

Face Models for Real-time Facial Motion Capture

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Abstract

The goal of this Independent Study was to determine and document the techniques and requirements for creation of facial models for use with the facial motion capture system Faceware LIVE that is loaded on the machines in the CS Graphics and Applied Perception Lab.



Figure 1: Penelope

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Timeline Analysis

Week 1- Week 4	<p>I gathered in-depth knowledge on the facial motion capture system Faceware LIVE. I then read about the requirements a 3D Character Model should satisfy when building in Maya to be compatible with the Character Setup of Faceware LIVE. I also worked with Victor – a standard model provided by Faceware to get a hang of the software and its setup in Unity.</p>	9 – 10 Hours per week
Week 4 – Week 8	<p>I started working on Penelope – a 3D Character Model of a girl. The structure of Penelope was not compatible with the Faceware LIVE setup and therefore I had to re-work on her structure by creating certain components that could be interfaced with Faceware LIVE. While I was working on this, I was in constant communication with Professor Marla Schweppe from the CIAS Department who was helping me understand the outline of the Model and go about re-structuring it by implementing certain tools and techniques. As I was building my model, I was testing each of its components with Unity and Faceware LIVE to see if I am going on the right track.</p>	11-12 Hours per Week

<p>Week 8 – Week 12</p>	<p>I was working on another head called Big Head – a 3D character Model of a clown along with Penelope. During this week, I worked on my Independent Study keeping ImagineRIT in mind. At the end of week 12 I had the final scenes and the models setup with Unity and Faceware LIVE Application.</p>	<p>12 Hours per week</p>
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Introduction

For this Independent Study, I worked extensively with Maya, Faceware LIVE and Unity to get the Character models running for the project “Secret Passageways with Avatar Faces” exhibited at ImagineRIT 2018. I worked on three different Facial models – Penelope, Victor and Big Head which were modelled in Maya Software and interfaced with Faceware LIVE System using Unity 3D Game Engine. The main components of my Independent study involved

1. Maya
2. Faceware LIVE
3. Unity

The above-mentioned components will be explained in detail in the later sections. It is required to have a decent knowledge of working of Maya interface and Unity3D Game engine to understand the following report.

I will also be mentioning the links to the tutorials I referred to while working on my study. I would advise you to get familiar with the Faceware LIVE system before you start working on your model.

Also, note that I independently worked on my own model to understand how to model faces but didn't pursue it beyond the Rigging stage. However, I reworked Penelope's structure from the Rigging stage so I will be referencing to the Penelope model only throughout my report.

Components

Maya is a 3D Computer Graphics Application owned by Autodesk Inc. It is used to create interactive 3D Applications, including video games, movies, animated cartoons and also for visual effects. It is used to generate 3D assets for use in video games, films, television and game development. The working environment is called a scene which is the virtual workspace in which the assets can be created using the primitive geometry models in built in the functionality of Maya. These scenes can be saved either with a Maya ASCII convention, Maya Binary convention and can be exported using the FBX format. I saved the Maya model files with the Maya Binary extension since the FBX export did not give me the components I required in Unity. Maya uses a node graph architecture wherein each scene elements are node based having their own attributes and customization. These node graph components are connected to form a graph.

Download Maya: <https://www.autodesk.com/products/maya/overview>

Unity 3D is a cross platform game engine used to develop three dimensional and two-dimensional video games and simulations. It is a multipurpose game engine that supports 2D and 3D graphics, drag and drop functionality and scripting using C#. I used Unity to import the 3D models into Unity from Maya for setting up with the Faceware LIVE system.

Download Unity: <https://unity3d.com/>

Faceware LIVE is a high quality real time animation software that tracks facial movement from video. It uses computer vision and deep learning techniques to track faces and create animation in real time. It does not require any depth camera. It calibrates the face using a simple webcam and maps the facial expressions onto any 3D character model using computer vision techniques. Applications of this include live player to player chatting interactive application and live interaction displays and activation. The two components of Faceware LIVE include the Live Client and the Live Server. Live Client is an asset that can be download from the Asset Store in Unity.

Faceware: <http://facewaretech.com/products/software/realtime-live/>

3D Model Creation Pipeline

The following sequential sections give a high-level overview of the steps that you need to perform for Modeling the Face for Faceware LIVE. I will not be going into the Maya terminology since it is assumed that the you have a working knowledge of the Maya Interface. The pipeline is quite similar to the conventional Modeling and Rigging Pipeline for Facial Animation.

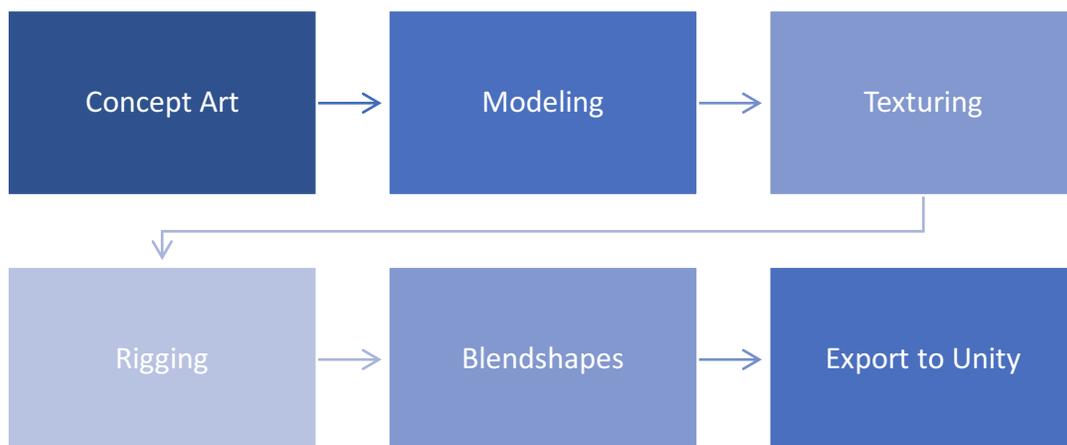


Figure 2: 3D Model Creation Pipeline

Concept Art

The first step for creating a character's face in Maya is to have a 2D concept of your character which includes the front view and the side view and a character sheet which can be used as the two image reference planes while modelling your character. These sketches can be created and aligned in Adobe Photoshop.

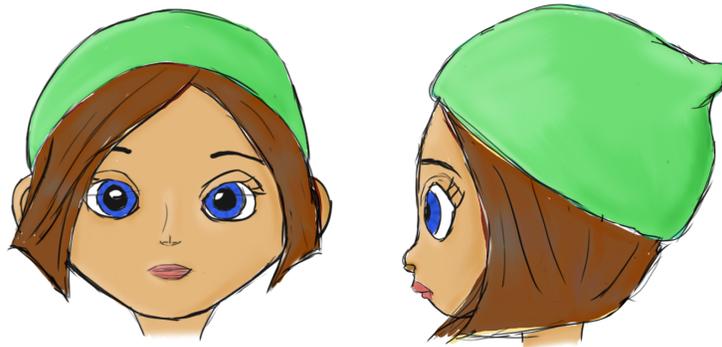


Figure 3: Front View and Side View Reference Images

Modeling

Before we dive into the steps, I would advise you to look at the following tutorial, Head Modeling in Maya (Female): <https://www.youtube.com/watch?v=GdFyLLHVfqY&t=525s>. It has many subsequent parts but the first part gives you an understanding of how to start with your Maya project.

1. The first step is to create a new project in Maya with the right name before you begin creating your Model. Do not start modeling your character before setting your project.
2. Copy your reference images in the sourceimages folder of your project.
3. Once your project is set, import the reference images in your scenes. Remember to align the reference images as per Maya viewport. Maya has four different viewports. Move the reference

image in the front viewport such that the Y axis line intersects the middle of the face along the bridge of the nose. Repeat the same process for the side viewport. I generally place both the reference images at the origin and move them apart along the x and z axis from the perspective viewport. Remember that we create only one side of the face and duplicate the other half so everything needs to maintain symmetry and shape.

4. Using all four viewports of the scene, model the character component by component starting with the face mesh and details like eyes, eyebrows, nose and lips. Check all viewports to see if the model is coming out appropriately.

I generally like modelling by first finishing the face mesh and then doing the face parts. I use both the Vertex mode and Edge mode generally to go about modeling the mesh. I also use the move tool, scale tool, rotation tool, extrude to go about building the mesh. Remember that if you click extrude and you forget to extrude, duplicate set of vertices get created so you have to be careful while working with extrude. Remember to move every vertex carefully in the front view and side view with your reference images as you develop your mesh.

It is advisable to keep switching between every view to check the geometry of your mesh perspectives since any small manipulation in the wrong direction can change the shape and appearance of the model. I have also used edge loops to get the flow around certain areas such as the eyes and lips. Good edge loop placement gives a clean and more realistic looking model.

5. Once half of your face is modeled, duplicate the half to get a complete face. Remember that you want a mirror of your half and not the same half. Also, remember to merge the vertices using the Merge Vertex tool wherever necessary in order to get a complete realistic looking head.

