GUIDE TO RTIVIEWER

Document version 1.0.2

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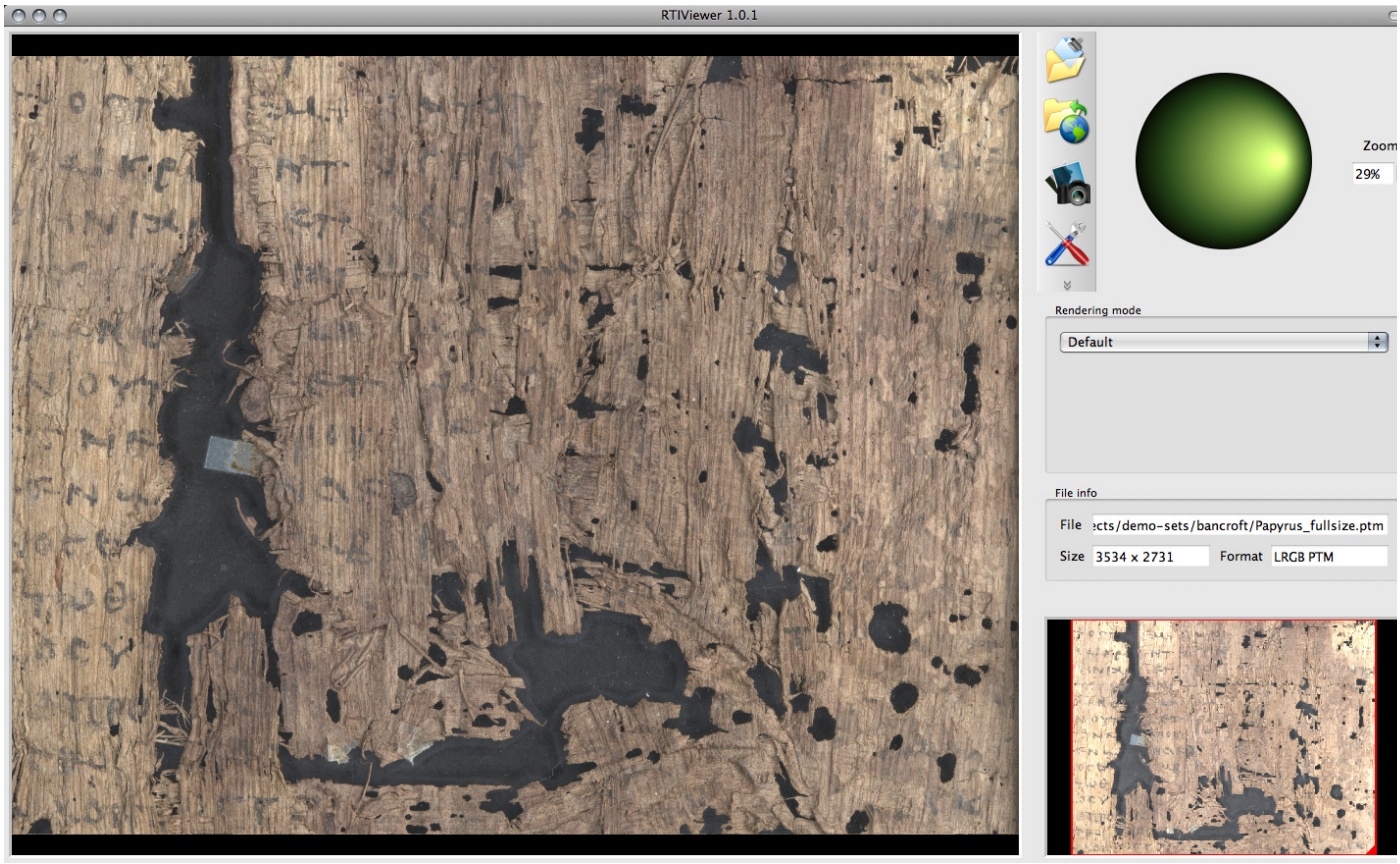

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Guide to RTIViewer v1.0.2

Acknowledgments

The RTIViewer tool, designed for cultural heritage and natural science applications, was primarily developed by the Italian National Research Council's (CNR) Institute for Information Science and Technology's (ISTI) Visual Computing Laboratory (http://vcg.isti.cnr.it) The work was financed by Cultural Heritage Imaging (http://www.c-h-i.org) with majority funding from the US Institute of Museum and Library Services' (IMLS) National leadership Grant Program (Award Number LG-25-06-0107-06) in partnership with the University of Southern California's West Semitic Research Project. RTIViewer also contains significant software and design contributions from the University of California Santa Cruz, the Universidade do Minho in Portugal, Tom Malzbender of HP Labs, and Cultural Heritage Imaging.

Core research under the IMLS grant to develop the multi-view RTI technique along with the RTI and MVIEW file formats, and hemispherical harmonics fitter was largely performed at UC Santa Cruz under Professor James Davis, in collaboration with Tom Malzbender of HP Labs and staff of Cultural Heritage Imaging. Additional funding for this work was provided by the University of California Center for Information Technology Research in the Interest of Society (CITRIS), and a ARCS Foundation Fellowship to graduate student Oliver Wang.

Along the way others contributed testing, feature ideas, reviews of the guide and other helpful work. It is impossible to name everyone who contributed, but we would especially like to acknowledge Roberto Scopigno and Paolo Cignoni of CNR Visual Computing Lab for providing management, technical oversight, and licensing advice, as well as general support of the project.

This guide and the RTIViewer software were funded in part by a grant from the Institute of Museum and Library Services. Its contents are solely the responsibility of the authors and do not necessarily represent the official position or policies of the Institute of Museum and Library Services.

Additional funding was provided by charitable contributions to Cultural Heritage Imaging.

Special thanks to Judy Bogart for donating her time and expertise in the development and writing of this guide.

Installing RTIViewer

RTIViewer is available in Windows and Mac OS versions. It does not run on Mac PowerPC.

Download RTIViewer for your platform from the CHI web site:

http://CulturalHeritageImaging.org/Learn/

- To install the application in Mac OSX, copy the alias in the disk image into the destination folder.
- To install the application in Windows, run the installer. See Installation notes for Windows below.

This viewer allows you to load PTMs and RTIs from your local machine or over the web. The download site also offers a utility, RTI Webmaker, that allows you to break up large PTMs into a folder with smaller chunks (like a zoom browser) in order to distribute large PTMs over the web; see "Preparing images for remote viewing" on page 25.

Installation notes for Windows

For older versions of Windows, if you try to start the application and it doesn't work, download and install the Microsoft Visual C++ 2008 Redistribution Package:

http://www.microsoft.com/downloads/details.aspx?familyid=9B2DA534-3E03-4391-8A4D-074B9F2BC1BF&displaylang=en

Memory usage in Windows

The viewer offers the option of using a large (3GB) virtual address space, in order to optimize the handling of large images. If you are running a 32-bit version of Windows, you must set an operating-system parameter in order to take advantage of this ability. Log in as administrator and run the following command in a command shell:

In Windows XP	`bootcfg /raw "/3GB" /A /id 1`
In Windows 7/Vista	`bcedit /set increaseuserva 3072`

If you do not do this, the virtual address space is limited to 2 GB.

In order for the viewer to work properly, the memory required by an RTI you wish to load should be no more than 80% of the available virtual memory. If the RTI is too large, applying a rendering method can cause RTIViewer to crash.

