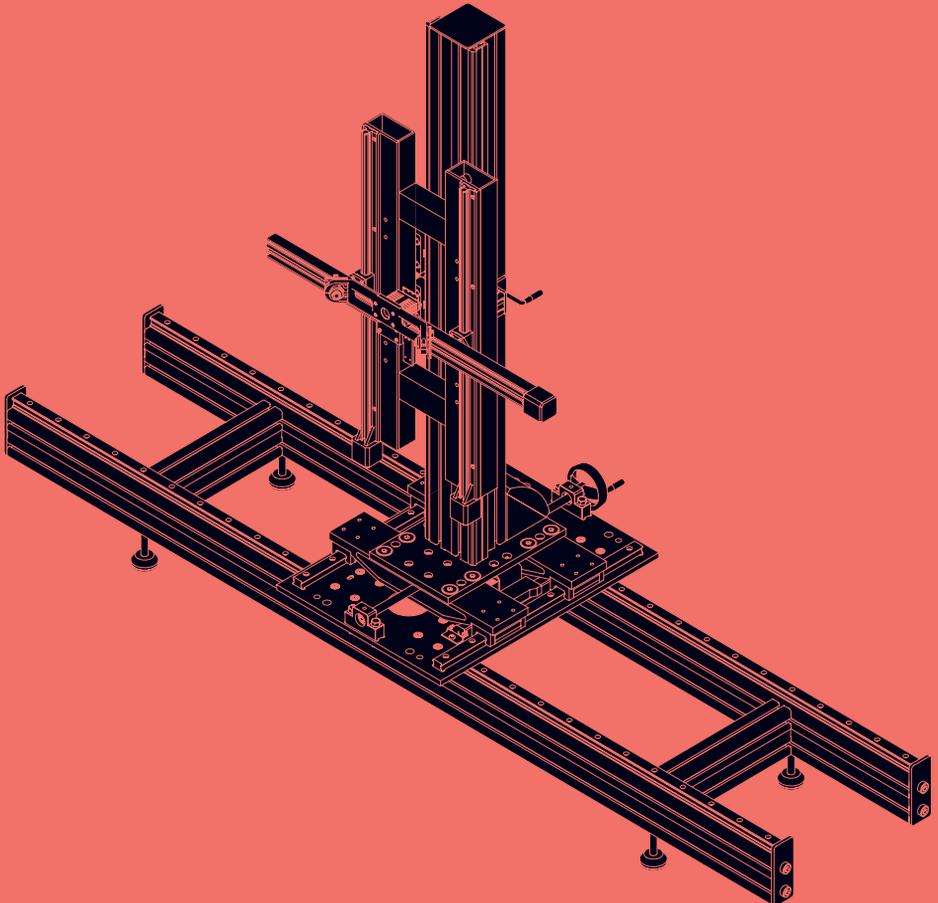


Lucida 3D Scanner

Factum Foundation



Training guide III: Processing applications



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6

Merging

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Donato da Montorfano, *Crocifissione*, c. 1497, fresco, 730 x 880 cm (detail).
3D scanned in 2014 in Santa Maria delle Grazie, Milan.

Merging re-scans

The Merging Application works with RIS files and is used to merge a re-scanned section with its corresponding base tile. It is recommended that all re-scans are merged with their tiles before moving on to the next processing step: Editing.

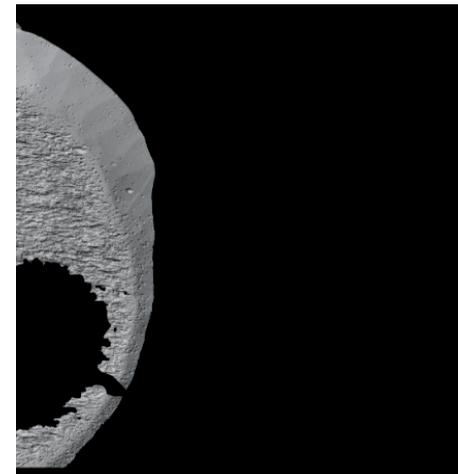
Reasons for having re-scans of one or more sections in a tile include:

- a) *Local vibrations*: these appear as regular patterns of vertical lines in specific areas. In such a case, it would not have been necessary to modify the settings of the scanner before rescanning the necessary area.
- b) *Areas with black data*: these result from too low a laser intensity. In this case the settings (laser intensity, exposure or threshold) would have been changed prior to rescanning.
- c) *Areas that are out of range*: these occur when the laser is either too close or too far from the object. In this case it would have been necessary to use the hand wheel to modify the distance (z-axis) between the scanner and the object. The use of a caliper or a ruler to know the exact distance moved is essential, as we will see in the merging tutorial.

For the Merging Application to work properly it is important that the rescans were done with the same origin as the base tile. This will ensure that the rescan is in the correct position in relation to the original tile. It is recommended that all rescans comprise some extra area to allow for a margin of error when merging. For more information about re-scans see Lucida Operator's manual, p.p. 31-33.

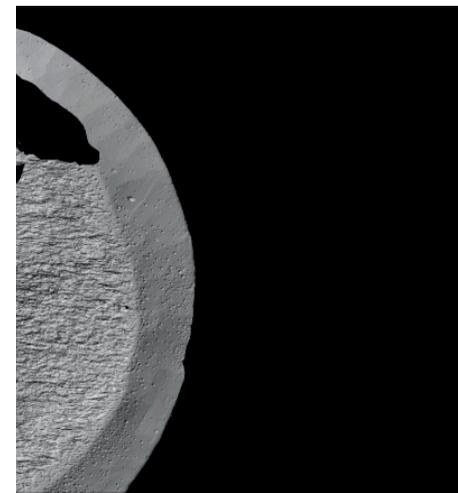
Example

The following example demonstrates the merging of tile 01B with tile 01B_RS1 (RS = rescan). 01B is the main tile and 01B_RS1 is the rescanned section, sharing the same origin.



01B

This object has a complex topography. The area in black was out of range (in this case, too far away from the scanner). The resulting data from the first scan is the file 01B.

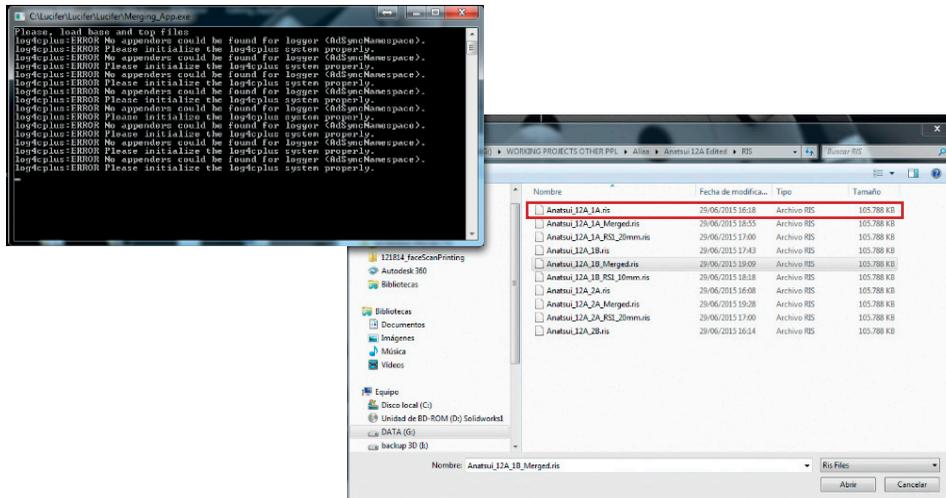


01B_RS1

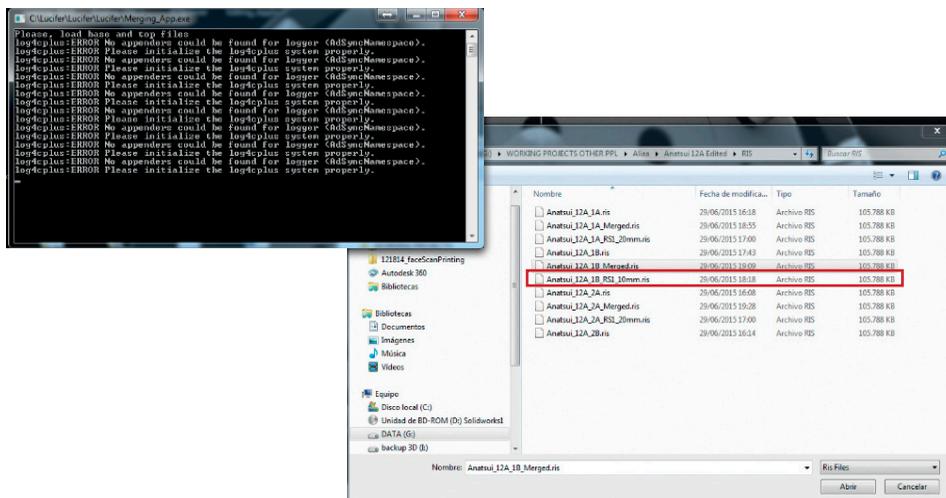
Keeping the same origin, a second scan was done (re-scan) after modifying the distance to the object. The re-scanned tile has the name 01B_RS1.

(The new black areas are caused by the scanner being too close to the object).

01. Open the Merging Application and load the main tile (01B.ris).



02. Load the first re-scan (01B_RS1.ris).

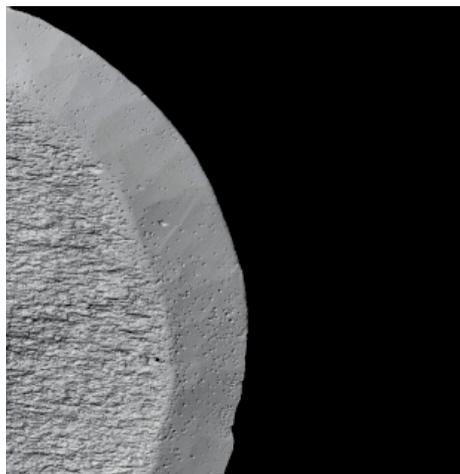


03. The following message will appear: 'Please enter the "z" axis caliper reading in millimetres' (the displacement value). If the distance of the scanner to the object was not modified, enter 0. If the scanner was moved, enter the distance in millimetres, which you should know from the scanning session. Movement away from the object is recognised by the software as a positive value and movement closer to the object as a negative value.

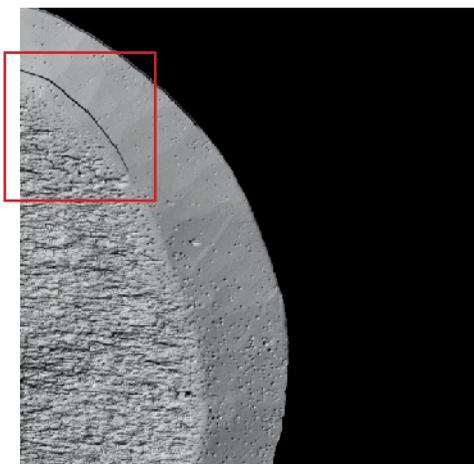


In this case the scanner was moved 10 mm away from the object thus the value entered is 10. If the scanner was moved 10 mm closer to the object, -10 would be entered.

The result of the merge will appear along with the window shown in step 5. The following images illustrate an example of a succesful merge using the correct displacement value and an unsuccessful merge using an incorrect displacement value.



01B and 01B_RS1
succesfully merged with the correct
displacement value.



01B and 01B_RS1 were not
succesfully merged in this case
because of an incorrect displacement
value. Note the thick black line that
appears around the filled area.

04. The following window will appear alongside the final merge after the input of the displacement value. In the next step it will be possible to adjust the final merging, moving the re-scanned tile in the three directions (X, Y, Z) in order to match the correct displacement.

Note: do not save the file until the merging is complete.

```
'x' translation (um) = 0
'y' translation (um) = 0
'z' translation (um) = 0

Points used to evaluate the 3 recommended translations:      23537
Recommended translation along the 'x' axis (um):           -100
Recommended translation along the 'y' axis (um):           -100
Recommended translation along the 'z' axis (um):            0

Press 'u, i' to translate 100 um along the 'x' axis
Press 'o, p' to translate 100 um along the 'y' axis
Press 'q, w' to translate 50 um along the 'z' axis
Press 'e, r' to translate 10 um along the 'z' axis

Press 'g' to aply the 3 reccomended translations along the 3 axis
Press 'h' to aply the reccomended translation along the 'x' axis
Press 'j' to aply the reccomended translation along the 'y' axis
Press 'k' to aply the reccomended translation along the 'z' axis

Press 's' to save merged data as RIS and exit
Press 'a' to save merged data as TIF32 and exit
Press 'x' to exit without saving
```

