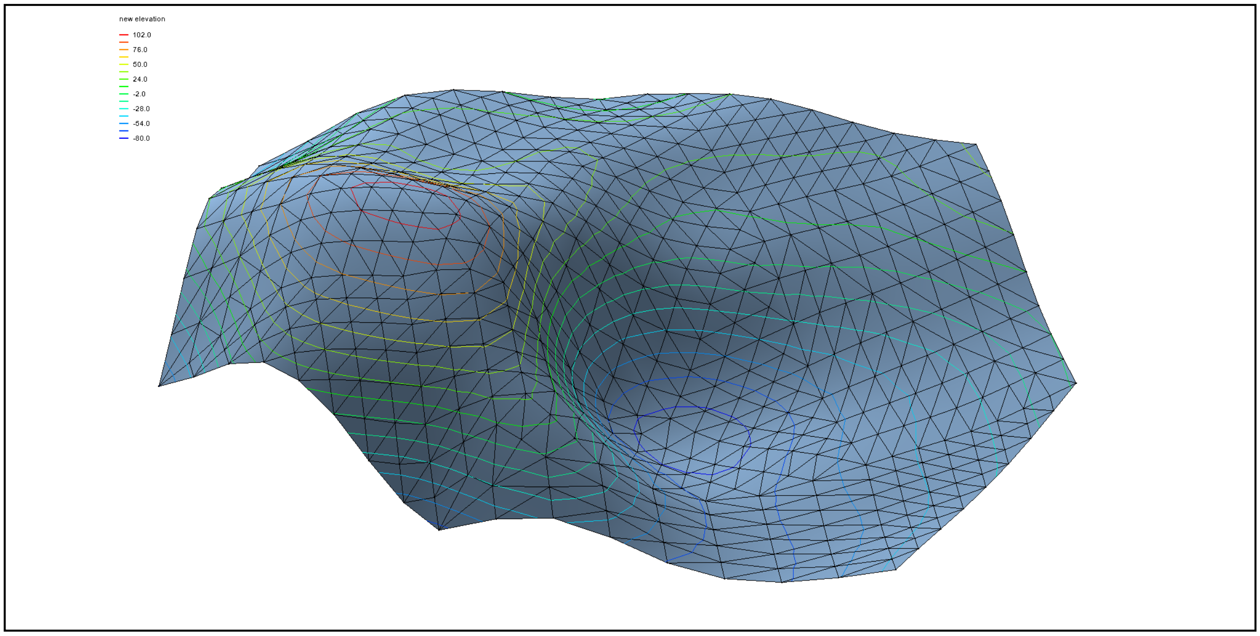
v. 9.2

GMS 9.2 Tutorial

Stratigraphy Modeling – TIN Surfaces

Introduction to the TIN (triangulated irregular network) surface object



Objectives

Learn to create, read, alter and manage TIN data from within GMS.

Prerequisite Tutorials

- None

Required Components

- Geostatistics
- Sub-surface Characterization

Time

- 30-60 minutes

1 Contents

2 Introduction

The *TIN* module in GMS is used for general-purpose surface modeling. TIN is an acronym for Triangulated Irregular Network. TINs are formed by connecting a set of xyz points with edges to form a network of triangles. The surface is assumed to vary linearly across each triangle. TINs can be used to represent the surface of a geologic unit or the surface defined by a mathematical function. Elevations or other values associated with TINs can be displayed with contours. TINs are used in the construction of solid models and 3D finite element meshes.

2.1 Outline

This is what you will do:

1. Create a TIN by importing vertices and triangulating.

2. Change the contour and lighting options.

3. Edit the TIN vertices.

4. Smooth the TIN.

5. Read in another TIN and manage multiple TINs.

3 Getting Started

Let's get started.

1. If necessary, launch GMS. If GMS is already running, select the *File* | *New* command to ensure that the program settings are restored to their default state.

4 Importing Vertices

To begin reviewing the tools available for TIN modeling, we will first import a set of vertices from a file. To import the vertices:

1. Select the *Open* button .

2. In the *Open* dialog, locate and open the directory entitled **Tutorials\Stratigraphy_ Modeling\TINs**.

3. Select the file named **verts.gpr** and click *Open*.

A set of points should appear on the screen. The points are not connected by triangles yet.