Using RTIViewer

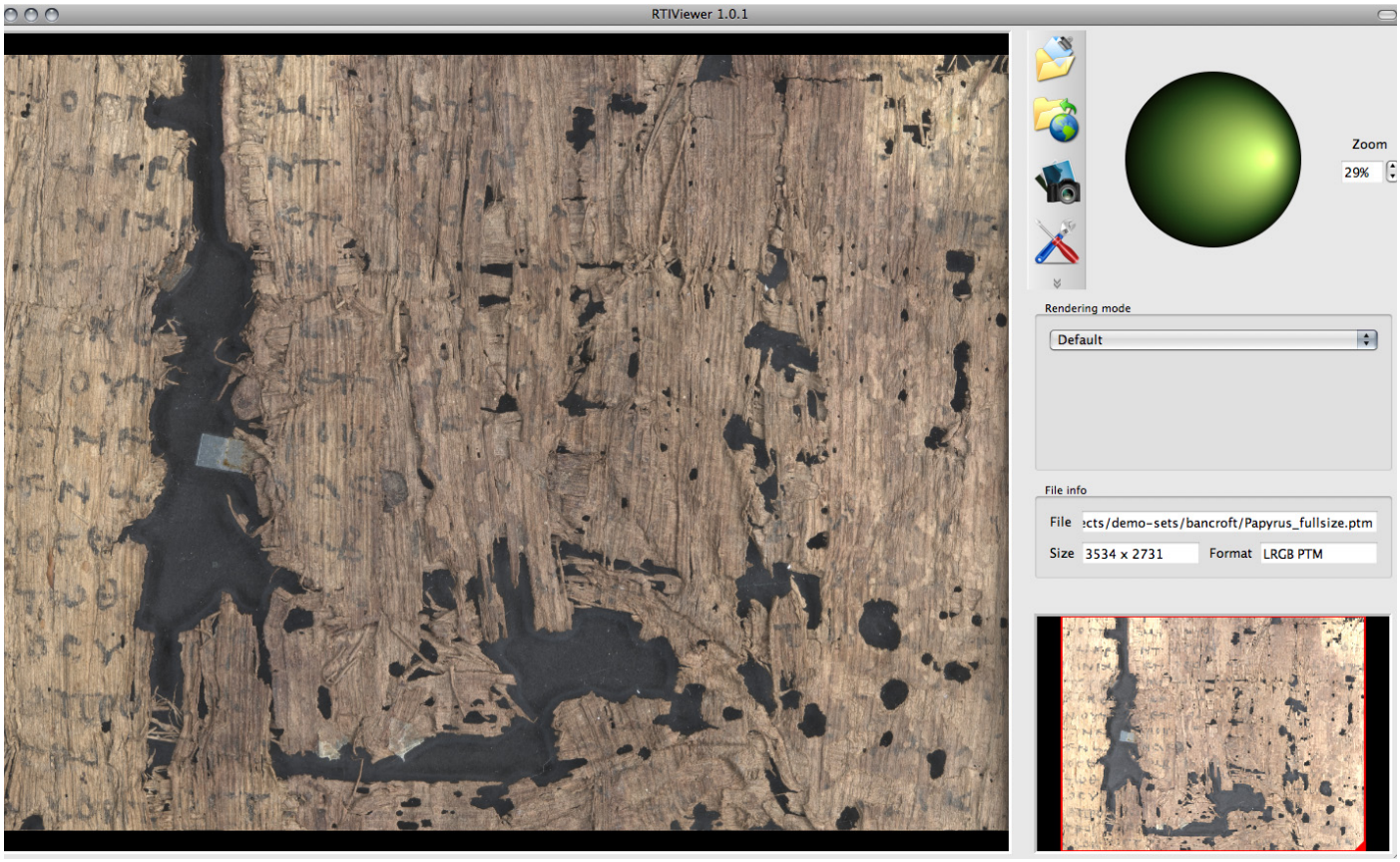
RTIViewer allows you to load and examine images created with reflectance transformation techniques. This tool supports these formats, collectively called RTI files:

- Polynomial Texture Map (PTM file)
- Reflectance Transformation Imaging (RTI file)
- Multi-view RTI (MVIEW file) This is a collection of single-view images together with optical flow data that allows the generation of intermediate views.

RTIViewer offers interactive rendering of images, allowing you to change the view and alter the apparent direction of lighting. In addition, it offers a number of enhancement modes, which apply mathematical transformations to the image data to enhance or emphasize particular features of the target object.

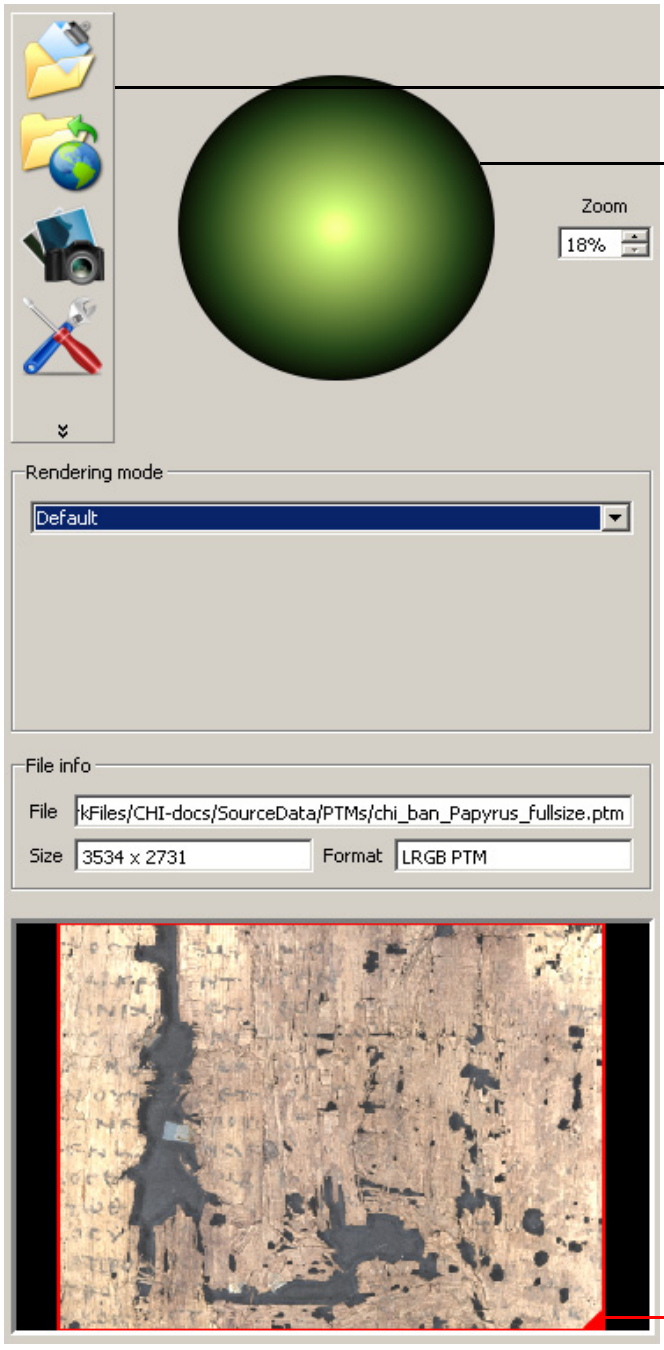
The RTIViewer window

The RTIViewer GUI allows you to load and examine image files, providing options for manipulating the image to take advantage of the captured surface data in ways that help you study the target object.



Main viewing panel **Control panel**

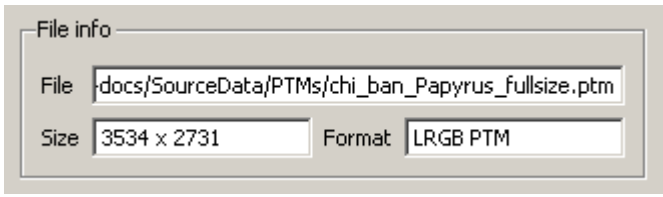
- The control panel on the right allows you to load image files, save views, move the angle of the virtual light on the image, and configure the view in a number of ways.
- The main viewing panel on the left displays the current image, rendered and lit according to your choices in the control panel.



Menu bar and file details

The icons on the menu bar allow you to:

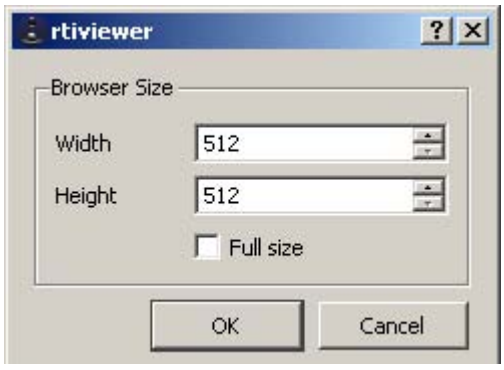
- Browse your local disk to find and load image files for viewing.
- Browse the internet to find and load image files kept on remote servers; see "Viewing remote image files" on page 7.

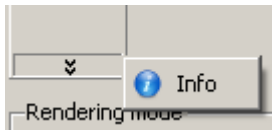


When you have loaded a file, the location, size, and format are shown in the File info box.

The menu also allows you to:

- Save a *snapshot*, which is a PNG or JPEG image of the current view shown in the main viewing panel; that is, the currently selected portion of the file, with the currently selected lighting angle and rendering style.
- Configure the viewer; the configuration dialog allows you to set the size of the viewer window. Check the "Full size" box to maximize the image within the main viewing panel.
- Bring up the About box, which provides version information and contact information for the developers and sponsors.



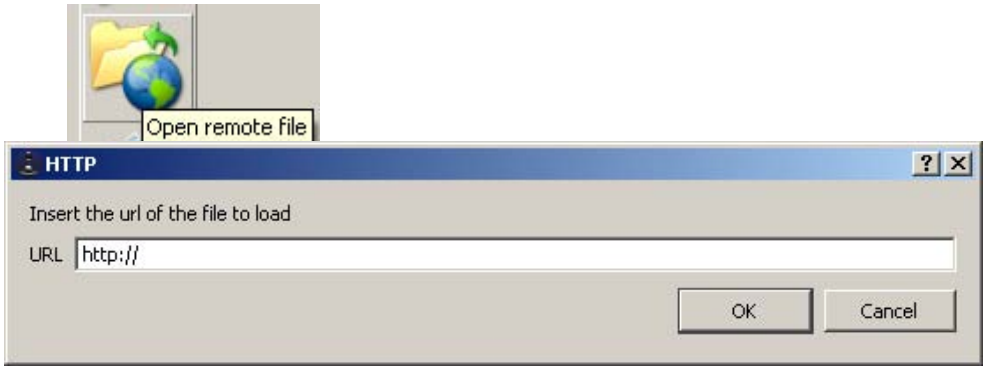


Bring up About box

Viewing remote image files

RTIs are typically large files with very fine resolution; for this reason, it can be more practical to store the images on servers for sharing. The RTIViewer allows you to load and display images stored on a local hard drive, or on a remote server through an HTTP connection. For information on creating and storing images for remote viewing, see "Preparing images for remote viewing" on page 25.

