# Vic-2d

Software Manual

Version 7.0

correlated
SOLUTIONS

# Contents

# Chapter 1

# Vic-2D Manual

## 1.1 Navigating the Online Help System

This document is also available in the Vic-2D software and can be accessed by selecting the *Help* menu entry. This will open up a help window to view the documentation. The help viewer provides a contents tree view that can be expanded and collapsed to navigate the sections of this manual. Double-clicking on items in the content tree will display the corresponding page. Furthermore, a keyword search is provided in the *Index* panel and a full-text search can be accessed by clicking on the *Search* tab.

Context-sensitive help is available for many dialogs by pressing the `F1` key while the dialog is active. This will automatically display the corresponding section in the manual.

Vic-2D uses context menus that can be activated by right-clicking on many user interface elements (lists, image views, plots etc.) to provide quick access to common functions. Before searching the help, a right-click may reveal how to access the sought for functionality.

## 1.2 Getting More Help

If you cannot find an answer to your question in this manual, please do not hesitate to contact our technical support at support@correlatedsolutions.com. You can also find contact information at our web site at www.correlatedsolutions.com.

We will be happy to assist with topics such as:

- Designing digital image correlation experiments
- Calibration
- Troubleshooting errors
- Interpreting test data
- Achieving optimal results

## 1.3 Bug Reports and Feature Requests

If you encounter a bug in Vic-2D, please let us know about it. Send a short description of the problem to support@correlatedsolutions.com along with any project or image files you think may help us reproduce the bug.

Also, if you think Vic-2D can be improved by adding a particular feature you would find helpful, let us know about it. We will try to incorporate your requests in our future updates of the software.

# Chapter 2

# Overview

The user interface of Vic-2D has many of the familiar control elements found in other applications. The image below illustrates the user interface. The most commonly used functions can be accessed by clicking on tool buttons on the **Tool Bar**. The windows, such as the **AOI Editor** and **Plot** windows are grouped inside a **Workspace**. The **List View** on the left of the main window provides a quick overview of image and data files.

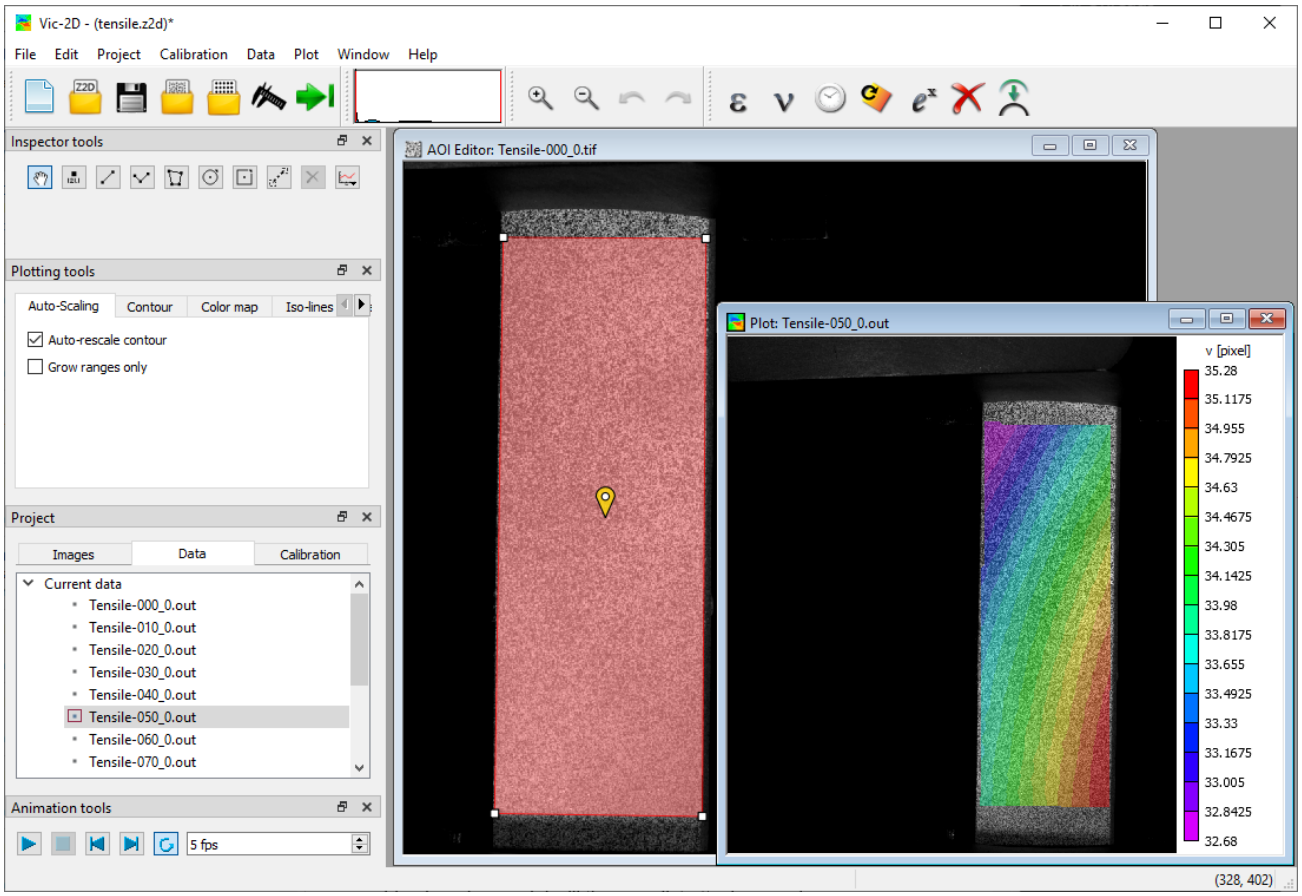



Figure 2.1: Vic-2D Application Window

## 2.1 File Menu

The *File Menu* provides the following functions:

- **New** - creates a new project
- **Open** - open an existing project
- **Open recent** - select from recently accessed projects
- **Save** - save the current project
- **Save As...** - save the current project under a new file name
- **Mode** - select a Vic-2D project type
- **Install module licenses** - use this menu entry to activate software modules you have purchased
- **Quit** - quit Vic-2D

## 2.2 Edit Menu

The *Edit Menu* provides the following functions:

- **Undo** - undo the last editing operation in the reference image
- **Redo** - redo the last editing operation in the reference image
- **AOI tools** - each AOI tool is selectable from this menu.

## 2.3 Project Menu

The *Project Menu* provides the following functions:

- **Speckle images**- adds speckle images to the project for analysis
- **Calibration images** - adds calibration images to the project.
- **Speckle image groups** - add a group of speckle images with the same prefix
- **Calibration image groups** -add a group of calibration images with the same prefix
- **Data files** - adds pre-existing output data files to the project
- **Analog data** - adds analog data files from Vic-Snap
- **Video clip** - adds generated AVI files

## 2.4 Calibration Menu

The *Calibration Menu* provides the following functions:

- **Calibrate scale** - use a calibration image to create a pixel:mm scale calibration
- **Distortion correction** - use an analyzed distortion sequence to create a parametric distortion correction
- **Clear distortion** - removes the current set distortion map
- **More** - set advanced parameters [i.e., aspect ratio]

## 2.5 Data Menu

The *Data Menu* provides the following functions:

- **Start analysis** - shows the Run dialog to begin analysis
- **Postprocessing tools** - shows a submenu to choose from various postprocessing calculations
- **Export** - various options for exporting full data set or reductions

## 2.6 Plot Menu

The *Plot Menu* provides the following functions:

- **New plot**- adds a new plot window to the work space
- **Inspector**- allows choice of various data inspection tools

## 2.7 Window Menu

The *Window Menu* provides the following functions:

- **Cascade** - organizes all MDI windows in a cascade
- **Tile** - tiles all MDI windows

## 2.8 Help Menu

The *Help Menu* provides the following functions:

- **User manual** - show this manual.
- **About** - show version information.

## 2.9 Main Toolbar

Figure 2.2: The main toolbar.

The buttons on the main toolbar control commonly used Vic-2D functions. From left to right:

File tools:

- New project

- Open project
- Save project
- Add speckle images
- Add calibration images
- Calibrate stereo system
- Start analysis

Histogram control
Plotting tools:

- Zoom in/out
- Undo/redo

Postprocessing tools:

- Calculate strain
- Calculate velocity
- Time filter data
- Calculate in-plane rotation
- Apply a custom function
- Remove variables
- Remove rigid motion

The histogram control displays the gray level distribution for the currently displayed image. The red bars on the histogram may be used to adjust the image display. Double-click on the histogram to automatically adjust the balance, or drag the red bars to set the black and white levels manually. Double click again to remove the balance adjustment.

The balance control is for display only and does not affect image analysis or stored images.

## 2.10 Animation Toolbar


Figure 2.3: Animation toolbar.

The buttons on the animation toolbar allow stepping through and animating image files or plots. The controls, from left to right:

- **Play** - begins automatically stepping through images/plots.
- **Stop** - stops the animation.

- **Step Back / Step Forward** - goes to previous or next image/plot.
- **Loop** - toggles between looping from last image to first, and bouncing from forward to backward animation.
- **Frame rate** - selects the speed of the animation.

## 2.11 Other Functionality

In the right corner of the status bar at the bottom of the main window, the cursor position and image grey value is displayed when the mouse is moved inside the reference image or a deformed image. On the left side of the status bar, a short description of tool buttons and menu items is displayed when the mouse moves over them.

In the list view on the left side of the main window, some functions can be activated by right-clicking. Details can be found in the appropriate sections of this menu.

# Chapter 3

# The Start Page

The start page in Vic-2D gives convenient access to frequently-used tasks, recent projects, and project type selection.

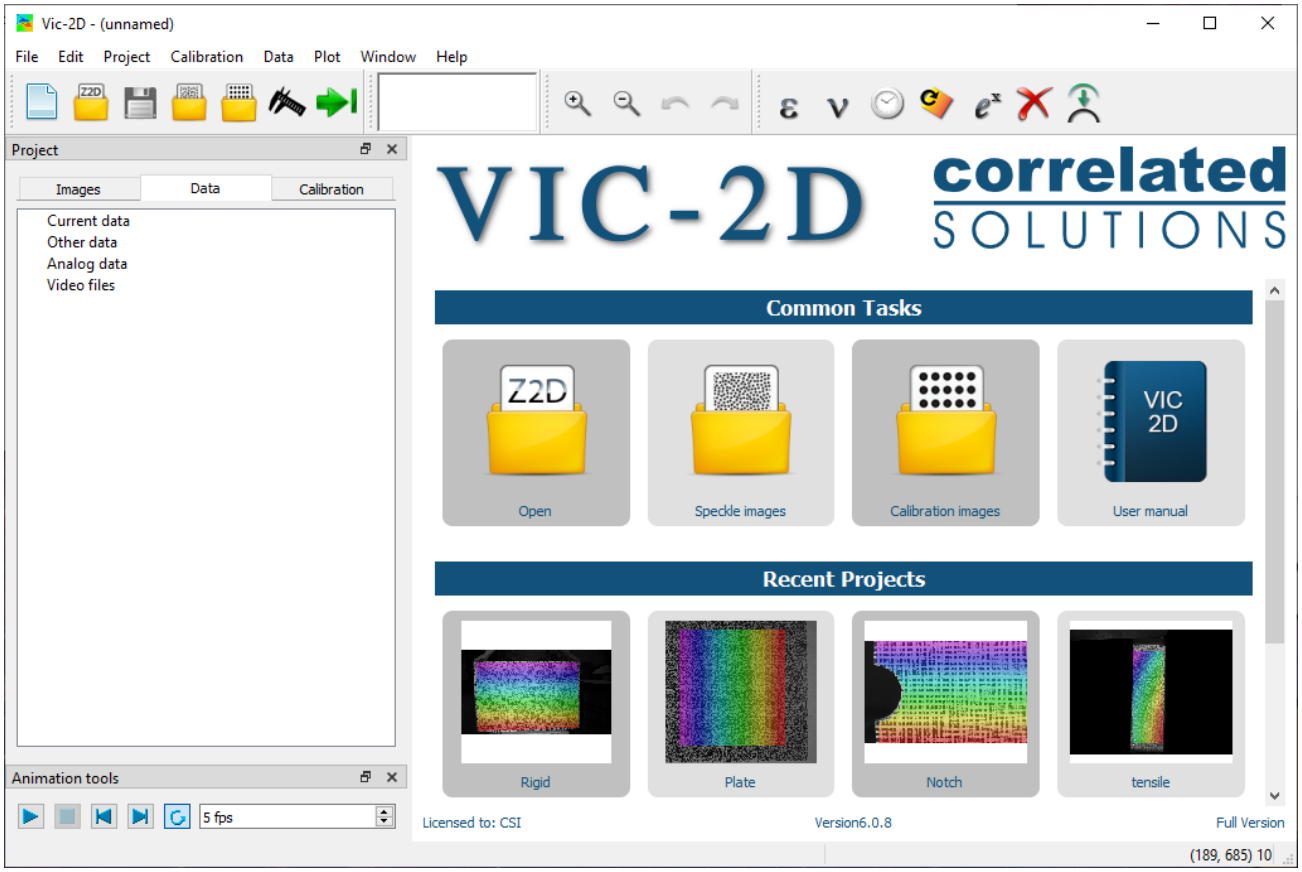



Figure 3.1: Vic-2D start page.

## 3.1 Common Tasks

This section duplicates common tasks from the menu bar. Click to open a project, add speckle or calibration images, or view this user manual.

## 3.2 Recent Files

This section contains a list of the most recently accessed projects. Click on an icon open the project; mouse over an icon to see recent plots and images.

# Chapter 4

# Projects in Vic-2D

In Vic-2D, all the files and information associated with a test are stored in a *project*.

Initially, projects are blank. Before completing a Vic-2D analysis, the project must contain:

- One or more speckle images , including a reference image
- One or more areas of interest

Note: Adding speckle images to the project adds them by filename reference only; they are not copied or moved on the disk.

When you run a Vic-2D analysis, the output files are stored on a disk and added (by reference) to the project file. If the project file is not saved or if the data files are manually removed, they will remain on the disk.

In addition to the items above, you can also choose to add auxiliary data references to the project file:

- Generated video clips
- Analog data files from Vic-Snap

## 4.1 Notes

- In general, it is good practice to save project files often to avoid losing changes.

# Chapter 5

# The Project Toolbar

The project toolbar is displayed at the left side of the work area by default. It contains information about image files, data, and calibration for the current project.

## 5.1 The Images Tab

This tab shows all speckle and calibration images associated with the project.

To add speckle images, select *Images... Speckle images* from the menu bar, or click the speckle images icon on the main toolbar. The small red arrow indicates the reference image; to set an image as the reference, right click and click *Set as reference*.

To add calibration images, select *Images... Calibration images* from the menu bar, or click the calibration images icon on the main toolbar.

To remove an image or series of images, select them, right click, and click *Remove* or *Remove selected*.

## 5.2 The Data Tab

The Data tab lists all output data, analog data, and video files associated with the project.

All generated output files are added to the *Current data* list. Output files not associated with current speckle images are added to *Other data*. Double-click on a data file to view a plot.

Analog data from Vic-Snap is listed under *Analog data*. To add an analog data file, select *File... Add Files... Add Data Files* from the main menu. To view a spreadsheet of the data, double-click the filename.

Generated video files from 2D animations are added to the *Video files* list. Double-click on a video to display it in an external viewer.

## 5.3 The Extractions tab

Any inspector extractions that are created will be listed here. These extractions are saved in the project file and will be available in the *iris* workspace.

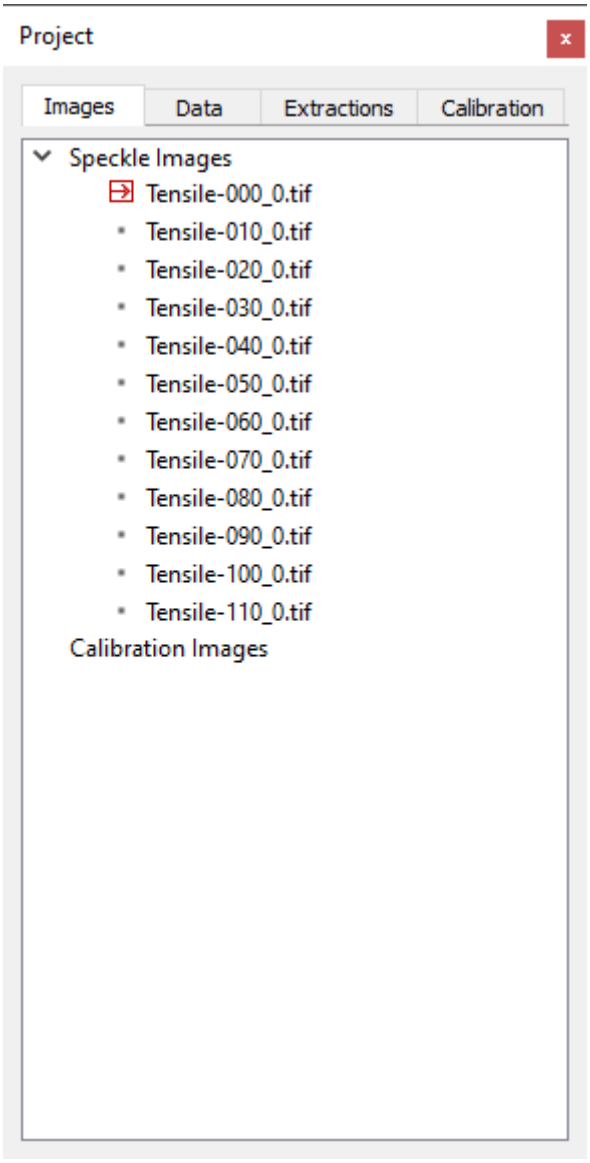



Figure 5.1: Project toolbar files tab.

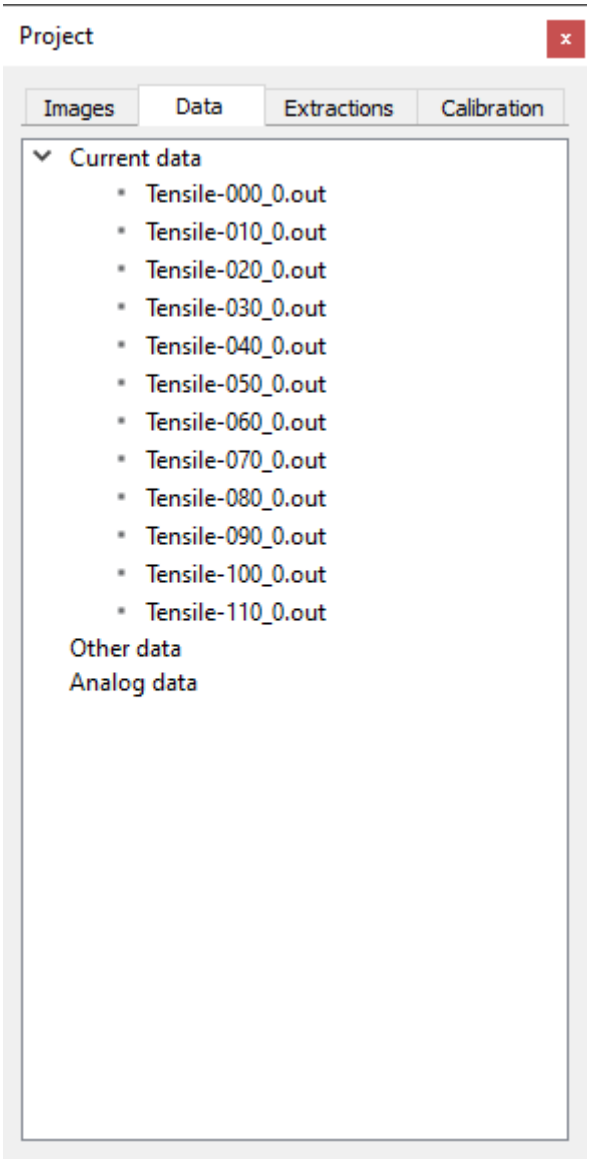



Figure 5.2: Project toolbar data tab.

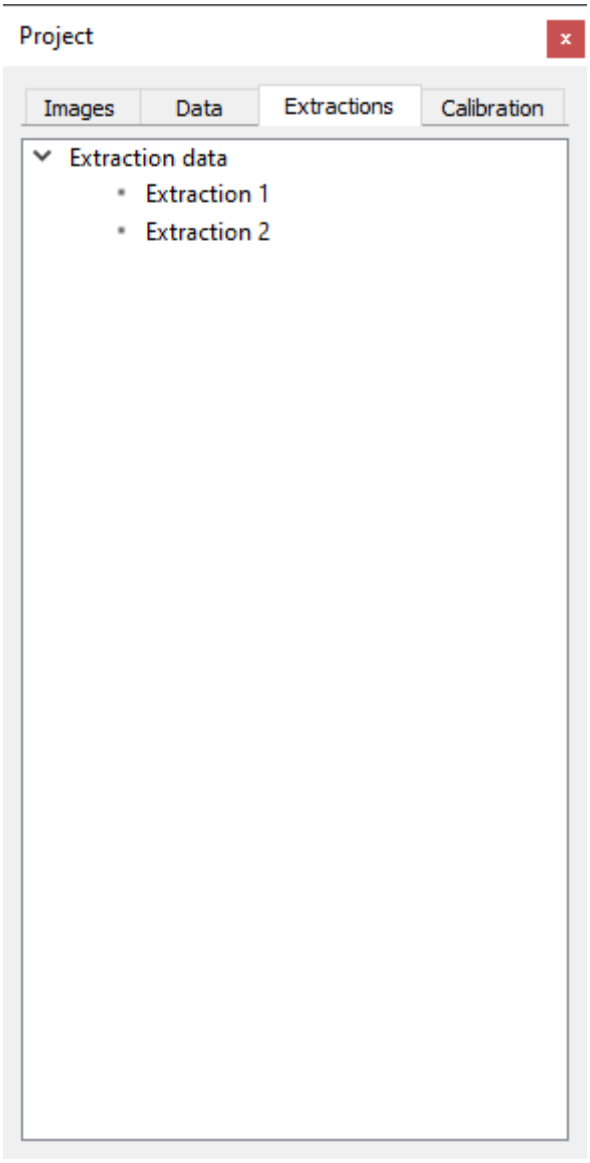



Figure 5.3: Project toolbar data tab.

## 5.4 The Calibration Tab

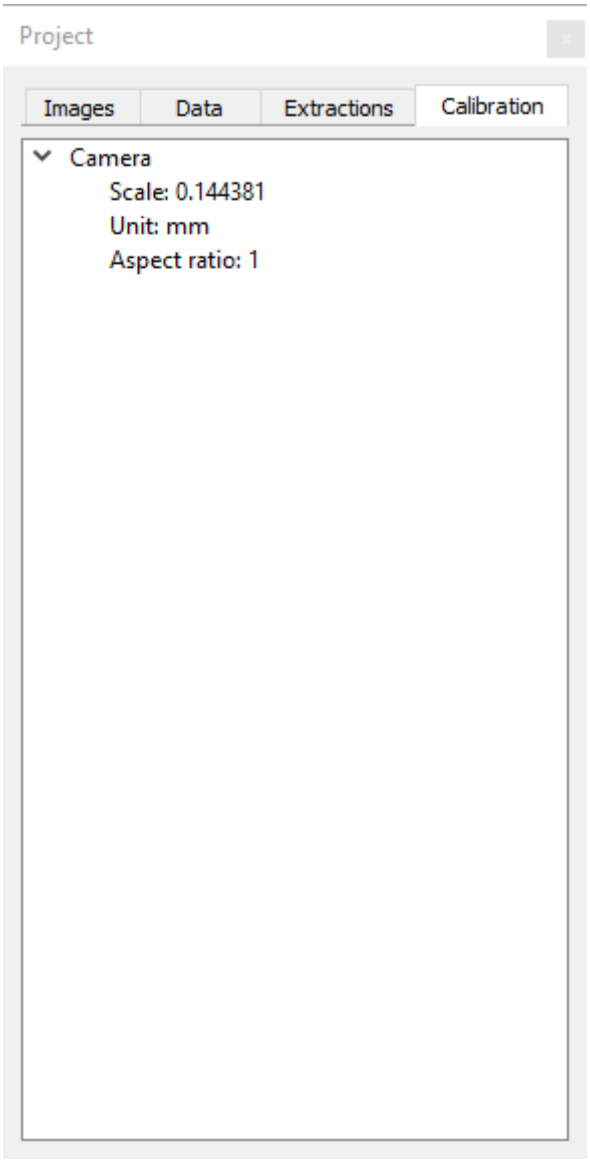



Figure 5.4: Project toolbar calibration tab.

This tab is a static display of the current calibration information for the project. This will consist of a calibration scale; a unit; and the camera's aspect ratio.

# Chapter 6

# Speckle Images

In Vic-2D, speckle images are image or set of images taken of a specimen as it undergoes load or motion. You may add one or multiple speckle images by selecting the *Speckle images* entry from the *Project* menu, or by clicking the  icon on the main tool bar.

If more than 300-400 images are to be added, select *Project... Speckle image groups* to add sets of images from a specified folder. Select a folder to see a checklist of image prefix groups; select one or more to add as speckle images. (Trying to add too many images directly through the normal *Speckle images* dialog may result in an error due to operating system limitations.)

After adding speckle images to the project, they will be displayed in the workspace and listed in the *Images* tab of the project bar as shown in the figure below.

## 6.1 Viewing Images

Deformed images can be displayed in the workspace by double-clicking on an entry in the image list view. Alternatively, clicking the right mouse button on an entry of the list view will show a popup menu providing different options, one of which is *View*.

When viewing deformed images, you can use the zoom in/zoom out entries in the *Edit* menu or the corresponding tool buttons to change the scale of the displayed image.

## 6.2 Animating Images

To animate speckle images, display an image and then use the controls on the Animation Toolbar to animate the sequence.

Removing Images

Speckle images can be removed by selecting one or multiple images in the list view, and right-clicking on your selection. Select *Remove* or *Remove selected* to remove images from the list.

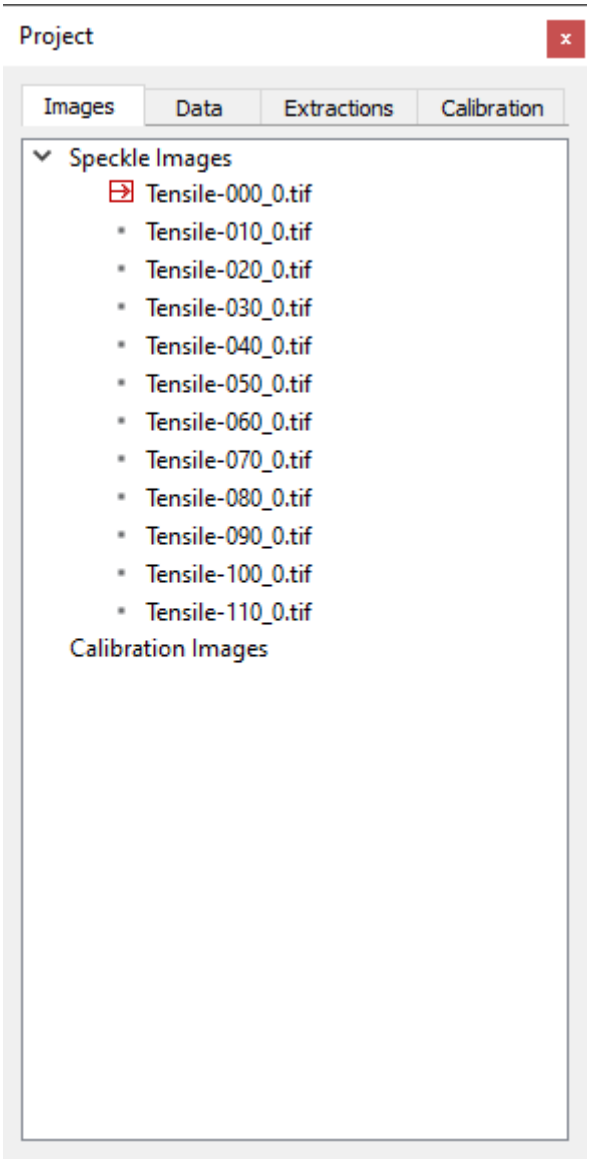



Figure 6.1: Project image panel showing speckle images.

