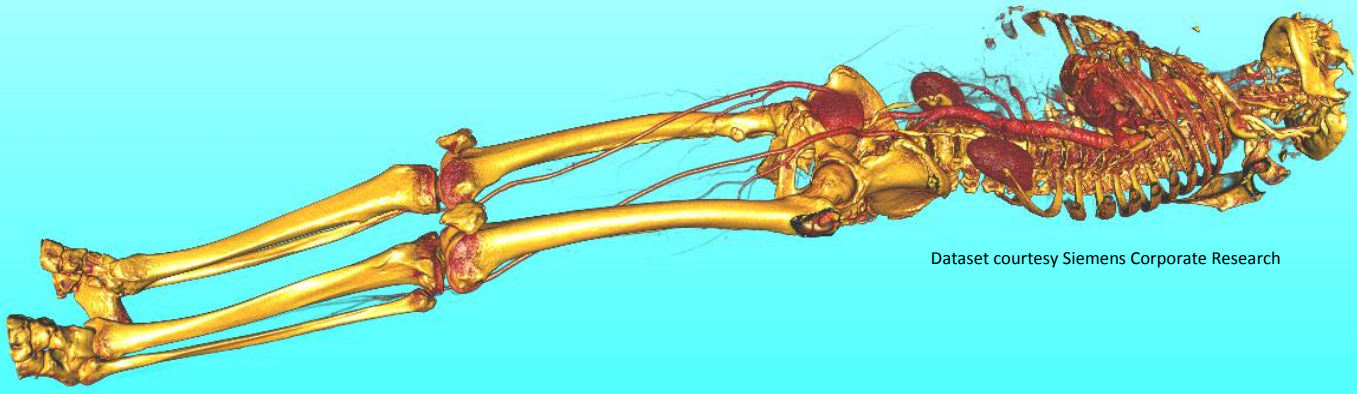
www.sci.utah.edu



Dataset courtesy Siemens Corporate Research

ImageVis3D Version 1.3

Users Manual

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2. Introduction

Welcome to the world of interactive volume visualization! In this manual we are going to introduce you to ImageVis3D, a lightweight, feature-rich volume rendering application which was specifically designed for rendering data which is significantly larger than the available memory of the machine. While ImageVis3D can take advantage of many recent advances in graphics hardware, advanced scheduling and caching algorithms ensure interactive performance even on older systems. We sincerely hope that ImageVis3D will improve the workflow in your environment and that you will have as much fun using it as we had developing it. If you have a question, bug-report, or feature request, feel free to contact us on the iv3d-users@sci.utah.edu mailing list, or use the built in "reporting" feature of ImageVis3D (see Section XVI on about details on this feature).

I. Getting ImageVis3D

If you already downloaded and installed the latest version of ImageVis3D on your system, feel free to skip this Section.

a. Downloading

ImageVis3D is a free open source program released under the MIT license, which means you can download, change, and do whatever you want with few restrictions (see Section XXIII). Practically, this means you can browse to http://www.ImageVis3D.com, click the download button and pick the latest binary that is suitable for your operating system (OS). If you do not know what your operating system is, and whether it is 32 or 64bit, ask you system administrator or consult your computer's owner's manual. If you feel more like playing around with the latest and greatest "in development" version of ImageVis3D you can also browse to http://software.sci.utah.edu/devbuilds/imagevis3d/ and download the latest build. These latest versions often offer new exciting features but are still under development and may not run as stable and reliable as the release versions that you can get from the "Download" site.

b. Installation and Uninstallation

As the installation of ImageVis3D differs between operating systems we will describe the process separately for the most common operating systems.

Windows XP and above

On Microsoft Windows you can either choose to run the installer directly by left-clicking the installer on the website (recommended) or right click the installer and choose to save it to your system. If you have downloaded the installer to your system instead of running it directly you should have either have an "ImageVis3D-1.0-64bit.exe" or "ImageVis3D-1.0-32bit.exe" binary in your browser's download folder (see Figure 1).

Figure 1 64bit and 32bit Windows Installer Packages

To start the installation process, double-click on the installer. On Windows Vista and Windows 7 you will be prompted by the "user account control" to allow the installer to run; just click "OK" to continue. Next, you will see the familiar windows installer dialogs, as shown in Figure 2. We recommend that you leave all settings at their default values.

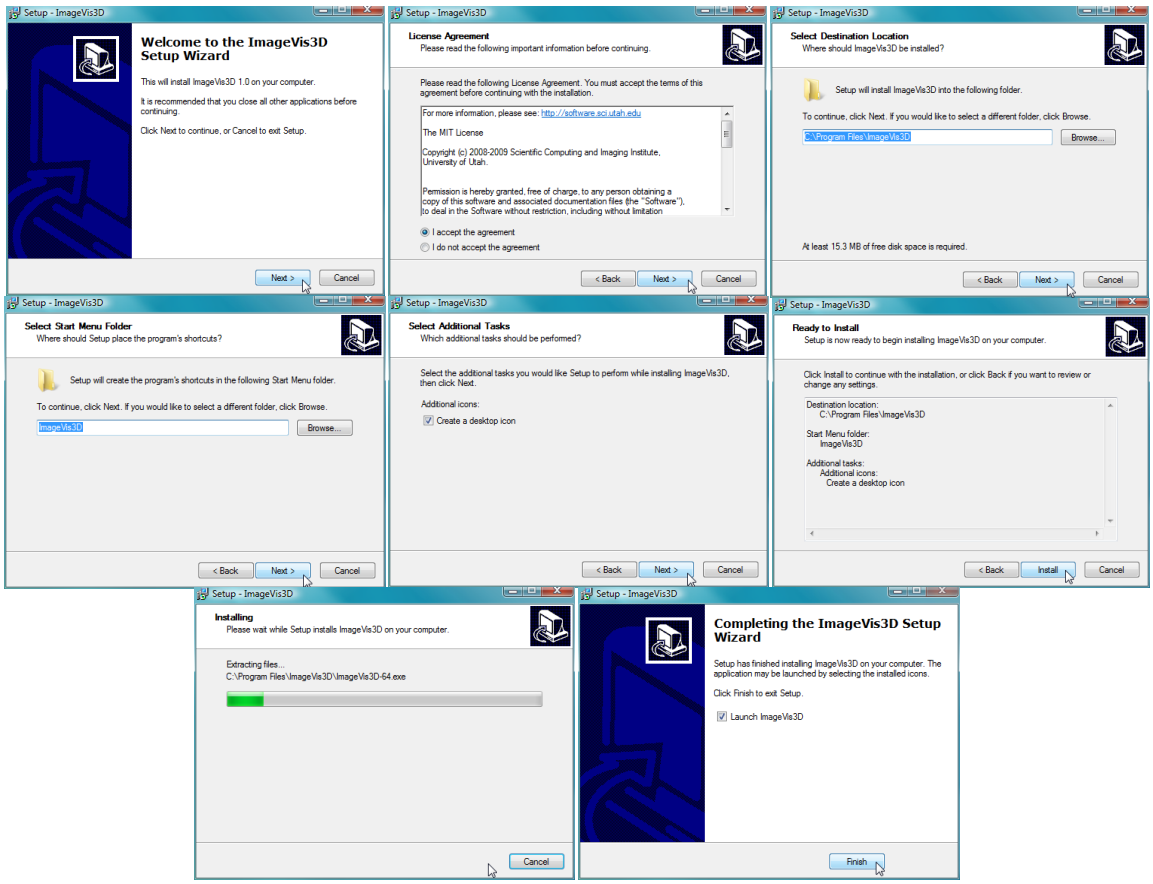

Figure 2 The Install Wizard on Windows Systems

After the wizard has finished the installation it will automatically start ImageVis3D or – if you have deselected the option to do so – you will have to start it manually by clicking on the new desktop item or by selecting ImageVis3D from Windows' Start menu (bottom left on most systems).

To uninstall ImageVis3D later all you have to do is to double-click ImageVis3D 1.0 from the software list (called Programs and Features on Vista and Windows 7) in the "Control Panel".

OS X

On a Macintosh computer running OS X, download the DMG disk image regardless of what Macintosh computer you have. This one image contains ImageVis3D versions for multiple configurations and automatically picks the right one. If you perform the download with the OS X default browser, Safari, the entire installation process will happen completely automatically. After the DMG has been downloaded, mounted, extracted, dismounted, and finally deleted, you should see the ImageVis3D program in your download folder. If you want to you can now move it into the application folder, so it is stored alongside with all your other OS X applications.

If you ever want to uninstall ImageVis3D all you have to do is drag the ImageVis3D icon from the Download (or from the Application folder) into the Trash.

Linux

Linux binaries are distributed in two manners: from a Launchpad PPA (personal package archive), and as tarballs (with the extension *tar.gz*).

The Launchpad PPA is only usable on apt-based Linux distributions, such as Debian and Ubuntu. Information on configuring your distribution's package update system to include ImageVis3D updates is available on Launchpad:

https://launchpad.net/~tfogal/+archive/ppa

The second type of ImageVis3D Linux binary is a simple tarball containing the executable in a non-packaged form. This type of binary is distribution agnostic, and should therefore work on most Linux systems. To install this form of the binary, download the tarball and extract it using the *tar(1)* command.

```
tar zxvf ImageVis3D-1.3.tar.gz
```

It is also possible to compile ImageVis3D directly from source; see Section XXIII for details.

When using the tarball-based binary, you may need to install some dependency libraries to get ImageVis3D to run on your system. If this is the case, the system will generate an error message detailing the list of missing libraries; in most cases, you will be able to simply load up your package manager and install the required libraries. In some cases, you will need to compile ImageVis3D from source.

When using the Launchpad PPA, all dependency requirements are handled automatically.

II. Screenshots and Operating Systems

As mentioned before, ImageVis3D runs on all major operation systems, such as Windows, OS X, and Linux. While the overall look and feel of the program remains the same, it will look slightly different on operating systems. For this manual we will mainly use screenshots

from a Windows Vista system. As can be seen in Figure 3 this difference should not be a major problem, but if you still find it impossible to understand a certain part of this manual feel free to send an email to iv3d-users@sci.utah.edu and we will gladly help you with your problem and will also make the necessary changes to improve this manual for everyone else.

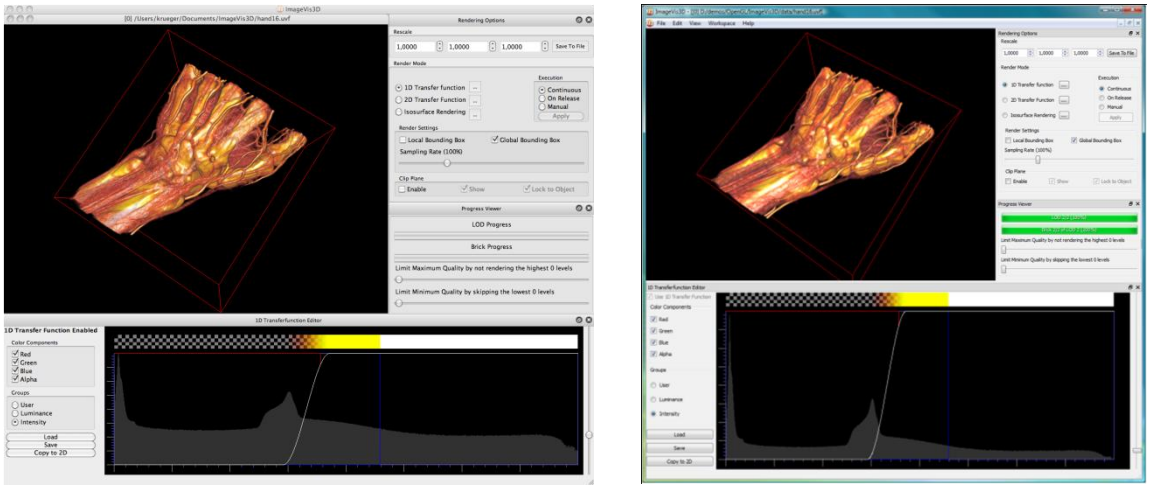

Figure 3 ImageVis3D running on OS X and Windows Vista

III. The First Start of ImageVis3D

When you start ImageVis3D for the very first time the "Initial Setup Dialog" (see Figure 4) will open up and ask if you would like to change the default settings ImageVis3D has picked. For an inexperienced user it is best to just click, "No", and accept the defaults. Later (in Section XV) we will describe how to change those settings if it becomes necessary.

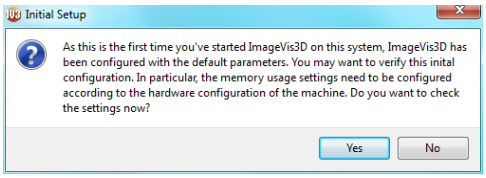

Figure 4 The Initial Settings Dialog

If you accidently clicked "Yes" in the "Initial Setup Dialog" do not worry: just close the "ImageVis3D Settings Dialog" with either "OK" or "Cancel" and no harm is done.

After you managed to pass the initial Setting/Setup phase ImageVis3D will start by presenting the "Welcome Screen" (see Figure 5).

Figure 5 The ImageVis3D Welcome Screen

3. User Interface Basics

In this Section we will introduce the basic concepts of ImageVis3D's User Interface (UI). ImageVis3D was designed to be intuitive if you are already familiar with graphical user interfaces (GUIs) in general. Figure 6 shows an annotated screenshot of ImageVis3D's user interface during a visualization session.