To browse for a remote image file, click the "Open remote file" icon, and enter the URL in the resulting dialog.



Efficient storage of RTIs using multi-resolution tiling and JPEG2000 compression allows asynchronous loading, with increasing resolution as loading proceeds.

Tiled image data with increasing resolution allows incremental loading from a remote site.

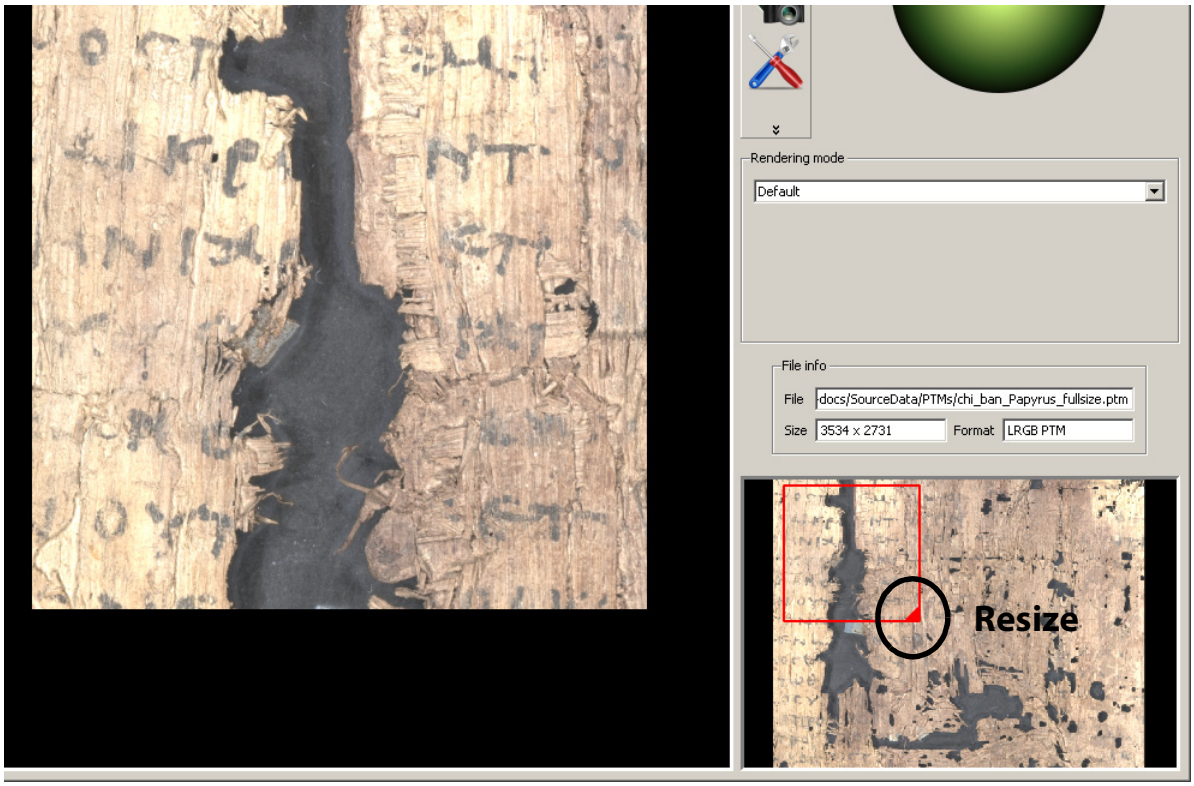
Image navigation and lighting

You can control the portion of the image you are viewing, and the angle of the virtual light; the light controller and image navigator in the control panel allow you to make changes, and also reflect the current state when you change the view by directly manipulating the image in the main viewing panel.

Using the image navigator

The small image at the bottom right allows you to select a subset of the image to show in the main image panel.

- Click anywhere in the red square to drag it around the small image. The portion of the image inside the square is shown in the large viewing panel.
- Drag the triangle in the lower right corner of the red square to resize the selection (within the built-in constraints).

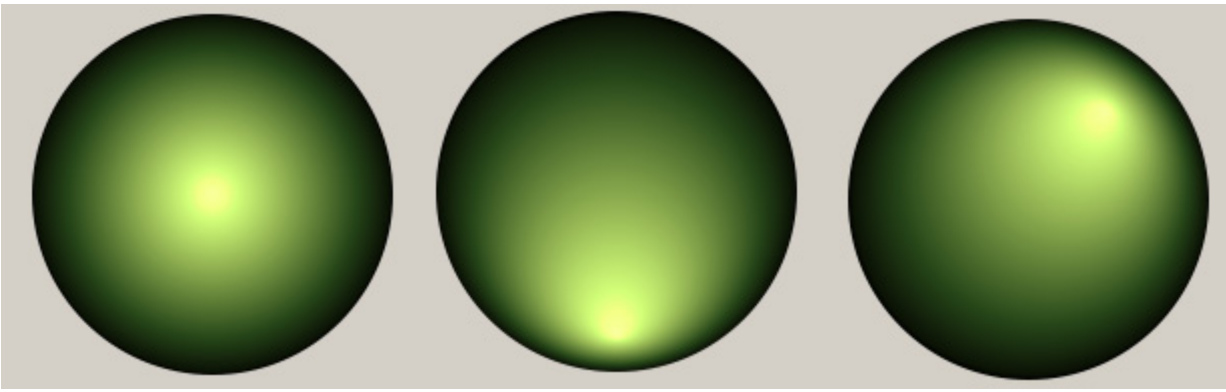


You can also use the scroll wheel on the mouse to zoom in and out interactively, from either the image navigator or the main viewing panel. See "Manipulating the image view in the main viewing panel" on page 10

Using the light controller

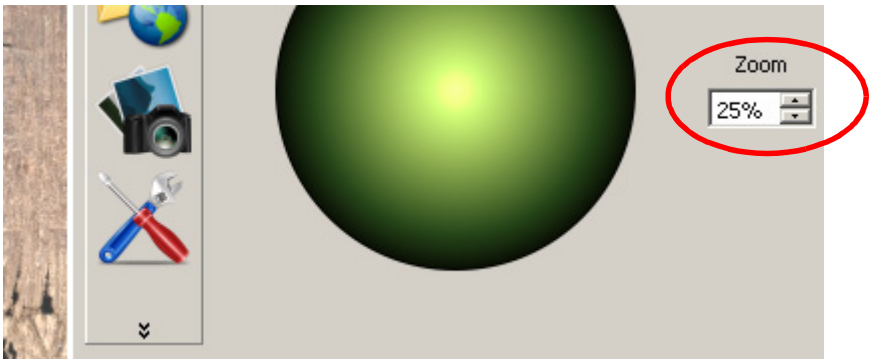
The green circle controls the angle of the virtual light in the large viewing panel. The bright spot is the light source, shown as if it were reflected in a dome. You can drag the spot around the dome to change the angle.

- When the light source is in the center of the dome, the virtual light comes from the "high noon" position, directly above (or in front of) the object.
- As you drag the light source to the top, bottom, right, or left, the virtual light approaches the horizon in that direction, creating a raked-lighting effect.