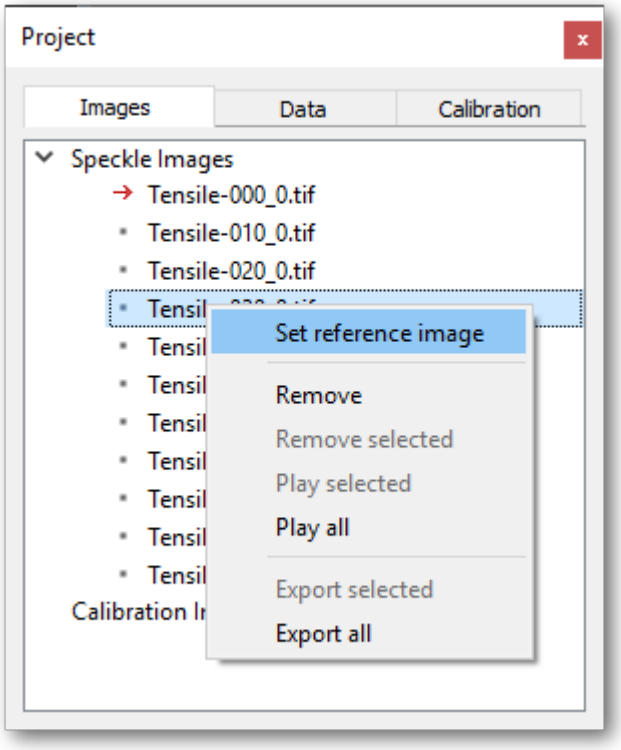



Figure 6.2: Calibration image list in project panel.

# Chapter 7

# The Reference Image

The term *Reference Image* is used in this manual to describe the image of the specimen taken while no load was applied. All displacement analyses in Vic-2D are with respect to this reference image, i.e., the displacements are obtained in a Lagrangian coordinate system.

To select a reference image, right-click on it in the Speckle images list, and select *Set as reference.*

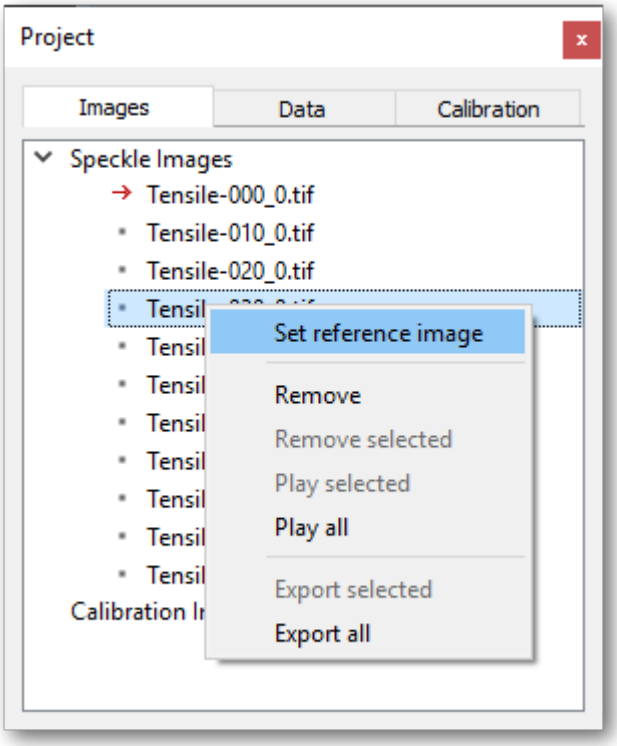



Figure 7.1: Speckle image list right-click menu.

After the reference image has been selected, it will be indicated with a red arrow in the images list.

When the reference image is displayed, the Aoi tool buttons become active.

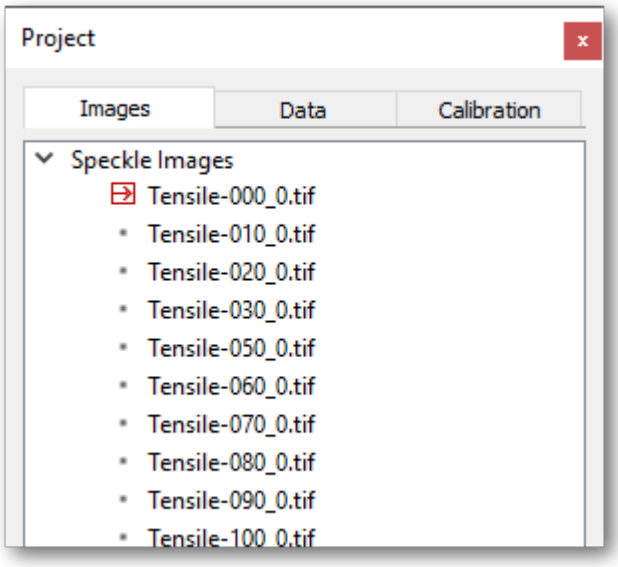



Figure 7.2: Reference image indicator

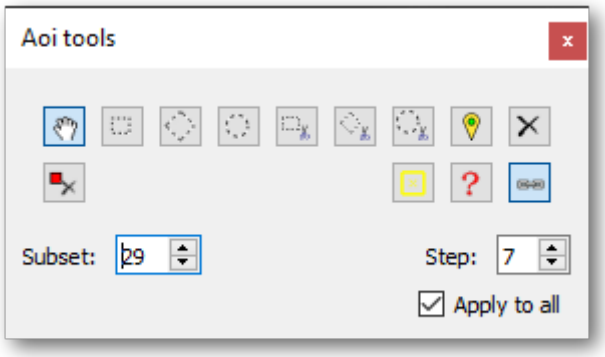



Figure 7.3: Aoi tool box.

## 7.1 Selecting an Area-of-Interest

Vic-2D supports the following types of AOIs:

- **Rectangle:** Points are contained in a rectangular area.
- **Polygon:** Points are contained in an arbitrary polygon.
- **Circle:** Automatically creates a roughly circular polygon.

To specify a particular type of AOI, select the corresponding entry in the *Edit* menu or the appropriate button on the tool bar. The selected AOI type will be indicated by the mouse cursor.

After selecting the AOI type, move the cursor to the desired position in the reference window and click the left mouse button. You can now move the mouse to the next position, e.g. the end of the line or the second corner of the rectangle. Clicking the left mouse button again

will complete the AOI selection for all AOI types except polygons. For polygon selection, a double-click is used to specify the last point of the polygon.

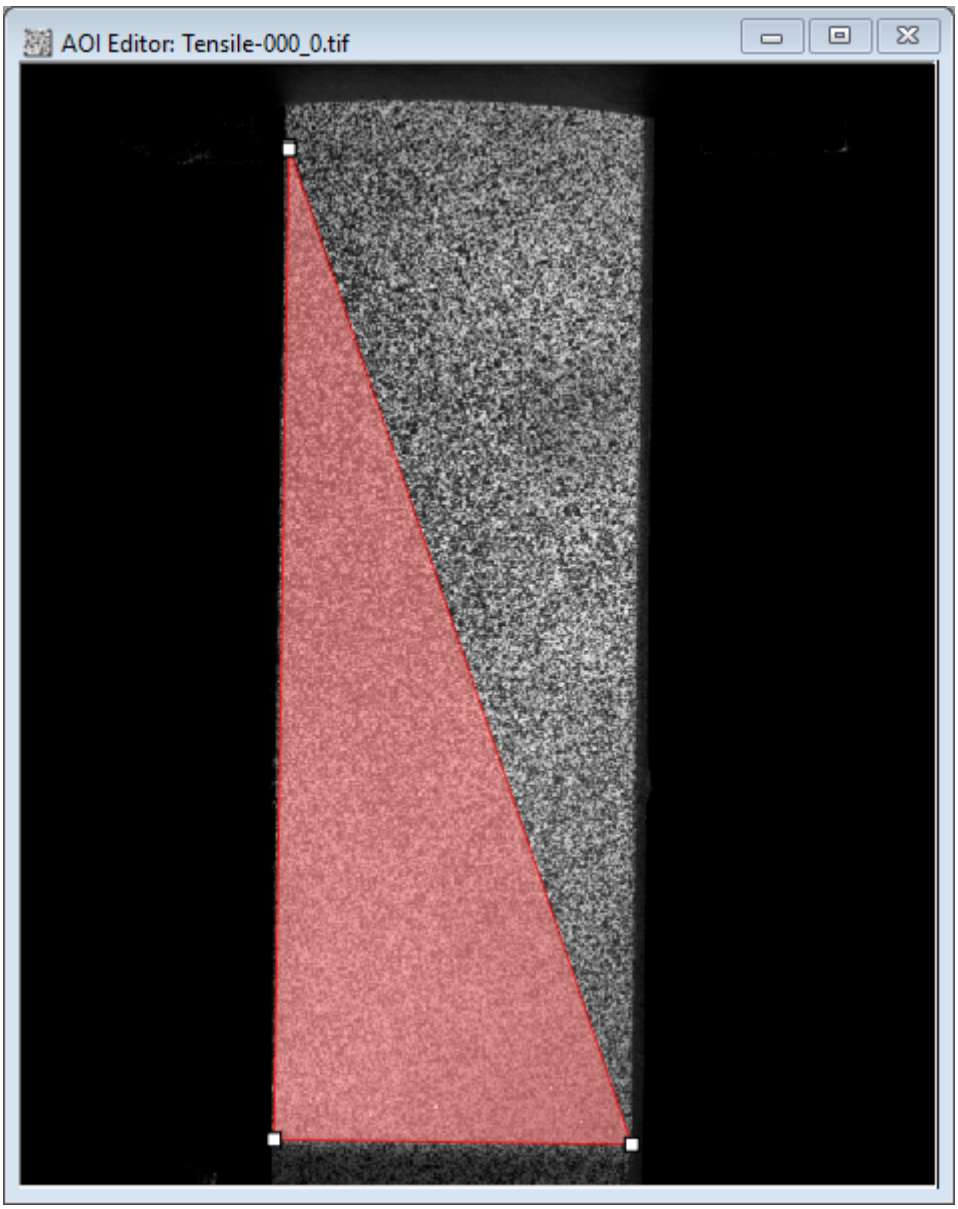



Figure 7.4: Selecting an area-of-interest.

**Editing AOIs**

To edit an existing AOI, select the Pan/Select tool. Mouse over any of the white nodes in your AOI; the mouse cursor changes to indicate node movement. Click and drag to move. You can delete a node by clicking the icon, then clicking the desired node.

If the merge polygons icon ( ) is selected, any overlapping polygons will be merged with each other. If the icon is not selected, overlapping AOIs will remain separate.

## 7.2 Cutouts

For rectangular and polygon AOIs, the scissors tool can be used to cut areas from the AOI. This feature is most commonly used if the specimen has cracks, holes, or other areas where correlation is impossible.

To cut an area from an AOI, click the scissors button on the tool bar or select *Edit... Cut region*. The selection of the area to be cut works like selecting a polygon AOI, i.e., corner points of a polygon can be added by single-clicking the left mouse button, and the last point is specified by a double-click. Once the cut is complete, new nodes are added to your AOI; these may be moved like other nodes.

## 7.3 Choosing the Subset and Step Size

The subset and step size can be selected after an area of interest is created. Both are adjusted using the spin boxes in the AOI Toolbar.

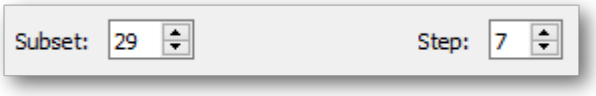



Figure 7.5: Subset and step size control.

The subset size controls the area of the image that is used to track the displacement between images. The subset size has to be large enough to ensure that there is a sufficiently distinctive pattern contained in the area used for correlation. If you change the subset size, you will see the current size illustrated by a grid briefly displayed on the AOI. To have Vic-2D suggest a subset size, click the ? icon:

Vic-2D will choose a subset size which is calculated to give an optimal match confidence of 0.01 pixel for a given assumed noise level. The default of 8 works well for most cameras. To accept the suggested size, click **Ok**; to return without making a change, click **Cancel**. The step size controls the spacing of the points that are analyzed during correlation. If a step size of 1 is chosen, a correlation analysis is performed at every pixel inside the area-of-interest. A step size of 2 means that a correlation will be carried out at every other pixel in both the horizontal and vertical direction, etc. Note that analysis time varies inversely with the square of the step size; i.e., a step size of 1 takes 25 times longer to analyze than a step size of 5.

To cause subset and step size changes to apply to every AOI, check the *Apply to all* box. If this box is cleared, subsets and steps can vary between AOIs.

## 7.4 Placing start points

In some situations, start points may be need for the correlation. To place a start point, click the icon. The Initial Guess Selection page has more information about selecting end editing start points.

To remove a start point, click the icon, then click the start point.

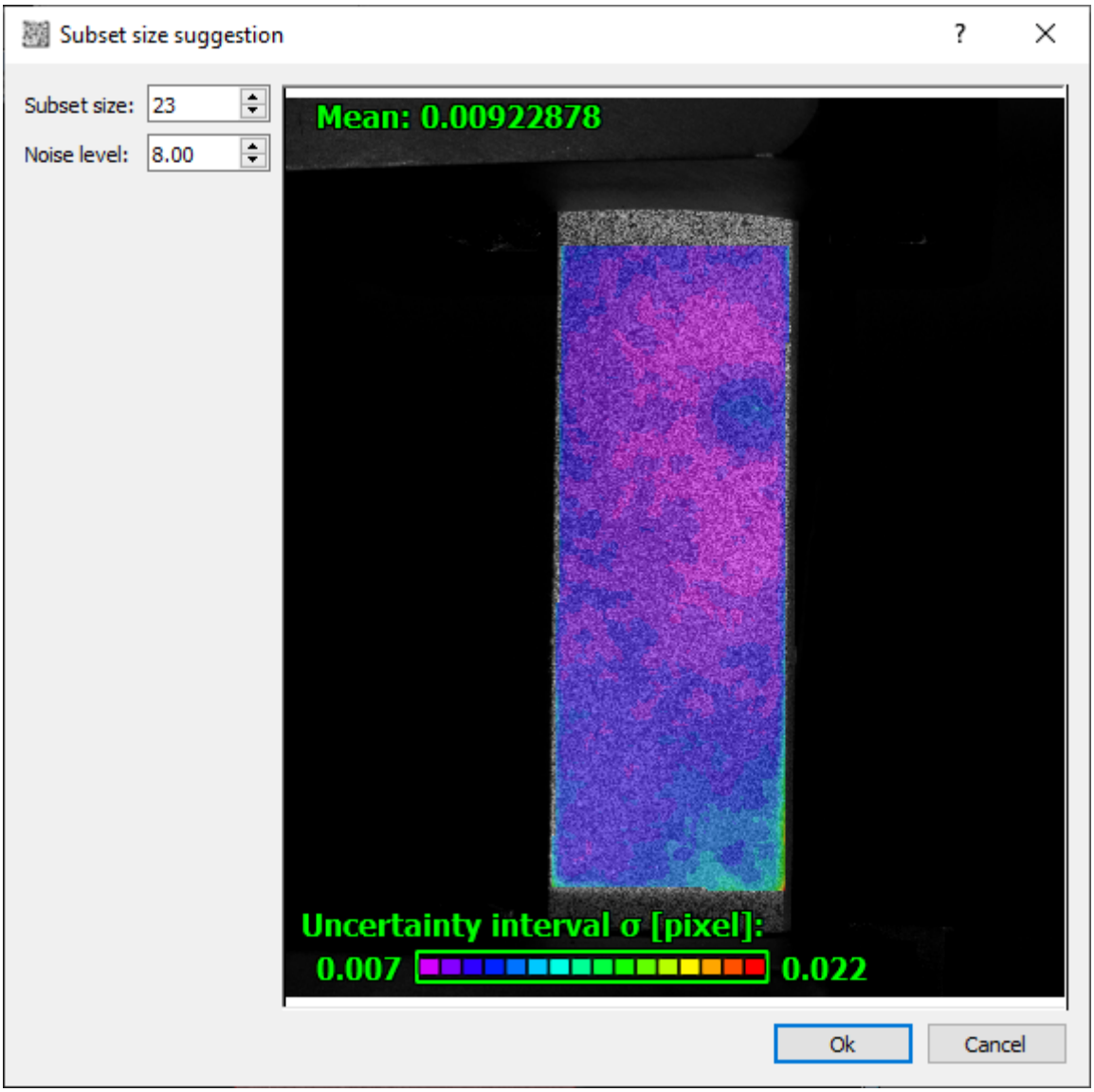



Figure 7.6: Subset size suggestion dialog.

- Use the scroll wheel to adjust the size of the image.
- When using multiple AOIs for one image, click on an AOI with the pan/select tool to activate it.
- During AOI selection, the image can be scrolled by moving the mouse outside the reference image window. This will cause the image to auto scroll if the image does not fit on the display.
- You can use the Undo/Redo buttons to undo AOI selection and other operations. The Undo/Redo buttons in the *Edit* menu will indicate what changes can be undone/redone.

# Chapter 8

# Calibration Images

Calibration images can be added by selecting the *Calibration images* entry from the *Images* menu, or by clicking the icon on the main tool bar.

After adding calibration images to the project, they will be listed in the *Images* tab of the project bar, as illustrated below.

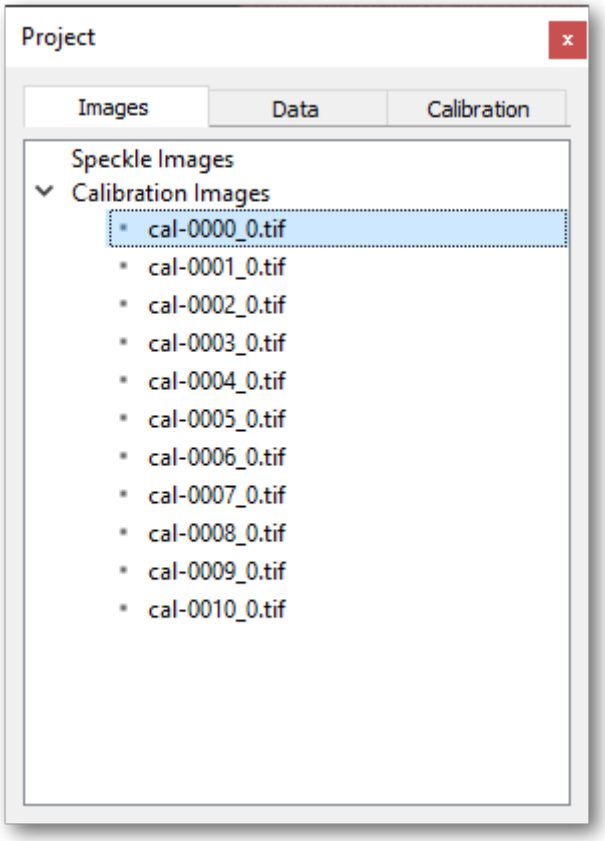



Figure 8.1: Project image panel showing calibration images.

## 8.1 Viewing Images

Calibration images can be displayed in the workspace by double-clicking on an entry in the list view on the left. Alternatively, clicking the right mouse button on an entry of the list view will show a popup menu providing different options, one of which is *View*.

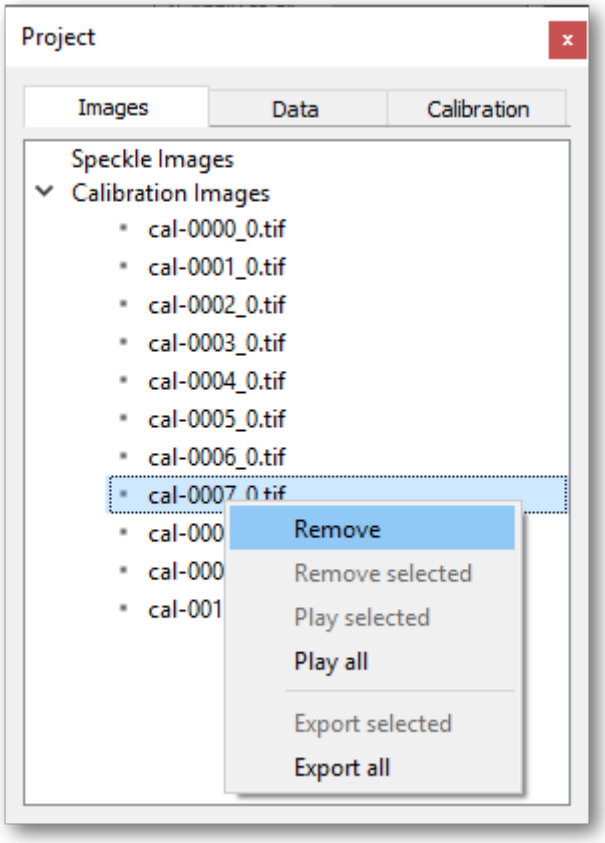



Figure 8.2: Calibration image list right-click menu.

When viewing calibration images, you can use the zoom in/zoom out entries in the *Edit* menu or the corresponding tool buttons to change the scale of the displayed image.

## 8.2 Removing Calibration Images

Calibration images can be removed by selecting one or multiple images in the list view, and right-clicking on your selection. Select *Remove* or *Remove selected* to remove images from the list.

# Chapter 9

# Calibration

The scale calibration dialog may be used to establish a physical scale for your measurements.

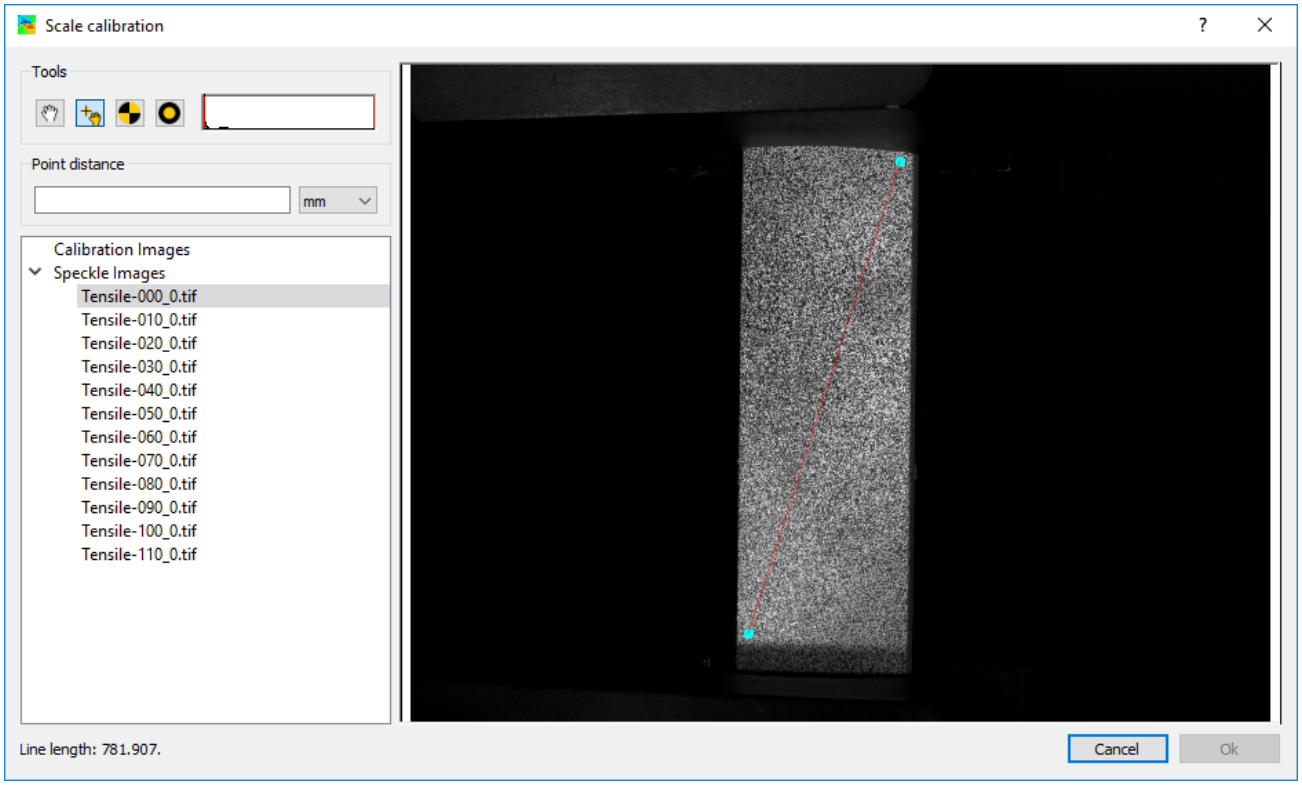



Figure 9.1: Scale calibration with manual points.

There are three tools for scale calibration.

- Manually select: this tool is used to select two manually identified points.
- Snap to cross: this tool is used to select two quadrant markers.
- Snap to circle: this tool is used to select two elliptical markers.

The known distance between the two points is entered in the *Point distance* field. Once a calibration is present, correlation results will be presented as metric locations and displacements.

# Chapter 10

# Initial Guess Selection

In Vic-2D, initial guesses will be needed very rarely. Some instances where they may still be necessary include:

- Large rotations between successive images
- Very fine or indistinct speckle patterns
- Poor calibration.

In the absence of these conditions, you can generally run the correlation immediately after selecting an AOI. If the correlation fails or runs very slowly, an initial guess may be needed.



Even if an initial guess is not required, placing a start point in an appropriate location (see below) can make the analysis faster. This is the case even if the start point location is not pre-computed for all images before correlation analysis.

## 10.1 Placing Start Points

A start point may be placed by clicking the icon in the Mask tools box from the AOI Editor. Once a start point is placed, Vic-2D will start looking for initial guesses in the background. If initial guesses are not automatically found, manual editing may be required.

Generally, it is best to place a start point in the area of the image that undergoes the least amount of motion during the test. For instance, if a specimen is tested in a tensile frame, the start point should be placed as close to the stationary grip as possible. Placing the seed point this way will help ensure fully automatic correlation. If a specimen is expected to fail or crack, it may help to put start points on either side of the specimen so that once failure occurs there will still be a start point on both surfaces.
For very large transformations or rotations, it can be very helpful to place fiducial marks on the surface. This can be integrated into a printed pattern or simply drawn on the surface with a marker. These marks may be located much more easily than the random pattern especially if, i.e., one image is rotated 180 degrees from the other.

## 10.2 Editing Initial Guesses

The initial guess dialog can be accessed by double clicking on the icon in the AOI editor, or right-clicking and selecting *Edit guesses*. The Initial Guess Editor will appear.