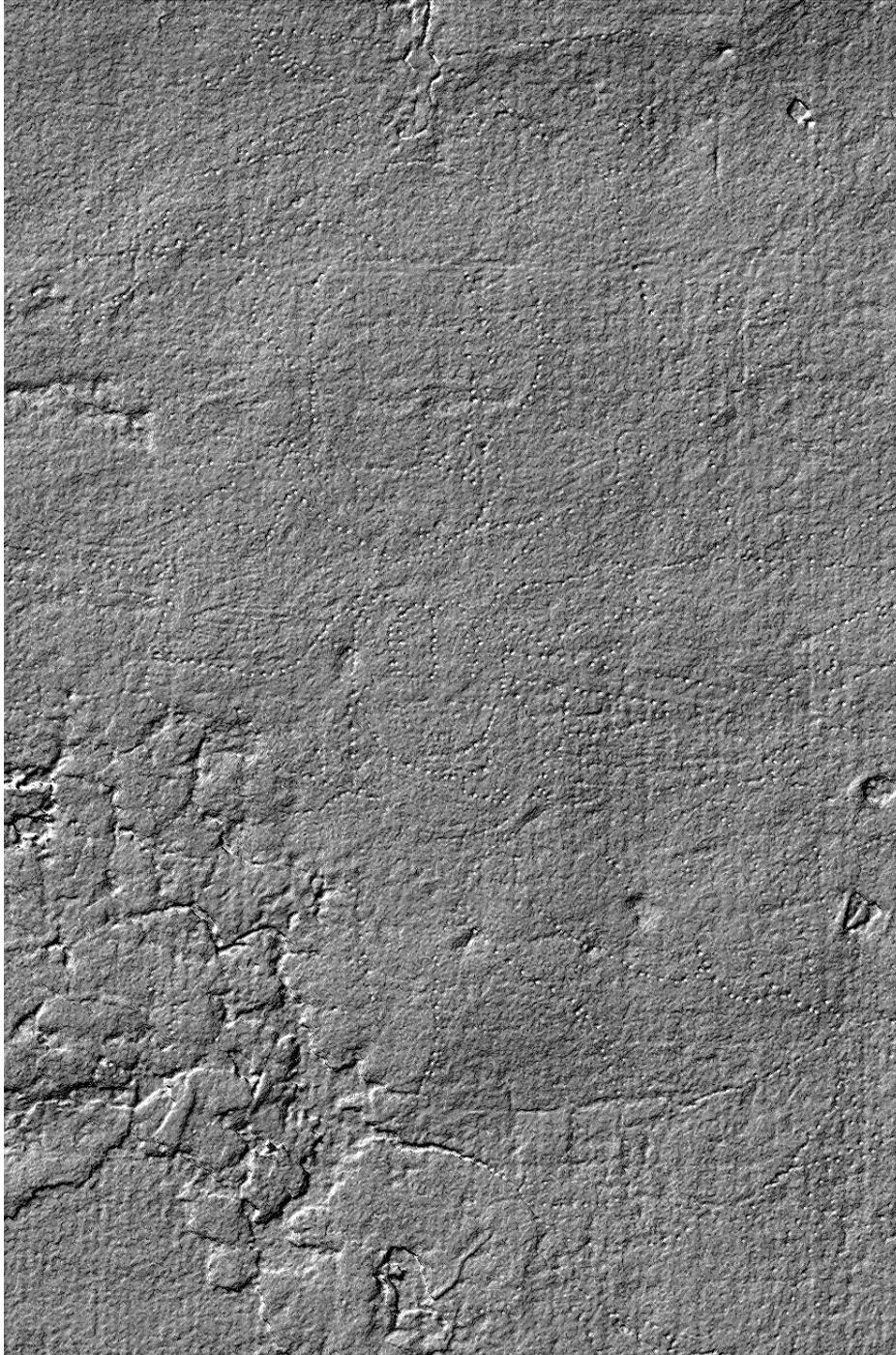
05. To automatically adjust the position of the re-scanned tile, try:

- 'g': adjusts position in the x,y,z-axes
- 'h': adjusts position in the x-axis
- 'k': adjusts position in the z-axis
- 'j': adjusts position in the y-axis

06. To manually adjust the position of the re-scanned tile, try:

- 'q': moves tile down along z-axis by 50 microns
- 'w': moves tile up along z-axis by 50 microns
- 'e': moves tile down along z-axis by 10 microns
- 'r': moves tile up along z-axis by 10 microns
- 'u': moves tile left along the x-axis (-x) by 50 microns
- 'i': moves tile right along x-axis (+x) by 50 microns
- 'o': moves tile down along y-axis (-y) by 50 microns
- 'p': moves tile up along the y-axis (+y) by 50 microns

07. If the two tiles have been correctly merged, it will be impossible to tell where the join is i.e. there will be no artifacts. Once you are satisfied with the result, press 'a' i.e. to save the outcome as a 32 bit TIF. Then press 's' to save it as a RIS file. It is suggested that the user save the file in both formats. If the merge is still unsuccessful, press 'x' and restart the merging process with a different displacement value.



7

Editing

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Raphael, *The Holy Family with the Lamb*, C16th, ink on paper, 27.5 x 22.7 cm (detail).
3D scanned in 2015 in the Ashmolean Museum, Oxford.

Editing original data

The Editing Application is used for improving (cleaning, correcting...) the original relief data obtained with the Lucida 3D Scanner. It has been specifically designed to deal with common artifacts that appear in most recordings, such as:

'Noise': grainy texture that appears all over the scanned data, usually when the used laser intensity used is too high for the characteristics of the recorded material (glossiness, darkness, etc.).

'Spikes': artifacts in the shape of single points that are elevated too far above the average height of the recorded data. These are usually produced by shiny materials.

'Gaps': local absence of data, produced by a range of causes, which results in black areas of a few pixels size. These areas must be filled by the Editing App in order to guarantee the continuity of the data.

'Rain': artifacts in the shape of floating points that appear around the edges of the scanned data, produced by reflections of the laser.

A subjective process

Modifying original scanned data involves taking a series of decisions that will affect the final result. The user has many options when editing the data. Which option is taken depends on the desired output for the scan... (whether it is for visualization, prototyping, combination with other types of 3D data...).

For heritage documentation it is essential to keep the original files as a record of the information captured by the scanner. There are infinite ways of processing the recorded data but there is only one original version, which contains information that could become relevant at a later stage.

The Editing Application can load Lucida tiles as RIS format and save as RIS, 32 bit TIF (depthmap) or 8 bit TIF (shaded) file formats.

The Editing App can only operate on one tile at a time. For editing a series of tiles it is necessary to carry out the same process for each of them. Various tiles of the same object will probably require similar settings. Therefore, after determining the optimum settings for the first tile, the same settings can be applied to the rest of them.

Tools & Commands

The Editing app allows the user to modify the original data using two types of elements: tools and commands. Whereas the tools can be applied to a specific area, the commands are filters that are applied to the whole tile. In both cases it is possible to specify the extent or the intensity of the correction. The range and recommended values will be described specifically for each tool and command. The order in which the tools and commands are applied will influence the final result.

The quality of the Editing process depends on the operator's eye and experience. The specific steps for cleaning or correcting a tile depend on each case and should be determined by trial and error. The general aim of the Editing process is to eliminate or reduce the different artifacts produced during the scanning session, and which are not part of the real data. The process is entirely subjective... because deciding when the editing process is complete depends almost entirely on the operator's judgement.

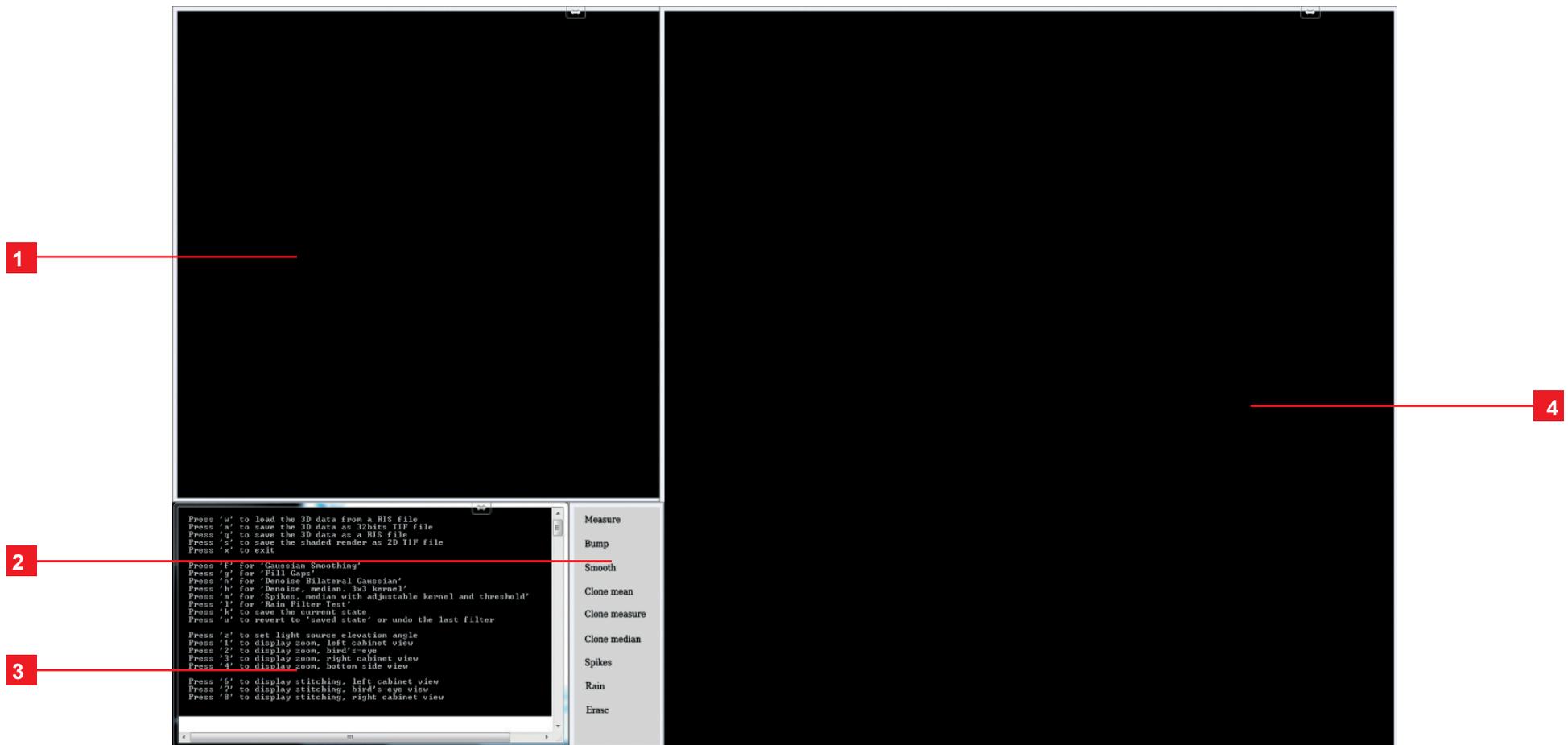
The optimum result is achieved when the data is continuous (without gaps), coherent (without spikes or floating points) and corresponds to the real surface (with less noise). However, it is important to make sure that this 'cleaning' does not modify the original data too much. In other words, for each dataset it is important to find a middle ground.

The user interface

- 1 Full view window: displays the full file. With the cursor it is possible to navigate or select the area that you want to zoom into.
- 2 Tools menu: contains the list of editing commands.
- 3 Commands window: contains the list of editing commands and allows the user to insert intensity values for the different filters. Press 'Esc' at any time to make the Commands window visible again.

- 4 Zoom view window: displays a zoomed-in view of the selected area. This window shows the area in detail, allowing the user to test and check the effect of the different filters and tools applied in the editing process.

Required screen resolution: 1920 x 1080 px.



Tools & Commands

List of Commands

The commands can be selected by typing their correspondent key:

'w': load the 3D data from a RIS file.

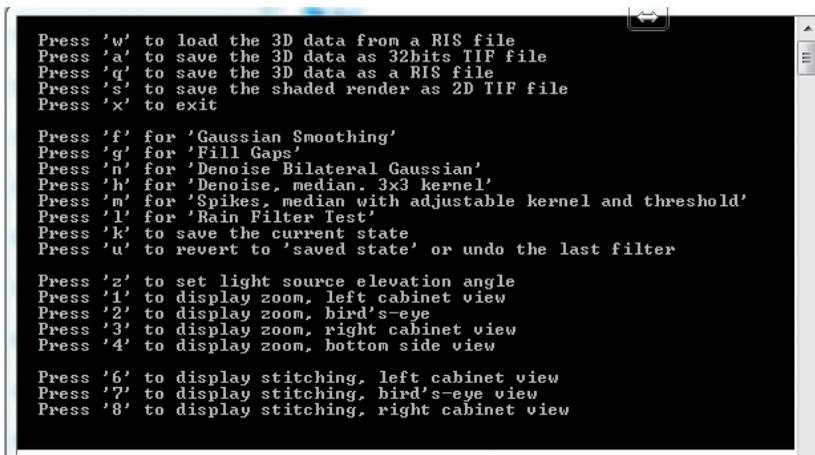
'a': save the 3D data as 32 bit TIF file.

'q': save the 3D data as a RIS file.

's': save the shaded render as 2D TIF file

'x': exit (without saving)

Note: after editing a tile it is recommended that the user always saves a file in the three formats: RIS, 32 bit TIF (depth map) and 8b bit TIF (shaded). Where possible, the user should also select a local folder and choose a short file name.



```
Press 'w' to load the 3D data from a RIS file
Press 'a' to save the 3D data as 32bits TIF file
Press 'q' to save the 3D data as a RIS file
Press 's' to save the shaded render as 2D TIF file
Press 'x' to exit

Press 'f' for 'Gaussian Smoothing'
Press 'g' for 'Fill Gaps'
Press 'n' for 'Denoise Bilateral Gaussian'
Press 'h' for 'Denoise, median, 3x3 kernel'
Press 'm' for 'Spikes, median with adjustable kernel and threshold'
Press 'l' for 'Rain Filter Test'
Press 'l' to save the current state
Press 'u' to revert to 'saved state' or undo the last filter

Press 'z' to set light source elevation angle
Press '1' to display zoom, left cabinet view
Press '2' to display zoom, bird's-eye
Press '3' to display zoom, right cabinet view
Press '4' to display zoom, bottom side view

Press '6' to display stitching, left cabinet view
Press '7' to display stitching, bird's-eye view
Press '8' to display stitching, right cabinet view
```

'f': 'Gaussian Smoothing'.

This command is used to smooth extremely rough surfaces. Values range from: 'sigma': 0.5, 'kernel': 3x3 to 'sigma':1.5, 'kernel':7x7. The lowest smoothing value is 0.5 and 1.5 is the highest.

'g': 'Fill Gaps'.

The possible values here range from 1 mm to 10 mm in diameter. The value should be chosen according to the size of the holes or 'gaps' to be filled. For small holes choose a minimum value, but always base your decision on the largest hole in the tile to fill.

'n': 'Denoise Bilateral Gaussian'.

This command reduces the noise from the surface by smoothing it slightly. This is mainly used for flat and less textured surfaces (like paintings on canvas or wooden panel).

'h': 'Denoise, median, 3x3 kernel'.

This is a more general command to reduce speckle noise. It should only be used for higher relief surfaces as its smoothing effect is much stronger than that of the 'Denoise Bilateral Gaussian'.