Zooming

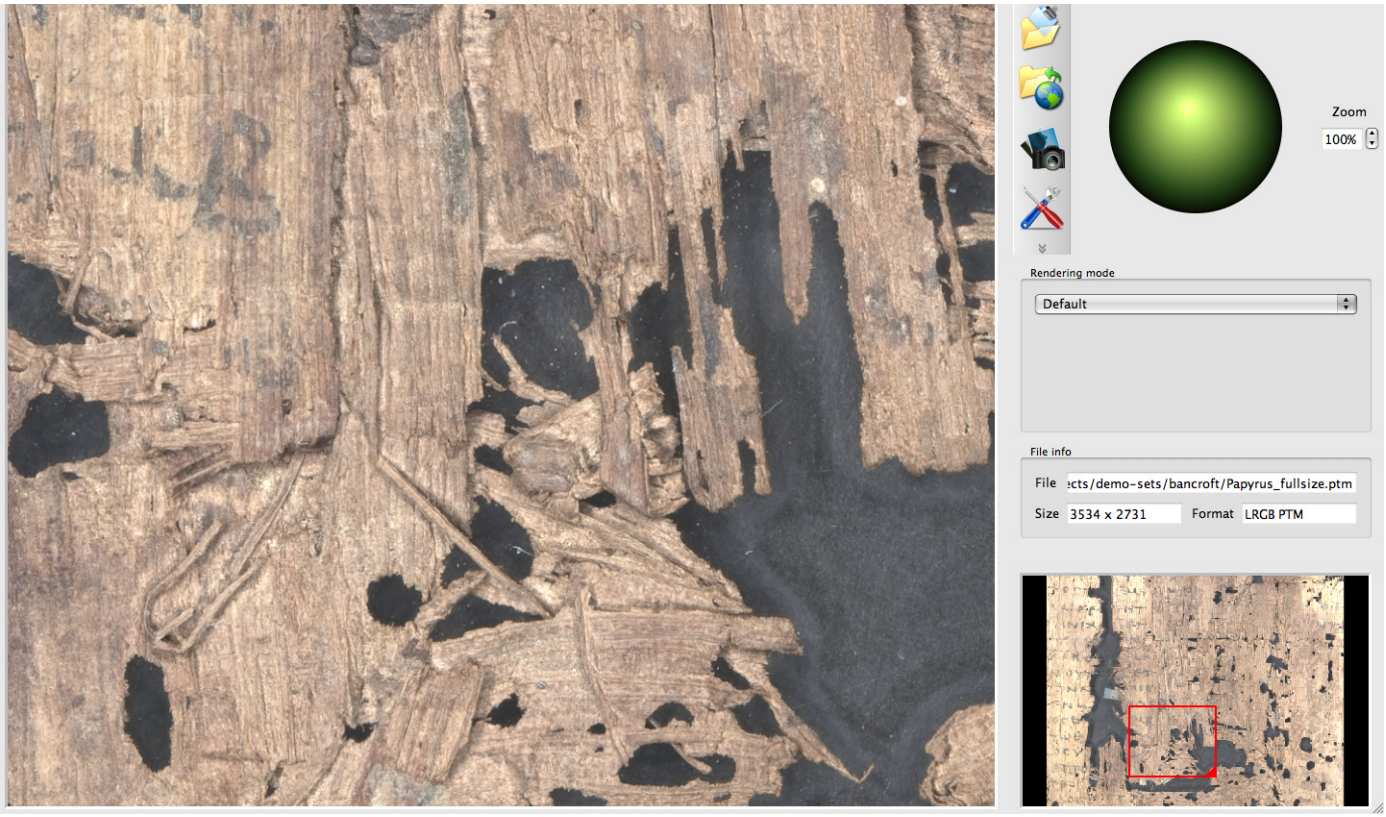
Next to the light controller, a Zoom selector allows you to change the magnification at which the image is displayed.



By default, an image is displayed at a magnification factor that allows the entire image to be seen in the viewing area. You can use the up and down arrows in the Zoom selector to increase and decrease the magnification my 1% increments, or you can type a new zoom factor into the text box and press return.

You can zoom in to a magnification above 100%, although this requires interpolation beyond your real data, and may not look sharp.

If you resize the displayed image using the resize handle in the image navigator, or zoom in or out using the scroll button on the mouse, the current zoom factor is reflected in the Zoom selector.



Manipulating the image view in the main viewing panel

You can manipulate the image view directly from the main viewing panel; the navigator updates to show you what part of the image is currently displayed, the light controller updates to show you the current light angle, and the zoom selector updates to show the current magnification.

- Left-click in the large image and drag in any direction to move the image in that direction.
- Right-click in the large image and drag to adjust the lighting angle.
- Use the scroll wheel in the large image to zoom in and out. (You can also zoom in with the keyboard shortcut CTRL+ and zoom out with CTRL-.)
- Double-click a point in the image to center and zoom in on that point.
- In Mac OS, you can use a two-finger gesture on the mouse pad, separating the fingers to zoom in, and bringing them together to zoom out.

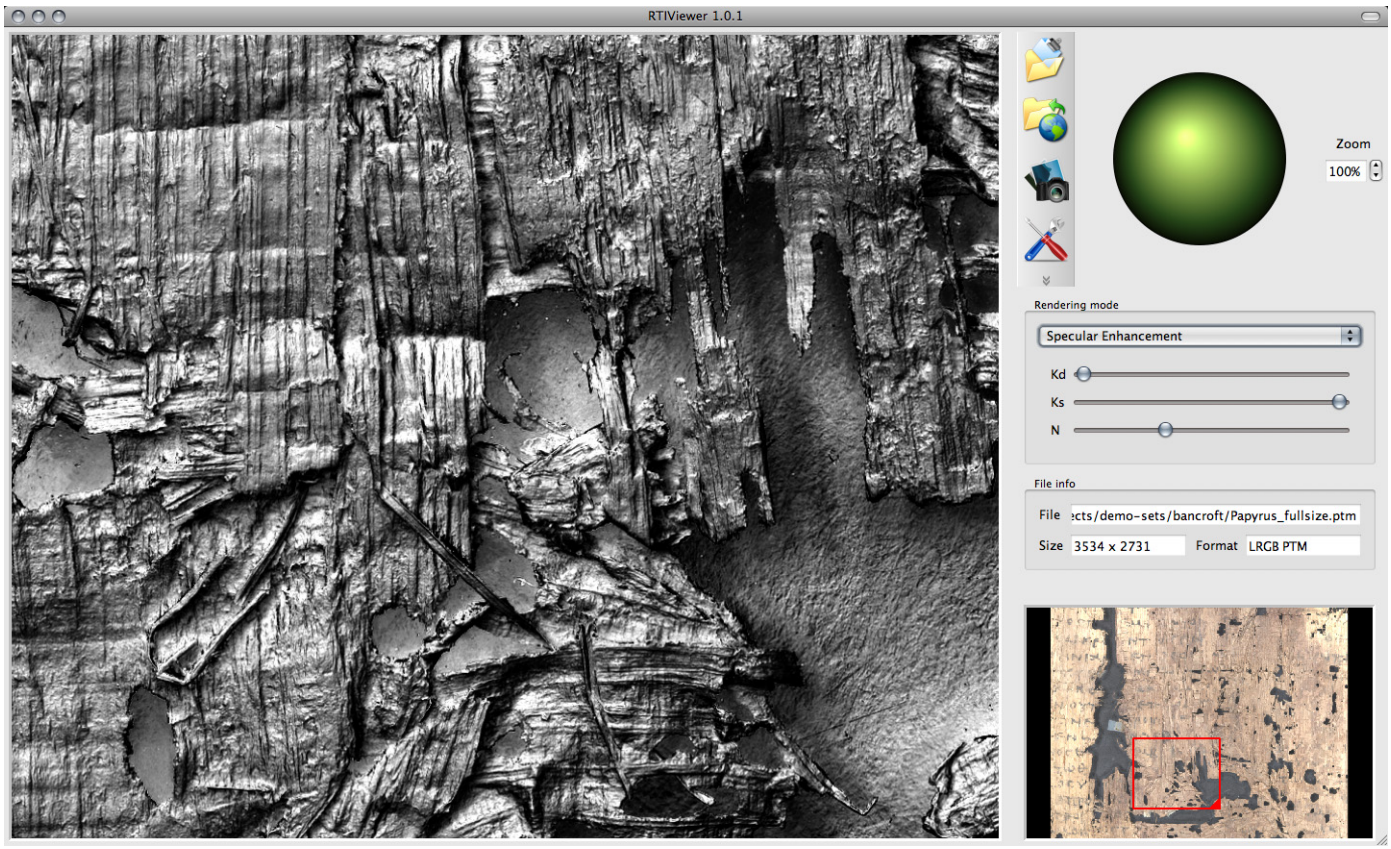
Rendering modes

While traditional image files record only color information for each pixel, an RTI also records the subject's *surface normal* along with the RGB color information at each pixel. Each normal encoded into the RTI image corresponds to a point on the subject, and records the angle of reflectance of light coming from any direction at that point. Together, the normals provide accurate information about the subject's surface shape. As you change the direction of the virtual light source in the RTIViewer, the reflectance provides your brain's perceptual system with everything it needs for you to see the subject in three dimensions.

Applications such as Adobe Photoshop can digitally enhance traditional images (to lighten or darken them, or change the color tone, for instance) by applying mathematical transformations to the color information at each pixel. Various kinds of transformations (often called *filters* or *effects*) consider the relations between pixels to find edges, for example, and perform sharpening or blurring.

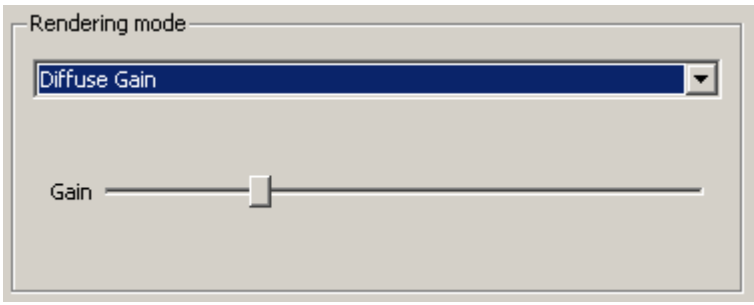
RTIViewer can also apply mathematical transformations to the surface normal as well as the RGB color information, resulting in reflectance enhancements of various kinds. These enhancement tools (or *rendering modes*) use information from surface shape and color in combination or surface shape or color by themselves. By using the shape data in RTI images, the enhancement functions in RTIViewer can disclose far more information about the subject than filters that use only RGB color data at each pixel.

