

Aracne

Version 4.3.15

A Software Tool for Thread Counting in Fabrics of Canvases

User manual

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In collaboration with the Museo Nacional del Prado

2026

Aracne 4.3.15. User manual

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Preface

This software was born as a collaboration with the Museo Nacional del Prado to develop a tool to count threads in X-ray images of canvases. The main objective was to count the vertical and horizontal threads along large areas of an X-ray image. Aracne goes beyond this request and provides:

- Thread counting along the whole image or a selected area, for every spot of the canvas, displayed as colour density maps.
- The angle deviation of the threads from the vertical and horizontal axes, also as maps.
- Histograms and statistics (mode, mean and standard deviation) of the densities, and the power spectral density of the fabric.
- The possibility to compare canvases not only through their average counts but also through the values of the counts along the width and height of the paintings.

Version 4 is a complete rewrite of the program with a new interface. It works with very large images (more than a gigabyte), accepts grayscale, colour and 16-bit images, lets the user analyse rectangular or polygonal areas, shows the results over the original image, and saves projects and results safely. It runs on Microsoft Windows and macOS. This manual describes version 4.3.15.

The software is still under development. Any feedback is welcome; please write to murillo@us.es.

1. Installation

Aracne is distributed as a standalone application for Microsoft Windows (64-bit, Windows 10 or 11) and for macOS (Apple silicon). It runs on the free MATLAB Runtime, release R2026a, so MATLAB itself is not needed.

1.1. Installing

1. Download the installer for your system: `AracneInstaller.exe` (Windows) or `AracneInstaller.app` (macOS).
2. Run it and follow the steps. If the MATLAB Runtime R2026a is not yet installed on the computer, the installer downloads and installs it (an Internet connection is needed; it is a large download, done only once). If the installer closes while downloading the Runtime, which happens with some recent versions of macOS, install the Runtime by hand (see the box below) and then run the Aracne installer again.
3. Start Aracne from the Start menu (Windows) or from the Applications folder (macOS).

The **first** start after installing Aracne or the MATLAB Runtime can take several minutes, without any window: the system checks the new Runtime files and Aracne prepares itself. Wait for it and do not start it again meanwhile. The following starts take a few seconds.

Important: the MATLAB Runtime must be release R2026a, **Update 5 or later**. With an older update (or another release) the program does not start: its icon appears for a moment and disappears. If you install it by hand, download it from `https://www.mathworks.com/products/compiler/matlab-runtime.html` and choose release R2026a, the latest update, for your operating system.

On macOS, the first time the program is opened the system may say that it cannot verify the developer. In that case open it with a right click (or Control-click) on the application and Open, or allow it in System Settings > Privacy & Security.

1.2. Memory

The image is kept in memory while it is analysed. A typical X-ray (a few hundred megabytes) works on any current computer. Images of more than a gigabyte can be loaded, but analysing the whole of such an image needs several more gigabytes of free memory. If

the memory runs out, Aracne says so and keeps the previous results (see Appendix B); in that case analyse a smaller area.

2. A quick start

A complete analysis consists of loading the image, selecting the area to process (or the whole image), setting the parameters, running the thread counting, looking at the results and saving them. In this chapter we go through these steps in the simplest way: we load an image, select an area, keep the default parameters, count the threads and look at the results. The following chapters explain each step in more detail.

2.1. Opening the tool

After starting Aracne we get the window in Figure 2.1. From top to bottom it has the menus (File, Region, Parameters, View and About), a toolbar with shortcuts to the most used menu options (Table 2.1), and three tabs: Original image panel, where the loaded image and the selected area are shown; Thread counting, with the density and angle maps, the histograms and the statistics; and Power spectral density. Buttons are greyed out until they can be used: for instance, becomes available once an area has been selected.

Figure 2.1.: Aracne just after opening it

2.2. Loading an image

Click  or use File > Load image, and choose the file. Figure 2.2 shows the result for the example image `MNP_P07905.tif`, an X-ray of a canvas of about 38×29 cm, which we

Table 2.1.: Toolbar buttons, from left to right, and the equivalent menu option

Button	Menu option and description
Load image	File > Load image. Opens an image (Section 2.2).
Load project	File > Load project. Opens a saved project (Section 4.1.2).
Save project	File > Save project (Section 4.1.1).
Save images	File > Save images: the result images (Section 4.2).
Select zone	Region > Rectangular area (Section 2.3).
Count threads	Runs the thread counting on the selected area (Section 2.4).
Invert gray	View > Invert gray (Section 3.2.2).
Show grid	View > Show grid (Section 3.2.3).
Overlap	View > Overlap: results over the image (Section 3.1.1).
Clear all	Clears the image and the results (Section 4.3).

use in the rest of this manual. An X-ray is the usual input, but a photograph of the fabric can be used as well.

The usual formats are accepted (TIFF, PNG, JPEG, BMP…). Colour images are converted to gray, and 12- or 16-bit images are converted to 8 bits using their whole range of gray levels. What matters is the *resolution*, i.e., the number of pixels per centimetre or per inch, which Aracne needs to give the densities in threads per centimetre:

- If the file stores its resolution, it is used. Otherwise Aracne asks for it, in pixels per cm. If the unit of the resolution is not known, it asks whether it is in inches or in centimetres.
- Images with less than 50 pixels per cm cannot be analysed.

Appendix A shows the information stored in a typical X-ray file. If an image or a project is already open, Aracne asks before replacing it.

Very large images are shown at a reduced size, so the program stays responsive. When you zoom in (Section 3.2.1) the detail is redrawn progressively, down to the original pixels.

2.3. Selecting the area to process

Aracne processes an area of the image or the whole of it. The options are in the Region menu:

Analyze full image selects the entire image (Figure 2.5).

Rectangular area (also): click and drag on the image to draw a rectangle (Figure 2.3). It can then be adjusted by dragging its sides and corners, or moved by dragging it. To confirm, **double-click inside** the rectangle.

Custom area selects a polygon: click on each vertex and double-click to close the polygon; then double-click inside it to confirm (Figure 2.6). Only the inside of the polygon is analysed.