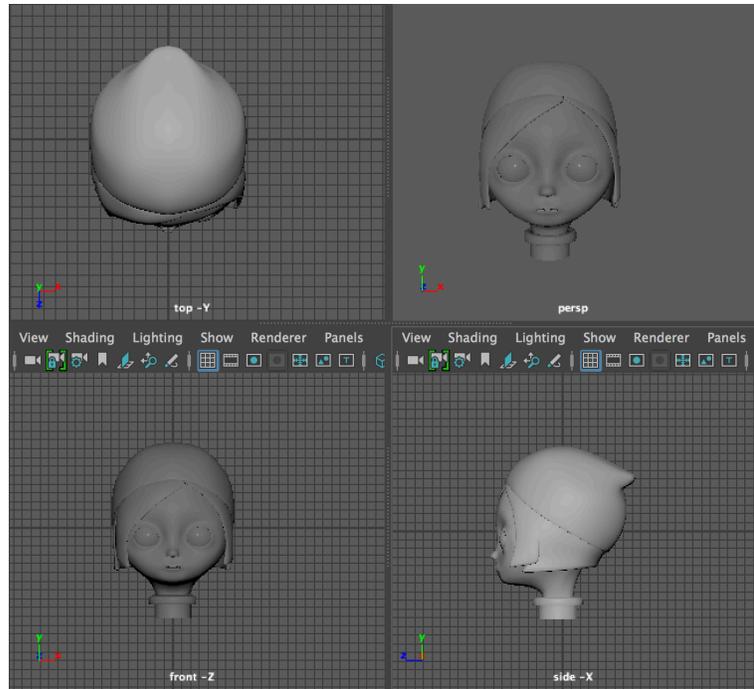


Figure 4: Model in Maya Viewports

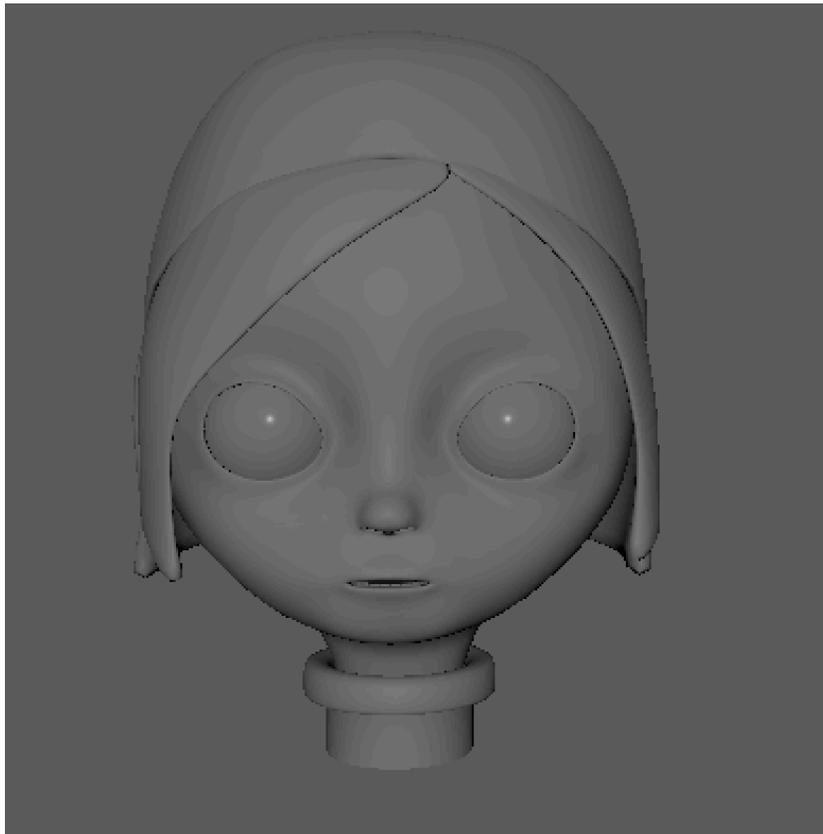


Figure 5: Final Model

Texturing

Assign different textures to the face mesh and other parts of the face respectively by assigning new material to each. You must deal with UV mapping which needs to be carefully done in order to get proper texture to the character. The Texturing process is again as same as the conventional Texturing process in the 3D Modeling Character Pipeline of Maya. You can refer to this video tutorial for guidance

Autodesk Maya 2014 Tutorial Boy Character Modeling, Texturing Part 1:

<https://www.youtube.com/watch?v=eTIENJkgwXI>



Figure 6: Textured Model

Rigging

Please view this tutorial before getting started. Rigging a Photorealistic head for Performance Capture: <https://www.youtube.com/watch?v=5ELCfLF-XGY>

The significant difference lies in the Rigging step wherein Morph Target Animation or Blend shapes is used to create Facial Expressions. Once the character model is ready, we must rig it to

obtain the facial movements and expressions. Rigging is the process of making the model ready for animation. In my understanding, there are generally three ways of Rigging the character

1. Using Joints
2. Using Blend shapes
3. Using Joints to create the Blend shapes

A skeleton is creating with joints on the face and the mesh is bound and weighted to to the joints to get the appropriate facial movements. Joints can be used to deform the mesh in any orientation. You can achieve blink by attaching joints to the lower and upper eyelid and move them accordingly to get the blink movement. Joints are hierarchical in nature. Once you create all the joints, the skin needs to be attached to the joints in order to move the mesh as per the movement of the joints.



Figure 7: Rigged Model with Joints

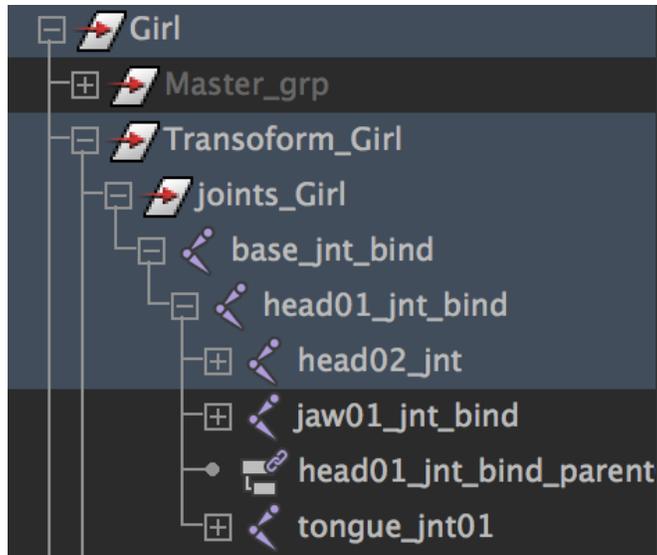


Figure 8: Joint Hierarchy in the Outliner

Useful Tip: You can show/hide the joints by selecting it and clicking show/hide in the Display menu at the top.

Blend shapes

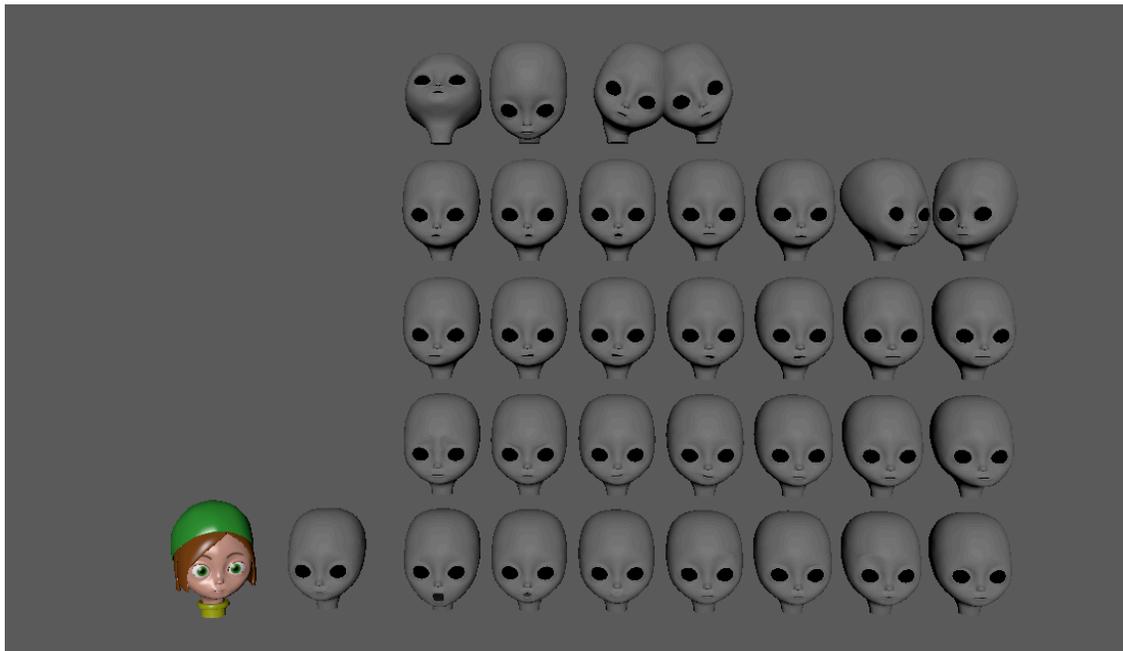


Figure 9: Blend shapes

Please refer to this tutorial: Blend shape Overview in Maya:

<https://www.youtube.com/watch?v=wmCy02S2Vh0> for a good understanding of the Blend

Shapes concept before continuing through the below mentioned steps. Creating Characters for

LIVE: <http://support.facewaretech.com/creating-characters-for-live>

Morph Target Animation is a method of 3D computer animation. In Morph Target Animation, a deformed version of mesh is stored as series of vertex positions. It is easy to get confused between Rigging and Blend Shapes creation. Remember that you can Rig the character using joints and create the Blend Shapes by manipulating the rig. Interpolation is used to achieve the movement from neutral face to a deformed expression face. Morph Target is a deformed version of a face. For our purpose, we create a face with a neutral expression and other target deformations are created for different expressions. For facial animation, these targets are referred to as key poses. Interpolation achieves smooth blending between the neutral and target mesh.

