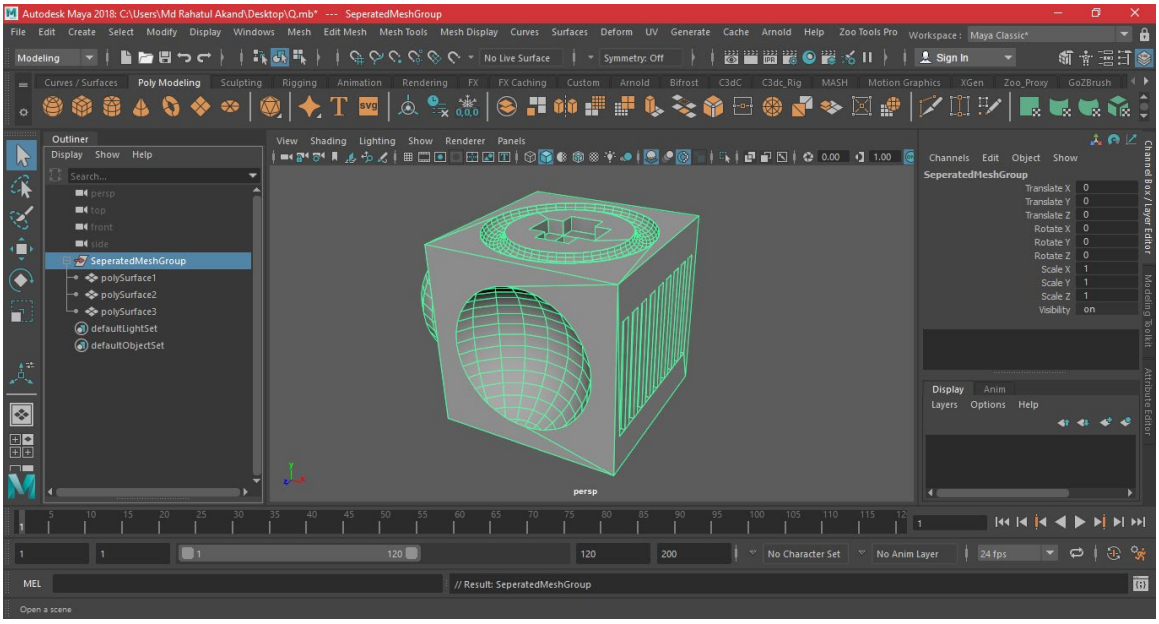

Figure 6.4.3 Separated Mesh.

Go to Mesh> Clean Up option box and set up like the image below.

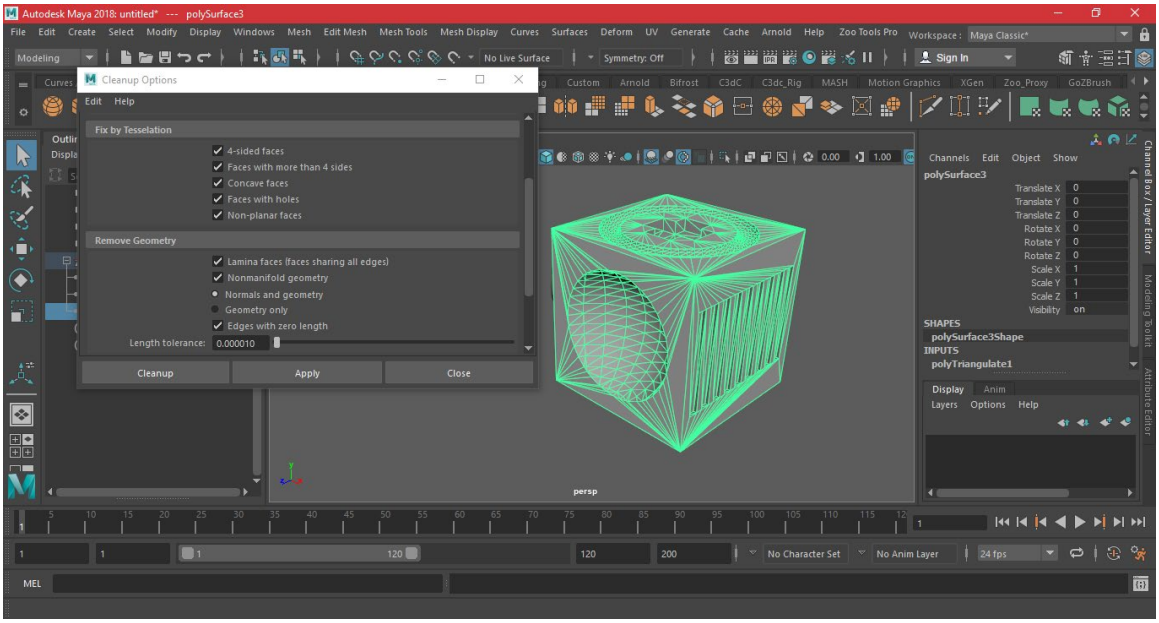

Figure 6.4.4 Mesh Cleanup.

