

Retopology of a Human head 3D scan in Autodesk Mudbox 2010



Next Engine By Ara Kermanikian

This document describes how you will be able to transform the 3D scan data of a human head scanned with the Next Engine 3D Desktop Scanner into topology you can animate, paint and sculpt in other 3D programs using Autodesk Mudbox 2010.

The Benefits and Challenges of 3D Scan Data

3D scan data is extremely useful to create digital representations of real world people and objects. When digital doubles are required for movies, ads or videogames, using a 3D scanner and capturing the representation of the real subject is quick, simple and fairly inexpensive. However, the generated data from the 3D scan is only the start of having a model that we can animate, paint or manipulate in 3D applications.

There are several reasons for this:

1. 3D scanners sample points on a surface of the scan subject to create a likeness without giving any consideration to topology or polygon count. The data from the 3D scan is usually in the order of thousands or even millions of triangles arranged in a pattern to represent the surface of the scanned subject. Even though the representation is perfect, the makeup of that representation is not.
2. Another challenge is anomalies such as ripples or stretching that appear on the 3D scan. The slightest movement of a human subject, even ones who are able to stand relatively still during the scan process always generate undesirable surface anomalies.
3. Occluded areas such as ones that fold over or have holes on the surface of our subject are blind spots for the 3D scanner, and cause undesired anomalies. A recurring example of this on a 3D scan of a human head is ears and nostrils.
4. Surfaces that are reflective, transparent, extremely dark, or contain small multidirectional fibers such as hair also result in undesired anomalies.
5. The scan data does not contain mapping coordinates that enable texture artists to paint on the model or for modelers and digital sculptors to add, remove or enhance features on the model.

Data from a 3D scan could only be used with minimal processing when the object is to be rendered in a stationary position. Even in these cases, the model still needs to be cleaned up of 3D scan anomalies and optimized to reduce the polygon count so that rendering engines can process the data and render the scene in a reasonable time frame.

3D scan cleanup and re-topology

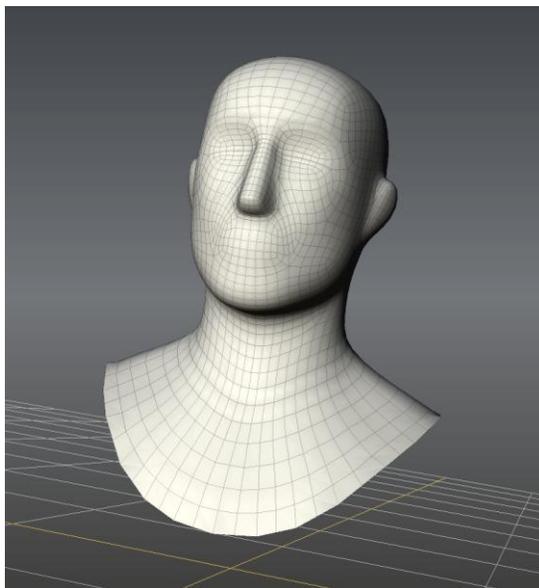
The solution to the challenges mentioned is to start with a 3D scan of the subject, remove the anomalies from that scan, and transfer the likeness onto a polygonal topology that can be animated. This process is called **3D scan cleanup and retopology**.

Starting with 3D scan data saves many hours of modeling work as it generates an exact likeness, accurate proportions, and comprehensive surface details. Modelers and digital sculptors use the 3D scan data as a starting point and utilize the complex 3D scan mesh as a template to snap on their own points and polygons with the needed topology. This used to be a time-consuming process, but it is getting a lot less so, and much easier because of re-topology tools and plug-ins for major 3D modeling software.

With the availability of digital sculpting tools such as Mudbox and ZBrush, this process has gotten even easier because they enable the manipulation of multimillion polygon models. Modelers and digital sculptors can now easily use the sculpting tools to clean up the scan data, and then use a library of generic base mesh models onto which they wrap or project the 3D scan detail with relative ease and speedy results.