When creating Blend shapes for Faceware LIVE, there are a certain specific Blend shapes that we need to create. You can find these in the Expressions set of the Character Setup of Live Client for Unity. For every expression, there needs to exist a target deformed shape or key pose. However, for Eye Directions or head movement you can use the corresponding joints if they exist to rotate the part in the desired direction in the Unity scene itself and save the pose. To get started with the Blend shape creation, by now you should have your model complete and rigged. There are several things to remember while creating the Blend shapes. Firstly, we need only those that are listed in the Expressions.

I always have my Outliner open on the left to see which node I am working on.

In non- technical words, have one mesh that is a parent mesh to all the Blend shape targets. I prefer working on the main mesh rather than creating a duplicate since you don't want to export all the blend shapes so you would want only one mesh that contains all the target shapes. Select your main mesh which we bill your parent mesh to all the blend shape targets, go to the Animation Editor and open shape editor. Rename your main mesh as face_neutral or whatever name you want to give it; This is just to keep the blend shape list organized and corresponding to the expression set of the Live Client Asset. For the Neutral Expression in your Expression set there is a corresponding Face_Neutral Mesh in Maya and continuing. To create a blend shape for Jaw_Open, duplicate your main mesh and rename it as face_jaw_open. Move the duplicate mesh aside and deform the vertices to get the desired expression/pose. Once your blend shape is created, select the target mesh and your main mesh and in the shape editor click "Create Blend Shape" if you are creating a blend shape for the first time. With this action, a blend shape is created for your main mesh and the deformed mesh is added as a target. You can vary the slider in the shape editor to see the deformation. Repeat the same process for every expression and in the end, you will have a series of key poses added to the main mesh. Remember if your subsequent deformed meshes are associated with the same geometry, you need to add target and not create a new blend shape for every key pose.

However, you must keep in mind some things. Blend shapes only consider deformation of vertices and not translation, rotation or scaling. Only if your vertices are deformed or moved then only will the blend shapes work properly. If you are working on creating a blend shape for eye direction up, you might just duplicate the eyes, translate them, rotate them in an upward direction and add the target but it won't work this way. Transformations don't show up as a deformation. You need to deform the vertices. The solution to this is, duplicate the eyes, rotate in the same place, then freeze

the translation and rotation and then add the target. When you duplicate, see that the coordinates are same as the original mesh coordinates. Keep in mind there exists a local axis and world axis. If you don't ensure that the duplicate has the same coordinates as the original, your target shape might linearly move to a different location instead of translating and rotating at the same place. If you are separating and combining your mesh, the above steps need a special attention because the separation and combine operation can change the local or world axis. Use the shape editor to check for every target and its working and see if its interpolating as desired by varying with weight.

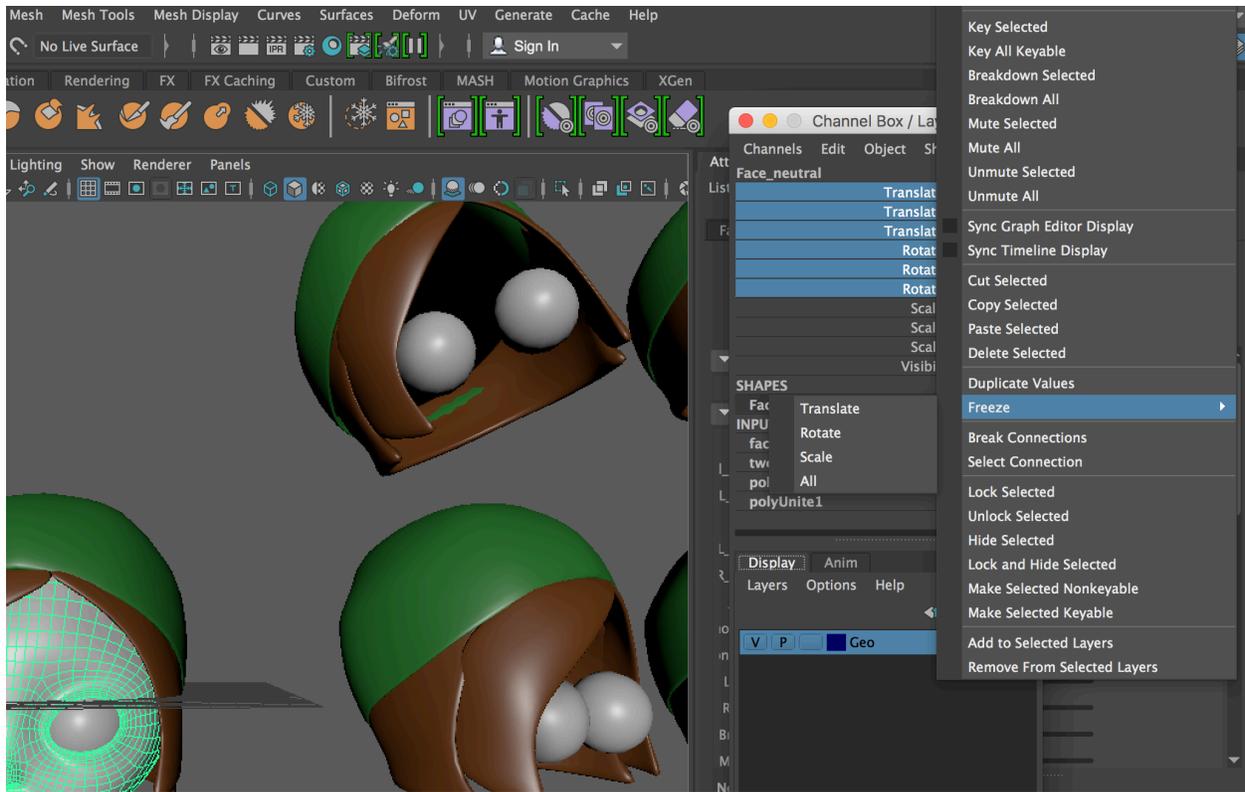


Figure 10: Freeze Transformation

Remember that if you face has any accessories like a hat, hair or anything external which is not a part of the main mesh, you need to consider the transformation of the external components as well. Here in my model, I created three different Blend shapes for three different geometries.

1. Face Geometry
2. Eyes
3. Hat and Hair

This is because when the head rotates, its external components should also rotate along with it and for this interpolation, you need to have either a joint that does this for you or create a blend shape for it. It is generally advisable to have a joint using which you can just rotate the hat and hair in the desired direction in the Unity scene itself.

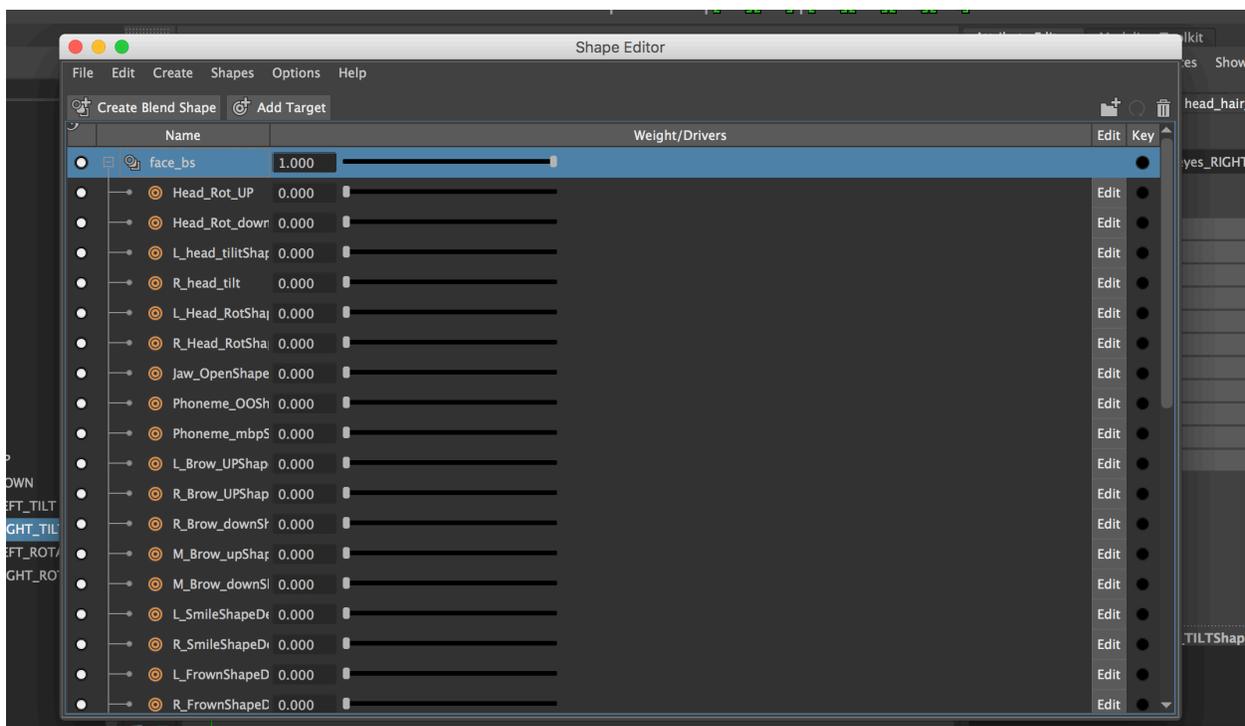


Figure 11: Shape Editor

See Windows->Animation Editors->Shape Editors for Shape Editor Window

For my model, there are three blend shapes

1. face_bs with parent Mesh Face_Neutral

2. HAT_HAIR_BS with parent Mesh HAT_HAIR_NEUTRAL
3. EYES_BS with parent Mesh EYES_NEUTRAL

Every geometry has its blend shape and every blend shape has its respective target shapes for example for Head Tilt to Right, I have a face head tilt, hat and hair head tilt and eyes tilt right. This is to have the complete model move at the same time. You can vary the weight for all the three to see a complete head tilt of the face geometry along with the external components.