5 Triangulating

To construct a TIN, we must triangulate the set of vertices we have imported. To triangulate the points:

1. In the *Project Explorer,* expand the "TIN Data" item , if necessary, so that the "verts" TIN can be seen.

2. Right-click on the "verts" TIN in the *Project Explorer* and select the *Triangulate* command from the pop-up menu.

The vertices should now be connected with edges forming a network of triangles. The triangulation is performed automatically using the Delaunay criterion. The Delaunay criterion ensures that the triangles are as "equi-angular" as possible. In other words, wherever possible, long thin triangles are avoided. A more complete description of the triangulation algorithm can be found in the *GMS Help*.

There are some long skinny triangles on the border that we should get rid of. GMS can find them automatically.

3. Select the *TINs | Advanced | Select Boundary Triangles* menu command.

4. Hit the *Delete* key.

The long skinny triangles are now gone.

6 Contouring

Now that the TIN is constructed, we can use it to generate a contour plot of the TIN elevations.

1. Select the *Display Options* button .

2. Make sure the *TIN Data* item is selected in the list in the upper left corner of the dialog.

3. Turn **off** the *Vertices* and *Triangle edges* options and turn **on** the *TIN boundary* and *Contours* options.

4. Click *OK*.

The contours are generated by assuming that the TIN defines a surface that varies linearly across the face of each triangle.

7 Lighting

Another way to visualize a TIN is to use a light source.

1. Select the *Display Options* button .

2. Turn **off** the *TIN boundary* and *Contours* and options and turn **on** the *Triangle faces* option.

3. Select the *Lighting Options* item in the list on the left.

4. Verify that the *Enable shading* option is turned on.

5. Click *OK* to exit the *Display Options* dialog.

6. Select the *Oblique View* button .

You should now see the TIN shaded with a red material and pattern as in Figure 1. The material color and pattern can be adjusted be selecting the *Material* button.

7. Select the rotate tool and drag the mouse in the graphics window to rotate the view.

Feel free to adjust the lighting options to see how they affect the display of the TIN.

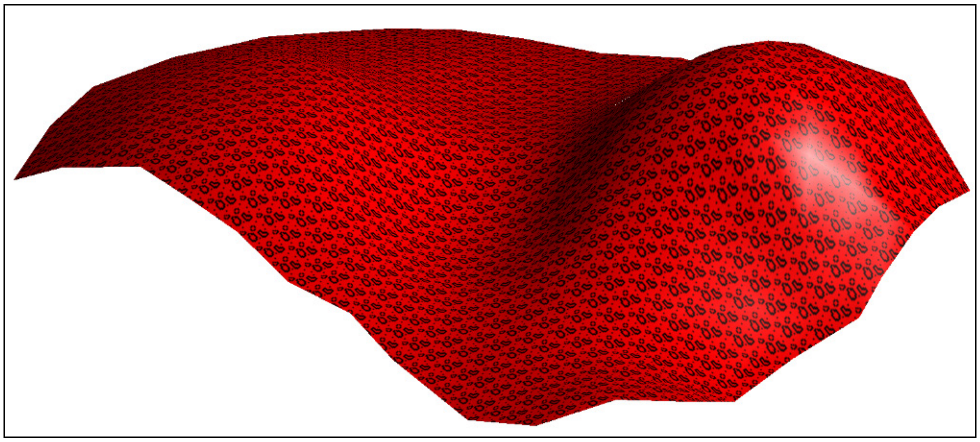


Figure 1. TIN with faces, patterned material, and light source.

8 Editing TINs

A variety of tools are provided in GMS for editing TINs. Before reviewing these tools, we will reset some of the display options.

1. Select the *Display Options* button .
2. Turn **on** the *Vertices, Triangle edges* and *Contours* options.
3. Turn **off** the *Triangle faces* option.
4. Select the *Options* button to the right of the *Contours* option.
5. In the section titled *Contour interval*, select the *Specified Interval* option and change the interval to **20.0**.
6. Click *OK* to exit the *Contour Options* dialog.
7. Click *OK* to exit the *Display Options* dialog.