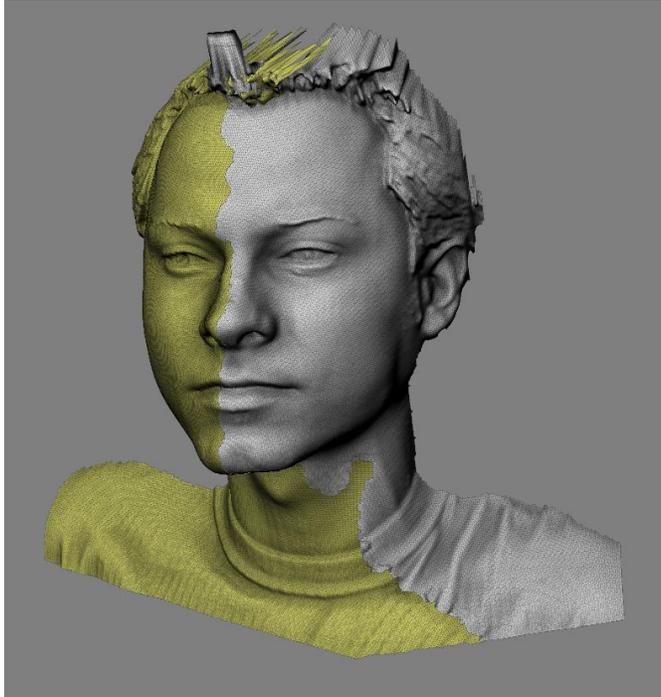
Importing and Retopologizing 3D Scan Data in Mudbox

To demonstrate this process, you will go through the process of loading 3D scan data of Todd's face into Mudbox and mapping the detail onto a human head primitive.



Mudbox Basic Head Primitive

After scanning your subject with the Next Engine 3D Scanner you will have either a single scan or a combination of multiple scans output as an .obj file. In our example, the scan subject has been scanned from two angles and the result is a single .obj file with two separate halves of the face.



These are the steps you will need to go through to apply a new topology to the head:

1. Import the 3D scan data of the head into Mudbox.
2. Add the Mudbox Basic Head primitive to the scene and align it to the 3D scan.
3. Extract a displacement map.
4. Use the Sculpt Model Using Displacement Map option to add apply the 3D scan to the Mudbox Basic Head primitive.
5. Sculpt out the anomalies and add sculptural details.

Step 1: Importing 3D Scan Data into Mudbox

1. Start Mudbox and close the Welcome screen. Choose **File > Import** and import the todd_face_3d_scan.obj file. IF you get a warning that this is a high polygon count model, click OK to close the warning dialog box. It will take from a few seconds to a few minutes, based on your system, to load the 3D scan mesh. Click on the model and choose the Gesso material from the Material Presets tray (6th material). In the Object List tray, note that we are have two mesh objects that are the halves of the face. One is composed of 68,039 polygons and the other 60,778.

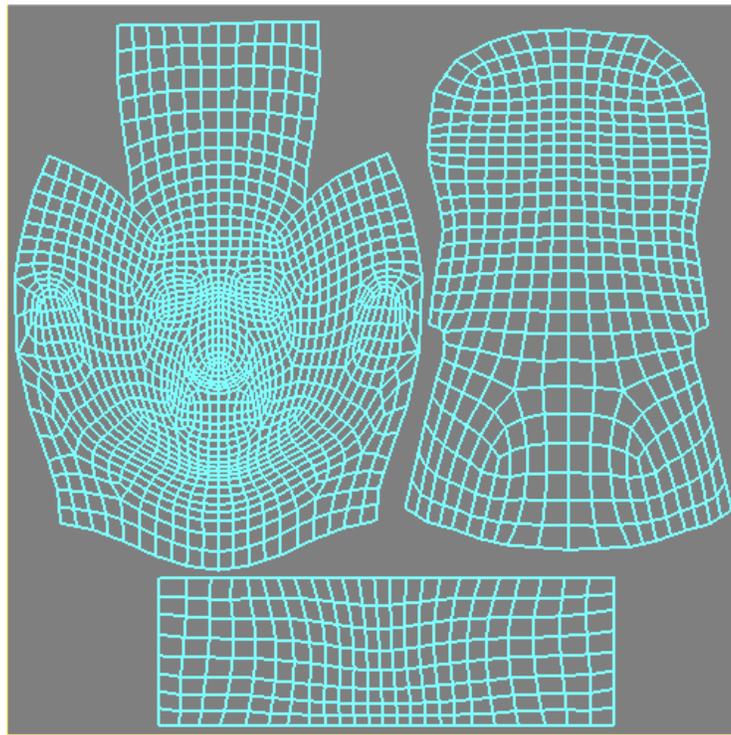
	Name	Information
Scene	Scene	Geometries: 3 Cameras: 4 Lights: 1
Perspective	Perspective	FOV: 0.49 Near: 1.0000 Far: 10000.00 Ortho: 0
Top	Top	FOV: 0.49 Near: 1.0000 Far: 10000.00 Ortho: 1
Side	Side	FOV: 0.49 Near: 1.0000 Far: 10000.00 Ortho: 1
Front	Front	FOV: 0.49 Near: 1.0000 Far: 10000.00 Ortho: 1
Light 01 - Directional	Light 01 - Directional	Intensity: 1.00
Default Material	Default Material	
mesh1	mesh1	Levels: 1 Layers: 0
mesh1 (level: 0, faces: 68039)	mesh1 (level: 0, faces: 68039)	Faces: 68039 Hidden: 0 Vertices:34619 UVs: 34620
nsfr2	nsfr2	Levels: 1 Layers: 0
nsfr2 (level: 0, faces: 60778)	nsfr2 (level: 0, faces: 60778)	Faces: 60778 Hidden: 0 Vertices:30911 UVs: 30912
basicHead	basicHead	Levels: 1 Layers: 0