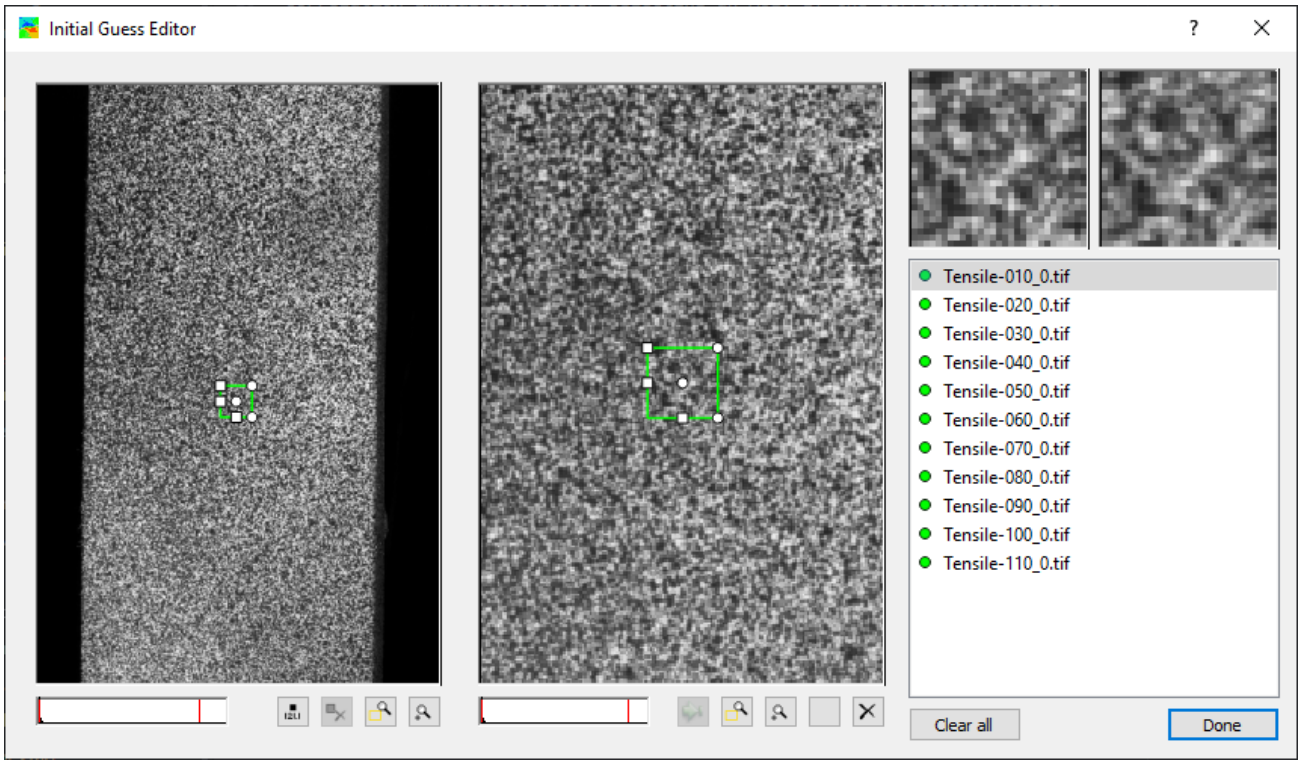



Figure 10.1: Initial guess editor.

The two windows on the left show the reference image on the left and the selected deformed image on the right. The small windows at the upper right show the zoomed-in guess for the same two images. The list at the lower left shows all the deformed images; where a guess is

already present, the marker will be green. A yellow marker indicates a guess exists for only one image of that pair, and a red marker means no guess exists.

To add a guess, drag the corresponding square from the stereo or deformed image until it is in the same spot as the reference image (at left). To make control easier, you can zoom in and out of the image with the mouse wheel, or by clicking the icon and drawing a box; or click the icon to zoom into the current guess area. A histogram control is provided for the reference and deformed images. Adjust the red bars to control image balance; this can be useful for finding detail in very dark images. Double click the histogram to automatically set/reset the limits.

Below, the deformed image guess has been dragged to the approximate correct location:

To check the guess, click the icon, or just right-click in the desired image:

If the correct match is found, you will be prompted to right-click again to accept it. If the match is not found, you can check the location and try again; but where severe scaling or shear is present, you may need to add more details by adding more points or setting scaling/shear with the control nodes.

## 10.3 Initial Guesses from Corresponding Points

Initial guesses, including deformation components, can be set using corresponding control points. Control points may be added to the reference image by clicking the icon and then clicking on an easily identifiable image feature, e.g. the center of a speckle. Up to three points can be added:

The control point locations are automatically shown in the deformed views based on the current guess parameters. These points may be dragged to the correct location by clicking on them and then dragging the mouse while keeping the button pressed. Note that Vic-2D will not allow points that are too close together, or too close to colinear. Control points may be deleted by first clicking and then clicking on the point to remove.

While you are dragging, you will see that the small view to the upper right changes to reflect the transformed subset. When the match is good, the two views will look very similar:

You may also drag the control points on the red rectangle to adjust the transform more directly. The upper left control point affects rotation; the left and bottom points control X and Y scaling; and the upper right and lower right points control shearing.

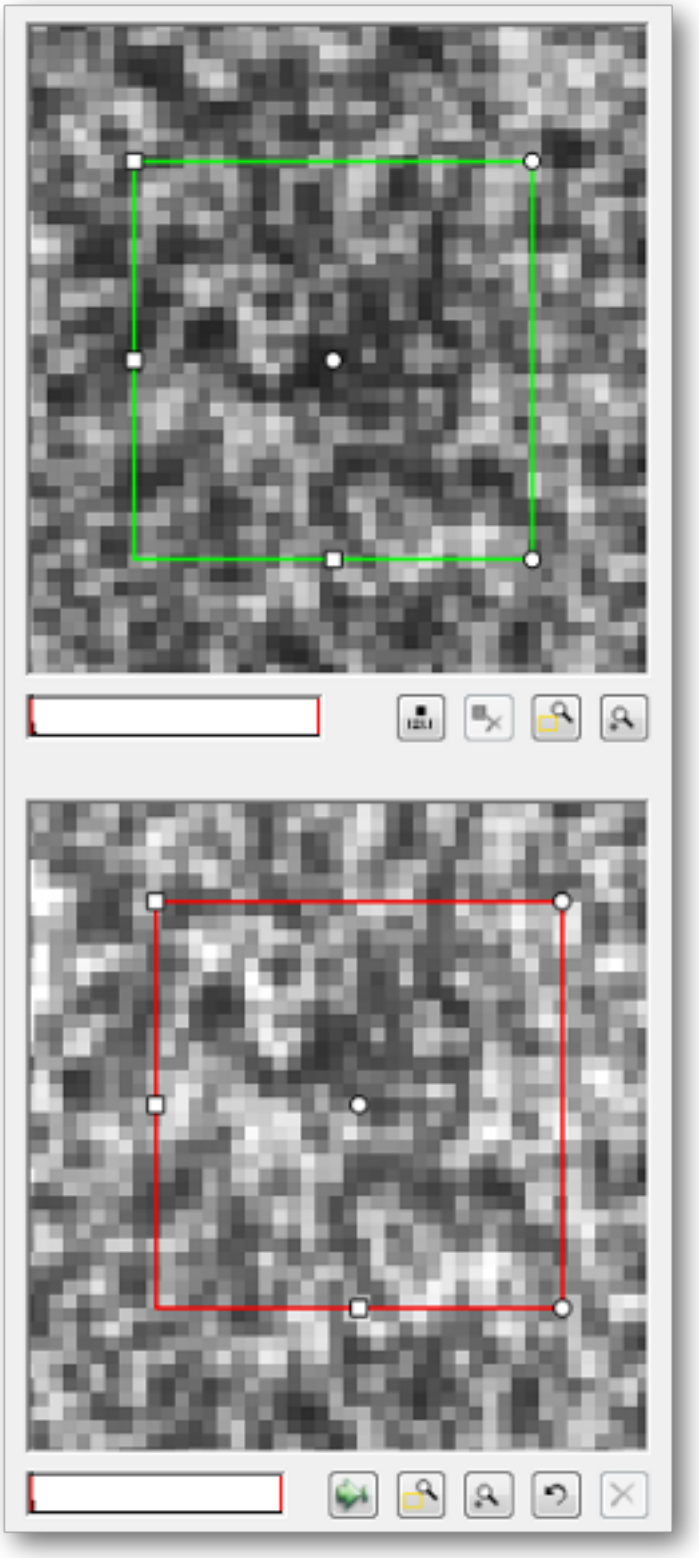


Figure 10.2: Approximate guess location.

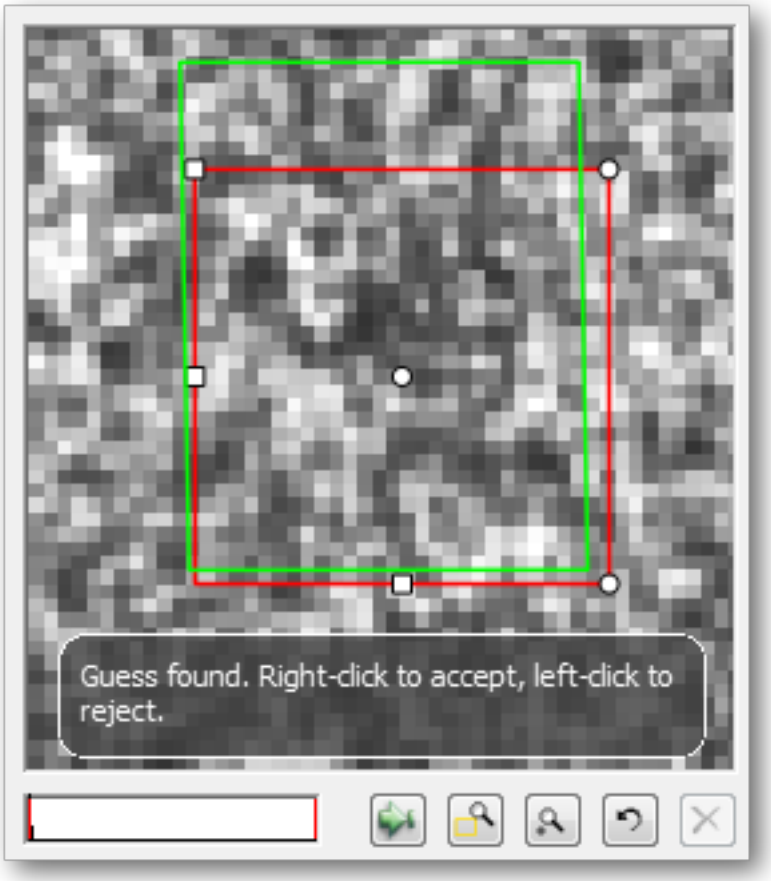



Figure 10.3: Initial guess found.

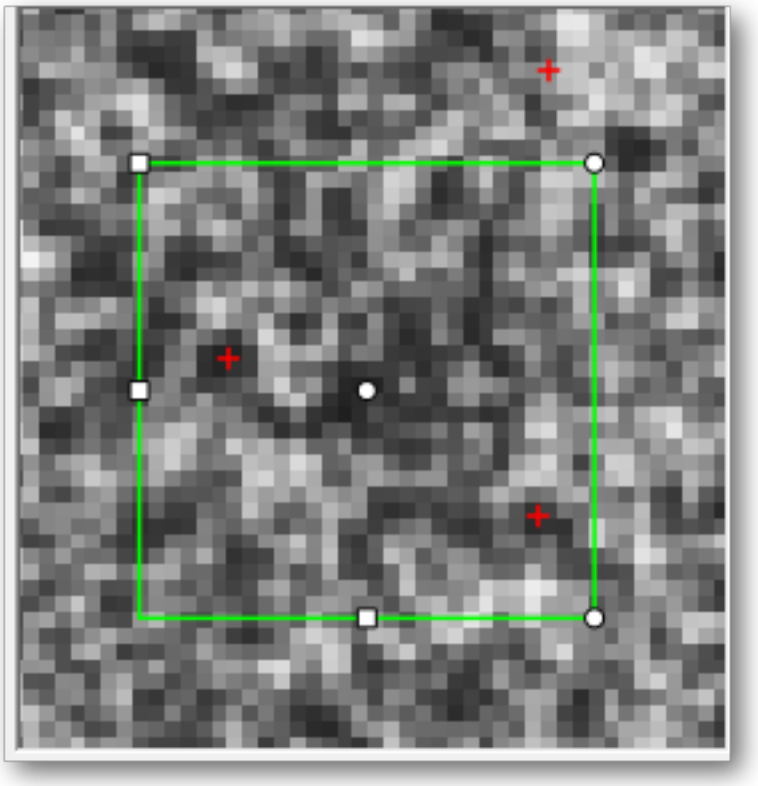


Figure 10.4: Setting control points.

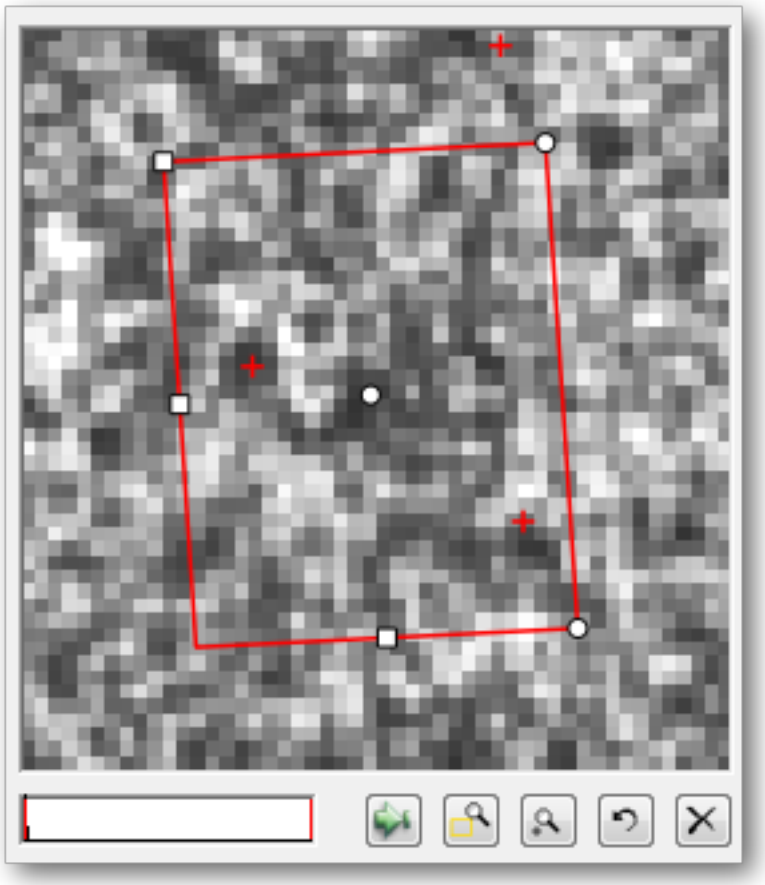


Figure 10.5: Red rectangle control points.

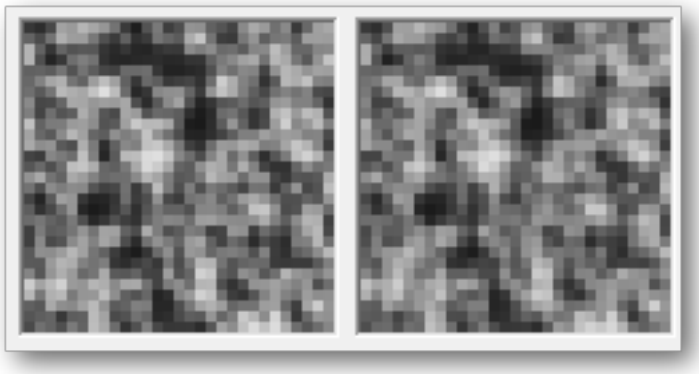


Figure 10.6: Comparison view of reference and resampled deformed subset.

# Chapter 11

# Running the Correlation

To run the displacement analysis, select the *Run Correlation* entry from the *Data* menu, or press the  button on the tool bar.

## 11.1 The File Tab

This tab displays the following options:

## 11.2 Selecting Images

The deformed images to use for correlation analysis can be selected from the list box on the dialog. Selected images are indicated by a check mark. Above the list box, buttons are available to select/deselect all image files contained in the list box. To select 1 data file from every 2, 5, 10, or $n$ , right-click in the file list and choose the desired option.

If no images are selected, only the reference image is analyzed.

## 11.3 Backup copies

When this option is checked, Vic-2D will make backup copies of existing output files by replacing their file extension with *bak*.

## 11.4 Output directory

The directory in which the output files are stored can be selected by clicking the folder icon.

## 11.5 The Options Tab

This tab displays the following options:

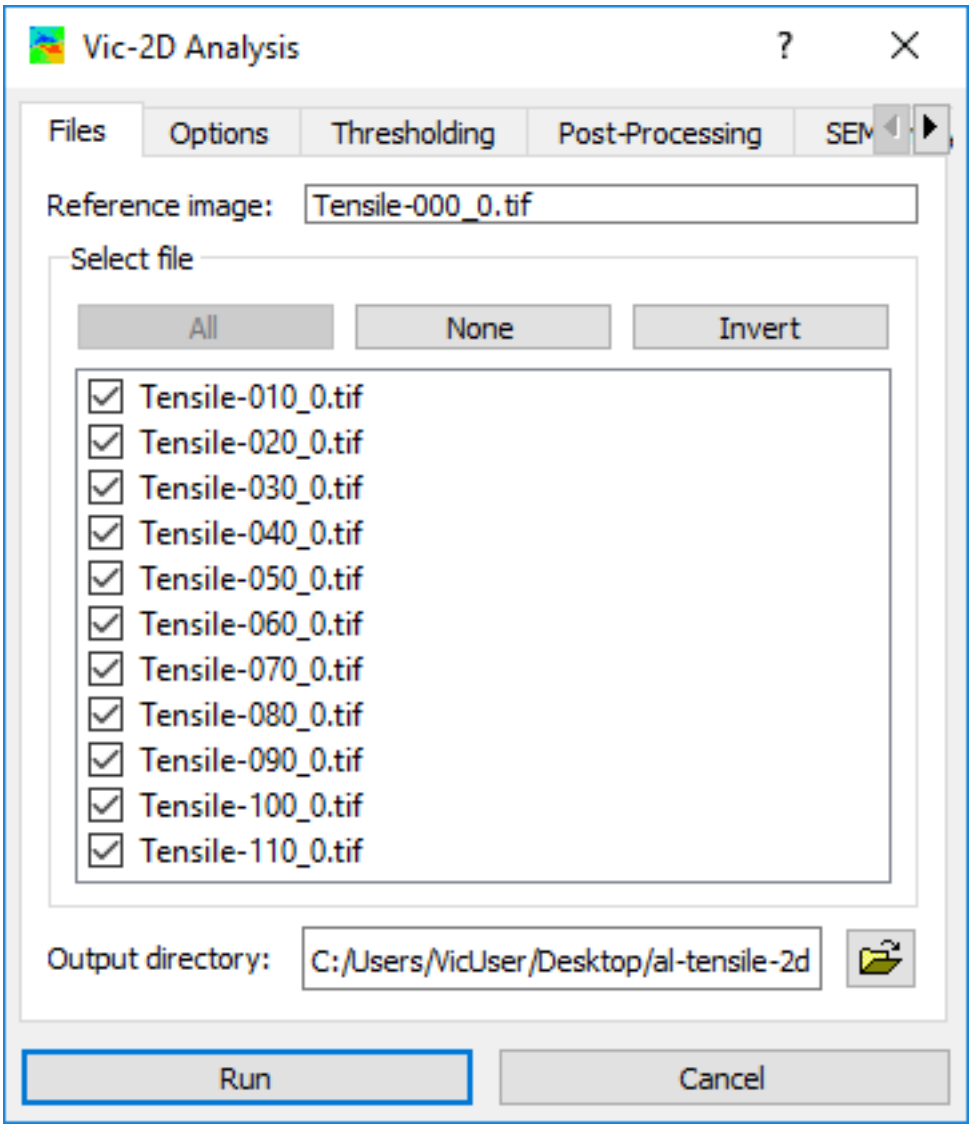



Figure 11.1: Analysis dialog file tab

## 11.6 Subset weights

This option controls the way pixels within the subset are weighted. With Uniform weights, each pixel within the subset is considered equally. Selecting Gaussian weights causes the subset matching to be center-weighted. Gaussian weights provide the best combination of spatial resolution and displacement resolution.

## 11.7 Interpolation

To achieve sub-pixel accuracy, the correlation algorithms use gray value interpolation, representing a field of discrete gray levels as a continuous spline. Either 4-, 6-, or 8-tap splines may be selected here.

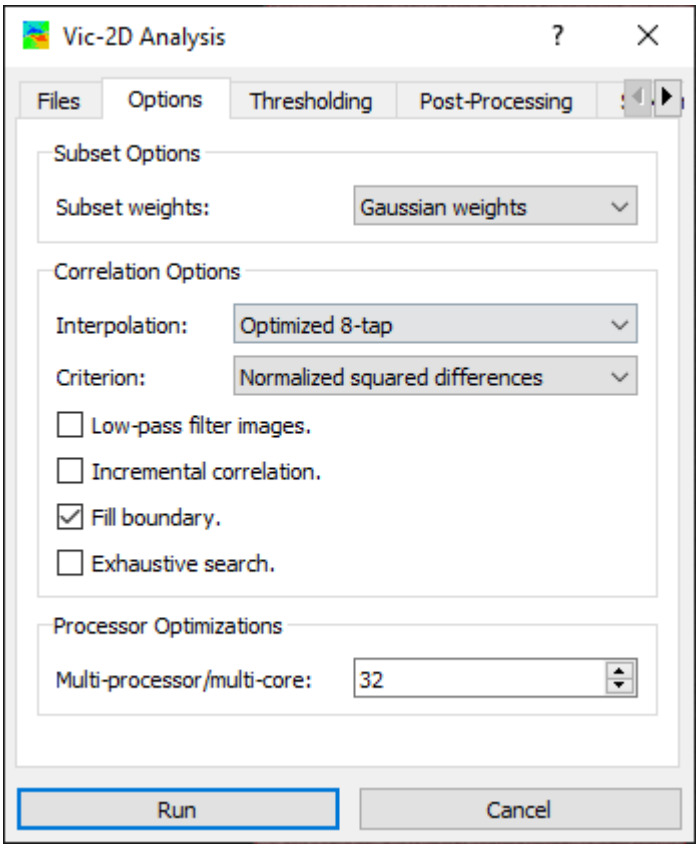



Figure 11.2: Analysis dialog options tab

Generally, more accurate displacement information can be obtained with higher-order splines. Lower-order splines offer faster correlation at the expense of some accuracy.

## 11.8 Criterion

There are three correlation-criteria to choose from:

- Squared differences: Affected by any lighting changes; not generally recommended.
- Normalized squared differences: Unaffected by scale in lighting (i.e., deformed subset is 50% brighter than reference.) This is the default and usually offers the best combination of flexibility and results.
- Zero-normalized squared differences: Unaffected by both offset and scale in lighting (i.e., deformed subset is 10% brighter plus 10 gray levels.) This may be necessary in special situations. However, it may also fail to converge (produce a result) in more cases than the NSSD option.

## 11.9 Low-pass filter images

The low-pass filter removes some high-frequency information from the input images. This can reduce aliasing effects in images where the speckle pattern is overly fine and cannot be well represented in the image. (These aliasing effects are often visible as a moire-type pattern in the output data.)

## 11.10 Incremental correlation

With incremental correlation, each image is compared to the previous image rather than the reference image. This can be useful in cases of pattern breakdown or extremely high strains (>100%). This comes at the expense of an increase in noise for later images, because the noise continues to add over each successive correlation.

## 11.11 Fill boundary

Checking this option will cause Vic-2D to interpolate subset gradients to fill displacement data out to the very edge of the AOI.

### 11.11.1 Exhaustive Search

Enabling this option will cause Vic-2D to repeat a coarse search for matches after each time the correlation fails. This may result in more data recovery at the expense of vastly increased processing time.

## 11.12 Processor Optimizations

This option controls the number of processors/cores Vic-2D uses for analysis. In most cases this will be correctly determined automatically by Vic-2D.

## 11.13 The Thresholding Tab

This tab provides options for removing any data that is bad or suspect while maximizing the amount of retained data. Four thresholding options are available. For a typical test, the default values will work very well, but when conditions are unusual or substandard (blur; debris; poor lighting; etc), some adjustment may be required.

## 11.14 Consistency threshold

After Vic-2D analyzes the seed point, the analysis is propagated to each of its four neighbors, and so on. Each point is fed with a prediction of its approximate match. After the match is

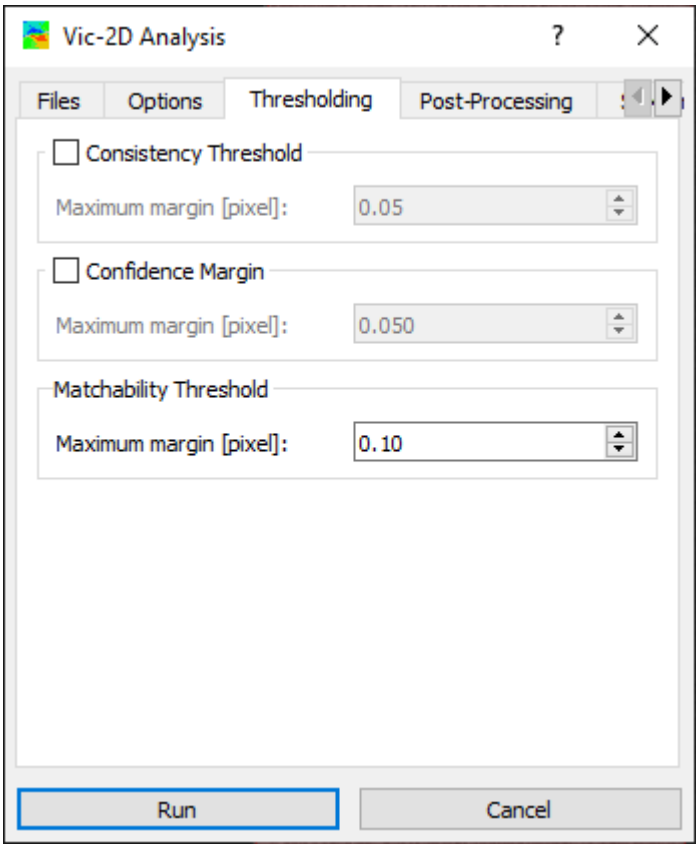



Figure 11.3: Analysis dialog thresholding tab

made, a *back*-prediction is calculated. If the back-prediction does not closely match the actual location of the prior neighbor, this threshold will remove the data.

## 11.15 Confidence margin

For each match, Vic-2D calculates a statistical confidence region, in pixels, using the covariance matrix of the correlation equation. If the confidence region exceeds this threshold, the data will be removed.

## 11.16 Matchability threshold

This option automatically removes subsets that show a very low contrast, i.e, subsets that don't contain very much information. Increase this value to remove more data; reduce to retain more data, i.e., if lighting conditions were poor.

## 11.17 The Post-Processing Tab

The tab on the dialog displays the following options:

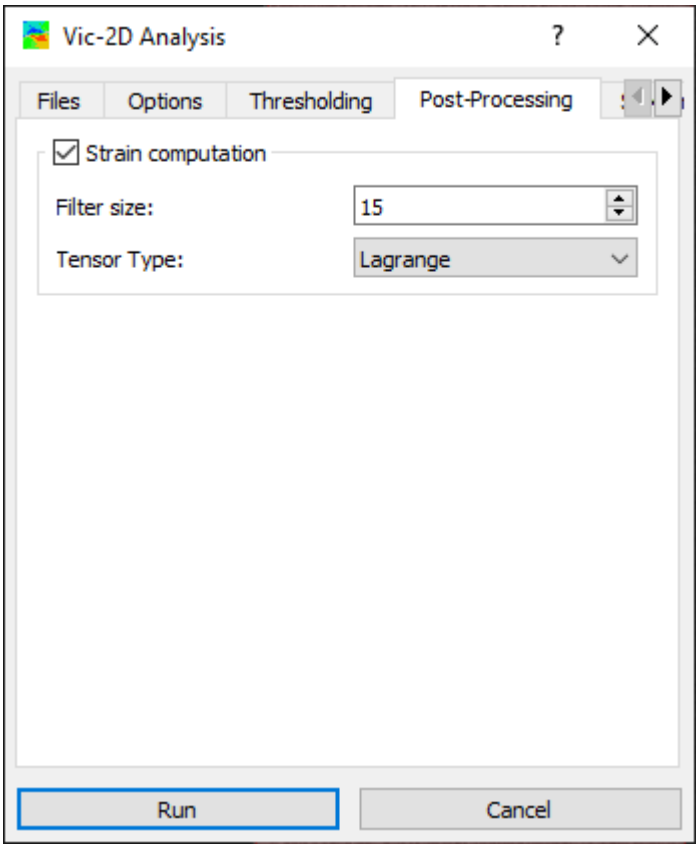



Figure 11.4: Analysis dialog post-processing tab

## 11.18 Strain Computation

Checking this option performs a strain computation as each image is processed; results can be viewed in the preview.

## 11.19 Correlation Results

After you begin the correlation, the following window appears.

The window contains an overview of correlation progress and results.

**File -** the progress and total number of files to analyze.

**Points -** the number of data points calculated for the image.

**Error -** this is the average confidence margin for the data set; lower numbers indicate a better quality match.

**Time** - The amount of time spent on correlation analysis in seconds.

**Progress bar** - indicates the progress of each individual file as it is correlated.

This window also contains a preview of the output data. This data may be viewed and manipulated as with a standard plot.

