User Guide

Melody 1.2

Normal Map Creation & Multiple LOD Generation

DA-01601-001-v01
November 2004

DEVELOPMENT

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Introduction to Melody

Melody (Multiple Levels-Of-Detail Extractor) is an application used by game artists to reduce high-poly count 3D models down to multiple, lower resolution models, with corresponding bump maps. These 2D bump maps (technically, normal maps) create the impression of higher detail, by capturing the high-resolution/high-frequency details in the texture. The combination of the low resolution model and the bump map looks quite similar to the original high resolution model, while being more efficient to render and also enabling per-pixel lighting.

Features

- **Simplification and LOD Creation**
  Provides the ability to take an existing model and simplify it. You can create and assign multiple levels of detail (LOD) from the original mesh.
- **Normal Map Creation**
  Create a normal map that makes a low-poly version of a model look like a high-poly version of that model. The low-poly version can be an LOD created using Melody or one that you created elsewhere. The normal map generator can also create normal map texture coordinates for you.
- **Texture Coordinate Calculation**
  Melody can calculate texture coordinates or calculate coordinates from a reference model by projection.
- **Fitting Model to a Reference Model**
  You can fit a low resolution model to a high resolution reference model.

Figure 1 shows the Melody main dialog window. Models with up to 65k polys can be converted to .3ds, .obj or .ply format using Polytrans or exported directly from 3ds max or Maya. You can download Polytrans from the following web site:

http://www.okino.com/conv/conv.htm

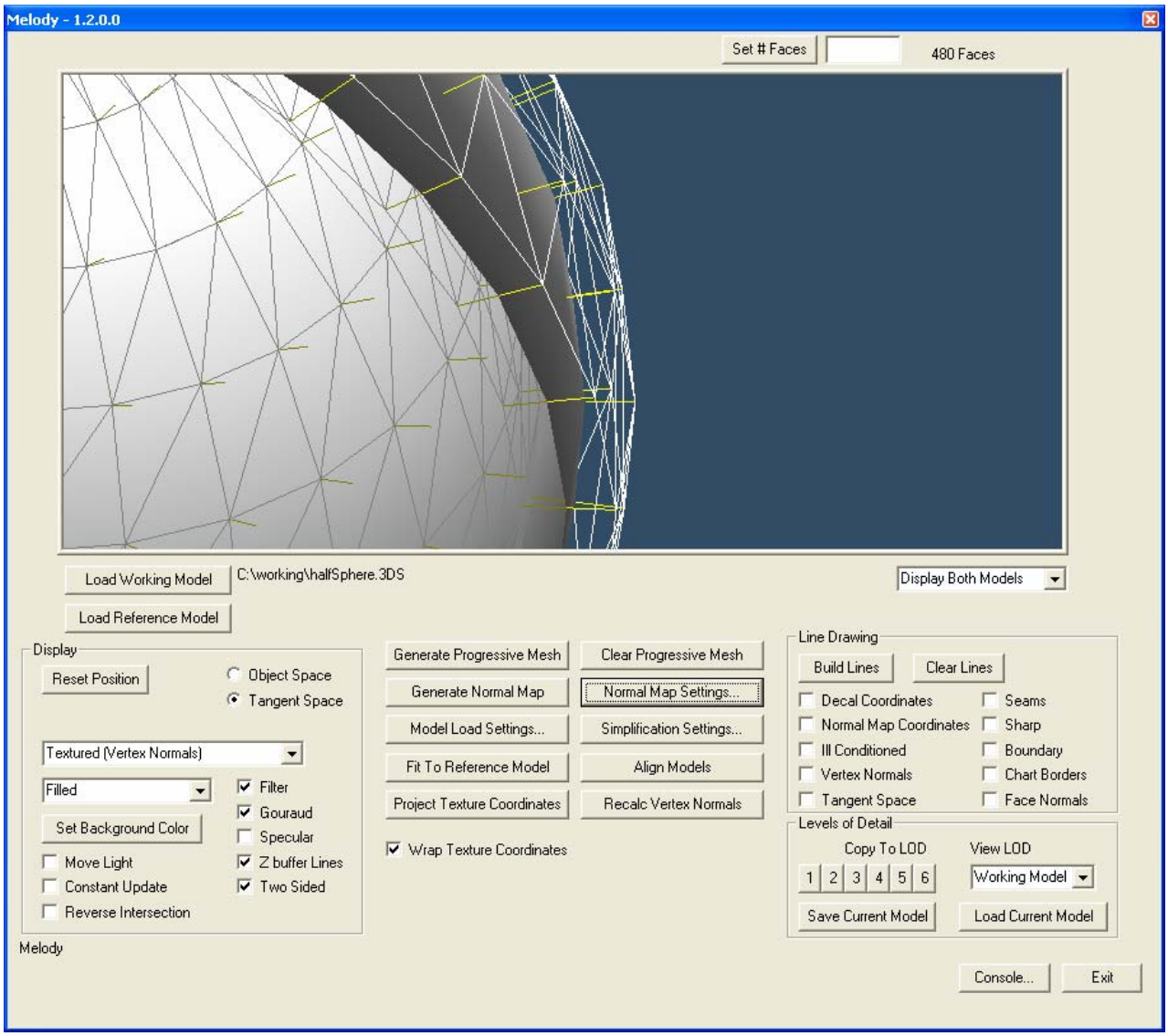


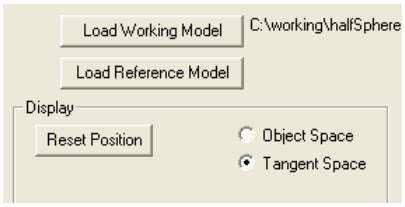
Figure 1. Melody Main Menu

Loading a Model

When working with Melody, you are going to be loading two models into the application. The first one is the *working model*, the one you will modify, simplify and create LODs from. The other is the *reference model*, which is usually a high resolution model. Initially, they may be the same model, but as you reduce and optimize the working model, they will diverge.

- **Working Model**
  This is the model that is to be manipulated and used to generate geometric levels of detail and normal maps.
- **Reference Model**
  This is the high-resolution model that is used as a reference when simplifying, optimizing and generating normal maps. This can be the same as the working model.