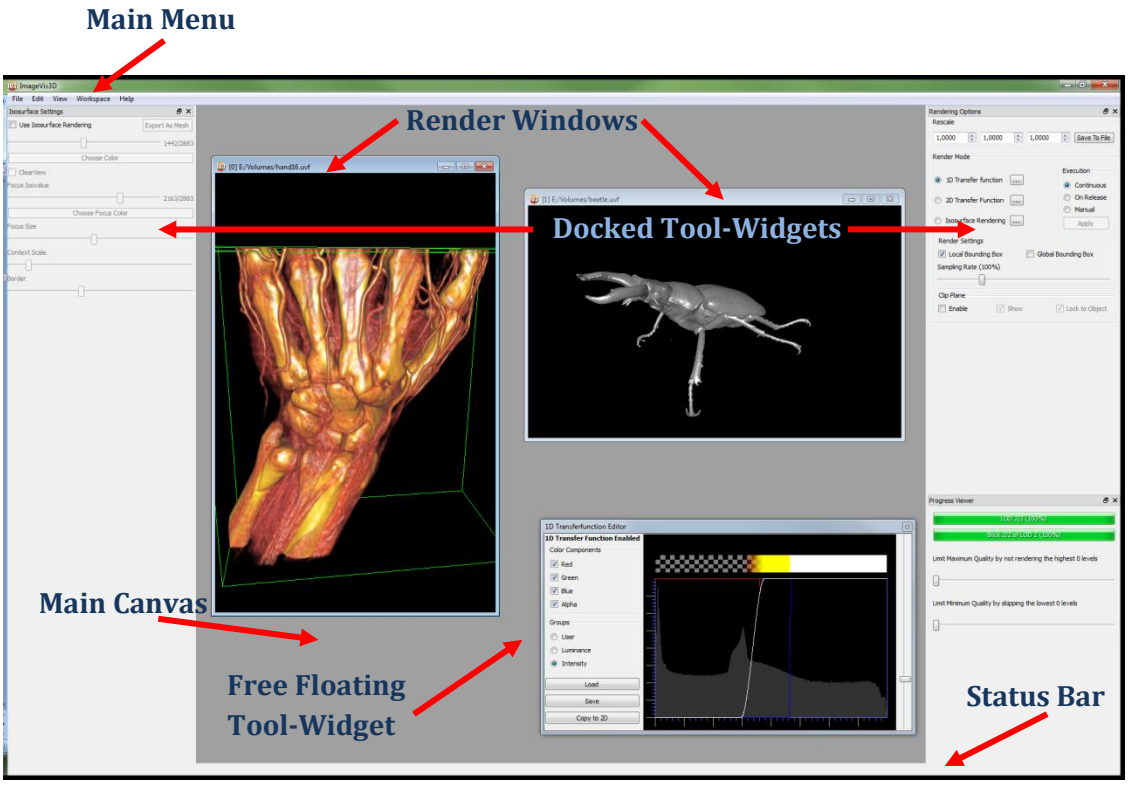

Figure 6 ImageVis3D's UI elements

IV. The Welcome Screen

If you start ImageVis3D the "Welcome Screen" (see Figure 5) opens up, unless disabled in ImageVis3D's settings (see Section XV on how to re-enable it). In this window you can open data sets, see the video tutorials, open the local manual or the online help, or check whether you have the most recent version of ImageVis3D. To quickly try out ImageVis3D without having to use you own data you can also choose to download example data sets from our webpage. Particularly helpful in daily routine is that ImageVis3D keeps track of recently accessed data sets and lets you load these directly without having to find them on disk (see Figure 7).

Figure 7 The Welcome Screen showing the most recently used items.

V. The Main Menu

Like most programs, ImageVis3D has a Main Menu from which the basic features are accessed (see Figure 8). For example, loading and saving from the "File"-menu or "Settings" from the "Edit"-menu.

Loading and saving is down from the "File" menu; settings are accessed from the "Edit" menu (note that on OS X the Settings are located in the "ImageVis3D"-Menu on the top left as "Preferences"). Other menus are more specific to ImageVis3D's task. The "View" menu will become important once we start working with multiple datasets at once (for details see Section XIII); the "Workspace" menu is used to load and save all of the "Tool" widgets (see Figure 6); finally, the "Help" menu gives access to the online help, automatic update, and bug reporting features of ImageVis3D.

.

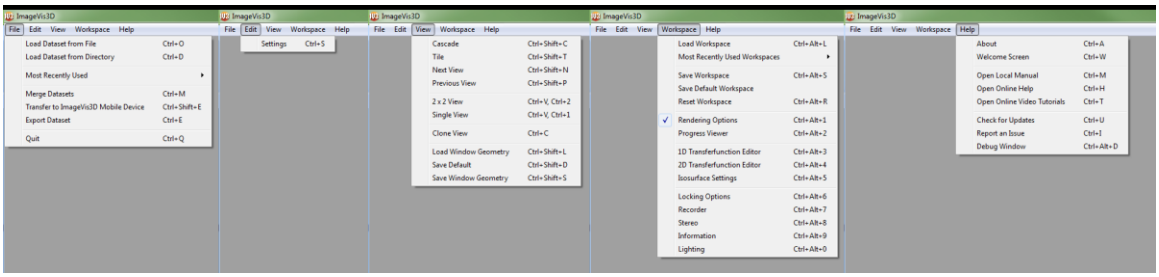

Figure 8 ImageVis3D's Main Menu
(The "Transfer ImageVis3D Mobile Device"-option is only visible when it is enabled in the Settings)

VI. The Main Canvas

c. Tool Widgets

Key elements in ImageVis3D's user interface are the "Tool Widgets". These user interface elements contain most of the controls you need to operate ImageVis3D. To make ImageVis3D's interface as flexible as possible, these widgets can be arranged freely by the user. It is also possible to completely hide such a widget if it is not needed, thus devoting more space to the Render Windows, and therefore the data under analysis. In Figure 6 a few of these Widgets are shown, with two of the widgets attached to the sides (left and right) and one widget floating freely. To attach a Widget to the sides, top, or bottom of the ImageVis3D window, drag it close to the border and release it. Please note that a Tool Widget can only be attached to a border of the main window if it fits, i.e. the main window is large enough accommodate the current Tool Widget at its minimum size. To detach a widget, click on its window icon (second icon from the right in the top bar of every widget). To re-attach that widget at the same location, double-click the top bar. To show a Tool widget select it in the workspace menu, to hide a widget either click on the cross icon (rightmost in the top bar) or deselect it in the workspace menu. You can also resize the Tool Widgets just like any other window in the user interface by dragging their borders. By default ImageVis3D remembers the layout of all of the Tool Widgets when it is closed and restores them when it is restarted. Sometimes, however, it is beneficial to have multiple predefined Tool Widget layouts at hand for different workflows. Thus it is also possible to save and load additional workspaces via the "Load Workspace" and "Save Workspace" options in the "Workspace" menu (see Figure 8).

d. Render Windows

The next important user interface element of ImageVis3D is the "Render Window". It literally is the window to your data. In Figure 6 two such windows are shown (the hand data set and the stag beetle). Render windows are so similar to normal windows on your desktop, which can be maximized, minimized, or windowed, but Render windows are restricted to ImageVis3D's main canvas. If you drag around your ImageVis3D main window,

the Render Windows will follow. Note that detached Tool Widgets are not restricted to the canvas and can be placed anywhere on your screen, even on another monitor if you have multiple monitors attached to your computer. To open a Render Window you need to Load a data set into ImageVis3D or clone an existing window. Also note that the arrangement options in the "View" menu (see Figure 8) apply to Render Windows. To interact with a data set left click and drag to rotate and right click and drag to move (see Section IX).

4. Data Set Handling

The primary focus of a scientific visualization tool is of course the data. In this Section you will learn how to convert data, load it into ImageVis3D, and also export it for other programs to use.

VII. Loading Data

In this first subsection we focus on opening data files from disk, whether they are in ImageVis3D's native "UVF" format or foreign formats.

e. Loading Native UVF Data

ImageVis3D converts and stores all data sets in its own Universal Volume File (UVF) format. Once created these data sets are simple to load: select "Load Dataset From File" from the "File" menu and choose the UVF file in the file browser. (see Figure 9).

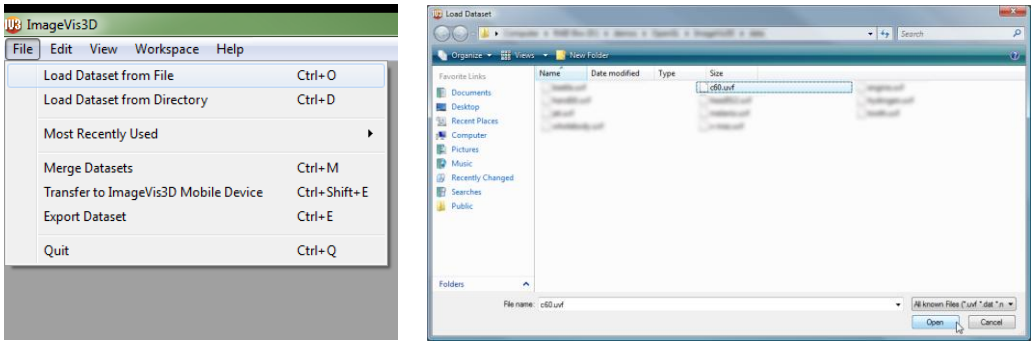

Figure 9 Steps to load a UVF File

After selecting the file from the file browser and clicking "Open" a new Render Window will be displayed within ImageVis3D showing the dataset. Note that you can also access the five most recently used datasets from the "Most Recently Used" entry in the "File"-menu (see Figure 9) or from the welcome screen (see Figure 7).

Do note that ImageVis3D features a checksum feature to verify that the file being opened has not been corrupted. This verification process can take a considerable amount of time for large datasets, so users may consider disabling this feature in ImageVis3D's "Settings" dialog. See Section XV for details.

f. Importing Data

Often data is not stored in the UVF format already but in some other external format. In that case the data needs to be converted first. ImageVis3D distinguishes between two types of conversions, from a single file (or sometimes a two-file header/data pair) and from a stack of files. Prominent examples for single-file data are NRRD or RAW files, while stacked data most often comes from a DICOM stack or a set of slice images.

Importing Data from a Single File (or a Header/Data Pair of Files)

To import a dataset from a supported foreign file format, the same steps as for loading a UVF file are performed, as shown in Figure 9. ImageVis3D will automatically detect that the selected file is not a UVF dataset and will select the appropriate converter. ImageVis3D can import the following formats:

- *.dat — QVis Data (including RGBA and float extensions)
- *.nrrd & *.nhdr — Nearly raw raster data
- *.stk — Metamorph STK Volumes
- *.tiff & *.tif — TIFF Stack Volumes
- *.vff — Visualization File Format
- *.bov — VisIt Brick of Values
- *.rek — Fraunhofer EZRT
- *.* — Any raw data (text & binary encoding, zipped, bzipped)

Next ImageVis3D asks for a target filename. As any foreign format is converted into UVF before visualization, a name for the newly created target UVF file has to be selected.

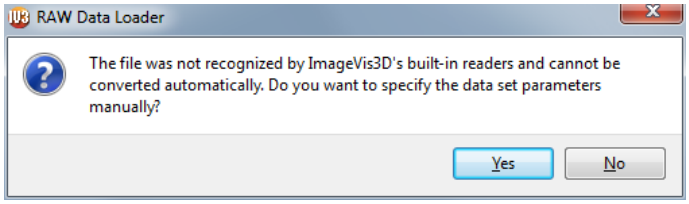

Figure 10 RAW Data Loader Question Dialog

If ImageVis3D cannot load the file with any of the known converters in the list above, it will ask whether the selected file is raw data and if the parameters can be supplied manually (see Figure 10). Next ImageVis3D presents the dialog shown in Figure 11, which asks for a manual specification of the dataset's information. ImageVis3D will assist you in this by verifying the parameters given while they are entered. An information message above the "OK" and "Cancel" will tell you if the current parameters match the dataset (Figure 11).

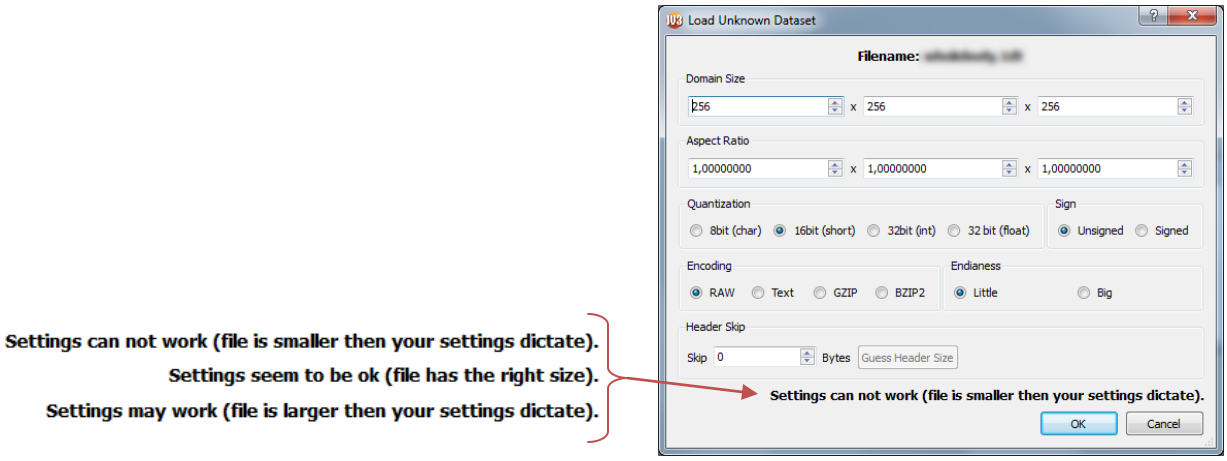

Figure 11 RAW Data Loader Dialog

In both cases – when the file was detected as a known format or for the manual RAW loader – ImageVis3D will process the file, pre-computing derived quantities of the data (such as level of detail, histograms), write the converted data into the new UVF file, and finally load the UVF file. Note that the source dataset was only *read* by ImageVis3D during the conversion, so no changes were made to the input file, nor is the file required in the future (the generated UVF file can be loaded directly). Thus a conversion of a dataset only needs to be performed once.

Importing Data from a Directory Containing DICOM Files or Slice Images

While the previous section covered the loading of data in a single file (or pairs of files as in the case of QVis and some NRRD data), often the data are stored as a set of files. Data in the very popular DICOM format, for instance, are commonly stored as many separate files in a single directory. That same directory may even contain multiple distinct DICOM stacks. To load these DICOM or image stacks into ImageVis3D select “Load from Directory” instead of “Load From File” in the “File” menu. This will cause a directory selection dialog to open In that dialog select the directory that contains the data stack (see Figure 12).

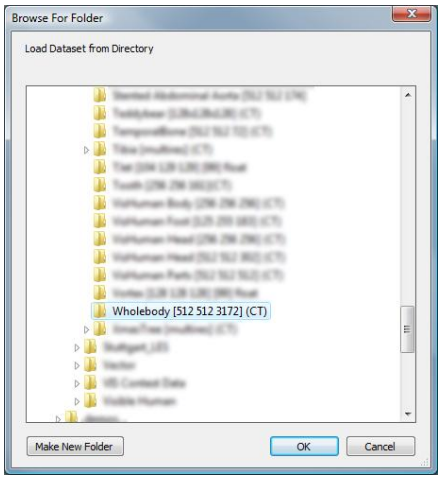

Figure 12 The Open Directory Dialog (on Windows Vista)

ImageVis3D will automatically scan the entire directory for DICOM and image stacks, order the stacks, and open a stack selection dialog as shown in Figure 13.