When the analysis is complete, you may click View Report to see a summary of the above data.

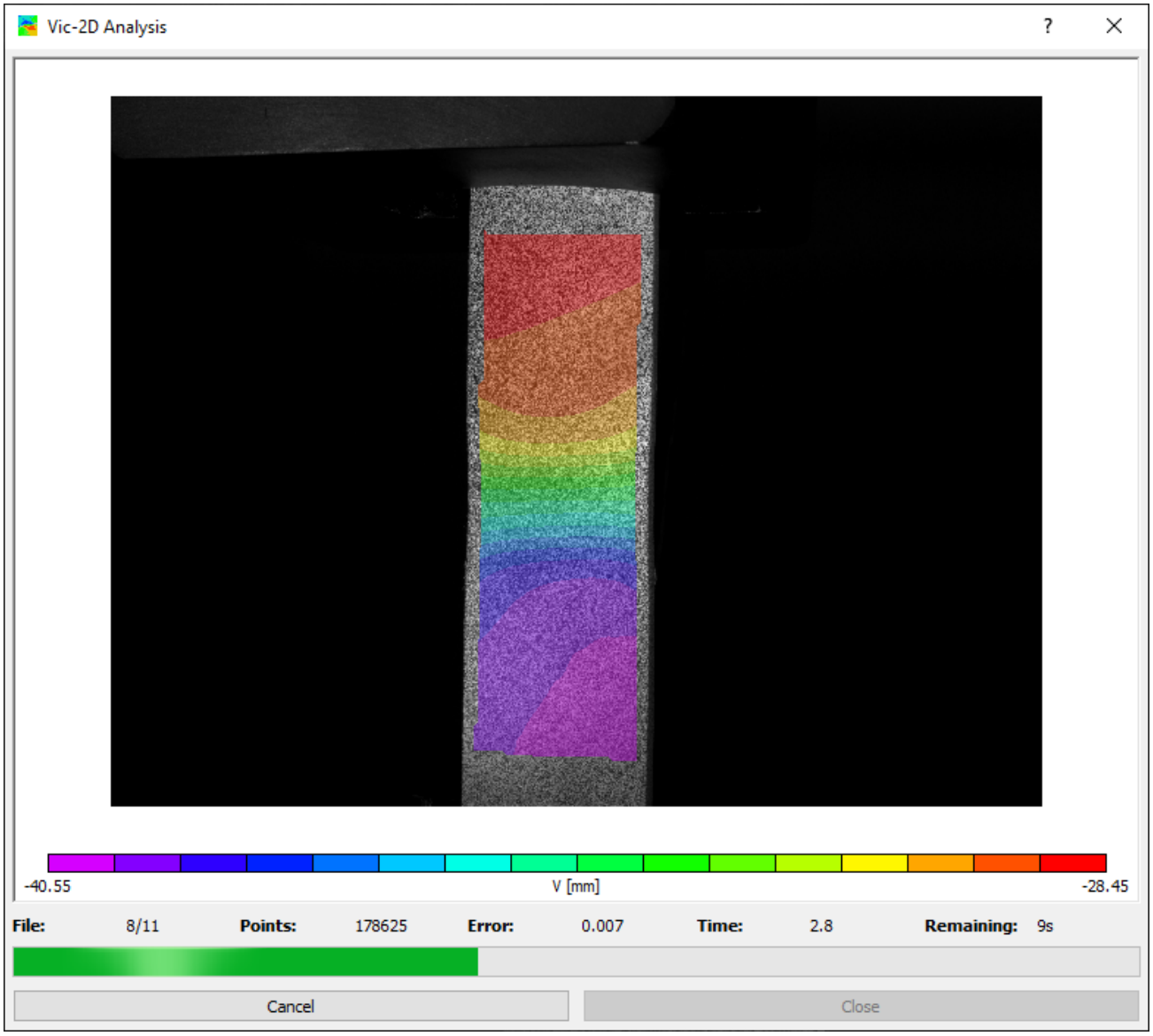



Figure 11.5: Analysis progress during correlation.

For more information on interpreting correlation results and troubleshooting errors, please contact Technical Support.

# Chapter 12

# Postprocessing tools

Once the initial position and displacement fields are calculated, several tools are available for processing the data.

- **Calculate strain** - calculate surface strain tensors
- **Remove rigid motion** - removes overall object motion, leaving only deformation
- **Apply function** - apply arbitrary user-defined functions to create new variables
- **Calculate velocity** - uses time information to calculate velocity and strain rate
- **Calculate in-plane rotation** - calculates local surface rotation
- **Smooth** - smooths data over a user-specified diameter
- **Delete variables** - remove variables created with other postprocessing tools
- **Apply math operation** - applies simple math operations to discrete variables

## 12.1 Strain Calculation

To calculate strain for one or more data sets, select *Data... Postprocessing options... Calculate strain* from the main menu. This will show the strain computation dialog as illustrated in Fig. 12.1. Note that strains may also be computed during the correlation analysis, see Section 11.18 for details.

### 12.1.1 Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses your selection.

### 12.1.2 Preview

To view the effects of the calculation for a single data file, highlight the file and click the *Preview* button. You may view the plot in 2D or 3D (in Vic-3D) as with a standard data plot.

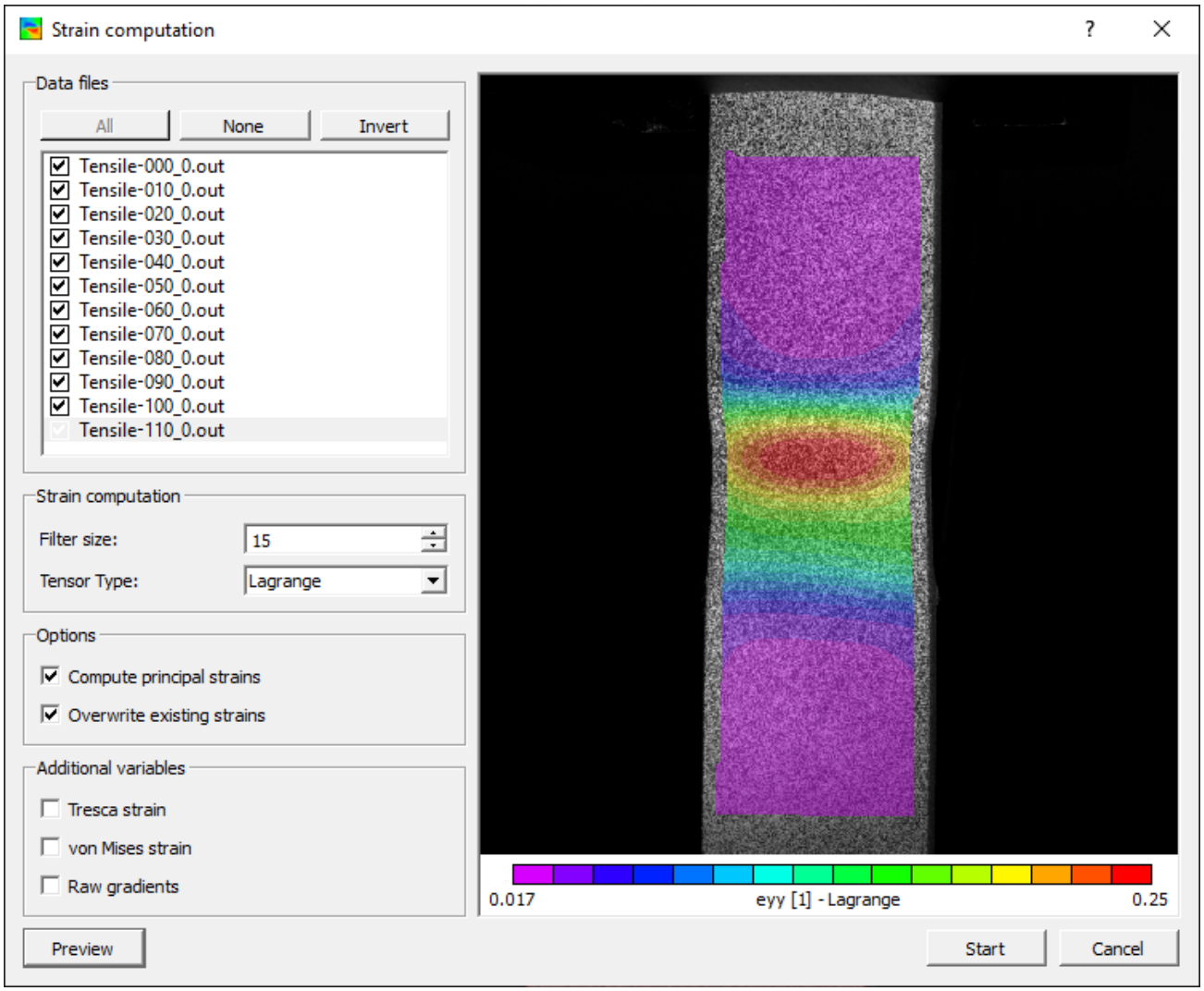



Figure 12.1: Strain dialog.

### 12.1.3 Compute Principal Strains

Check this box to add principal strains and principal strain angle to the calculated output data.

### 12.1.4 Overwrite Variables

Check this option to overwrite any existing strain calculations. If this box is clear, more data fields will be added to the output data set each time strain is calculated.

### 12.1.5 Compute Tresca/von Mises strain

Select these options to compute the Tresca/von Mises strain criterion along with the strain tensor calculation.

### 12.1.6 Filter size/type

Calculated strains are always smoothed using a local filter. The *Filter* box allows selection of a smoothing method. The decay filter is a 90% center-weighted Gaussian filter and works best for most situations; the box filter is a simple unweighted averaging filter.

The *Filter size* box controls the size of the smoothing window. Since the filter size is given in terms of data points rather than pixels, the physical size of the window on the object also depends on the step size used during correlation analysis.

### 12.1.7 Raw Gradients

This option can be used to output the components of the deformation gradient tensor $\mathbf{F}$. Note that the deformation gradient tensor is computed in the local tangential plane of the surface, and the $x$-direction is taken as the projection of the global $x$-coordinate onto this plane.

### 12.1.8 Tensor Type

Select the desired strain tensor. The default is Lagrangian finite strain. Note that in the case of Vic-3D, strains are computed in the local tangential plane of the surface, and the $x$-direction is taken as the projection of the global $x$-coordinate onto this plane. All strain tensors are derived from the deformation gradient tensor $\mathbf{F}$. Some of the definitions below use the Cauchy-Green deformation tensor

$$\mathbf{C} = \mathbf{F}^T \cdot \mathbf{F}$$

which is computed from the deformation gradient tensor $\mathbf{F}$.

**Lagrange**

This is the default strain tensor and is given by

$$\mathbf{E} = \frac{1}{2}\left(\mathbf{C} - \mathbf{I}\right)$$

**Hencky**

The Hencky strain, also called logarithmic or true strain, is given by

$$\mathbf{E}_H = \frac{1}{2}\ln\left(\mathbf{C}\right)$$

**Euler-Almansi**

The Euler-Almansi tensor is given by

$$\mathbf{e} = \frac{1}{2}\left(\mathbf{I} - \mathbf{F}^{-T} \cdot \mathbf{F}^{-1}\right)$$

**Logarithmic Euler-Almansi**

The logarithmic Euler-Almansi strain is computed according to

$$\mathbf{e}_l = \frac{1}{2}\ln\left(\mathbf{F} \cdot \mathbf{F}^T\right)$$

**Engineering**

In order to avoid non-sensical strains due to rigid body rotations, the engineering strain is not computed directly from the derivatives of the displacement, i.e., $\epsilon_x \neq dU/dX$. To access the plain derivatives, see Section 12.1.7 above. To make the strains insensitive to arbitrary rigid-body motion, the engineering strains are computed from the Lagrange strain tensor in the following manner:

$$\epsilon_x = \sqrt{(1 + 2E_{xx})} - 1$$

$$\epsilon_y = \sqrt{(1 + 2E_{yy})} - 1$$

$$\epsilon_{xy} = \sin^{-1}\left(\frac{2E_{xy}}{\sqrt{(1+2E_{xx})(1+2E_{yy})}}\right)$$

**Biot**

The Biot strain tensor is given by

$$\mathbf{E}_B = \mathbf{C}^{1/2}$$

## 12.2 Removing Rigid Motion

This tool is used to remove rigid-body displacement from deformed images, leaving only deformation components of displacement.

Once the displacement fields have been calculated from the speckle images, this tool can be started by selecting *Data... Remove displacements*.

### 12.2.1 Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

### 12.2.2 Processing Method

To remove all rigid body displacement, select *Use average transformation*. This will calculate the average transformation for each image, and invert it to obtain an image with an average displacement/rotation of 0. Only object *deformation* will be reflected in the transformed U, V, and W displacements. This is useful for visualizing displacement fields in tests where deformation is obscured by larger, rigid-body motions.

To keep a single point stationary, select *Keep 1 point fixed* and click the desired point in the image. Only points within the data set (highlighted in blue) may be selected. With this method, the selected point will become stationary, with all other displacements remaining relative to this point. Any initial rotation will still be present after the operation.

To keep three points stationary, select *Keep 3 points fixed*; then, click three desired points in the image to define the fixed points. With this method, all displacements and rotations will be

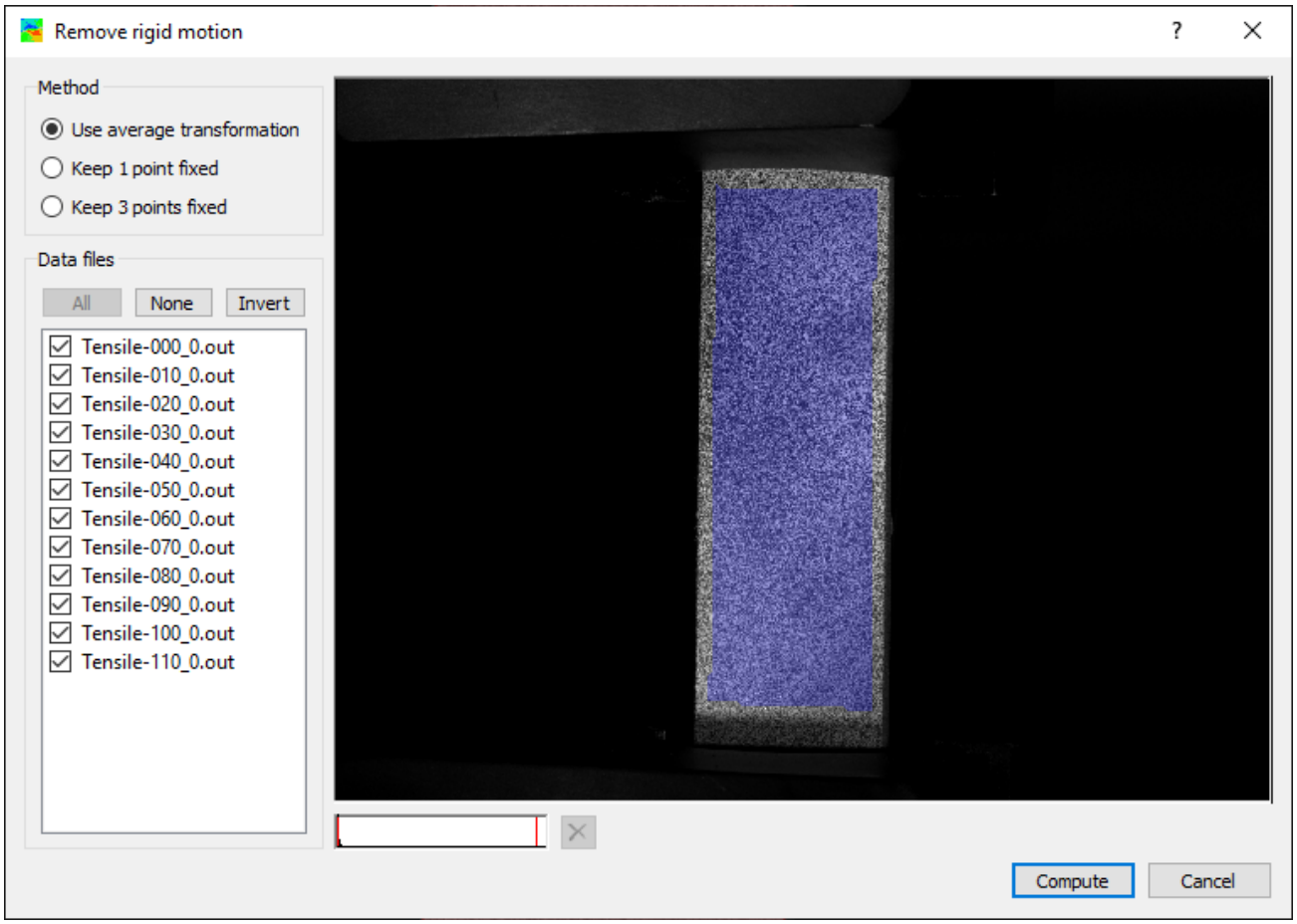



Figure 12.2: Rigid motion removal dialog.

relative to the three selected points, which will become stationary. The point- and three-point displacement options are useful for, i.e., determining deformation of a test subject relative to fixed mounting points or standoffs.

If the three points you select are in three different AOI's, you will be given the option to use the entire AOI for the operation. This will be useful if, for example, you have small AOIs on top of three separate fixed posts of a test fixture.

Click *Compute* to proceed with the computation.

**Strain calculation**

Note that these transforms will not affect calculated strain, nor are they necessary in order to correctly calculate strain; the strain algorithm is, by nature, insensitive to rigid-body displacements.

## 12.3 Applying Functions to Data

Vic-2D and Vic-3D support the generation of new variables based on equations applied to the data. This feature may be used, for instance, to compute engineering strains from Lagrange

strains, to compute stresses from strains or to compute thinning of a strained specimen of known thickness based on the Poisson's effect or volume conservation during plastic deformation.

Functions may be created, modified, and applied to data by selecting *Data... Postprocessing options... Apply function* from the main menu.

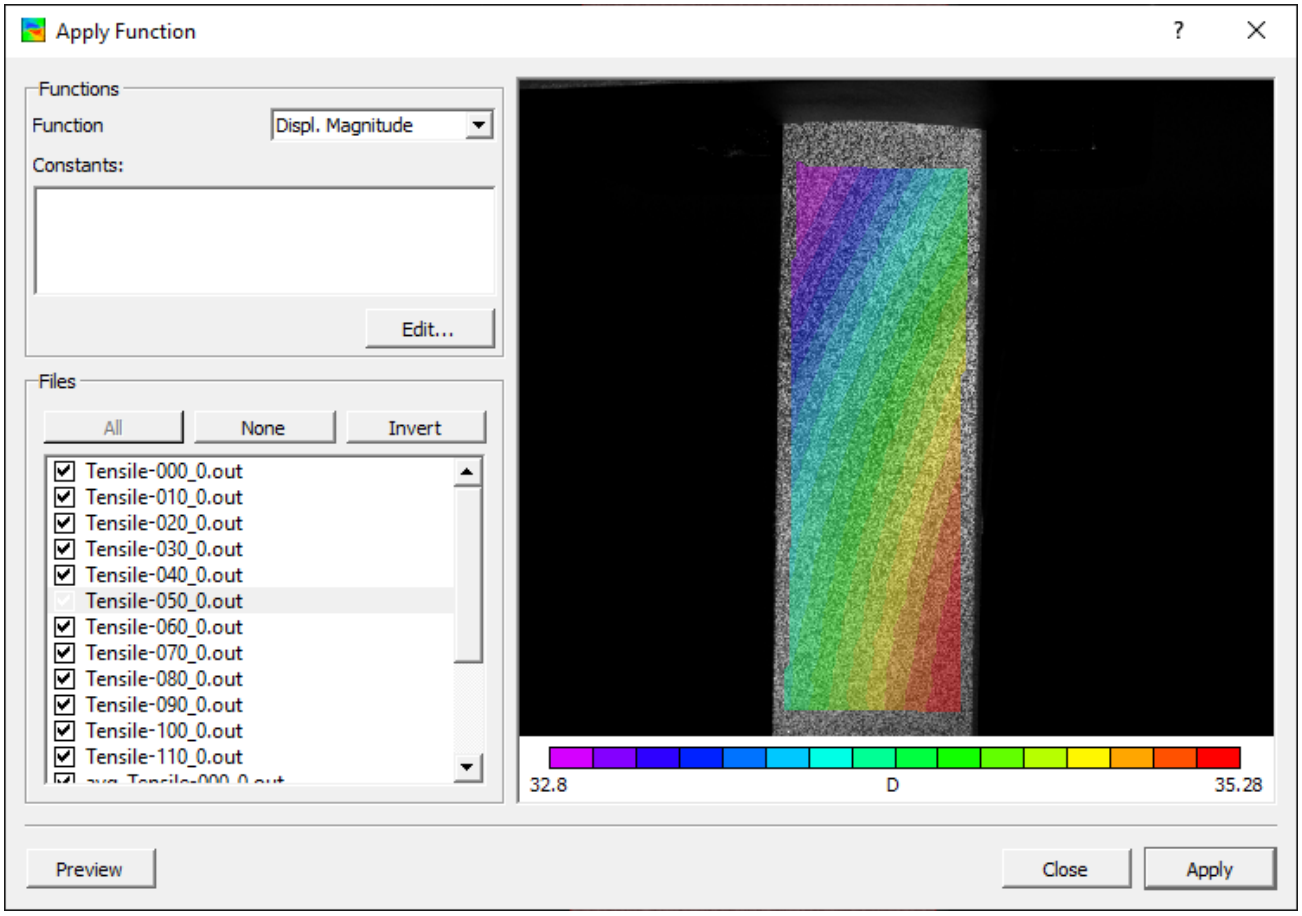



Figure 12.3: Apply function dialog.

A previously defined function may be selected from the *Function* pull-down menu in the upper left corner of the dialog. Each function may have one or more constants that are used in its equations. When a function is selected, the corresponding constants are displayed next to their current values. Some constants may contain pre-defined options for the value. Selecting any of the options in the value combo-box will set the constant to that value.

### 12.3.1 Creating and Editing Functions and Constants

New functions and constants can be created and existing ones can be edited. Click on the **Edit...** button to open up the *Edit Functions* dialog.

All available functions and constants are listed. Constants local to a function and the outputs of a function are listed underneath the function they belong to.

The four buttons underneath the list allow for the creation, editing and deletion of functions or constants. Each of the buttons are as follows:

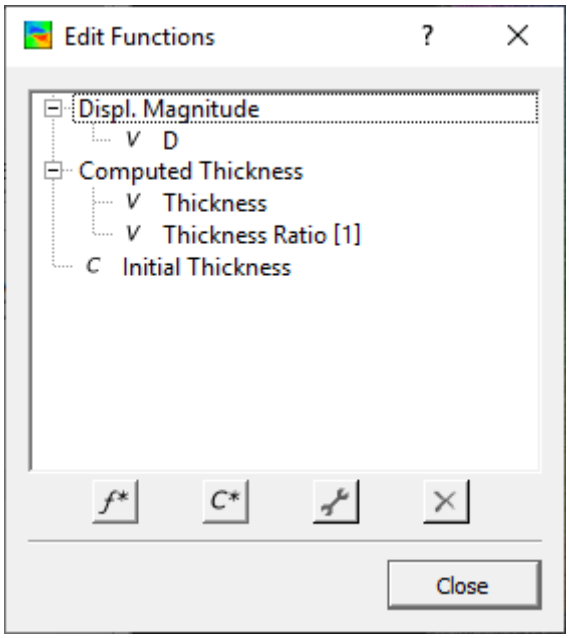



Figure 12.4: Edit functions dialog.

- $f^*$ Opens the wizard to create a new function.
- $C^*$ Opens the wizard to create a new constant.
- Opens a wizard to edit the selected function or constant. If an output is selected it opens the function wizard to the edit outputs page.
- Deletes the selected function or constant. If an output is selected it deletes the function it belongs to.

Double-clicking on any item in the list will open the respective wizard for editing.

### 12.3.2 Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. Files to be processed can be selected in the list at the top left by checking or unchecking. There all also buttons to select and deselect all files and to invert the current selection.

### 12.3.3 Preview

The effects of the calculation on a single data file may be previewed by highlighting the file and clicking the *Preview* button. You may view the plot in 2D or 3D as with a standard data plot.

### 12.3.4 The Function Wizard

Functions and their output variables can be defined and edited in the function wizard. The wizard is a multi-page dialog that allows the user to enter all information required to define a

function with one or more output variables.

#### 12.3.4.1 Function Information

The first page of the function wizard is for entering a brief description of the function and the scope in which the function is stored. The *Global* scope option stores the function in the program settings where it can be used by any project. The *Project* stores the function in the project itself. If the project option is selected, then the function and it's local constants are stored in the current project and is only accessible by the current project.

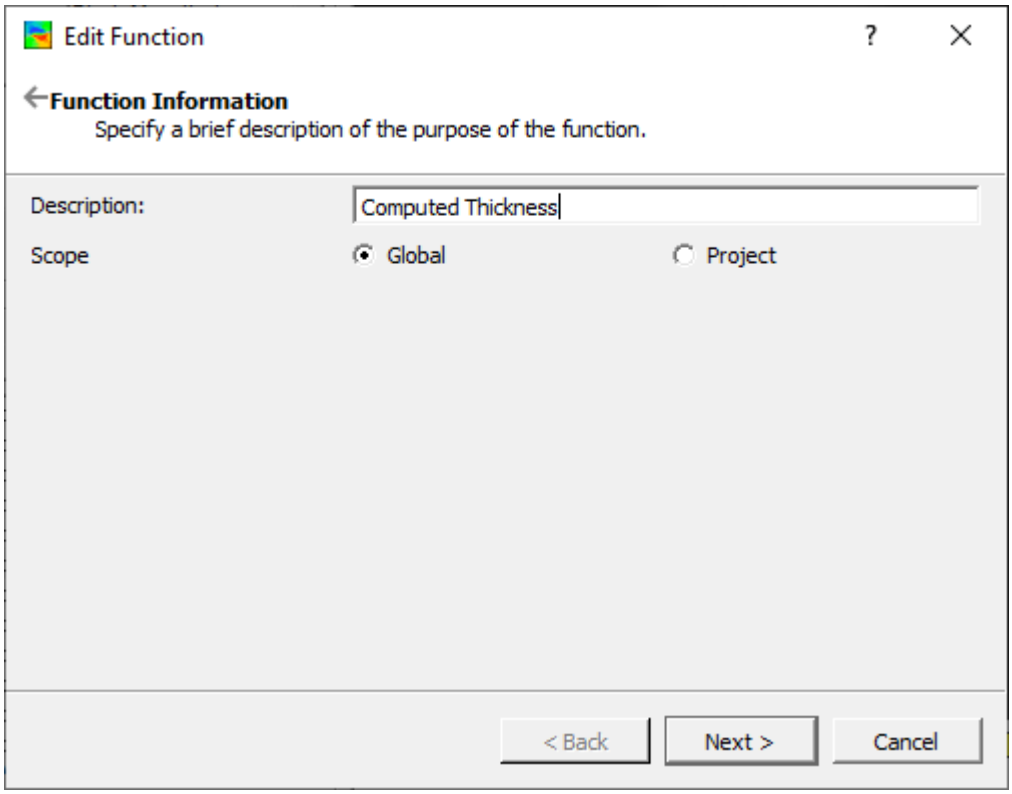



Figure 12.5: Function wizard information page.

#### 12.3.4.2 Define Equations

The next page is where the actual equations are entered. There can be multiple equations and they are separated by a new line; each should be in the form (variable)=(function definition). Double click on a variable at left to insert it at the cursor.

After you enter your equations and click *Finish*, any errors will be announced and corrections will be required before proceeding. For details on the equation syntax and built-in math functions, please refer to Section 12.3.6.