Import the exported FBX from Maya to Blender 3D, select elements one by one, got to Object Data> Normals and tick Auto Smooth.

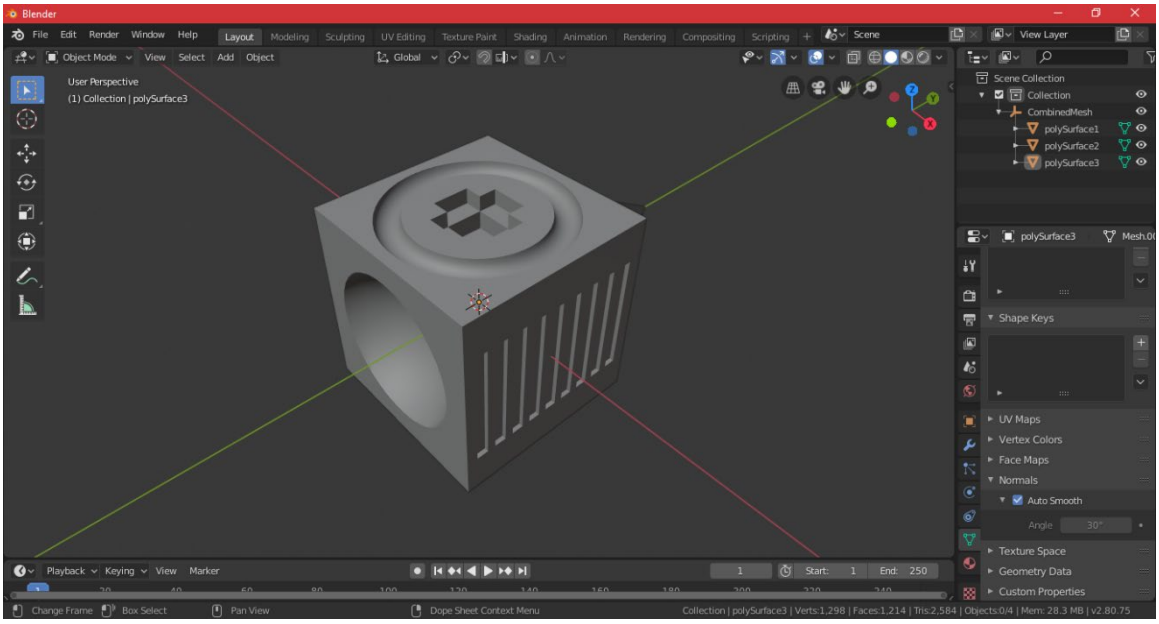

Figure 6.4.5 Apply Smooth Mesh in Blender3D.

Bake Mesh Maps in Substance Painter again and now the problem is fixed.