RTIViewer's enhancement functions do not manipulate the color information as such (although the Specular Enhancement mode can remove color information from a rendering in order to emphasize only the reflectivity, as show in the figure below). After applying the desired lighting conditions and shape-based enhancement functions to an image, you can export it from RTIViewer. You can then use applications like Photoshop to do further color-based transformation on the exported image that already includes the desired shape-based effects.



Basic rendering modes

The rendering mode that you choose controls how the information in the RTI is transformed to an image on the screen. When you select a rendering mode, the UI provides appropriate controls with which to set the parameters that mode uses.

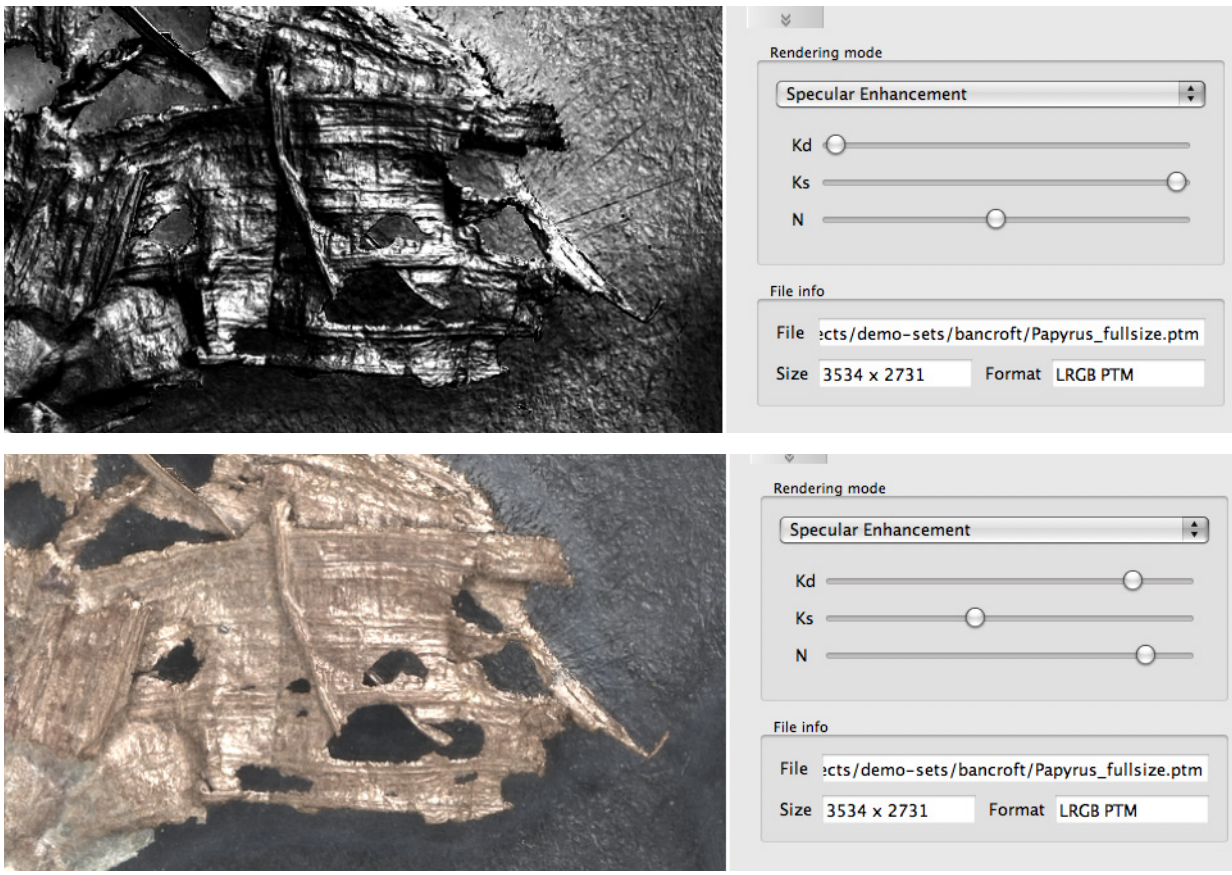


Not all rendering modes can be applied to all types of images; only those that can be applied to the current image are offered in the drop-down menu.

Rendering mode	Description
Default	Presents the RTI image without mathematical enhancement. This mode has no parameters.
Diffuse gain	Increases the representation of quickly-changing height and depth on the subjects surface. For example, if a surface area has a quickly-changing sequence of normal directions that form a depression, this enhancement function deepens the depression by increasing the directional rate of change (the second derivative) of the surface's slope. This mode enhances the perception of surface shape features of the subject for interpretive purposes. This mode can have the side effect of introducing false color in some images. Use caution in assessing the reliability of RGB color values in the resulting image. *Parameters:* **Gain**: Adjusts the amount of enhancement.
Specular enhancement	Different materials have different degrees of shininess. Matte objects (such tennis balls) have large and soft specular reflections while very smooth materials (such as billiard balls) have small and sharp specular reflections. This algorithm separates out the diffuse RGB color, specular reflection derived from the surface shape of the subject, and the size of the specular highlights. It can then render the shape-based reflections and RGB color either separately or in combination. This mode also enhances the perception of the surface shape.

Rendering mode	Description
Specular enhancement *(cont'd)*	*Parameters:* The parameter names are based on variables in the computer rendering algorithm, the Phong reflectance model. **Kd**: Adjusts the percentage of diffuse RGB color information used in the rendering. When *Kd* is at 100% and *Ks* is at 0%, only diffuse RGB color is rendered. **Ks**: Adjusts the percentage of specular reflection, derived the surface shape of the subject and it reflection of light from any given direction. When *Ks* is at 100% and *Kd* is at 0%, only the effects reflected light from a given direction are rendered. **N**: Describes the size of the area encompassed by individual specular reflections. A low *N* value produces a large, soft (matte) reflection. A high *N* value produces a small sharp (shiny) reflection. When using specular enhancement in isolation from the RGB color information, you can reduce the *N* value to spread the area influenced by the specular reflections, in order to illuminate the entire surface. This can be helpful when composing a rendering for image export.

These figures show examples of the application of different rendering modes to the same portion of the same image, with the same initial lighting angle.



Sharpening modes

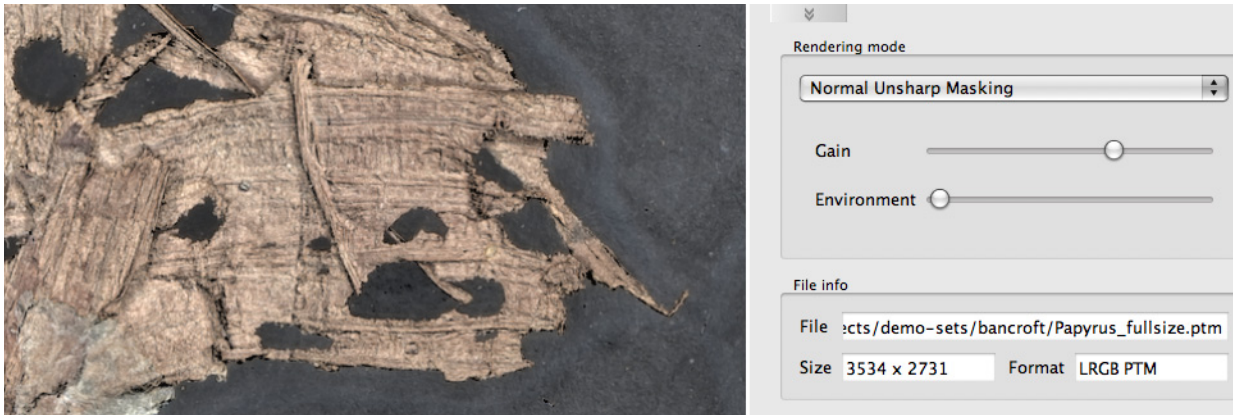
Sharpening applies an *unsharp mask* to the image data in order to enhance the high frequency details and increase the edge contrast of the image. Sharpening algorithms look for discontinuities in the data that typically indicate edges in the photographed object. In an RTI, the mask can be applied to the normal data, finding and emphasizing sharp changes in depth as well as color.