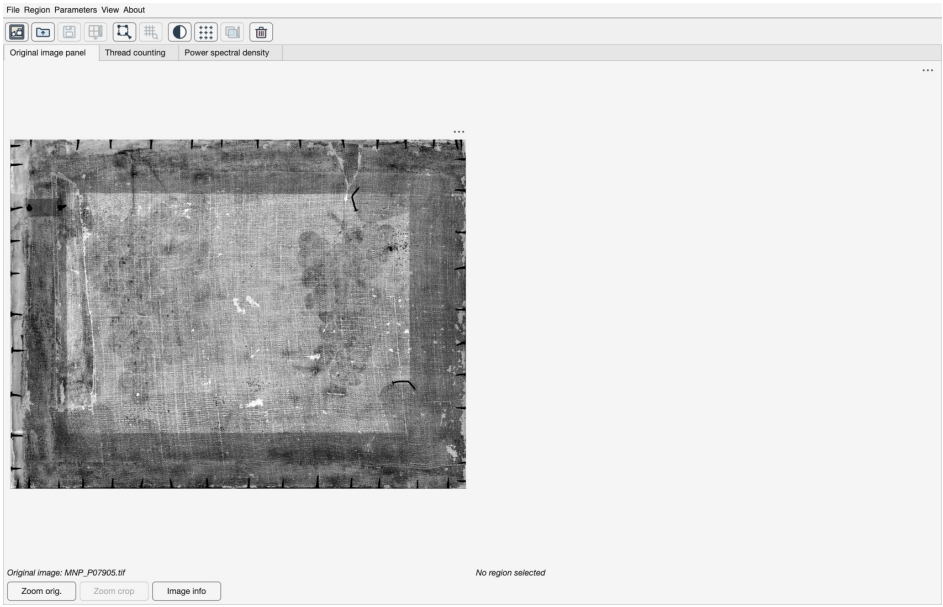


Figure 2.2.: The example image loaded

While you are selecting, the instructions are shown below the image. **Esc** cancels the selection at any moment (while drawing, or before confirming), and the previous selection is kept.

Once confirmed, the selected area is shaded in blue on the image and shown on the right of the panel (Figure 2.4). You may select another area at any time. In the following we work on the rectangle of 15×12 cm in Figure 2.4.

2.4. Running the thread counting

To run the algorithm with the default parameters just click . The analysis has up to three stages, each with its progress bar, shown inside the Aracne window: Preliminary analysis (a quick pass that estimates the thread densities to adapt the pre-processing), Pre-processing and Xcounting (the counting itself, with an estimate of the remaining time). Each one has a [Cancel] button: cancelling stops the count and leaves everything as it was before, including any previous results. While the count runs, the other buttons do nothing.

If the preliminary pass finds that the image is very uniform, Aracne may ask whether to pre-process it anyway; the usual answer is [Process] (see Section 5.3).

At the end, the Thread counting tab is shown with the results (Figure 2.7). It has three areas:

- On the left, four tabs with colour maps: Vertical density and Horizontal density, the thread counts of the vertical and the horizontal threads in threads/cm, and Vertical

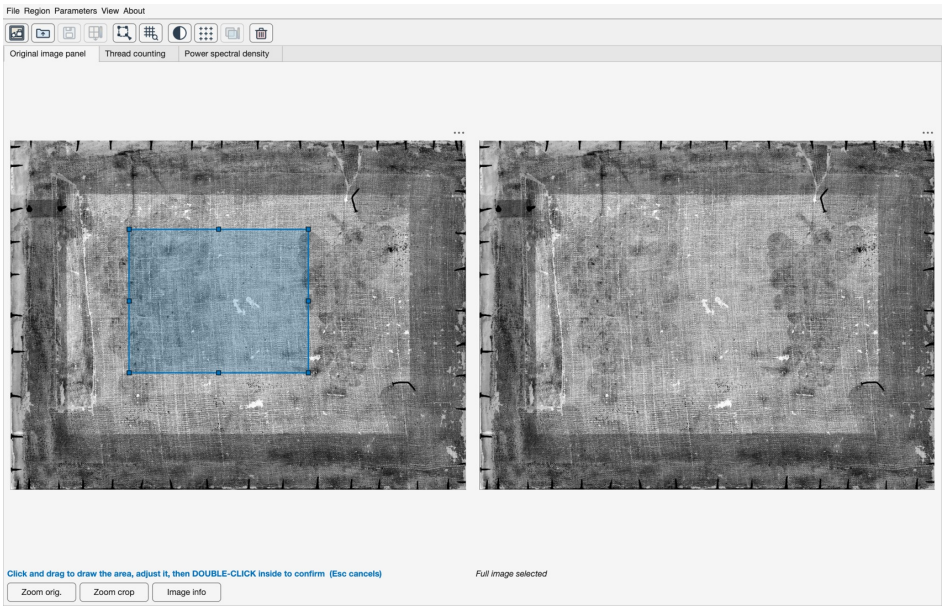


Figure 2.3.: Drawing a rectangular area. The instructions are shown below the image

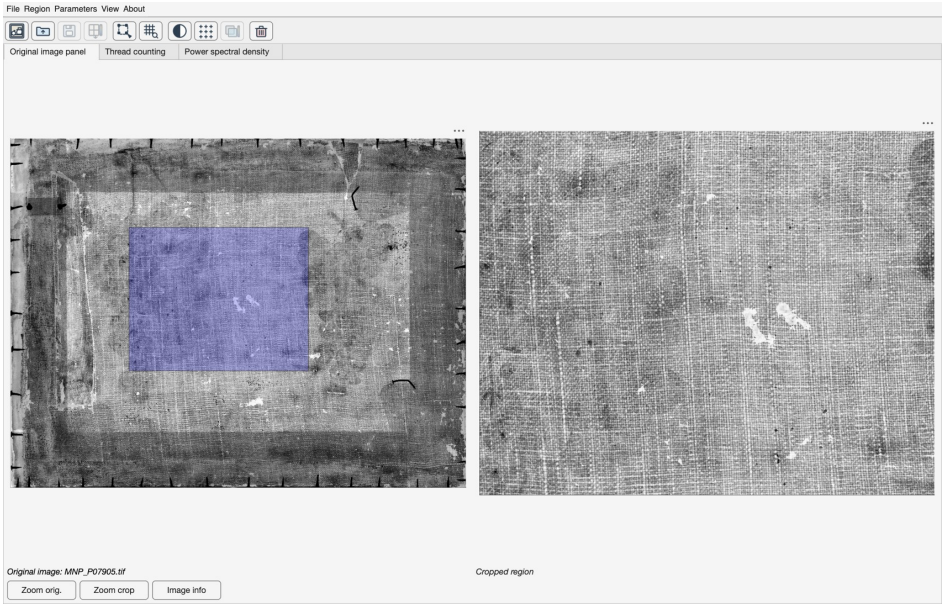


Figure 2.4.: The selected area, shaded in blue on the left and shown on the right

