# Generating Surface Files from Objects

Surface generation offers users the ability to create and export surface files for 3D printing, additive manufacturing, and CAD applications. There is a fundamental transformation that needs to take place between the voxel-based volume image world and an explicit surface description file, for which Analyze provides several helpful algorithms.

Analyze provides the ability to efficiently and accurately extract and represent a surface from a specific object of interest, exporting this surface in several common surface description formats including STL (see table for a list of supported surface formats).
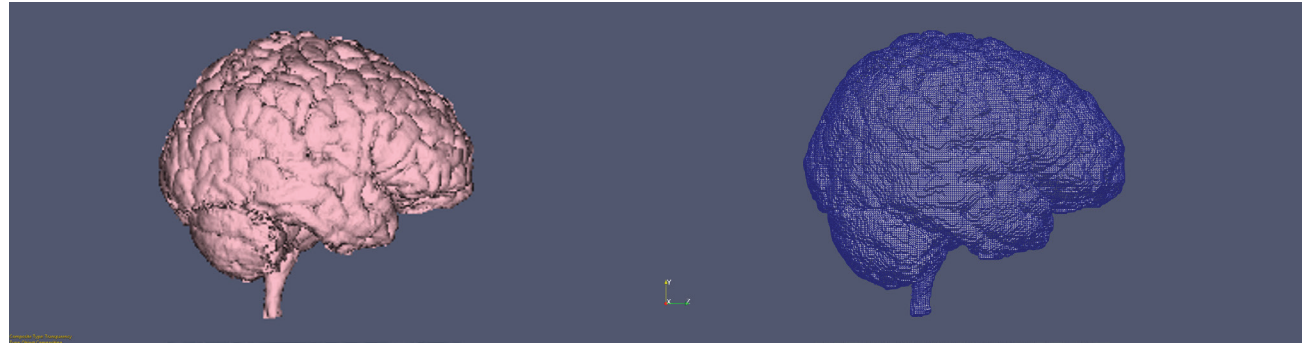
Format	Extension
Alias Wavefront	.obj
Autocad	.dxf
Compressed IGES	.iges
IGES	.iges
Inventor	.iv
Patran	.out
Ply	.ply
Poly	.poly
3D Systems	.stl
Binary 3D Systems (default)	**.stl**
VRML	.wrl

The key to surface generation is to use Analyze to accomplish a segmentation of the particular structure of interest from the volume image data, using any of the available tools provided with Segment, and then use the segmented object to drive the surface extraction process for the optimal definition and output of the surface data.
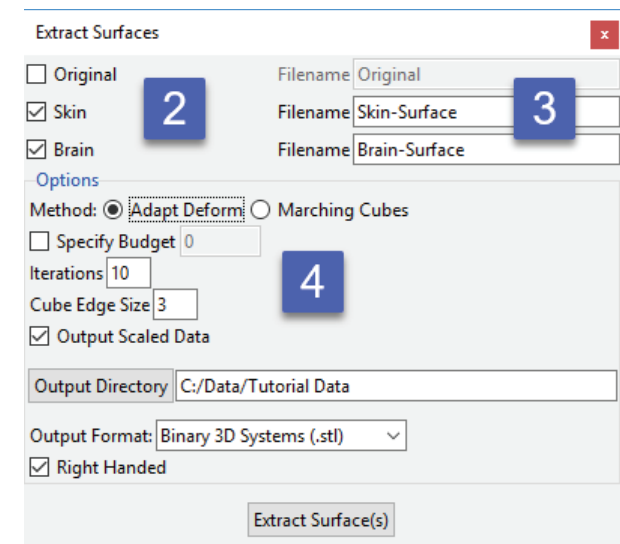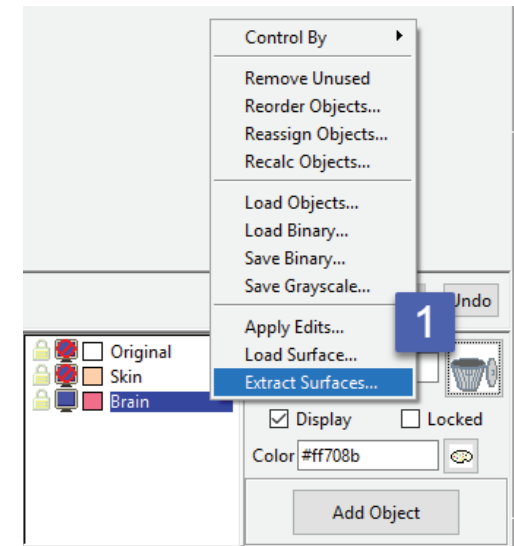
Surface Generation Options

