

# CTvox Quick Start Guide

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*For Software Version 3.3*

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## Version history

- Version 3.3
  - When using multiple volumes, the effect of the cutting/clipping shape can be specified per volume.
  - R, G and B markers matching a specified color can be added to the transfer function.
- Version 3.2
  - The Annotations dialog has been expanded: support for more labels and introduction of tick labels.
- Version 3.1
  - VXM export for mobile devices supports multiple volumes.
- Version 3.0
  - CTvox supports multi-volume rendering.
  - CTvox can open VXM files generated for the CTvox mobile app.
  - When exporting data for the CTvox mobile app, the volume can be cropped using the clipping box.
- Version 2.7
  - The Transfer Function Editor and View Options panes are now dockable/floatable and resizable.
  - The transfer function editor allows zooming in on a portion of the X range.
  - A color bar legend can be added to the rendering.
  - A pair of customizable labels can be added to the rendering.
- Version 2.6
  - CTvox can handle volume data in DICOM, RAW and ISQ formats.
  - The number of digits used in indexing dataset files is adjustable.
- Version 2.5
  - CTvox supports exporting data for the CTvox mobile app.
- Version 2.4
  - Scale markers can be added to the clipping box.
  - In addition to the directional light source, a spotlight is available when using lighting effects.
- Version 2.3
  - CTvox supports exporting data for the ImageVis3D Mobile volume rendering app.
- Version 2.2
  - CTvox supports saving and loading of key frames.
  - CTvox supports smooth (spline-based) animation.
- Version 2.1
  - CTvox supports cutting and clipping using various shapes.
  - Out-of-plane translation (for volume object, clipping box, cutting/clipping shape) can be performed interactively using the middle mouse button.
- Version 2.0

- CTvox supports lighting effects.
  - The transfer function supports selection of a base color, allowing to easily convey color to the rendering.
  - If, when loading volume data, a transfer function definition file with the same base name is found in the data folder, it will be automatically loaded.
  - The color of the clipping box is adjustable.
  - The maximum volume size can (and should preferably) be configured by specifying the video memory size.
- Version 1.0

## Introduction

In order to work comfortably with CTvox, we suggest the following configuration:

- a display adapter with 1 GB or more of *dedicated* video memory (installation of the latest drivers is recommended, for maximum OpenGL compliance)
- 1600 x 900 screen resolution or better


### *Important note*

CTvox's capabilities and performance are ultimately determined by the graphics card installed in your computer. Before starting using the software, please adjust the maximum volume size to fit your specific graphics adapter, as follows:

1. Find out how much dedicated video memory your graphics adapter has.  
One method to look up the amount of dedicated video memory is consulting the *System Information*. This can be launched through the *System Info...* button in CTvox's *About* dialog or directly through **Start > Programs > Accessories > System Tools > System Information**. In the *System Information* dialog, select *Components > Display* in the left pane. The entry *Adapter RAM* will show the video memory size.
2. Enter this value into the *Video memory* drop down list in the *Preferences* dialog (in the **Options** menu). Mind: if your PC is equipped with a graphics chipset using shared memory, make sure to use the *Shared* setting.
3. Should you experience problems loading volume data, please refer to the *Configuration* section of the online help to fine tune your configuration.

Online help is available through **Help Topics** in the **Help** menu.

Context-sensitive help is also provided:

- Clicking  on the toolbar first and then any element of the user interface will pop up help on that specific item.
- Pressing **F1** in any dialog will pop up help specific to that dialog.

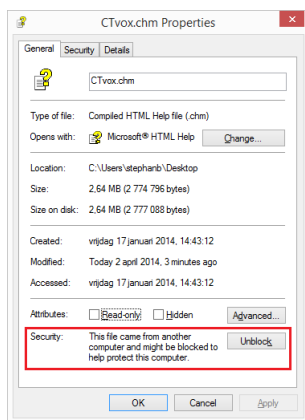
### *Important note*

A common nuisance after installing a new version of CTvox is that the content of the online help and the welcome screen appears inaccessible: the page is either blank or shows an error message along the lines of *Navigation to the webpage was cancelled*.