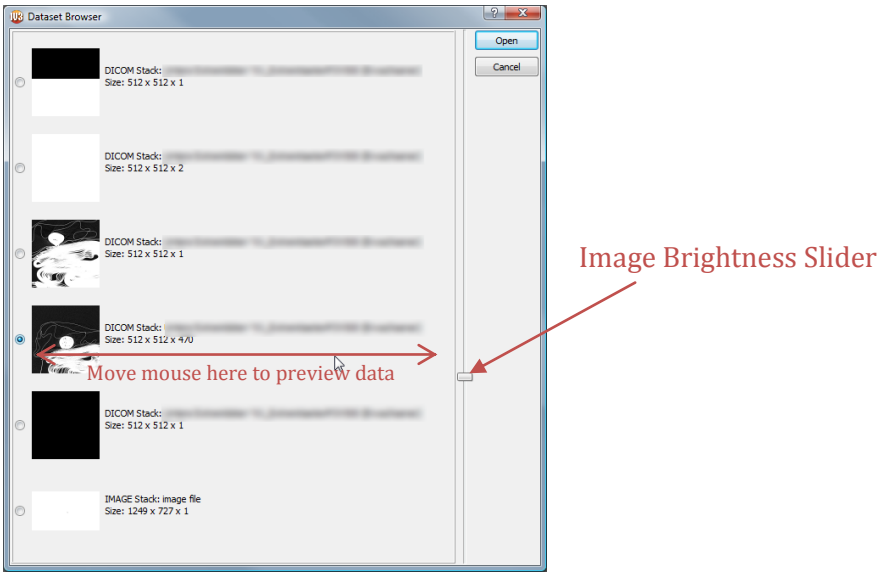

Figure 13 Stack Selection Dialog

In that dialog you can preview the volumes slice by slice by moving over a row in the table with the mouse, thus flipping through the data. You can also use the vertical slider on the right to adjust the brightness of the preview. If you found the right stack, select it by clicking on the respective row and select “OK”. The rest of the import process is similar to the single file process. First a filename for the new UVF file is requested, then the data are converted, and finally the data are loaded into ImageVis3D. Just as before, ImageVis3D does not modify the DICOM or image data nor does ImageVis3D require that stack in the future.

VIII. Exporting Data

ImageVis3D can also export UVF files into external formats for other tools to read the data. There are two kinds of data that ImageVis3D can export: the input data as a volume, and, given an iso-value, a triangle mesh that represents the iso-surface.

g. Exporting Volumetric Data

To export a dataset into an external volume format, it first needs to be loaded into ImageVis3D (see Section VII). Next select "Export Dataset" from the "File"-menu and select a target filename and file type (Figure 14, left and center). If your dataset is relatively small it will be exported instantly, for larger datasets another dialog will open (Figure 14, right) asking you which resolution you want to export. This allows you to export smaller versions of the data for use in software that does not support working with large datasets.

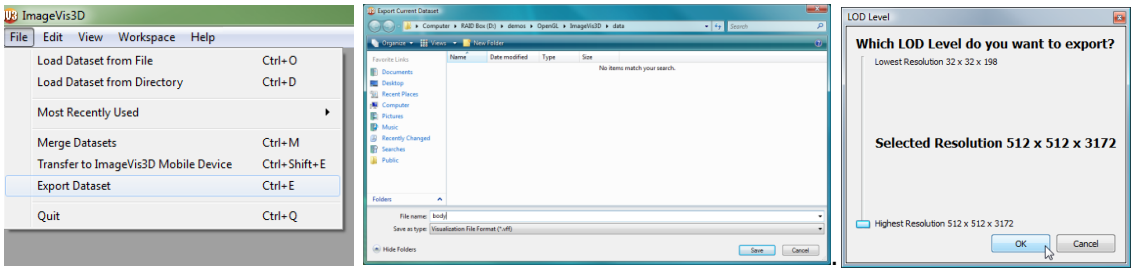

Figure 14 Steps to Exporting a Volume

h. Exporting Mesh Data from an Iso-Surface

Instead of exporting the dataset as a volume, you may also want to export a triangular surface for a given iso-value (see Section m for details on iso-surface rendering). These data may then be processed using a mesh processing tool. To export data in this form, first load the dataset, then switch ImageVis3D into iso-surface rendering mode from the "Render Options"-tool widget (see Section v). Choose an appropriate iso-value from the "Isosurface Settings"-tool widget, and click on the "export as Mesh"-button (see Section z). Finally, you will be asked for a mesh filename and – just like for the volume export feature – will see a "LOD Level"-dialog for large datasets (see Figure 14, right).

i. Transfer to an ImageVis3D mobile device

To transfer data to an ImageVis3D Mobile (IV3Dm) enabled device at first IV3Dm features need to be enabled in the settings pane (see Section t). Once enabled a new menu entry "Transfer data to an ImageVis3D Mobile device" appears in the "File" menu (see Figure 8). Selecting this new option ImageVis3D opens up the data transfer dialog. If data is transferred for the first time the network port should be double-checked to make sure it is not blocked by a firewall or another application is using this port; if you have a firewall installed, note that ImageVis3D uses a single TCP port for the entire communication so only this port needs to be enabled in the firewall configuration, (22 by default). To prepare the

current dataset and its transfer function for the mobile device and initiate the transfer simply click start. On the mobile device enter the hostname or IP address of the computer running ImageVis3D and the port selected and start the transfer.

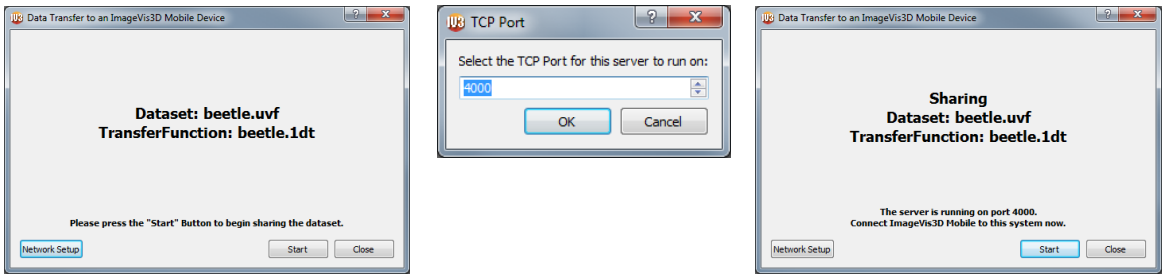

Figure 15 ImageVis3D Mobile Transfer

Windows Firewall

On Windows you may see a message from the built-in firewall asking you to allow or deny ImageVis3D access to the network. You must allow ImageVis3D access for data transfer to work. After allowing ImageVis3D access, you must click on 'Start' again to actually start the network server (the previous 'Start' has been blocked by the windows firewall).

j. Merging Datasets

Besides loading, converting, and exporting datasets. ImagVis3D also allows the merging of multiple datasets into a single volume. This feature requires multiple input volumes of the same size. To start the merging process select "Merge Data sets" from the "File"-menu to open the merge dialog (see Figure 16, left and center). In this dialog click on the "Add Data Set" button to add as many datasets as you like, if Auto-Analyze is checked ImageVis3D will automatically check the added files for their size and values (as in Figure 16, right). Note that ImageVis3D does not need to open datasets for rendering just to merge them. The datasets also do not need to be in UVF format; ImageVis3D can merge data directly from all supported external formats as well.

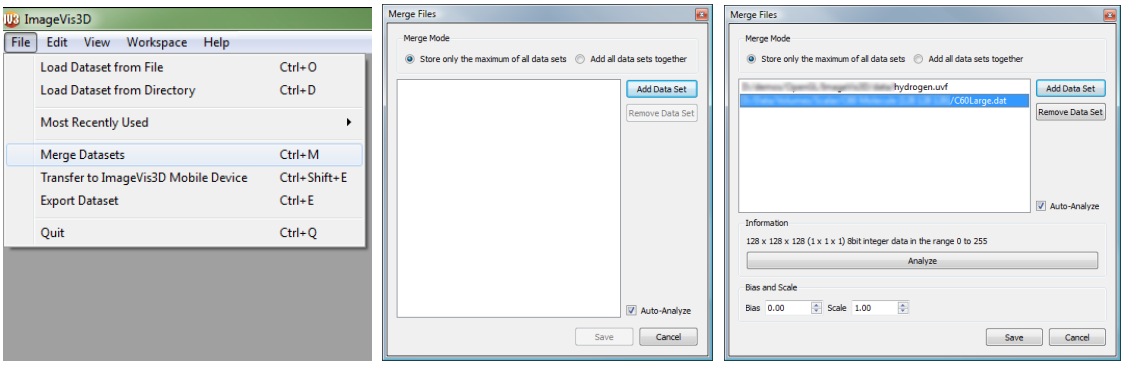

Figure 16 Merging multiple Datasets

Once all datasets that need to merged are added, the merge mode can be selected and every dataset can be scaled and biased. For every voxel of the merged dataset, m, one of the following merge equations is computed using the input datasets d_1 to d_n.

a) $m = \max\left((d_1 + bias_1) \cdot scale_1, \cdots, (d_n + bias_n) \cdot scale_n\right)$
b) $m = \sum_{i=0}^{n} (d_i + bias_i) \cdot scale_i$

Equation a) is computed when "maximum" is selected, and Equation b) is computed when "add" is selected

To start the merge process click "Save" and select a target filename. After merging, this file can then directly be loaded into ImageVis3D. Figure 17 shows an example of two datasets being merged into a single dataset.

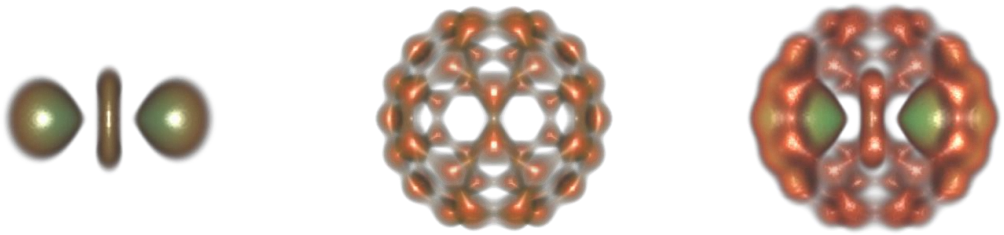

Figure 17 A Hydrogen Atom Dataset (left) merged (right) with a C60 Molecule (center)

5. Interacting with the Data

ImageVis3D's focus is on the interactive exploration of large volume data, and thus naturally the interaction component is the most important part of ImageVis3D's interface. There are two main ways of changing the appearance of a dataset. First, by changing the view parameters (e.g. rotating, translating, zooming) and second by changing the rendering parameters, such as the transfer function or iso-value.

IX. Interaction inside the Render Window

The primary means of interacting with render window is the mouse. Click and drag the left mouse button to rotate the dataset. Drag the right mouse button to move the dataset within the render window. Rotate the mouse wheel forward and backward to zoom closer or farther away from the dataset.

ImageVis3D utilizes keys to control some aspects of the render window. While the render window has focus,

- Press the **R** key to reset the view
- Press the **C** key to enable a small *C*oordinate cross, detailing the current dataset's orientation.
- Press the **A** key to toggle between *A*bsolute and relative rotation
- Press the **Page-Up** and **Page-Down** keys for fine scale zoom

For a complete list of the keyboard controls, see Section XX

X. Changing Render Modes

ImageVis3D has three different 3D rendering modes: one dimensional and two dimensional transfer functions, and isosurface rendering. To change between them quickly, select the "Rendering Options" tool widget (see Section v) from the "Workspace" menu. The "Render Mode" can be selected by clicking the text of the desired mode with the left mouse button. Use the "…" button to quickly open the tool widget for changing properties specific to the associated render mode.

Other global rendering settings are also configurable from the "Rendering Options" tool widget. The "Rescale" at the top can be used to scale the dataset in any dimension, to account for data formats which may not store enough information for ImageVis3D to discern this automatically (see Figure 18). Clicking "Save To File" on the top left will save the new scaling factor permanently to the UVF file.

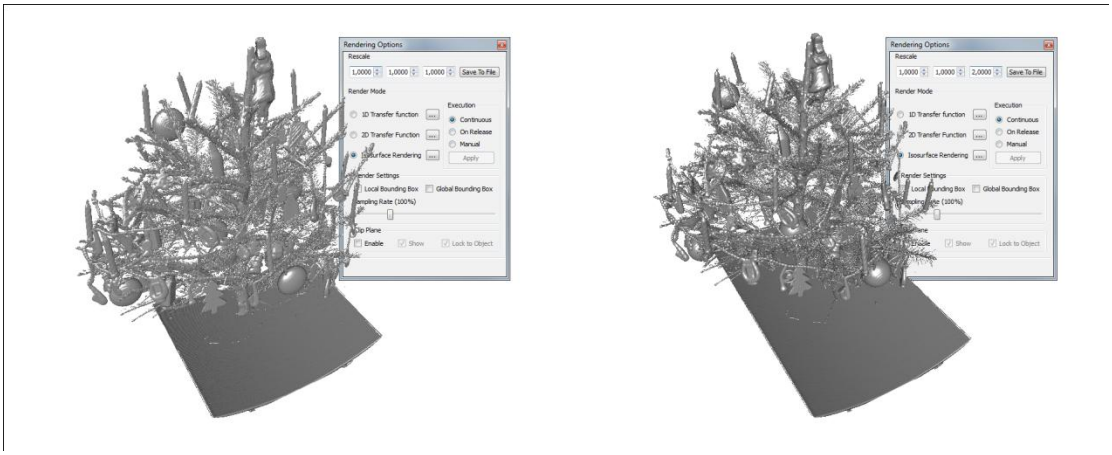

Figure 18. Using the 'Rescale' Feature To Correct the Aspect Ratio of a Dataset.

ImageVis3D supports multiple execution models, mostly to provide a better user experience on older hardware. The default setting is "Continuous", which causes the rendering to be updated instantly when any rendering parameter is changed (such as a transfer function or iso-value). The "On Release" setting waits until you release the mouse when interacting with the widget affecting the rendering parameter. Finally, the "Manual" execution mode waits for the user to click the "Apply" button before updating the render window with new

render settings. This setting is most useful on legacy hardware which cannot interactively re-render changes to the rendering parameters.

Clip planes will be described in Section XI, so the last configurable options in the "Rendering Options" window are the "Render Settings." "Global Bounding Box" will render a red box around the extents of the dataset; "Local Bounding Box" does the same for each individual "brick" of the dataset, which is mostly useful for developers. Finally, the "Sampling Rate" controls rendering quality: use lower settings for increased performance, and higher settings for generating publication-quality renderings.

k. Working with a 1D Transfer Function

One dimensional transfer functions are the typical manner for examining data in a volume rendering data. A transfer function is a mapping from the scalar values of the input dataset to color and opacity values. A volume renderer takes the transformed color and opacity values and blends them together.

To edit a 1D transfer function in ImageVis3D, select the 1D Transfer Function editor from the "Rendering Options" tool widget (by left-clicking the "…" button to the right of the label), or the "1D Transfer Function Editor" from the "Workspace" menu. This will open the editor in a separate tool widget (see Section x).

In the dominant portion of the widget is a function plot with a histogram of the data. Use the scrollbar on the rightmost side of the window to control the scale of histogram. The transfer function is (by default) the white line which forms a smooth-step function across the data. On the left are several checkboxes which allow one to control specific channels of the transfer function; popular groupings of the channels can be quickly selected via the radio buttons below, or the "User" setting can be used with the checkboxes to control the channels specifically. "Load" can be used to load an alternate transfer function; note that ImageVis3D will automatically load a transfer function based on the name of the dataset, using "1dt" as the file's extension. "Save" can be used to record the current transfer function for later use, or to send to a colleague. Finally, the "Copy To 2D" button can be used to copy the current 1D transfer function into the active 2D transfer function.