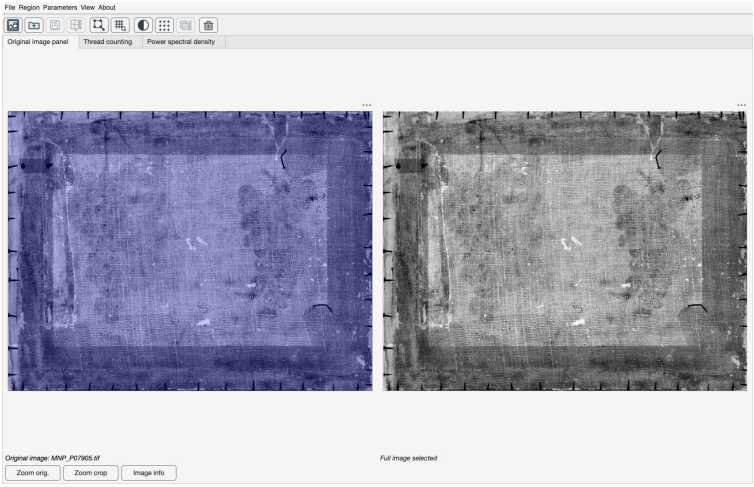


Figure 2.5.: The whole image selected

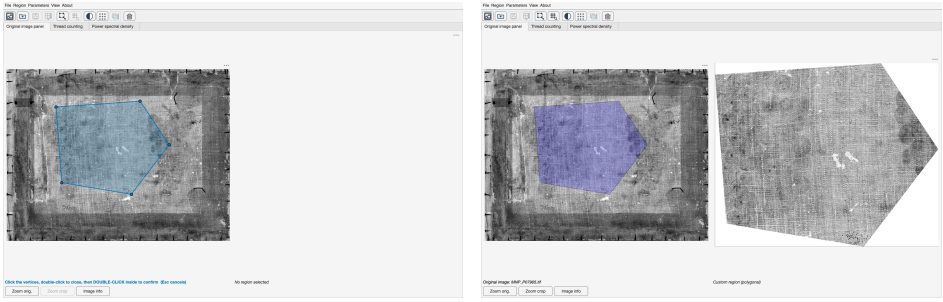


Figure 2.6.: A custom (polygonal) area: while it is being drawn (left) and once confirmed (right)

deviation and Horizontal deviation, the angle of the threads (Figure 2.8). The colour bar translates the colours into values. Each pixel of a map results from the analysis of a square window around it, 1 cm wide by default (Chapter 5). The deviation is measured from the vertical for the vertical threads and from the horizontal for the horizontal ones, in degrees. As for polar angles, a positive value means that the threads are turned *anticlockwise* as seen on the screen. The axes are in centimetres, from the top left corner of the selected area.

- On the upper right, the histograms of the vertical and horizontal densities: how many times each density value is found in the area.
- Below them, the statistics of the counts: mode, mean and standard deviation, for the vertical and the horizontal threads, together with the resolution of the image (px/cm) and the width and height of the area. Under the statistics are the ranges used for the colour scales and the histograms (Section 3.1.2).

The [Zoom] button under each map opens it in its own window.

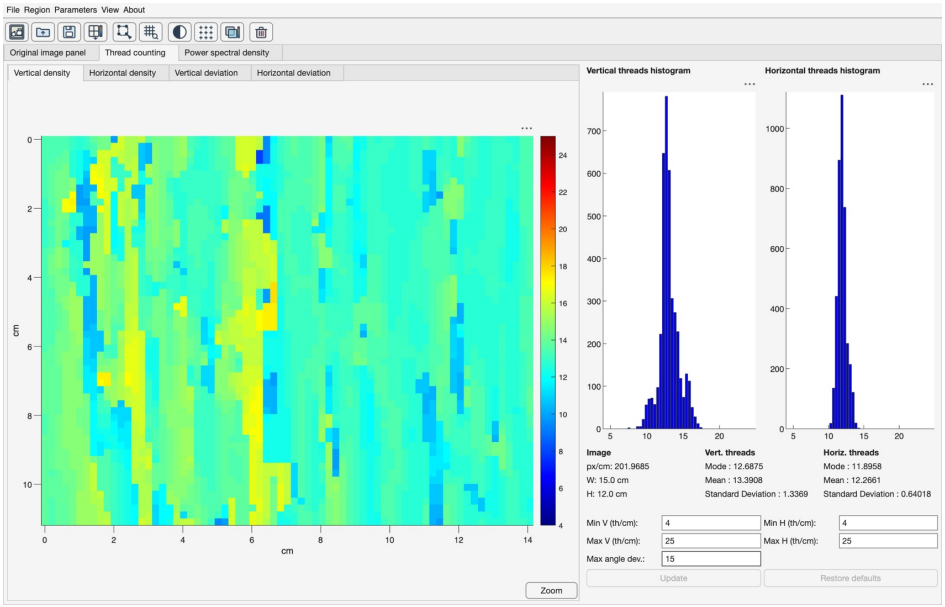


Figure 2.7.: Results of the thread counting for the selected area: the vertical density map, the histograms and the statistics

To see where each value lies on the canvas, turn on (Section 3.1.1).

2.4.1. The power spectral density

The tab Power spectral density (Figure 2.9) shows the average power spectral density (PSD) of the area, as contour lines on the left and as a 3D mesh on the right. The axes are

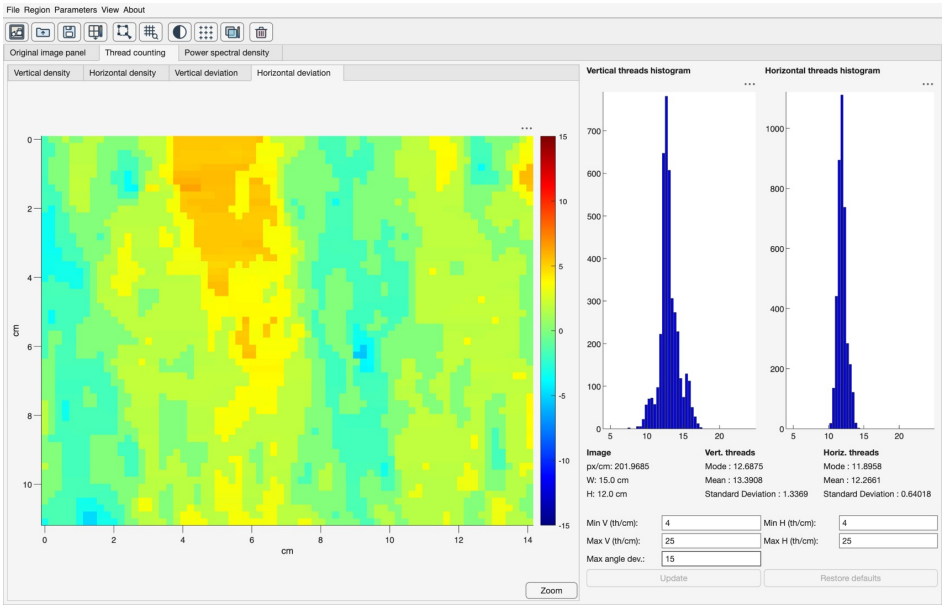


Figure 2.8.: The angle deviation of the horizontal threads

in threads/cm. The maxima on the horizontal and vertical axes correspond to the densities of the vertical and the horizontal threads; other maxima reveal the weave. The table at the bottom left lists the main maxima found, with their position (V and H, in threads/cm) and their value. The controls of this tab are described in Section 3.1.4.