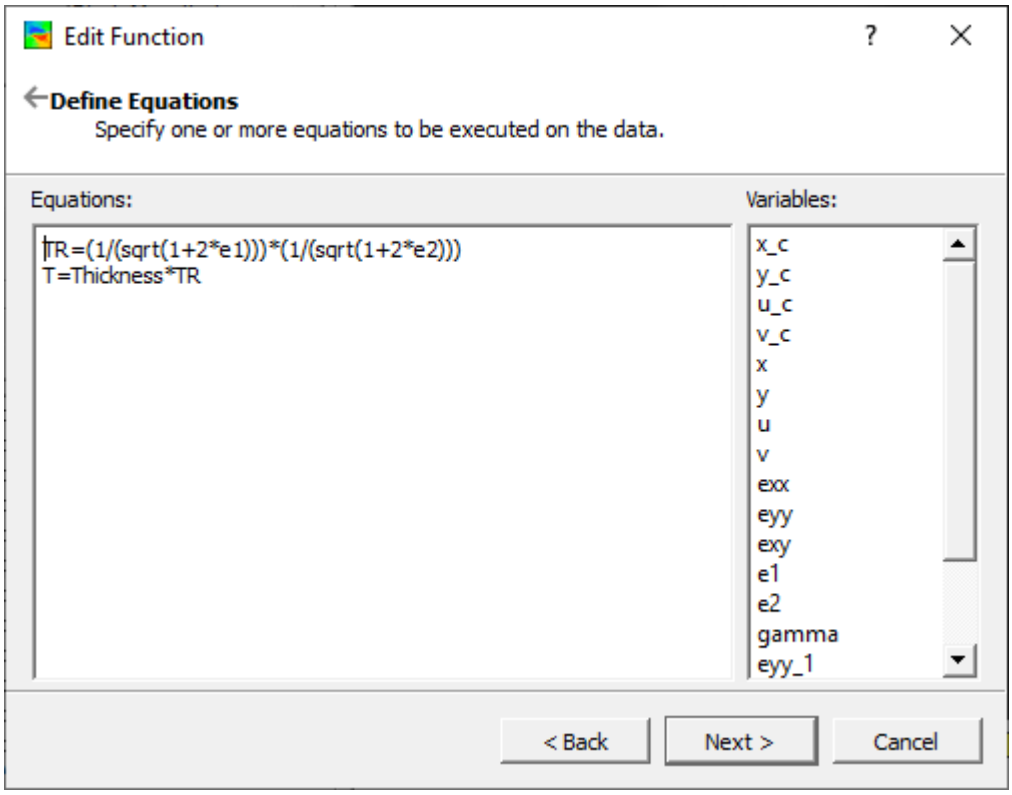



Figure 12.6: Function wizard equation page.

#### 12.3.4.3 Define Output Variables

Every function must have at least one output variable. The output variable is the information that is stored in the data files of the project. To add one, simply click *Add an output...* There are two things to be entered for each output. The first is the actual variable itself as used in equations. The second is a brief description of the variable - this will be displayed in plot context menus. The 'X' icon is the delete button. Clicking it will delete the associated output.

### 12.3.5 The Constant Wizard

Constants for use along with predefined values can be created and edited in the function wizard.

#### 12.3.5.1 Constant Information

The label defines what is to identify a given constant in an equation. The scope defines whether or not the constant is accessible to all functions (*Global*) or if it is only accessible to a specific function. The description is used to note the purpose of the constant.

#### 12.3.5.2 Define Options

Defining options is not necessary but it can be helpful; for instance, a preselected group of material property constants, as in the example below. There are two values for each option: a

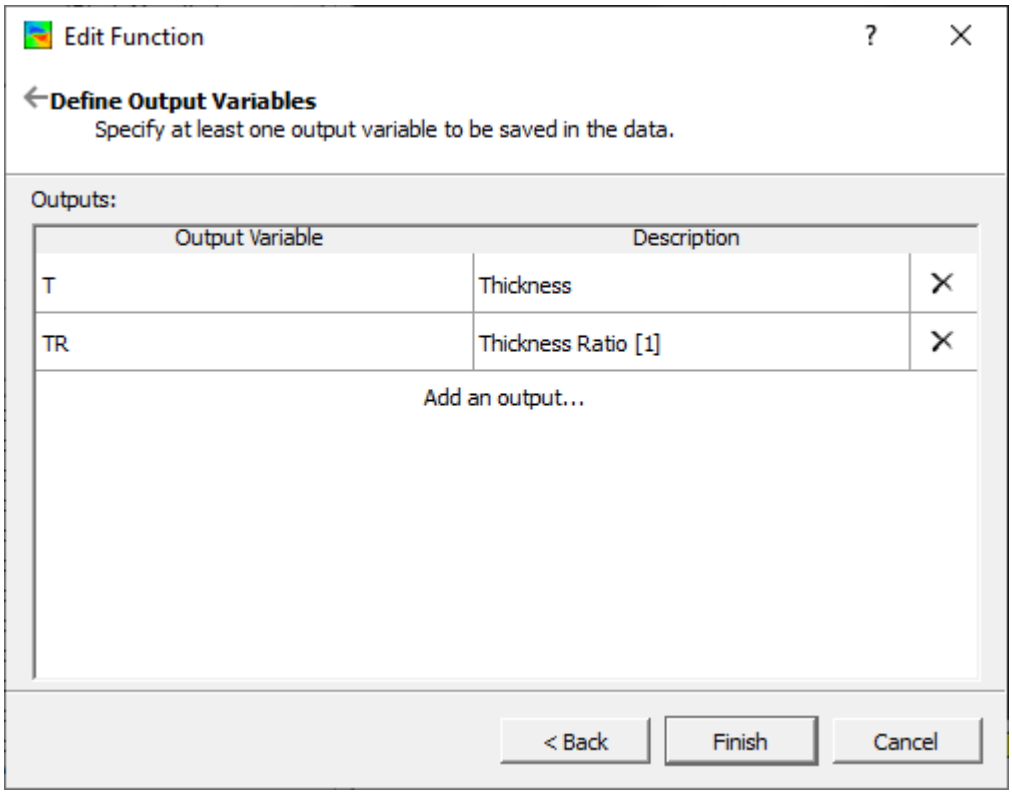



Figure 12.7: Function wizard outputs page.

description and a value.

### 12.3.6 Equation Format, Operators and Built-in Functions

The following table lists the functions that can be used in equations in Vic-2D and Vic-3D and the number of arguments they require.

| Function name | Argument count | Explanation |
|---|---|---|
| `sin` | 1 | sine function |
| `cos` | 1 | cosine function |
| `tan` | 1 | tangens function |
| `asin` | 1 | arcus sine function |
| `acos` | 1 | arcus cosine function |
| `atan` | 1 | arcus tangens function |
| `sinh` | 1 | hyperbolic sine function |
| `cosh` | 1 | hyperbolic cosine |
| `tanh` | 1 | hyperbolic tangens function |
| `asinh` | 1 | hyperbolic arcus sine function |
| `acosh` | 1 | hyperbolic arcus cosine function |
| `atanh` | 1 | hyperbolic arcus tangens function |
| `log2` | 1 | logarithm to the base 2 |

| Function name | Argument count | Explanation |
|---|---|---|
| log10 | 1 | logarithm to the base 10 |
| log | 1 | logarithm to the base 10 |
| ln | 1 | natural logarithm to base e (2.71828...) |
| exp | 1 | e raised to the power of x |
| sqrt | 1 | square root of a value |
| sign | 1 | sign function -1 if x<0; 1 if x>0 |
| rint | 1 | round to nearest integer |
| abs | 1 | absolute value |
| min | var. | min of all arguments |
| max | var. | max of all arguments |
| sum | var. | sum of all arguments |
| avg | var. | mean value of all arguments |

The table below lists the binary operators available in Vic-2D and Vic-3D in order of priority (higher values mean higher priority).

| Operator | Meaning | Priority |
|---|---|---|
| and | logical and | 1 |
| or | logical or | 1 |
| xor | logical xor | 1 |
| <= | less or equal | 2 |
| >= | greater or equal | 2 |
| != | not equal | 2 |
| == | equal | 2 |
| > | greater than | 2 |
| < | less than | 2 |
| + | addition | 3 |
| - | subtraction | 3 |
| * | multiplication | 4 |
| / | division | 4 |
| ^ | raise x to the power of y | 5 |

## 12.4 Calculating Velocity

Vic-2D and Vic-3D can calculate rates for displacement and strain, using either a specified time interval or time retrieved from a .CSV log file.

Once the displacement fields have been calculated from the speckle images, velocities may be calculated by selecting the *Calculate Velocity* entry on the *Data* menu. (If strain rates are desired, strain should be calculated before opening the *Calculate Velocity* dialog.) This will display the dialog shown in Fig. 12.10.

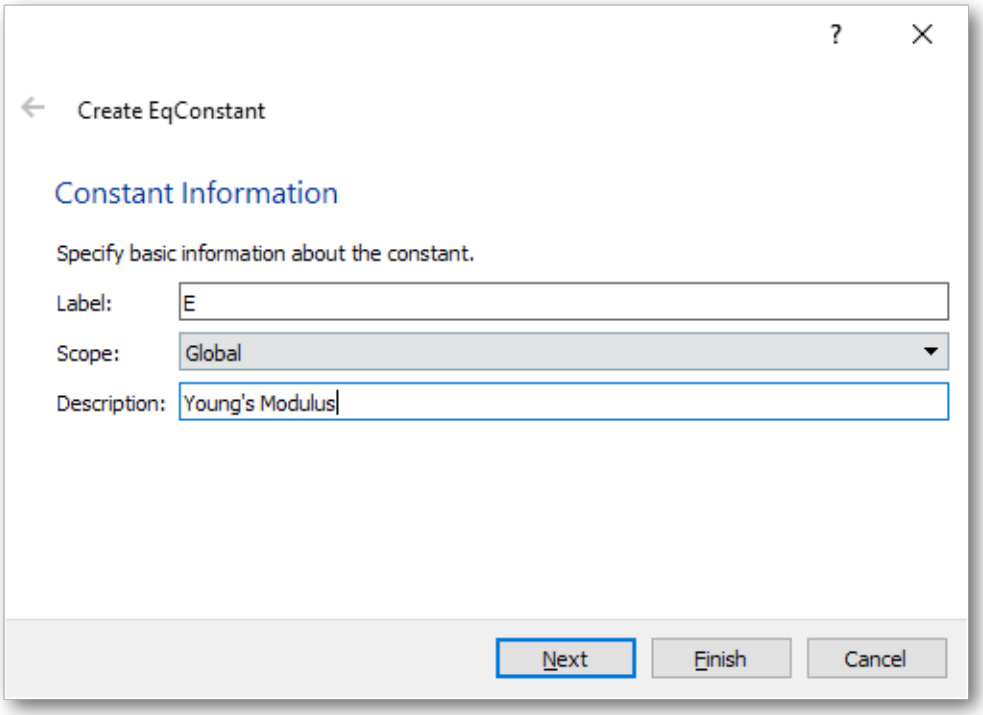



Figure 12.8: Constant wizard information page.

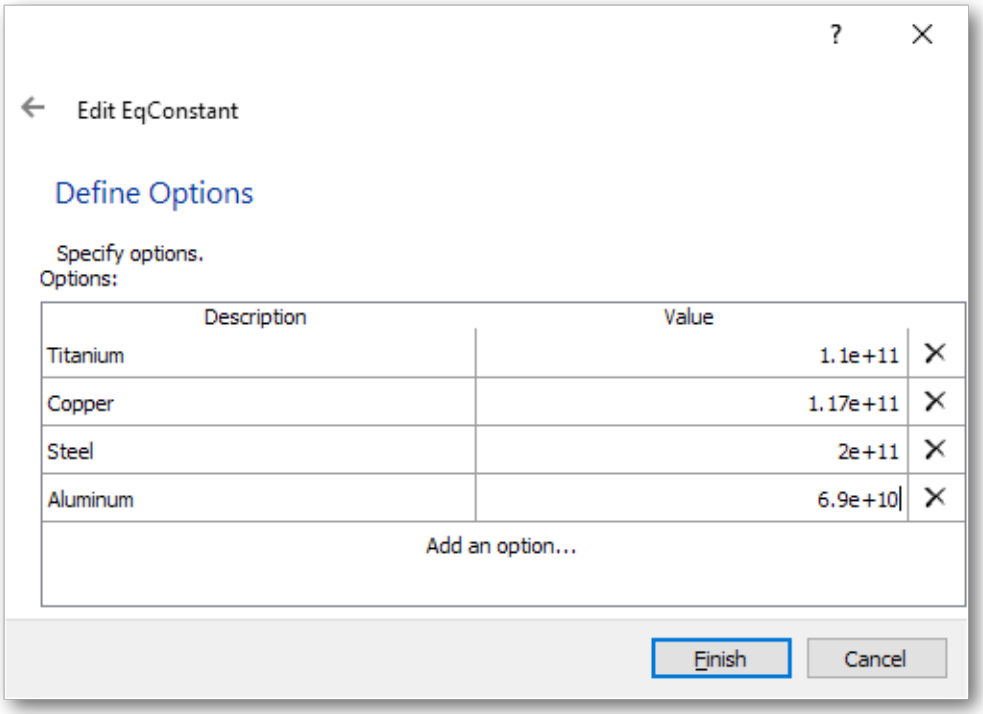



Figure 12.9: Constant wizard options page.

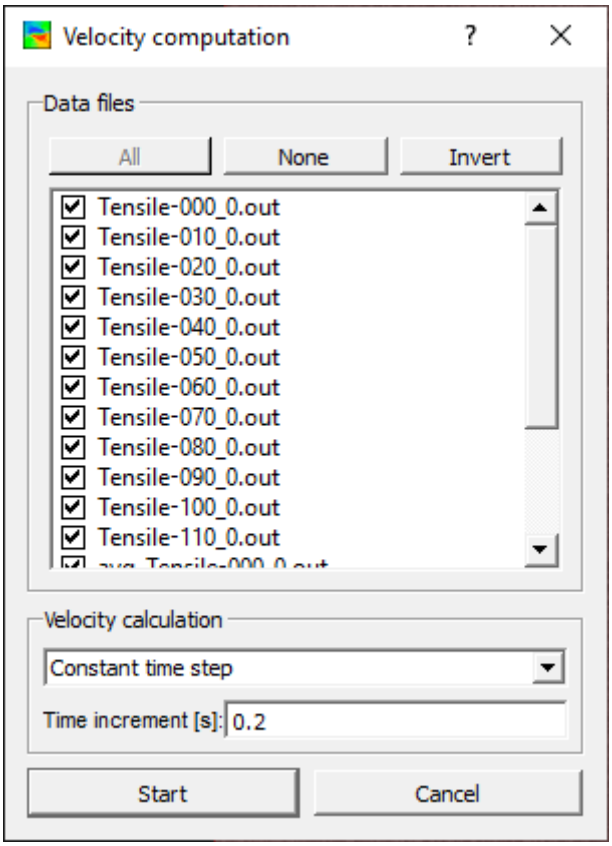



Figure 12.10: Velocity dialog.

### 12.4.1 Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

### 12.4.2 Velocity Calculation

If a Vic-Snap .CSV log file exists for the project, you may select "Time From File" from the dropdown and select the file, if necessary. Otherwise, select "Constant Time Step" and enter the known time increment, or select "Constant Frame Rate" to enter a known frame rate, e.g., for data from a high-speed camera.

Click Start to begin; the progress bar will indicate completion. For each strain and displacement variable in the dataset, a derivative in time will be added and can be viewed as a contour overlay.

## 12.5 Rotation Calculation

To calculate local in-plane rotation for a set of data, select *Data... Postprocessing options... Calculate in-plane rotation* from the main menu. This displays the dialog illustrated in Fig. 12.11.

> This function computes the in-plane rotation around the local surface normal. To compute rigid-body rotation angles for the entire data set or selected areas (Vic-3D only), see Section 14.9.1.

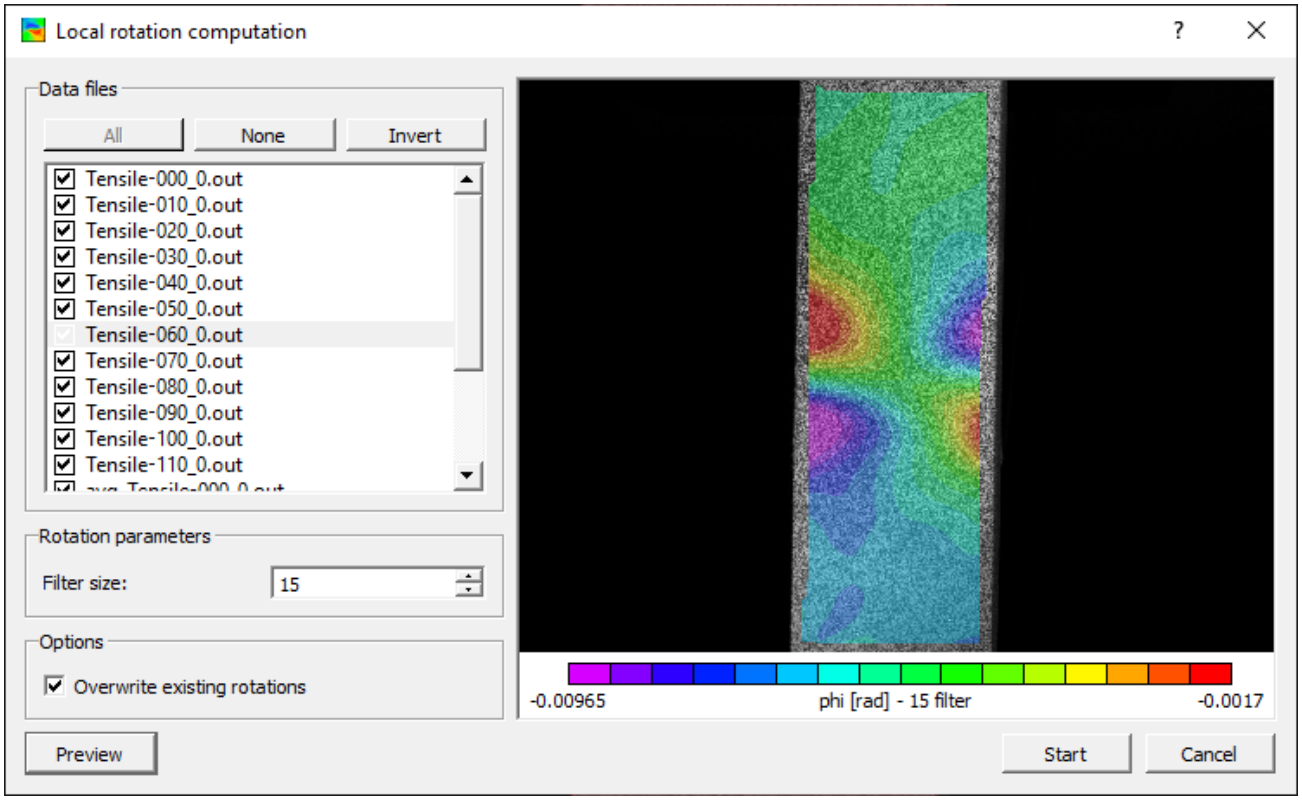



Figure 12.11: Rotation computation dialog.

### 12.5.1 Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. The files that will be processed are indicated with a check mark on the left. Selections can be made by clicking on the check boxes or by selecting one or multiple entries and pressing *Space* or *Enter*. The context menu provides further options for selecting a subset of data files. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses the current selection.

### 12.5.2 Filter Size

The *Filter size* box controls the size of the window over which the rotation is computed. Note that a Gaussian weight function is applied to the window. Since the filter size is given in terms of data points rather than pixels, the physical size of the window on the object also depends on the step size used during correlation analysis.

### 12.5.3 Overwrite Variables

This box can be checked to overwrite any existing rotation variables from a previous computation. If this box is not checked, more data fields will be added to the output data set each time rotation is calculated.

### 12.5.4 Preview

To view the effects of the calculation for a single data file, highlight the file and click the *Preview* button. Note that the context menu of the plot can be used to switch between 2D and 3D plotting modes.

## 12.6 Smoothing Data

A smoothing filter may be applied to one or more data files by selecting *Data... Postprocessing options... Smooth variable* from the main menu.

### 12.6.1 Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses your selection.

### 12.6.2 Preview

The effects of the calculation for a single data file may be displayed by highlighting the file and clicking the *Preview* button. The resulting plot may be viewed in 2D or 3D (for Vic-3D) as with a standard data plot.

### 12.6.3 Filter Size and Type

Data is smoothed using a local filter. The *Method* box allows selection of a smoothing method. The decay filter is a 90% center-weighted Gaussian filter and works best for most situations. The box filter is a simple unweighted averaging filter.

The *Filter size* box controls the size of the smoothing window. Since the filter size is given in terms of data points rather than pixels, the physical size of the window on the object also depends on the step size used during correlation analysis.

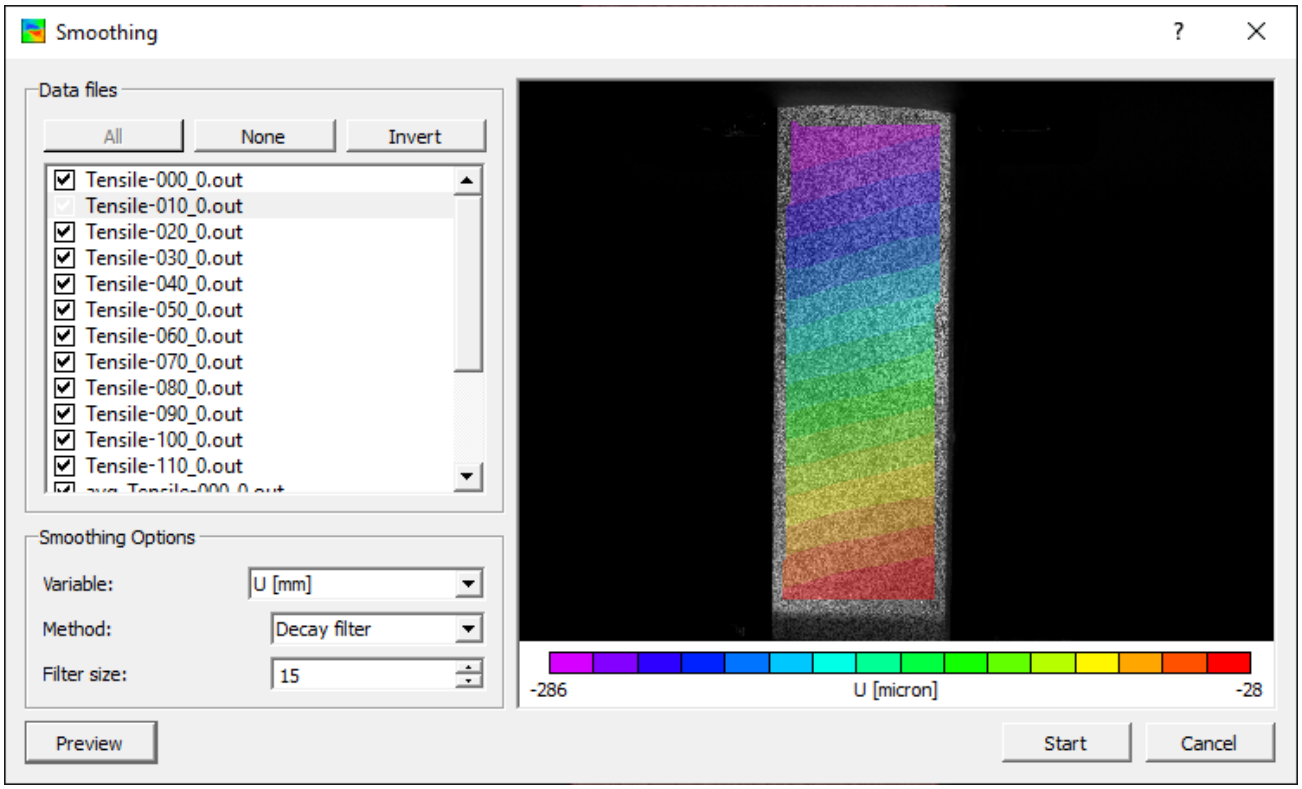



Figure 12.12: Smoothing dialog.

By default, 3D plots display deformed data - the sum of each point's X,Y,Z location and its U,V,W displacement. Because of this, creating a smooth plot of 3D data like the one above requires smoothing both Z and W.

## 12.7 Deleting Variables

User-generated variables can be deleted from data files.

Use this functionality with caution. Once removed, variables cannot be restored other than by reprocessing.

To remove variables from data files, select *Data... Postprocessing tools... Delete variables* from the main menu.

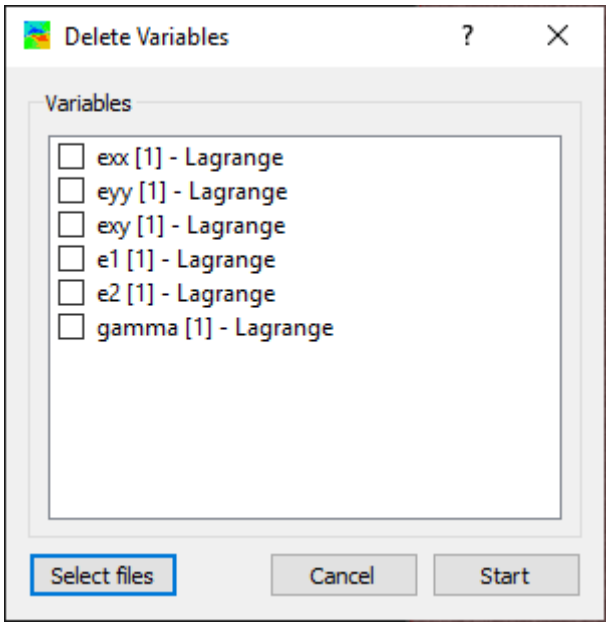



Figure 12.13: Delete variables dialog.

### 12.7.1 Selecting Data Files for Processing

Clicking **Select files** will bring up a standard file selection dialog, allowing the choice of some or all files to be processed.

### 12.7.2 Selecting Variables

The available variables are listed in the list box on the right of the dialog. Checking the box next to a variable will cause it to be deleted.

> Only user-generated variables such as strain, velocity, etc. may be deleted. Displacement, position, etc., may not be removed.

## 12.8 Time Filter

Time filters can be used to filter the full-field data along the time axis. Currently, filters for removing outliers and for smoothing are provided. The time filter dialog provides the ability to select multiple filters to create a filter chain. This can be used to, e.g., remove outliers and smooth data in a single pass. The time filter dialog is shown below.

To apply time filters to a data sequence, select *Data... Postprocessing options... Time filter* from the main menu.

Placing an inspector point prior to opening the dialog will allow visualization of the filtering effect on the data.