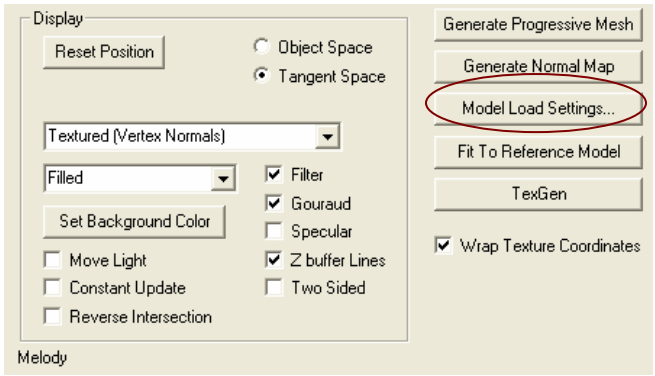
Click the **Load Working Model** button on the Main Window to browse for the file. After loading the working model, use the **Load Reference Model** button to browse for the reference model file.



Note: You can load a model directly into a level of detail by selecting **View LOD 1**, then **Load Current Model.**

Model Loading Setting

Before you load the working model, you might want to alter the loading criteria. Click on the **Model Load Setting** button on the Main Menu to display the **Initialization and Loading Settings** window (Figure 2).
The options in this window are described in Table 1.



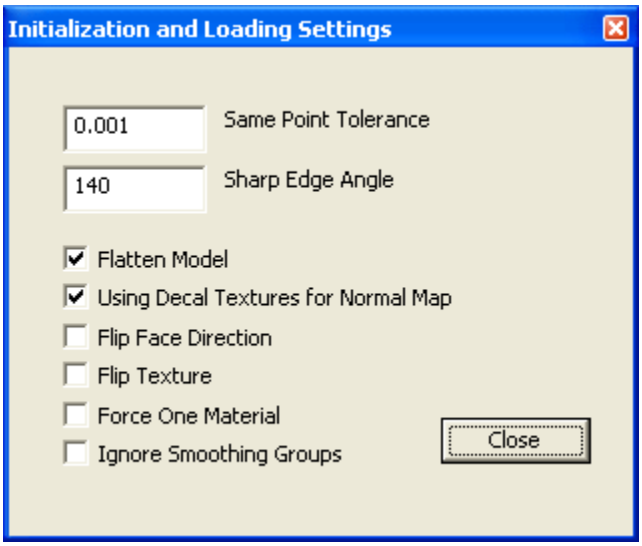


Figure 2. Model Initialization and Loading Settings

Table 1. Initialization and Loading Settings Options

Window Option	Description
Same Point Tolerance	Distance below which points are considered to be coincident. This is a percentage of the object
Sharp Edge Angle	Angle below which an edge between two faces is considered sharp. A flat surface has angle 180 degrees. A typical sharp angle is 140 degrees.
Flatten Model	Remove model hierarchy
Using Decal Texture for Normal Map	Select this if you are using decal texture coordinates for normal maps.
Flip Face Direction	Reverse the direction of the faces during loading
Flip Texture	Flips the textures vertically
Force One Material	Use only one material for the whole model
Ignore Smoothing Groups	Ignore normal information supplied with reference model.

Display Options Panel

The **Display** section of the Main Menu is used to define how your model is displayed. Figure 3 shows the panel and Table 2 lists the options.

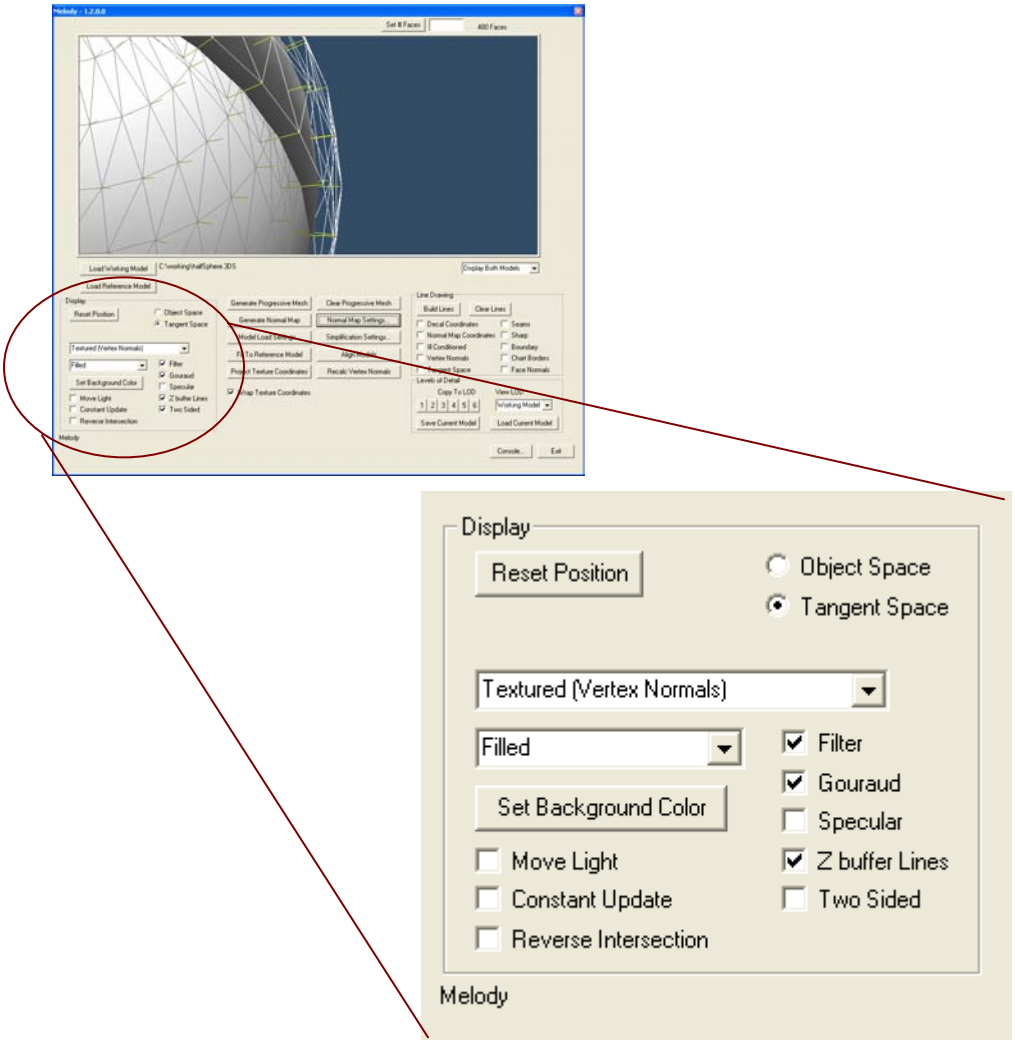
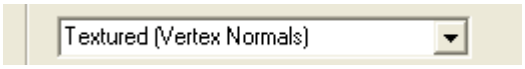