The cause of the problem is that Windows is blocking the freshly downloaded content for security reasons (one may experience the same problem when running CTvox from a network drive.)


To resolve the issue:

- In the Windows file explorer, navigate to the folder where you unzipped the CTvox installation files.
- Right-click on the file **CTVOX . Chm** and select the **Properties** menu item.
- Click the **Unblock** button near the bottom of the *General* tab.



If the highlighted section doesn't appear, you may have insufficient user rights. Retry using an Administrator account.

## Loading a dataset

To load the dataset of your choice, select **Load Volume...** in the **Actions** menu, or click the  button on the toolbar. Alternatively, you can drop a file from the dataset on (a shortcut to) CTvox: the application will start and load the dataset without further prompting.

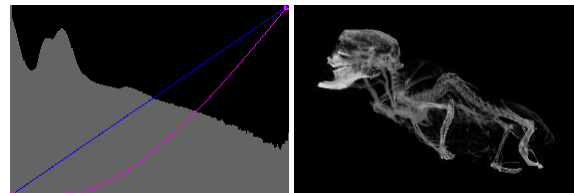
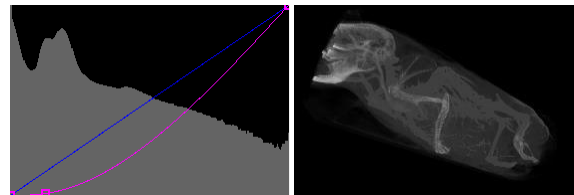
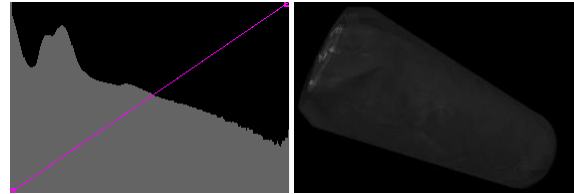
On the right, the *Load Volume* dialog offers several options to resize your dataset:

- reducing the dataset in all directions
- loading only a central portion of the dataset, either in-slice (XY) or in the z-direction

Once a dataset has been loaded, the transfer function plot area (in the *Transfer Function* pane, in the upper left corner) will also display a histogram for the data. Since low intensities dominate the distribution (due to noise and other contributions), the histogram is best displayed using a log scale: right-click in the transfer function window and select **Log-scaled histogram**.

Likewise, these low-intensity contributions (which dominate the periphery of reconstructed images) tend to obscure the core of the volume data. Therefore, it is usually useful to suppress these low intensities in the rendering to some extent, by making them highly transparent:


- Make the *opacity channel* active in the transfer function editor, by selecting *Opacity* from the *Channel* drop down box. The markers for the purple opacity curve (initially a straight line, with just two markers, one at each end) appear, to indicate it is active. Opacity is the opposite of transparency. Hence, we will need to map low intensities to low opacities (= high transparency).
- Add a knot to the opacity curve by clicking in the lower left corner of the transfer function window: the curve changes to smoothly pass through the new and existing markers.
- Try moving the marker to smoothly change the transfer function and obtain the desired effect: left click the marker and drag the mouse with the left mouse button held down. One can switch between a *spline* (smooth) curve and a *polygonal line* by toggling **Use splines** in the context menu (invoked by right-clicking in the transfer function plot area). The context menu also includes entries to reset the currently active or all curves and to delete a marker (when invoked with the mouse pointer over a marker). Markers can also be deleted by double clicking them or dragging them outside the plot area.



Often, the bitmaps making up the dataset will contain overlaid scales or textual information, which also hide the actual object from view. To remove these, proceed as follows:

- The wireframe box surrounding the object acts as a *clipping box*: its faces can be moved independently, to selectively clip away portions of the object.



The visibility of the clipping box can be toggled using the  button on the toolbar.

*Scale markers* can be added to the clipping box by using the  button on the toolbar. The drawing style of these markers can be adjusted in the *Preferences* dialog, accessible through the **Options** menu.