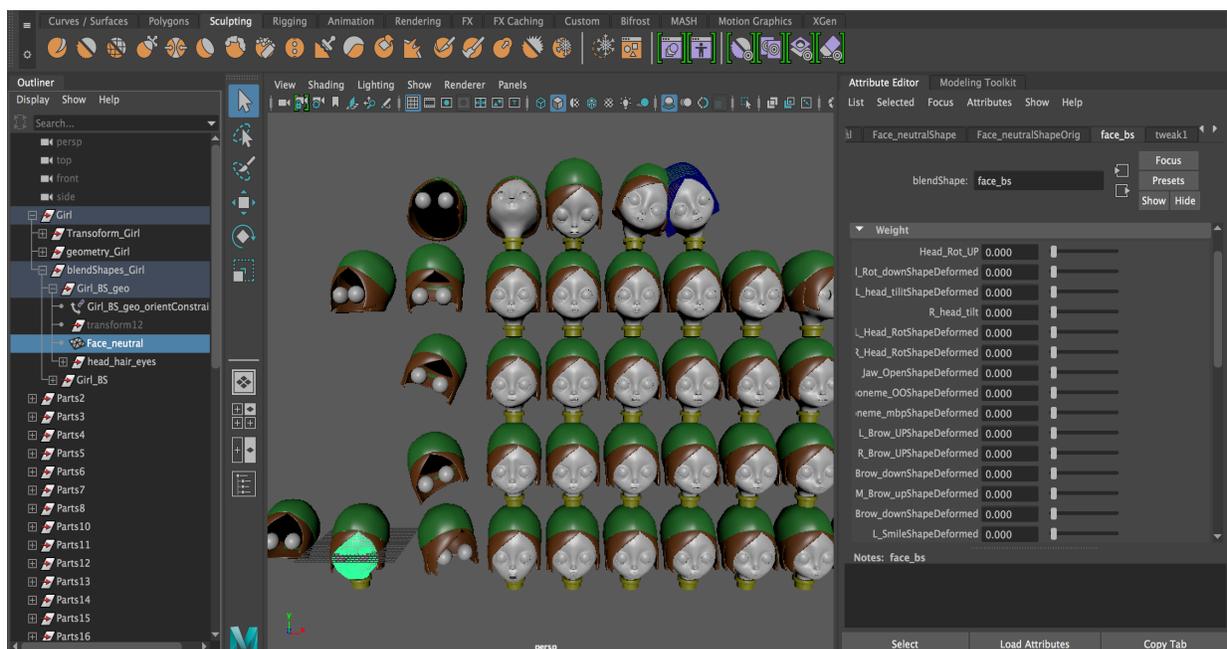


Figure 12: Parent Mesh containing all Blend Shape targets.

In this image, you can see in the Outliner window that I have a parent mesh, a face neutral mesh that contains all the blend shapes. When you click create blend shape in the shape editor, you can check the attribute editor of the selected node and see the blend shape present. Here you can see face_bs blend shape in the right. You can vary the weights here as well to see the interpolation from neutral expression to the deformed expression. We want only one single parent mesh since we can just reference this in Unity for getting all the target blend shapes.

There are two ways of creating blend shapes but I prefer using the Shape Editor to create one. You can also go to the Deform menu on the top and click create blend shape.

Exporting to Unity

By now you will have your main mesh weighted with all the target shapes. You do not want to export all the target heads or key poses. You want only your main mesh which is your parent mesh that contains all the target blend shapes. Remember you can have multiple parent meshes for multiple geometries. For instance, like I mentioned I have three different geometries so I ensured all three of my parent meshes were selected. You can just select your entire model that is made up of these geometries and export that selection. Select your main mesh and export it as a Maya Binary file. When I exported a fbx file, I did not get the desired structure in Unity. Therefore, save your export with a .mb extension. Do not forget to save your scene. Also, another issue I encountered is that the .mb file got corrupted and did not open on many systems so ensure you have a .ma Maya ASCII file saved that contains your complete scene. The export file will only contain your main model that is constituted of the geometries and their respective blend shapes.

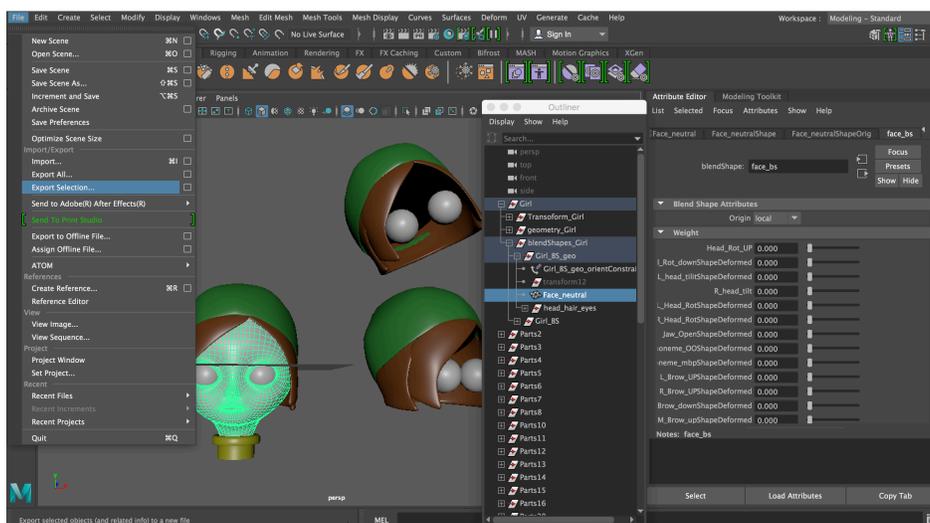


Figure 13: Exporting from Maya

Importing in Unity

Create a Unity Project and name it appropriately. Remember to have Maya working on the system in which you will be importing your model in Unity. If Maya is not present or corrupt or for some reason not working, Unity will throw an error “Maya not found”. If you are working on a system that doesn’t have Maya, you may have to export a FBX file of your model but I would advise against that since it did not work properly for me.

Import the Name_of_the_file.mb into Unity by going to Assets->Import New Asset->File. Ensure that you are on the Scene window and not the Game Window. You will see the Model in your scene. You may have to adjust the position of the model and may also have to scale it by few factors.

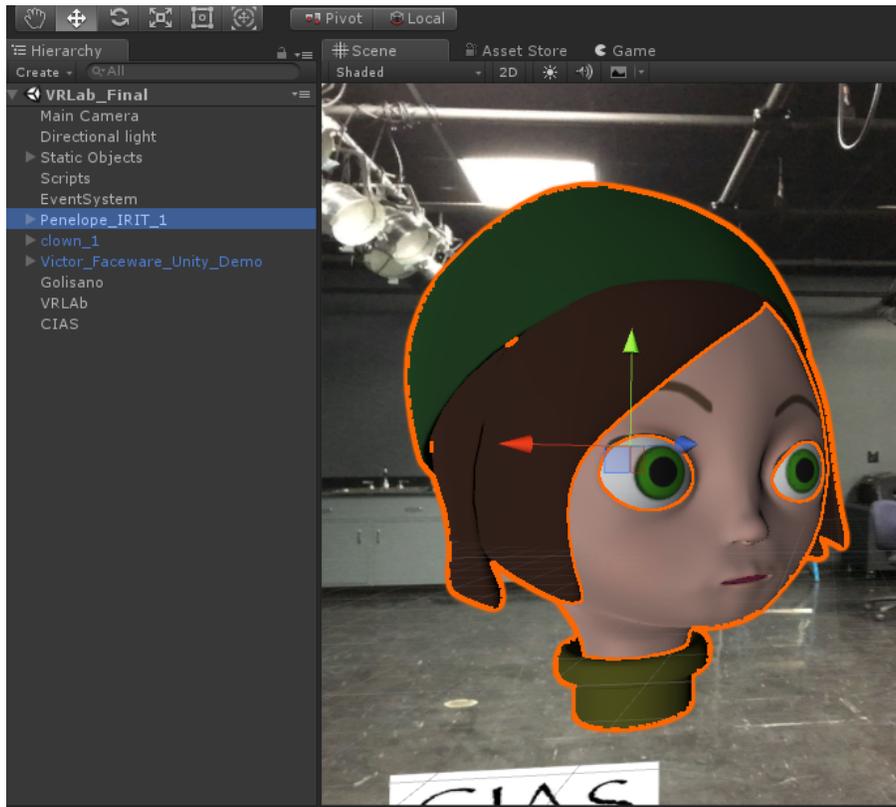


Figure 14: Importing in Unity

To find the target blend shapes, in the hierarchy find your blend shape parent node that contains all the blend shapes. Notice that this hierarchy is same as the selection hierarchy in Maya. Click on your parent blend shape node and you will see the list of blend shape targets appear on you right side in your Inspector.

As you can see I have a Face_neutral parent mesh for Face geometry, a HAT_HAIR_NEUTRAL mesh for Hat Geometry and a EYES_NEUTRAL mesh for Eyes geometry. All the target blend shape names are named as per the expression set list of the character setup provided by Faceware LIVE Client.