The Segment module provides the mechanism to extract a surface description of segmented objects from volume image data via two unique Analyze-specific algorithms; Adapt Deform or Marching Cubes. Both Adapt Deform and Marching Cubes extract an optimal description of the surface with as few polygons as possible. Once extracted, the surface can be saved in many common surface description formats and imported into third party 3D printing program, CAD software, or rapid prototyping equipment.

Extract Surface: The Extract Surface window provides users with the interface to generate surface files. To access the window right click in the Object List and choose Extract Surface [1]. The following options are available:

- **Object:** The Object selection area allows users to select objects to generate surfaces for [2]. Note that multiple objects can be selected, each object will be exported to its own surface file. If users wish to combine objects in a single surface file objects either need to be combined prior to surface extraction using the Reassign Object function or combination needs to be conducted after export using a third-party application.

- **Filename:** Surface file names are specified in the Filename field. [3] This field becomes available once an object is selected.

- **Options:** The Options area allows users to specify the surface extraction method for surface generation. When a method is selected method specific options become available. User can choose between Adapt Deform and Marching Cubes:

  · **Adapt Deform:** The Adapt Deform algorithm (enabled by default) [4] specifies that the adaptive deformation algorithm will be used to generate the tiled surface.

Surface Generation Options (continued)

• **Options (continued)**

  · **Adapt Deform (continued):** This algorithm is based on an adaptive mesh model; a discrete dynamic system constructed from a set of nodal masses that are interconnected by adjustable springs. This system is governed by a set of ordinary differential equations of motion (discrete Lagrange equations) that allow the system to evolve to equilibrium.

    In the mass-spring model, the set of coupled equations are solved iteratively in time to update the position of the nodal masses until the masses reach an equilibrium position. For the purposes of surface reconstruction, the equilibrium positions of the nodal masses will approximate the surface of the object. The initial positions of the nodal masses are determined by creating a rough approximation of the surface using a surface tracking technique. A cubic grouping element is used to create a lower resolution version of the data set, which is then systematically triangulated to form the initial approximation of the surface. The following options are available:

  · **Specify Budget:** Allows users to specify the maximum number of polygons in the final surface.

  · **Iterations:** Iterations allows the user to specify the number of iterations of the deformation process. While there are a maximum number of iterations beyond which there will be little or no improvement in the quality of the final surface, that point is highly dependent on the data.

  · **Cube Edge Size:** The Cube Edge Size option allows users to adjust the length (in voxels) of a side the initial cubic grouping element. This grouping element is used to form the initial surface approximation. If the polygonal budget is set to 0, then smaller cubes will result in higher resolution surfaces, otherwise cube size should be inversely related to the polygonal budget in order to reduce the number of iterations required to reach equilibrium (small polygonal budgets require large cube sizes).

Surface Generation Options (continued)
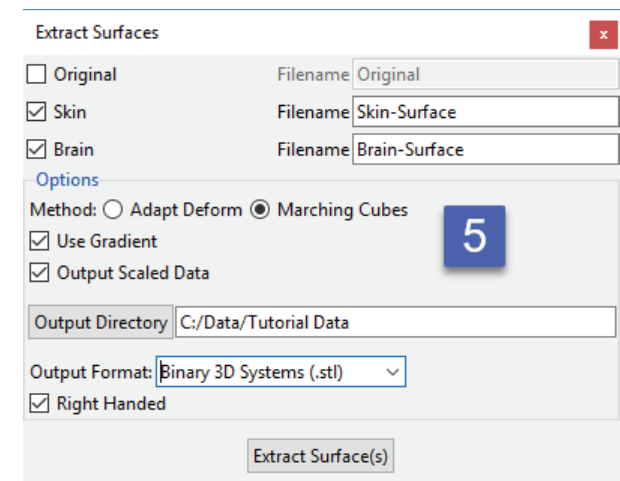
- **Options (continued)**

  · **Adapt Deform (continued):**
    The effects of changing the cube edge size on the resulting surface can be seen in this image. The larger the cube edge size the smoother the generated surface is. Note, increasing the resolution (reducing cube edge size) increases the processing time and this is demonstrated by setting the 'Cube Edge Size' to '1'.