Figure 3. Display Options Panel

Window Option	Description
Reset Position	Resets models to initial position.
Display Options	
Textured (Vertex Normals)	This dropdown option is the texture and light model using per vertex normal.
Textured (Per Pixel Normals)	This dropdown option is the texture and light model via per pixel normal.
Grey Shaded (Vertex Normals)	This dropdown option is the light model via per vertex normal.
Grey Shaded (Per Pixel Normals)	This dropdown option is the light model via per pixel normal.
Vertex Normals	This dropdown option displays per vertex normals.
Per Pixel Normals	This dropdown option displays per pixel normals with normal map (if present).
Charts	This dropdown option displays charts that were creating during the normal map generation.
Attribute Groups	This dropdown option displays the faces by attribute groups.
Tangent To Object Space	This dropdown option rotates tangent space normals into object space to compare to reference model normals.
Tangent Space Map Lighting	This dropdown option defines lighting using the tangent space normal map. Rotate light into tangent space.
Object Space Map Lighting -	This dropdown option uses object space normal map to display lighting.
Object Space	Radio button used to select object space.
Tangent Space	Radio button used to select tangent space.
Render Options	
Filled	Displays object filled.
Outline	Displays outline of object.
Wireframe	Displays the object as a wireframe.
Move Light	Toggles using mouse to move the light instead of the model.

Window Option	Description
Constant Update	Keep update
Filter	Toggles texture filtering.
Gouraud	Toggles gouraud/flat shading
Filter	Toggles texture filtering.
Specular	Toggles specular lighting display
Z buffer Lines	Hide lines behind triangles
Two Sided	Enable/Disable showing both side of triangles
Set Background Color	Displays a palette menu to change the background color.

Mouse Controls

- **Rotate –** CTRL + LMB + Mouse Move
- **Pan –** SHIFT + LMB + Mouse Move
- **Zoom-** CTRL + SHIFT + LMB + Mouse Up/Down

(LBM = Left Mouse Button)

Manipulating a Model

The center portion of the Main Menu is used to manipulate your model. Figure 4 shows the area of the Main Menu. The buttons are described in the following paragraphs..

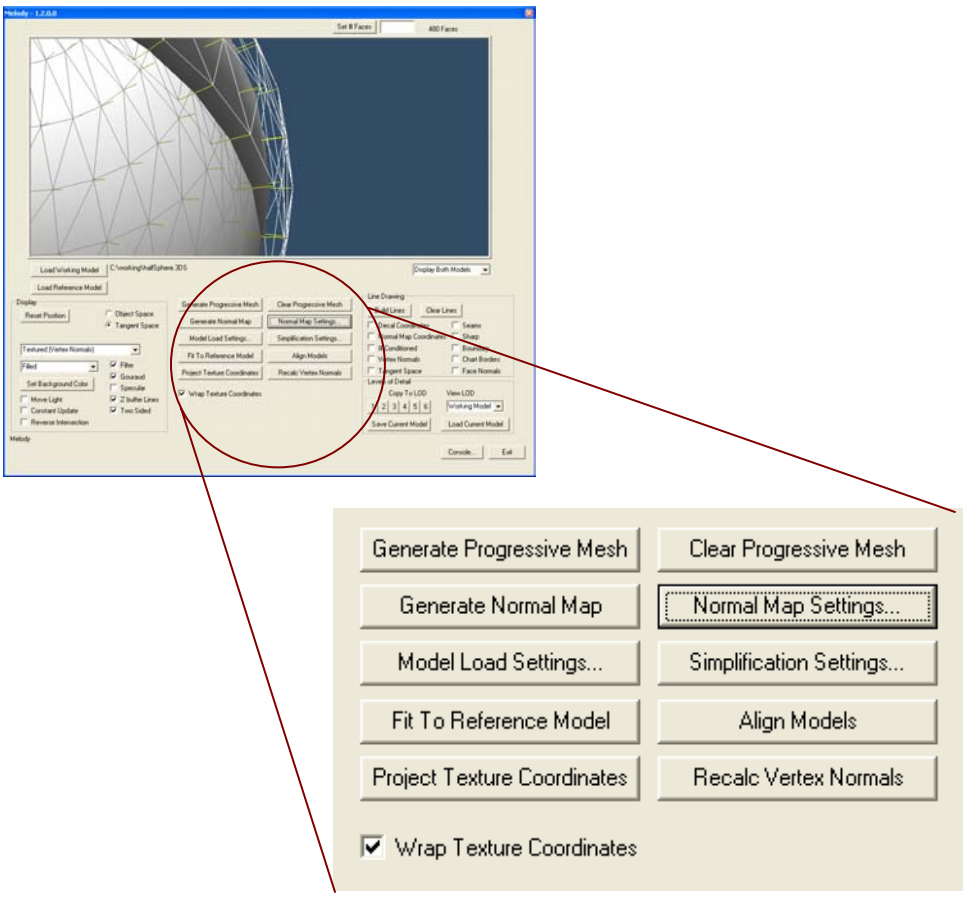


Figure 4. Buttons to Manipulate Your Model

Simplification and LOD Creation

The **Generate Progressive Mesh** button creates a complete simplification for your mesh. Each edge of the working model is collapsed until there are no more legal collapses. The entire sequence of collapses (called a progressive mesh) is stored so you can adjust the slider to select the number of desired faces. You can change the simplication settings in the **Simplification Settings** dialog.

Once the program computes a complete simplification sequence, you are able to move the vertical slider up and down to scan through various levels of model complexity. By noting the polygonal count displayed and the visual appearance of the working model, find a point where the model matches the desired model

complexity for a particular LOD. By clicking on a button in the LOD panel, you can assign that model to a level of detail. There are six levels that can be assigned and each LOD may have separate, later operations performed on them, such as optimization. Be careful to note whether you are viewing the working model or a particular LOD. In other words, you should **Copy** *to* LOD, then **View** the LOD to further operate on it.