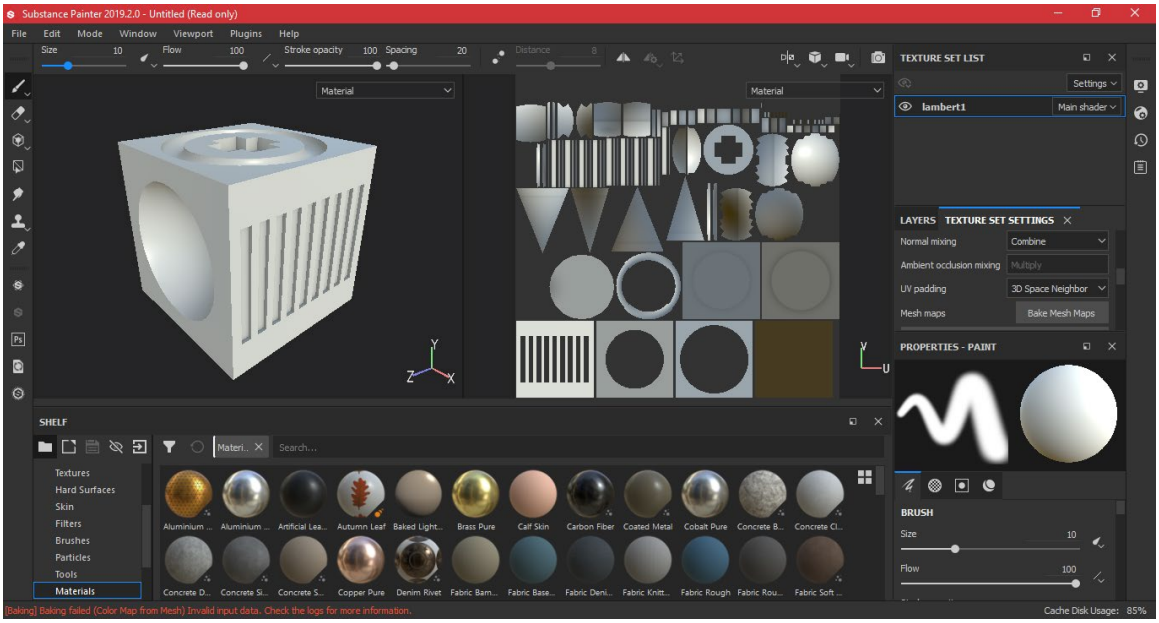

Figure 6.4.6 Accurate Baking.

6.5 Layout According to Material Issue

Always select all the components with the same materials at once and Layout UVs at the same UV Set.

6.6 Tweaking the Shape of a Hi-Res Mesh Issue

The simple solution for tweaking a mesh after converting it into a High-Resolution mesh is using Lattice Deformer.

6.7 GLB to FBX Convert and Editing Issue

When we export a file into GLB format, the mesh gets triangulated and breaks into pieces and if we want to import and edit a GLB model, we need to merge the separated overlapped vertices using very small threshold.

CHAPTER 7
Discussion

This chapter will be discussing the future potential opportunities as well as real-life dangers that we might face during using augmented reality. There are some previous records of damages and fatality and some security concerns also.

7.1 Future Potential Opportunities

So, let's say we are planning on spending tens of thousands or even millions of dollars on some stunning AR experiences to bring our brand to successive level as they buy our product. Great! our customers can love it! however what happens once the next phone comes out? And what concerning those AR glasses we've heard of? How do we sustain with devices like Magic Leap and HoloLens? Do not they need utterly totally different formats, apps, and installations? These are all valid queries.

The AR world has passed its state of infancy, however it's a fast-moving toddler that's nearly not possible to stay up with. And rather like a toddler that never stops growing, it's high-priced to stay up with and develop for each platform. For many brands, it's downright not possible. They need to select a platform or two and simply roll with it, hoping to capture no matter audience can be on those platforms.

The world will alter quickly when Apple launches its AR glasses. Let's take an instant to explore the probabilities of AR glasses, and we may be astonished at how game-changing this technology are. But again, attempting to stay up with this technology for a brand could be a drain. We nearly wish to rent an entire technology team to manage this for our brand. But, even for the largest brands, this is often nearly impossible because of the huge maintenance that will be needed for each single solution. Already these days, there are half a dozen major ways in which to deploy AR, and that they all use totally different approaches, technology and content! So, we must try to keep up with the AR technology and grab all the opportunities it can give in the near future.

The Future of Augmented Reality Augmented reality may be a technology that has been

incorporated into many various aspects of our life. however, I think that AR has a lot of potential than it is given credit for. the use of AR in games like Pokémon Go are Brobdingnagian success stories, however the fact of AR and also the potential it is to impact our lives can't be unheeded.

AR will remodel our lives for the better. There are cars that are already incorporating displays that project our speed, GPS routes, and different information that one might have or just wish onto the windscreen of the automobiles more easily visible than it is presently.

Google Glass is already being used within the work surroundings in factories as a way of potency. augmented reality is additionally serving to automobile mechanics as they service cars, and it is conjointly serving to train medical professionals and future medical professionals furthermore.

The reality is, as augmented, because it is also, the advances in technology are heading within the right direction and can revolutionize the method we have a tendency to live for the better.

7.2 The Dangers of Augmented Reality

7.2.1 Reality Modifications

In a paper entitled "Death by Pokémon GO," scientists at the Krannert School of Management at Purdue University argue that the game induced "a disproportionate rise in vehicle accidents and related harm to vehicles, personal injuries and deaths in the vicinity of places, called PokéStops, where consumers can play the game while driving." Exploitation of data from one municipality, the paper extrapolates what that might mean nationwide and concluded " the rise in the amount of accidents attributable to the introduction of Pokémon GO is 145,632 with an accompanying rise in the amount of accidents of 29,370 and an accompanying increase in the number of deaths of 256 between 6 July 2016 and 30 November 2016." The authors calculate the price of these crashes and fatalities at between $2billion and $7.3 billion for constant period. What is more, quite one in 3 surveyed advanced web users would love to change troubling parts around them, like garbage or graffiti. They'd wish to even modify their surroundings by erasing street signs,

billboard ads, and uninteresting shopping windows. So, it appears that AR is the maximum amount a threat to firms because it is a chance. Although, this might be a nightmare to various brands that don't manage to capture client imaginations it conjointly creates the danger that the wearers of augmented reality glasses might become unaware of encompassing dangers. customers wish to use augmented reality glasses to alter their surroundings into something that reflects their personal opinions. Around 2 in 5 wish to alter the way their surroundings look and even however individuals appear to them.