To change the transfer function, click and drag the left and right mouse buttons in the histogram on the right. Using the right mouse button allows general control over a smoothstep function from low to high, or high to low by holding the "shift" key. Moving the mouse up and down controls the inclination of the function's slope, while moving right to left controls the location of the midpoint of the function. The left mouse button allows fine grained control of the transfer function. As mentioned earlier, only the channels which are enabled on the left will be modified by mouse interactions. Figure 19 shows two transfer functions and their effect on the same dataset.

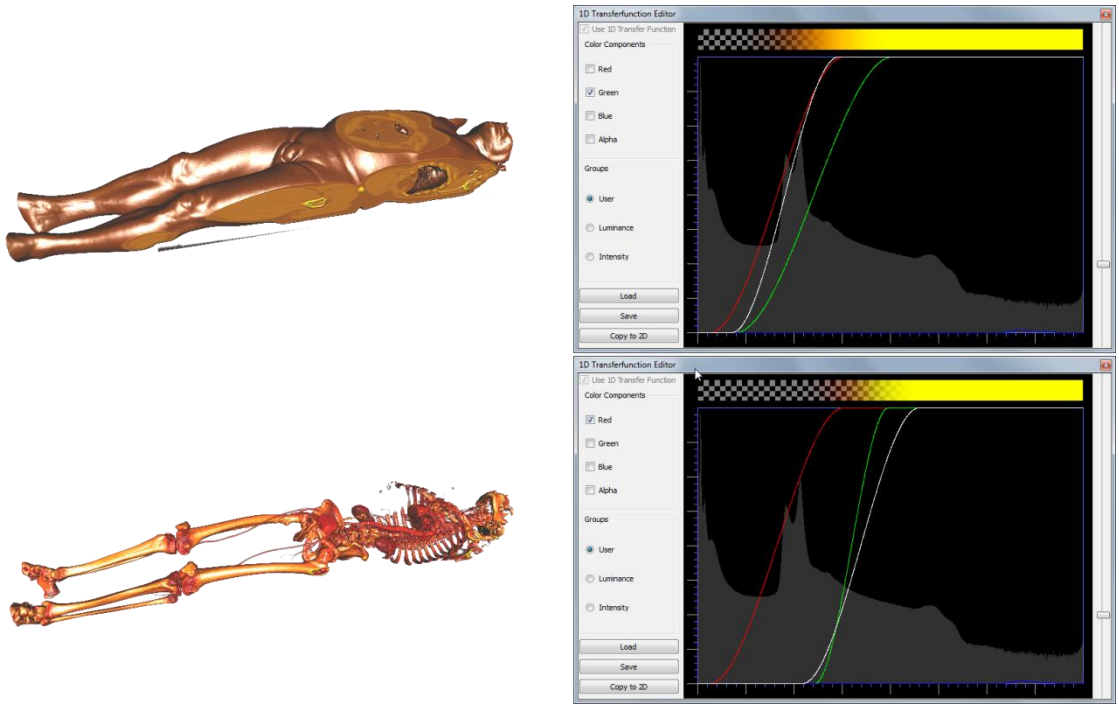

Figure 19 Effect of 1D Transfer Function on a Dataset Rendering

I. Working with a 2D Transfer Function

Two dimensional transfer functions are an alternate method of describing a transfer function, and therefore of understanding scalar volume data.

General

To edit a 2D transfer function in ImageVis3D, select the 2D Transfer Function editor from the "Rendering Options" tool widget (by left-clicking the "…" button to the right of the label), or the "2D Transfer Function Editor" from the "Workspace" menu. This will open the editor in a separate tool widget (see Section y).

In the dominant portion of the widget is a plot of the data on the X axis, and the gradient magnitude of the data on the Y axis. The opacity of a point is increased when many locations in the dataset share that same combination of values. As with the 1D transfer function editor, the scale can be controlled using the scrollbar on the right. Also in common with the 1D transfer function editor are the "Load" and "Save" buttons located at the bottom left of the widget. As with 1D transfer functions, ImageVis3D will automatically load a transfer function with the same name of the dataset, but with the "uvf" extension replaced by a "2dt" extension. To zoom in or out of the 2D transfer function use the mouse wheel. Click the middle mouse button and drag the mouse to navigate in the zoomed transfer function (see Figure 20).

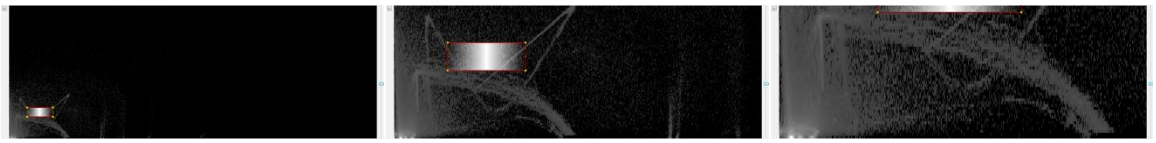

Figure 20 Zooming into a 2D Transfer Function

2D transfer functions are described using a series of widgets which are layered on top of the plot to the right. By default, a large white square with a linear gradient is configured, normally causing a majority of the dataset to be visible. Figure 22 depicts the effect of the transfer function widgets on the rendering of the dataset. ImageVis3D offers two modes to interact place and modify the widgets. The "Basic Mode" that offers a simplified user interface while in "Expert Mode" the full potential of ImageVis3D's 2D transfer function modeling capabilities become accessible at the cost of a more complicated user interface.

Basic Mode

In basic mode only two different types of widgets can be placed within the domain, rectangles and triangles (technically the "triangles" are really trapezoids but we do call them triangles for historic reasons). In ImageVis3D arbitrarily many of these primitives can be added to the domain by pressing the "New .." buttons below the transfer function domain canvas (see Figure 21). To delete a widget, first select it by clicking inside it (a red border indices the selected widget) and press the "Delete ..." button below the domain canvas. To change the color and opacity of a widget make sure it is selected and press the "Choose Color" button and use the "Opacity" slider.

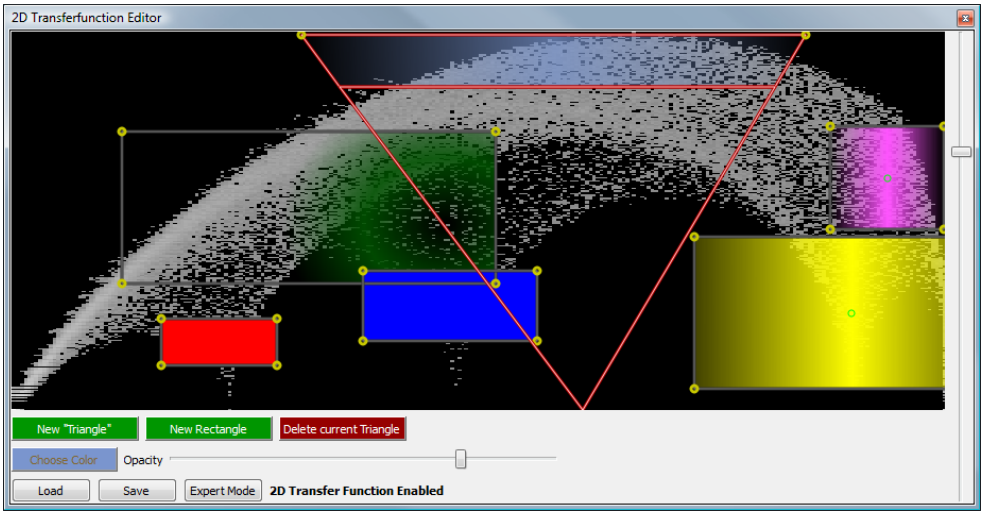

Figure 21 The 2D Transferfunction Edit in Basic Mode

To move any widget simply click and drag it. To resize a rectangle click and drag either the vertices or the edges, to change the center of a rectangle's gradient drag the green circle

within the rectangle. To reshape a triangle click on the top edge or its two vertices. To move the lower cutoff simply drag the lower edge of the triangle.

At the very bottom of the basic "2D Transferfunction Editor" are the "Load" and "Save" buttons and the toggle button to switch to the "Expert Mode". As in "Expert Mode" more sophisticated polygon widgets and also more sophisticated gradients can be created, these polygons will show up as a third widget type. These "Other" widgets can be moved by clicking and dragging within the widget and can be reshaped by dragging the edges and vertices. Note that ImageVis3D will continuously attempt to classify these "Other" widgets, e.g. if a "triangle" is moved in expert mode the intersection point of the two side edges will most likely not be on the lower edge of the domain anymore, thus it becomes an "Other" widget. However, if it is moved to the correct height it re-attaches to the bottom of the domain and becomes a "triangle" again.

Expert Mode

To interact with a widget in expert mode, first select the corresponding widget from the “Polygons” list on the left. This will cause various components to be rendered on the highlighted widget: a red border, a series of yellow control points, and two green circles for gradient control. Left click and drag the mouse on any of the yellow control points to change the shape of the widget. Left click and drag on the green circles to control the falloff of the gradient. Right click to add a new control point to the widget (note that the name of the widget in the “Polygons” list will change accordingly when doing this). Conversely, right clicking directly on a control point will remove that control point from the widget. To resize the widget uniformly, hold the control key (command key on Mac), left click in the widget, and drag the mouse. To move the widget, hold the shift key, left click in the widget, and drag the mouse. Finally, to rotate the widget, hold shift and control (again, command on a Mac), left click in the widget, and drag the mouse up and down.

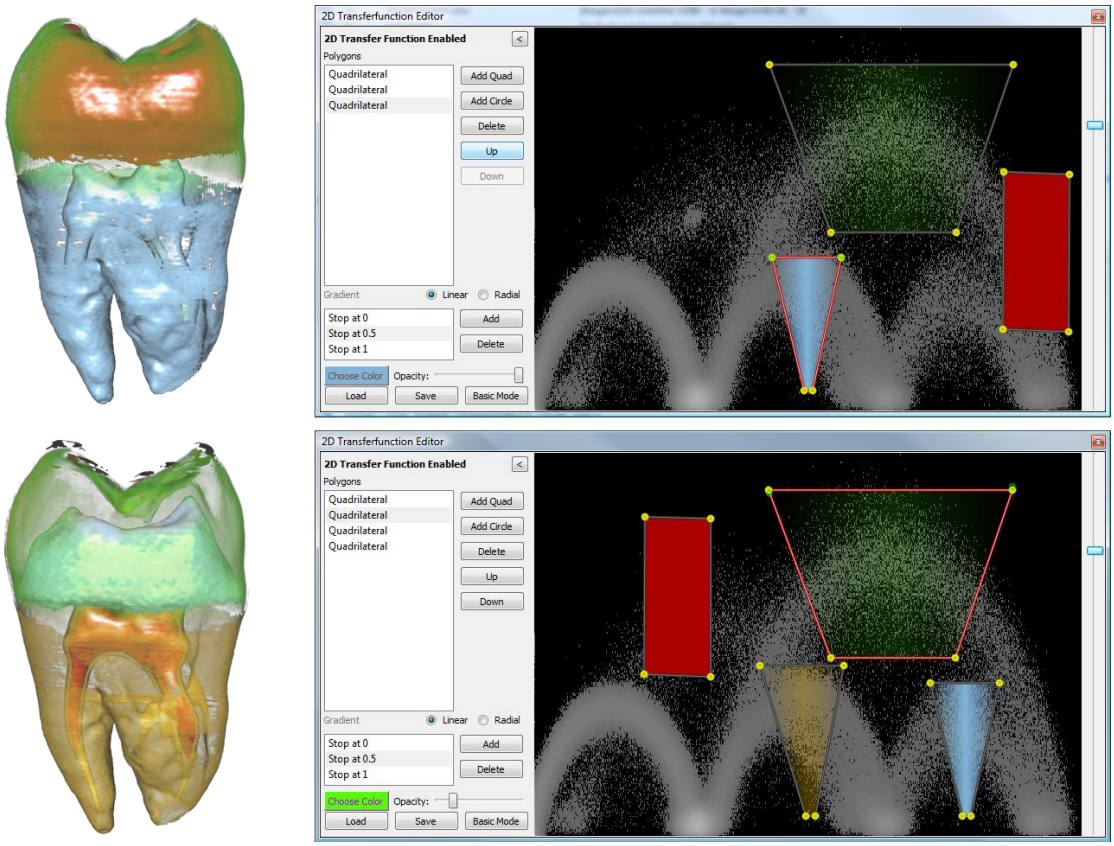

Figure 22 Effect of 2D Transfer Function Widget Positioning on a Dataset

Creating a new widget is done with the buttons to the left of the plot, use one of the "Add" buttons. To delete a widget altogether, highlight it in the "Polygons" list and then click the "Delete" button. The "Up" and "Down" buttons control the ordering in the list, which also affects the compositing order and thus the renderings produced when two widgets overlap. Below the polygon list is a control to select whether the currently active widget should use a linear or radial gradient. When using a radial gradient, the left green circle of the widget no longer controls the falloff of the gradient, instead controlling the center of the circular gradient function.

Near the bottom of the dialog is a control for the number of steps in the currently active widget's transfer function. By default, there are three steps, at 0, 0.5, and 1. Steps can be added and removed using the "Add" and "Delete" buttons to the right, or modified by highlighting the step in the list and then using the color and opacity controls below. Click the "Choose Color" option to change the color of the currently highlighted step. Drag the "Opacity" slider to the left to make the function more transparent, or to the right to make the covered portion of the dataset opaque. Please note that light source colors specified in the lighting tool widget (see Section dd) change the global light source color while the

settings in the Isosurface widget change the material color of each layer. For best results it is recommended to leave either the light color or the surface color monochromatic.

m. Working with IsoSurface Rendering

ImageVis3D also supports an isosurface rendering mode, which renders a surface composed entirely of data points which share the same value.

To edit the isovalue used for rendering, select the Isosurface Rendering editor from the "Rendering Options" tool widget (by left-clicking the "…" button to the right of the label), or the "Isosurface Settings" from the "Workspace" menu. This will open the editor in a separate tool widget (see Section z). The only relevant parameters are the color of the isosurface and the isovalue used to generate the surface. Drag the slider left and right to choose the isovalue. Click the "Choose Color" button to change the color of the isosurface.

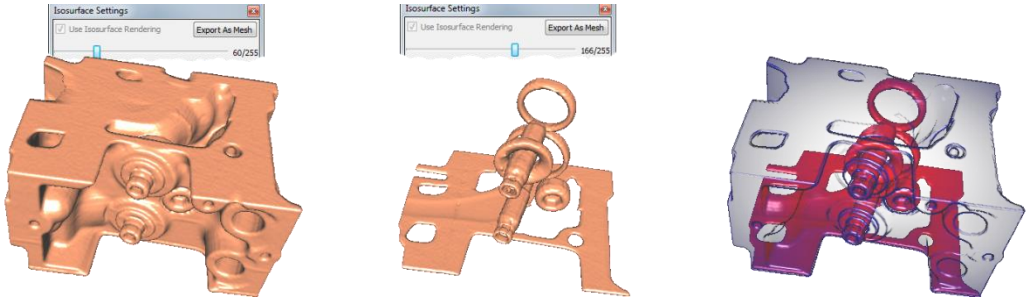

Figure 23. Multiple Isosurfaces and ClearView Rendering of the Same Two Isovalues

n. Working with ClearView

ClearView is a rendering mode which focuses on highlighting a region of interest without losing potentially important context in the data surrounding that region. It works by rendering two isosurfaces of the data, so-called "context" and "focus" isosurfaces. The focus isosurface is only displayed in a small region, controlled by the ClearView lens, whereas the context isosurface is displayed everywhere. Over the ClearView lens, the context isosurface's prominent features are kept, but the isosurface is made mostly transparent to allow viewing of the focus isosurface.