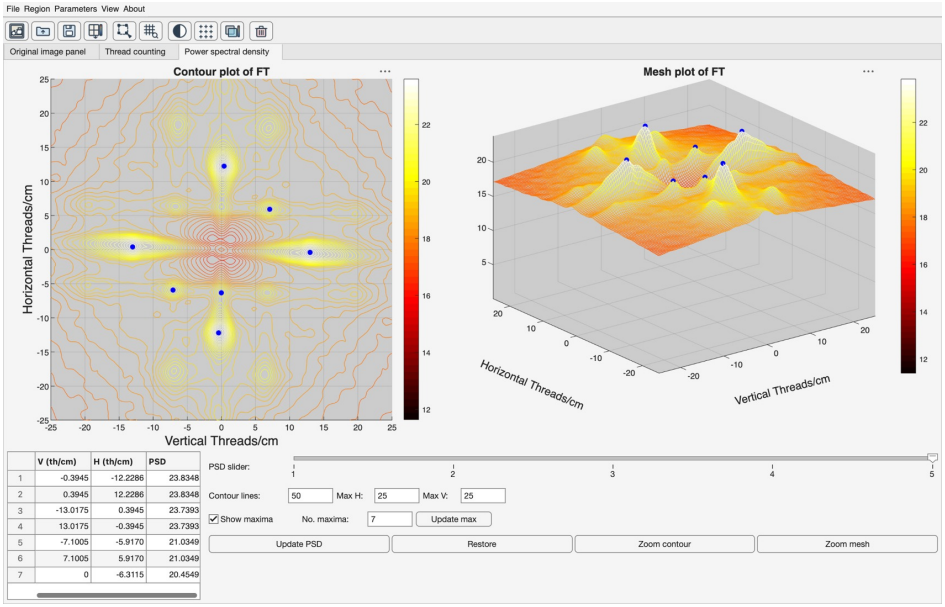


Figure 2.9.: The power spectral density of the selected area, as contour lines (left) and as a mesh (right), with the maxima found

3. Visualization options

Several options help to look at the results and at the loaded image. They do not change the analysis: they can be used at any time after it, and the results are not recomputed.

3.1. Visualization of the results

3.1.1. Overlapping the results and the original image

To locate the result of the thread counting or of the angle deviation within the canvas, click or use View > Overlap after the count. The colour maps are then drawn with transparency on top of the selected area of the original image (Figure 3.1); every coloured pixel covers the window of the canvas used to compute its value. Zooming into an overlapped map also sharpens the image below. Click the button again to go back to the plain maps.

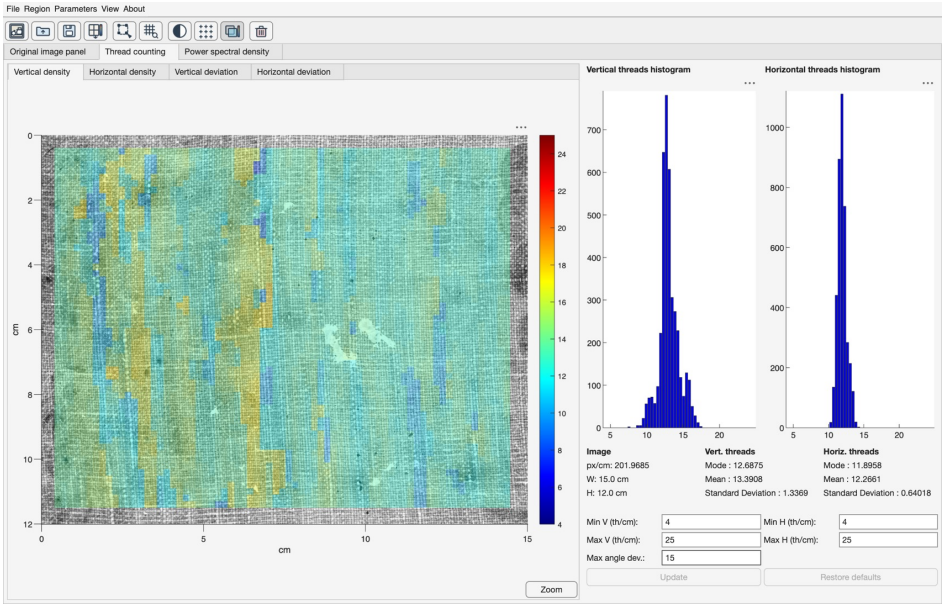


Figure 3.1.: The vertical density overlapped on the selected area of the original image

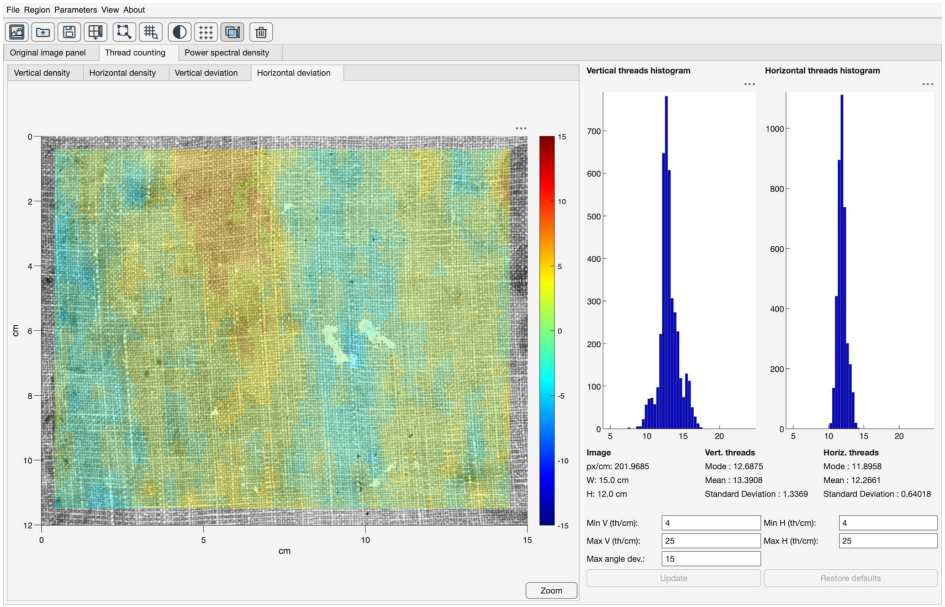


Figure 3.2.: The angle deviation of the horizontal threads overlapped on the original image

3.1.2. Ranges of the maps and the histograms

Under the statistics in the Thread counting tab (Figure 2.7) there are some fields with the ranges used to display the results:

Min V, Max V the range, in threads/cm, of the vertical threads: the limits of the colour scale of the Vertical density map and of the x-axis of its histogram.

Min H, Max H the same for the horizontal threads.