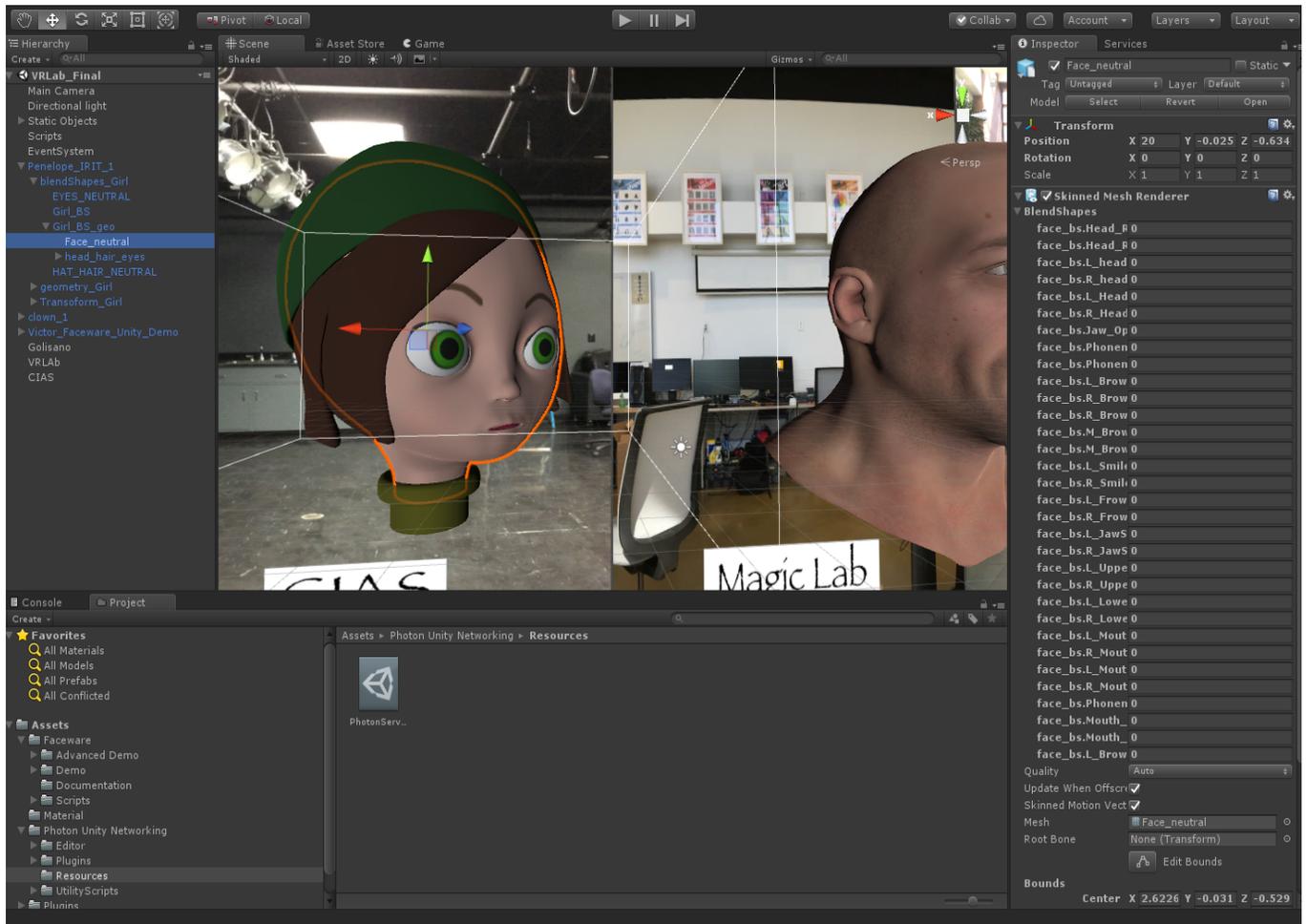


Figure 15: Face geometry target blend shapes in Unity

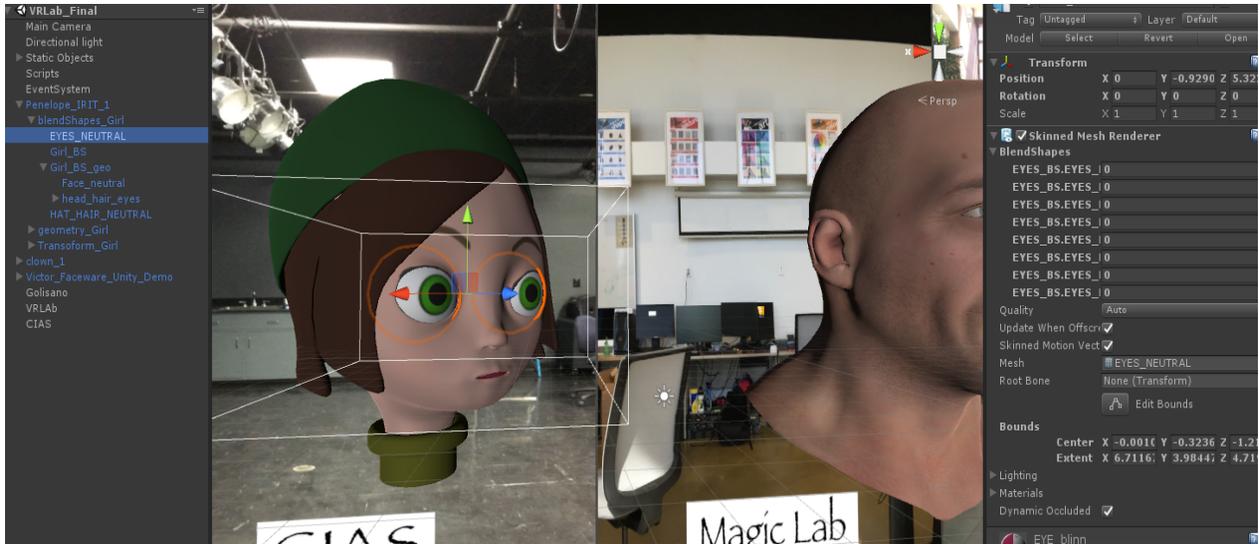


Figure 16: Eyes geometry target blend shapes in Unity

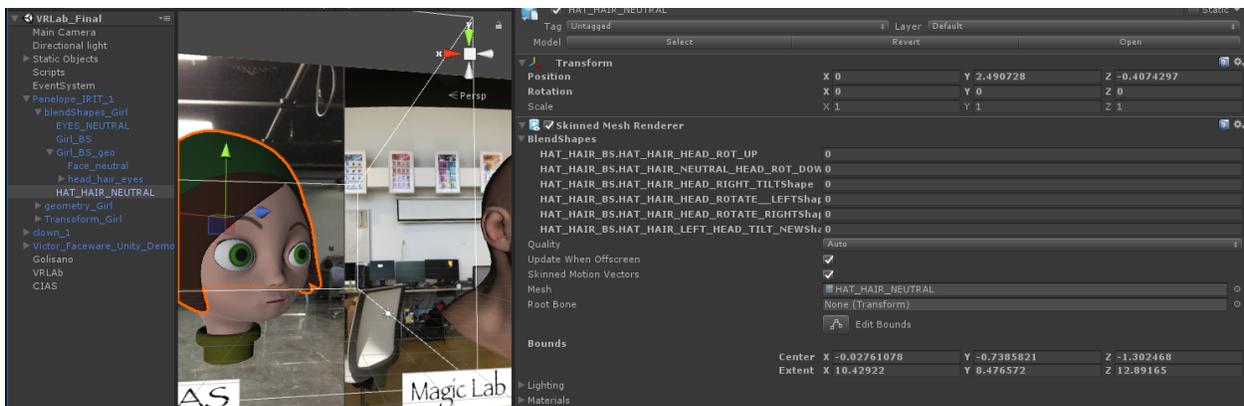


Figure 17: Hat and Hair geometry target blend shapes in Unity

Setting up Live Client

By now your model should be setup at the proper position and at proper scale with the main camera facing the model. Check that the lighting is properly illuminating the model. Install the Live Client from the Asset Store. Once the Live Client is downloaded and the packages are imported, you will see a Tools option appear at the top. When you click on it you will see “Faceware”. Also in your

Assets folder, you will see a Faceware folder created which will have the Victor Unity Demo Scene. For your understanding, you can work with Victor first and see how the character is setup using the blend shapes of Victor model. Once you are familiar with the Faceware working demo, we can start working on the model you have created. Watch Faceware LIVE Tutorials on their YouTube channel. Following are the links which are most helpful to understand the setup.

LIVE Server 2.5: Getting Started: <https://www.youtube.com/watch?v=I5aRM5O16l8&t=132s>

Faceware LIVE Client for Unity – Character Setup:

<https://www.youtube.com/watch?v=3pMcvHAB-HY>

LIVE Client: <http://support.facewaretech.com/live-client-for-unity-2>

It's time to setup your model with the Faceware LIVE Client. You will have to create a character setup file and map the poses from the expression set to your blend shape targets.