ClearView is controlled via the same tool widget as the isosurface rendering method. Select the "ClearView" checkbox in that window to enable the ClearView rendering mode. This will enable many of the UI elements which were previously grayed out below the normal isosurface settings. The context isosurface is controlled via the same slider which is used when rendering only a single isosurface. The slider labeled "Focus Isovalue" controls the isovalue used for the focus isosurface. Similar to the context isosurface, the focus isosurface's color can be changed with the "Choose Focus Color" button.

After enabling ClearView and selecting isovalues for both the focus and context isosurfaces, the ClearView lens can be moved over the dataset. To do so, move the mouse inside the

render window, and then begin holding “shift”. Now as the mouse moves, the ClearView lens will center itself on the mouse cursor. Note that it is *not* necessary to hold the left mouse button; simply moving the mouse is enough to change the location of the ClearView lens.

Three new sliders are specific to the ClearView lens. The first, “Focus Size”, controls the radius of the lens. “Context Scale” controls how prominent features on the context isosurface will be when the ClearView lens is covering them. “Border” controls the width of the black line which details the edge of the ClearView lens.

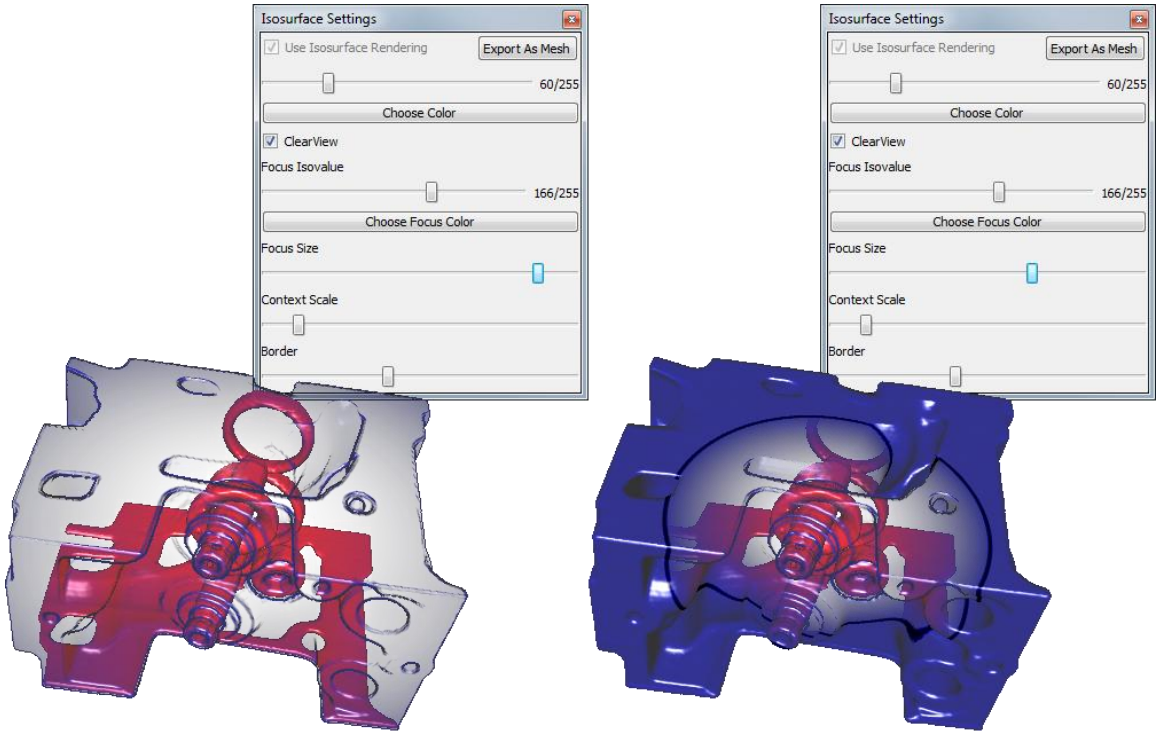

Figure 24. Effect of the Focus Size ClearView Rendering Parameter

XI. Clip Plane

A clipping plane can be enabled via the “Rendering Options” tool widget. At the bottom of this widget is a group of three checkboxes which control how the clip plane affect rendering and interaction with the dataset.

To enable the clip plane, check the “Enable” checkbox. By default, the “Show” and “Lock to Object” checkboxes will be checked. “Show” causes a visible widget to be drawn which highlights the plane being rendered.”Lock to Object” will cause the clip plane to be affected with view transformations which affect the dataset.

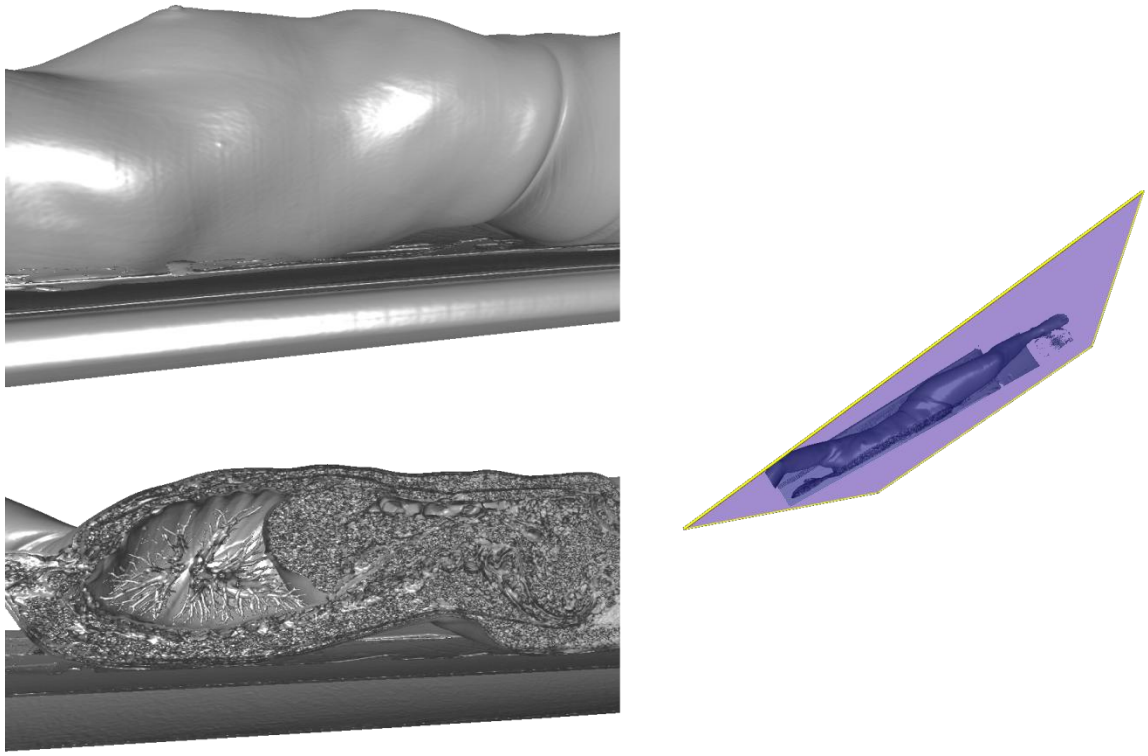

Figure 25 Example use of the clipping plane. Half the data are clipped away so that the interior of the dataset is easily visible.

The clipping plane uses the same mouse controls used in normal dataset interactions, except that the control key must be held down. Thus, to rotate the clipping plane, hold control, then left click and drag the mouse inside the render window. Similarly, hold control while right-clicking and drag the mouse to move the clip plane.

XII. The Render Window Revisited

Despite the name, "ImageVis3D", the program is also capable of developing common 2D imagery, such as slice and MIP-based views. These rendering modes are configured via specific keyboard controls instead of the "Rendering Options" tool widget.

o. Single Window vs. Two by Two View

The default view is the 3D view, to properly display volumetric renderings. ImageVis3D also supports a 2x2 rendering mode, with the 3D view in the top left and the other three views comprised of axis-aligned slice planes. The slices planes are rendered by the current 1D or 2D transfer function (note that the 1D transfer function is used when the isosurface render mode is enabled). To enable this mode, click in the render window you'd like to change to and hit 'space'. In the 2x2 mode, the bottom left image shows slices along the Z axis; the bottom right shows slices along the X axis, and the top right shows slices along the Y axis.

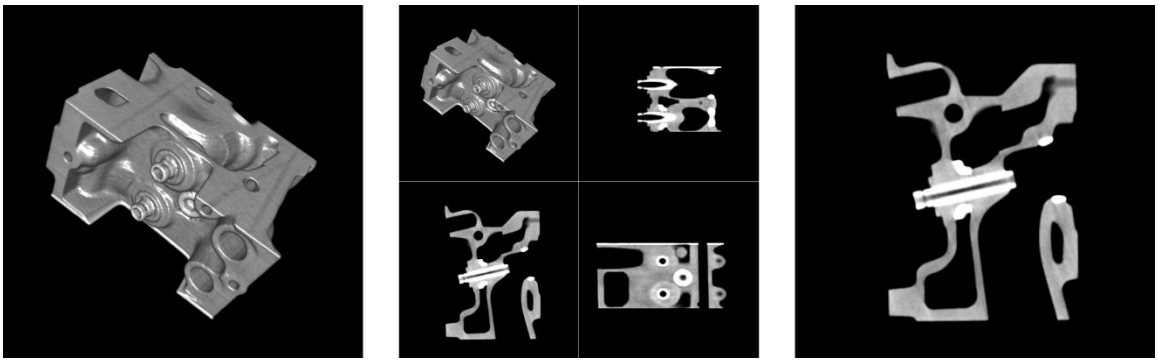

Figure 26. Using Multiple Views. 3D rendering mode, Two-by-two Mode After Hitting 'Space', and Hitting 'Space' Again to Highlight a Particular Slice View.

To change which slice is displayed, hover the mouse pointer over the region which shows the axis you are interested in, and rotate the mouse wheel. The slices can be flipped along the X and Y axes by using the 'X' and 'Y' keys, respectively. To display the position of the 2D slice in 3D press the 'P' key (see Figure 27 center). To use the entire region for a particular slice view, hover the mouse pointer over that region and hit 'space'. This can also be used to return to the normal 3D view, by hovering the mouse pointer over the top left image before hitting 'space'.

p. Maximum Intensity Projection (MIP) View

ImageVis3D also supports a MIP rendering mode. A maximum intensity projection renders the maximum value along a series of slices. For example, in a CT scan of a head, a MIP is likely to pick up the skull as opposed to skin or brain tissue.

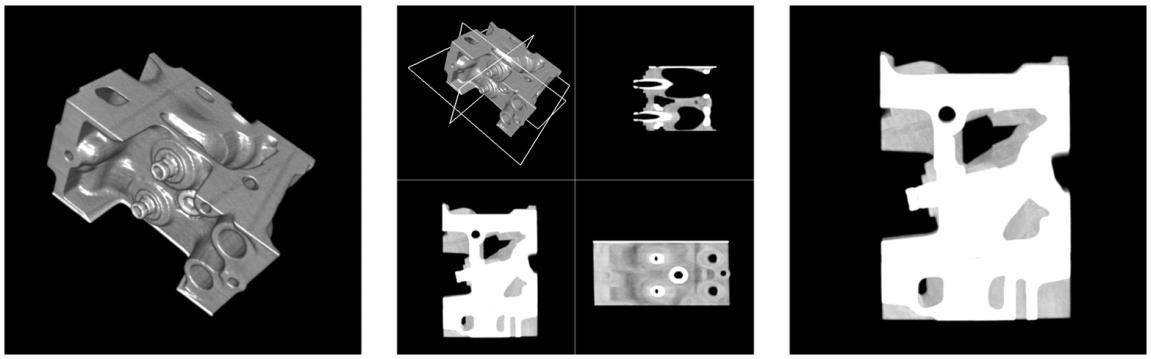

Figure 27. Example of MIP Views; the Bottom Two Views use the MIP Rendering Mode also notice the plane position marker of the 2D slices in the 3D window in the top left in the 2 by 2 view.

The MIP rendering mode can be enabled by hovering over a slice view and hitting the 'm' key. Note that the 'X' and 'Y' keys can still be used to flip the axes, as with the slice views.

XIII. Working with multiple Windows

ImageVis3D allows any number of render windows to be open at once.

q. Locking

When multiple render windows are open in ImageVis3D, rendering parameters can be locked between them. This can be useful for analyzing the same dataset while changing only a single rendering parameter. For example, one could lock a view and change a transfer function, to observe the differences between transfer functions without worrying if the configured view settings are identical. To enable locking of multiple render windows, open the "Locking Options" from the "Workspaces" menu.

As can be seen in Figure 45, the bottom of the widget contains a list of render windows, as described by the dataset which is loaded in them. Note that the currently active window is not shown, and thus the list of render windows will be empty if only a single render window is open. To lock settings, click the "View Transformation" or "Render Mode" options and then select the window which should be locked to the currently highlighted window in the list of render windows. Click a render window in the list a second time to deselect it, thereby unlocking it from the currently active render window.

The "View Transformation" locking modality will lock view parameters between the two render windows. Thus every rotation, translation, or clip plane modification will propagate to locked windows. The "Render Mode" locking modality causes the three major rendering modes (1D transfer function, 2D transfer function, and isosurface rendering) to be locked between the render windows.

XIV. Stereo Rendering

ImageVis3D allows datasets to rendered in anaglyph red/blue stereo to enhance the illusion of depth perception. To enable stereo rendering in any render mode simply click on "Enable Stereo Rendering" in the "Stereo"-tool widget (see Section cc). You can use the "Eye distance" slider to increase or decrease the perceived depth and use the "Focal Length" slider to change the depth relative to the computer screen (i.e. if the image appears behind or in front of the screen). Figure 28 shows an example of such an anaglyph image.