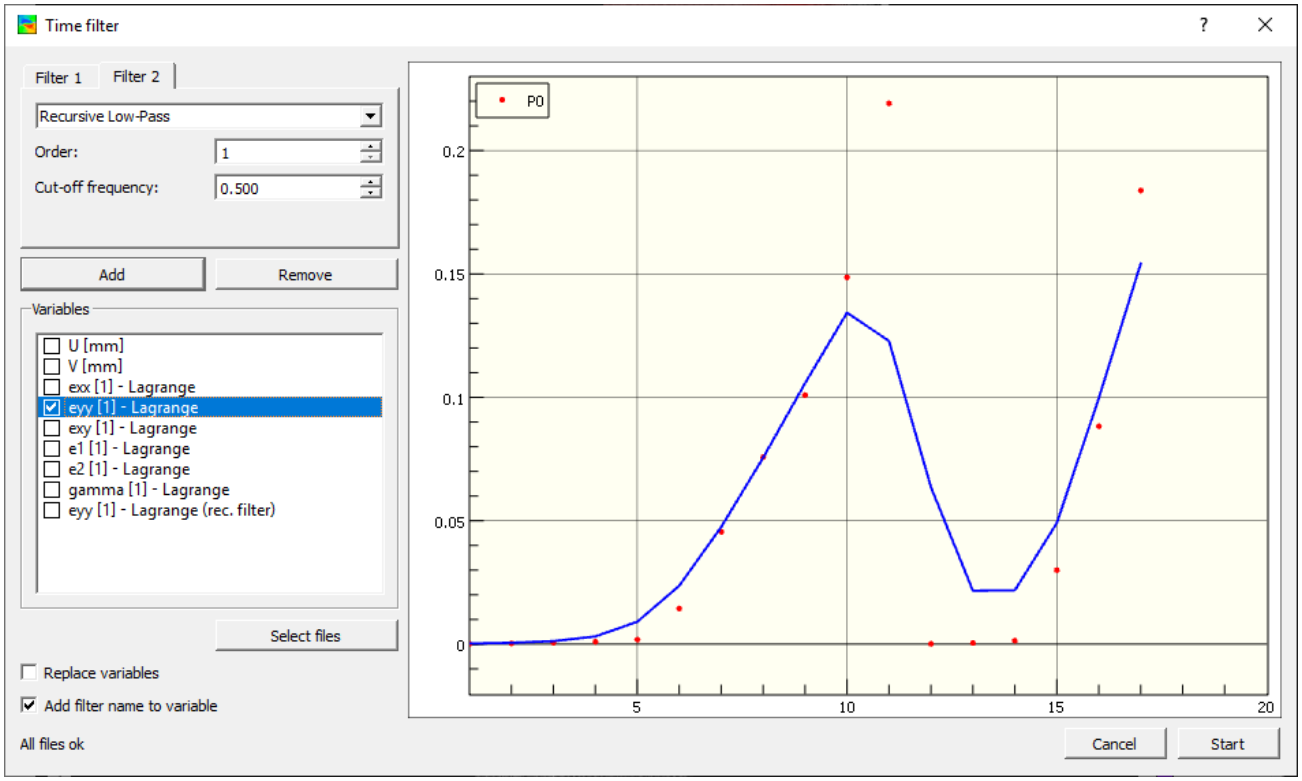



Figure 12.14: Time filter dialog

### 12.8.1 Validation

On startup, the time filter dialog validates the data files in the project. A progress bar in the bottom left corner indicates the progress of this operation. For projects with a large number of data files, this process may take some time to complete.

### 12.8.2 Preview

The time filter dialog can provide a preview that is updated in real time. This preview is available if inspector points, discs or rectangles have been added to any of the contour plots in the project. Note that the preview only becomes available after validation of the input files and after a variable for filtering has been selected.

### 12.8.3 Variables

In the variable box, one or more variables can be selected to which the filters are applied. The *Replace* variables check box can be used to overwrite the existing variables with the filtered results instead of creating new variables. The *Add filter names* to variables check box indicates whether the variable names of the filtered data should contain a description of the filter chain or not.

### 12.8.4 Filter Selection and Filter Chains

The type of filter to be applied can be selected in the drop-down box in the top-left corner of the dialog. By clicking the *Add* button, a second or third filter can be added to the filter chain. The *Remove* button can be used to remove an unwanted filter from the filter chain. Note that the filters are applied in the order they are added, as indicated by the number for the filter displayed on the tab bar.

### 12.8.5 Binomial Filter

The binomial filter is useful to apply moderate amounts of smoothing to the data. The binomial filter is a simple convolution filter. For a filter size of 3, the convolution mask is 1/4[1 2 1], and the larger filter masks can be obtained by repeated convolution of this mask with itself. The filter options for the binomial filter are shown below.

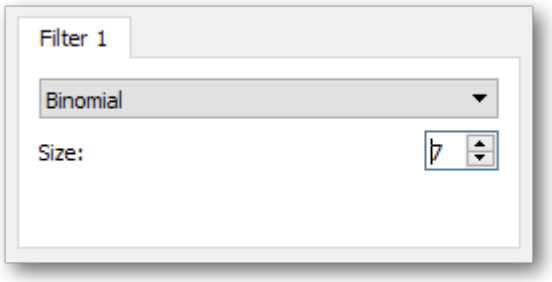



Figure 12.15: Binomial filter options.

### 12.8.6 Median Filter

The median filter is useful for removing outliers from the data. The filter computes the median value in a neighborhood with user selectable size (see figure below). If the median filter is used in a filter chain, it should always be selected as the first filter so that outliers do not contribute to the results of the other smoothing operations.

### 12.8.7 Recursive Low-Pass Filter

The recursive low-pass filter can be used to efficiently provide a large amount of smoothing. As illustrated below, the filter provides a user-selectable cut-off frequency and order. The cut-off

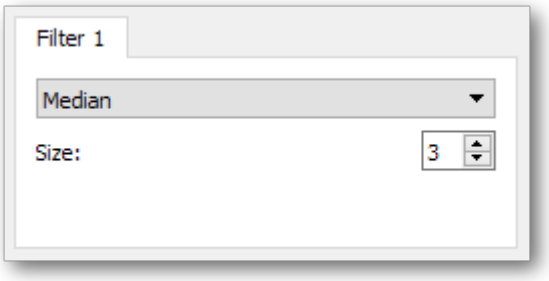



Figure 12.16: Median filter options

frequency is the (normalized) frequency at which the transfer function has a value of 50%. The order determines the steepness of the fall-off. Note that for very low cut-off frequencies, this filter does not preserve the mean value of the data.

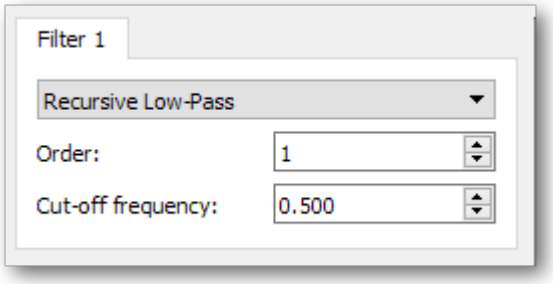



Figure 12.17: Recursive low-pass filter options.

### 12.8.8 Spline Fit Filter

The spline fit filter can be used to provide large amounts of smoothing. Depending on the order of the spline (linear, quadratic or cubic), this filter fits a curve consisting of multiple segments with c0, c1 or c2-continuity between the segments. The lower the number of segments, the more smoothing is accomplished. Note that the number of segments must be lower than the number of data points. The options panel for the spline fit filter is shown below.

## 12.9 Time Averaging Data

The Time Averaging dialog is used for dealing with data which requires time averaging to eliminate certain biases or provide extra accuracy.

This functionality is designed to work with data which has been acquired in a specific way: for each specimen state, $n$ image pairs should be acquired. For instance, 10 images taken at the reference state, 10 images taken at the first load step, etc. Next, the data including all images should be analyzed as usual. With the data below, we have taken 5 images at each of 8 load states, including the reference state.

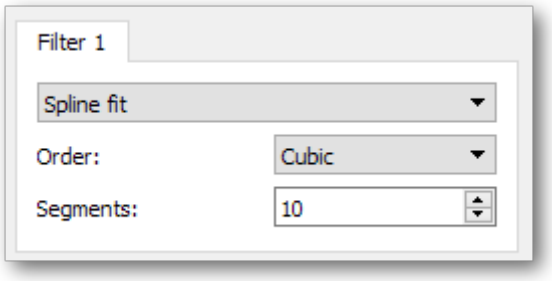



Figure 12.18: Spline fit filter options.

Once the data is calculated from the speckle images, click *Data...* *Postprocessing tools...* *Time Average Data* on the main menu.

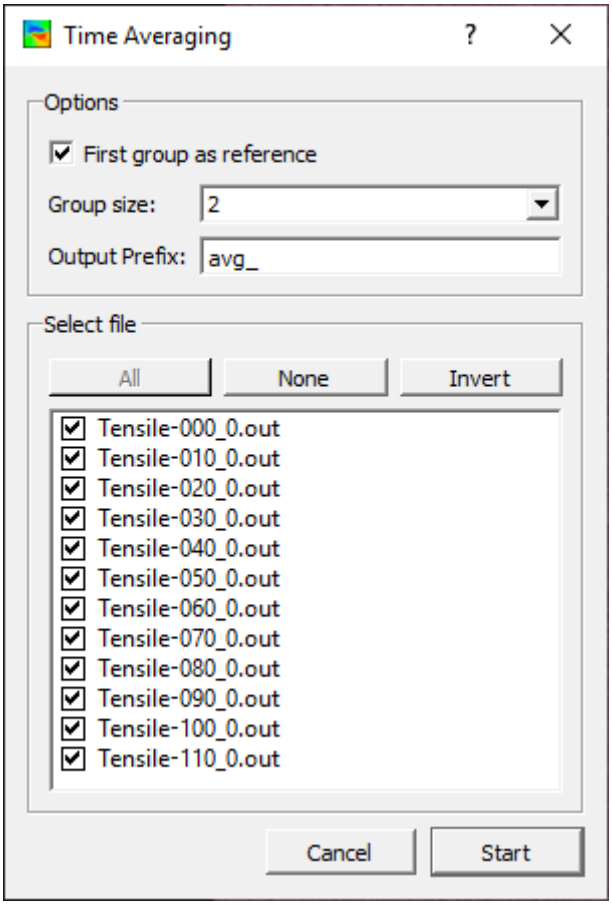



Figure 12.19: Time average dialog.

### 12.9.1 Options

If the **First group as reference** box is checked, the first set of data will be averaged to create a new reference configuration; then, this reference configuration will be subtracted from later groups, in effect re-referencing all of the data to a new, averaged meta-reference image.

The **Group size** indicates the number of images taken at each stage. Only divisors of the data file count may be selected so it is important that the correct number of input data files are present (an even multiple of $n$ from above).

The new data files are prefixed with the selected **Output prefix**.

### 12.9.2 Selecting files

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

To begin the computation, click the **Start** button.

### 12.9.3 Results

Once the computation is finished, a new set of averaged data files will appear in the project panel under *Other data* as illustrated in Fig. 12.20. These data files contain the time averaged (and re-referenced, if selected) data. For plotting purposes, each averaged file is linked to a single input image so that 2D plots will display correctly.

### 12.9.4 Usage notes

The time average function can be used for any data that is noisy over time. Examples would include data which has pixel noise due to low light/high gain, as well as data which is corrupted by refractive heat waves. The specimen itself should be in exactly the same position for each of the $n$ images to avoid any bias; ideally, the only thing changing within an image set is the relevant noise.

## 12.10 Math Operations

The *Math operations* dialog allows manipulation of output data by basic math operations. Open this dialog by selecting *Data... Math Operations* from the main menu bar.

### 12.10.1 Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

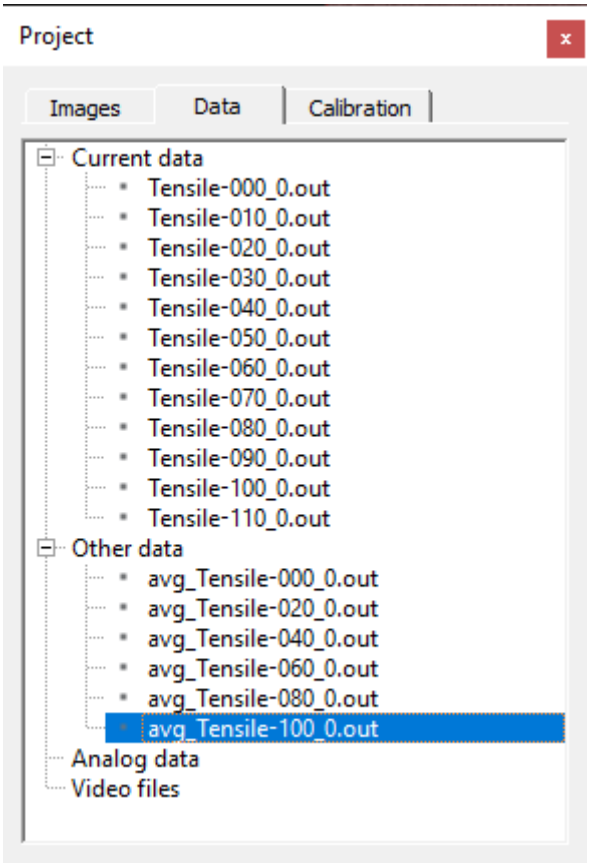



Figure 12.20: Project data panel showing time average data.

### 12.10.2 Operation

Choose Add, Subtract, Multiply, or Divide to perform the specified operation.

### 12.10.3 Arguments

The *Variable* box is used to select the variable to operate on. Any variable in the data set may be selected.

To use a constant argument, select the *Constant* radio button and enter the value. For example, the selections below will multiply the u-displacement value from each data file by 10.

To use the data from an output file, click *Data* and select a data file. For example, the selections below will subtract the Z shape from the first data file, from all data files.

Click Start to begin; the progress bar will indicate completion. For each strain and displacement variable in the dataset, a derivative in time will be added and can be viewed as a contour overlay.

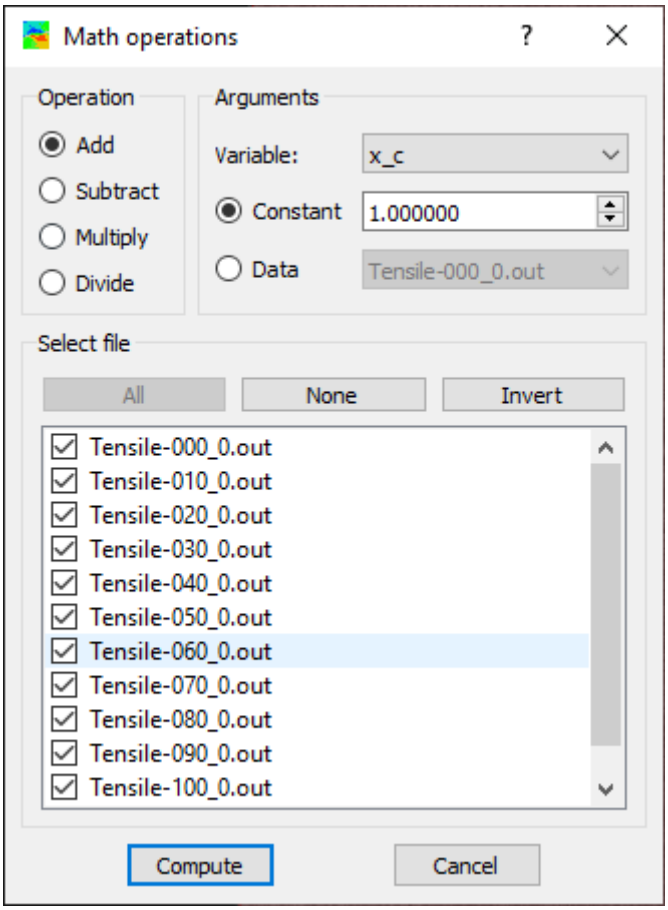



Figure 12.21: Math operations dialog.

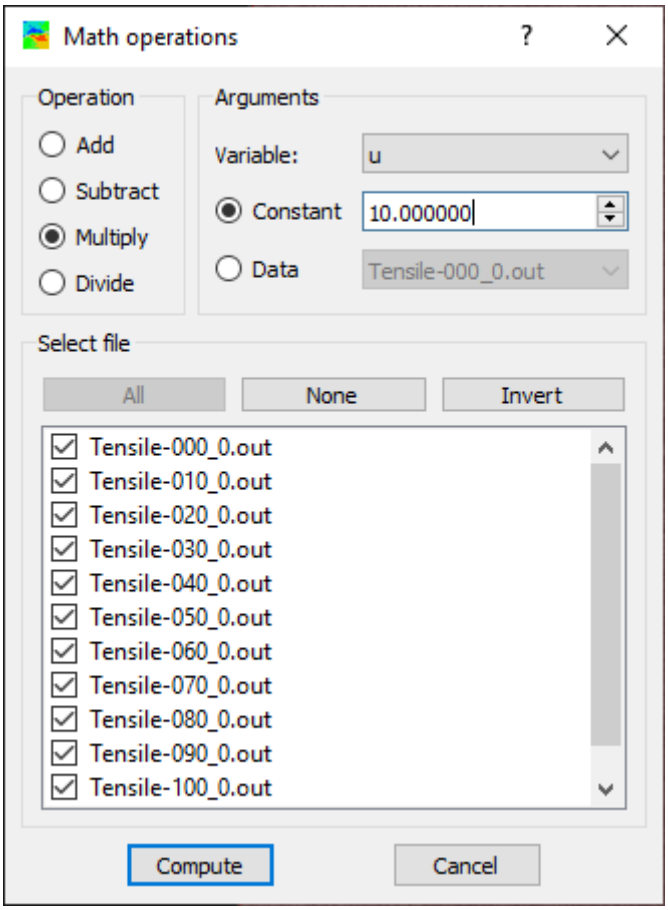



Figure 12.22: Math operation using a constant input.

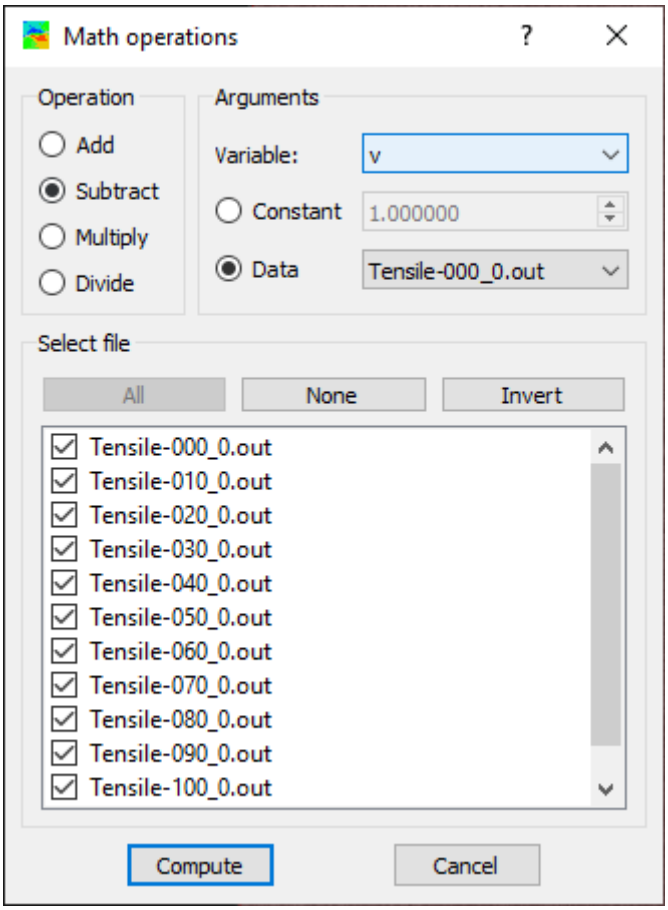



Figure 12.23: Math operation using a data file as input.

# Chapter 13

# Exporting Data

Calculated position and displacement data, along with transformed and post-processed variables, can be exported via several different options:

- **All data** - export entire data set
- **Pixel grid data** - sample data set on a pixel grid
- **Metric node data** - place surface nodes using metric coordinates, e.g., for FE comparisons
- **Aggregate statistics** - export mean, median, deviation, min, max for selected files and variables

When viewing exported data, keep in mind that X, Y, and Z are the *reference* position of each point. In Vic-3D, these values are displayed as changing through time for visualization, but in exported data, these values will be *constant* through time.

## 13.1 Exporting All Data

For efficient file access, data is stored in a binary file format. To use the data with other programs for post-processing and plotting, the data can be exported by selecting the *Export* item from the *Data* menu or using the keyboard shortcut `CTRL+E`. The dialog shown in Fig. 13.1 will appear.

### 13.1.1 Selecting Files for Exporting

The available data files are displayed in the list box. To select which files to export, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files.

### 13.1.2 File Formats

The data files can be exported to the following formats:

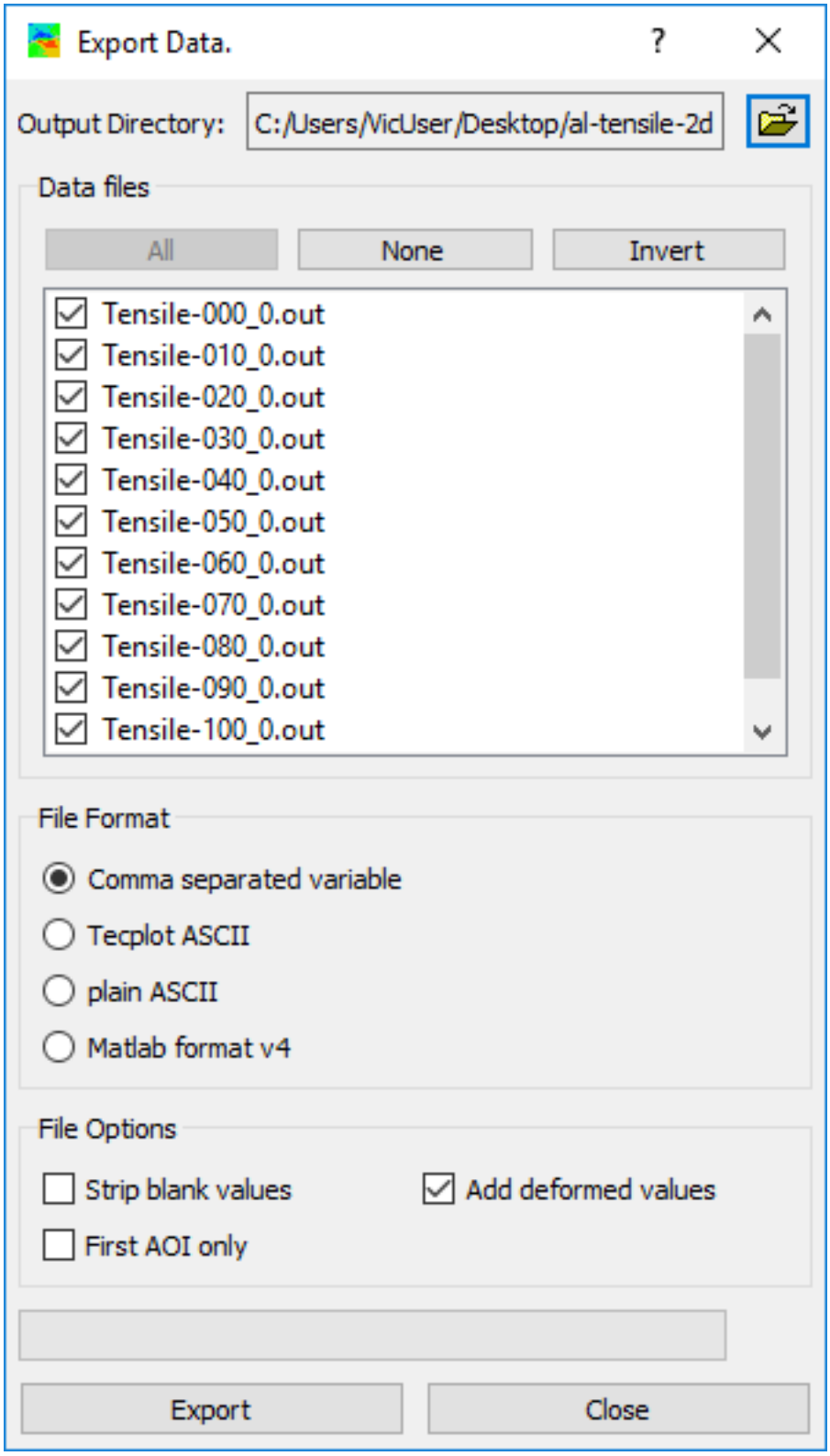



Figure 13.1: Export data dialog.

**Comma-Separated Variable**
: Data entries are separated by commas. This format is understood by most spreadsheet programs and plotting packages. Variable names are stored in the data file as comma-separated strings in quotation marks. Exported files will have the extension *csv*.

**Tecplot**
: Used for plotting the data with *Amtec's* (www.amtec.com) plotting program *Tecplot(TM)*. Exported files will have the extension *dat*.

**Plain ASCII**
: This format is plain, space-delimited ASCII text data with one data point per line. Note: There are no variable names in the data file, and data from different AOIs is concatenated. Exported files will have the extension *txt*.

**STL Format**
: This format provides a triangulated surface compatible with many CAD programs.

**Matlab V4**
: This format provides compatibility with Matlab and many other programs capable of reading Matlab files. Note that if multiple AOIs are present in a datafile, unique names for each of the matrices are generated by appending increasing numbers to the variable names. For instance, the X-coordinate for the first AOI will appear as *X* in the matlab file, and for the second AOI it will appear as *X_0* and so forth.

If none of the available file formats fit your needs, please contact support@correlatedsolutions.com. We will gladly implement data exporting to a format that best suits your needs.

## 13.2 Exporting Grid-Based Data

This option can be used to export your data, sampled at regular intervals spatially (in the image domain) and for each data file, to a single text file. To begin, select *Export Grid Data* from the *Data* menu.

### 13.2.1 Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

### 13.2.2 Options

To change the sample interval in pixels, adjust the *Sample step* value. A value of 1 will sample every pixel; higher values will result in a sparser data set.

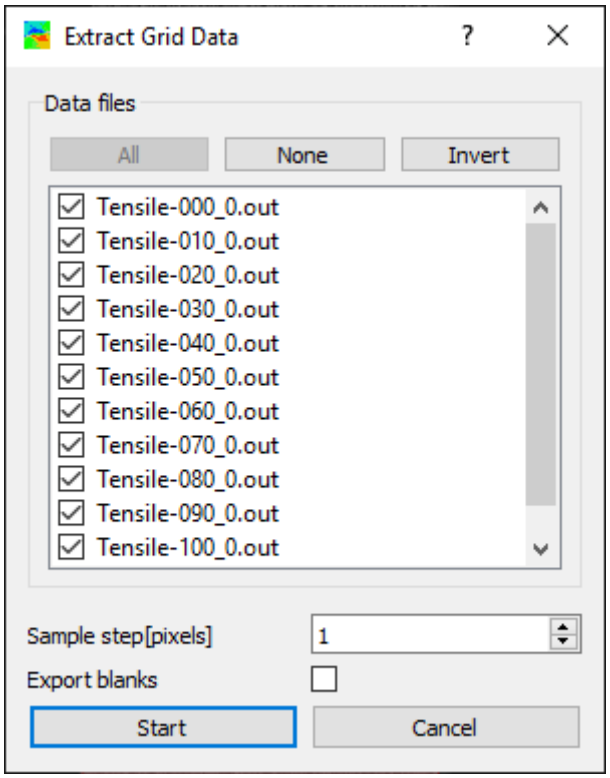



Figure 13.2: Extract grid data dialog.

To export blank values to the output file, with a value of 0, check the *Export blanks* box. If this box is cleared, blank data points will not be present in the output file.

### 13.2.3 Extracting Data

To begin, click *Start*. You will be prompted for an output .csv file name. A progress bar will appear; when extraction is complete, the dialog will close.

## 13.3 Calculating Statistics

To export statistics for calculated variables and data files, select *Data. . .* *Statistics* from the main menu bar.

### 13.3.1 Statistics

Check the desired item to include or exclude the statistic from the output file.

### 13.3.2 Variables

Check the desired variables to add them to the calculation. By default, all metric variables are included, while correlation and pixel variables are excluded.