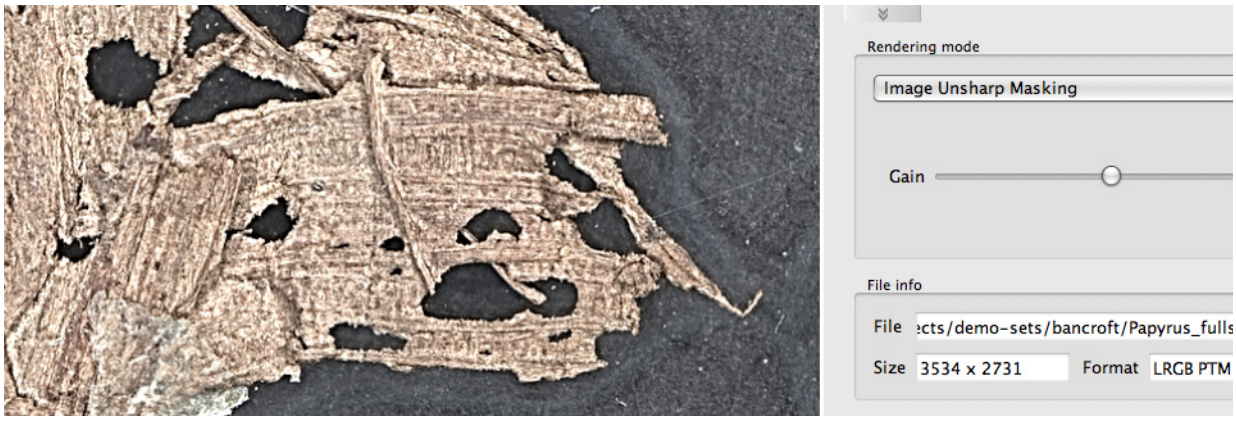
RTIViewer offers several variations on the sharpening algorithm:

- Image unsharp masking enhances edge contrast by applying the specified gain factor to image color data.
- Normal unsharp masking enhances surface contrast by applying the specified gain factor to image normal data, as well as color data.
- Luminance unsharp masking creates a different effect, amplifying depth discontinuities without affecting the color, by applying the specified gain factor only to normal data.
- Coefficient unsharp masking emphasizes discontinuities in reflectivity, by applying the gain factor to each coefficient of the reflectance function.

Rendering mode	Description
Normal Unsharp Masking	Applies an unsharp mask to the surface normals. *Parameters:* **Gain**: Adjusts the amount of enhancement. **Environment**: Adjusts the amount of indirect lighting.
Image Unsharp Masking	Applies an unsharp mask to the Y channel of the color space YUV. *Parameters:* **Gain**: Adjusts the amount of enhancement.
Luminance Unsharp Masking	Applies an unsharp mask to the luminance component of an LRGB PTM; cannot be applied to simple RGB files, which do not include luminance data. *Parameters:* **Gain**: Adjusts the amount of enhancement.
Coefficient Unsharp Masking	Applies an unsharp mask to the coefficients of the polynomial of the PTM. *Parameters:* **Gain**: Adjusts the amount of enhancement.

These figures show the application of various sharpening modes to the same portion of the same image, with the same initial lighting angle.




Rendering mode
Image Unsharp Masking
Gain
File info
File ects/demo-sets/bancroft/Papyrus_fulls
Size 3534 x 2731
Format LRGB PTM


Rendering mode
Luminance Unsharp Masking
Gain
File info
File ects/demo-sets/bancroft/Papyrus_full
Size 3534 x 2731
Format LRGB PTM

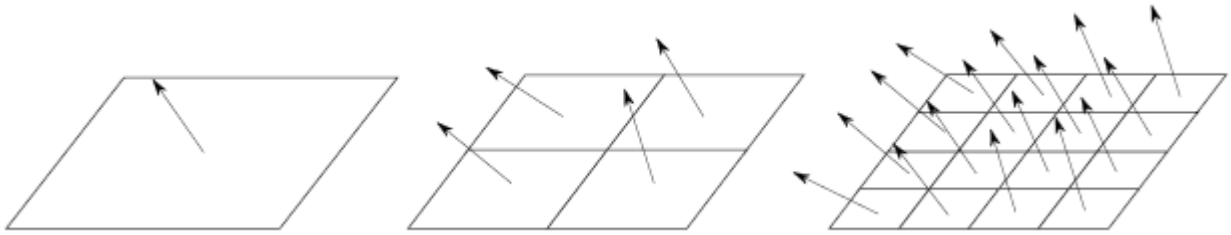

Rendering mode
Coefficient Unsharp Masking
Gain
File info
File ects/demo-sets/bancroft/Papyrus_full
Size 3534 x 2731
Format LRGB PTM

Multi-light enhancement modes

The multi-light enhancement modes choose different lighting angles for parts of an image in order to enhance surface details, optimizing sharpness and brightness. For example, if you choose a low, raking light to maximize contrast, there will be areas that are in deep shadow and show no detail. These rendering modes can add back detail to those areas by choosing a higher lighting angle for them, without changing the lighting angle in the areas that are already sharp. The resulting view looks as if light was coming from several directions, in addition to the virtual light source you have chosen using the Light Controller.

To achieve this effect, the algorithm subdivides the image into tiles, then, for each tile, chooses a light direction that maximizes a chosen *energy function*. It chooses a nearby light direction that increases local contrast, in order to enhance as many details as possible in a single view.

The image is first divided into an *initial* number of tiles, and the choice of lighting angles for each tile is constrained to be within a specified offset from the original light direction, as indicated by the Light Controller. The optimal lighting angle chosen for each initial tile then influences the choice of angles when that tile is subdivided.



There is a static mode, and a dynamic mode:

- The static mode applies the rendering you have chosen to the current view; you cannot change the starting light source interactively while this view is displayed. This is a special case of the dynamic mode, which is optimized to produce a high-contrast, well-illuminated static image, suitable for stand-alone presentation, high-quality printing, and so on.
- The dynamic mode automatically re-applies the rendering as you change the starting light source interactively, using the Light Controller. This mode allows more detailed control, but can also produce visual artifacts where there are great lighting variations across the image.

These figures show an application of static and dynamic multi-light renderings to the same portion of the same image with the same initial lighting angle.

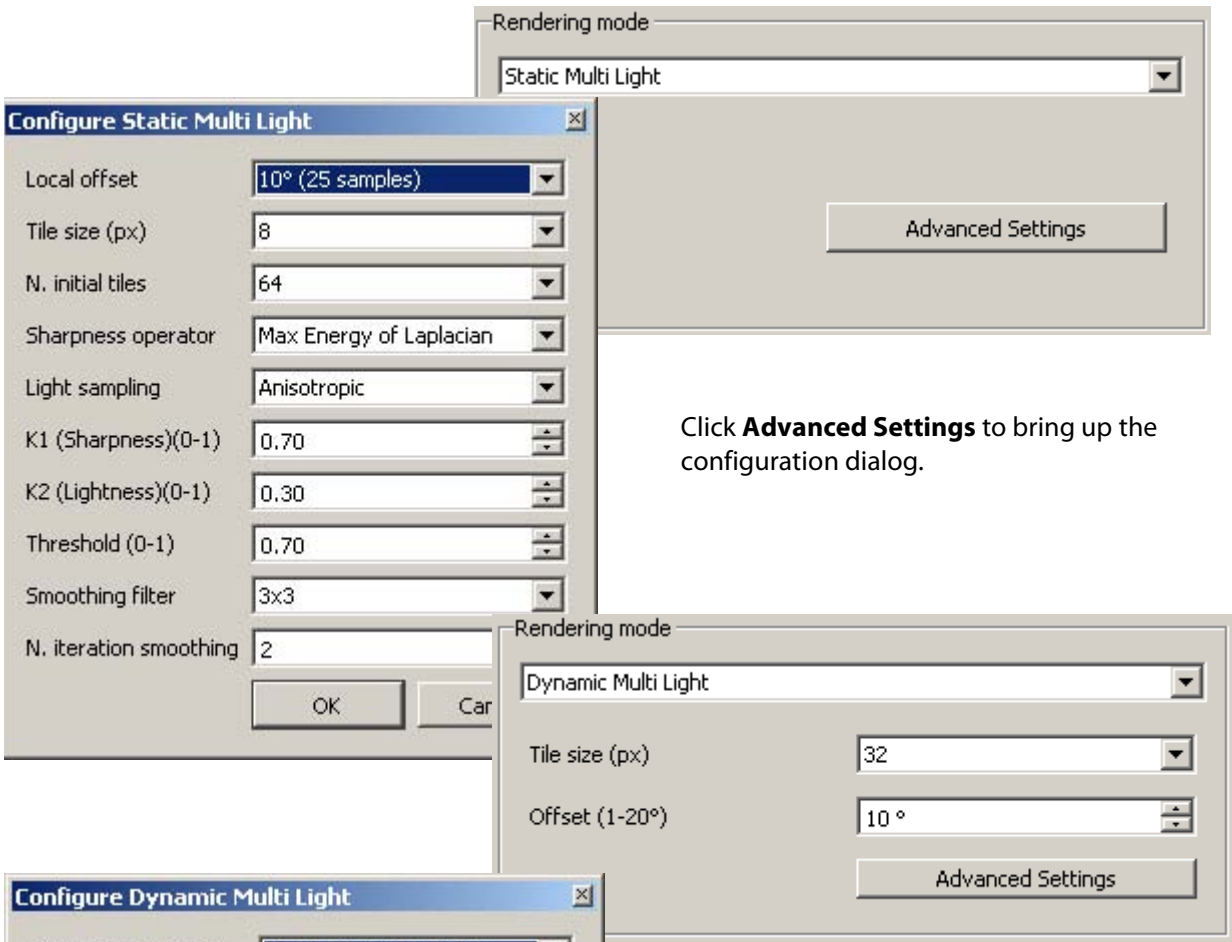

Rendering mode
Static Multi Light
File info
File
Size 3534 x 2731


Rendering mode
Dynamic Multi Lig
Tile size (px)
Offset (1-20°)
File info
File
Size 3534 x 2731

Multi-light enhancement parameters

The two multi-light enhancement modes have a number of parameters that allow you to vary the effects. You can specify the number and size of the tiles, the energy function to maximize, and various factors in the algorithm.