An example of Simplification and LOD Creation is given below. Starting at the Main menu:

1. Press **Load Working Model** to load the model that is going to be processed.
2. Press **Load Reference Model** to load the high resolution reference model.
3. Press **Generate Progressive Mesh** to create the complete simplification sequence.
4. Use the slider to view collapse sequence.
5. Select **Copy to LOD1** to make a copy of the current working model which is copied to LOD1
6. Select **View LOD1** and notice that hitting any other view button displays nothing. The other levels of detail have not been assigned yet. Select **View LOD1** again.
7. Optionally, select **Fit to Reference Model** to fit the low resolution model to the reference model using the data points sample from the reference model.

Simplification Settings… Button

This button displays the **Simplification Settings** window that provides the settings that are used in the simplification routines. This window is shown in Figure 5.

The QEM simplification technique was created by Michael Garland and Paul Heckbert. Their paper, *Surface Simplification Using Quadric Error Metric*, can be found at: http://graphics.cs.uiuc.edu/~garland/papers/quadrics.pdf .

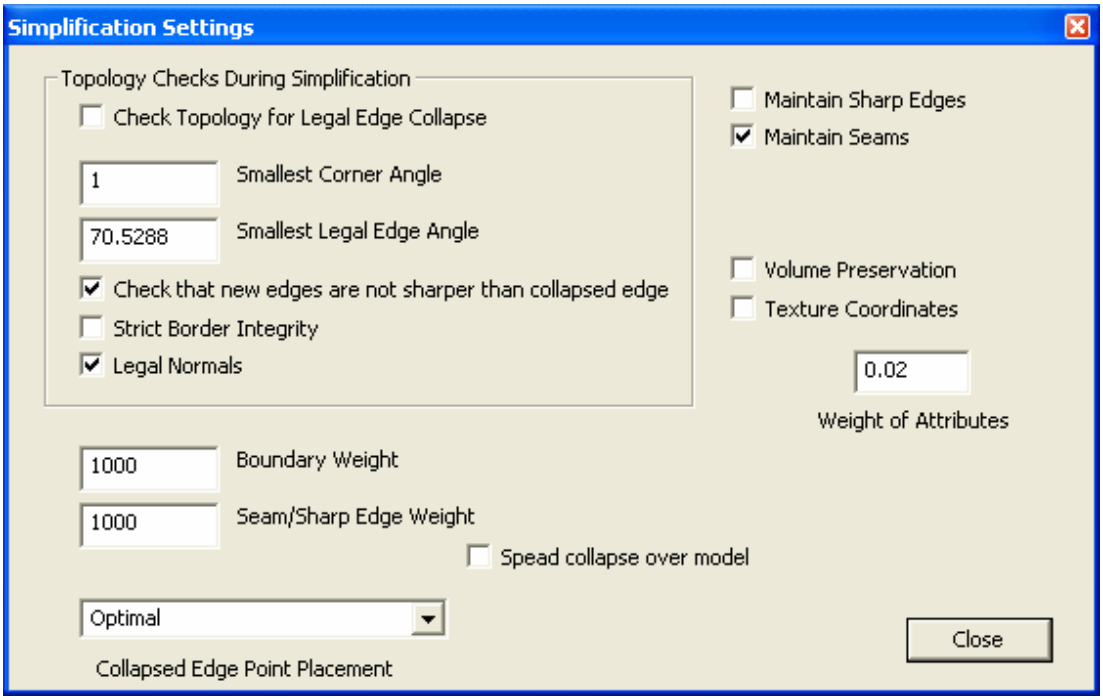


Figure 5. Common Simplification Settings

Check Topology for Legal Edge Collapses

During edge collapses, does not allow the creation of *folded geometry*. Enabling this usually allows folded geometry to be simplified. If the geometry in the model is well behaved, then this should not be necessary. Well behaved geometry does not have:

> *Folded geometry* - Where two faces face opposite directions, share an edge and are coplanar. Three or more faces sharing an edge

Smallest Corner Angle

This is the angle between to edges on one face. This prevents sliver triangles from being created.

Smallest Legal Edge Angle

This is the angle that is between to faces that share one edge. During edge collapses, this determines the smallest sharpness edge angle that is allowed to be created.

Check that new edges are not sharper than collapsed edge

Checking this means that the newly created geometry will not introduce more sharpness than is already present.

Strict Border Integrity

Prevents dangling edges from being created. In the diagram shown in Figure 6, the edge in red (or bold) will not be collapsed if this is checked.

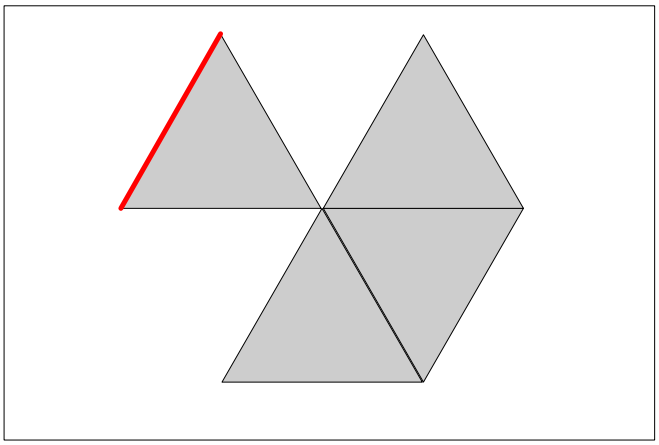


Figure 6. Border edge ignored when Strict Border Integrity is Set.

Legal Normals

Prevents a collapse where the vertex normal is pointing in the opposite direction from the face normal. This prevents very sharp edges from being created.

Boundary Weight

Displays how strong the boundary is weighted compared to the surrounding faces.

Seam/Sharp Edge Weight

Displays how strong sharps edges and seams are weighted.

Collapsed Edge Point Placement Combo

When an edge is collapsed, the resulting single point is placed in one of the following dropdown options:

- **Endpoints**
  At either one of the endpoints which has the least quadric error. This is recommended for situations where you do not wish to have vertices move, such as when they already have vertex weights.
- **Endpoints or Middle of Edge**
  At either one of the endpoints or the middle of the edge which has the least quadric error.
- **Anywhere Along Edge**
  Anywhere along the edge that minimizes the quadric error.
- **Optimal**
  Choose the optimal position, not necessarily on the edge.

Scale QEM

Scales quadric error depending on number of collapses. Sometimes allows collapses to be distributed better.