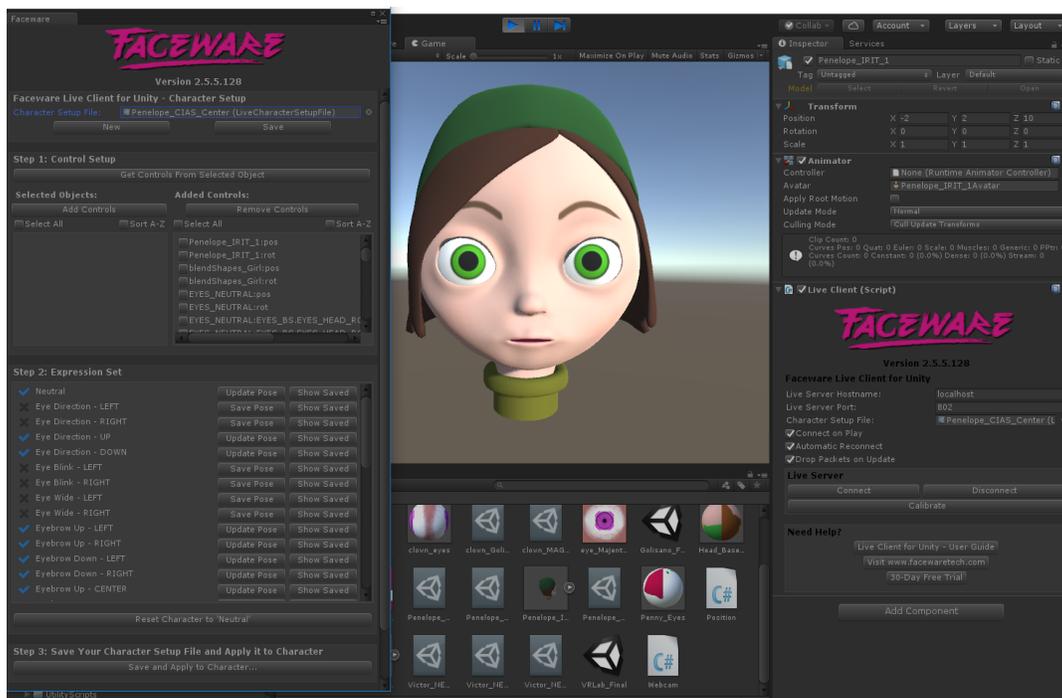


Figure 18: Faceware LIVE Client in Unity

The process for setting up your character will be same as setting up Victor which you must have seen in the Faceware LIVE Tutorial. All you have to do is map every expression with your corresponding Blend shape target. If your target names are same as the names given in the expression set, things become much easier. Therefore, always remember to name your target shapes appropriately and as per the convention expression.

Here is an instance of setting up Penelope “Head Rotation UP” Expression in the Expression Set. Since there are three different geometries, I need to change all three to get a complete head rotation of the model. Manipulating just one geometry will give me an incomplete result as you can see below.

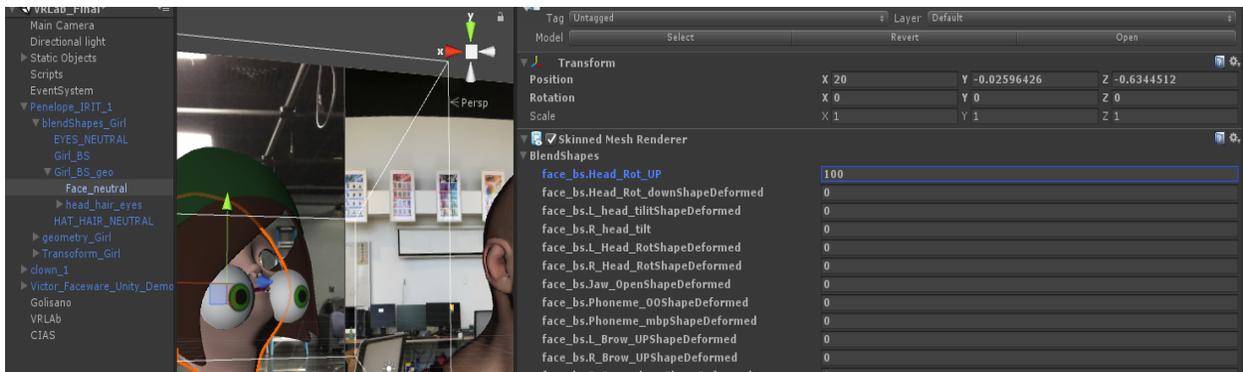


Figure 19: Referencing Face geometry target blend shape

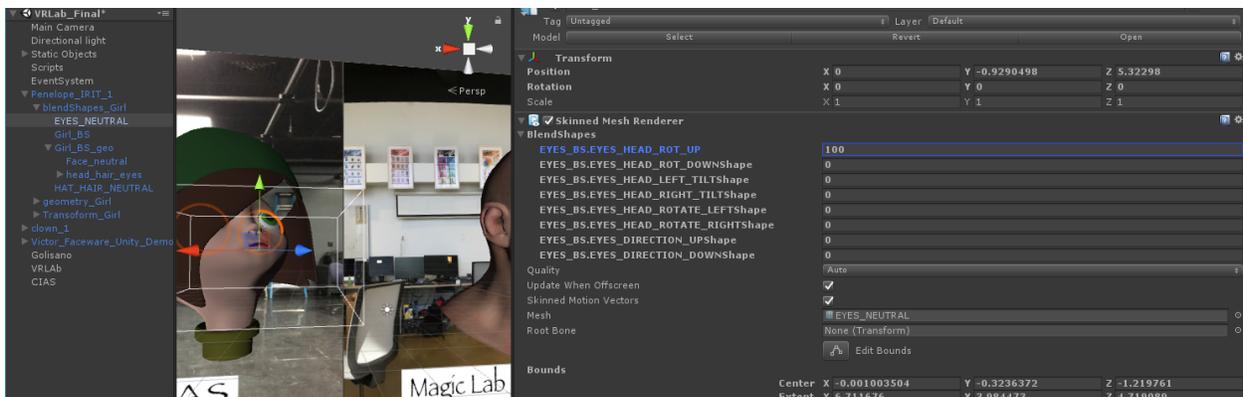


Figure 20: Referencing Eyes geometry target blend shape

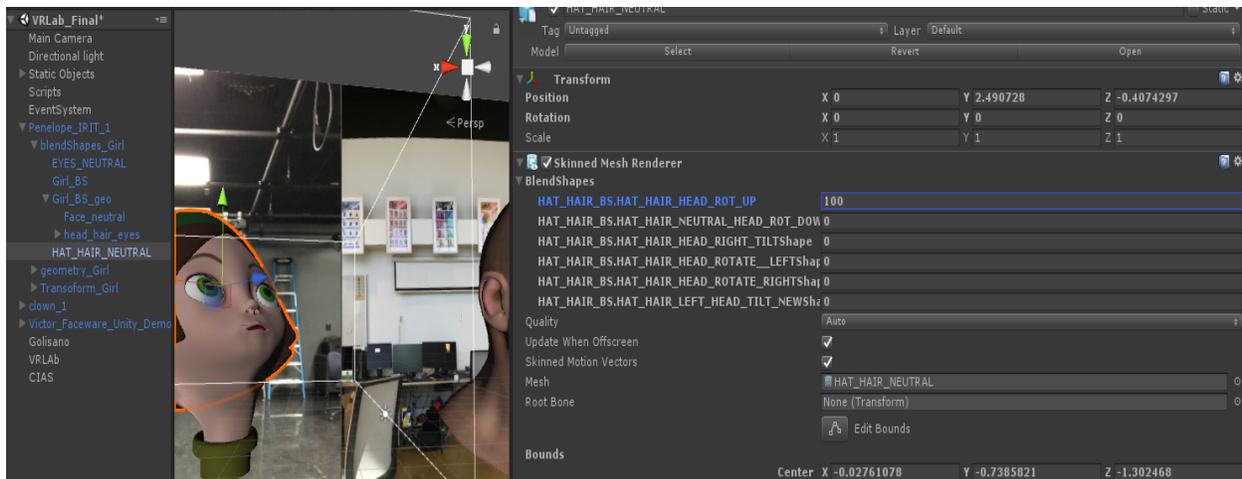


Figure 21: Referencing Hat and hair geometry target blend shape

If you can access the joints in the Unity hierarchy, you need not create blend shapes for eye movement and head movement. You can achieve this by rotating the joints in Unity. Using the transformation tools of Unity, you can achieve your desired rotation.

Remember to reset the character to Neutral before updating every pose and also remember that the asset file expression set is position dependent. If you place your character at a different position, when you run the asset file, your character will migrate to the coordinate location you set it up at the first time. Therefore, you cannot use the same character setup file for character at different locations. You have to create multiple asset files for multiple locations. Also, you cannot use the same character setup file for any other model. You will find your character asset file in the Assets folder of your project. To reuse one of your old character asset files, just click on the circle beside the Character Setup File box to see a list of your saved character setup files.

Helpful Reading for Setup of Live Client: https://faceware.zendesk.com/hc/en-us/articles/204025035-Live-Client-for-Unity?mobile_site=true

Live Client Setup: <http://support.facewaretech.com/live-client-for-unity>

Setting up Live Server

By now you should have your Maya model setup in Unity with its respective character setup file updated with all the expressions in the expression set. Install LIVE Server as per directed on the Faceware LIVE website. Once your LIVE Server is up and running you have to perform the following steps