The parameters are offered slightly differently for the two modes, but are essentially the same. The dynamic mode offers different defaults and more range of choices (although this means, of course, that the calculations take longer).



Click **Advanced Settings** to bring up the configuration dialog.

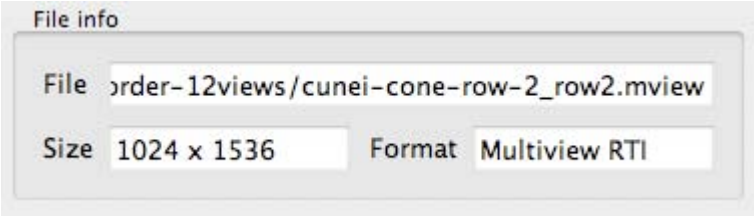
In Dynamic mode, you can apply a set of parameters, then change the initial lighting angle and re-apply the same rendering.

Multi-light mode parameters	
Local offset (*static*) Offset (1-20^{o}) (*dynamic*)	Constrains the choice space of additional light directions to be within a chosen offset from the starting direction chosen in the Light Controller. ▶ For Static mode, you can choose from these values: 5^{o} (9 samples) 10^{o} (25 samples) 15^{o} (49 samples) ▶ For Dynamic mode, you can choose any value between 1 and 20 degrees.
Tile size (px)	Sets the size of the tiles in square pixels. ▶ For Static mode, you can choose from these values: 8 16 32 ▶ For Dynamic mode, you can choose from these values: 8 16 24 32
N. initial tiles	Sets the initial number of tiles for Static mode. This constrains the selection of light directions to avoid rendering imperfections. ▶ For Static mode only, you can choose from these values: 4 16 64
Sharpness operator	The method used to compute the sharpness of each tile. ▶ You can choose from these values: Max Laplacian Max Energy of Laplacian L1 norm Sobel L2 norm Sobel
Light sampling	The strategy used to select the light direction. ▶ You can choose from these values: Isotropic Anisotropic
K1 (Sharpness)(0-1)	The weighting factor for the sharpness value. ▶ You can choose a percentage value from 0.0 to 1.0.

K2 (Lightness)(0-1)	The weighting factor for the brightness value. ▶ You can choose a percentage value from 0.0 to 1.0.
Threshold (0-1)	A factor that affects the choice of candidates for the light direction for each tile. ▶ You can choose a percentage value from 0.0 to 1.0.
Smoothing filter	The size in tiles of a filter used to smooth the selected light direction over the entire image. ▶ You can choose from these values: 3x3 5x5 7x7
N. iteration smoothing	The number of times to apply the smoothing filter. ▶ You can choose a value from 0 to 10.

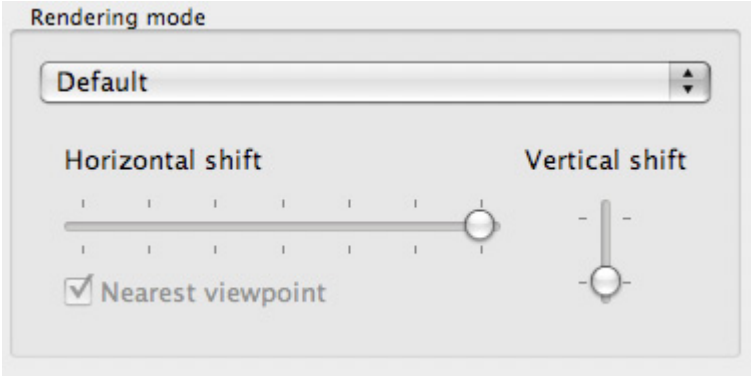
Multi-view RTI viewing

RTIViewer allows you to view multi-view RTIs; that is, a set of RTIs that were created from multiple camera viewpoints and can be viewed in an integrated manner. This type of image is contained in a set of files with the `.mview` extension. When you load such an image, the viewer indicates that the file is of type **Multiview RTI**.



This technology was developed at the University of California Santa Cruz. The current MVIEW file format specification can be downloaded at www.culturalheritageimaging.org/learn. The software to build an MVIEW file from appropriate captured and numbered sequences of RTIs is available under the GNU General Public License version 3, by writing to info@c-h-i.org.

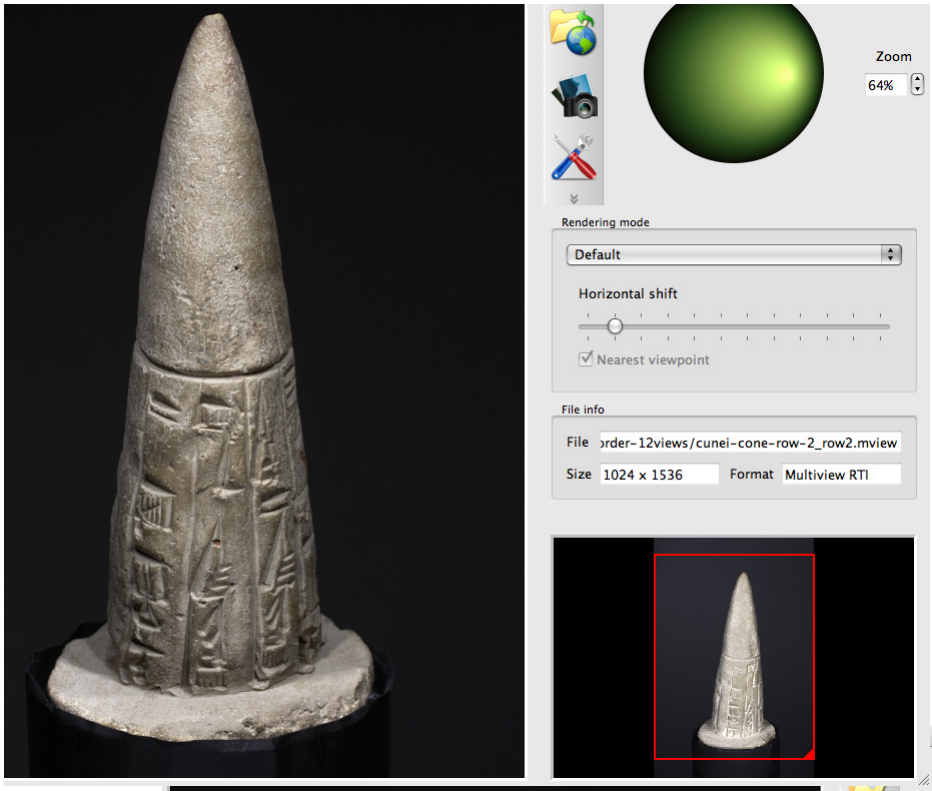
The default rendering mode for multi-view images allows you to choose among the contained set of viewpoints. As determined by the number of latitudinal samples (horizontal rotation of viewpoint right of left around the subject) and the number of longitudinal samples (vertical rotation of the viewpoint up and down around the subject), you are offered a choice of horizontal and vertical viewpoints from which to explore the subject.



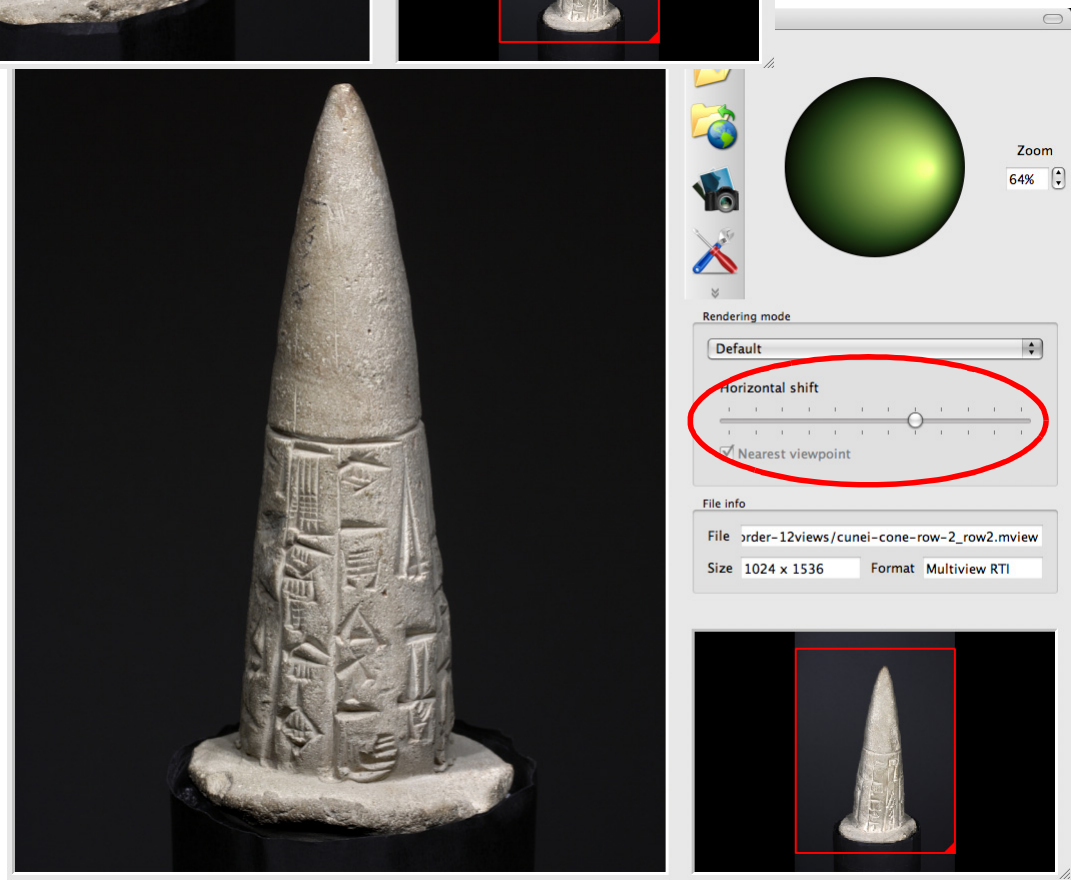
The number of views on each scale corresponds to the number of available sampled viewpoints. Images with more viewpoints are, of course, much larger than those with fewer.