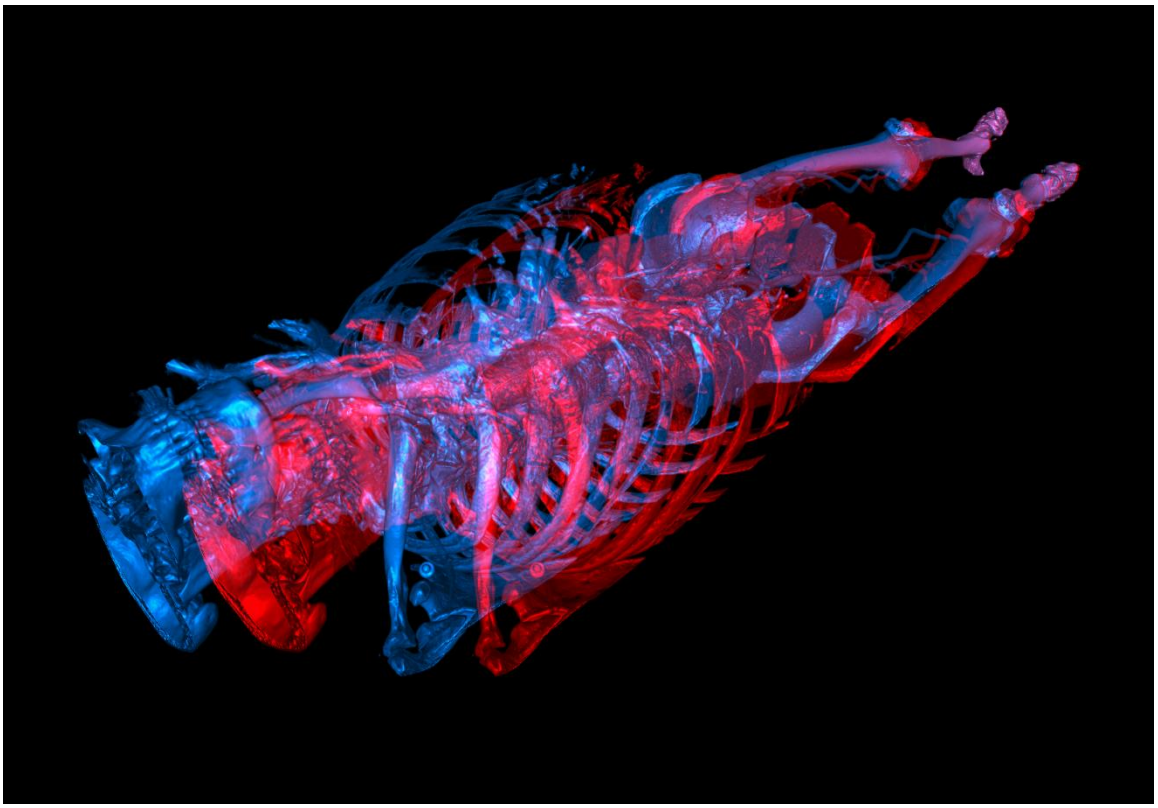

Figure 28 An Anaglyph Stereo Image

6. Capturing Images and Sequences

Often it is helpful to send an image or movie of a specific view to a collaborator or integrate renderings into a publication. For this purpose ImageVis3D features a set of capturing options in the "Recorder" tool widget (see Figure 46 & Figure 29). To better understand the capturing process we consider the ImageVis3D session as shown in Figure 29, which shows the cover image of this manual being generated. In that session a dataset has been loaded and the "Recorder"- tool widget has been opened.

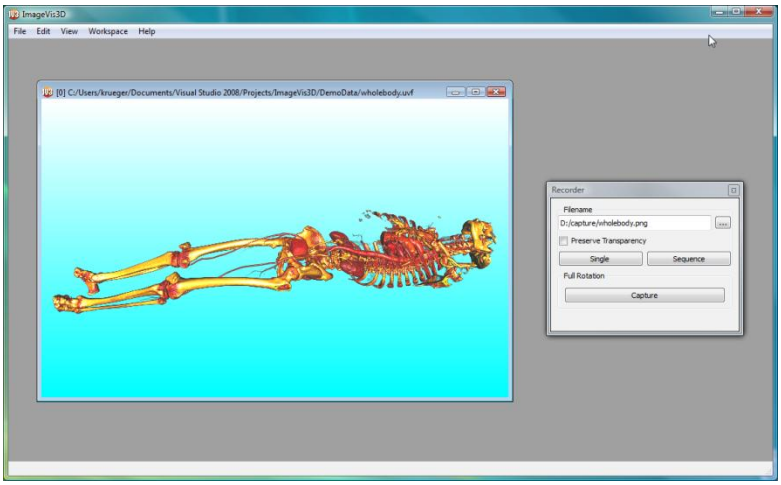

Figure 29 Capturing in ImageVis3D

In the text field of the "Recorder" tool widget the target filename for the captured image is shown. To change the filename, press the "..." button to the left of the text field and select a file. ImageVis3D automatically detects the file type by the file's extension (png in this example). If you press the "Single" - button a new file with the exact filename given in the text field is created overriding any existing file with that name. To capture multiple files with similar names press the "Sequence"-button instead. This will create files with a numbered added to sequentially order them, never overriding any data. The "Capture" - button on the bottom will automatically create a set of images while rotating the dataset around the Y - axis. The number of images is specified in second dialog that opens once "Capture" is pressed (see Figure 30 left). Rotations can also be captured in MIP mode, which enables a few more options (see Figure 30 right). Note that when using the 3D view, images are automatically captured using the current view parameters, including stereo rendering.

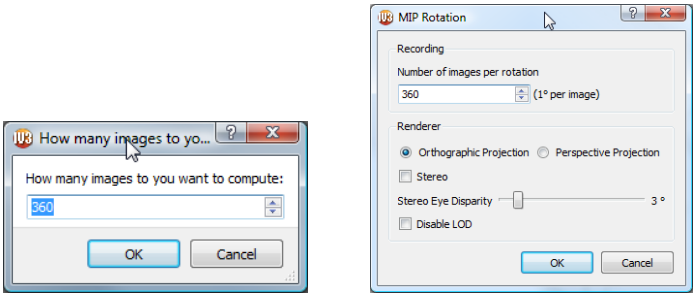

Figure 30 Full Rotation Capture Dialogs (3D view left, MIP view right)

The result of a rotation capture is a set of images that can be easily used in many movie creating tools to create an animation of a spinning dataset. See Figure 31 for an example set of images created from the in Figure 29 by selecting to record 16 images. Note that those

images were captured with the "Preserve Transparency" switch turned off (seen in Figure 29), thus showing the background as opaque. If the switch "Preserve Transparency" is turned on the transparency information is stored in the image if that image format supports transparency (e.g. PNG, TIFF). Capturing transparent images is useful if the image should later be combined with other images. Figure 32 shows the difference of a transparent and a non transparent image composited on top of a stripe pattern.

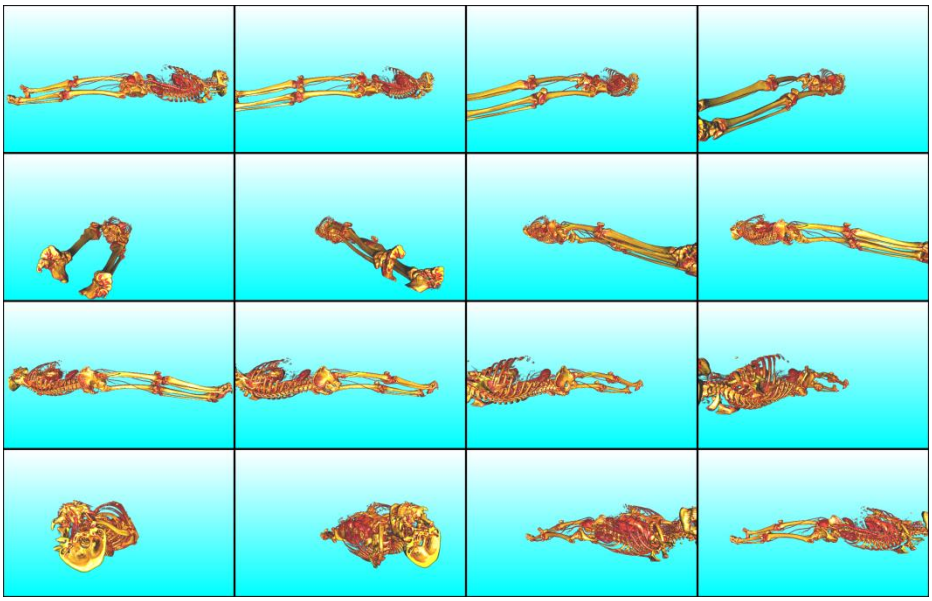

Figure 31 A set of 16 images automatically created with the "Capture" feature

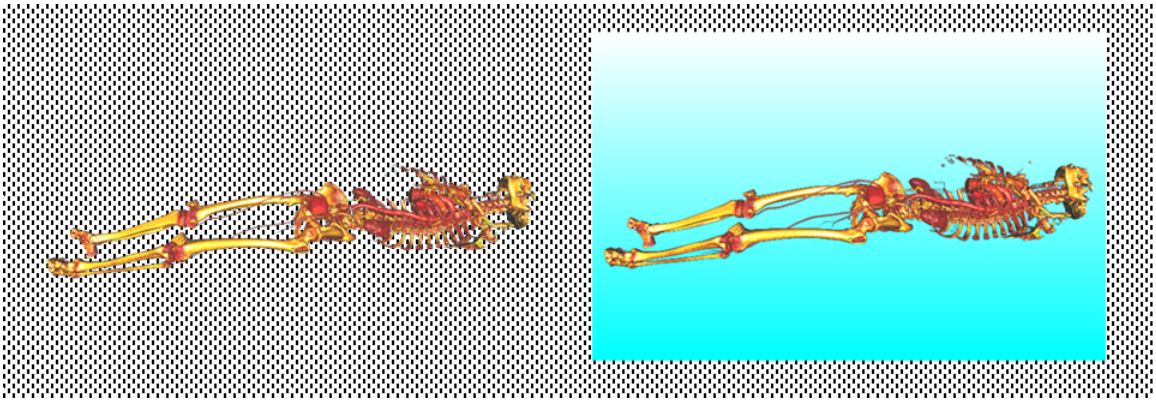

Figure 32 A Transparent image (left) vs. Opaque Image (right)

7. Working With Workspaces

A very important part of ImageVis3D's User Interface is the concept of *Workspaces*. A Workspace is a particular layout of the Tool Widgets (see Section XIX for a list of all Tool Widgets). Unless changed in the settings ImageVis3D remembers the workspace once it is quit and restores it when it is restarted. Thus one a useful layout of the tool widgets is chosen ImageVis3D will always look the same. Sometimes, however, a single workspace only works for a specific task (e.g. specifying a 2D Transfer function) but may leave too little space for other tasks. Therefore, ImageVis3D allows the user to specify, save and load as many different workspaces as desired. Simply arrange the tool widgets in ImageVis3D as necessary for a certain task and then click "Save Workspace" in the "Workspace" menu or press Ctrl+Alt+S. To load a previously saved workspace from disk click "Load Workspace" in the "Workspace" menu or press Ctrl+Alt+L. To quickly toggle between most recently loaded workspaces you may also want to use the "Most recently used Workspaces" list in the "Workspace" menu or use the Ctrl+Alt+[number] shortcuts to quickly change workspaces. Hint: As the most recently loaded Workspace gets assigned to Ctrl+Alt+1 and the second most recent workspace is assigned to the shortcut Ctrl+Alt+2, pressing Ctrl+Alt+2 will toggle between the last two workspaces.

8. Advanced Topics

XV. Changing Parameters

ImageVis3D has a number of settings to control performance and user interface behavior. When first run, ImageVis3D will ask if you would like to change these settings, but you can modify them at any time by selecting “Settings” from the “Edit” menu (on Mac: “Preferences” from the “ImageVis3D” menu).

r. Memory

ImageVis3D contains advanced memory management code to make sure it does not attempt to exceed the capabilities of your system. To effectively perform that task, it must know what those capabilities are.

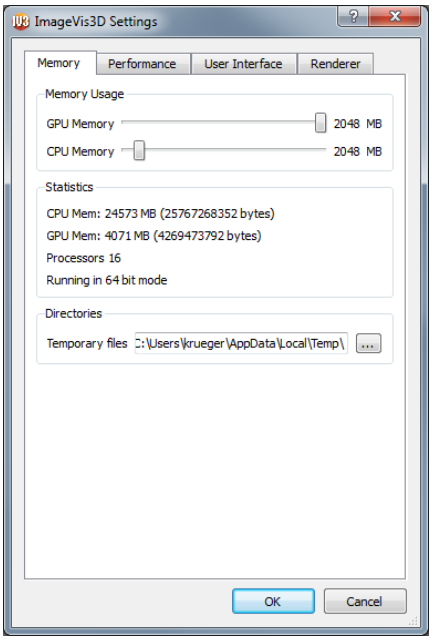

Figure 33 ImageVis3D Settings Dialog "Memory" tab

The *GPU Memory* slider tells ImageVis3D how much memory you have on your graphics card. Mac OS X users can obtain this information from the System Profiler. Linux users can normally glean the amount of video memory from */var/log/Xorg.0.log*. The *CPU Memory* slider controls the amount of system RAM; ImageVis3D will assume it can access the amount of memory given here quickly. For this reason, especially if you're running many other applications, it can be a good idea to set the *CPU Memory* a bit lower than your system's actual available RAM.

It is not so bad if you set these sliders a bit too low, but it can affect performance severely if you set them too high. Thus, if you are unsure, you should utilize conservative settings. It is essentially unheard of for any GPU to have less than64mb of memory these days; likewise, most systems purchased in the last 3 years have a gigabyte (1024 MB) of memory or more.

s. Performance

The *Performance* tab lets you customize the interactivity of ImageVis3D. The *Open files without verification* checkbox is off by default, and it is probably a good idea to leave it as such. ImageVis3D verifies that the data you load are not corrupt, so you can be sure you are viewing exactly what you saved last week (or your colleague was viewing before they sent it to you). However, this process can be slow, and so if you are opening the same file repeatedly it can be nice to disable the check.

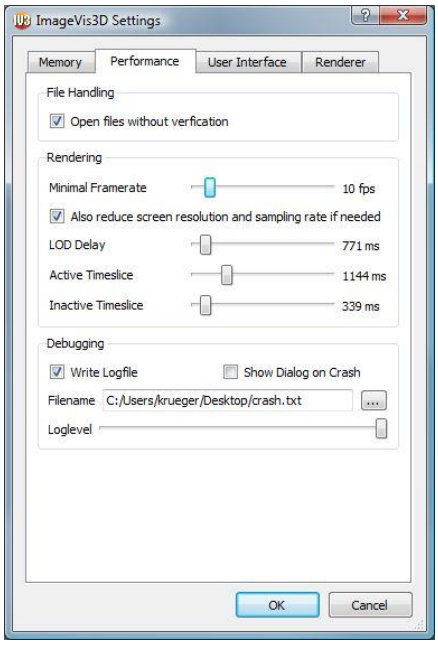

Figure 34 ImageVis3D Settings dialog "Performance" tab

The four sliders allow control of ImageVis3D's interactivity at the expense of raw performance. *Minimal framer ate* is a target frame rate that ImageVis3D will try to maintain at all times. *Active Timeslice* and *Inactive Timeslice* have the largest effect on interactivity; they control how often ImageVis3D will check to see if you are changing rendering parameters. Larger timeslices will lower total rendering time, but may cause ImageVis3D to feel as if it “lags” behind your input.