Max angle dev. the limit, in degrees, of the colour scale of the two deviation maps (from −value to +value).

After a count they are set to 4–25 threads/cm and 15 degrees (the upper density limit is the Default display max. freq. parameter, Chapter 5). Type new values and click [Update]. In the example of Figure 2.7, a range of 10–16 threads/cm shows the histograms in more detail. The mode, mean and standard deviation are recomputed using only the values within the range, so outliers can be left out of the statistics. [Restore defaults] goes back to the initial values.

These ranges only affect the display and the statistics. The densities that the algorithm searches for are set by the minimum and maximum frequencies in the parameters (Chapter 5).

3.1.3. Zooming into the maps

Each map can be zoomed and panned with the axes toolbar that appears at the top right corner of the map when the mouse is over it (zoom in, zoom out, pan and restore view). The [Zoom] button under the map opens it in its own window, which can be enlarged to the whole screen.

3.1.4. Power spectral density options

The tab Power spectral density (Figure 2.9) has these controls:

PSD slider The average PSD is accumulated while the area is processed, from top to bottom. The slider shows the PSD averaged over the first part of the area only; its last position, the default, is the PSD of the whole area. Comparing positions shows whether the fabric changes along the canvas.

Contour lines number of contour lines of the left plot.

Max V, Max H range, in threads/cm, of the axes of both plots: Max V for the axis of the vertical threads (the horizontal axis of the plots), Max H for that of the horizontal threads.

Update PSD redraws the plots with the values typed above; [Restore] goes back to the defaults.

Show maxima, No. maxima, Update max show or hide the maxima found (blue dots) and choose how many of them are found and listed in the table.

Zoom contour, Zoom mesh open each plot in its own window.

3.2. Visualization of the original image

These tools act on the original image and on the selected area, in the Original image panel.

3.2.1. Zoom

Both images can be zoomed and panned with their axes toolbar, at the top right corner of each image (zoom in, zoom out, pan and restore view). The detail is redrawn as you zoom, down to the original pixels, even for very large images. *Restore view* goes back to the whole image.

The buttons [Zoom orig.] and [Zoom crop], below the images, open the original image and the selected area in their own windows, at full screen size. Figure 3.3 shows such a window zoomed into a detail of the fabric.

3.2.2. Invert gray levels

The threads may be easier to see with the gray levels inverted. Click ◐ or use View > Invert gray (Figure 3.4); click again to go back. Only the display changes: the analysis is the same.

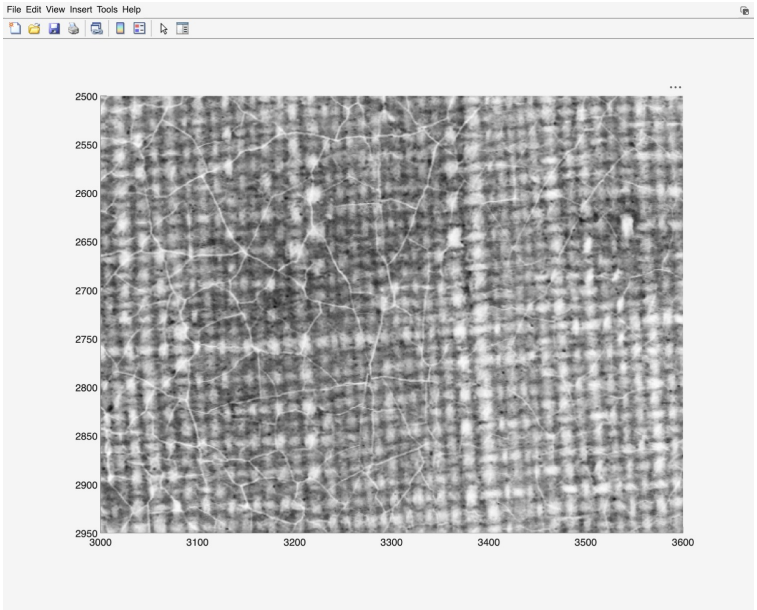


Figure 3.3.: The [Zoom orig.] window, zoomed into a detail of the fabric (axes in pixels)

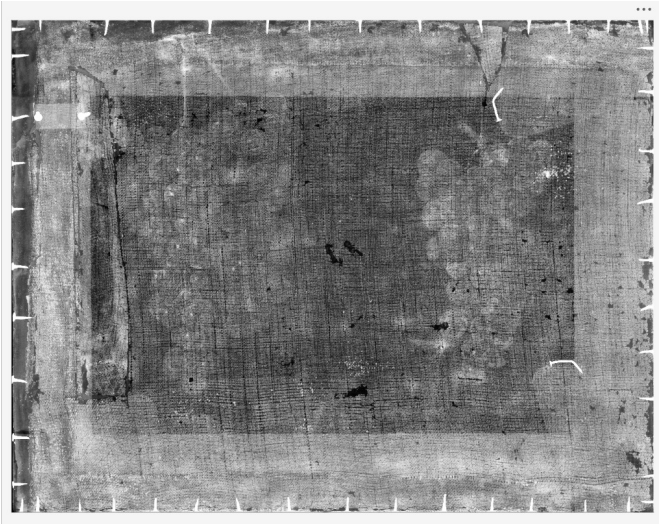


Figure 3.4.: The loaded image with the gray levels inverted

3.2.3. Grid

A grid can be drawn over the original image and the selected area, for instance to count threads by visual inspection. Click or use View > Show grid. A small window asks for the separation of the grid, in centimetres, and its style (Figure 3.5): Crosses, a red cross at every node (Figure 3.6), or Lines, a full red grid (Figure 3.7). Click the button again to remove it. The grid is saved with the project.