Figure 7.2.1.1 Playing Pokémon GO while driving.

Figure 7.2.1.2 Car crushed during playing Pokémon GO.

Next, to the potential privacy problems that are represented below, overload and over-reliance problems are the biggest danger of AR. For the development of recent AR-related product, this suggests that the user-interface ought to follow certain guidelines as to not overload the user with data whereas conjointly preventing the user from over-relying on the AR system specified vital cues from the surroundings are incomprehensible. This is often referred to as the virtually-augmented key. Once the secret's unheeded, people might not desire the real world any longer.

7.2.2 Privacy Concerns

The thought of contemporary augmented reality depends on the flexibility of the device to record and analyze the environment in real-time. Due to this, there are potential legal considerations over privacy. While the primary modification to the united states Constitution permits for such recording within the name of public interest, the constant recording of an AR device makes it troublesome to try and do thus while not conjointly recording outside of the general public domain. Legal complications would be found in areas where a right to an explicit quantity of privacy is anticipated or where proprietary media are displayed.

In terms of individual privacy, there exists the benefit of access to information that one shouldn't promptly possess about a given person. This is often done by biometric identification technology. If AR automatically moves data about individuals the user sees, something can be seen from social media, criminal records and marriage status.

CHAPTER 8

Conclusion

In this Report I have shared my own experiences, problems that I faced during 3D modeling and texturing for Web-based Augmented Reality and their solutions. Also, I have shared the efficient way of modeling, texturing and optimizing website-compatible 3D models for AR. Last 6 months I was doing several projects for **DataSoft Systems Limited Bangladesh**. I have learned real-life use cases of the combination of AR and 3D. Made product models for using them in websites. A customer can interact with the product, place the product virtually to the real environment and can experience the look, measure the product comparing the space they have before buying.

I have faced various issues during doing these projects. Done some research and development online and solved most of the issues. But, also failed to solve few of them. I am still searching for making the models more efficiently spending as less time as possible. Learned some very useful shortcuts that made the production process much comfortable and less tedious. Through this Report I represented the complete and proper pipeline and workflow of modeling, texturing and optimizing the 3D models for website compatibility.

References

[1] Viewing 3D models in AR from an Android browser | ARCore | Google Developers. https://developers.google.com/ar/develop/java/scene-viewer, last accessed on 21-06-2019 at 12:00pm.

[2] 5 Things to Consider when Launching Augmented Reality for eCommerce. https://blog.seekxr.com/5-things-to-consider-when-launching-augmented-reality-for-ecommerce, last accessed on 09-07-2019 at 08:00pm.

[3] Infographic: The History of Augmented Reality - Augment News. https://www.augment.com/blog/infographic-lengthy-history-augmented-reality/, last accessed on 10-07-2019 at 11:00am.

[4] Augmented reality. https://en.wikipedia.org/wiki/Augmented_reality#The_dangers_of_AR, last accessed on 25-08-2019 at 03:00pm.

[5] Augmented reality. https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/Augmented_reality.html, last accessed on 22-08-2019 at 02:00pm.

[6] Augmented and Virtual Reality Technologies. https://jitp.commons.gc.cuny.edu/realizing-the-past-charting-a-course-for-sustainable-instruction-and-engagement-with-archival-materials-using-augmented-and-virtual-reality-technologies/, last accessed on 12-08-2019 at 07:00pm.

[7] Augmented reality. https://b2b.partcommunity.com/community/knowledge/en/detail/8529/Augmented+reality#knowledge_article, last accessed on 26-08-2019 at 05:00pm.

[8] Augmented reality explained. https://everything.explained.today/Augmented_reality/, last accessed on 13-08-2019 at 04:30pm.

[9] Application of Virtual, Augmented, and Mixed Reality to Urology. https://www.researchgate.net/publication/309718974_Application_of_Virtual_Augmented_and_Mixed_Reality_to_Urology, last accessed on 06-07-2019 at 09:00pm.

[10] Articles and Tutorials. https://www.gamedev.net/articles/visual-arts/?page=1&d=1&rss=1, last accessed on 02-07-2019 at 05:30pm.

[11] Creating a Realistic Teddy Bear in Maya, https://cgi.tutsplus.com/tutorials/creating-a-realistic-teddy-bear-in-maya-part-1--cms-26659, last accessed on 14-06-2019 at 03:30pm.

[12] Augmented reality. https://www.cnet.com/special-reports/vr101/, last accessed on 16-08-2019 at 10:30pm.

[13] Handbook of Augmented Reality. https://epdf.pub/handbook-of-augmented-reality.html, last accessed on 14-07-2019 at 12:30pm.

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