ArcView 3D Analyst Features

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Overview

The ArcView® 3D Analyst™ extension to ArcView GIS software turns conventional two-dimensional flat maps into dynamic, interactive three-dimensional views. Users can create and display surface data in three dimensions for analysis and visualization.

ArcView 3D Analyst supports three primary data types for modeling three-dimensional features—grids, triangulated irregular networks (TINs), and shapefiles (2D and 3D). Grids and TINs are used to model continuous data or surfaces. Three-dimensional vector features, where X, Y, and Z values are stored for every vertex, let users capture and precisely represent geographic features.

Both two-dimensional and three-dimensional data can be viewed in perspective using the ArcView 3D Analyst 3D Scene Viewer. With the viewer, a user can rotate, zoom in and out, and pan the data from any angle in a scene.

With ArcView 3D Analyst, users can perform a wide range of activities.

- Create realistic surface models from multiple input sources.
- Determine height at any location on a surface.
- Find what is visible from an observation point.
- Calculate the surface area and volume between surfaces.
- Work with three-dimensional vector features to make realistic models of the three-dimensional world.
- Visualize data in three dimensions.
- View in pan and zoom mode as well as interactively tilt and rotate data, featuring fly-through simulation.
- Turn maps into Web-viewable VRML files.
- Allow creation of TINs from any combination of point, line, and polygon feature types or from grids.
- Import gridded elevation models including USGS DEMs.

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Creating Three-Dimensional Data

ArcView 3D Analyst creates surfaces from a wide variety of data sources. Users make grids by importing U.S. Geological Survey (USGS) digital elevation models (DEMs), digital terrain elevation data (DTED) files, raw ASCII files, or one of many image formats. With these surfaces users can create spot heights, profiles, contours, view sheds, steepest paths, and more. Attributes of thematic data can be used for height, facilitating the creation of three-dimensional block diagrams or choropleth maps.

The three data types used in ArcView 3D Analyst for modeling surfaces are grids, TINs, and shapefiles.

Grid

A grid is an object that stores spatial data in a raster data format in which space is partitioned into square cells and each cell stores a numeric data value.

Data Types

ArcView 3D Analyst supports two types of grids: discrete and continuous.

Discrete grids—Named for categorical information such as country names, land use types, ZIP Codes, road types, and land ownership. The values are always stored as an integer grid theme.

Continuous grids—Phenomena along a range such as population density, pH, average income, elevation, and the price of land. Values can be stored as either an integer or floating point grid theme.

Convert from a Feature Theme

Feature themes created from any type of source file can be converted to a grid theme regardless of whether the source data is a computer-aided design (CAD) drawing, ARC/INFO® coverage, or shapefile. Only the selected features in a theme will be converted to the output grid theme. If the theme does not contain a selected set, then all features will be converted to the output grid theme.

Converting Polygons, Lines, and Points

Polygons, lines, and points can be converted using both string and numeric fields. If a string field is used, then each unique string in the feature theme is assigned a unique value in the output grid theme.

Converting Images

An image theme with single or multiple bands can be converted to a grid theme. The conversion of image themes to grid themes is a change in file type. The output grid theme will have the same extent, cell size, and cell values as the original image theme. The analysis environment settings for the view are ignored.

Interpolation Methods

Four interpolation methods are available to create grid surfaces: inverse distance weighted (IDW), spline, kriging, and polynomial trend.

- IDW assumes each input point has a local influence that diminishes with distance. IDW weights the points closer to the processing cell greater than those farther away. A specified number of points, or all points within a specified radius, determines output value for each location. IDW assumes the variable being mapped decreases in influence with distance from its sampled location.

- Spline fits a minimum-curvature surface through the input points. It minimizes the total curvature of the surface. Spline fits a mathematical function to a specified number of nearest input points while passing through sample points.

- Kriging assumes the distance or direction between sample points reflects spatial correlation that can be used to explain variation in the surface. Kriging fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location.

- Polynomial trend fits a mathematical function, a polynomial of specified order, to all input points. When calculating the mathematical function to describe the resulting surface, polynomial trend uses a least-squares regression fit. The resulting surface minimizes the variance in relation to the input point values.

Grids can also be created from TINs through the use of linear interpolation on the TIN's triangle facets.