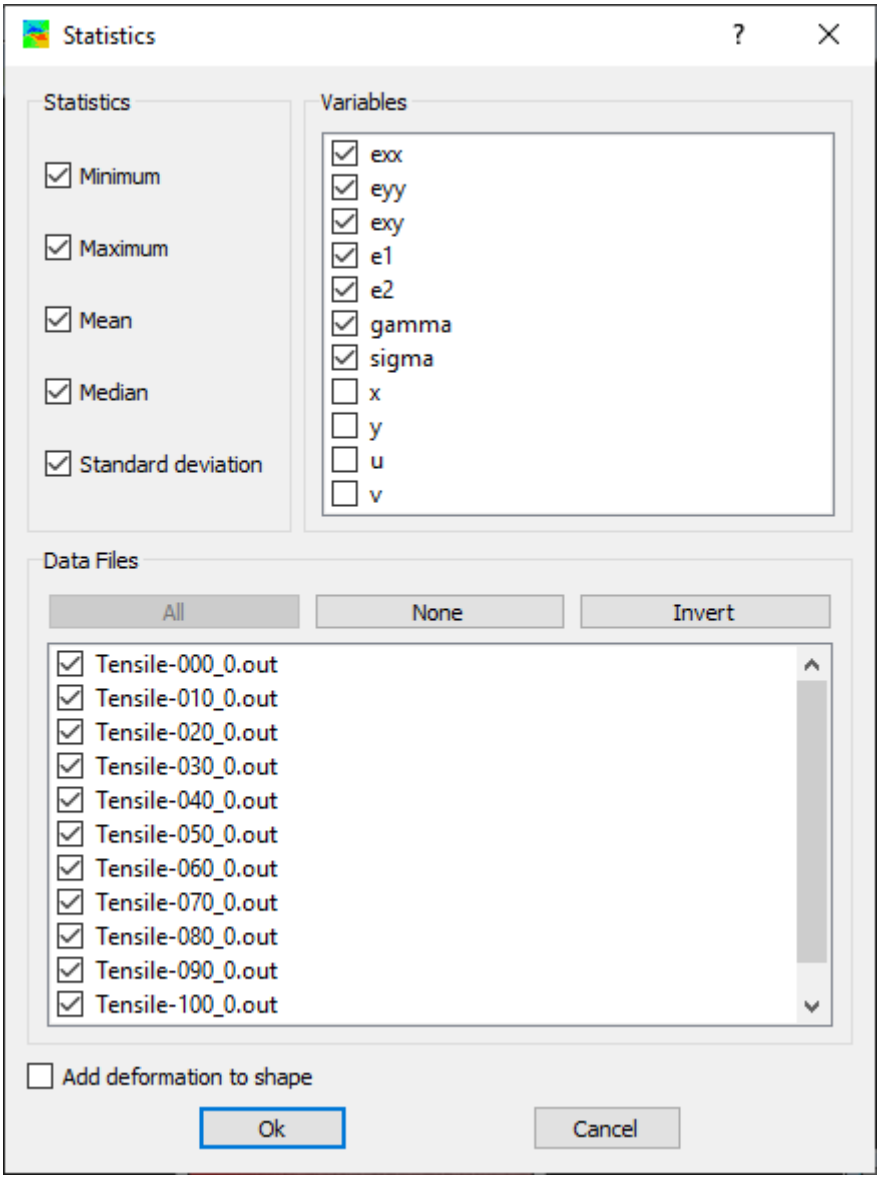



Figure 13.3: Statistics dialog.

### 13.3.3 Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

### 13.3.4 Exporting

To complete the calculation, click *Ok*. You will be prompted for a filename, and the data will be exported as a .CSV file.

# Chapter 14

# Plots

A plot of the data can be displayed by double-clicking on a data file in the list view to the left of the workspace. A plot will be displayed in the workspace as shown below.

## 14.1 Plot Options

Plot options can be accessed by right-clicking in the plot window.

The *Contour variable* submenu can be used to select the variable to display.

The *Show min. value* and *Show max. value* options will flag the minimum and maximum valued data points.

By default, data is displayed in the deformed location on the deformed image. To show the reference position for the data, click *Show reference data*.

Click *Change legend orientation* to toggle between a horizontal and vertical legend.

Click *Statistics* to view a summary of data for the current image, for the currently selected contour variable.

*Copy* copies the current plot to the clipboard; *Save* allows saving the plot as an image file.

Select *Export video* to save an animated video.

Click *Detach* to keep this plot static instead of updating it each time a new data file is clicked in the Data tab.

## 14.2 Editing Plot Parameters

To edit other plot parameters, use the plot toolbar.

## 14.3 Inspector Tools

Tools for probing and extracting data are located in the Inspector Toolbar, and can also be selected by clicking *Plot... Inspector* in the main menu bar.

From left to right, the tools are:

- Pan/Select: Pans around the contour image, when zoomed in; selects existing extract points. To select an item, click on the small square handle.

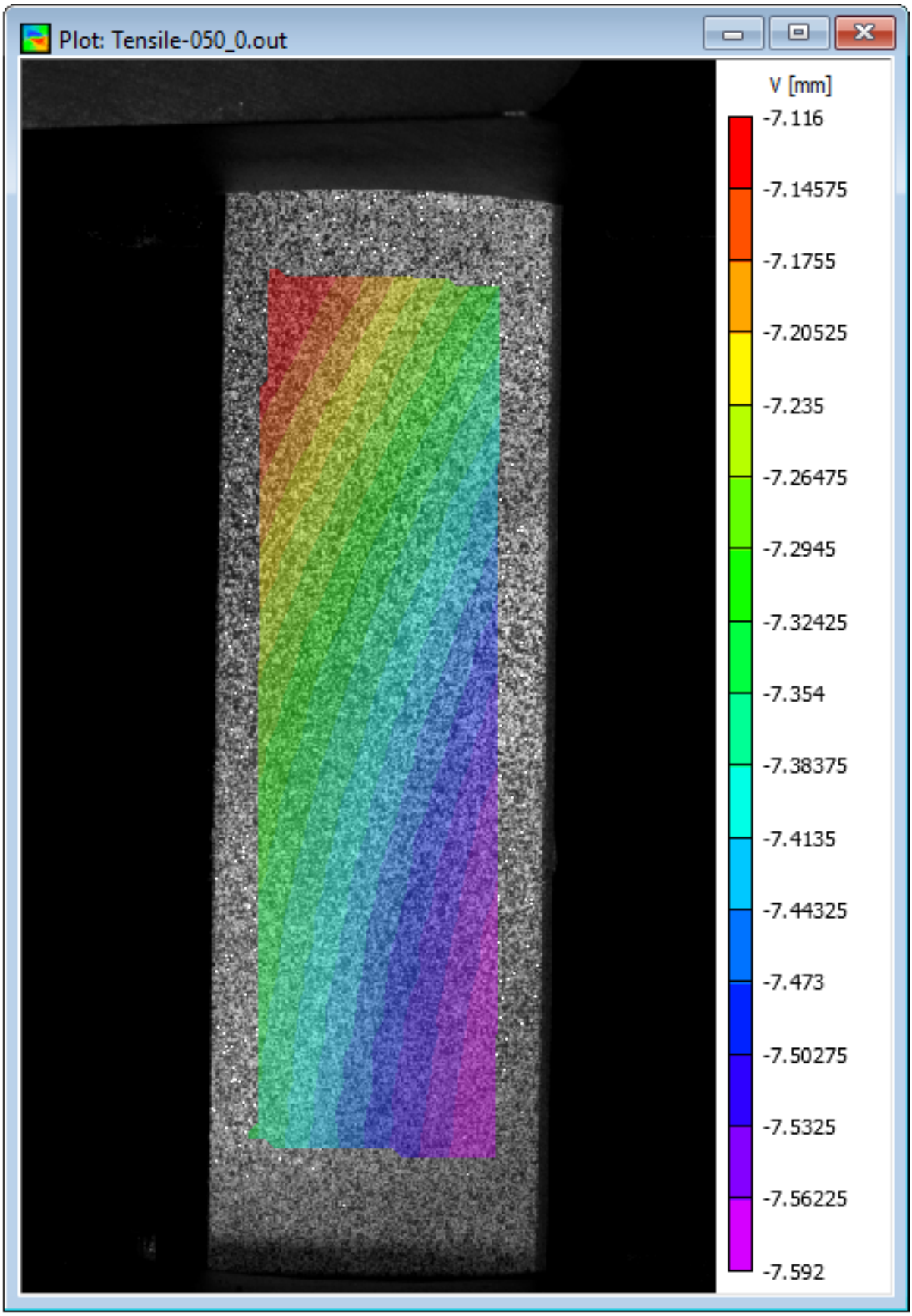



Figure 14.1: 2D contour plot display.

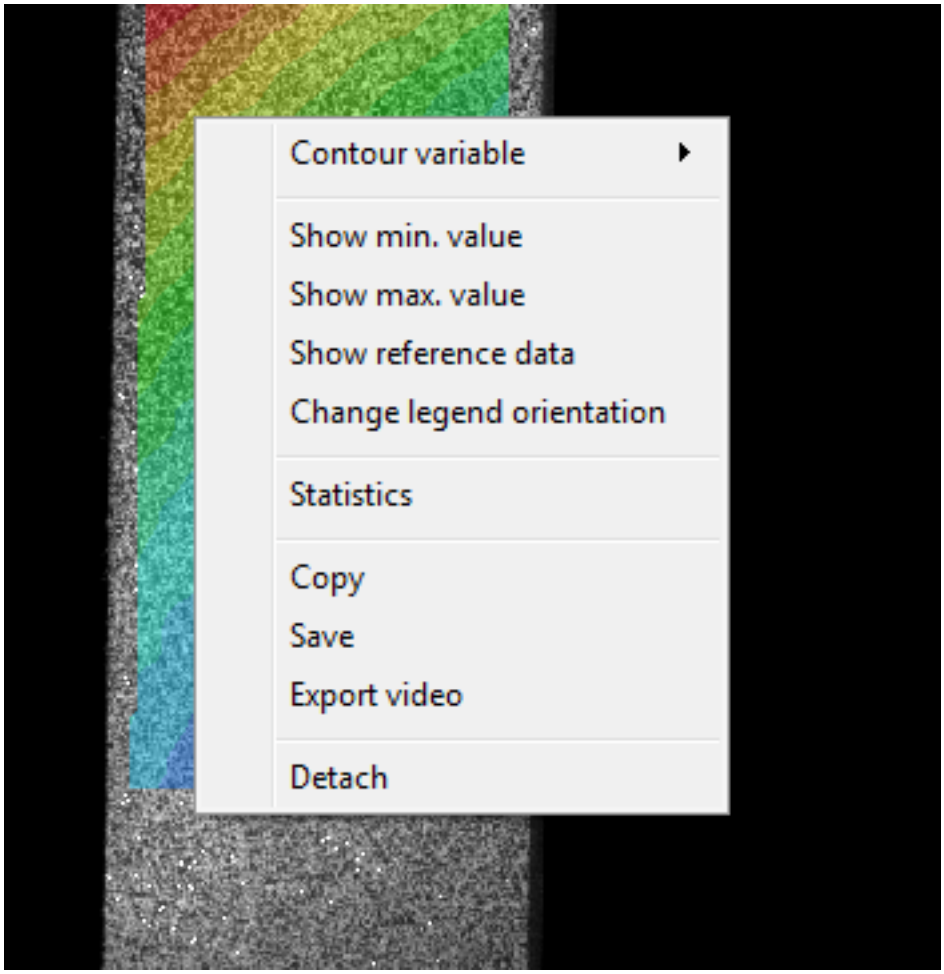



Figure 14.2: 2D plot context menu.

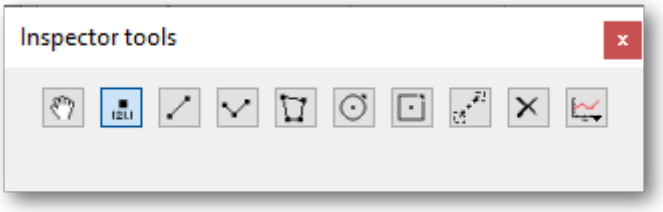



Figure 14.3: Inspector tools

- Inspect point: select this tool and click to probe at a single point. The value for the currently selected contour variable, at the chosen point, will be displayed.
- Inspect line: select this tool and click once to start a line; click again to finish. The value will be displayed at each node.
- Inspect polyline: select this tool and click to create line nodes; double-click to finish. The value will be displayed at each node.
- Inspect circle: select this tool and click to define a center; click again to define a disc. The value at the center will be displayed.
- Inspect rectangle: select this tool and click to define a center; click again to define a rectangle. The value at the center will be displayed.
- Extensometer: select this tool and click two points; this tool shows the extension (change in length divided by initial length) between the two points.
- Delete: choose this tool and click on an existing point/line/area to remove it.
- Extract: click to open the Extraction dialog.

Once a tool is selected, you can place it on the plot by clicking.

- For the point tool, click once to place the point.
- For the circle, rectangle, and line tools, you can click once to place the first point, and again to define the shape.

Once a tool is placed, you can use the Pan/Select tool to move the inspector or to adjust the control points.

## 14.4 Animating Plots

To animate contour plots, bring up the plot display and then use the controls on the Animation Toolbar to animate the sequence.

## 14.5 Saving the Plot

The displayed plot can be saved as a BMP, PNG, or JPG image file by selecting *Save* from the context menu. To copy the plot to the clipboard, select *Copy*.

## 14.6 The Plot Toolbar

The plot toolbar is displayed at the top left edge of the work area by default. It contains options and controls for contour plots.

### 14.6.1 Auto-Scaling

This tab controls auto-scaling. Check or clear the boxes to enable auto-rescaling of contour overlay limits. Check *Grow ranges only* to allow ranges to get larger but not smaller. With

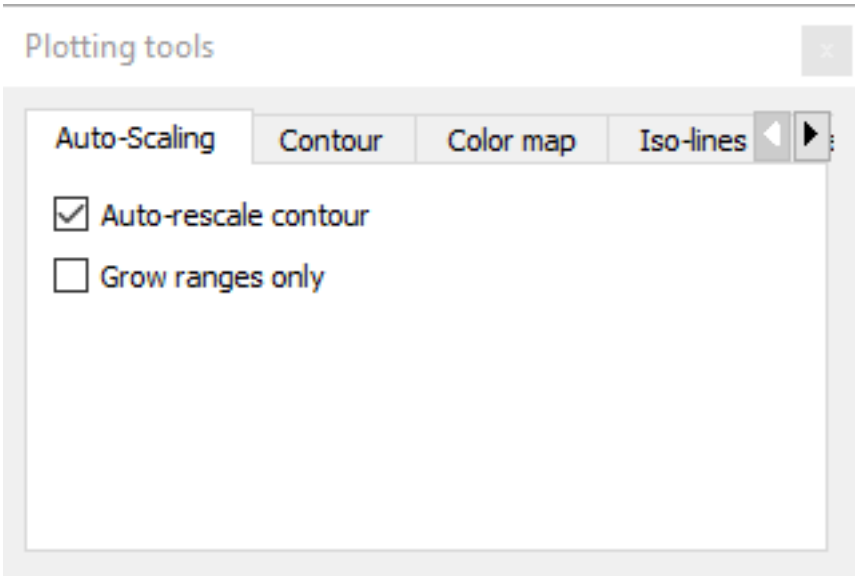



Figure 14.4: Auto-scaling tab.

this box checked, you can animate through all images to set the limits to the minimum and maximum over all data files. This is useful for producing consistent animations and videos.

### 14.6.2 Contour

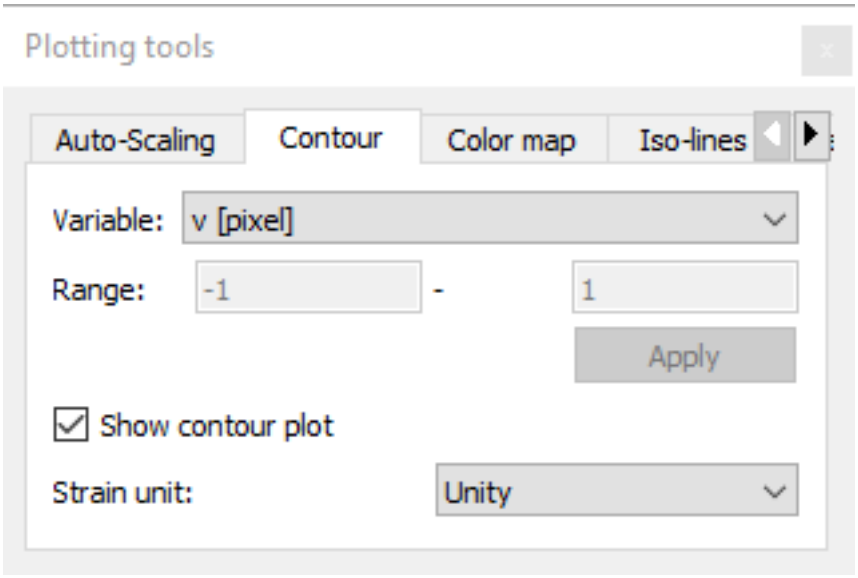



Figure 14.5: Contour tab.

This tab allows control of the contour overlay of 2D plots. To automatically scale these values to fit the data, check the *Auto-rescale contour* box. To manually set the limits, clear this box and enter the desired values.

Use the *strain unit* control to determine how strain values are displayed; the default is unity, i.e., mm/mm.

### 14.6.3 Color

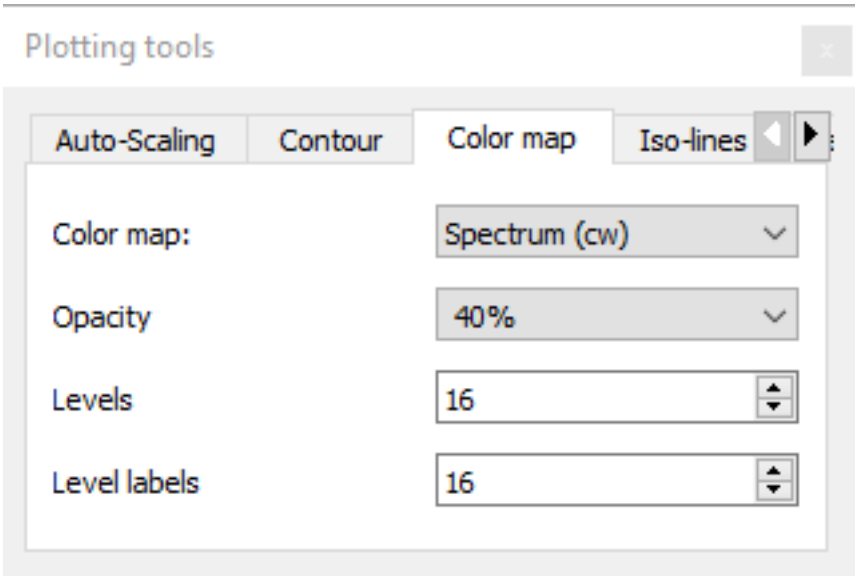



Figure 14.6: Color tab.

Use this tab to control the display of contour overlays. The *Color map* box chooses the overall color set for the plot. The *Opacity* box sets the opacity of the overlay; this option affects 2D plots only. The *Levels* box sets the n box sets the number of discrete contour levels. The *Level labels* box controls the number of numeric level indicators.

### 14.6.4 Iso-lines

Use this tab to display iso-lines on the contour plot.

If many levels are present, you can increase the *Level skip* to reduce clutter. The thickness of the isolines and the color can also be adjusted.

### 14.6.5 Vector

This tab controls display of strain and displacement vectors.

*Skip* and *scale* control the size and density of the vectors. The *use solid color* checkbox causes the vectors to be displayed in a single color rather than the underlying plot color; the color selector button can be used to choose this color.

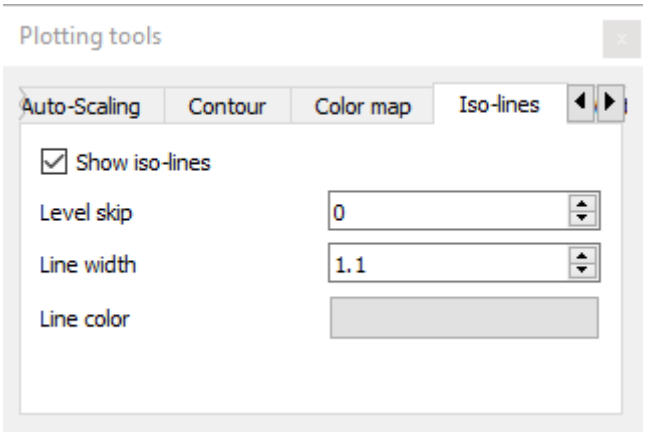



Figure 14.7: Iso-lines tab.

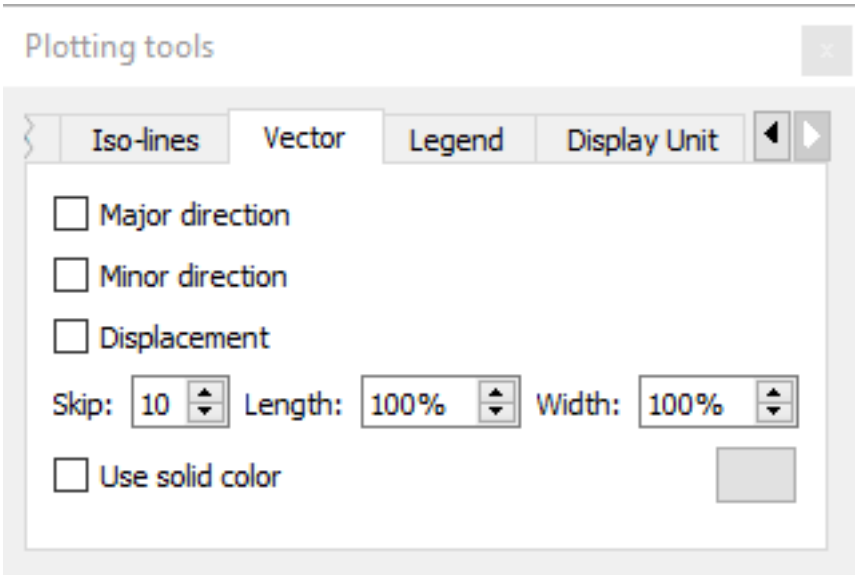



Figure 14.8: Vector tab.

### 14.6.6 Legend

These controls affect the format of the contour legend. Select a *Format* from Number, Scientific (exponential notation), or Best (most concise method). Select a number of *Digits*, or Automatic to use as much precision as necessary.

## 14.7 Exporting Videos

To export an animation from a 2D plot, right-click in the plot and select *Export Video*.

If the auto-rescaling feature is enabled for contours or axes, you will see a warning:

When rescaling is on, the animation may not appear as expected because each frame will be scaled differently. Click *Yes* to continue or *Cancel* to correct the condition. When complete,

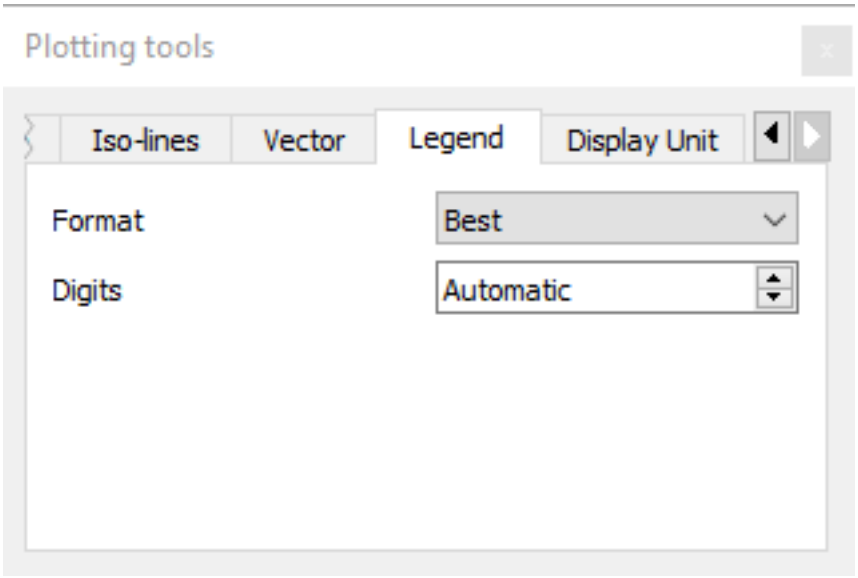



Figure 14.9: Legend tab.

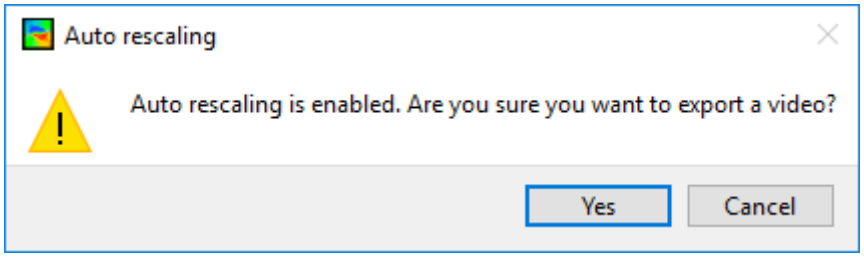



Figure 14.10: Warning message when auto rescaling enabled.

the following dialog appears:

### 14.7.1 File

Click the icon to select a filename for saving.

### 14.7.2 Encoder

- To use the built-in codecs, select *AVI*.
- To use a choice of external codecs with a supported external encoder, select *External converter*.
- Select *Image Sequence* to export a sequence of numbered individual images rather than a video.

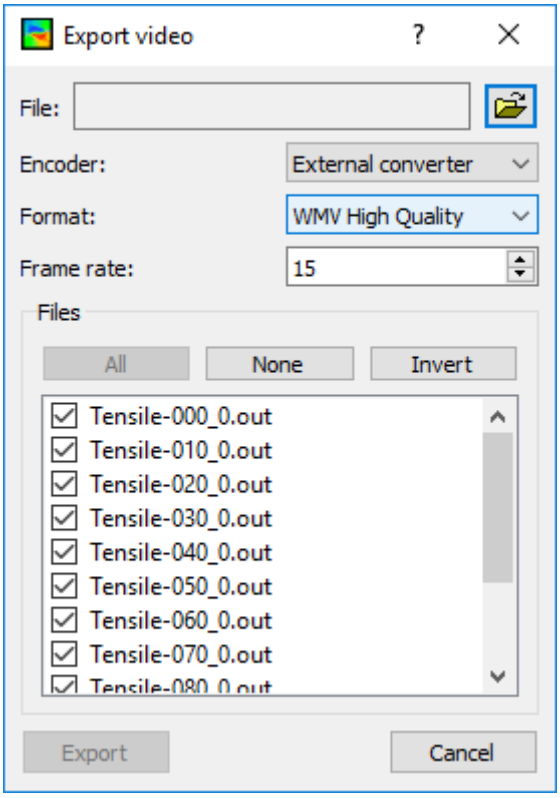



Figure 14.11: Video export dialog

### 14.7.3 Format

Select from available compression formats; options will vary based on system configuration and installed codecs.

For videos which will be recompressed, select RGB Uncompressed to make a very large but lossless video.

### 14.7.4 Data File Selection

The available data files are displayed in the list box. To select which files to process, click on the data file you want to select/deselect. This will toggle the check mark indicating whether the file is selected or not. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

To begin, click *Export*; a progress bar will indicate completion.

## 14.8 Extraction Plots

Extraction plots can be generated for the dataset as a whole, or for lines, points, and areas by using the Inspector Tools in a 2D plot. An extraction data plot as illustrated in Fig. 14.12 will be shown when the *Extract* button ( ) is pushed while viewing a 2D Plot. Note that an

extraction plot can be generated even if no inspector items are present. In this case, only the average values will be available for plotting. Depending on the types of inspector items that have been added to the contour plot, different plot types will be available:

- Points (default) for average, points, area averages.
- Line slices for lines and polylines.
- Extensometers.
- Points and Extensometers.