ImageVis3D achieves interactivity using multiple levels of detail (LOD). A typical scenario for scientists using visualization software is to configure a particular viewpoint, transfer function, or combination of rendering parameters such that the feature of interest is visible or prominent. While interacting with the software, it can be a nuisance to do a complete render every time some small setting is changed, because a complete render can take quite some time, and many more changes will need to be made before settling on a 'final' rendering. LOD techniques allow us to do a quick 'preview' render in this scenario, so the user may get an idea of how the completed render will look without committing to the time required for a full render.

To take advantage of this, ImageVis3D monitors how long it has been since the user changed a rendering parameter. If it has been 'long enough', then ImageVis3D will load and render the dataset at a higher resolution. The *LOD Delay* slider controls how long ImageVis3D will wait.

t. User Interface

This tab contains settings for what ImageVis3D will remember across runs.

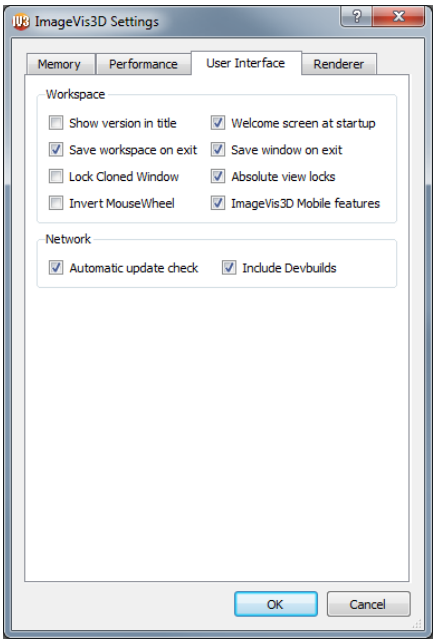

Figure 35 ImageVis3D Settings dialog "User Interface" tab

- *Show version in title* – Show the version number of ImageVis3D in the title bar of the main window.
- *Save Workspace on Exit* – Saves the set of open windows, e.g. the transfer function editors, or rendering options windows.
- *Save Window on Exit* – Which windows were open, plus rendering settings in those windows.
- *Lock Clones Windows* – Whether or not a cloned window has its view parameters locked with the source window, by default. This setting can always be changed on a per-window basis via the "Locking Options" tool widget in the "Workspace" menu.
- *Absolute View Locks* – Toggles between relative and absolute view locking. In both cases, rotation in one window will cause rotation in all windows which are locked to that window. With relative locking the view parameters allowed to differ, so you could (for example) view a volume from opposite angles.
- *Welcome screen at startup* – Display the ImageVis3D welcome screen when ImageVis3D is launched, which provides quick access to recently used datasets and online help.
- *Invert MouseWheel* – inverts the zoom function of the mouse wheel, it controls if scrolling up or scrolling down zooms in or out.
- *ImageVis3D Mobile features* – enables server features for transfer to ImageVis3D mobile enabled devices.

- *Automatic update check* – Enable ImageVis3D's automatic updating feature, which will inform you when a new version of ImageVis3D has been released.
- *Include Devbuilds* – When checking for new versions (if *Automatic update check* is enabled), include a notification if a new "developer build" has been posted (note: developer builds may not be as stable and certainly aren't as well-tested as a normal ImageVis3D release but may contain new features that are not included in the normal releases yet).

u. Renderer

The *Renderer* tab contains compatibility and quality settings. The *Render Method* selects the renderer type; in general, *Slicing* and 2D Slicing are compatible across more graphics cards, but *Raycasting* gives better quality. *Blend Precision* tells ImageVis3D how much detail to retain when rendering; *8 bit* is supported across all graphics cards, but recent GPUs support *16 bit* or even *32 bit* blending, which will generate higher quality images.

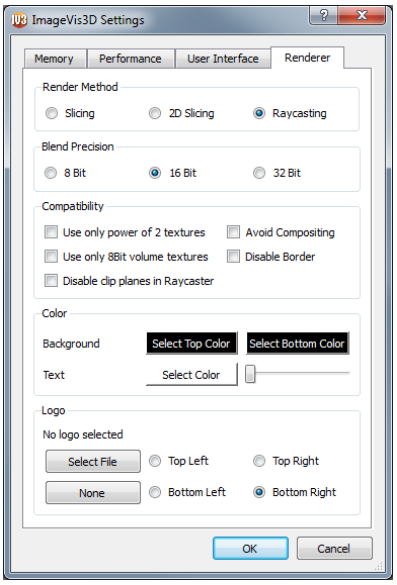

Figure 36 ImageVis3D Settings dialog "Renderer" tab

Compatibility options modify the manner in which ImageVis3D renders, in order to work around issues with graphics cards or bugs in GPU drivers. Use *only power of 2 textures* should be enabled on all but the most modern graphics cards; without it, ImageVis3D will perform poorly. *Avoid Compositing* is necessary to work around defects in some GPUs / GPU drivers. If an image seems to disappear into the background arbitrarily, or you notice polygons which seem to 'pop' and flicker as you rotate the volume, you will need this setting. Unfortunately this currently disables ImageVis3D's ClearView rendering mode. *Use only 8Bit volume textures* downscales even high resolution data down to 8 bits before sending it to the GPU. This is sometimes necessary to get very old video cards to run ImageVis3D, but can significantly degrade quality. *Disable Border* deals with a technical

rendering issue. Try checking the option and seeing the affect on performance for your system – leave it checked if the performance impact is negligible. Check the "Disable clip-planes in raycaster" if you experience extremely slow performance in ray-casting mode (system appears to be frozen for minutes).

The “Color” settings control how ImageVis3D uses color for the background and text annotations. The two buttons next to “Background” allow configuring a gradient background in render windows (see Figure 37). The “Select Color” button next to “Text” controls the color used for rendering of all text annotations in ImageVis3D; the adjacent slider controls the opacity.

ImageVis3D can add a logo to each image it renders (see Figure 37), configured using the last section of the “Renderer” tab. Click the “Select File” button to open a dialog and browse to the desired image file. Click the “None” button to remove a previous choice and top rendering a logo. One of the four options on the right must be selected to detail where the logo should be rendered.

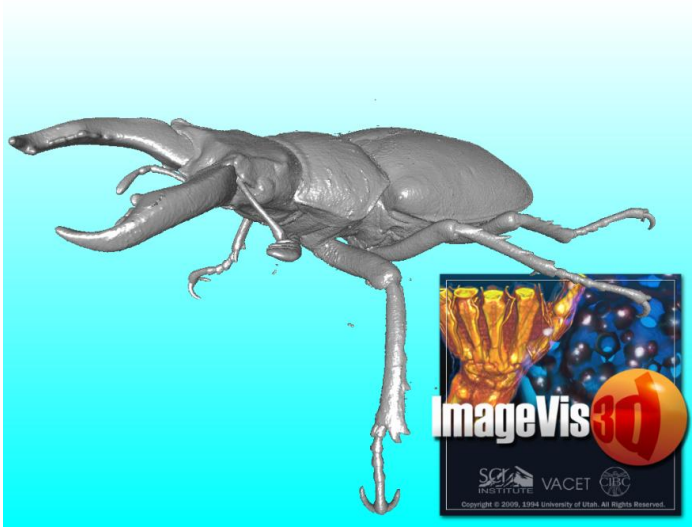

Figure 37 Using logo and background gradients in a rendering.

XVI. Reporting a Issue

ImageVis3D has a built in dialog which can be used to report any undesirable behavior you may come across. This can be accessed via the “Help” menu or by pressing Ctrl+I. The ImageVis3D development team asks that you use this dialog whenever possible to report problems you encounter with ImageVis3D. Using this dialog automatically includes much of the most useful information for developers, and helps streamline your report for easy access and review.

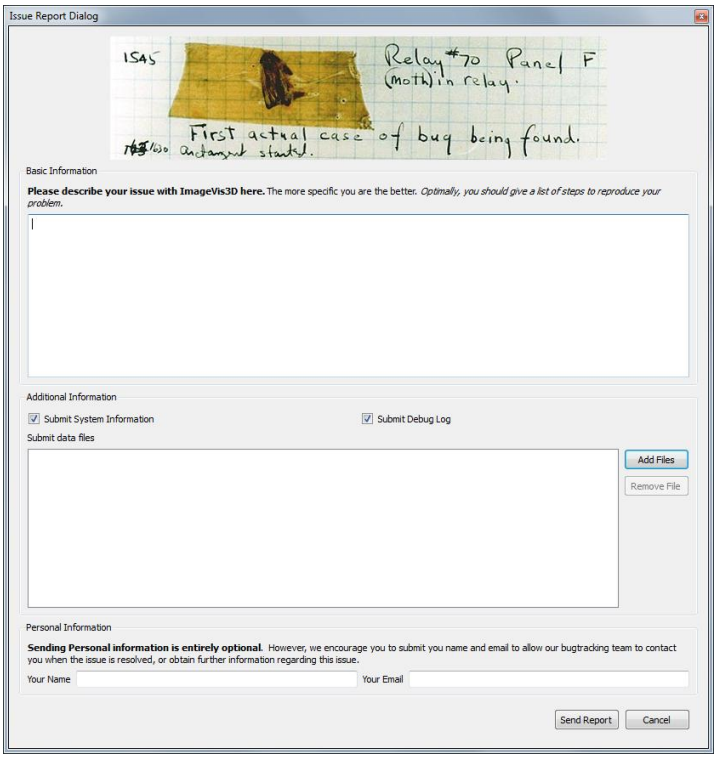

Figure 38 ImageVis3D "Report an Issue" dialog

XVII. The Debug Console

ImageVis3D has a debug console to detail any problems it comes across while rendering, and include useful information on what it is doing 'under the hood'. You can enable the debug window by selecting "Debug Window" from the "Help" menu or by pressing Ctrl+D. By default, the only information which is displayed will be errors, which means most systems would never see any output. However by enabling the "Warnings" and "Messages" checkboxes at the top of the window, detailed information about what ImageVis3D is doing will be displayed.

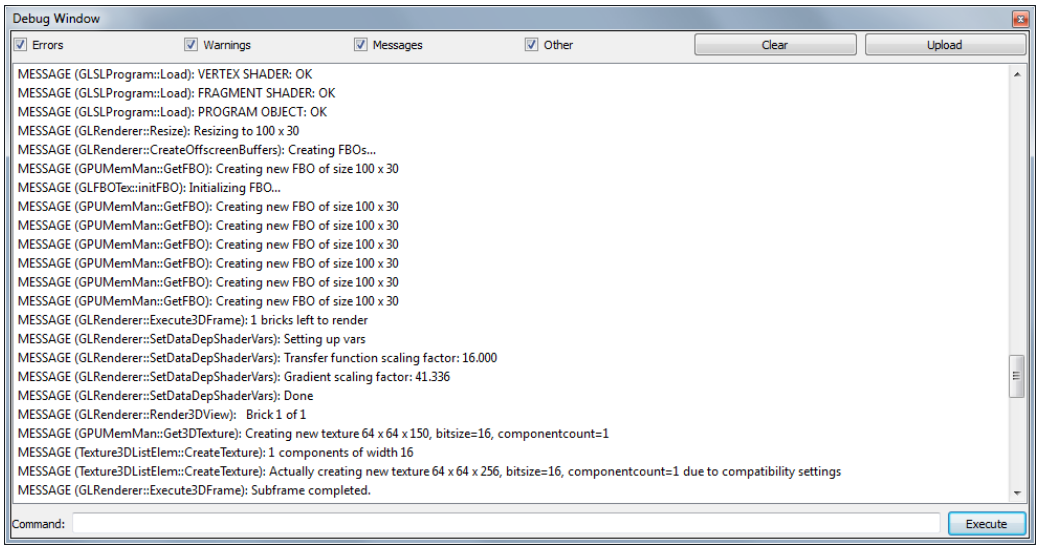

Figure 39 ImageVis3D's debug window with all debug channels enabled.

For the most part, this information will not be useful to users, but developers can use it to help pinpoint an issue with ImageVis3D. The current debug log can be sent to the ImageVis3D developers by clicking the "Upload" button at the top right. Do note that the same information is also given when using the "Report an Issue" dialog, however. Finally, at the bottom of the window is a text input field to allow commands to be entered to ImageVis3D manually.

XVIII. Running a Script

ImageVis3D can run a script file which controls basics rendering parameters. This is useful for configuring ImageVis3D to immediately highlight a particular region of a dataset, or to generate images in batch, potentially from a series of datasets.

ImageVis3D comes with a number of commands built-in, the most important of which being "open", "resize", "rotate[X|Y|Z]", "capturesequence", and "quit". "open" opens a dataset and makes that the currently active render window. "resize" takes two parameters (e.g. "resize 100 90") and resizes the active window's to match those arguments. The "rotate" commands (e.g. "rotateX 90") take a single argument which gives the number of degrees to rotate around the given axis. Finally, "capturesequence" creates an image file of the given name, with an automatically increasing sequence number tacked on the end (see Section bb).

A full list of commands can be found in the appendix, section XXI.

9. Appendix

XIX. List of all Tool Widgets

In this section we review the tool widgets available in ImageVis3D.

v. The Rendering Options

This widget controls the basic rendering parameters it is opened by pressing Ctrl+Alt+1.

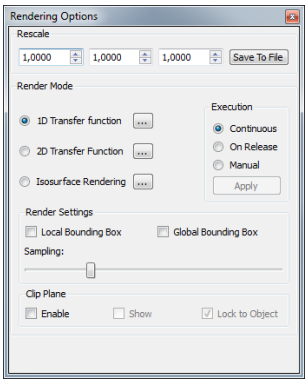

Figure 40 The "Rendering Options" Tool Widget

w. The Progress Viewer

The progress viewer details the current status of the rendering it is opened by pressing Ctrl+Alt+2. The top bar details the current level of detail (LOD) that ImageVis3D is rendering; the second bar shows the progress of that LOD as determined by the number of bricks already rendered for that level. It also contains the controls to limit the maximum and minimum quality levels.

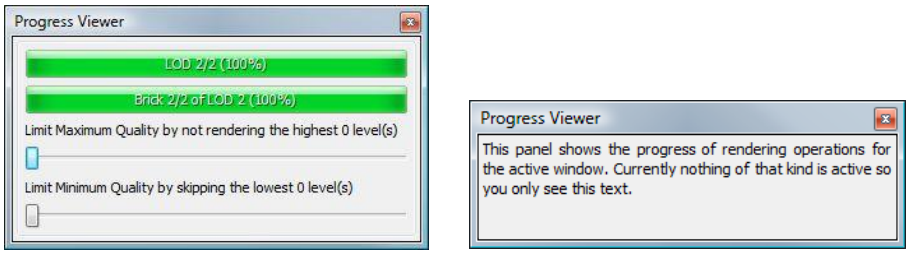

Figure 41 The "Progress Viewer" Tool Widget in activestate (left) and inactive state (right)

x. The 1D Transferfunction Editor

The 1D transfer function editor allows modification of the current 1D transfer function, it is opened by pressing Ctrl+Alt+3.