Maintain Sharp Edges

Tries to preserve sharp edges.

Maintain Seams

Try to preserve material discontinuities.

Wrap Texture Coordinates

Allow the texture coordinates to wrap around from 1 to 0 and vice versa.

Volume Preservation

Add an additional term to try to preserve the volume of a model during simplication.

Texture Coordinates

If you model has decal texture coordinates and you wish to preserve them during simplification, you can enable this option, but the simplification will take significantly longer. You also have the option to apply the decal texture coordinates from the hi resolution model. It is much faster to simplify a model then derive the texture coordinates.

Weight of Attributes

When simplifying using attributes, this sets the relative strength of attributes vs. position.

Generate Progressive Mesh

Once the simplifications are set, **Generate Progressive Mesh** creates a history of face simplifications that are accessed using the scroll bar. The desired number of faces can also be entered directly without using the scroll bar. **Clear Progressive Mesh** clears the history above the bar's current level. To change the settings of the simplification, move the bar to the full-face count and then **Clear Progressive Mesh**.

Generate Normal Map Button

You can create normal maps for your working model. Texture map coordinates may be generated automatically by grouping faces together into charts. A *chart* is a set of faces that are grouped together in a texture. After texture coordinates have been generated, ray casting is used to sample the reference model. You can choose the size of the normal map for each LOD.

For more information on texture mapping, refer to *Texture Mapping Progressive Meshes* by Pedro Sander, John Snyder, Steven Gortler, and Hugues Hoppe at:

http://people.deas.harvard.edu/~pvs/research/tmpm/

The image in Figure 7 is a normal map that shows the faces grouped into charts.

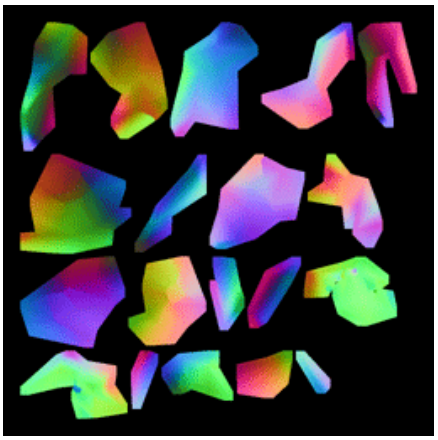


Figure 7. Normal Map Charts

Normal Map Settings… Button

The **Normal Map Settings...** button displays the menu shown in Figure 8. The Normal Map Settings menu can be divided into three functions: generating texture coordinates for normal map, casting rays, and ray bounds. Descriptions of these functions are in Table 2, 3, and 4.

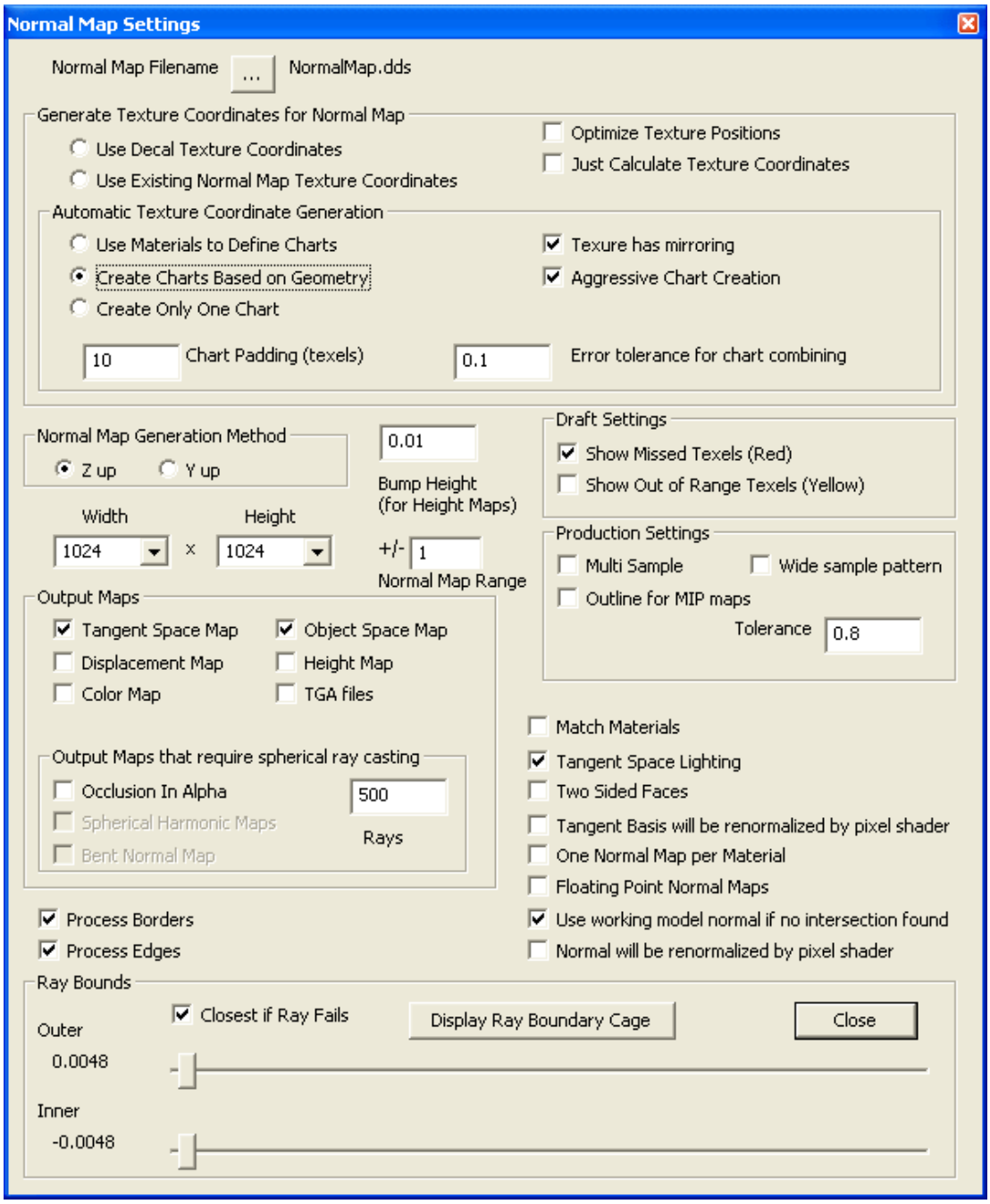
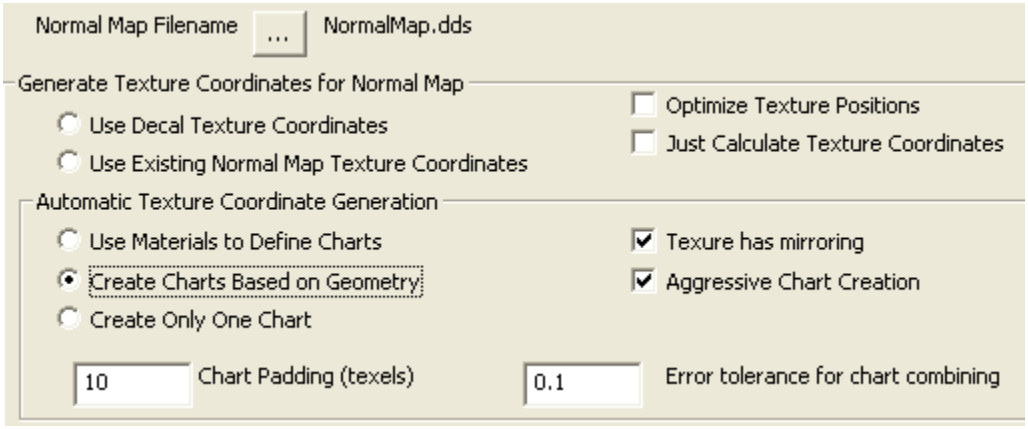