2. Zoom in on the scanned head. Notice the anomalies caused by the hair, and the area under the chin. Also notice how good a likeness of a person's face this is.
3. At any point press **a** to focus your selection

Step 2: Adding and Aligning the Basic Head Primitive

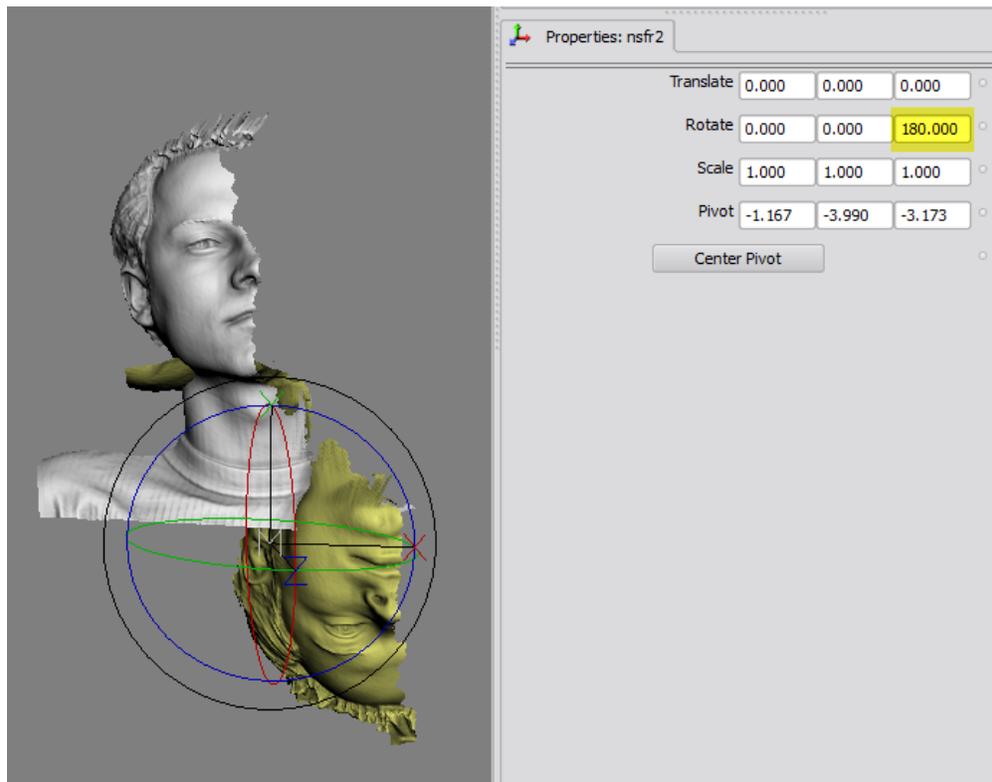
1. Choose Create ➤ Mesh ➤ Basic Head to add the Mudbox Basic Head primitive to the scene. The Basic Head scale is significantly bigger than the scanned head image. Press **A**, and you will see the Basic Head primitive but not the scanned head. As you tumble around in your scene, you will notice that the 3D scanned head is tiny compared to the Basic Head primitive. We will need to align these heads as best we can before we can move on. You could use one of the many human head base meshes that are available on the Internet for free or, of course, one of you have modeled on your own in a 3D application like Maya, 3DS max, Modo or any of the other fine 3D applications. We need to make sure that the base mesh we are transferring the 3D scan detail to already has UVs. The Basic Head base mesh in Mudbox has UVs and has a topology you can subdivide and sculpt. You can see the UVs by selecting the head

and clicking on the UV View tab in the 3D view.