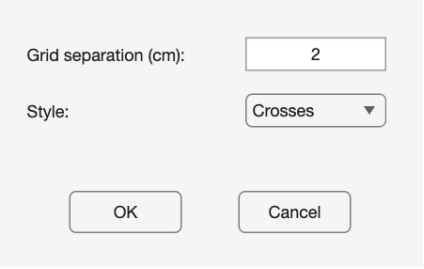


Figure 3.5.: Separation and style of the grid

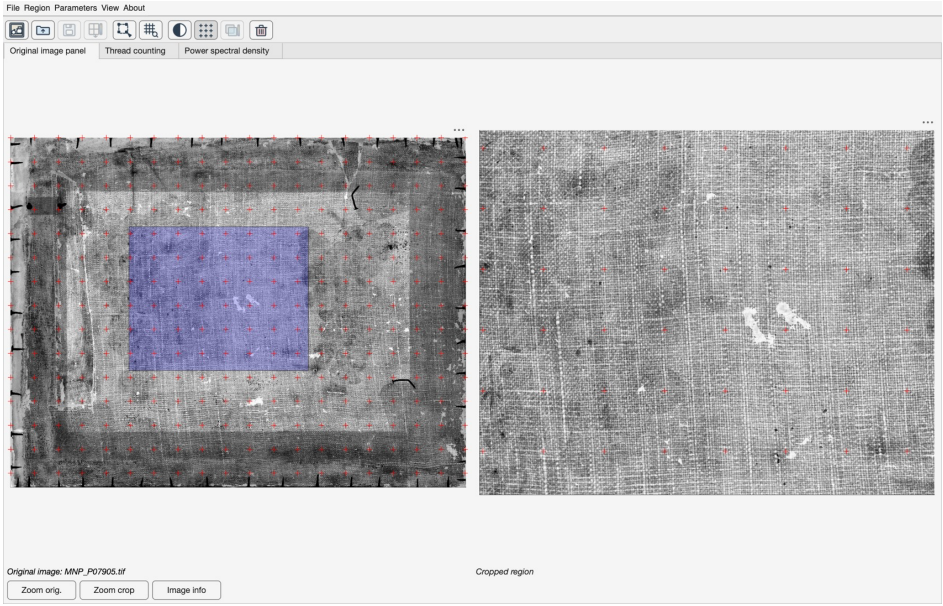


Figure 3.6.: A grid of crosses every 2 cm

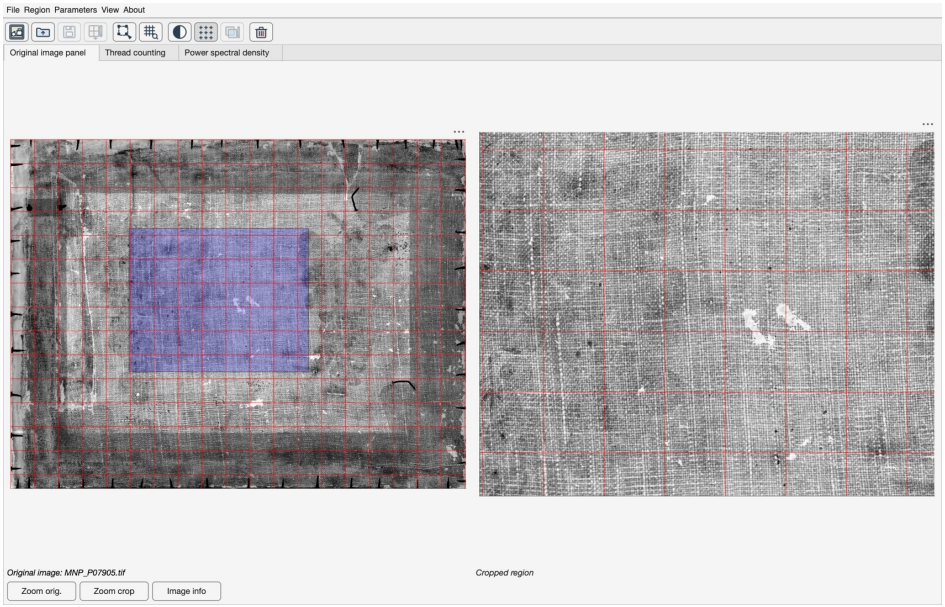


Figure 3.7.: A grid of lines every 2 cm

3.2.4. Image properties

The button [Image info], below the images, shows the information stored in the image file: size in pixels, bit depth, colour type, resolution and its unit, etc. (Figure 3.8). Appendix A explains the fields Aracne uses.

Attribute	Value
FileSize	45330404
Format	tif
FormatVersion	[]
Width	7688
Height	5893
BitDepth	8
ColorType	grayscale
FormatSignature	[73 73 42 0]
ByteOrder	little-endian
NewSubFileType	0
BitsPerSample	8
Compression	Uncompressed
PhotometricInterpretation	BlackIsZero
StripOffsets	24974
SamplesPerPixel	1
RowsPerStrip	5893
StripByteCounts	45305384
XResolution	513
YResolution	513
ResolutionUnit	Inch
Colormap	[]
PlanarConfiguration	Chunky

Figure 3.8.: Information stored in the image file (first fields)

4. Saving results and projects

Once the threads have been counted, one may wish to keep the results and the configuration used. Aracne saves them as a *project*, which can be opened again later, and can also save the result images.

4.1. Projects

A project gathers everything about the analysis of an image: where the image is, the selected area, the parameters used, the results and the display options (ranges, PSD options, grid). The image itself is not copied into the project, to save space: the project stores its location and its size.

4.1.1. Saving a project

Click  or use File > Save project, and choose the folder and the name. The name proposed is the name of the image with the prefix `Aracne_`; you may change it. Three files are written, all starting with that name:

`.mat` the project itself, to be opened again with Aracne. It cannot be opened with other programs.

`.txt` the main numeric results in plain text (Section 4.1.3).

`_Parameters.csv` the parameters used, which can also be loaded into the parameters dialog (Section 5.4).

Several projects can be kept in the same folder, as long as their names are different. If any of the files already exists, Aracne lists them and asks once: [Overwrite], [Change name] (back to the file dialog, to type another name) or [Cancel]. The files are written first to a temporary folder and moved into place only when all of them are complete, so an error while saving never leaves a half-written project nor destroys the previous files.

The project keeps the parameters *used for the results*. If you change the parameters after a count, Aracne reminds you that the results shown were computed with the previous ones until you count again.

4.1.2. Loading a project

Click  or use File > Load project and select the `.mat` file. Aracne returns to the state it was in when the project was saved: the image, the selected area, the results and the display options.

If the image is no longer where it was (for instance, the project and the image were copied to another computer), Aracne asks you to locate it. The image may have another name or be in another folder: it is recognised by its size in pixels. Projects saved with earlier versions of Aracne can also be opened; missing information is completed with the default values.

4.1.3. The plain text file

Opening a whole project just to look up, say, the mode of the densities can be cumbersome. The `.txt` file holds the main numeric results, as lines of the form "name, value" that can be read with any text editor or imported into a spreadsheet such as Microsoft Excel (accept the default import options). Table 4.1 shows the first fields for the area analysed in Chapter 2. After them, the file lists the bins and values of both histograms, exactly as shown on the screen, which is useful to plot them with other programs, and the maxima of the PSD shown (with the position of the PSD slider).

Table 4.1.: First fields of the text file for the area analysed in Chapter 2

Field	Value
Image name	MNP_P07905.tif
Whole image	No
Min row – Max row	1500 – 3924
Min column – Max column	2000 – 5030
Pixels per cm	201.97
Width (cm)	15.00
Height (cm)	12.00
Vertical threads Mode / Mean / Deviation	12.69 / 13.39 / 1.34
min – max vertical values	4.00 – 25.00
Horizontal threads Mode / Mean / Deviation	11.90 / 12.27 / 0.64
min – max horizontal values	4.00 – 25.00
Scale FFT	4
Shift Fraction	0.20
Number of windows	1.00
Rotation angle	0.00
Maximum deviation angle (degrees)	25.00
Type of window	hamming

The statistics are those shown in the Thread counting tab, computed within the ranges shown there (Section 3.1.2); the ranges are written in the file. Number of windows is the side of the analysis window in centimetres (Chapter 5).