8.1 Locking/Unlocking Vertices

In many cases, some of the vertices defining a TIN come from actual measured data such as a borehole log and can be considered "hard" data. In other cases, vertices are added manually and represent "soft" data used simply to fill in gaps. By default, TIN vertices are locked and not editable so that a vertex corresponding to an actual measurement is not accidentally edited. Editing TIN vertices can be accomplished by unlocking the vertices.

1. Select the *TINs* | *Lock All Vertices* menu command to unlock the vertices.

The TIN vertices are now unlocked and can be edited. Unlocked vertices are locked by again selecting the *TINs* | *Lock All Vertices* menu command.

8.2 Dragging Vertices

One of the simplest ways to edit a TIN is to drag the vertices with the mouse. This can be accomplished with the *Select Vertices* tool.

1. Select the *Plan View* button.
2. From the *Tool Palette,* choose the *Select Vertices* tool.
3. Choose one of the vertices in the interior of the TIN and drag it to a new location.

Notice that you are not allowed to drag an interior vertex beyond the boundaries of the adjacent triangles. This prevents the triangles from becoming inverted.

8.3 Dragging in Oblique View

When dragging in plan view, the vertex is constrained to move in the xy plane. To change the z coordinate, we must drag the vertices in oblique view (or front or side view).

1. Select the *Oblique View* button.
2. Select one of the vertices and drag the vertex up and down.

Notice that as you drag the vertex in oblique view, you are constrained to move the vertex along the z axis.

8.4 Using the Edit Window

In many cases, dragging vertices with the mouse is not adequately precise. It is often necessary to change the vertex coordinates to a specific value. This type of editing can be accomplished with the input fields at the top of the GMS window.

1. Click on any one of the vertices to select it.

Notice that as the vertex is selected, the coordinates of the vertex are displayed in the fields at the top of the window. The edit fields can be used to change the x, y, or z coordinates of the selected vertex.

Figure 2. XYZF edit fields.

2. Move the cursor to the z coordinate field and enter a value that is 10 more than whatever the current z value is.

3. Hit the *Return* or *Tab* key.

8.5 Adding Vertices

As mentioned above, when working with TINs it is often necessary to edit a TIN by adding supplemental vertices to the TIN to provide more resolution or detail in an area of interest. Vertices can be added to a TIN in GMS simply by pointing and clicking.

1. Select the *Plan View* button
2. Select the *Create Vertex* tool.
3. Place the cursor in the interior of one of the triangles in the TIN and create a vertex by clicking the mouse button.

The new Z value for the vertex is computed using a linear interpolation of the surrounding vertices. The vertex is selected and can be edited, if unlocked, using the edit fields in the *Edit Window*.

8.6 Deleting Vertices

It is also frequently necessary to delete vertices. To delete the vertex you just created:

1. Make sure the vertex is still selected, or select it again if necessary (using the *Select Vertices* tool).
2. Select the *Edit* | *Delete* menu command.

Notice that all of the triangles connected to the vertex were deleted. By default, this is what happens when a vertex is deleted. The resulting void can be filled with triangles by using the *Create Triangle* tool to manually create triangles. However, another option is available for deletion that causes the region surrounding a deleted vertex to be automatically retriangulated.

3. Select the *TINs* | *TIN Settings* menu command.
4. Turn on the *Retriangulate after deleting* option.
5. Select the *OK* button.
6. Choose the *Select Vertices* tool .
7. Select one of the vertices in the interior of the TIN.
8. Select the *Edit* | *Delete* menu command.

Notice that the triangles next to the deleted vertex are deleted but the resulting void is retriangulated.

9 Smoothing a TIN

As mentioned above, a TIN represents a piecewise linear surface. If the vertices defining the TIN are sparse, the linear surface defined by the triangles may appear excessively irregular. A TIN can be smoothed in GMS by copying the TIN vertices to a scatter point set, subdividing the TIN into a denser set of triangles, and interpolating the elevations to the new vertices in the TIN. The resulting TIN is still piecewise linear but it appears much smoother since the triangles are smaller.