- If necessary, rotate the object by *dragging the mouse* with the *right button* held down (see further below) until the mouse pointer can be brought *directly* over the cube face that needs to be moved inward.
- With the mouse pointer directly over the cube face, click and hold down the *left mouse button* while holding the **Shift** key pressed. This will '*pick*' the clipping plane: to reflect this, the face's edge turns from purple to yellow.
- By dragging the mouse, the cube face can be moved along its perpendicular, clipping away portions of the object that fall outside the clipping box.
- Release the mouse button when the desired position is reached: the face's edge shifts back to purple, to indicate it is no longer picked.

## Navigating the scene

Two modes exist for navigating the scene:

-  *Object movement*: the orientation (rotation) and position (translation) of the object can be adjusted using the right and left mouse button respectively; the camera can be moved closer to or farther from the object using the mouse wheel.
-  *Camera movement*: the object is held in place; the camera can be rotated around the object (right mouse button) and the camera viewing angle can be adjusted (left mouse button); again, the mouse wheel moves the camera forward or backward.

The following table summarizes the navigation controls:

| Mouse interaction      | Object movement               | Camera movement               |
|------------------------|-------------------------------|-------------------------------|
| Left button down       | Object translation            | Camera viewing angle          |
| Left button + Ctrl     | Clipping box only translation | Clipping box only translation |
| Left button + Shift    | Pick clipping plane           | Pick clipping plane           |
| Middle button [+ Ctrl] | Out-of-plane translation      | Camera forward/backward       |
| Right button down      | Object rotation               | Camera rotation               |
| Right button + Ctrl    | Clipping box only rotation    | Clipping box only rotation    |
| Mouse wheel            | Camera forward/backward       | Camera forward/backward       |
| Double click           | Toggle interaction mode       | Toggle interaction mode       |

The right mouse button controls rotation in both modes.

In object movement mode, the left button controls the translation *in the viewing plane*. *Out-of-plane* translation (i.e. perpendicular to the viewing plane) is performed using the middle mouse button.

In camera movement mode, the left button controls the *camera viewing angle* (acting as a zoom, but introducing perspective distortion when the camera is close to the object; the viewing angle can also be set in the *View Options* pane.)



By holding the **Shift** key down while left clicking, the face of the clipping box under the mouse pointer can be 'grabbed' and subsequently dragged to clip a portion of the object.

Holding the **Ctrl** key during rotation or translation (in both modes) will keep the object in place and move only the clipping box, allowing positioning a clipping plane appropriately.

The mouse wheel controls the distance between camera and object in both modes.

Double clicking either mouse button in the imaging window toggles the movement mode.

Precise motion control is available through the **Movement > Numeric...** command in the **Actions** menu.

The orientation and position of the camera and object can be reset to their starting state using **Actions >**

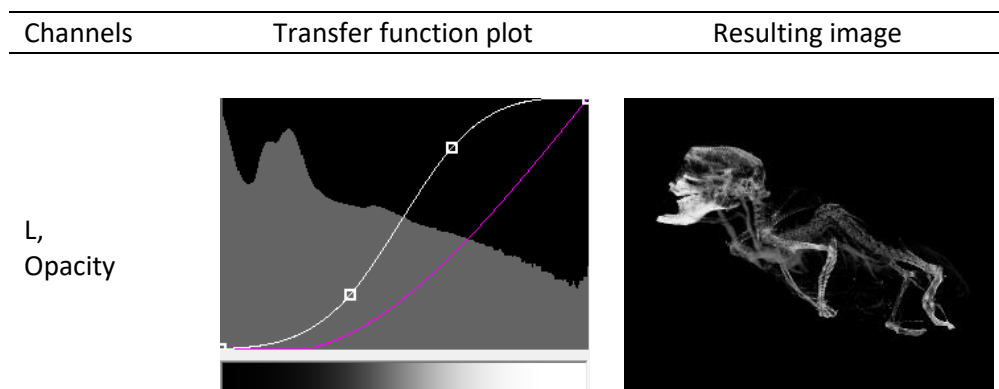
**Movement > Reset Camera** (  ) and **Actions > Movement > Reset Object** (  ) respectively.