'm': 'Spikes, median with adjustable kernel and threshold'.

This is used to eliminate spikes and it also creates a smooting effect.

'l': 'Rain Filter Test'.

This command removes floating particles that occur due to excess of ambient light, particularly found around the edges of a painting.

'k': save the current state.

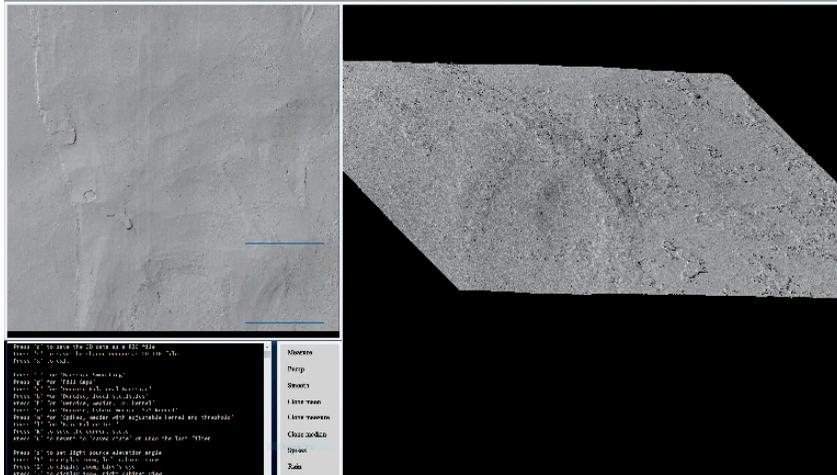
'u': revert to 'saved state' or undo the last filter.

Right click on a selected area in the Full view window to see the previous state. In order to compare the previous and current state, alternate between the left and right click on the mouse.

'z': set light source elevation angle.

Commands '1, 2, 3, 4' change the view in the Full view window. Commands '6, 7, 8' change the view in the Zoom view window.

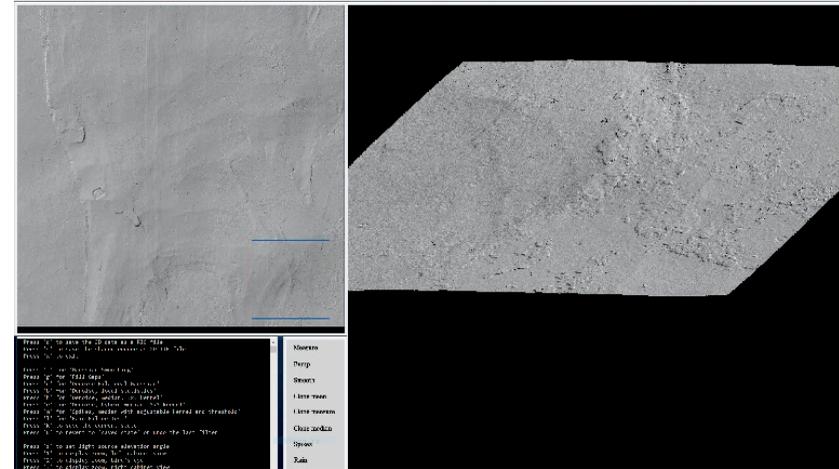
'1': display zoom, left cabinet view.



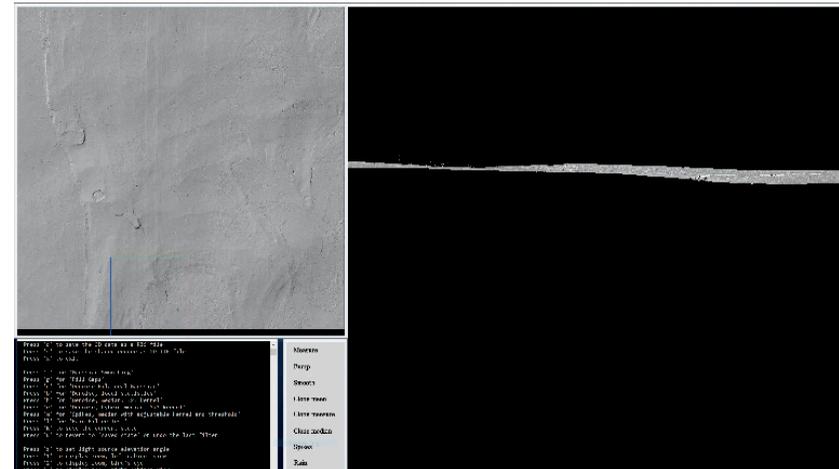
'2': display zoom, bird's eye view.



'3': display zoom, right cabinet view.



'4': display zoom, bottom side view.



'6': display stitching, left cabinet view.

'7': display stitching, bird's-eye view.

'8': display stitching, right cabinet view.

List of Tools

Tools are used to manually modify specific local selections in the tile. Select the area to be edited in the Full view window and edit directly on the Zoom view Window. Tools are secondary to Commands and should be used only if the Command did not work to full effect. Input the necessary values into the window that appears when you select the tool.

Measure: shows the coordinates of each point.

Bump: creates curvature to specific areas.

Smooth: smooths out local areas that show too much noise.

Clone mean; Clone measure; Clone median: these tools are used to replicate texture, taking source data from nearby areas. .

Spikes: eliminates the spikes.

Rain: removes floating particles and is particularly used on the edges

Erase: it can be used to erase unnecessary data - for example data lying outside the area of interest (outside of the painting).

Measure

Bump

Smooth

Clone mean

Clone measure

Clone median

Spikes

Rain

Erase

Standard session

Below is the recommended order of commands when implementing an editing session:

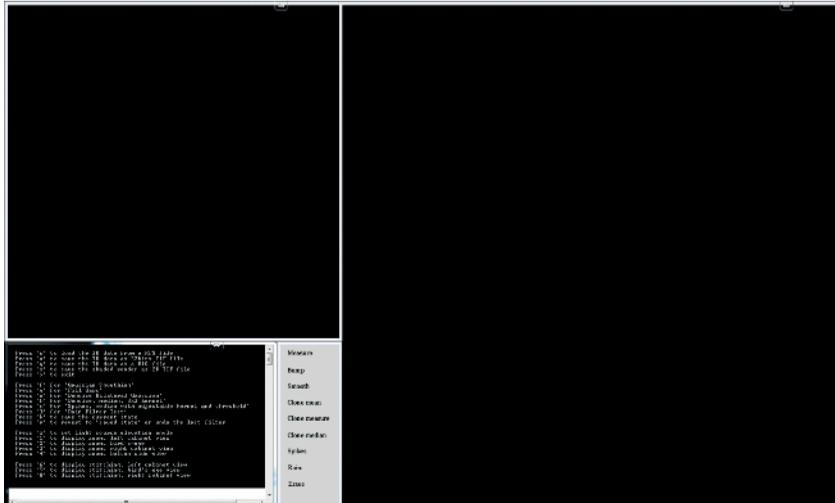
01. Load the file in the Editing Application ('w').
02. Look for holes ('gaps') in the tile. Use '1/2/3/4' to change views.
03. Use the 'Fill Gaps' ('g') command to fill the holes on the surface.
04. Use the 'Rain Filter' ('l') to remove the floating particles.
05. Check for more holes or gaps and if applicable fill them again (sometimes holes that were not visible before appear as a result of removing floating particles).
06. Use the 'Spikes Median' ('m') to remove any spikes if necessary.
07. Use the applicable 'Denoise, median. 3x3 kernel' ('h').
08. Use the 'Gaussian Smoothing' ('f') if necessary.
09. Save the file in all three formats ('a', 'q', 's').
10. Exit the application ('x').

It is recommended that the user checks the result after applying each command. The values will have to be determined specifically for each editing session, as the optimum result depends on the type of data scanned.

Additionally, Tools can be used to refine certain areas where the commands did not remove or smooth out the imperfections. It is best to apply the selected tool directly following its corresponding command (ie. 'Rain' tool after 'Rain Filter', 'Spikes' tool after 'Spikes Median', etc.).

Example

01. Open the Editing Application.

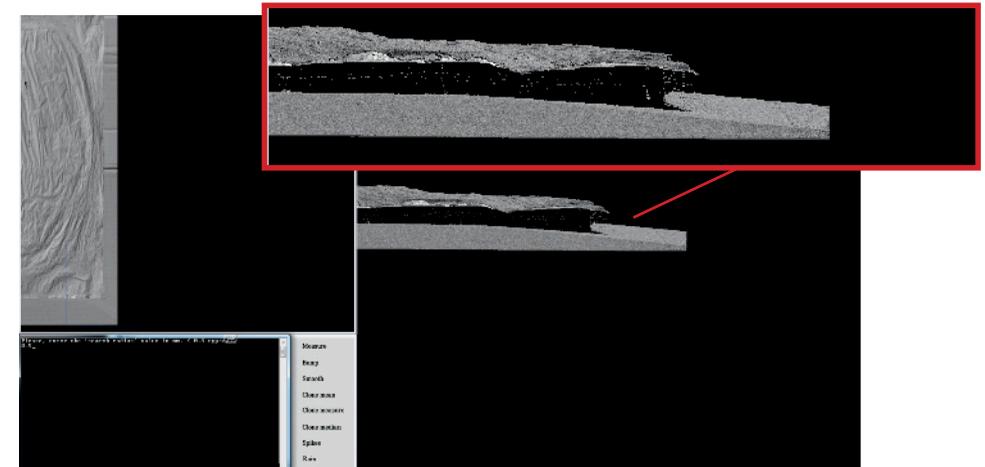


02. Press 'w' to load the 3D data from a RIS file.



03. Press 'g' for "Fill Gaps". Possible values range from 1-10 mm in diameter. If in doubt choose a mid-range value (e.g. 5).

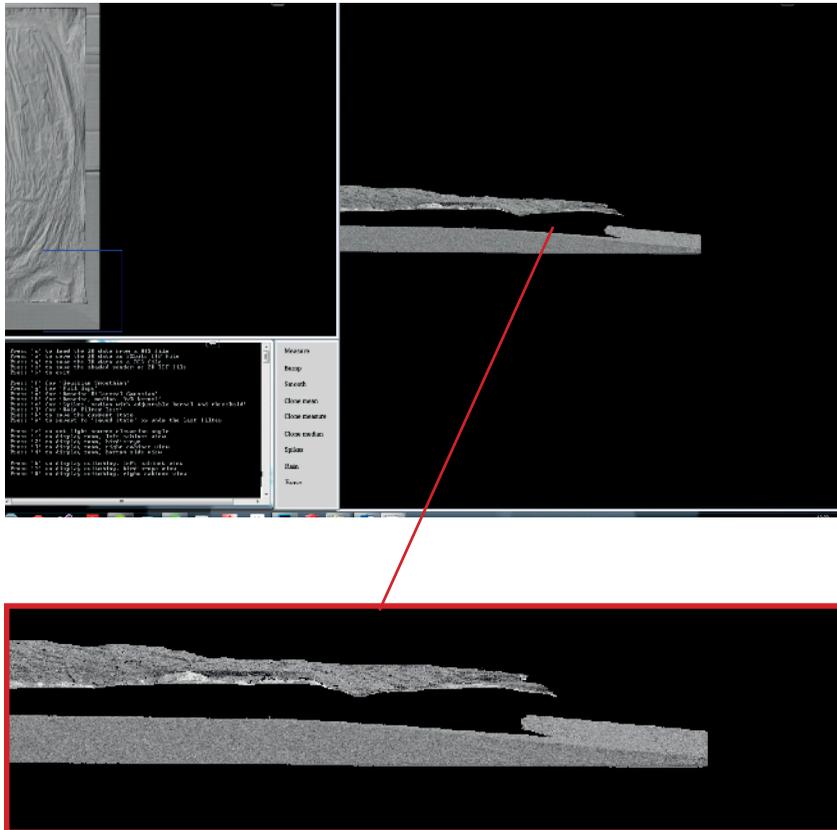
04. Remove the floating particles surrounding the scan using the 'Rain Filter Test' ('f') command. Then enter a search radius value. This value represents the radius from the surface above which particles will be removed. Possible values range from 0.1 to 0.8.



Note: pay particular attention to the edges by using the side view. Select an area in the render view window and press '4' to display zoom, bottom side view in order to make the floating particles visible.

05. You will then be prompted to enter the percentage threshold value as an integer. For scans with more floating particles use a higher threshold value. The value to be used is subjective, but 75 is typical. For this example the search radius value was 0.5 mm with a 60% threshold.

Result after 'Rain Filter':

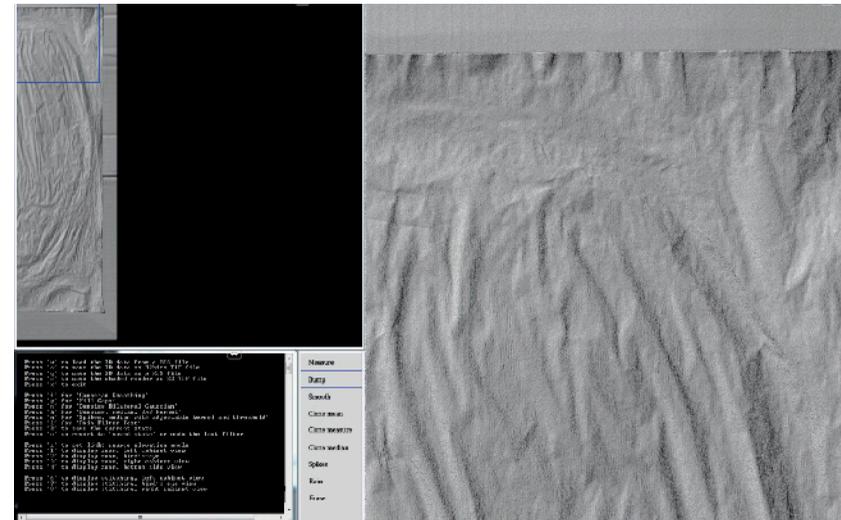


06. Revise the data for any other holes that were not visible earlier. It is usual to find more holes appearing as some of them were covered by floating particles now removed by the rain filter. If applicable, press 'g' for 'Fill Gaps' again.