Figure 8. Normal Map Setting Menu

Generating Texture Coordinates for Normal Map

This section of the Normal Map Settings menu specifies what texture coordinates to use when creating normal maps.

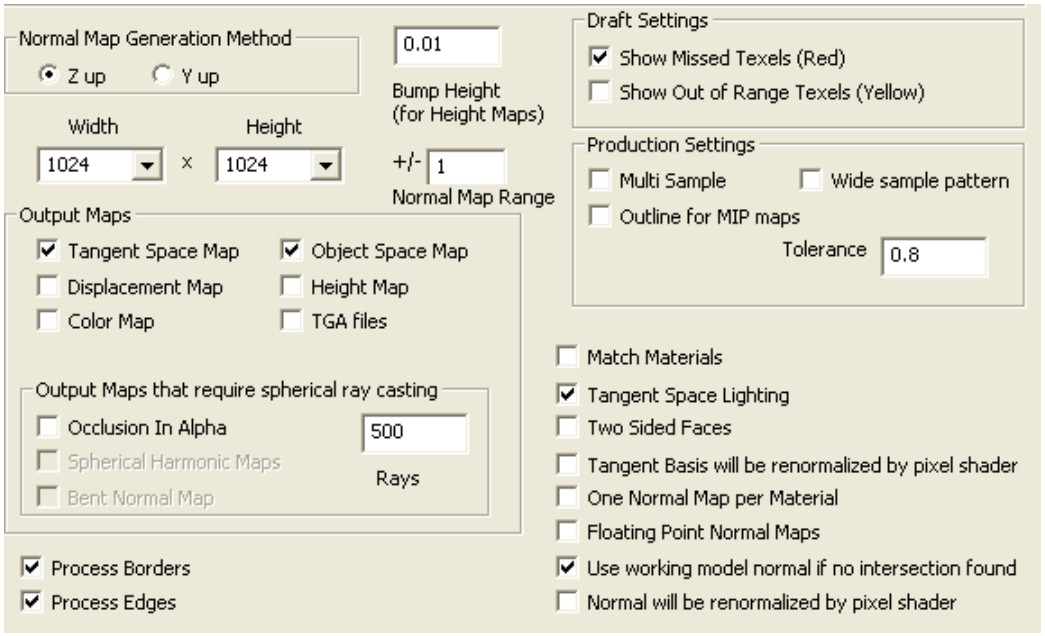
Table 2. Top Section of Normal Map Setting Menu

Menu Function	Description
 Top section of **Normal Map Setting** menu	
Use Decal Texture Coordinates	Specifies to use the texture coordinates that are used for the decal texture.
Use Existing Normal Map Texture Coordinates	Specifies to use the existing texture coordinates that are used for the normal map. This is usually selected when you are repeating a normal map calculation after using Generate Normal Map Texture Coordinates.
Use Materials to Define Charts	Automatically generate normal map texture coordinates. This method groups texture coordinates by attribute group.
Create Charts Based on Geometry	Automatically generate normal map texture coordinates. The geometry defines how charts are assigned. Flat area will tend to be combined into one chart and sharp corners will define chart boundaries. This method is an implementation of the chart combining technique.
Create Only One chart	Specifies to automatically generate normal map texture coordinates. Use this method if you have one connect boundary on your model.
Chart Padding	How much extra space is left between groups on the chart for MIP mapping. Specified in texels
Error Tolerance for chart combining	how flat faces are to each other to determine if they are part of the same group.
Optimize Texture Positions	This option will reduce the texture distortion by flattened out charts to minimize distortion. This operation will rotate charts to re-pack them.
Just Calculate Texture Coordinates	Only calculate texture coordinates and do not generate normal maps

Menu Function	Description
Texture has Mirroring	If your texture has mirroring (a chart is reflect onto two parts of a model. For example, your chart only contains half of a head, but is used for both sides of the head). This option will prevent half of the model from looking like "up" bumps go "down".
Aggressive Chart Creation	Aggressively combine charts. Unchecking this creates more charts, but may fix some lighting problems.

Casting Rays

Table 3. Middle Section of Normal Map Setting Menu

Menu Function	Description
 Middle section of **Normal Map Setting** menu	
Z up/Y up	Specifies which component of the normal vector encoded the 'up' direction (the direction of the surface normal).
Width x Height	Define the size of the normal map.
Bump Height	If there is a bump map applied to the reference model, this specifies the scale of the bumps relative to the size of the reference model.
Normal Map Range	A typical normal map is in the range [-1,1], but you can set this larger if your tangent space normals fall out of this range due do excessive shearing.
Output Maps	In addition to normal maps, you can output displacement, height and color maps.
	Displacement Map: Stores the distance from the working model to the reference model.
	Color Map: Resamples the decal texture in the normal map texure coordinates.