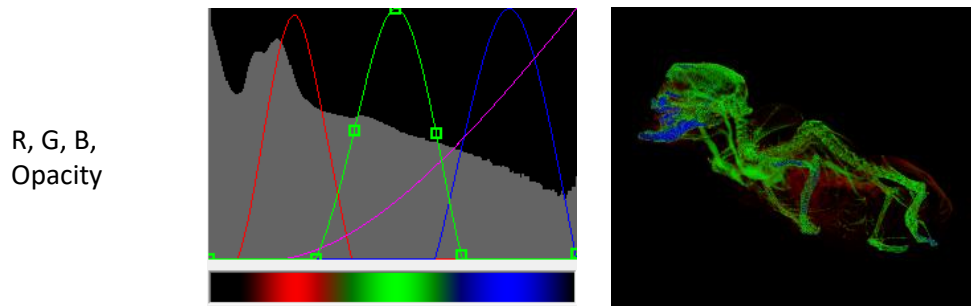
## Transfer Function

In *volume rendering*, every voxel in the volume data is assigned an emission color (the color the voxel emits, determined by its red (R), green (G) and blue (B) components) as well as an opacity (opacity is the opposite of transparency). Both of course depend on the original volume data and the mapping is governed by the so-called *transfer function*, displayed on the left side of the CTvox window. The horizontal axis in the plot represents the original scalar data (the x-ray attenuation), the vertical axis represents one of the transfer function components (R, G, B, L, Opacity).


Modifying the opacity controls the visibility of the corresponding voxels and how much they obscure more distant voxels. By setting the opacity for a given intensity range to zero (full transparency), the corresponding voxels are effectively made invisible.

The color channels can be linked (yielding the L [for *luminance*] channel), in which case only gray values will appear in the image, or controlled independently (R, G and B channels), allowing to introduce color in the image.







## Blending mode

After startup, the *blending mode* is set to *Volume* blending (this blending type can be selected at any time by selecting **Blending > Volume** in the **Actions** menu or pressing the  button on the toolbar), meaning the emission-absorption model as described above is used.

Other blending modes available are:

-  *Attenuation*  
 This mode corresponds to digitally reconstructing a radiograph: a radiograph along the current viewing direction is generated.
-  *Maximum Intensity Projection*  
 For every ray hitting the screen, only the most intense voxel along the ray is retained. Hence, this mode automatically highlights the structures of maximum intensity.

## View options

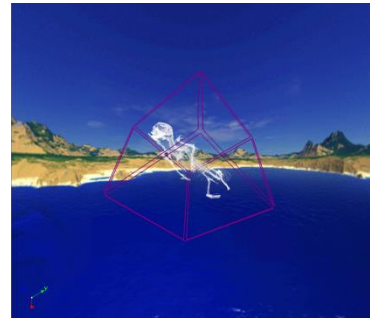
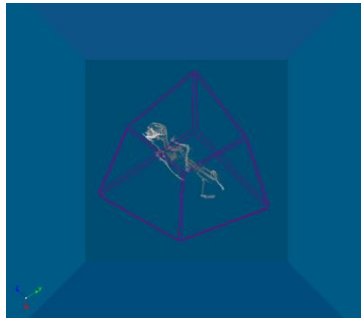
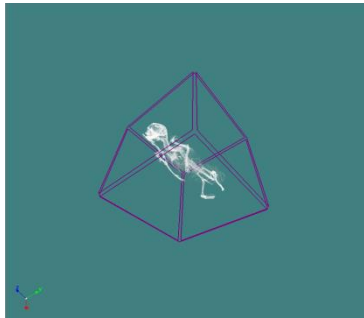
The *View Options* pane, on the left, groups settings that determine the general appearance of the scene. The *camera viewing angle*, described above, can be set using the corresponding slider.

The *background* against which the scene is displayed can be specified:

- Color fill*  
 An homogeneous background of the user-specified color. In this mode, the camera position is unbounded.


- *Color cube*  
A cube with faces of slightly varying color, based on a user-specified color. The *cube size* can be specified. In this mode, camera movement is limited, such that the camera remains within the cube.
- *Image cube*  
A cube whose faces are painted with user-specified bitmaps. A default set of bitmaps is provided to generate the coastline scenery depicted below. Here, too, the camera position is bounded by the cube and the cube size adjustable.