07. The next steps varies for different scans depending on their texture and the amount of relief present in the data:

- for high-relief surfaces press: 'h' for 'Denoise, median. 3x3 kernel'
- for flat/low-relief surfaces press: 'n' for 'Denoise Bilateral Gaussian'

This example requires the 'h' command because the texture is rough:

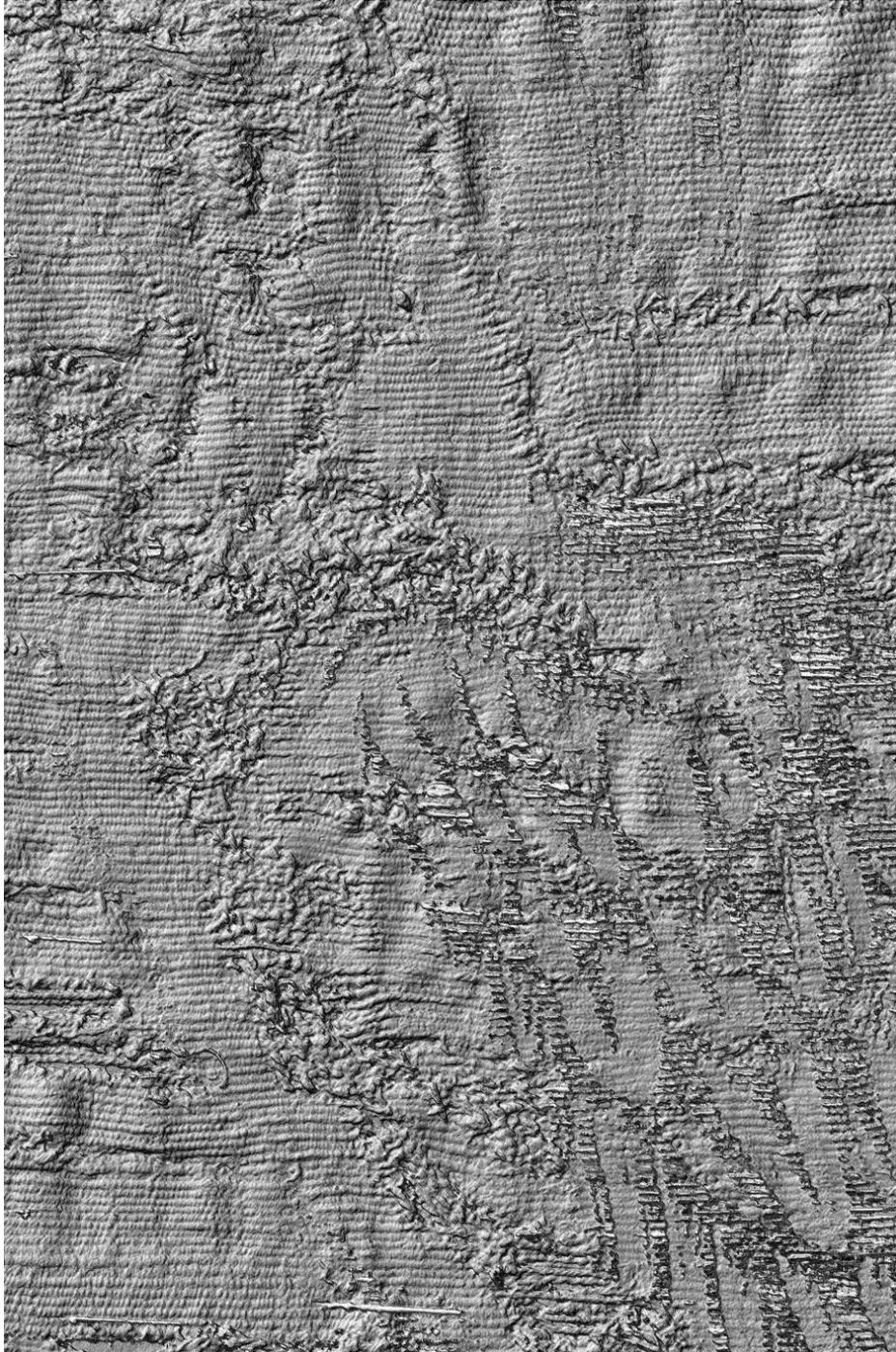


08. The final step involves saving the file in three different formats:

- 8.1. Press 'q' to save the 3D data as a RIS file
- 8.2. Press 'a' to save the 3D data as 32 bit TIF file
- 8.3. Press 's' to save the shaded render as 8 bit TIF file

09. Press 'x' to close the Application.

10. Now apply similar editing steps to all the tiles recorded from the same object. After all tiles have been edited, they are ready for the next processing step: Aligning (with PTGui).



8

Aligning

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Verdure tapestry, anonymous, C18th, wool and silk, 385 x 436 cm (detail).
3D scanned in 2015 in the Real Fábrica de Tapices, Madrid.

PTGui

The process of aligning (or stitching) various tiles recorded with the Lucida 3D Scanner is performed using the panoramic composite software PTGui. This tutorial describes the step-by-step process using PTGui Pro 9.2.0 on Windows 7.

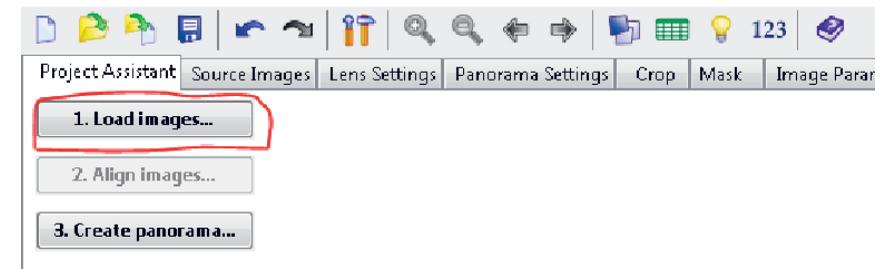
One of the great advantages of Lucida is the possibility of working with 3D information as TIF files, both as depthmap and shaded. The alignment process roughly consists of two steps: first, create a panorama using the shaded renders (8 bit TIF files); second, substitute each tile with its correspondent depthmap (32 bit TIF files).

Do not use original files for aligning. Instead, use the edited and merged tiles you have created in the previous processing steps.

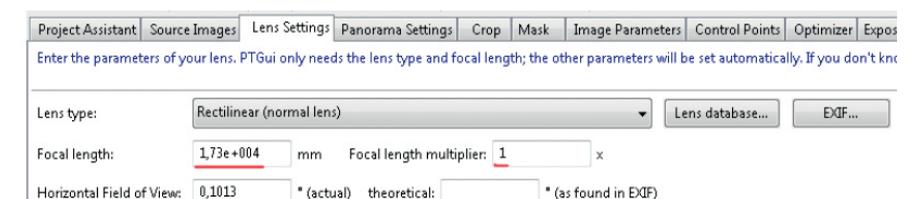
At the end of the process two panoramas will be generated: a shaded panorama, which can be used as an image, and a depthmap panorama, which can be used as 3D information for various outputs.

Loading images

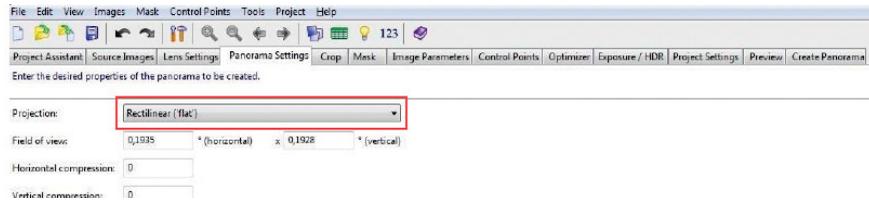
01. Open PTGui.
02. A series of default settings must be changed before starting:
 - 2.1. On the Menu bar click on 'Options' (under a tool icon).
 - 2.2. Go to 'Advanced' tab and uncheck 'Load 16bit as 8 bit'.
 - 2.3. In the same tab check 'Allow stitching even if estimated TIF/PSD size is over 4Gb'.
 - 2.4. Check 'Disable SSE/Altivec acceleration'.
03. On the top right corner of the software interface click on the 'Advanced' tab in order to access the advanced options.
04. Select the image files: 'Project Assistant' > '1. Load images...'



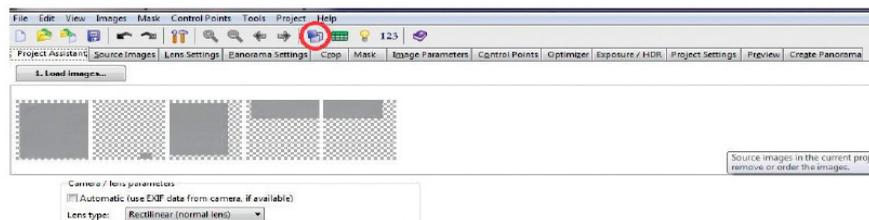
05. A window will pop up saying that no EXIF data was found. Do not worry about this message: unlike most DSLRs, the Lucida scanner does not attach EXIF data to its files. Close the window. This issue will be addressed in the next steps.
06. When the images have loaded, click on the 'Lens Settings' tab
 - 6.1. 'Lens type' should remain 'Rectilinear'. Set 'Focal Length' to 17,300
 - 6.2. 'Lens correction parameters' should remain as '0'. This will avoid any warping to the images.



07. On the 'Panorama Settings' tab 'Projection' should be set to 'Rectilinear' in order to keep the lines straight.



08. Click 'Align images'.



It is recommended to preview the stitched panorama by clicking on the 'Panorama editor' icon on the Menu bar or using the shortcut 'Control + E'.

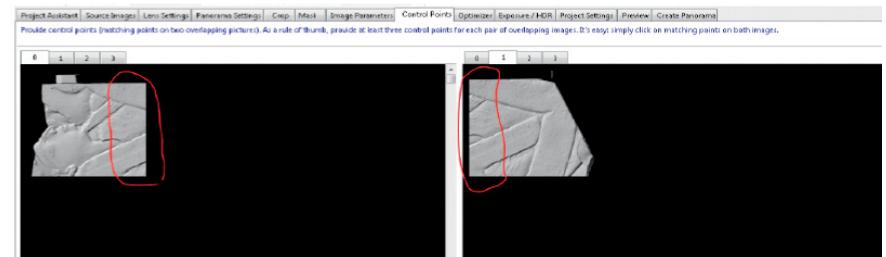
Control points

09. Assign control points. PTGui calculates the translations and rotations required for an image to fit with its neighbour by using a minimum of four 'correspondence points'. This can be done automatically by the software but to ensure accuracy it is better to do it manually.

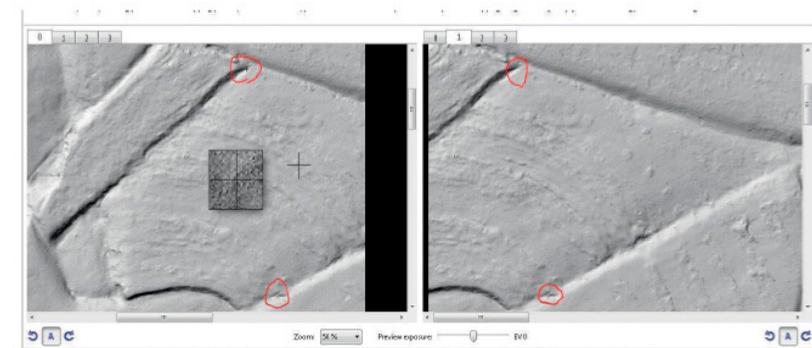
Note: the accuracy of the control points should be sub-pixel. To identify whether this is the case, use the Optimize button (step 15).

09.01. Click on the 'Control Points' tab.

09.02. Select a pair of overlapping images, for instance: 'Image 0' and 'Image 1'.



09.03. The pair of images as currently displayed in the viewer are too small to achieve a good pixel correlation. Adjust the Zoom to around 50%. Locate any clear visible features, as shown in the image below.



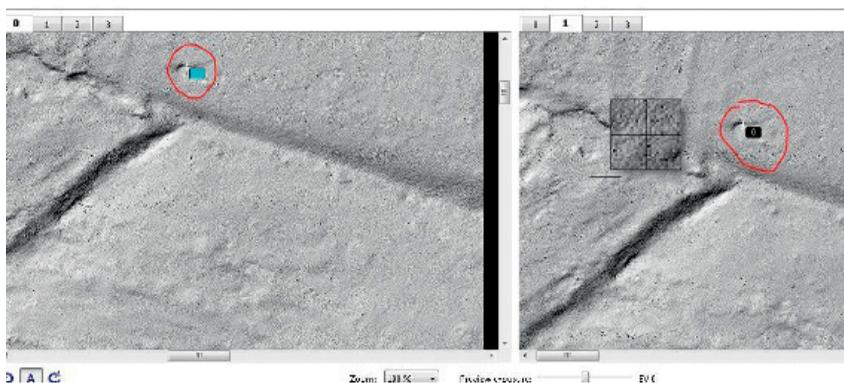
09.04. Once features have been located, increase the Zoom level until the chosen feature can be clearly identified. In the example below, the Zoom is set at 200%.



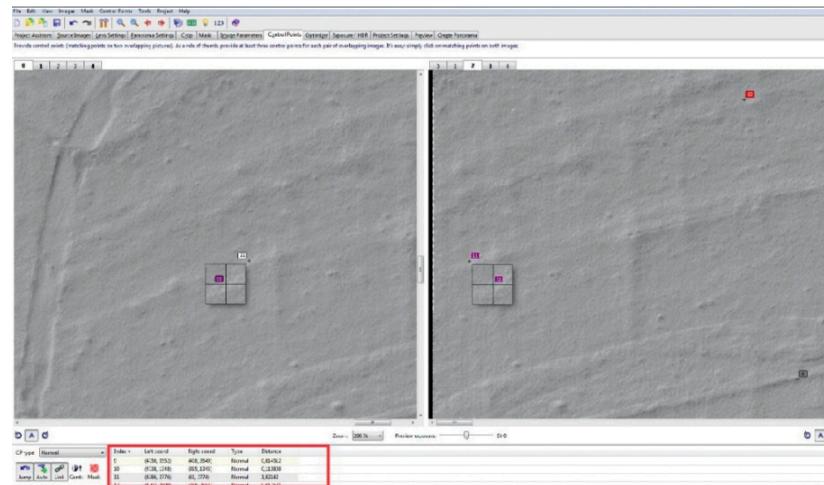
09.05. Once the corresponding features have been located, go into the left hand viewport and left-click on the feature .