Menu Function	Description
	Height Map: Stores the distance from the working model to the reference model as shades of white. Scales maximum distance as 255.
	Occlusion in Alpha: You can create a visibility be cast may rays from the working model. The result is the percentage of rays that are not occluded.
	TGA: You can output Targa (.tga) files instead of .dds files.
Draft Settings	**Show Missed Texels** (Red) – When a ray is cast from the working model and no intersection is found on the reference model, make the texel red. This is usually set initially when determining the ray casting distance. If you get a lot of red texels, increase the ray bounds and see how they compare to the reference model.
	Show Out of Range (Yellow) – Some time the tangent space gets distorted so that the tangent space normals fall out of the range [-1,1] which is the range usual range for a tangent space normal map. Setting this displays all out of range normals as yellow.
Production Settings	**Outline for MIP maps**: Makes a border around the charts so MIP mapping will not show artifacts.
	Multi Sampling: Cast mulitple samples per texel instead of one.
	Wide Sample Pattern: When multisampling, the sample pattern is scattered over a larger area. May cause some blurriness.
	Tolerance: Determines when multi-sampling will be enabled. This is the dot product of two normals. The number ranges from -1 to 1. -1 is the least samples and 1 will generate the most multisamples.
Match Materials	When trying to locate the normal from the reference model, you can examine only those triangles that have the same material.
Tangent Space Lighting	Pixel shader will perform lighting in tangent space vs object space.
Two Sided Faces	Usually, we want triangles facing the same direction and the vertex normal. This option allows all triangles from the reference model to be considered.
Tangent Basis will be renormalized by pixel shader	The interpolated tangent space basis matrix will be reorthonormalize in the pixel shader.
One Normal Map per Material	Set this if each material has its own texture coordinate set and you are using those texture coordinates for your normal map. A normal map for each material will be created.
Floating Point Normal Maps	Output of normal maps is floating point.
Use Working Model Normal if no intersection is found	If a ray is cast from the working model and it does not intersect anything in the high resolution model, the use the normal from the working model. This can happen in the working model geometry extends beyond the reference model. Example is a leaf, the working model is a plane and the reference model is detailed. Potions of the working model will not intersect the reference model.
Normal will be renormalized by the pixel shader	To overcome bilinear interpolation artifacts, the pixels shader might renormalize the samples from the normal map.

Menu Function	Description
Process Borders	The borders of triangles are processed separately. Use this to disable this. This is mostly for debug purposes.
Process Edges	The borders of triangles are processed separately. Use **Process Edges** to disable this. (Mostly used for debug purposes.)

Ray Bounds

Rays are generated from the low resolution mesh outward and intersect the high resolution mesh to get the surface values from the reference mesh to store into texture maps. Sampling the normal from the high resolution mesh and storing it in a texture map is called a *normal map*. The distance that these rays start from models is specified as a distance, per vertex, from the working model.

Figure 9 shows the outer cage and the inner cage. The rays start from the outer cage (in white) and stops at the inner cage (in grey).

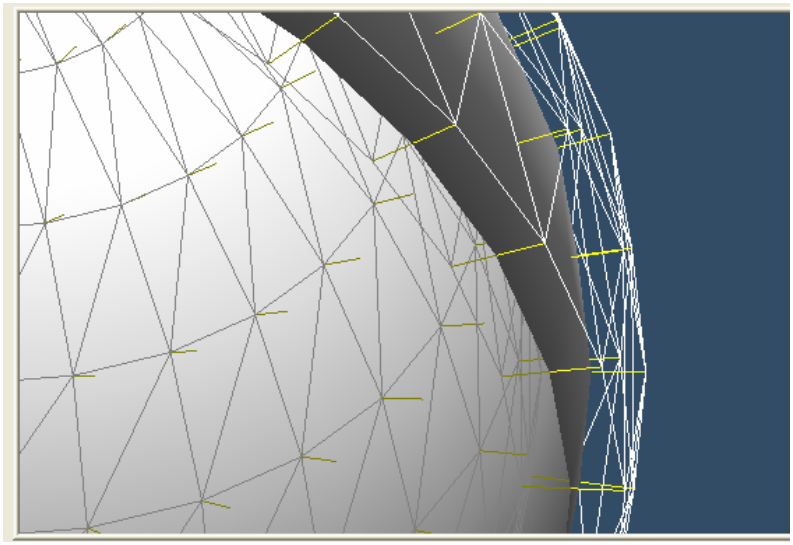
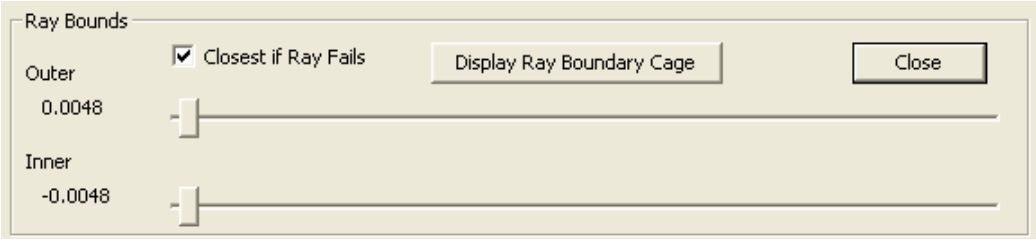
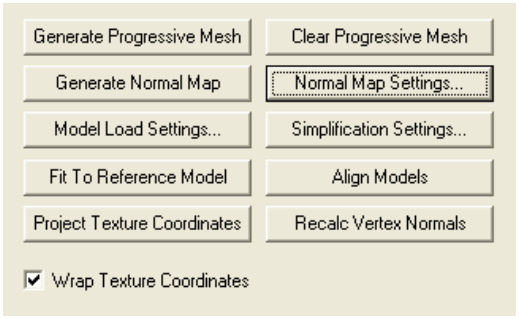


Figure 9. Ray Bounds

Table 4. Bottom Section of Normal Map Setting Menu

Menu Function	Description
 Middle section of **Normal Map Setting** menu	
Closest if Ray Fails	If the ray cast fails to find an intersection point, find the nearest point on the reference model.
Display Ray Boundary Cage	Displays the ray cage in the main display. To change the ray bounds, set the **Outer** and **Inner** sliders, then press the display button again. The ray bounds are display in the main dialog. Hit **Clear Lines** in the main dialog to clear the ray bounds.

Fit to Reference Model (Main Dialog)



The Fit Point to Reference Model operation moves each vertex so that the mesh is close to the original mesh.