The three types of background are illustrated below:



## Cutting/clipping shapes

In addition to the clipping box, CTvox offers the *cutting/clipping shape*. As the name suggests, it supports both *clipping* (i.e. the portion of the volume lying *outside* the shape is removed) as well as *cutting* (i.e. the portion of the volume lying *inside* the shape is removed). Furthermore, multiple shapes are available: in addition to the familiar box, a sphere, a cylinder, a wedge and a prism.

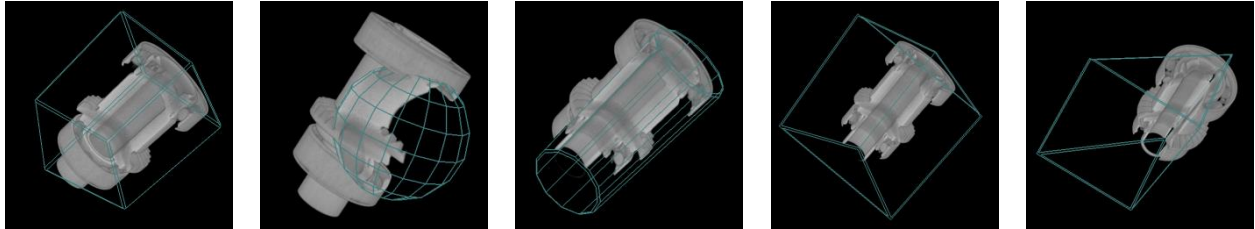
To show or hide the cutting/clipping shape, click the  button on the toolbar to open the *cutting/clipping shape* dropdown menu and select **Show Cutting/Clipping Shape**. To specify the behavior of the shape, select either **No Cutting/Clipping**, **Cutting** or **Clipping**. Selecting one of the listed shapes will change the geometry of the cutting/clipping shape accordingly.

Unsurprisingly, the handling of the cutting/clipping shape shows many parallels with that of the clipping box:

- Holding down the **Alt** key while translating or rotating (using the left or right mouse button respectively in object movement mode), will move the cutting/clipping shape independently from the volume. (Compare this to holding down the **Ctrl** key in the case of the clipping box.)
- Similarly, to move any surface of the cutting/clipping shape, left click while holding down both **Shift** and **Alt** keys to 'grab' the surface under the mouse pointer and drag the mouse to move the surface accordingly. (Compare this to holding down the **Shift** key in the case of the clipping

box; as a matter of fact, holding down both **Shift** and **Ctrl** keys will also work for the clipping box.)

The following images illustrate the effect of cutting for the various shapes:







## Lighting effects

Lighting effects can also be added to the scene: such lighting effects increase the realism of the resulting image by providing additional depth cues and enhancing small-scale structures. To invoke/hide the

*Lighting* dialog, select the **Options > Lighting** command or click  on the toolbar.

Two types of lighting effects are available:

-  *Shadows*  
This effect adds shadows to the image (by taking into account the attenuation of the light as it travels from the light source), greatly enhancing the depth perception and the visual realism.
-  *Surface lighting*  
This effect emphasizes the local structure or roughness of the object (by modeling the reflection of the light), lending the appearance of realistic materials to surfaces.

Use the  button to switch from *Object* or *Camera movement* to *Light movement*: the right mouse button now controls the orientation of the light source. This orientation can be reset using the  button.

When the *Spotlight* checkbox is checked, the light source behaves like a *point source*, whose distance can be adjusted using the *Distance* slider. When unchecked, the light source is *directional*: it can be thought of as a point light source at infinite distance.

The *Shadows* slider controls the intensity of the shadows.

The *Light color* pane allows modifying the color of the light source, either through the separate *Red*, *Green* and *Blue* sliders or through the color picker.