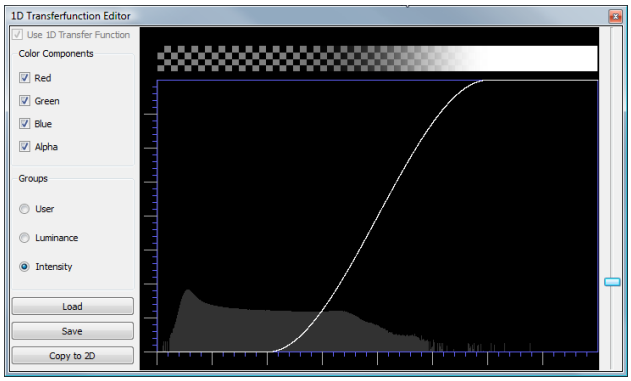

Figure 42 The "1D Transferfunction Editor" Tool Widget

y. The 2D Transferfunction Editor

The 2D transfer function editor allows modification of the current 2D transfer function it is opened by pressing Ctrl+Alt+4.

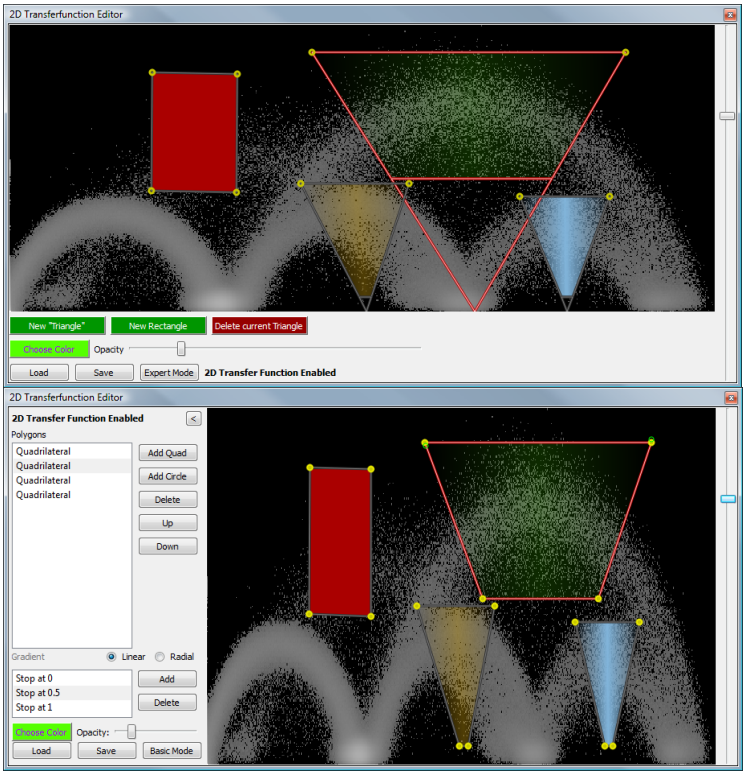

Figure 43 The "2D Transferfunction Editor" Tool Widget (Basic Mode top / Expert Mode bottom)

z. The Isosurface Settings

The isosurface editor allows modification of the current isosurface and ClearView settings it is opened by pressing Ctrl+Alt+5.

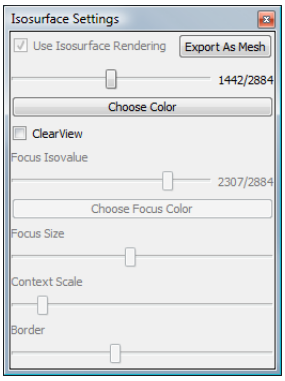

Figure 44 The "Isosurface Settings" Tool Widget

aa. The Locking Options

The locking options widget controls which render windows are locked to the currently active render window, and in which modes those locks apply, it is opened by pressing Ctrl+Alt+6. “View Transformation” locks the view parameters, and “Render Mode” locks the usage of 1D, 2D, or isosurface renderers. Note that view locks take effect immediately, whereas render mode locks are only respected from the time of locking forward.

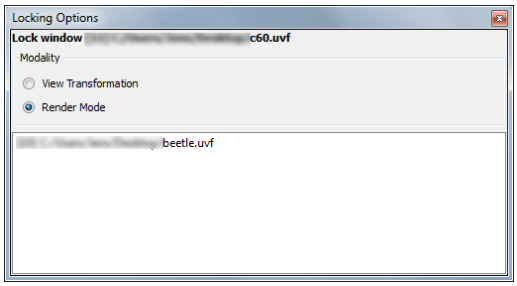

Figure 45 The "Locking Options" Tool Widget

bb. The Recorder Widget

The recorder widget is used for saving images and series of images, it is opened by pressing Ctrl+Alt+7. Using the “Capture” button and corresponding UI, rotations about the Y axis can also be performed, outputting a series of images which can be assembled together into a movie using external tools.

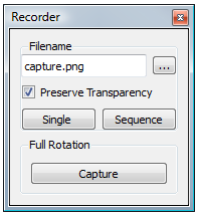

Figure 46 The "Recorder" Tool Widget

cc. The Stereo Widget

The stereo widget enables and configures anaglyph rendering, which can enhance the illusion of depth which an image generates it is opened by pressing Ctrl+Alt+8.

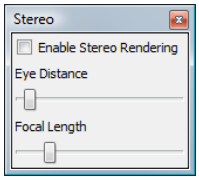

Figure 47 The "Stereo" Tool Widget

dd. The Lighting Widget

The lighting widget configures and previews the ambient, diffuse, and highlight colors and intensities of the light source. Please note that this widget changes the color of the light source. Thus, it is still possible in isosurface- and ClearView-mode to also change the object colors.

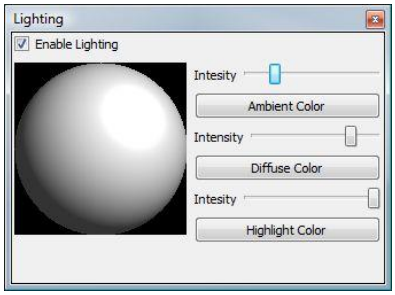

Figure 48 The "Lighting" Tool Widget

XX. List of Keyboard Shortcuts and Mouse Gestures

ee. General

- Ctrl+O - Load or Import a dataset from file
- Ctrl+D - Import a dataset from a stack of files in a directory
- Ctrl+ 1 - to Ctrl+ 5 - Load the most recently used datasets
- Ctrl+M - Merge datasets
- Ctrl+E - Export the current dataset
- Ctrl+Q - Quit ImageVis3D

- Ctrl+S - Open the settings dialog

- Ctrl+Shift+C - Cascade the renderwindows
- Ctrl+Shift+T - Tile the renderwindows
- Ctrl+Shift+N - Bring next renderwindow to top

- Ctrl+Shift+P - Bring previous renderwindow to op
- Ctrl+V Ctrl+1 - Activate single view for current window
  (or simply press space to toggle between 2x2 view and single view)
- Ctrl+V Ctrl+2 - Activate 2x2 view for current window
  (or simply press space to toggle between 2x2 view and single view)
- Ctrl+C - Clone the current renderwindow
- Ctrl+Shift+L - Load ImageVis3D window geometry
- Ctrl+Shift+D - Save the Default ImageVis3D window geometry
- Ctrl+Shift+S - Save the ImageVis3D window geometry

- Ctrl+Alt+L - Load a workspace from Disk
- Ctrl+Shift+1 - to Ctrl+Shift+5 - Load the most recently used workspaces
- Ctrl+Shift+S - Save the current workspace to disk
- Ctrl+Shift+R - Reset the workspace to the default workspace
- Ctrl+Alt+1 to Ctrl+Alt+8 opens/closes the tool widgets
  - Ctrl+Alt+1 - The Rendering Options
  - Ctrl+Alt+2 - Progress Viewer
  - Ctrl+Alt+3 - 1D Transferfunction Editor
  - Ctrl+Alt+4 - 2D Transferfunction Editor
  - Ctrl+Alt+5 - Isosurface Settings
  - Ctrl+Alt+6 - Locking Options
  - Ctrl+Alt+7 - Recorder Settings
  - Ctrl+Alt+8 - Stereo Options

- Ctrl+A - Show the About Dialog
- Ctrl+W - Open the Welcome Screen
- Ctrl+M - Open this manual that came with your installation
- Ctrl+H - Open the online help from the ImageVis3D webpage
- Ctrl+T - Open the online Video tutorials
- Ctrl+U - Check for updates of ImageVis3D
- Ctrl+I - Report an issue to the ImageVis3D development team
- Ctrl+D - Open the Debug and scripting Window

ff. Render Window

- r – Reset the render window parameters
- c – Enable/disable the coordinate cross
- space – switch between single and 2x2 view modes
- x – swap slice view in the X dimension
- y – swap slice view in the Y dimension
- p - enable/disable the plane preview in the 3D window

- m – Enable/disable MIP rendering for slice views
- a – toggles between absolute and relative rotation (i.e. if the rotation arc ball is moved together with the data set or stays in the center)
- control (Windows / Linux), command (Mac) – hold to change clip plane orientation and position.
- shift – hold to move the ClearView lens when ClearView is enabled (note: left clicking is *not* required!).
- hold the left mouse button and drag the mouse to rotate the data set
- hold the right mouse button and drag the mouse to move the data set
- use the mouse wheel to zoom in or out

gg. 1D transfer function editor:

- hold the left mouse button and drag the mouse to draw the exact shape of a transfer function
- hold the right mouse button and drag the mouse to insert a smooth-step function into the transfer function
- shift – invert the direction of the smooth-step function (high to low instead of low to high)

hh. 2D transfer function editor (Basic Mode):

Rectangles

- left click and drag an edge or vertex of a rectangle to resize it
- left click and drag within a rectangle to move it
- left click and drag the green circle within a rectangle to change the gradient center

Triangles

- left click and drag the two top vertices and the top edge of a "triangle" to reshape it
- left click and drag the bottom edge to change the lower cutoff
- left click and drag inside the triangle to change the position

Other Polygons (created or modified in expert mode)

- left click and drag an edge or vertex of a polygon to reshape it
- left click and drag within a polygon to move it

ii. 2D transfer function editor (Expert Mode):

- shift – hold while dragging in the left mouse button to move the highlighted widget.
- control (Windows / Linux), command (Mac) – hold while left clicking and dragging the left mouse button to resize the current widget
- control + shift (Windows / Linux), command + shift (Mac) – hold while left clicking and dragging the mouse to rotate the currently active widget

- rotating the mouse wheel zooms in or out of the transfer function,
- holding the middle mouse button while dragging the mouse pans the zoomed view

XXI. List of Script Commands

ImageVis3D supports many commands

- "help" : show all commands
- "execute" filename: run the script saved as 'filename'
- "echo" on/off: turn feedback on successful command execution on or off
- "time" : print out the current time
- "date" : print out the current date
- "write" test: print out 'text'
- "seterrorlog" on/off: toggle recording of errors
- "setwarninglog" on/off: toggle recording of warnings
- "setemessagelog" on/off: toggle recording of messages
- "printerrorlog" : print recorded errors
- "printwarninglog" : print recorded warnings
- "printmessagelog" : print recorded messages
- "clearerrorlog" : clear recorded errors
- "clearwarninglog" : clear recorded warnings
- "clearmessagelog" : clear recorded messages
- "fileoutput" filename: write debug output to 'filename'
- "toggleoutput" on/off on/off on/off: toggle messages, warning, errors, and other output
- "clear" : clear this window
- "versions" : print version information
- "gpuinfo" : print basic information about the GPU, the driver and the rendering APIs
- "gpuinfoext" : print extensive information about the GPU, the driver and the rendering APIs
- "sysinfo" : print information about the system and the mem usage
- "imageformats" : print a list of the supported image formats
- "open" sourcefile [targetfile]: open the sourcefile and write it into targetfile if conversion is required
- "open1d" sourcefile: open 1D transfer function sourcefile
- "open2d" sourcefile: open 2D transfer function sourcefile
- "setiso" isovalue: set an isovalue from 0 to 1
- "setcviso" isovalue: set an isovalue from 0 to 1
- "mode1d" : switch to 1D transfer function rendering
- "mode2d" : switch to 2D transfer function rendering
- "modeiso" : switch to isomode rendering

- "`export`" targetfile [LOD]: export the current dataset into 'targetfile' using LOD level 'LOD' default is 0 (max quality) the filetype is determined by the extension
- "`exportiso`" targetfile [LOD]: export the current isosurface into 'targetfile' using LOD level 'LOD' default is 0 (max quality)
- "`compare`" file1 file2: compare file1 and file2
- "`close`" : close the current datawindow
- "`resize`" sizeX sizeY: resize the current data window
- "`rotateX`" angle: rotate the data by "angle" degree around the x axis
- "`rotateY`" angle: rotate the data by "angle" degree around the x axis
- "`rotateZ`" angle: rotate the data by "angle" degree around the x axis
- "`translate`" x y z: translate the data by [x,y,z]
- "`capturesingle`" targetfile: capture a single image into targetfile
- "`capturesequence`" targetfile: capture a single image into targetfile_counter
- "`stayopen`" : do not close the application at the end of the script
- "`pack`" source ... target: pack the files source0 to sourceN into a single file target
- "`upload`" source [target]: upload the file 'source' to the debug server with the name 'target' (by default a unique filename is generated automatically)
- "`delete`" file: delete the file 'file'
- "`quit`" : quit ImageVis3D

XXII. Command Line Parameters

ImageVis3D can be started with a few different command line options which can change the runtime behavior.

- -log *filename* – Create logging output in *filename*. The special filename "-" can be used to indicate the standard output stream.
- -loglevel *level* – The level of debug output put in the file given by *–log*
- -script *scriptfile* – Load a script and execute the commands on startup.

XXIII. Compiling ImageVis3D

ImageVis3D requires the Qt library to compile. In the ImageVis3D subversion repository we supply some scripts in the *Scripts* directory which can compile Qt from source automatically on each of the major platforms. If you are on windows, make sure to set the QTDIR32, QTDIR64, or both (depending on which configurations you want to build for) environment variables to the root location of the Qt installation.

Once you have a working Qt installation, grab the sources from the ImageVis3D subversion repository, using the svn URI:

https://gforge.sci.utah.edu/svn/imagevis3d/

On Windows systems, open up the *ImageVis3D.sln* file in Visual Studio 2008 or newer, and compile as is normal for this platform. On Linux, Mac, and other similar systems, open up a terminal, change directory to the newly checked out subversion repository, and run:

```
sh Scripts/unix-dev-cfg.sh
make -j2
```

This will compile ImageVis3D. The output binaries are stored in the *Build* directory; on Linux, there is a plain *ImageVis3D* binary. On Macintosh systems, a *ImageVis3D.app* bundle will be created in the *Build* directory.

XXIV. The MIT License

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XXV. List of Images