1. Calibrate your Neutral Pose

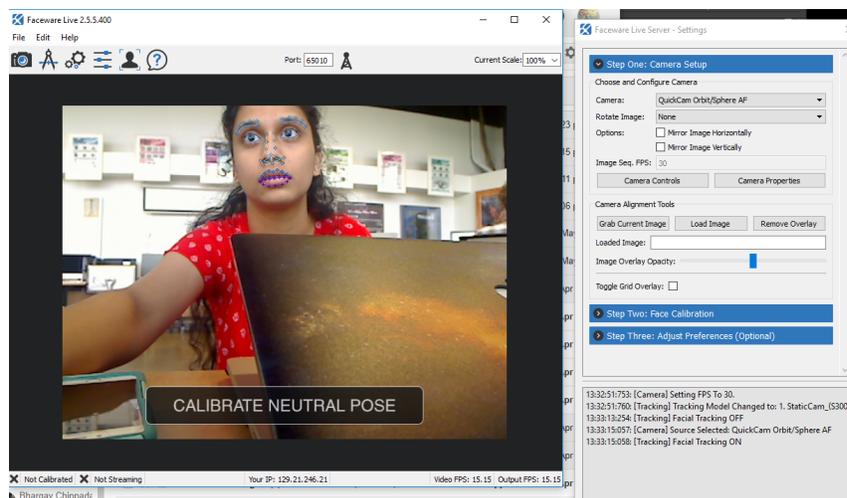


Figure 22: Calibrate Neutral Pose

2. Stream Animation. Check your port no. Generally, it is 802 but you can use any port no

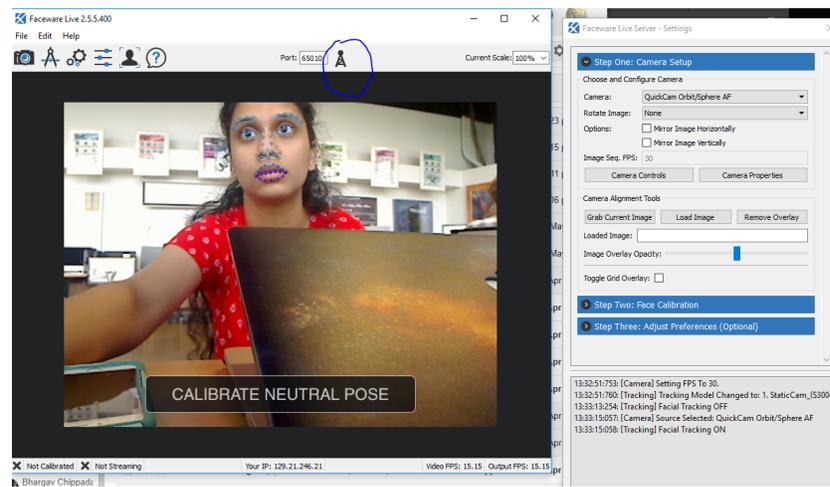


Figure 23: Stream Animation

3. Play the Unity Scene. Before Playing your scene, see that your Live Client Component is checked and if you are running from the server on the same computer the hostname can remain as localhost else you will have to enter the IP Address of the LIVE Server from which the animation is being streamed. Also, ensure that the port number is same. I had changed the port number from 65010 to 802. The Character Setup File should also be added and that field should not be left blank else you will not see any streamed animation. Ensure that the right character setup file is present.

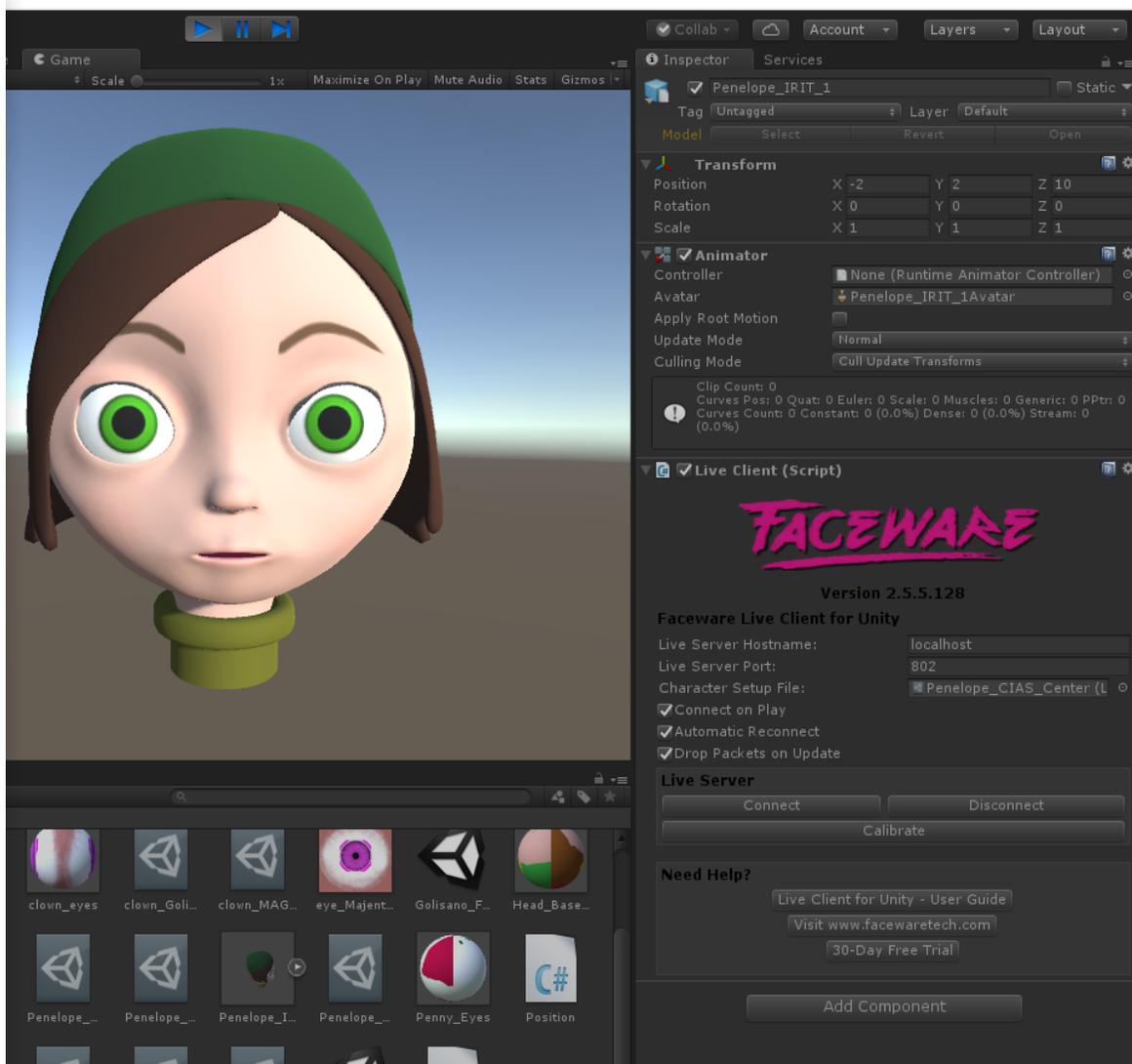


Figure 24: Playing the Scene

Results

Here are some results of my Independent Study. This is a result of the Real Time Facial animation that is being streamed from the LIVE Server to the character Model created in Maya.