9.1 Deleting the TIN

We will now go through an example of TIN smoothing, but first we will read in a different TIN since we have made several changes to this TIN.

1. Select the *New* button .
2. Select *No* to avoid saving the changes.
3. Select the *Open* button .
4. Open the file named "sparse.gpr".

9.2 Copying the Vertices

The first step in smoothing the TIN is to copy the vertices of the TIN to a scatter point set. This will allow us to use the scatter point set later to interpolate the z values of the original vertices to the new vertices created while subdividing the TIN.

1. Right click on the "sparse" TIN in the *Project Explorer* and select the *Convert To | 2D Scatter Points* menu command.

9.3 Subdividing the TIN

The next step is to increase the resolution of the TIN by uniformly subdividing the TIN.

1. Right-click on the "sparse" TIN in the *Project Explorer* and select the *Subdivide* menu command.
2. Move the scroll bar to select a subdivision factor of **8**.
3. Select the *OK* button.

9.4 Interpolating the Elevations

Notice that the contours of the TIN have not changed. There are more triangles in the TIN but they still define essentially the same surface. To smooth the TIN we must use one of the interpolation schemes and interpolate from the original vertices of the TIN to the new vertices created during the subdivision process.

1. Select the *Oblique View* button.
2. In the *Project Explorer*, right-click on the “sparse” scatter point set (not the “sparse” TIN).
3. Select the *Interpolate To | Active TIN* menu command.

At this point we could pick the interpolation options we want to use, but we will just use the default options.

4. For the *Interpolated data set name*, enter “**new elevations**”.
5. Click *OK*.

The TIN now appears smoother. You may want to switch between the “default” and “new elevations” data sets to see the difference on the TIN (you may need to expand the TIN in the *Project Explorer* to see the data sets).

9.5 Deleting the Scatter Point Set

The TIN smoothing process is now completed. Since we no longer need the scatter point set, we will delete it.

1. In the *Project Explorer*, right-click on the “sparse” scatter point set (not the “sparse” TIN) and select the *Delete* command from the pop-up menu.

10 Reading Another TIN

In GMS, several TINs can be modeled at once. For example, we will now read in another TIN without first deleting the existing TIN.

1. Select the *Open* button.
2. In the *Open* dialog, select the **All Files [*.*]** filter.
3. Select the file named “surface.tin”.
4. Click *Open*.

You should now see two TINs displayed at once.

11 Changing the Active TIN

Whenever multiple TINs are being modeled, one of the TINs is designated as the active TIN. Only the active TIN can be edited. A TIN can be designated as the active TIN using the *Project Explorer* or by selecting the TIN with the select TINs tool.

1. Expand the *TIN Data* folder in the *Project Explorer* if necessary.

2. Choose the *Select TINs* tool .

Notice that triangular shaped icons appear at the center of each TIN. A TIN is selected by selecting the TIN icon. The active TIN has a letter "A" displayed in the center of the icon.

3. Click on the TIN icon named **sparse**.

The letter "A" is now displayed in the icon for the “sparse” TIN. This TIN can now be edited. Also notice that the *Project Explorer* is updated to show which TIN is active.

4. In the *Project Explorer*, select the **surface** TIN .

Notice the “A” has switched back to the “surface” TIN.

12 Hiding and Showing TINs

When multiple TINs are in memory, it is sometimes useful to hide some of the TINs temporarily. This makes the display less cluttered and makes it easier to edit or visualize an individual TIN. For example:

1. In the *Project Explorer*, uncheck the TIN named “**sparse**”.

An alternative approach is to select the TIN and click the *Hide* button .

13 Conclusion

This concludes the tutorial. Here are the things that you should have learned in this tutorial:

- How to triangulate a set of points.
- How to visualize a TIN in different ways including using contours, turning on the triangle faces, and adjusting the lighting.
- How to edit the TIN by dragging, adding and deleting vertices.
- How to smooth a TIN via interpolation.

- How to specify the active TIN, and hide and show TINs.