4.2. Saving the result images

To keep the images of the results, click  or use File > Save images. A small window asks for the file format (Figure 4.1) and for the units of the axes of the maps: pixels, centimetres

or inches. Then choose the folder and the base name (by default, `Aracne_` followed by the name of the image). The files saved are listed in Table 4.2; they all start with the base name. The maps are saved as they are shown: with on, overlapped on the image. As for projects, existing files are never overwritten without asking.

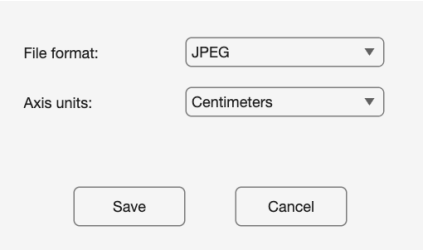


Figure 4.1.: Format and axis units of the saved images. JPEG and centimetres are proposed

Table 4.2.: Files written by Save images, after the base name

Name ending	Content
`_original`	The original image
`_selectedProcessedRegion`	The selected area
`_VerticalThreadsCount`	Density map of the vertical threads
`_HorizontalThreadsCount`	Density map of the horizontal threads
`_VerticalThreadsAngle`	Angle deviation map of the vertical threads
`_HorizontalThreadsAngle`	Angle deviation map of the horizontal threads
`_VerticalThreadsCountHist`	Histogram of the vertical threads
`_HorizontalThreadsCountHist`	Histogram of the horizontal threads
`_Contour, _Mesh`	The two plots of the power spectral density
`.txt, _Parameters.csv`	The text results and the parameters, as for a project
`scaled/`	A folder with TIFF versions of the maps (see below)

The folder `scaled` contains the four maps and the analysed area of the original image (`_OriginalScaled`) as TIFF files with one pixel per analysis window and no axes or colour bars. Their resolution is set so that, printed or placed in an image editor, they have the real size of the analysed area of the canvas. They are meant to be superimposed on other images of the painting.

4.3. Clearing and exiting

clears the image, the selection and the results, after confirmation, to start again. File > Exit, or closing the window, asks whether to save the project first.

During a session Aracne remembers the last folders used to open images, open and save projects, and import or export parameters, and the file dialogs start there.

5. Parameters

The parameters are important for a correct performance of the algorithm. To understand their effect one should first know how the algorithm works. We give an overview of it, with the parameters involved at each step, and then describe the parameters dialog.

5.1. Algorithm overview

Aracne centres a square window of side m cm on the image and computes, within it, the density and the angle deviation of the threads. The window is shifted $n \cdot m$ cm each time, horizontally and vertically, where the *shift fraction* n is a fraction of the side m. Each position of the window gives one coloured pixel of the result maps (Figure 2.7): the densities of the vertical and of the horizontal threads and their angle deviations.

Within each window the image is first pre-processed to equalise its contrast (Section 5.3), multiplied by a spectral window and transformed with a two-dimensional FFT of 128 p points, where p is the *FFT scale*. The FFT gives the power spectral density (PSD) of the window. The regular repetition of the vertical threads along the horizontal direction produces a maximum of the PSD on the horizontal frequency axis, at a distance from the origin equal to their density; the horizontal threads produce a maximum on the vertical axis.

The algorithm therefore searches for the maximum of the PSD near the horizontal axis, between a minimum and a maximum frequency, to estimate the vertical threads, and near the vertical axis for the horizontal threads. Since the threads of a canvas are rarely perfectly straight, the search is not restricted to the axes: it covers the directions up to $\pm\alpha$ degrees from them, the *maximum angle deviation*. The direction of the maximum found gives the angle deviation of the threads. If the whole canvas is tilted, the *rotation angle* β rotates the analysis before the search.

Finally, the PSD of all the windows are averaged to give the PSD of the area shown in the Power spectral density tab.

5.2. The parameters dialog

The parameters are set in Parameters > Change parameters (Figure 5.1). Parameters > Default goes back to the factory values; the menu shows a tick on the option in use. Table 5.1 lists the parameters with their default values and ranges, and they are discussed below.

FFT scale. The resolution of the thread counting, which can be seen as the width of the bars of the histograms, is $s/(128\,p)$ threads/cm, where s is the number of pixels per

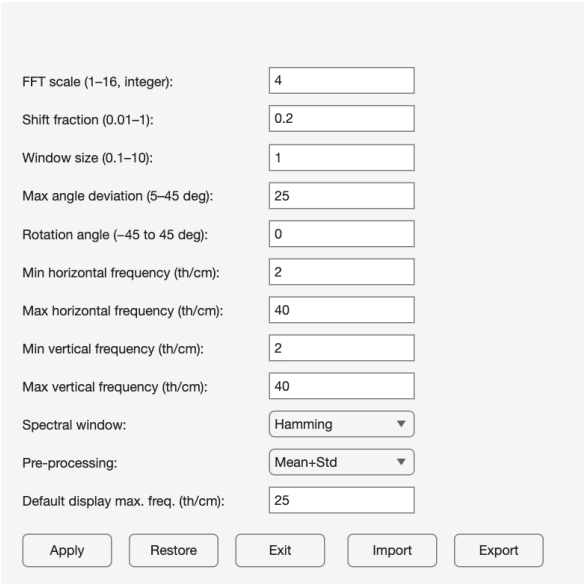


Figure 5.1.: The parameters dialog with the default values

Table 5.1.: Parameters, default values and ranges

Parameter (as in the dialog)	**Default**	**Range**
FFT scale (p)	4	integer 1 to 16
Shift fraction (n)	0.2	0.01 to 1
Window size (m, cm)	1	0.1 to 10
Max angle deviation (α, degrees)	25	5 to 45
Rotation angle (β, degrees)	0	−45 to 45
Min / Max horizontal frequency (th/cm): *vertical* threads	2 / 40	0 to 100
Min / Max vertical frequency (th/cm): *horizontal* threads	2 / 40	0 to 100
Spectral window	Hamming	see text
Pre-processing	Mean+Std	see text
Default display max. freq. (th/cm)	25	up to 100

centimetre of the image. For the example image, $s = 202$ and the default $p = 4$ give $202/512 \approx 0.39$ threads/cm. A larger p gives a finer resolution but takes longer. Powers of two are faster: 1, 2, 4, 8 or 16.

Shift fraction. Each step the window moves $n \cdot m$ cm. With the defaults the window moves 0.2 cm, so each pixel of the maps corresponds to 0.2 cm of the canvas. The maximum, 1, means that the windows do not overlap. A smaller value gives smoother and more detailed maps but takes longer.