Cube Edge Size 1

Cube Edge Size 3

Cube Edge Size 5
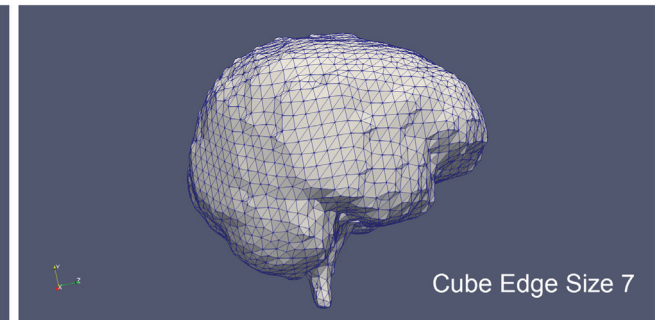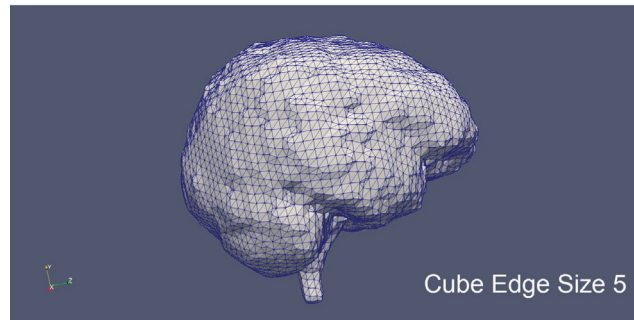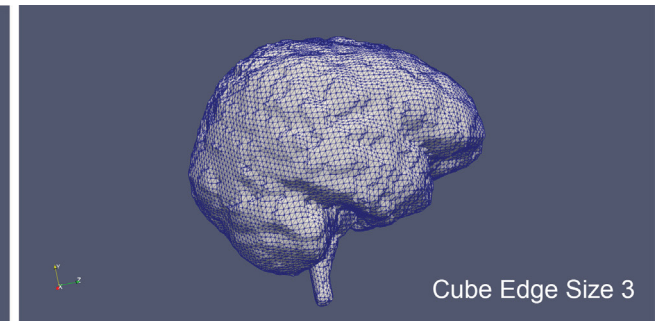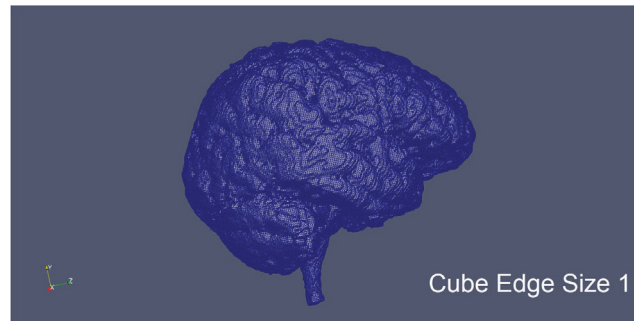
Cube Edge Size 7

  · In cases where a high resolution (Cube Edge Size of 1) is required, it is recommended that users use the Marching Cubes algorithm.

  · **Marching Cubes:** The Marching Cubes option [5] specifies that the marching cubes algorithm will be used to generate the tiled surface. The algorithm processes the data in scan line order and calculates the polygonal vertices using linear interpolation.

Surface Generation Options (continued)

- **Options (continued)**

  · **Marching Cubes (continued):** As discussed in Adapt Deform if a surface file of the exact segmented object (a cube edge size of 1) is required, then Marching Cubes should be used. This will provide an accurate surface description, in a smaller file, in a fraction of the time of Adapt Deform.

  · ***Use Gradient:*** The Use Gradient option is enabled (checked) by default.

  · *Checked:* When enabled the algorithm will use the gradient information present in the voxel data to estimate surface position. This results in a smooth surface that may have a higher error estimate than the equivalent binary surface extraction.