TIN

A TIN is another type of an object used to represent a surface. A TIN partitions a surface into a set of contiguous, nonoverlapping triangles. Users can create TINs from any combination of point, line, and polygon feature types, as well as grids. Data that has no height information, but is still important in defining a surface (such as a study area boundary), can also be used in creating a TIN. Some sources of data with Z values include

- Digitized cartographic sources—Contours and spot heights

- Remote accessing sources—Spot heights and break lines derived from aerial photography, satellite imagery, radar, or lasers

- Engineering sources—Survey, CAD, and global positioning system (GPS)

- Environmental sources—Weather stations, wells

- Geologic sources—Boreholes

TINs can be created in either View or 3D Scene documents using features in active feature themes as input for triangulation. Users can define three-dimensional graphics with the cursor. Heights for the graphics are interpolated from the active TIN or grid theme. There are tools for lines, points, and polygon boundaries.

Types of Surface Features

Features used in the triangulation process must be incorporated as a particular kind of surface feature type. Supported surface feature types for TINs include

- Mass point—Individual points are entered into the triangulation process as nodes to the triangulation.

- Break line—Linear feature represented as a sequence of one or more triangle edges.

- Polygon features—A closed sequence of three or more triangle edges.
- Replace polygon—The boundary and all interior heights will be assigned one constant value.
- Erase polygon—All areas within the polygon are marked as being outside the zone of interpolation for the model. Analytic operations, such as volume calculations, contouring, and interpolation, will ignore these areas.
- Clip polygon—All areas outside the polygon are marked as being outside the zone of interpolation for the model. Analytic operations will ignore these areas.
- Fill polygon—All triangles falling inside the polygon are assigned an integer attribute value. No height replacement, erasing, or clipping takes place.

Line and polygon surface features can be tagged as either hard or soft. Hard features indicate a significant break in slope such as roads, streams, and shorelines. Soft features indicate ridgelines or rolling hills. With a point theme as input, the only surface feature type will be mass points. With a line theme, the options will be mass points and hard and soft break line types. Options for a polygon theme are mass points, hard and soft break lines, hard and soft replace, erase, and clip polygon types.

Creating a TIN from a Grid

Converting grids into TINs is done by specifying the vertical accuracy required of the output TIN relative to its source grid. ArcView 3D Analyst will automatically select the subset of the input grid-cell centers that are needed to meet the specified accuracy and use them as points to create the TIN. The vertical accuracy represents the amount the resulting TIN can differ in height, above or below every cell center in the input grid.

TIN Editing

Simple editing of TINs is supported. Features can be added to an existing TIN and the heights of existing nodes can be modified.

Setting Node and Triangle Values

Values can be assigned to output node and triangle features by setting value fields. With the mass point output type, the values will be assigned to nodes. If the output type is polygonal, the values will be assigned to triangles. Values are stored with the TIN data model and can be used for display, query, and modeling. Some example uses for node and triangle values are

- Node values can be used to help assess the accuracy of interpolation results from one location on a TIN to another by letting users query information about nearby nodes.
- Land cover codes can be assigned to triangles that can be retrieved for use in a water runoff model or display polygonal information in three dimensions.

Shapefiles

Shapefiles are a third way to display and analyze three-dimensional data. Shapefiles contain vector data stored as X, Y, and Z coordinates to define simple, discrete geometry such as points, lines, and polygons.

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Convert Two Dimensions to Three Dimensions by Attribute or by Overlay

When only two-dimensional shapefiles are available, ArcView 3D Analyst can use attributes of thematic data for height, facilitating the creation of three-dimensional block diagrams or choropleth maps. Data can also be interactively overlaid on any surface. Users can convert two-dimensional shapes into three-dimensional display on the fly.

Edit Z Value at Vertex

Themes with Z values can be edited in the same manner as editing the X and Y values of a two-dimensional theme. In ArcView GIS Version 3.1, the Z values can be edited using the Shape Properties Dialog Box.

Load, Use, or Convert Three-Dimensional CAD Data

CAD files that already have a Z component can be loaded and viewed as a regular two-dimensional CAD file. In addition, three-dimensional CAD data can be read directly into a 3D Scene Viewer and viewed in three dimensions.

Analyzing Data in Three Dimensions

Surface Analysis

Many types of geographic analyses, such as suitability studies, hydrologic analysis, and line-of-sight determination, use surfaces in the analysis. Other types of surfaces that are often analyzed include average rainfall, chemical concentration, and population density. Since so many phenomena are made up of surfaces, analyzing those surfaces is an efficient way to understand the phenomena.