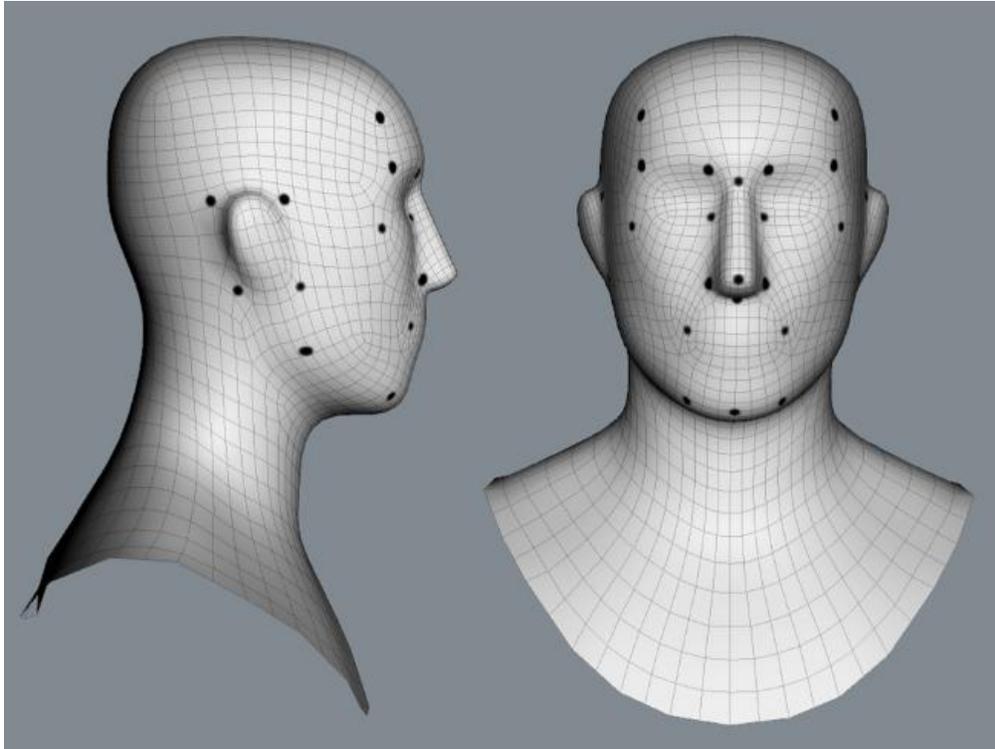


2. In the Object List, click the padlock icon next to the face_rt and face_lf objects to lock them. You need to do this because you want to make sure you don't move any of the points on the scanned 3D head.
3. Since the 3D scan of the head is in the scale that we need, we will resize the Mudbox primitive head to the relative size of the scanned head. From the Select/Move Tools tray click on the objects tool and click on the Mudbox basic head primitive model, it should get highlighted in yellow. Click on the Scale tool and click on the center white cube to scale the head in all 3 dimensions. Scale the head to approximately the size of the scanned head. Remember to press **a** to zoom in on the subject.
4. Notice that the scanned head is upside down. To get the orientation of it right, and align it with the Mudbox primitive head we will individually rotate the two halves of the 3D scanned head 180 degrees in z. In the Object List, click on one of the halves of the 3D scanned face and click on the Rotate tool in the Select/Move Tools tray. Notice that numerical text boxes appear in the Properties tray to numerically input the translate, scale, rotate and pivot coordinates. Type 180 in the z field of the Rotate row. Do the same