Note: it's fine if you forget where you've clicked exactly because PTGui will anchor these small windows for you.

09.06. Within the right hand viewport, click on the same feature as in the left hand viewport. Guide your eye using the small anchored window.



09.07. The first control point will now show up on the lower part of the interface. The distance value will be displayed once the project is optimized. From this value it will be possible to determine whether the assignment of control points was accurate enough.

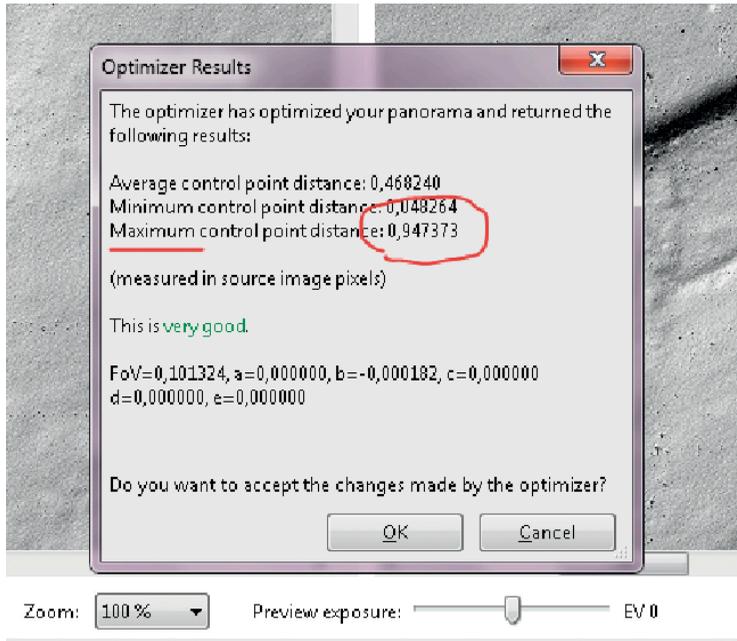


09.08. Repeat this process for each of the four pairs of images.

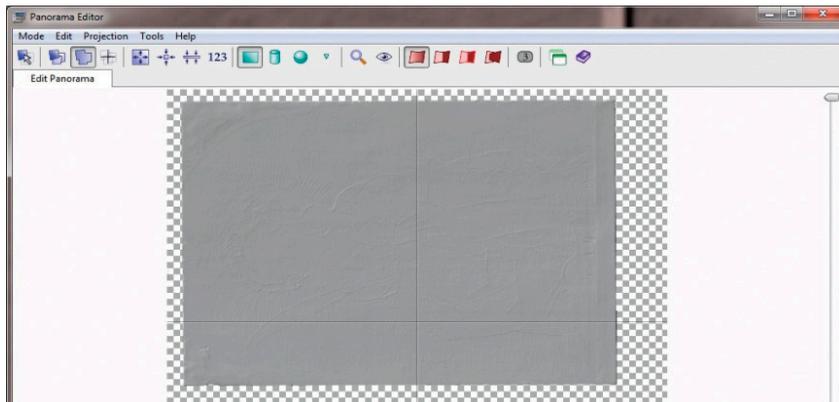
Note: once you have set 2 corresponding points manually, PTGui will be able to automatically estimate the rest for you.

10. Click on the 'Optimizer' tab and click on 'Optimize' in the bottom left corner or press F5.

10.01. The average error should be lower than 1 pixel. If the average error is higher or equal to 1.00, repeat the placement of the control points as many times as necessary. To manage the control points click 'Tools' > 'Control Points'.



12. At this point it is recommended that the user previews the resulting panorama by clicking on the 'Panorama editor' icon on the 'Menu' bar or using Control + E. The tiles below have been successfully stitched together:



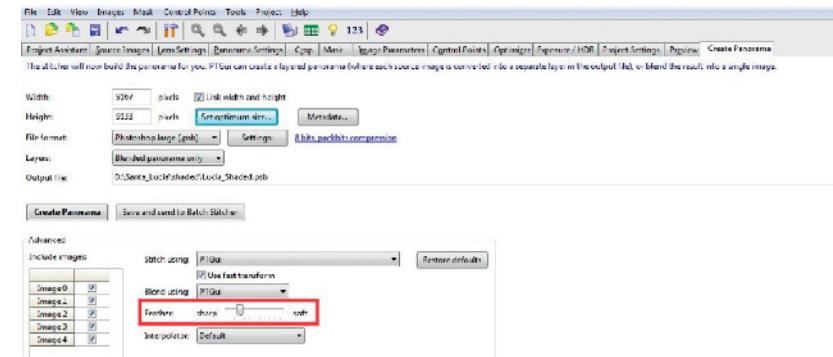
13. Click on 'Create Panorama' tab.

13.01. Click on 'Set optimum size' and then click on 'Maximum size' to make sure there is no loss of any details.

13.02. Set the 'File format' to 'Photoshop large file .psb'.

13.03. Click on 'Layers' > 'Blended Panorama only'.

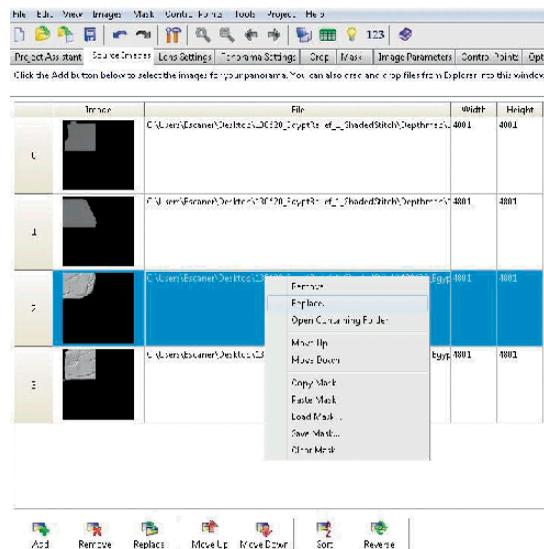
13.04. Adjust the 'Feather' to be close to the sharp side.



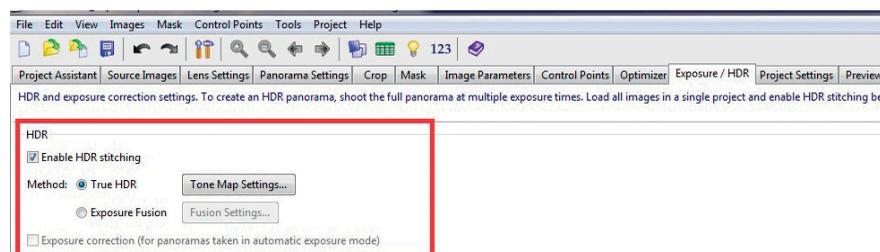
13.05 Click on 'Create Panorama'.

Replacing images

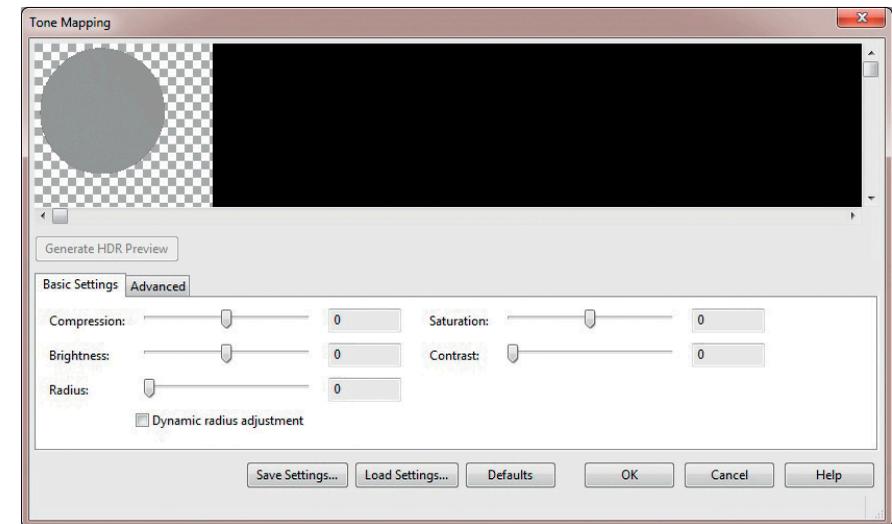
14. Open 'PTGui' > 'Open the stitched project'.
15. Go to the 'Source Images tab' and right-click 'Load Mask' on each image. Load the corresponding saved mask from Photoshop.
16. Go to 'Source Images' and right-click 'Replace' on each image to replace them with the corresponding depth map file.



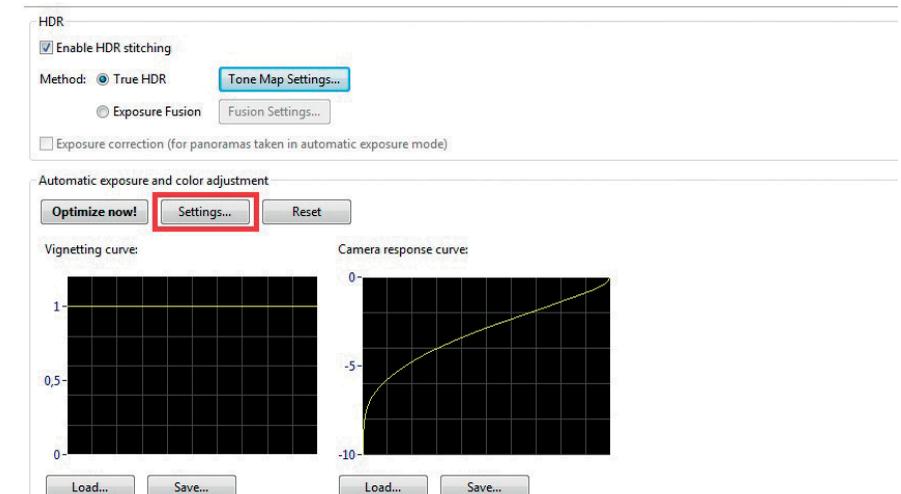
17. Once all the tiles have been replaced with their corresponding depth map files, click the 'Exposure/HDR' tab.
 - 17.01. Check 'Exposure correction', 'Enable HDR stitching' and select 'True HDR'.



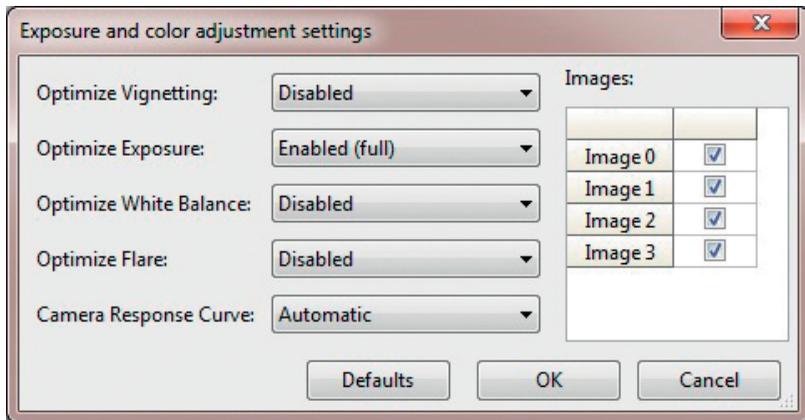
- 17.02. Click 'Tone map settings' > disable 'Dynamic radius adjustment' and set 'Radius' to 0.



18. Within automatic exposure and colour adjustment click on 'Settings'.



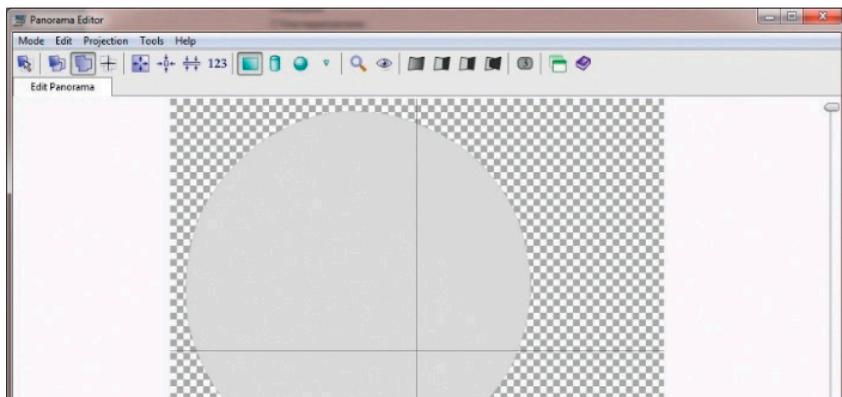
18.01. Disable 'Optimize Vignetting', enable 'Full optimize exposure' and click 'OK'.



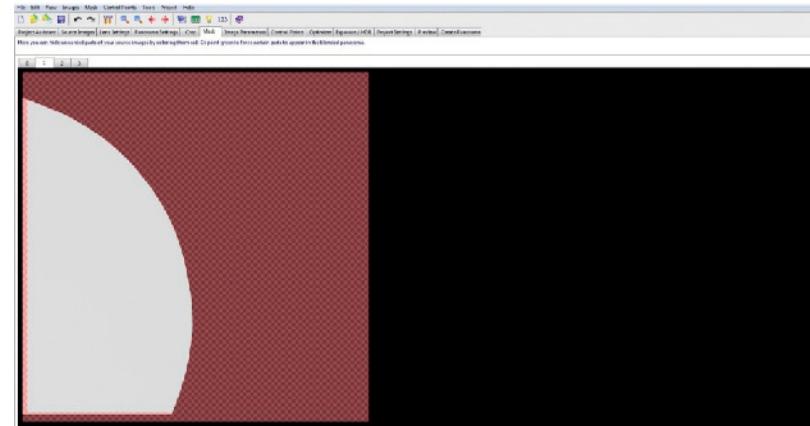
19. Within 'Automatic exposure and colour adjustment' click on 'Optimise now'. The Z values of each tile should have been compensated.