Slope and Aspect

ArcView 3D Analyst calculates the steepness and direction of surfaces, which is commonly referred to as slope and aspect.

- Slope identifies the incline of a surface. This feature is often used to find low slopes for potential construction sites and high slopes that may be prone to erosion or landslides. Slope values are output in degrees.

- Aspect is the direction the surface faces. It is often used to determine how much sun a hill will receive or the direction of runoff. The values of the output theme are in degrees.

Contour

Contour maps are frequently used to represent surfaces. Contouring produces an output line theme from an input grid or TIN theme. Each line represents all contiguous locations with the same height, magnitude, or concentration of values in the input grid or TIN theme.

Profile

Selecting three-dimensional lines from either the graphic or the active theme, users can create profile graphs to see and measure height along those lines. Profile graphs are used for things such as evaluating the difficulty of mountain trails or assessing a corridor for rail lines.

Steepest Path

The steepest path calculates the direction a ball would take if released from a given point on the surface. The ball will take the steepest downhill path until it reaches the perimeter of the surface model or a pit, a point all surrounding areas flow into.

Surface Area Surface area is measured along the slope of a surface, taking height into consideration. The area calculated will always be greater than simply using the two-dimensional planimetric extent of the model. When compared to planimetric area, surface area provides information about surface roughness. The larger the difference between the two values, the rougher the surface.

Volume Volume calculates the cubic space between a TIN surface and a horizontal plane located at any specific elevation. The volume can be determined either above or below the plane.

Cut and Fill Cut and fill analysis determines the volumetric difference between two surfaces. The amount of material lost or gained in an area can be calculated by comparing two surface models: one before a change and one after. Cut and fill analysis is particularly useful in construction projects and environmental applications.

Slope Curvature The curvature of a gridded surface is calculated on a cell-by-cell basis. A positive curvature indicates that the surface is upwardly convex at that cell. A negative curvature indicates that the surface is upwardly concave at that cell. A value of zero indicates that the surface is flat.

Hill Shade Hill shade display brings out the relief of a surface. Users can display TIN faces with single color hill shading. The faces will all display with the same hue, but brightness will vary depending on which way they face and how steep they are. Grids can be shaded using a categorical grid with a brightness theme.

Visibility

Determining what is visible on a surface from one or more locations is useful for a wide range of applications ranging from estimating real estate value to locating communication towers or placing military troops.

View Shed Areas on a surface that are visible from one or more observation points are known as view sheds. For any visible position, users can discover how many observers can see that position. In addition to controlling the height of an observer, the view-shed function can provide constraints on how far, how high, and which direction an observer can look.

Line of Sight Line of sight determines whether a given target is visible from a point of observation. If the target is obscured, the coordinates of the first obstruction are given. Users can also find out what is visible along the line of sight.

Neighborhood Analysis

Neighborhood analysis establishes relationships between nearby features so that questions pertaining to proximity and area of influence can be answered.

Thiessen Polygons Theissen polygons can be generated from a set of input points or a TIN. The area inside each polygon is closer to the point used to generate it than any other point in the data distribution.

Transformation

Merge Two or more grids in a grid list can be merged together. In areas of overlap, the value of the first grid takes priority over the value in the second grid.

Resample

The cell size of a grid can be resampled using one of three methods:

- Nearest Neighbor—Used primarily for categorical data, such as land use classification, since it will not change the values of the cells. The maximum spatial error will be one-half the cell size.

- Bilinear Interpolation—Determines the new value of a cell based upon a weighted distance average of the four nearest input cell centers. It is useful for continuous data and will cause some smoothing of the data.

- Cubic Convolution—Determines the new value of a cell based upon a weighted distance average of the sixteen nearest input cell centers. It is appropriate for continuous data.

Shift

Users can shift a grid to a new origin with the same or a new cell size.

Visualizing Data in Three Dimensions

Displaying data in three dimensions shows patterns that are not evident in two dimensions. Interpreting contour lines or shading is not necessary; three-dimensional visualization can actually show how steep a slope is. Displaying other forms of data, such as population, in three dimensions can dramatize the situation beyond what is possible in two dimensions.

Interactive Three Dimensions

Three-dimensional data can be viewed interactively in a 3D Scene Viewer. The data can be viewed from any angle by rotating and tilting the object in the viewer. The user also has control over zooming in and out, panning, and flying forward or backward.