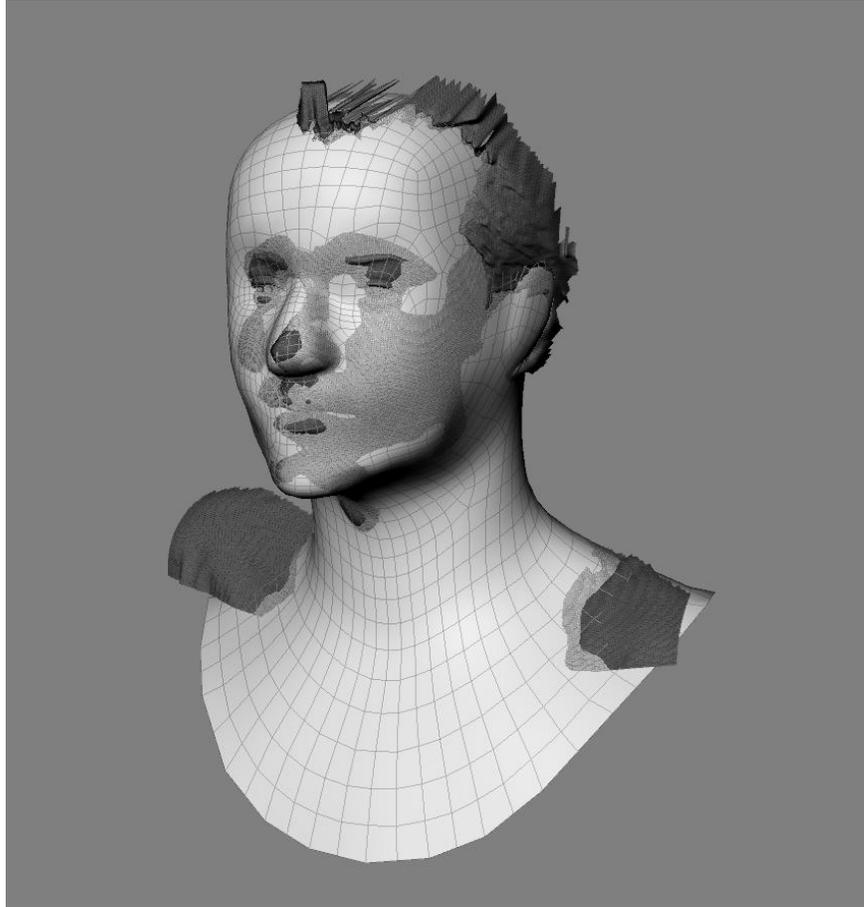
for the other half face.



5. Now that we have the heads in the same orientation, we need to move the Mudbox primitive head to align with the 3D scanned head. We could do it the other way around, but it is much more convenient to move one object instead of two. Select the basicHead object in the Object list and click on the Translate tool in the Select/Move Tools tray. Translate it so it is overlapping with the 3D scanned head. I usually align the tip of the nose first.
6. Use the Translate, Scale and Rotate tools to roughly align the key landmarks of the Basic Head primitive to those of the 3D scanned head.



7. Use the Grab tool in the Sculpt Tools tray, with a brush size of about 20 and move the landmark areas individually to align them as best as you can. Since there is no transparency, the best way to make the alignment is to move the surface in until it barely intersects the 3D scan surface then move it back out.



8. Press W to turn on the wireframe and make sure that your quads are well spaced and not overlapping or squashed together. Your alignment does not have to be precise, but the landmarks should roughly overlap those on the 3D scan.

Step 3: Extracting a Displacement Map

Next you will extract the displacement map of the 3D scanned head. You will use the 3D scanned head as the source model and the Basic Head primitive as the target model during your extraction. This will extract the displacement or surface depth information of the high-resolution mesh and map it onto the UVs of the Basic Head.

1. Choose Maps > Extract Texture Maps > New Operation.
2. Check the Displacement Map dialog box.
3. Next to the Target Models (Low Resolution Mesh) list box, click the Add All button. This adds all three model to the list. Click on **face_lf** and the click the Remove button. Do the same for the **face_rt** object so you are

just left with the **basicHead** object.

4. Click the Add All button next to the Source Models (high Resolution Mesh) list box. Click on the the **basicHead** primitive and click the remove button.
5. For the Search Distance option, click the Best Guess button. This sets the total distance that samples can be taken from the target model to the source model based on the distances of the bounding boxes of the two.
6. In the Choose Samples list, select Closest to Target Model. This creates the displacement map with samples closest from the range specified by the Search Distance option.
7. Select an Image Size of 4096×4096 because you want to use the maximum map size to get the most detail from the 3D scanned model.
8. Click the folder icon next to the Base File Name text box and enter 3Dscan_displacement or a name of your choice for your displacement map. Select OpenEXR [32 bit Floating Point, RGBA] as the file format and click Save. Again, this does not generate or save the displacement map; it just sets the name.