  · *Unchecked:* When enabled the algorithm will ignore gradient information and generate a surface based on binary thresholding. This will produce a "voxelated" surface that minimizes the error between voxel surface and the reconstructed polygonal surface.

  · **Output Scaled Data:** When selected will scale the surface file into real world coordinates. When the surface coordinates will be scaled from voxel dimensions in the header information of the data to real world dimensions. This requires the VoxelWidth, VoxelHeight, and VoxelDepth parameters be set correctly in the volume's header information.

  · **Output Directory:** Allows users to specify the location where the generated surface files will be saved to.

  · **Output Format:** Allows users to specify the format the generated surface files will be saved in (see previous table for formats)

  · **Right-handed:** For both the Adapt Deform and Marching Cubes extraction processes the surface files created will have a 3D left-handed coordinate system. Checking the right-handed option will flip the surface file to a right-handed coordinate system.

  · **Extract Surface(s):** Initiates the surface generation and export routine. When completed a dialog box will be returned.
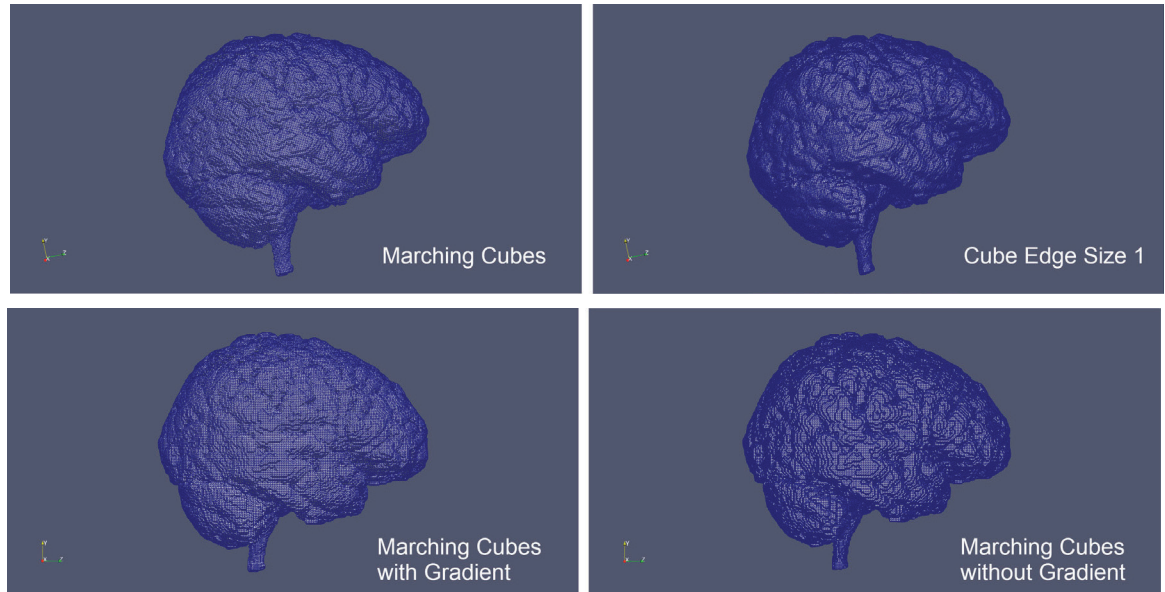
Generating Surface Files from a Selection of Objects

Here we will generate several surface files at once from objects we have previously segmented and which are contained in an object map.

To follow along, download the data set MRI_3D_Head from analyzedirect.com/data and load into Analyze using Input/Output.

- Select the data set and open Segment.
- Select File > Load Object Maps and load MRI_3D_Head.obj.
- Right click on the object list [1] and select Extract Surface [2].
- Select the objects that you will use to generate a surface file [3].
- The output surface name will be the same as the object name. If desired, rename the output surface file name [4].
- Select the surface generation method [5].
- Set the Output Directory [6].
- Choose the ouput format [7].
- Click Extract Surface(s) [8].
- When surface generation is complete a notification will be returned confirming that the selected surfaces have been generated and saved. Click OK [9] to close the window.

The generated surfaces can now be retrieved from the output directory and used in other third party applications such as 3D printing, additive manufacturing, or computer aided design.