Window size. The side of the analysis window, in centimetres. A larger window gives more reliable counts but less spatial detail. The window must fit within the selected area.

Max angle deviation. The range of directions, around each axis, where the maximum is searched (see the previous section).

Rotation angle. If the whole canvas is tilted, the analysis can be rotated to compensate it. Angles are positive *anticlockwise*, as in the deviation maps: if the threads are turned β degrees anticlockwise (the maps show about $+\beta$), enter β; if they are turned clockwise, enter a negative value.

Minimum and maximum frequencies. The range of densities, in threads/cm, where the maxima are searched. Note that these rows are named after the *frequency axis* where the maximum is searched: the horizontal frequency corresponds to the *vertical* threads and the vertical frequency to the *horizontal* threads. Values outside this range are regarded as meaningless: they correspond to windows where the counting could not be performed. The maximum must be below the highest frequency that the image can resolve, about half its number of pixels per cm; Aracne warns about it and, if needed, lowers it during the count. The ranges of the histograms shown after the count can be narrowed later without recomputing (Section 3.1.2).

Spectral window. The window applied before the FFT: Hamming (the default), Hann, Triangular, Rectangular or Blackman-Harris. Hamming is a good compromise for most images; windows such as Blackman-Harris reduce the leakage around strong maxima at the cost of wider peaks.

Pre-processing. See Section 5.3.

Default display max. freq. The upper limit of the density colour scales and of the axes of the PSD after a new count (Section 3.1.2). It only affects the display.

The buttons of the dialog are:

Apply checks the values and applies them. If any value is not valid, a message explains why and the field is highlighted; nothing is applied until all of them are correct.

Restore fills the fields with the factory values (they still have to be applied).

Exit closes the dialog without changing the parameters.

Import, Export see Section 5.4.

Important: if you change any value, do not forget to click [Apply]. Changing the parameters does not change the results already shown: count again to apply them.

Hint: for first trials you may use a low FFT scale and a high shift fraction, which are fast, and then lower the shift fraction and raise the FFT scale for the final counting.

5.3. Pre-processing

Pre-processing is a crucial step of the thread counting with frequency analysis: it equalises the brightness and the contrast across the image, so that the threads stand out everywhere. Its window is adapted to the thread densities estimated in the preliminary pass. The options are:

Mean+Std (default) local equalisation of the mean followed by the standard deviation.

Subtract mean local equalisation of the mean only.

Minvar like Mean+Std, but tries several sizes of the pre-processing window and keeps the one that gives the most uniform counts. It takes longer.

None no pre-processing.

CLAHE contrast-limited adaptive histogram equalisation, with tiles of about one thread period.

If the results are below expectations, try Subtract mean, None or Minvar.

5.4. Saving and loading parameters

[Export] saves the values in the dialog to a `.csv` file, and [Import] loads them from such a file, checking them as [Apply] does. The `_Parameters.csv` files written with projects and images (Chapter 4) can also be imported, which makes it easy to analyse several canvases with exactly the same parameters. Import and export start in the last folder used for parameters.

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- F. J. Simois-Tirado, J. J. Murillo-Fuentes, “On the power spectral density applied to the analysis of old canvases,” Signal Processing, 2017, Vol. 143, pp. 253-268.

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A. Image format

Table A.1 shows some of the fields stored in the file of the example image, as shown by [Image info] (Section 3.2.4). Aracne uses the following ones:

Width, Height the size of the image in pixels.

ColorType, BitDepth grayscale, colour (RGB) and indexed-colour images are accepted, with any bit depth. Colour images are converted to gray and images of more than 8 bits are converted to 8 bits using their actual range of gray levels. Transparency (alpha) channels and empty channels are ignored. Of a multi-page TIFF, the first page is used.

XResolution, YResolution, ResolutionUnit the resolution, which must be the same in both directions, in pixels per inch or per centimetre (PNG files store it in pixels per metre, which is also understood). If it is missing, Aracne asks for it when loading the image (Section 2.2).

In the example, 513 pixels per inch are $513/2.54 = 202$ pixels per cm, and the 7688×5893 pixels of the image correspond to 38.1×29.2 cm of canvas.

Table A.1.: Some fields of the file of the example image

Field	Value
Format	tif
Width	7688
Height	5893
BitDepth	8
ColorType	grayscale
Compression	Uncompressed
PhotometricInterpretation	BlackIsZero
SamplesPerPixel	1
XResolution	513
YResolution	513
ResolutionUnit	Inch

B. Messages

The main messages Aracne may show, and what to do:

Resolution is under 50 pixels per cm.
The image has too little detail for the analysis. Use an image scanned at a higher resolution, or check the resolution stored in the file.

Unable to study this image. Resolution is not defined.
The file has no resolution and none was given when asked (Section 2.2).

Unequal horizontal and vertical resolutions.
The image was scaled differently in each direction; it cannot be measured in cm.

Unsupported colour type.
The file is not a grayscale, RGB or indexed-colour image.

The region to process was too small.
The selected area is smaller than the analysis window: select a larger area or reduce the window size (Chapter 5).

The loaded image has not enough resolution for the analysis.
The frequencies searched are too high for this image: lower the maximum frequencies or the window size.

There is not enough memory for this analysis.
The previous results are kept. Select a smaller area, close other programs, or increase the shift fraction (Chapter 1).

The results shown were computed with the previous parameters.
The parameters were changed after the count; count again to apply them.

Please wait until the current operation finishes.
A count, a load or a save is still running. Wait for it or cancel it.

Original image not found.
When opening a project whose image has moved: locate the image (Section 4.1.2).

This image does not match the project.
The image selected does not have the size of the project's image.

The project (or the images) could not be saved.
The folder cannot be written, or the disk is full. Nothing was changed in the folder: choose another one.

C. Citing Aracne

If you use Aracne, please cite it in your work as follows (also in About > Cite):

Software

- J.J. Murillo-Fuentes, I. Fondón, M. Ternero, L. Córdoba, P. Aguilera-Bonet, F.J. Simois. "ARACNE: thread counting in X-ray images of canvases", version 4.3.15. Universidad de Sevilla and Museo Nacional del Prado, 2026. `https://grupo.us.es/gapsc/aracne/`

Publications

1. F.J. Simois-Tirado, J.J. Murillo-Fuentes, "On the power spectral density applied to the analysis of old canvases". *Signal Processing*, vol. 143, 2017.
2. A. Delgado, J.J. Murillo-Fuentes, L. Alba-Carcelén, "Thread Counting in Plain Weave for Old Paintings Using Regression Deep Learning Models". *International Journal of Computer Vision*, 133, 2025.
3. A. Delgado, L. Alba-Carcelén, J.J. Murillo-Fuentes, "Crossing Points Detection in Plain Weave for Old Paintings with Deep Learning". *Engineering Applications of Artificial Intelligence*, 126, 2023.

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