DISPLACEMENT MAPPING

Sometimes, rather than modeling the details of a surface, it is more convenient to use a Displacement Map. Displacement Mapping uses a texture to alter the shape of geometry. This is different than a Bump Map which simply alters the surface normals to create the illusion of surface relief.

Displacement Map  Bump Map

Displacement vs. Bump Map
Displacement Mapping in Maya

The Displacement Map is connected to the shading group node instead of the material node. This is because it is applied to the geometry rather than the shading. To see the connections in the Hypershade, select the material node and click on the **Output Connections** button. Then select the shading group node and click on the **Input Connections**. This will show the Displacement Map, the material node, and all of the geometry that belongs to the shading group. The following snapshot of the Hypershade shows an example of the nodes and how they are connected:

![Displacement Mapping Diagram](image)

*The Displacement node is connected to the shading group directly*

There are two types of Displacement Mapping available in Maya. When working with the original method, the bump channel on the material is mapped automatically. This is required for correct surface normals; without this Bump Map the surface will not shade properly. To use another Bump Map in addition to the one the Displacement Map requires, just follow the same chaining technique used earlier to apply two Bump Maps to the *rusty hull* material for the *spaceJet*. **Drag+drop** the second Bump node onto the displacement's Bump node. Connect the **Out Normal** to **Normal Camera**.

A newer type of displacement is called Feature Based Displacement Mapping. Its purpose is to add interesting details to surfaces. In order to capture small details with the original displacement method, the tessellation had to be increased for the entire surface. This would often lead to crashes from running out of memory. The Feature Based Displacement Mapping
solves the problem by attaining high quality displacement tessellation with minimum triangle counts. To achieve this, the tessellation is built so that the triangle density is greatest where the details are. This technique decouples the effect of tessellation parameters and Displacement Mapping parameters.

**Feature based displacement**

This exercise will make use of Feature Displacement to create the treads on a tire.

1. **Open the file called TireDisplacement.mb.**
   
   There are two display layers; one contains the tire geometry and the other contains the chrome rim. The rim layer can be made invisible to optimize test renders. The final material and Displacement Map is provided in the file as an example.

2. **Adjust the tessellation for the non-displaced tire**
   
   - Adjust the tessellation on the tire just high enough to capture the shape of the surface. There is no need to increase the tessellation parameters beyond this point for Displacement Mapping.

   ![Adjusting Displacement tessellation](image)

3. **Visualize the displacement texture**

   Because Displacement Maps cannot be previewed in hardware texturing, the following technique can be very useful.
Map the texture `tread.tif` to the Color channel on the material called `newTire`.

This is the intended displacement texture but mapping it to the color channel (temporarily) will help to position it and also help when setting the displacement attributes.

![tread.tif file texture](image)

- Turn On Hardware Texturing by pressing the 6 key.
- In the Attribute Editor for the `newTire` material, under the Hardware Texturing section, set the Texture Quality to Highest.

This increases the resolution of the display of the texture, making it easier to see the placement.

- Adjust the placement of the tire tread texture using the `place2dTexture` node.

**Tip:** It may be helpful to use the Interactive Placement in conjunction with IPR. Remember to use the MMB to move the handles on the interactive placement manipulator.
Suggested values for the texture placement

- Set the **Default Color** on the *tread.tif* file texture to **black**.
  
  Because the **Coverage** has been adjusted to less than 1.0, the **Default Color** is visible on the sides of the tire. Setting the Default Color to black (RGB 0,0,0), intentionally prevents the sides of the tire from being displaced when this texture is applied as a Displacement Map.

- Set **Display Render Tessellation** to **On** in the tire’s Attribute Editor to see the tessellation triangles.

**Display Render Tessellation turned on**

4 **Connect the Displacement Map**

- Drag the *tread.tif* file texture onto the *newTire* material. Connect to **Displacement Map**.

  This automatically connects the tread texture to the shading group node.
5 Tuning the displacement attributes

The displacement attributes are found in the Attribute Editor for the geometry, not the texture map.

- Make sure the Feature Displacement flag is turned On.

If the original tessellation triangle is large and the texture details are fine, then the Initial Sample Rate has to be large (from 30 to 50 or even higher). If the triangle is small and the texture details are not that fine, then Initial Sample Rate does not have to be very high (usually the default of 6 is good enough).

Observe how sharp the texture details are and if there are many clean lines or curved details. The sharper the features and the cleaner the lines, the higher the Extra Sample Rate needs to be.

- For each tessellation triangle, observe how much texture detail is in the triangle.

- Set the Initial Sample Rate based on your observations.

- For now, set the Extra Sample Rate to 0.

- Disconnect the file texture from the Color channel.

- Test render the tire to see the results of the Displacement Map.

It is not possible to use IPR to help tune the displacement attributes because the Displacement Map is applied to the geometry, not the shading. Changes in the shape of the geometry are not supported by IPR.

- If not enough details are captured, try increasing the Initial Sample Rate. Use the lowest acceptable value.

- If the features are too jagged, try increasing the Extra Sample Rate.

  This attribute refines the displacement results. It is a good idea to try it at 0 and see if the quality is good enough. This will help to keep the triangle count as low as possible. Increase it only if the quality is not good enough.

In the case of the tire, the triangles are medium sized where the tread lies on the surface and the texture details are fairly small (fine) relative to the size of the triangles. In order to capture enough information about the texture details in each triangle, a medium-high Initial Sample Rate is required.

To refine the results, the Extra Sample Rate should be increased from 0 very slightly until the edges of the texture details look acceptable.
6 Using the Displacement to Polygon Tool

Under the Modify menu on the main menu bar, there is a Convert menu that contains a tool called Displacement to Polygon. This tool is very useful because it bakes out the displaced surface as a polygon mesh, providing a great way to visualize the results instead of test rendering. The resulting polygonal object is created in the same location as the original and can be used instead of the original surface (in which case, the Displacement Map serves as a modeling tool). While the original surface is preserved, there is no history relationship between the original surface and the polygonal object. If changes are made to the original surface or any of its tessellation or displacement attributes, the Displacement to Polygon Tool must be used again to see the changes.