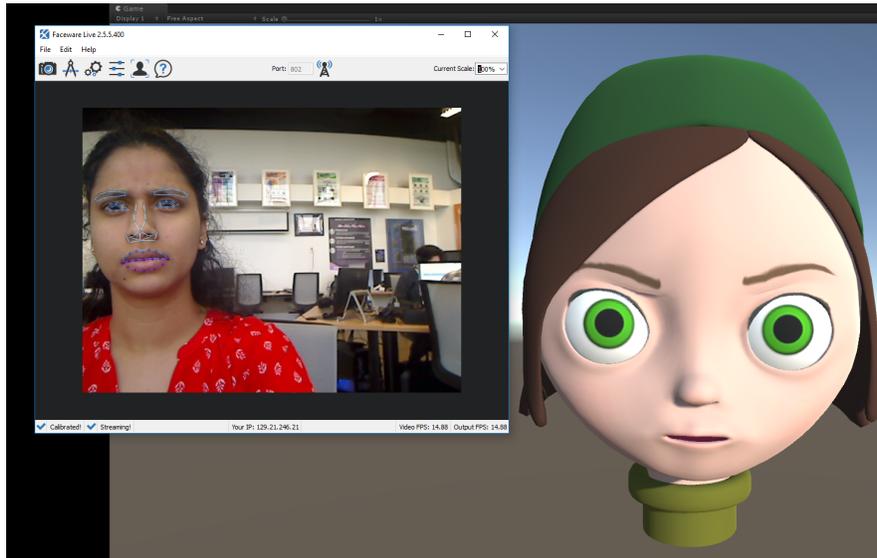


Figure 25: Angry Face/ Eyebrows Down Expression



Figure 26: Happy Face/ Smile Expression



Figure 27: Surprised Face/ Eyebrows Up and Jaw Open (Exaggerated) and Head Tilt

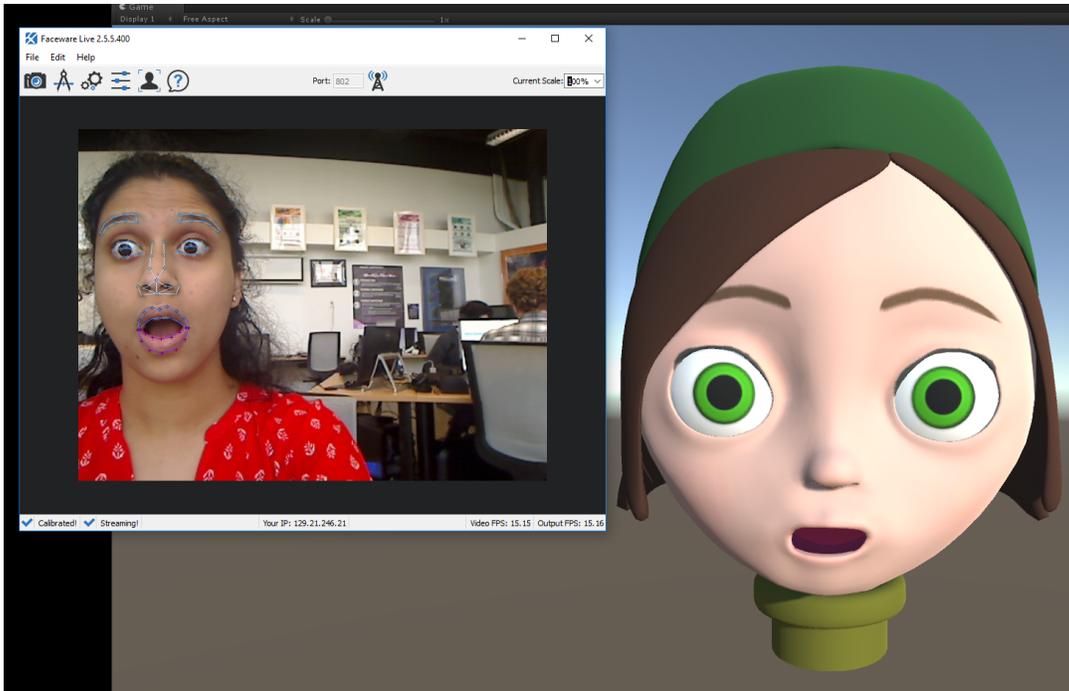


Figure 28: Surprised Face/ Eyebrows Up and Jaw Open

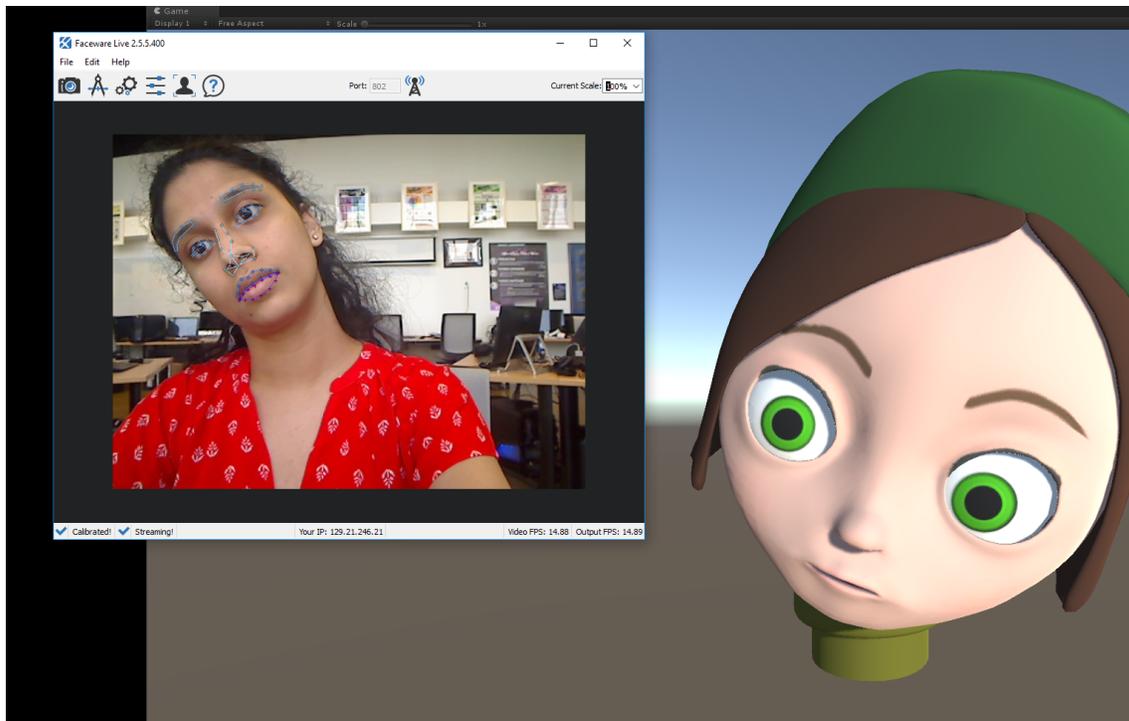


Figure 29: Neutral/ Head Tilt

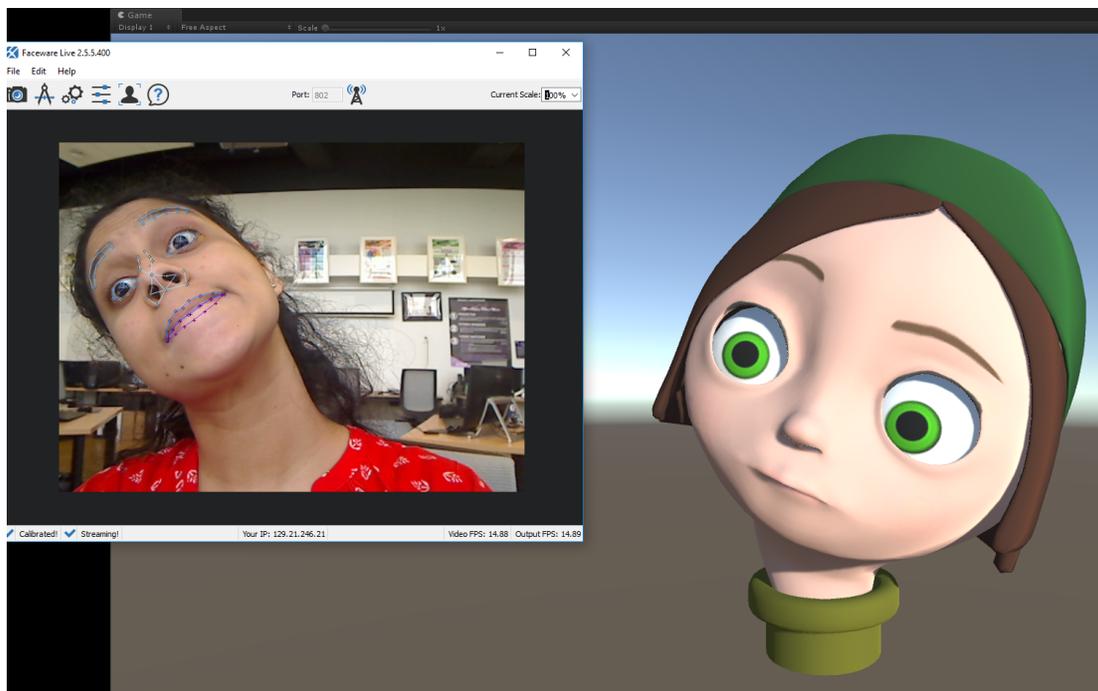


Figure 30: Tilted pursed lips/Head tilt and eyebrows up and MPB Phoneme

Conclusion

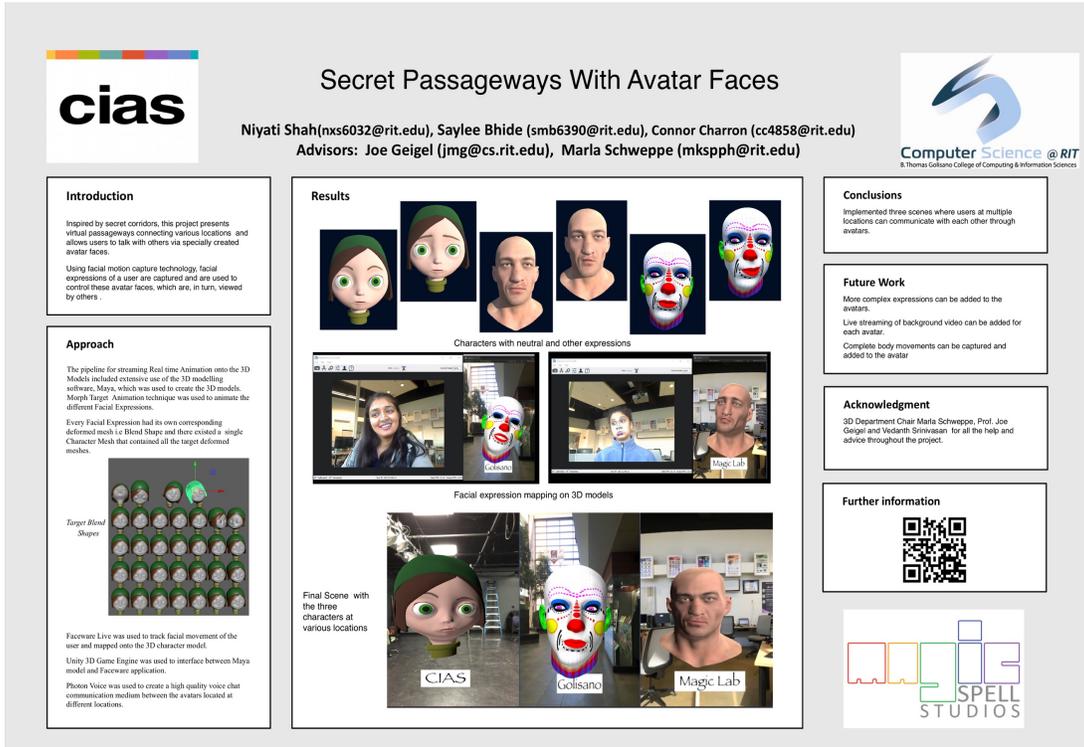


Figure 31: Secret Passageways With Avatar Faces Poster for ImagineRIT 2018

The culmination of this project led me to working on the “Secret Passageways With Avatar Faces” Project for Imagine RIT 2018. My Role in this project was to get all the three Models seen in the Poster working with proper Facial Animation so that different facial expressions of the User can be captured while he is communicating. While working on this project, I got a good understanding of working of Maya and its different features. I became familiar with the 3D Modeling Pipeline for Characters in general and for Faceware LIVE. I understood and implemented the integration of Faceware LIVE and Maya using Unity as a setup medium. I encountered many challenges on the way due to the relative newness of Maya and Faceware LIVE. I have documented the techniques for creation of Facial Models for Faceware LIVE and all the solutions for the challenges that one could encounter along the way.

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