Name:

Maps to Generate:

- Ambient Occlusion Map
- Displacement Map
- Normal Map

Displacement Map Extraction

Compare detailed and simple surfaces and extract the detail



Target Model **Source Model** **Displacement Map**

Extraction Options

Target Models (low resolution mesh)

basicHead	level 0	Add All
		Add Selected
		Remove

- Smooth Target Model
- Smooth Target UVs

Source Models (high resolution mesh)

face_lf	level 0	Add All
face_rt	level 0	Add Selected
		Remove

Smooth Source Models

Choose Samples:

Search Distance:

Image Size:

Antialiasing:

Displacement Map Output

Normalize to Search Distance:

Base File Name:

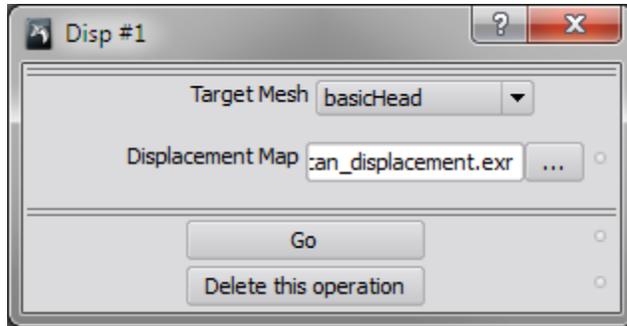
Bits per Channel: 32-Bit FP

9. Click the Extract button to extract the displacement map. This opens the Map Extraction Results dialog box, which shows you the progress of the extraction.
10. A dialog box opens to tell you that your map extraction finished without errors and the operation completed successfully. Click OK, and click Close to close the Map Extraction Results dialog box.
11. Click the Image Browser tab in the main viewport and navigate to the folder in which you extracted the displacement map. Examine the displacement map. You can use the + or – keys to increase or decrease the stop value, respectively, to see the level of detail the image has at different exposures. Also note that the displacement map has been extracted to match the UV map of the Mudbox Basic Head primitive.

Step 4: Using the Sculpt Model Using Displacement Map Option

At this juncture, you no longer need the 3D scan model. You will hide it and wrap the displacement map you generated to add the details of the 3D scan to a subdivided version of the Mudbox Basic Head primitive.

1. Click on the eye icons next to the face_lf and face_rt in the in the Object List tray to hide them.
2. Since our original scan had 128 thousand faces (68,039 +60778), we will subdivide our scanned model to about that range.
3. Select the basicHead in the Object List and press Shift+D three times to get about 128 thousand polygon subdivisions.
2. Choose Maps ➤ Sculpt Model Using Displacement Map ➤ New Operation.
3. From the Target Mesh, select the only mesh in the scene: basicHead.
4. Click the three dots next to the Displacement Map text box, select the displacement map you generated in the previous section (3Dscan_displacement.exr), and click Open.



5. Click Go. This displaces your Basic Head primitive.
6. Note that you now have the exact same model of the 3D scan, but if you press W, you will see that it is no longer composed of triangles and n-gons but of quads that the Basic Head primitive was made of.
Tumble around the head and notice that the holes have been filled, and that's another problem solved. But the model still has a lot of little spikes, surface and anomalies that need to be fixed.

Step 5: Sculpting Anomalies and Adding Details

You can no longer solve any of the remaining anomalies automatically. You will need to use good old digital sculpting to get the model to look like the scanned subject. Fortunately, this is not too difficult and is perfectly suited for Mudbox. To sculpt out the anomalies, it is easier to start at the lower subdivision levels and work your way up.