Projecting Texture Coordinates

There are two options when selecting Projecting Texture Coordinates.

Calculate Decal Texture Coordinates From Reference

Projects the decal coordinates from the reference onto the current LOD.

Calculate Normal Map Texture Coordinates From LOD0

Calculates the texture coordinates from LOD0 so that all the detail levels can use the same coordinates.

Align Mode Button

Use this button to reposition and scale the reference model and align it with the working model. Only do this if the reference model and the working model are not properly aligned.

Line Drawing Section

Use this section of the Main Menu to create a list of lines and display them. Select the types of lines and press **Build Lines**. Figure 10 shows the location of the Line Drawing interface and Table 5 lists the options of this section.

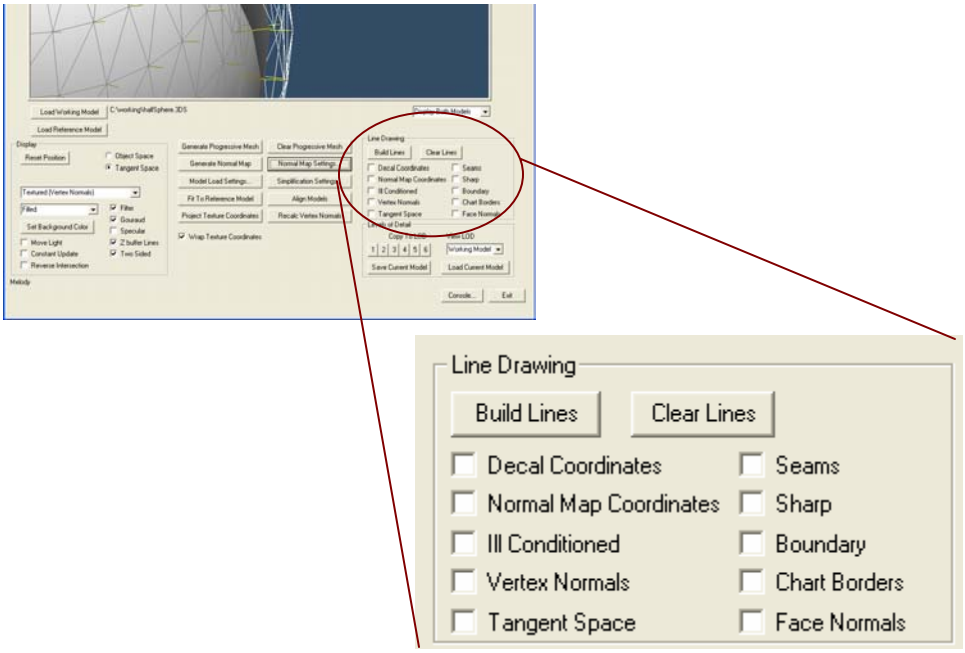


Figure 10. Line Drawing Interface of Main Menu

Table 5. Line Drawing Interface

	Description
Clear Lines	This button is used to clears the line list.
Decal Coordinates	Check this box to display texture coordinate chart.
Normal Map Coordinates	Check this box to display normal Texture map chart.
Ill Conditioned	Check this box to display ill conditioned edges in green. Ill conditioned edges have 3 or more connected faces.
Vertex Normals	Check this box to display all vertex normal.
Tangent Space	If available, the tangent and binormal and normal are displayed. This requires texture coordinates.
Seams	Check this box to display all edges that are seams
Sharp	Check this box to display all edges that are sharp
Boundary	Check this box to display boundary edges, (edges that have only one face)
Chart Borders	Check this box to display the border of charts

Levels of Detail

The Levels of Detail section of the Main menu

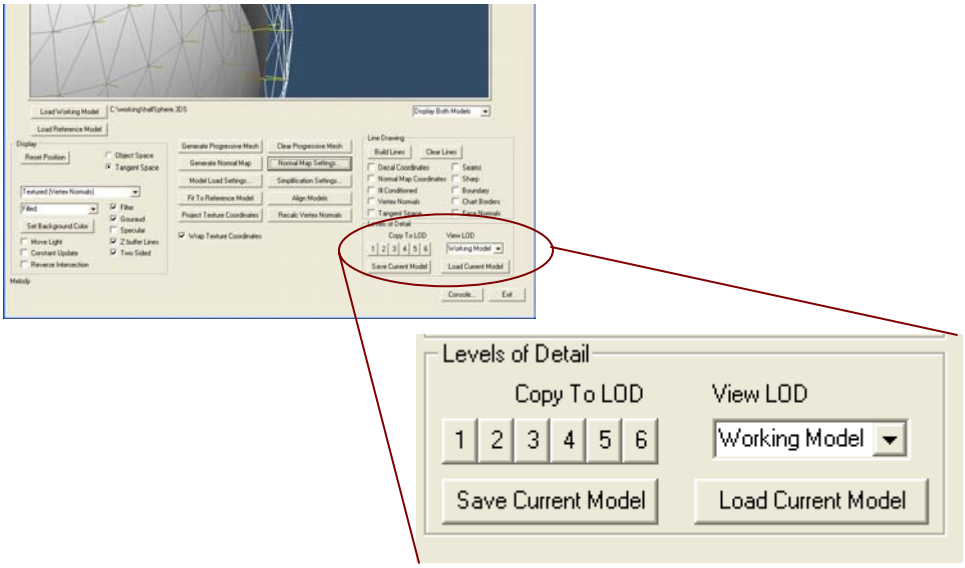


Figure 11. LOD Management Panel

Save Current Model

Saves the currently selected working model to a `.3ds` or `.obj` file.

- **`.3ds`**
  Allows only one set of texture coordinates. The normal map texture coordinates are exported
- **`.obj`**
  The normal map texture coordinates are exported. The tangent space basis and decal coordinates are stored as comments.

Load Current Model

Loads the current LOD with a model.

Command Line

The feature set of Melody is available as a command line program: **`MelodyCL.exe.`**

The options are set in an example file named **`Melody.ini.`**

The format is as follows:

```
MelodyCL  <init file> <reference model> <working model> <target model>
```

All of the options available in the Windows version are available by setting the values in the **`.ini`** file. See Melody.ini for a detailed description of each option.

Feedback

If you have any problems with Melody or questions, feature requests or just some feedback on Melody, please contact us via email at:

nvmelody@nvidia.com.

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