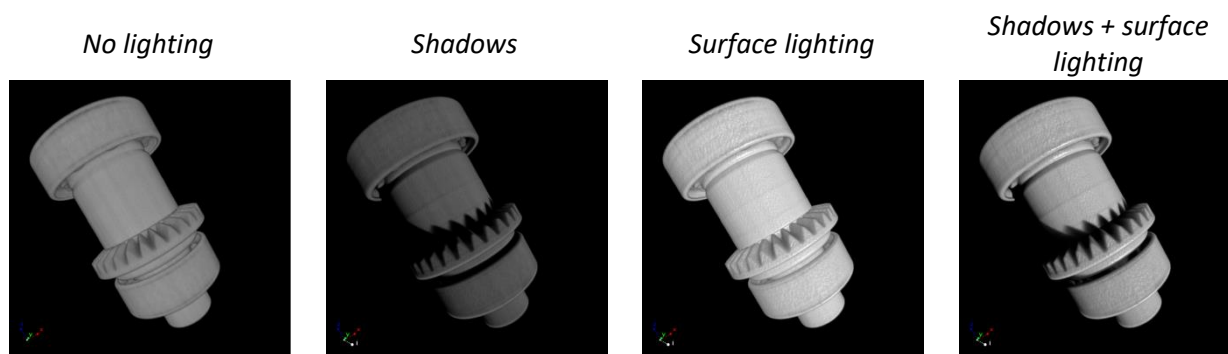
The *Material* properties determine the appearance of the object when using surface lighting:

- The *Material color* can be adjusted using the *Red*, *Green* and *Blue* sliders or the color picker.
- a number of sliders control the contributions of the various components making up the light:

|                 |   |
|-----------------|---|
| <i>Emission</i> | the contribution of the familiar emission component         |
| <i>Diffuse</i>  | the portion of the reflected light that is evenly scattered |
| <i>Specular</i> | the contribution of mirror-like reflection                  |


These material properties can be saved to file and restored at a later point using the **Save** respectively **Load** button. The **Reset** button resets the material properties to their default values.

The following images illustrate the various lighting effects:



## Annotations

Text labels and a color bar can be added to the rendering. When [multiple volumes](#) have been loaded, a legend to identify the various volumes becomes available as well. All settings relating to these informative elements are grouped in the *Annotations* dialog, accessible through the **Options >**

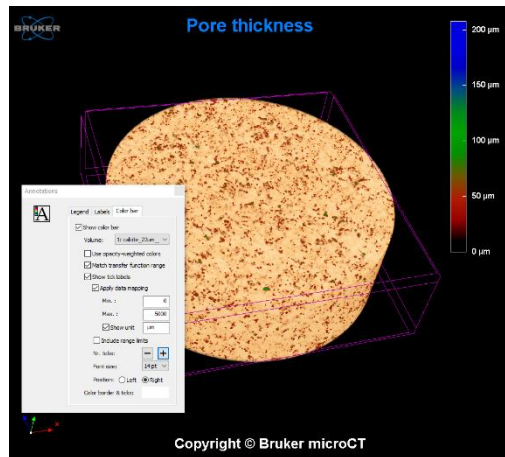
**Annotations** command or the  toolbar button.

Up to eight labels can be added. For each label, the font size and color can be specified. Additionally, a label can be framed.


Tick labels can be added to the color bar.

The labels, legend and color bar can be repositioned interactively using click-and-dragging. Additionally, the color bar can be resized by click-and-dragging its edges and its orientation (horizontal/vertical) changed by click-and-dragging its corners.

The following screenshot illustrates the use of such annotations:



## Flight Recorder

The Flight Recorder functionality can be used to produce fly-through animations for your 3D data. To invoke/hide the *Flight Recorder* dialog, select the **Actions > Flight Recorder** command or click  on the toolbar.


The idea is to set up the scene and to tag it as a *key frame* by clicking the *Add* button. When eventually creating the movie, the program will generate the specified number of intermediate frames by appropriately interpolating these key frames.

Use the following controls to navigate the sequence of key frames:


|    |                                       |
|----|---------------------------------------|
| <  | show the previous key frame           |
| << | cycle backward through the key frames |
| >  | Start preview                         |
|    | pause preview/cycling                 |
| >> | cycle forward through the key frames  |
| >  | show the next key frame               |

The *Hide clipping box* and *Hide cutting/clipping shape* checkboxes allow suppressing the clipping box and the cutting/clipping shape respectively in the generated movie, even though visible in the rendering.