20. At this point check whether the exposure has been compensated correctly. Press 'Control + E'. All transformations are done linearly.

21. Some black straight lines might be visible on the edge of the tiles within the Panorama editor. To remove them, click the 'Mask' tab and outline the overlapped parts of the tiles with the round red tool.



21.01. Press 'Control + E'. All transformations are done linearly.



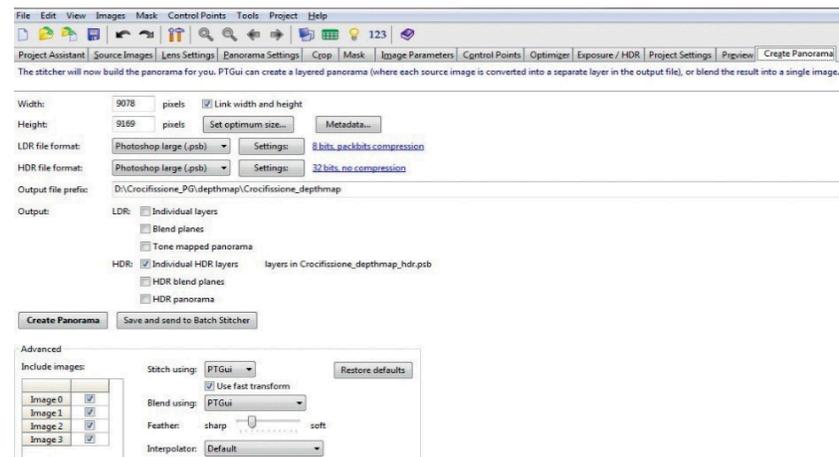
22. Go to the 'Create Panorama' tab.

22.01. Click 'Set optimum size' and then click 'Maximum size (no loss of detail)'. 'HDR file format' should be set to 'Photoshop large (.psb)'.

22.02. 'Output' should be set to '- HDR - Individual HDR layers' (disable all the other options).

22.03. Put 'Feather' close to the sharp end of the scale.

23. Click 'Create panorama'.





9

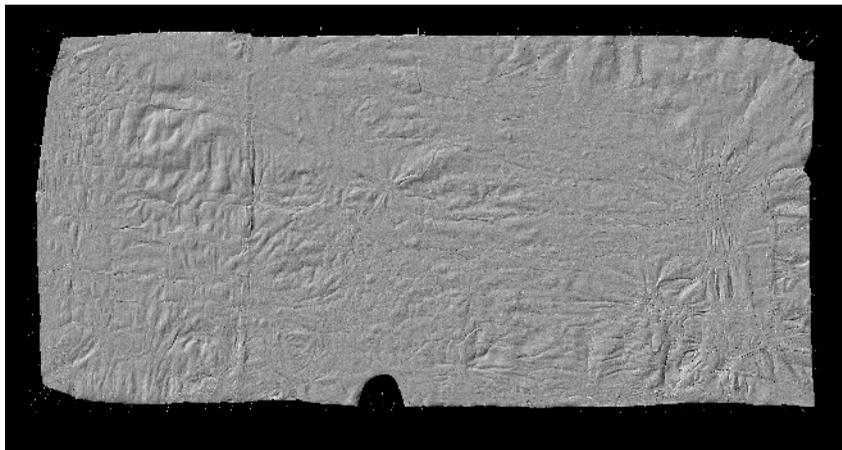
Blending

<<<

E. L. Kirchner, oil on paper, 72 x 92.3 cm (detail).
3D scanned in 2014 in the Courtauld Institute, London.

Preparing tiles

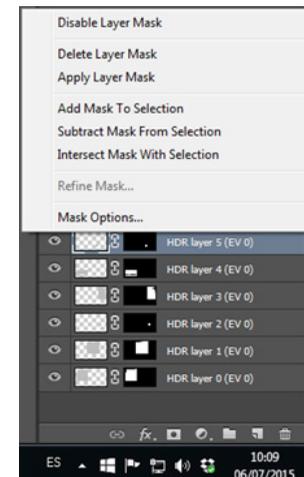
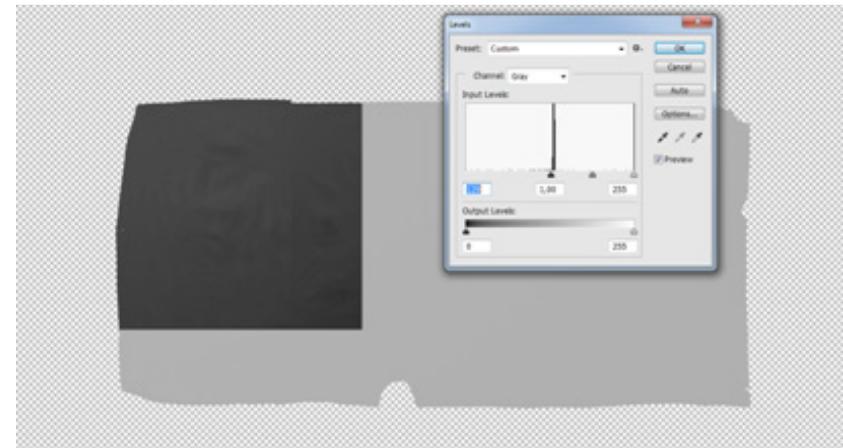
In order for the files to be processed by the Lucida Blending App, the tiles must have been prepared in Adobe Photoshop (CC version or higher). This example comprises six tiles. It serves to illustrate the required steps but should be used only as a guideline as each project will differ. Below the 8 bit TIF shaded and the 32 bit TIF depthmap versions:



Gough Map of Great Britain, Ashmolean Museum, Oxford.

01. Open the PSD file that contains the 32 bit depthmap panorama in which each tile is in position as an independent layer. This file must have been previously generated with PTGui.

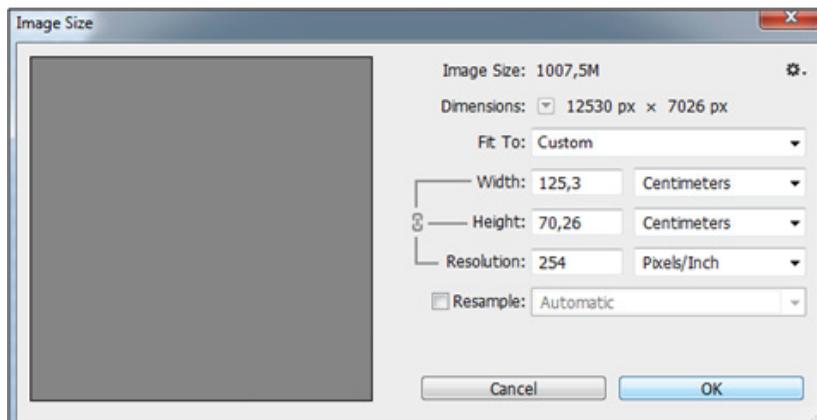
02. Check that the file is correct by selecting any layer and going to: Image > Adjustments > Levels and change the values to ensure that the relief looks as expected. Do not save changes.



03. Delete all layer masks that may have been created in PTGui. Right-click on each Layer Mask > Delete Layer Mask.

04. Check that 32 Bits/Channel is on: Image > Mode > 32 Bits

05. Adjust to correct resolution: Image > Image Size > Resample: Off (unchecked) > Resolution: 254 pixels/inch



Note: when 'Resample' is off, changing the resolution will change the width/height dimensions accordingly and not the overall 'Image Size'. As a result, the file will be in 'real dimensions'.

- 06. Image > Mode > Grayscale > Merge layers?... > Don't Merge
- 07. Edit > Color Settings > Gray > Linear
- 08. Modify the canvas size: Image > Canvas Size... > New Size: Width: 17000 px / Height: 9602 px (or 1700 x 960.2 mm)

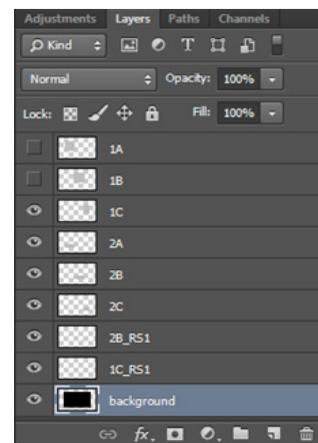
Note: if the file that has been stitched is larger than the new size listed above, the file must be split into sections. With the current Blending app this is the maximum file size that can be blended.

- 09. Create a 100% black (or white) background layer: Layer > New > Name: Background / Colour: Black > OK. With the new Background layer selected, use the Rectangular Marque Tool (see below) and outline the whole canvas. Right click > Fill: Black. Drag Background Layer to the bottom of the Layer Panel.
- 10. Change the name of each layer to its corresponding tile name e.g. 1A, 1B, 1C, 2A, 2B, 2B, 2C, etc. The horizontal dimension (rows) is marked with letters and the vertical (columns) with numbers.

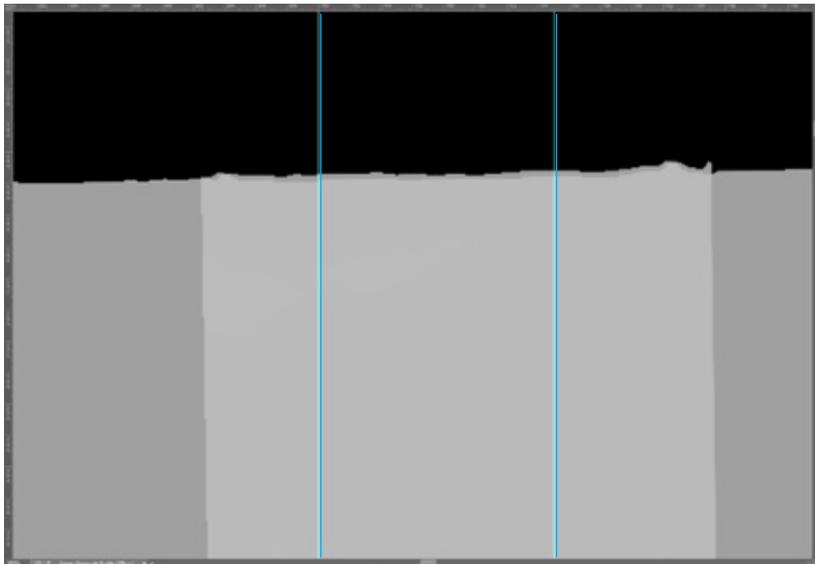
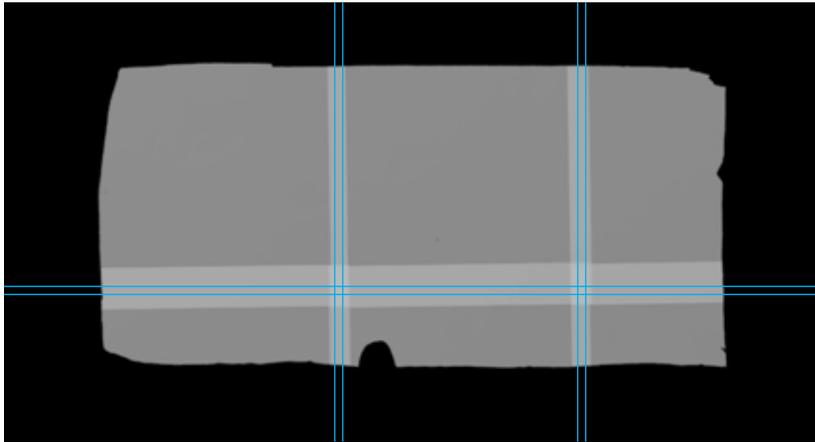
Note: The 'eye' button on the left of each layer will show/hide the layer, making its location identification on the canvas.

- 11. Reduce the opacity of the layers (e.g. 50%) to illustrate the overlap between tiles. The standard overlap between tiles should be around 50 mm.

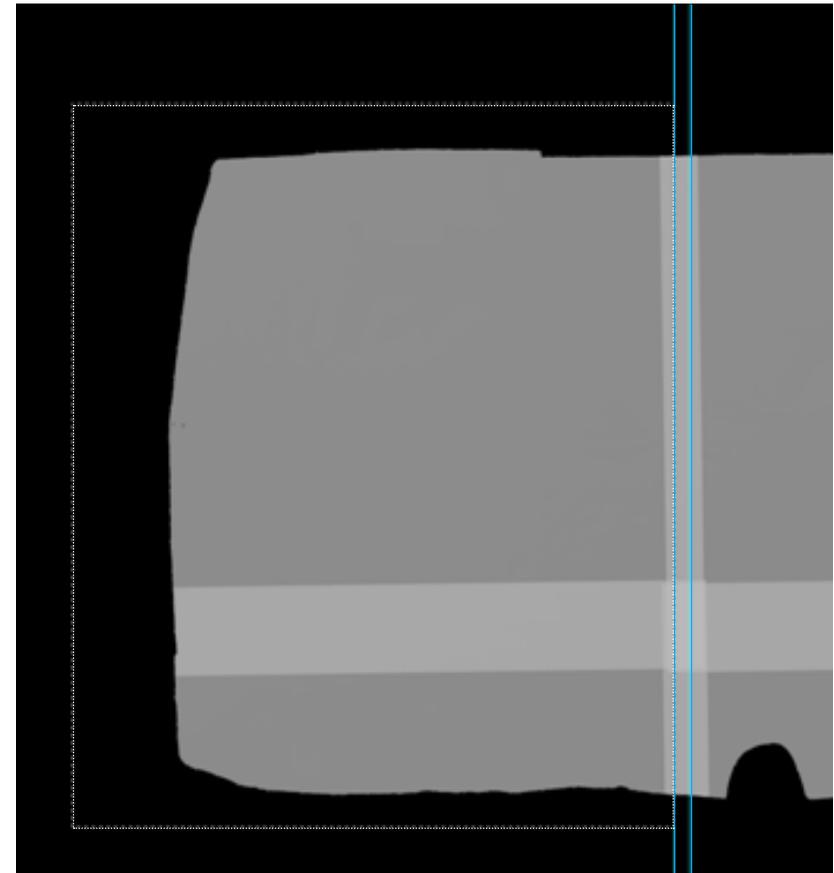
Note: click on the ruler at the edge of the screen to change the dimensions to mm.