Control of Light Source

Shading illuminates a theme to add a sense of depth and realism. Changing the position of the light source is easy, and shading can be turned on or off.

View Two-Dimensional Images or Vectors on Three Dimensions

The three-dimensional viewing environment can temporarily convert two-dimensional features to three dimensions on the fly. In this way, two-dimensional features can be viewed in perspective without the need to create three-dimensional data sets.

The height or Z source is selected from

- Surface—The height is calculated based on values in a grid or TIN.
- Attribute—A selection is made from a list of numeric fields in the theme.
- Constant—A value is provided as a constant Z value.

Two-dimensional data can also be converted into a three-dimensional shapefile, if desired.

Legend Classification

Grid themes are symbolized with a solid fill pattern with no outline. The color can be changed but not the fill pattern or outline. Reclassification options are available in the legend editor. Integer grid themes have more reclassification options than floating point grid themes.

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ArcView 3D Analyst provides many different ways to display TIN themes. TIN themes display multiple features. Points, lines, and area features can be drawn individually, simultaneously, or in any combination. ArcView 3D Analyst provides a special Legend Editor for TIN themes to control which features are displayed and how they are symbolized.

Extrude Two Dimensions by Attribute or Function

Extrusion changes the form of a feature in the 3D Scene Viewer. Points turn into vertical lines, lines turn into vertical walls, and polygons turn into three-dimensional blocks. There are two properties for extruding feature themes: (1) an expression or value that defines how far the features should be extruded and (2) the method that defines how the features will be extruded.

Offset Three-Dimensional Data

An offset is typically applied in one of two circumstances: (1) to separate themes with similar base heights or (2) when the only height attribute for a theme is relative to a surface that is used to provide the base heights (e.g., height of utility lines above terrain). Values greater than 0.0 raise the height above the base heights; values less than 0.0 lower it.

Transparency on Features

The transparency of a theme can be specified as ranging from completely opaque to completely transparent. Making a theme transparent allows users to see through it to the features of another theme.

Multiple Surface Support

More than one surface can be displayed at a time in a 3D Scene Viewer. Along with support of offsets, displaying multiple surfaces is a good way to compare surfaces or what is happening between them.

Scene and Z-factor Exaggeration

Vertical exaggeration refers to increasing or decreasing the height in a scene. It is common to increase height of terrain models where the horizontal extent is much larger than the vertical extent. The value specified for exaggeration will multiply heights for all themes.

Export Snapshot of Picture in 3D Scene Viewer

A snapshot of the picture displayed in a 3D Scene Viewer can be taken and exported into several image formats including JPEG, Windows Bitmap, and GIF formats. Windows Bitmaps are only available when running under Windows. GIF images require a license.

VRML Export

Users can export three-dimensional scenes to an exchange format for three-dimensional data called VRML. Because VRML browsers and plug-ins are inexpensive and widely available, the three-dimensional virtual worlds that users make from existing geographic data will be accessible to a wide audience. When a scene is exported, one main file is created that references a series of other files. A separate file is made for each theme that has its display turned on. An additional file is added if the scene contains graphics.

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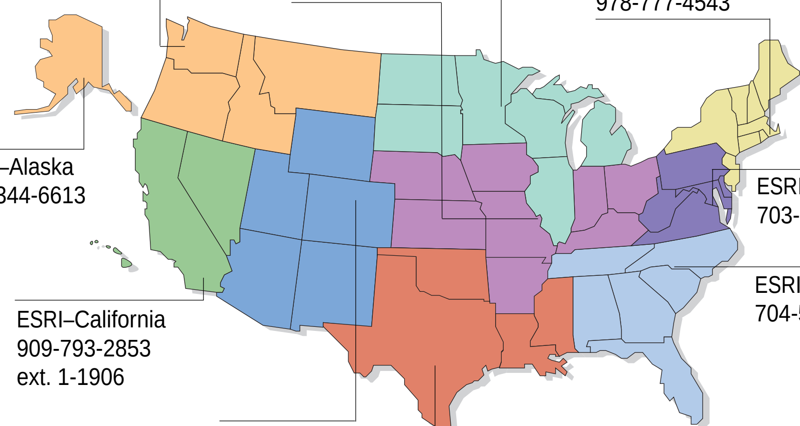

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