When ready, the movie can be generated by clicking *Save movie*. The output is either an AVI file or a series of bitmaps (BMP, JPG or PNG).

At any moment, a screen capture of the rendering can be saved (as BMP, JPG or PNG), using the **Save Image...** command in the **Actions** menu or the  button on the toolbar.


## Stereo Viewing

CTvox supports *stereo viewing*, to further enhance the 3D impression. To switch on/off stereo viewing, use the **Stereo Mode** command in the **Options** menu or click the  button on the toolbar. The *stereo angle* required for an ideal stereo image depends on the specific setup (i.e. the viewer's interocular distance and the distance from eyes to screen) and can be adjusted in the *Preferences* dialog, accessible through **Options > Preferences...**

## Multiple volumes

CTvox also supports *multi-volume rendering*: each volume retains its own transfer function; the contributions from the various volumes are weighted to produce a combined emission color and combined opacity.

To add a volume, rather than replacing the one(s) already loaded, click the **Add** button instead of the **Open** button in the *Load Volume* dialog. When loading multiple volumes, it is assumed that the volumes are *axis-aligned* and that their *centers coincide*.

The *Volume Manager* pane is central to working with multiple volumes. Its visibility can be toggled through **Options > Volume Manager** or by clicking the  button on the toolbar. First and foremost, the *active volume* selected in the volume manager determines which transfer function is being edited in the transfer function editor.

The volume manager presents additional information for each volume:

- the *visibility* of the volume: for convenience, the contribution of a volume to the rendering can be enabled/disabled with a single click of a checkbox.
- the *volume label* is editable and is used in the legend than can be added to the rendering to identify the various volumes. The settings relating to this legend can be found in the [Annotations](#) dialog.
- the *volume weight* allows to quickly adjust the relative contribution of the volume to the rendering, without having to resort to editing of the transfer function.
- for convenience, the [base color of the transfer function](#) (the color modulated by the *L(uminance)* channel) can be adjusted through the volume manager too.
- the *cutting/clipping mode*: the effect of the [cutting/clipping shape](#) (cutting, clipping or neither) can be set *per volume*.

## Exporting data for CTvox for mobile devices

A companion [volume rendering app](#) is available both for Apple iOS and Android devices. The app is available free of charge through Apple's [App Store](#) and the [Google Play](#) store.

Features of the app include:

- full-fledged transfer function editor
- saving and reloading of transfer functions
- transfer function files can be exchanged with the desktop version of CTvox
- multiple imaging modes (surface, MIP, attenuation)
- clipping/cutting box
- full in-app help.

The app loads datasets stored in the single-file *VXM file format*. VXM datasets can consist of up to four volumes; all currently visible volumes will be included in the exported dataset. To create the VXM file, select **Export as VXM Data...** in the **Actions** menu: the volume data is adequately resized and saved. The following information is included in the file as well:

- the transfer function(s) (one per volume)
- the scene's [background color](#)
- the [text labels](#)
- the [legend](#) (volume labels)
- the current set of [volume weights](#).

Checking *Export VOI defined by clipping box* in the *Save As* dialog will crop the exported volume to the region defined by the clipping box.

When *Protect content* is checked, the labels embedded in the VXM file cannot be hidden in the mobile app, thus enforcing the visibility of an author attribution/credit contained in those labels.

The easiest way to transfer a VXM file to your mobile device is to download it wirelessly using the device itself. Any method will do: through a web link, as an email attachment, using a cloud storage app such as *Dropbox*, *Google Drive* or *OneDrive*. Opening the downloaded file will copy it to the CTvox app's dedicated storage, then launch the app to open the dataset.

Alternatively, VXM files can be transferred over a USB connection (for iOS, *iTunes* is required.) This approach can prove more effective when multiple VXM files need to be transferred.

For more details, please consult the app's manual (downloadable as a PDF, in a version [for iPad](#), [for iPhone/iPod touch](#), and [for Android](#)) or the app's extensive online help.