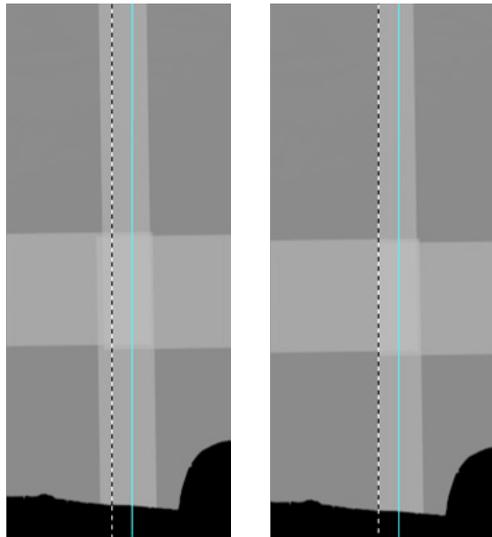


12. Drag guides from their corresponding horizontal and vertical rulers and place them onto the overlapped area to outline a space that is ≥ 10 mm and ≤ 25 mm. It is best to zoom in at this point to ensure accuracy and check that the overlapped area does not include any holes as they may be problematic later on.



13. After marking all overlapped areas within the correct range (in between 10 and 25 mm), use the Rectangular Marquee Tool to select an area that encompasses the excess overlap of each layer (overlap area outside the marked section). Then delete the excess area from the selection adjacent to the tile. Repeat this operation for each layer.

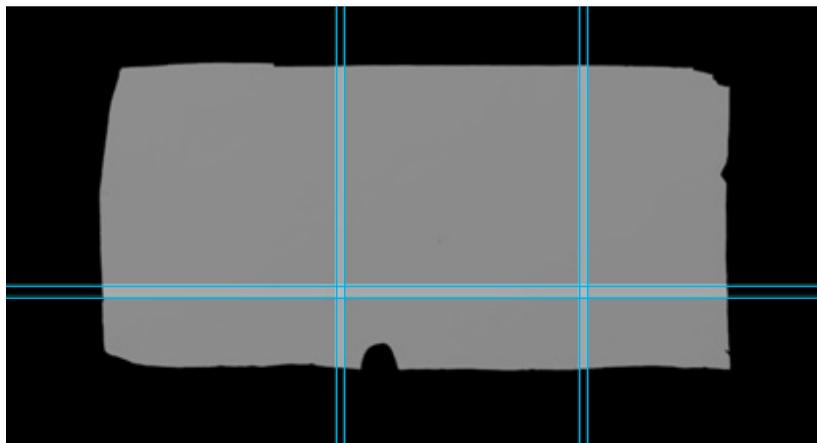




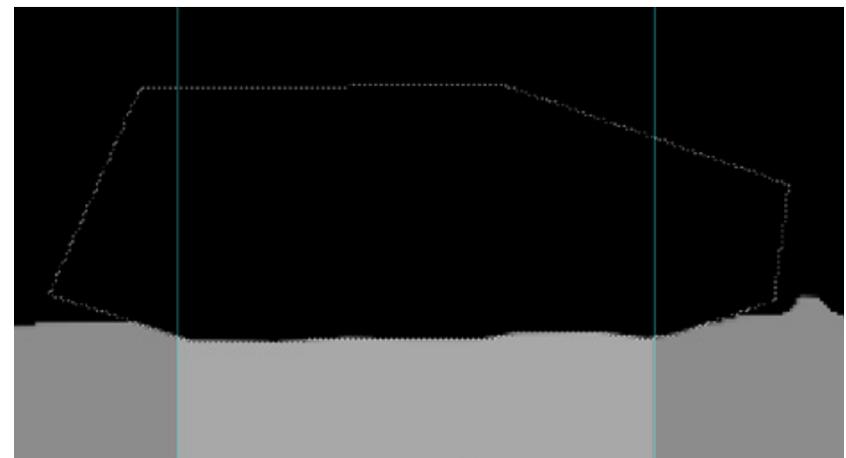
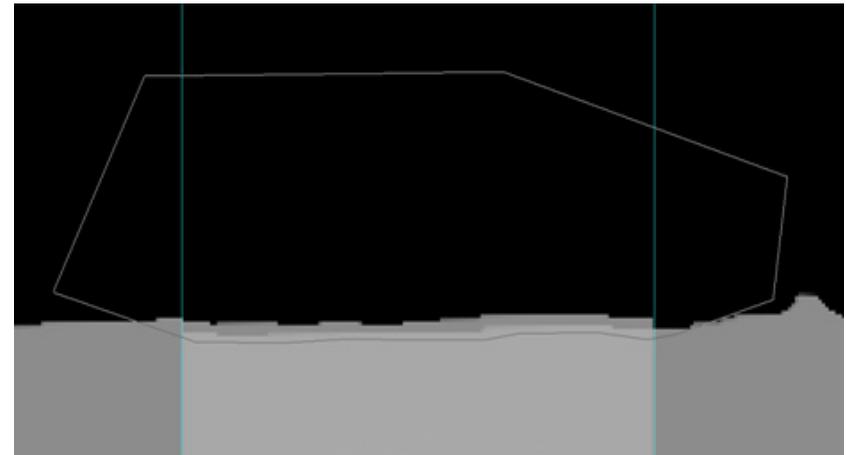
Before / After

Note: after removing the excess of overlap from every layer the resulting file must look like this (see image below). It is recommended that the user saves changes at this point as an intermediate step, so it is possible to return to this stage in the process if necessary.

For instance, save the file as: [name of work]_progress1.psb



14. In order for the Blending app to work correctly, the borders of the overlapped sections must be evened out. With the guides still in place, zoom in at the edge of an overlapped area and use the Lasso or Polygonal Lasso Tool to remove any uneven edges. Do this for all vertical and horizontal overlapped tiles.



Before / After

15. Change the opacity of the layers back to 100% and remove the guides: View > Clear Guides.

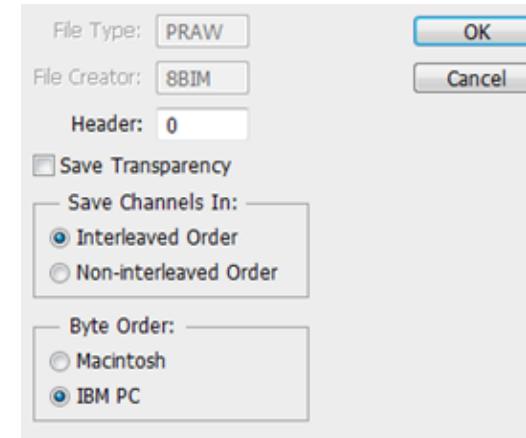


16. Save one RAW file for each independent tile. To do this, turn off all layers except the tile to be saved and the background layer.



17. File > Save As... > save as the corresponding tile name (eg. 1A) and as a RAW file. Repeat this operation for each tile.

Save Channels In: Interleaved order
Byte Order: IBM PC



18. Finally, save the Photoshop as eg. [name of work]_progress2.psb
All tiles are now ready to import into the Blending application.

Note: in order to avoid height distortion when working with Lucida reliefs in Photoshop, load the "Lucida_depthMaps_linearity.csf" colour profile. This colour profile is provided with the Lucida software distribution. To load the colour profile:

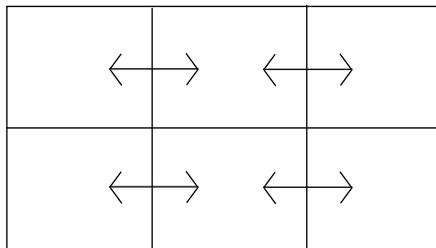
- Select Edit -> Colour Adjustment.
- A dialogue window will appear.
- Select 'Load'.
- Find the 'Lucida_depthMaps_linearity.csf' file.
- Click 'Ok'.

From now on the linear colour profile will be selected by default.

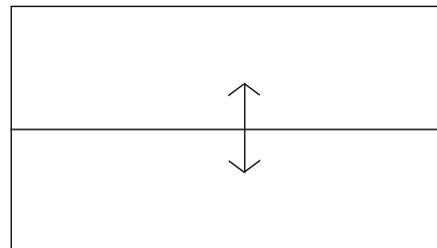
Blending tiles

The Lucida Blending application blends the tiles by aligning them along the Z-axis. Usually, the tiles are first blended horizontally in terms of each row. The resulting rows are then blended vertically to create a complete 3D file. The order of blending may vary depending on the nature of the project.

Horizontal blending



Vertical blending



Both the Horizontal Blending app and Vertical Blending app can load and save only RIS files with a canvas size of 17000 x 9602 px. Make sure all RIS files are loaded from, and saved to, a local hard drive.

Horizontal Blending application

01. Open the Horizontal Blending application: BlendingApp64bits.exe
02. The message 'Please load the first file' will appear. Navigate to the correct folder and load tile1A.
03. When prompted load tile 1B.

Note: the overlap amount must fall comfortably within the 10-25 mm range (in this example: 13.6 mm). If the value is out of range it means there is a problem with the preparation of the files in Photoshop. If this is the case, go back to the Photoshop file and review the overlap.

```
Overlap was: 13.6mm
Number of merged tiles: 2

Press 's' to save and exit
Press 'x' to exit
Press any other key to merge another tile
```

04. Press any key except 's' and 'x' and load 1C, the last horizontal tile to complete row 1.

05. When all horizontal tiles have been blended for this row press 's' and save as '1.raw'. The saved file should be in RAW format, although this will not be an option on the computer. This must be manually inputted by adding 'File_Name.raw'.

06. Repeat this process for row 2 (tiles 2A, 2B and 2C) and save the row as '2.raw'.

Vertical Blending application

07. Blend the two rows using the Vertical Blending Application:

23000Blend2Rows.exe

08. Open the Application and load '1.raw' into the App. When asked, load '2.raw'.

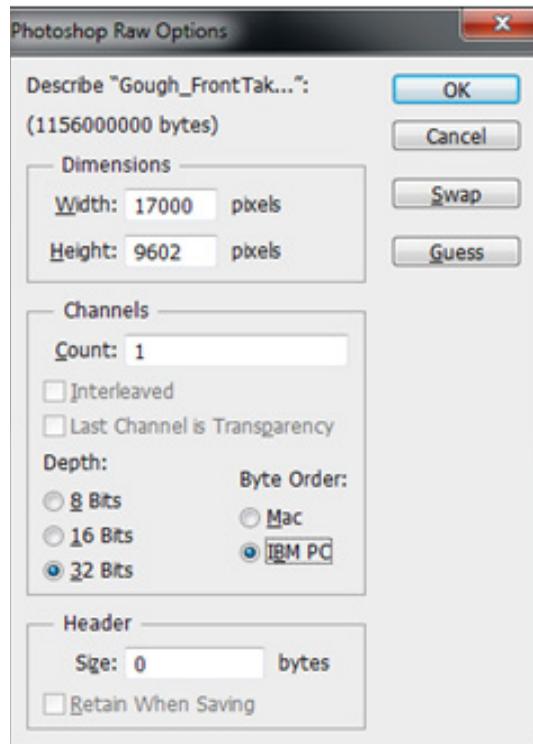
```
Overlap was: 14.6mm
Number of merged rows: 2

Press 's' to save and exit
Press 'x' to exit
Press any other key to merge a new row
```

Note: again, the overlap must be between 10 and 25 mm. In this case 14.6 mm means the files have been successfully blended.

09. Press 's' and be sure to add '.raw' to the end of the file name.

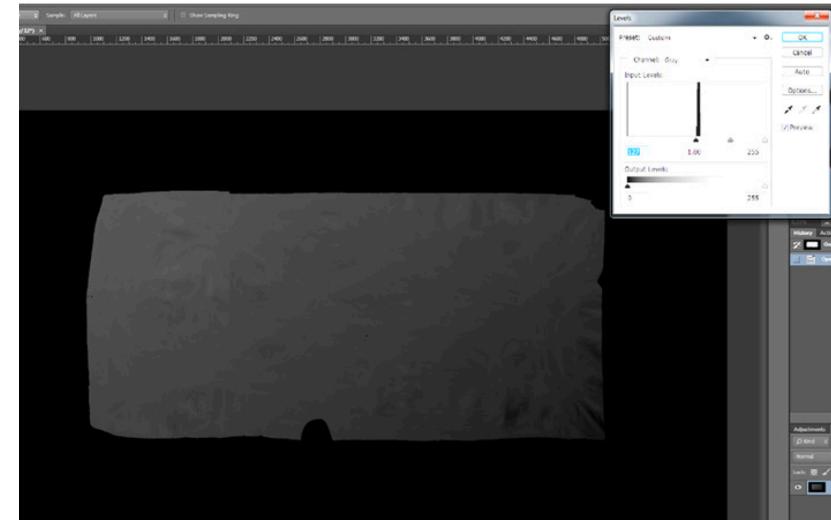
10. Open the final RAW file in Photoshop. Photoshop will not recognize the file as is. In order to open the file, alter the following parameters in the Photoshop Raw Options tab:



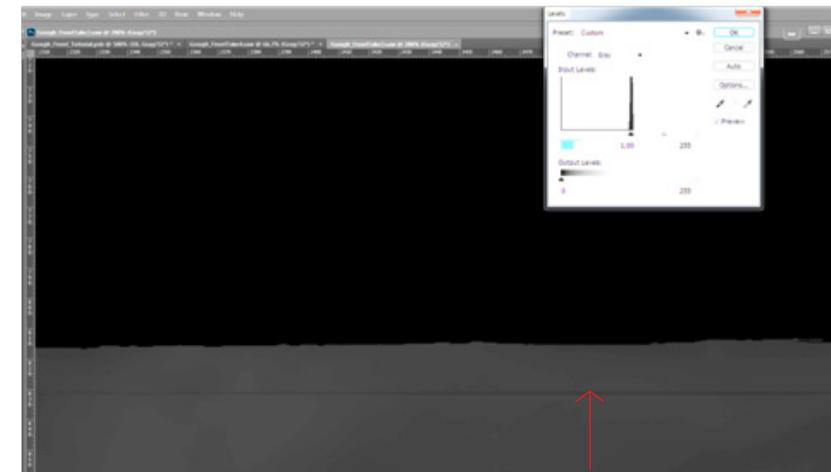
Width: 17000 pixels
Height: 9602 pixels
Depth: 32 bits
Byte Order: IBM PC
> OK

Specified image is smaller
than file, open anyway?
> OK

11. Use the levels to check that there are no mistakes in blending. Go to Image > Adjustments > Levels. Move the black arrow on the left (under Input Levels) closer to the middle arrow and notice the change in levels of the image (see p. 12). By doing this you will be able to see the relief of the file. Important: do not save any changes.