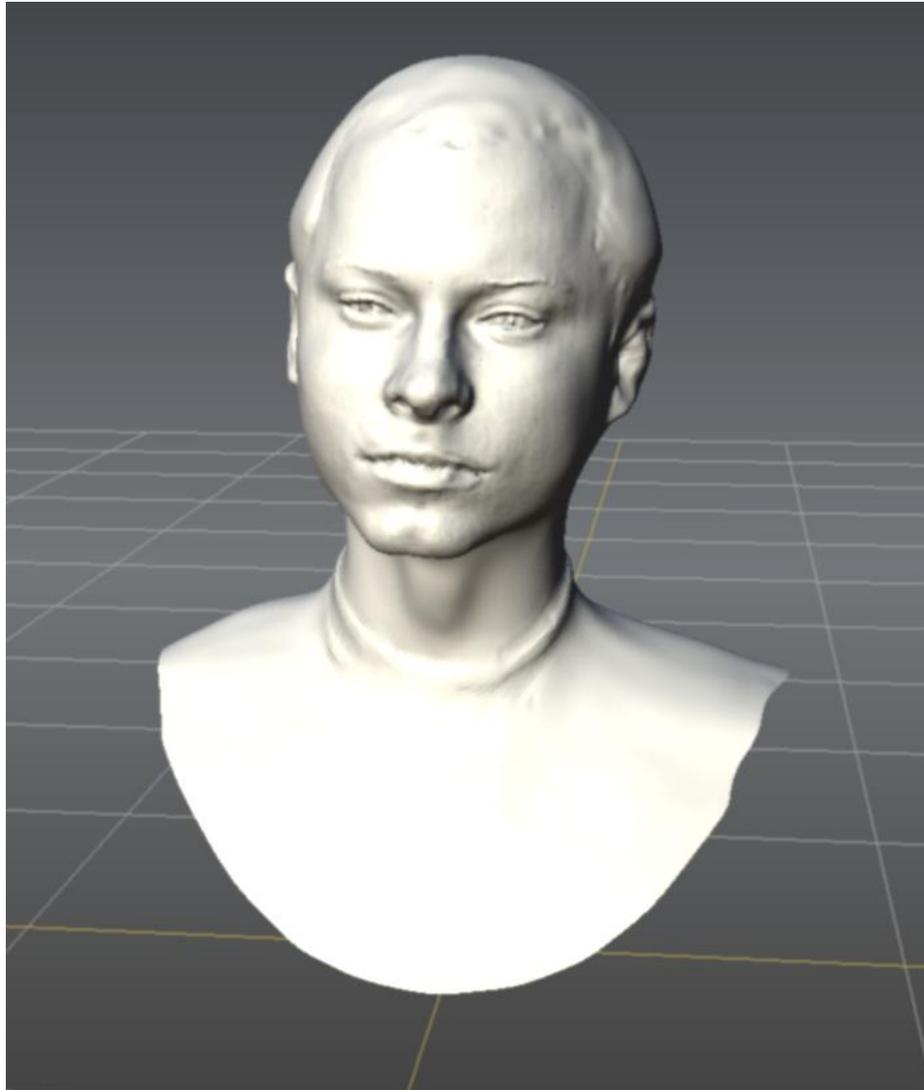
You will initially use the Smooth and Grab tools and then use the Wax tool to sculpt some details. It is also always a good idea to use smaller Size and Strength settings and work your way up.

1. Press Pg Dn until you are at level 1. Use the Smooth and Grab tools to smooth out the artifacts and move areas on the shoulder to align them better. Remember to use additive smoothing by using a lower Strength setting and gradually working your way up. Step up one level to 2 by pressing Pg Up. Repeat the process in step 1 to sculpt out the anomalies that show up. Note that there are still anomalies in the areas you fixed on level 1, but they are less severe than they would have been had you not done the work on level 1.
3. Step up to level 2 by pressing Pg Up. Now you can see some of the anomalies in more-granular detail. At this level, as you are getting rid of anomalies, you could just as easily also soften up needed surface

details. So, from this point on, it is a good idea to use a lighter hand on the tablet and really work with smaller tool sizes and lower strengths. Start out with the Smooth tool and move the tool in a circular motion over the anomalies to reduce their size. If the spikes persist, try using the Flatten tool, or drop back down a subdivision level and work on the same area.

Look at the Step_05.mud file to see the examples of the cleanup at each of the levels 1, 2 and 3.

At this point, the cleanup is done. Now is the time to sculpt the missing details, such as the inside of the ears, the indentation behind the ears, the nostrils, and all the other areas that you feel need detail.



When you are finished, you have a model with a believable likeness of the 3D scan subject, with UVs and usable topology that you can 3D-paint, further sculpt, or move into the next stages of the pipeline to get animated or 3D printed.

Summary

Three-dimensional scanning is an efficient method for getting near-perfect likenesses in little time, with very little specialized effort, and for nominal cost by using tools such as Mudbox.

The displacement map generation, and the sculpt using displacement map technologies in Mudbox, paired with the digital sculpting tools, have proven a great asset to many production pipelines.