In the case where all the acquired Multi-view RTI viewpoints that encompass the subject are along the same latitude, RTIViewer is configured as shown in the following figures.

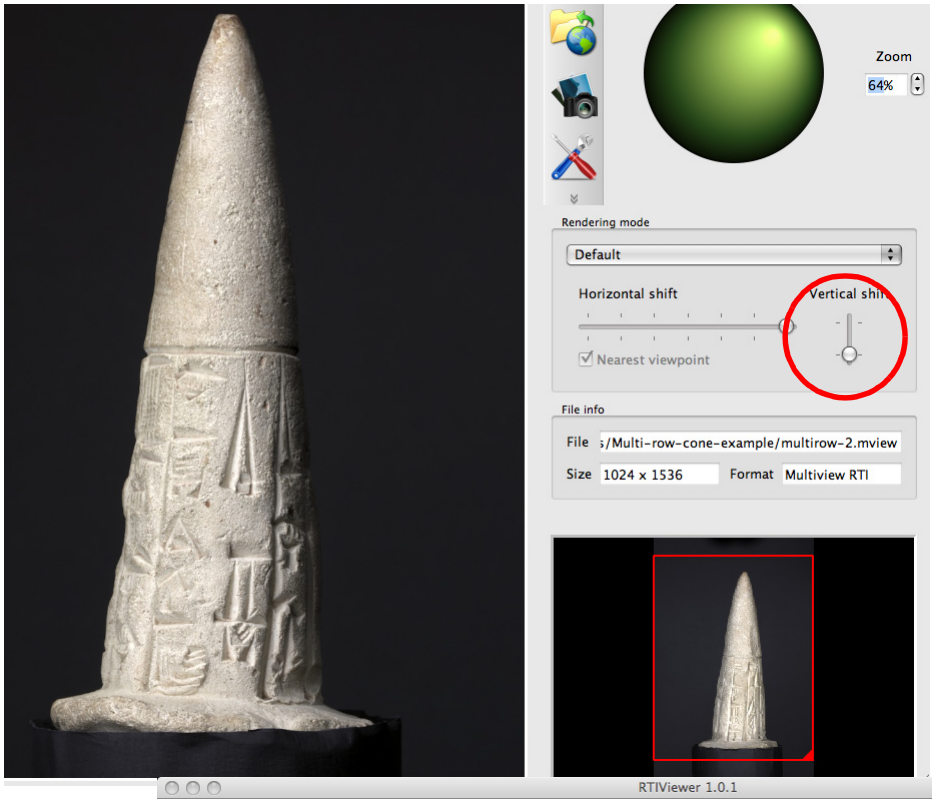
The top left figure is displaying the second viewpoint from the left-most viewpoint. The figure in the lower right displays the subject six viewpoints further to the right. You can display and relight the subject at each of the sampled viewpoints.



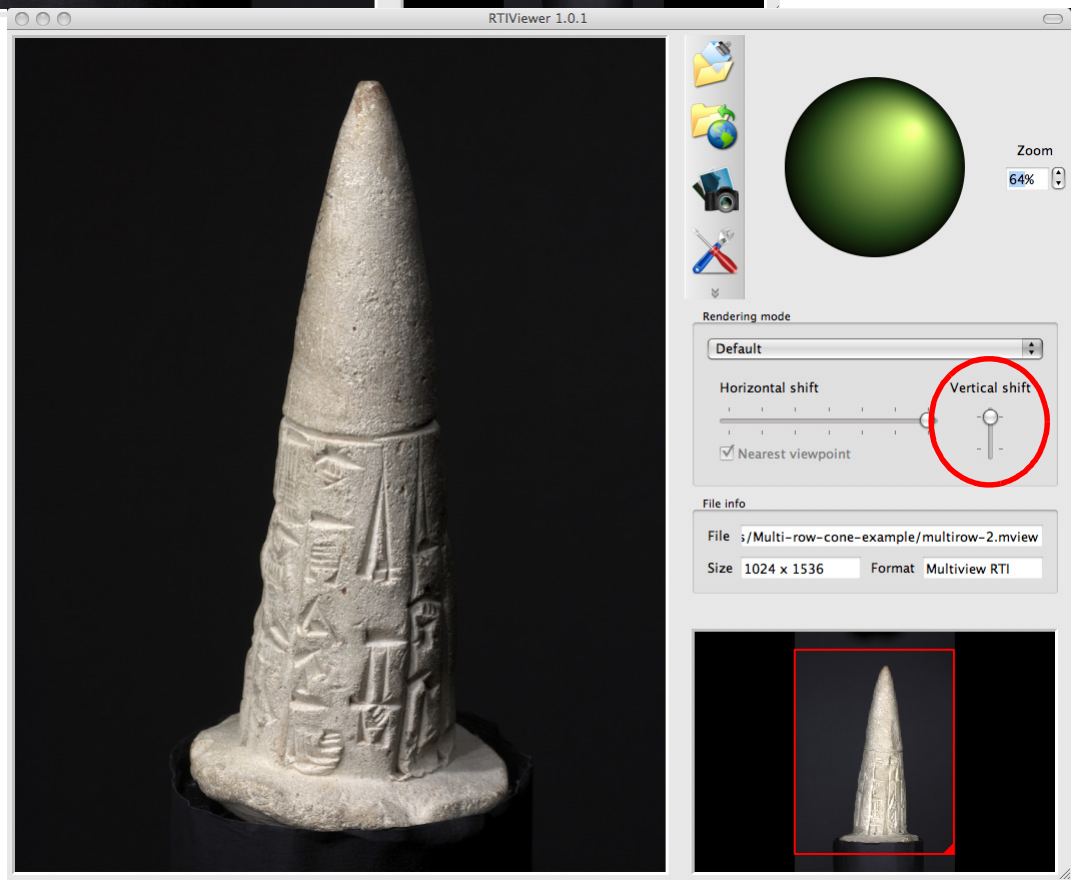
As you change the horizontal viewpoint, the object appears to rotate in the horizontal plane.



When a Multi-view RTI is captured at more that one latitude, a Vertical shift tool appears to the right of the Horizontal shift tool. These figures show the subject at two different longitudinal viewpoints.



As you change the vertical viewpoint, the object appears to rotate toward or away from you.



Exploring an RTI subject between viewpoints

RTIViewer is designed to accommodate the integration of new features for rotating and relighting multi-view RTI subjects that will allow you to explore a subject between the captured viewpoints. When appropriate optical-flow data is available, the viewer can display the subject from any desired rotational position between the captured viewpoints, and relight the subject interactively; activate this mode by deselecting the "Nearest viewpoint" checkbox.

NOTE: This feature is still in the early research stage of development, and is of experimental quality that is not user-friendly. Much of the functionality is currently designed for use with relatively low resolution files.

Even within the significant limitations, the research team has used optical flow technology to demonstrate that it is possible to create highly information-rich and interactive three-dimensional displays between captured viewpoints. Future implementations may address the generation and display of arbitrary rotation and relighting within high-resolution MVIEW files.

Preparing images for remote viewing

Remote viewing is available only for files in the LRGB PTM and HSH RTI formats. In order to use it, you must preprocess the target file using the RTI Webmaker command-line tool. This tool converts the PTM images into a more compact format that permits remote loading in chunks through HTTP. The command take two arguments, the path to the PTM or RTI file, and the *resolution level*, which controls level and number of chunks to produce. For example:

```
RTIWebmaker ..\rtiImage\test.ptm 3
```

The tool produces a folder containing the converted files; you can copy the entire folder to the server. The URL of the image is the path of the file in that folder that has the extension `.ptm` or `.rti`.

To install the RTI WebMaker in Mac OSX, copy the alias in the disk image into the same folder as RTIViewer. In Windows, run the installer.