12. Highlight the adjustment shadow input level number (box on far left) and zoom in close to the image. Use the mouse wheel to adjust the numerical value in the adjustment shadow input level box. Simultaneously adjust the levels and navigate across the image (especially the borders) in order to view any discrepancies.

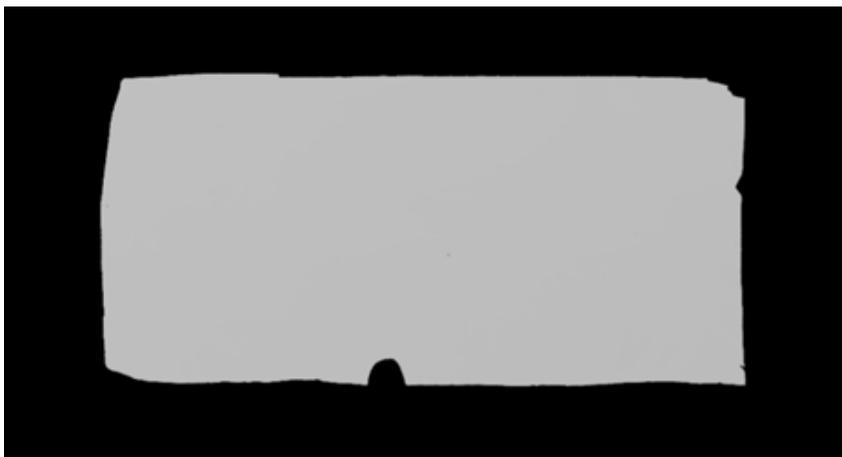


Note: the previous image shows that there was a problem with the blending procedure, indicated by the artifact (rigid line). When checking for discrepancies be sure to notice anything that seems out of character with the texture of the scanned surface, like features too uniform or straight, particularly along the edges. If problems are found, return to the preparation of the files in Photoshop and check that the overlapped borders have been evened out and that all the outlined parameters are met.

Saving as 32 bit TIF file

13. Once happy with the blending result, you have to save the file as a 32 bit TIF. Change the resolution back to 254 ppi before proceeding: Image > Image Size > Resample: Off (unchecked) > Resolution: 254 pixels/inch. Make sure the Color profile is set to Gray - Linear.

14. Save the file as: '[name of work]_3D_254ppi_32bit '. The result of the blended file will look like this:



Note: the 32 bit TIF depthmap file will contain all the information of the scanned data in the various gray levels. Nevertheless, most output methods will require the file to be converted to 16 bit TIF mode.

Saving as 16 bit TIF file

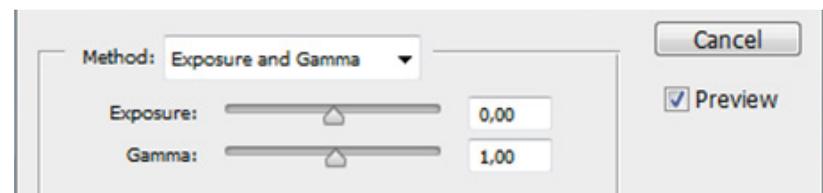
15. Go to Image > Mode > Change to 16 bit.

In the HDR Toning Window change the following parameters:

Preset: Custom

Method: Exposure and Gamma

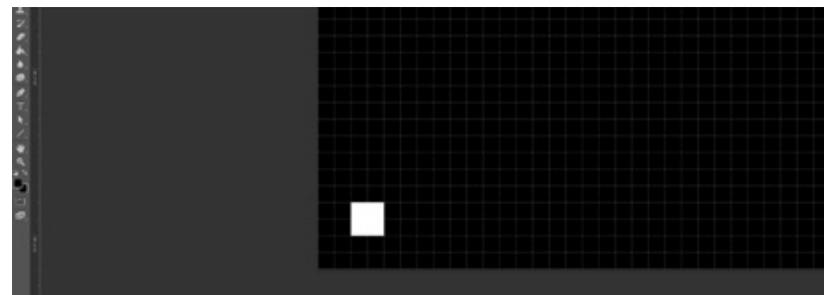
> OK



In order to rematerialize the 3D data (CNC routing, 3D printing, etc.) it is sometimes necessary to insert a tonal reference in the file. The depthmap information assigns a certain height to each gray value, according to the following scale: White = 0 mm; Black = 500 mm. All intermediate grey values will take this range as a reference. It is therefore necessary to include at least one black pixel and one white pixel to the file, in order to guarantee the real dimension of the data.

16. Zoom in until the pixels are apparent. Using the selection tool, select a few pixels on the background and Fill > Black.

17. Select a few pixels and Fill>White, always outside data.



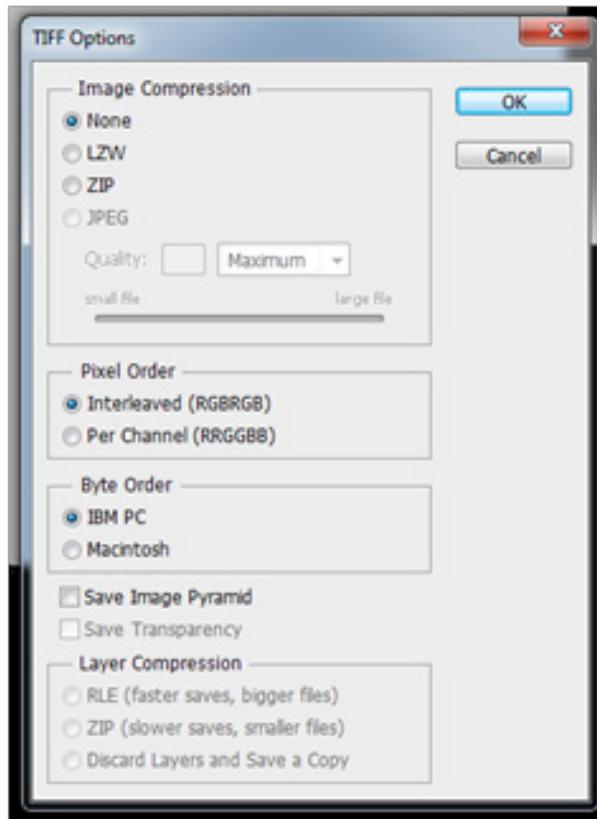
18. Save as a TIF file. When saving, name the image something along the lines of: '[name of work]_3D_254ppi_16bit_pixels'. Use these parameters when saving:

Image Compression: None

Pixel Order: Interleaved (RGBRGB)

Byte Order: IBM PC

> OK



19. Now the file is ready to be used in other 3D software that accepts 3D information as 16 bit TIF files, for different types of output.

Import into ArtCAM

This section explains how to import Lucida reliefs into ArtCAM, an Autodesk software that can be used to edit 3D files in preparation for CNC milling. This tutorial has been written for Artcam 2012 Pro and Photoshop CS6, but similar tools will be available in other versions.

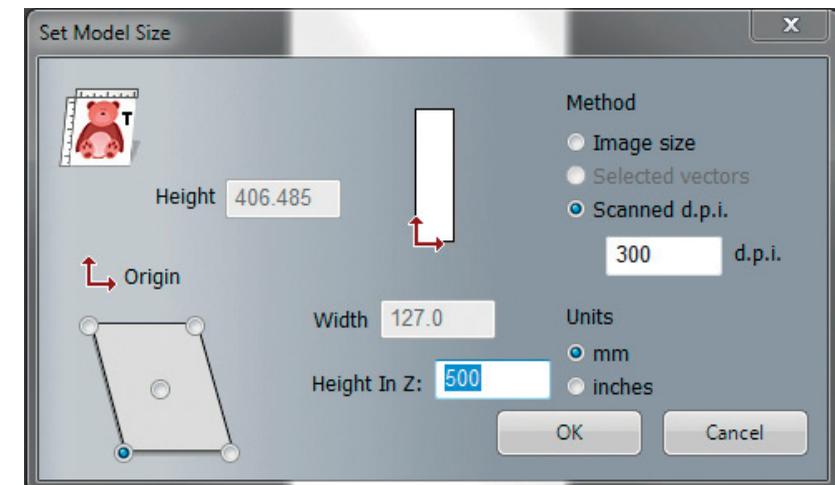
01. Open the Artcam software

02. Select File > New > From Image File

03. A dialogue window with the dimensions of the relief will appear.

Set the 'Height in Z' field to 500 mm.

Note: ArtCAM will measure the different depths of the grey scale image using the 500 mm scale: pure black will mark the lowermost and pure white the uppermost points in the scale.



04. Press 'OK' to finish importing the file.

Contact us

Support

factum@factum-arte.com

If you ever need help with your Lucida, email the address above. To help us understand the problem it is very helpful to include pictures or a video as attachments with your email.

You can also telephone us: +34 915 500 978

Feedback

factum@factum-arte.com

For general questions or for your comments and ideas send an email to the address above.

For more information

www.factum-arte.com

www.factumfoundation.org

Resources

Lucida user's manuals can be downloaded from Factum Arte's website:

Assembly Instructions

factum-arte.com/lib/kcfinder/upload/files/Lucida/manuals/2015_Lucida_A5_Assembly_Final.pdf

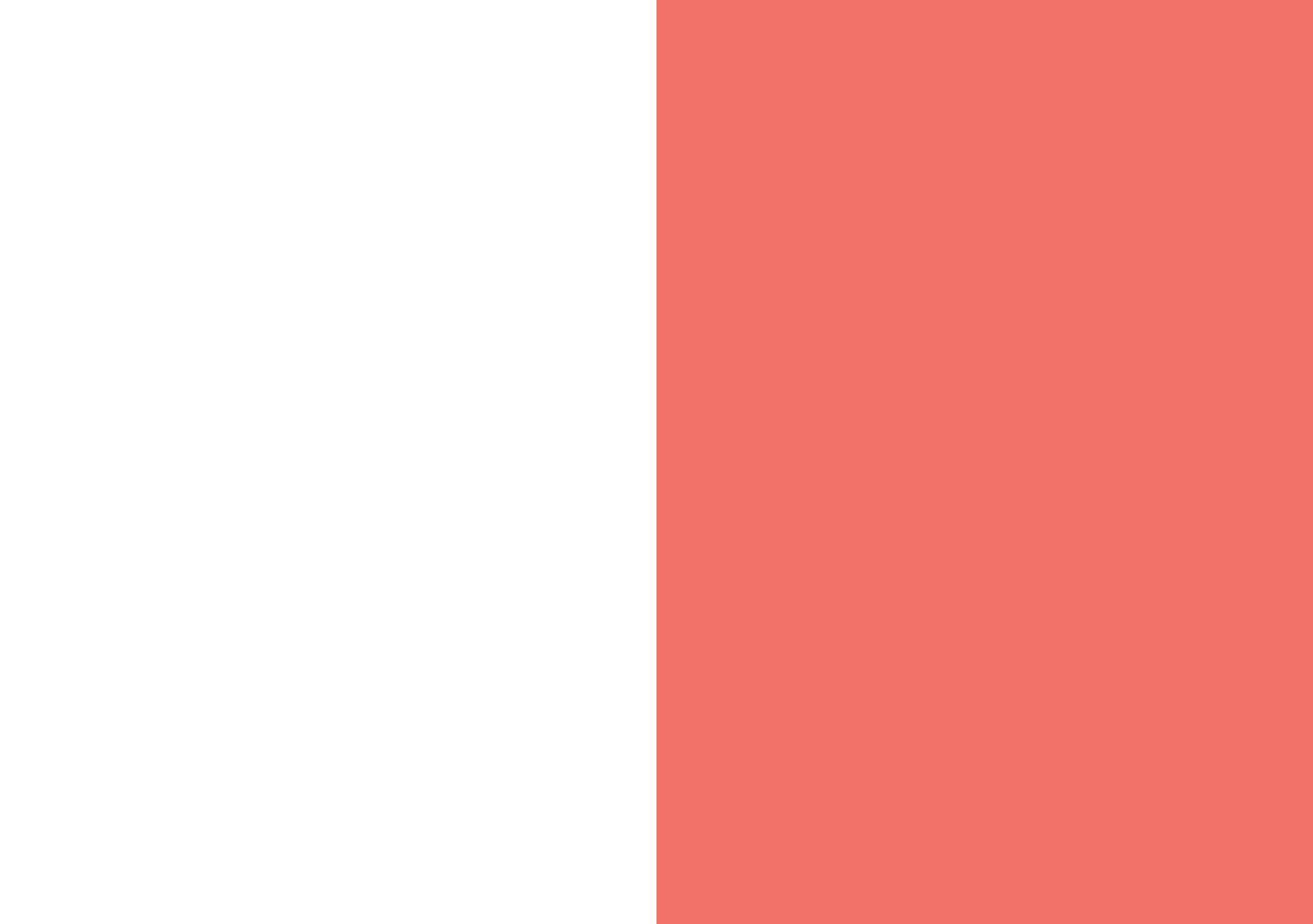
<https://vimeo.com/8261186> (password: factum53)

Operator's manual

factum-arte.com/lib/kcfinder/upload/files/Lucida/manuals/2015_Lucida_A5_Operator_Final.pdf

Processing applications

factum-arte.com/lib/kcfinder/upload/files/Lucida/manuals/2017_Lucida_A5_processing_Final.pdf



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