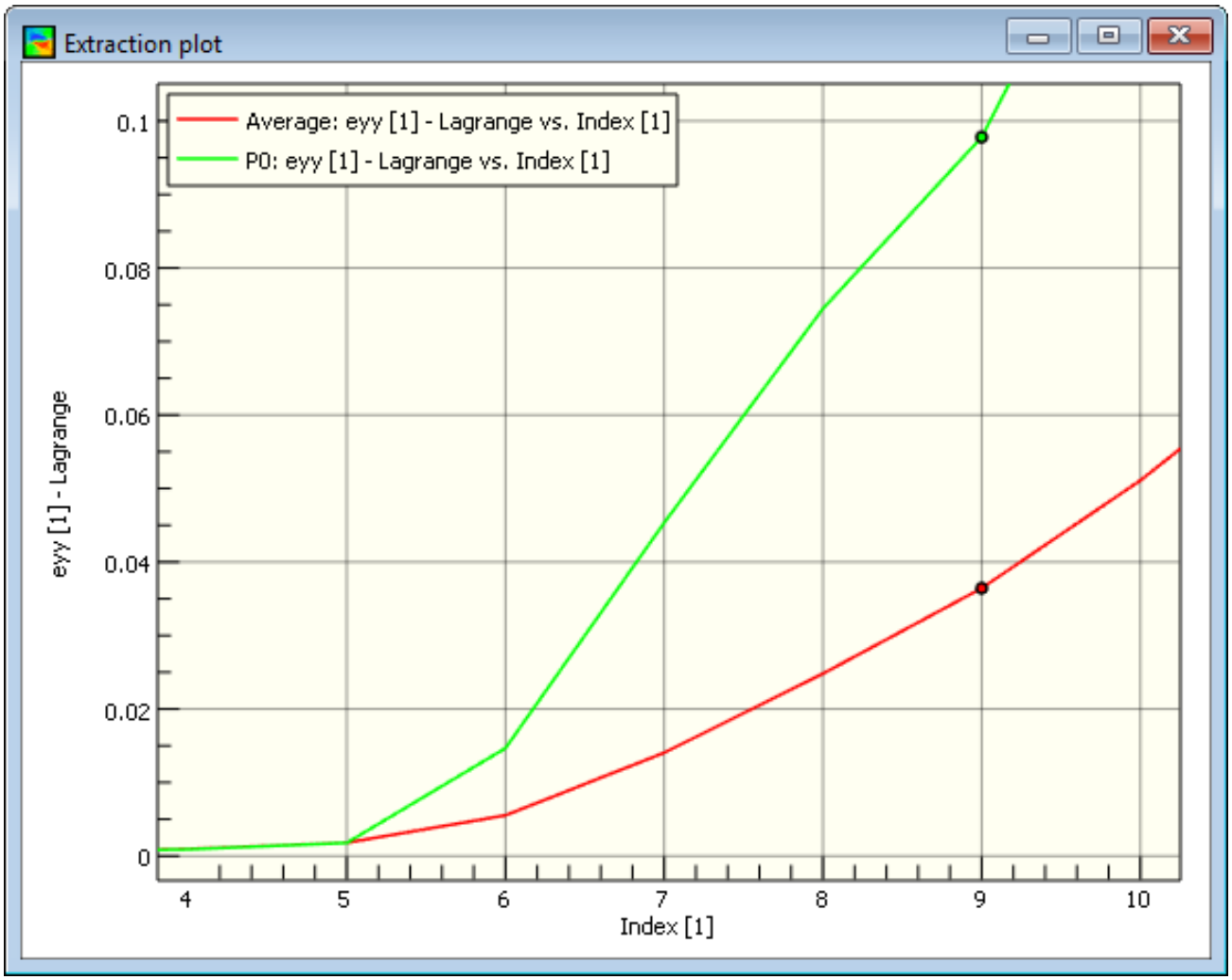



Figure 14.12: Extraction plot.

A long press on the ( ) button will allow selection of Complex plot extraction

### 14.8.1 Selecting X/Y Data for Plotting

Each X/Y data pair shown in the plot will be listed in the *Extraction tools* tool box (see Fig. 14.13) and shown in the plot's legend (if configured, see Section 14.8.8). The X/Y data that is shown

in the plot can be edited in the tool box.

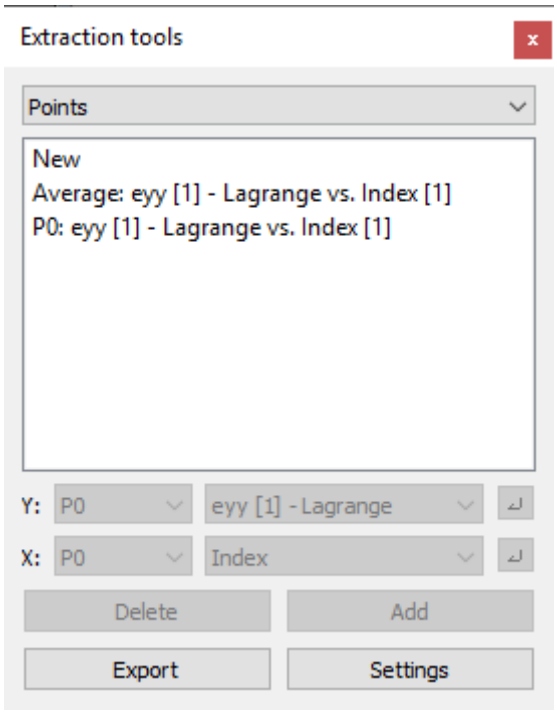



Figure 14.13: Extraction plot tool box.

To select the variables for a new or an existing X/Y pair, the X/Y data source and variable can be selected from the drop-down menus below the list box. Available data sources are:

- Average corresponds to the average value from the entire data set.
- P0, R0, C0, etc. are the values corresponding to inspector tools (points, rectangles, circles etc).
- Analog data corresponds to CSV data added to the project. This is normally a file generated by Vic-Snap.

After the variables for X or Y have been selected from the menus, the apply button on the right must be pressed to apply the changes. Note that the change applies to all X/Y pairs selected in the list box.

To delete an X/Y pair, the item must first be selected in the list box, followed by pressing the **Delete** button.

New X/Y data pairs can be added to the plot by first selecting the *New* item in the list box at the top. Then, the data source and variables can be selected from the drop-down menus and the new X/Y pair is finally created by clicking the **Add** button.

To export plot data, the **Export** button can be pressed to bring up the Export data wizard.

### 14.8.2 The Extractions Menu

**Only present in Vic-3D 9** the extractions menu allows for deleting of extractions as well as re-opening past extractions.

The main purpose of this workspace is to open past extractions to manipulate the data for use in the iris workspace.

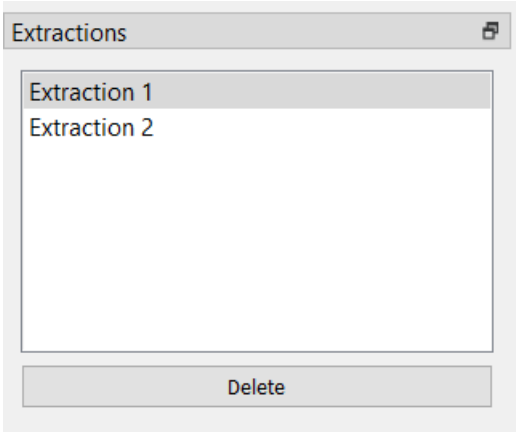



Figure 14.14: Extractions menu.

### 14.8.3 Navigating in the Plot

Use the mouse wheel to zoom in or out on the plot. Click and drag to pan; double click to fit the plot to the window.

To adjust a single axis scale, mouse over that axis; the cursor will change to indicate the axis is active. Then, use the mouse wheel to zoom only that axis.

To zoom to a selected box, hold the shift key and drag to indicate the zoom area.

### 14.8.4 The Context Menu

Right-click in the plot to access options.

- Cursor: select from axis indicators for X, Y, or both axes; select Snap Cursor to display the value reading closest to the cursor.
- Copy: copies the plot to the clipboard.
- Save: select to save the plot as a graphics file.
- X/Y axis scale: submenus allow changing between linear and logarithmic axis scaling.
- Settings: click to access the plot settings.
- Quick help: display a brief overview of the plot navigation controls.

### 14.8.5 Point Extractions

By default, extraction plots are shown in *Point* mode, which displays the average data as well as data generated by inspector items of type point and those that average over an area (discs, rectangles etc.). The plot type can be selected from the drop-down menu at the top of the extraction tool box, see Fig. 14.13.

### 14.8.6 Line Slice Extraction and Plotting

Line slices may be plotted only when an extraction line or polyline is present. They can be created using the Inspector Tools to add lines ore polylines to a 2D contour plot. An example of a line slice inspector item is illustrated in Fig. 14.15.

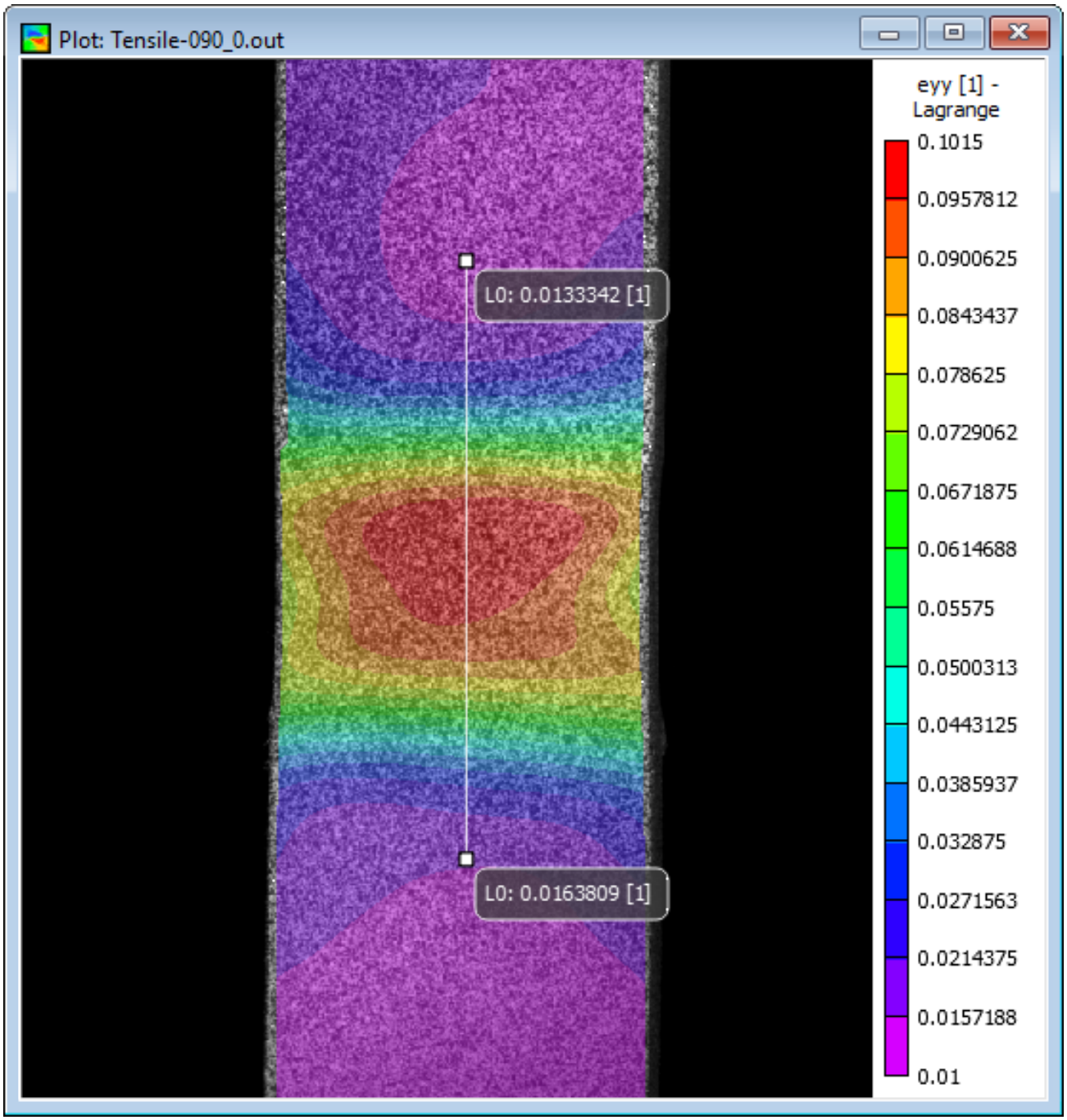



Figure 14.15: Line slice in contour plot.

After clicking the *Extract* button ( ) an extraction plot will appear in the workspace,

but will initially show the available *Point* extractions. To display the line extraction, the entry *Line slices* must be selected from the pull-down menu in the extraction tool box as illustrated in Fig. 14.16.

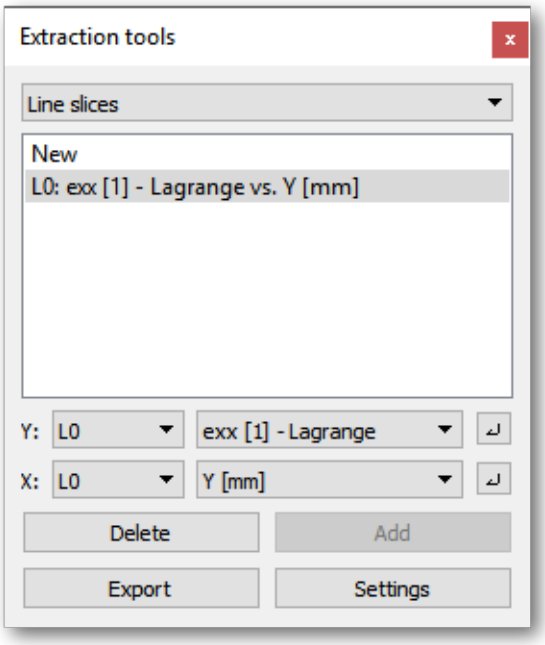



Figure 14.16: Extraction tool box for lines slices.

On the plot, a series of lines will be shown that shows the extracted data at different times. The line for the currently selected data file will be highlighted, as illustrated in Fig. 14.17. The number of lines that are shown in the plot can be configured in plot settings, see Section 14.8.8.

### 14.8.7 Extensometer Extraction and Plotting

Extensometer plotting will be available when one or more extensometers have been created using the Inspector Tools in a 2D plot view as illustrated in Fig. 14.18.

Clicking the *Extract* button ( ) brings up the plot window. To switch the display to extensometers, the entry *Extensometers* must be selected from the pull-down menu at the top of the extraction tool box as illustrated in Fig. 14.19. If both points and extensometers are present, the entry *Points and extensometers* will also be available to show extensometer and point extraction data in a single plot.

#### 14.8.7.1 Extensometer Variables

The extensometer plot can be used to show a number of variables that are available for each extensometer extraction, including the relative change in length as illustrated in Fig. 14.20.

The available extensometer variables are:

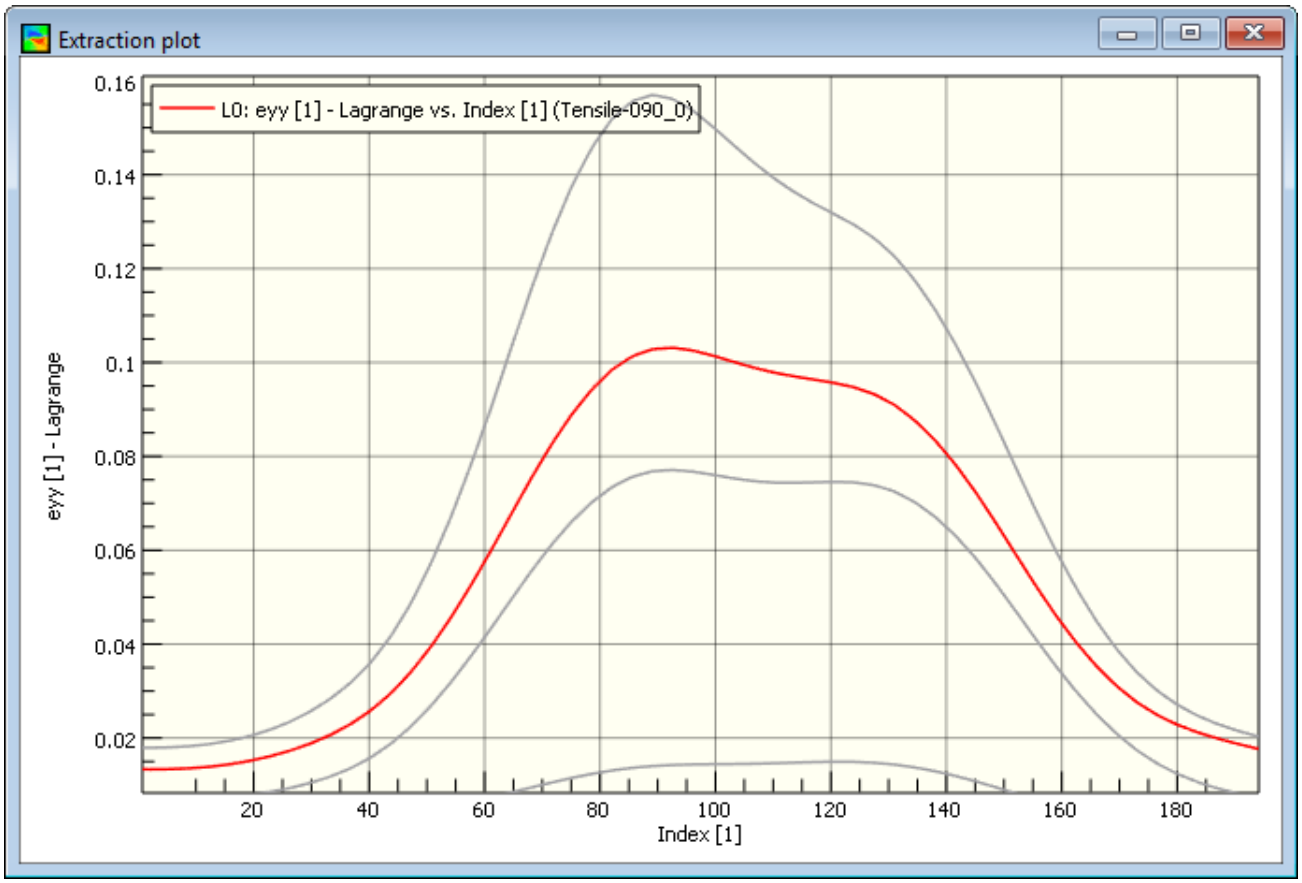



Figure 14.17: Line slice plot.

- ΔL/L0: The change in length divided by the initial length; unitless.
- ΔL: The change in length, in display units.
- L1: The deformed length, in display units.
- L0: The initial length, in display units.



The strain displayed here will not necessarily match the strain computed in the Strain dialog, depending on the tensor you have selected. The extensometer strain is a simple length calculation and does not account for bending, etc.

### 14.8.8 Plot Settings

The plot settings can be accessed from the context menu of the plot (see Section 14.8.4). This displays a dialog with different options to control the plots as illustrated in Fig. 14.21.

The first tab controls graph display settings.

- Graph style: select from lines, points, or both. If Points is selected, you can use the snap

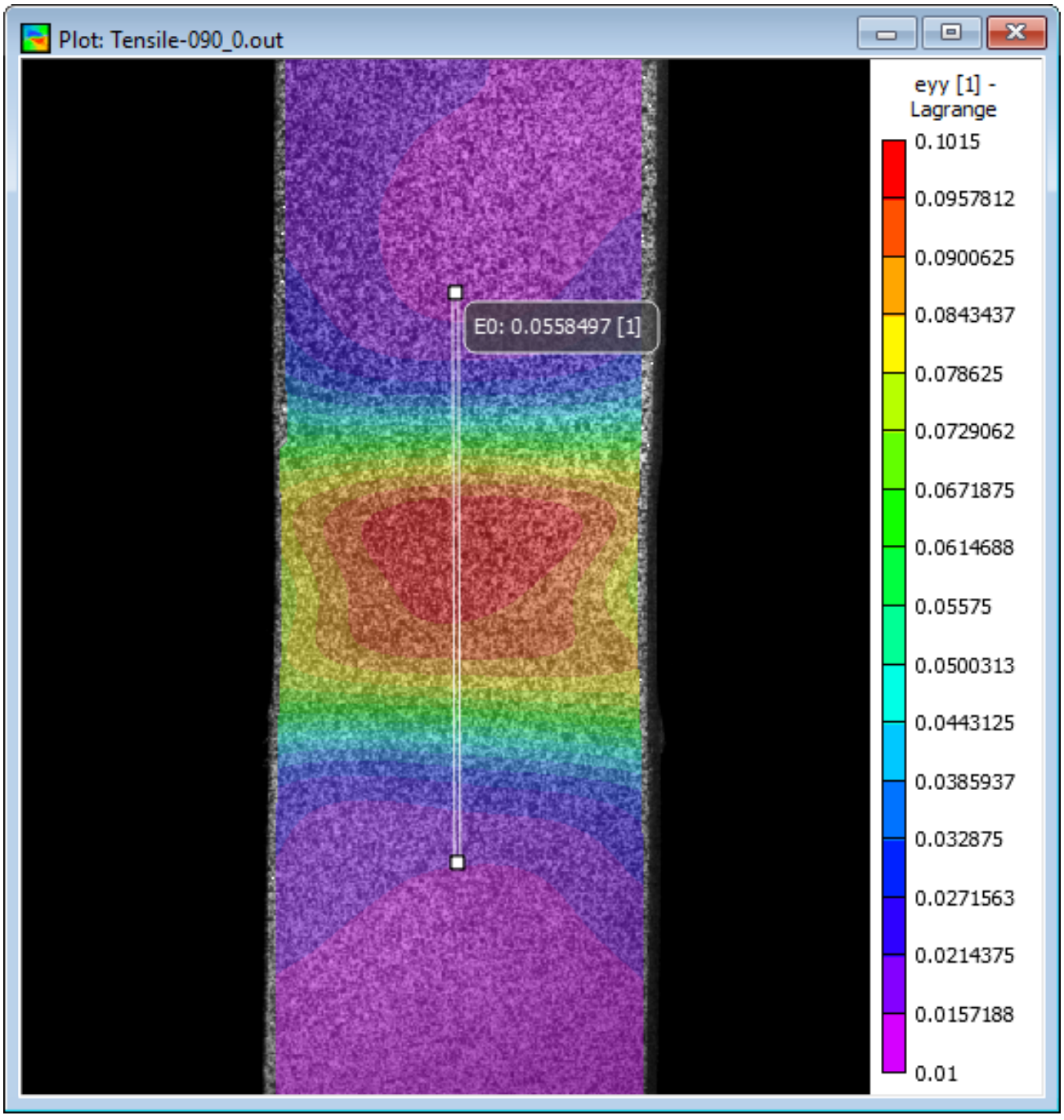



Figure 14.18: Extensometer in contour plot.

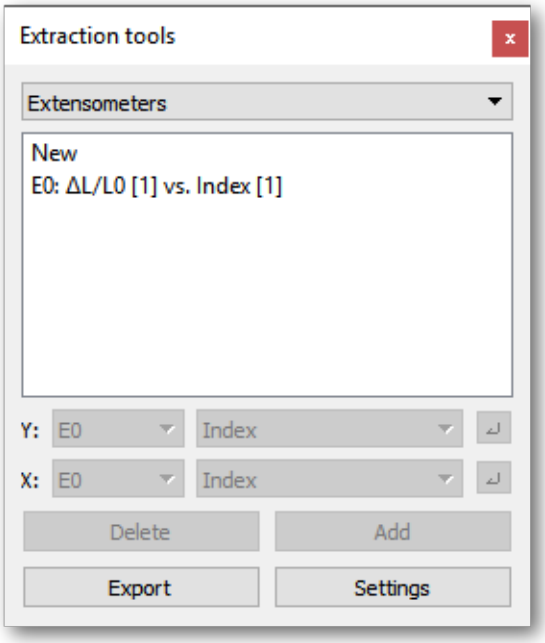



Figure 14.19: Extraction plot tool box for extensometers.

cursor to evaluate values at specific locations in the plot. With Lines selected, the snap cursor will give an interpolated value.

- Show legend: click to show or hide the legend.
- Legend position: select the location of the displayed legend on the plot.
- Theme: choose from a white background scheme ("Daytime") or a black background scheme ("Midnight").

The second tab applies to time extraction only. You can select whether to highlight the currently displayed data file; and select which data files to plot. All are plotted by default.

The third tab applies to line slice extractions only.

Under Mode, you can choose to display lines for the current file and the select files; only the current file; or only the selected files (select files from the list below). You can also adjust the style of the non-selected lines as well as the color for them.

Select the files to be extracted from the list at the bottom.

By default, 200 points are created along the extracted line. Since the line does not necessarily pass through exact data points, data points are interpolated at equidistant intervals along the line. The number of sample points can be changed by pressing the **Change** button. This will display an spin box control where the desired number of points can be selected. Note that changing the number of points results in the data being extracted again. The progress of this operation is indicated in a progress bar at the bottom of the plot window.

### 14.8.9 Exporting Slice Data

To export data, click **Export** in the extraction tool box. The *Export Data Wizard* will appear.

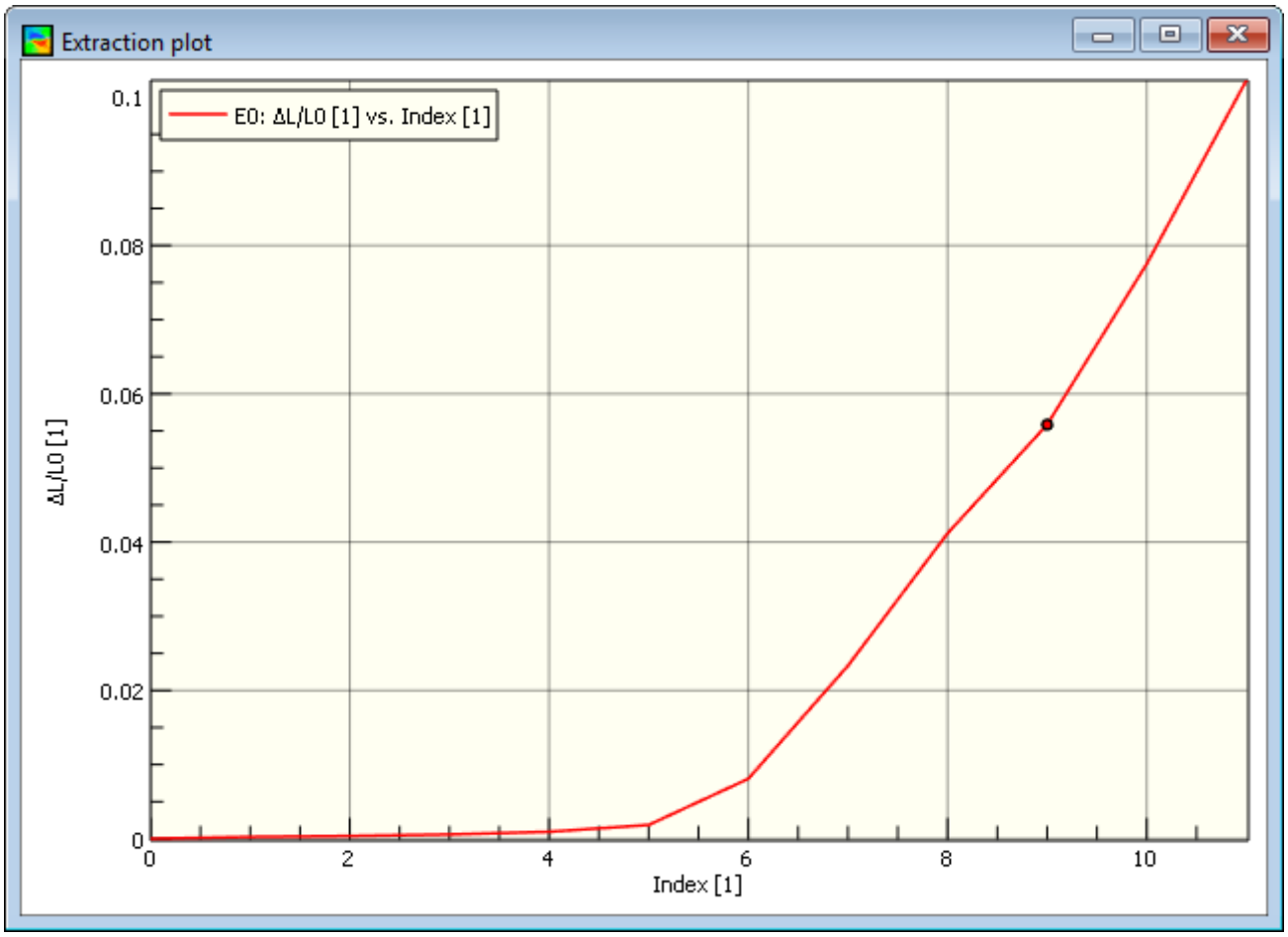



Figure 14.20: Extensometer extraction plot.

- Output file: click the folder icon to choose an output file.
- Data type: choose from line slice or time extraction.
- Format: select from comma separated (typical for use with Excel) or tab separated.
- Ordering: select row index to have a row for each file (most common), or column index to have a column for each file (useful for making waterfall type plots).
- Coordinates: if you select reference coordinates, the XYZ values will not change over time. Select deformed coordinates to add UVW deformation to the XYZ values, making them change with time.

## 14.9 Complex plot extractions

Holding the button will allow selection of Complex plot extractions via a dialog box.

While the simple extraction is limited to average values, complex extractions allow selection of statistical functions (minimum, maximum, mean, median, standard deviation) with the **Statistics** group.

The **Data Files** group allows selecting a subset of data.

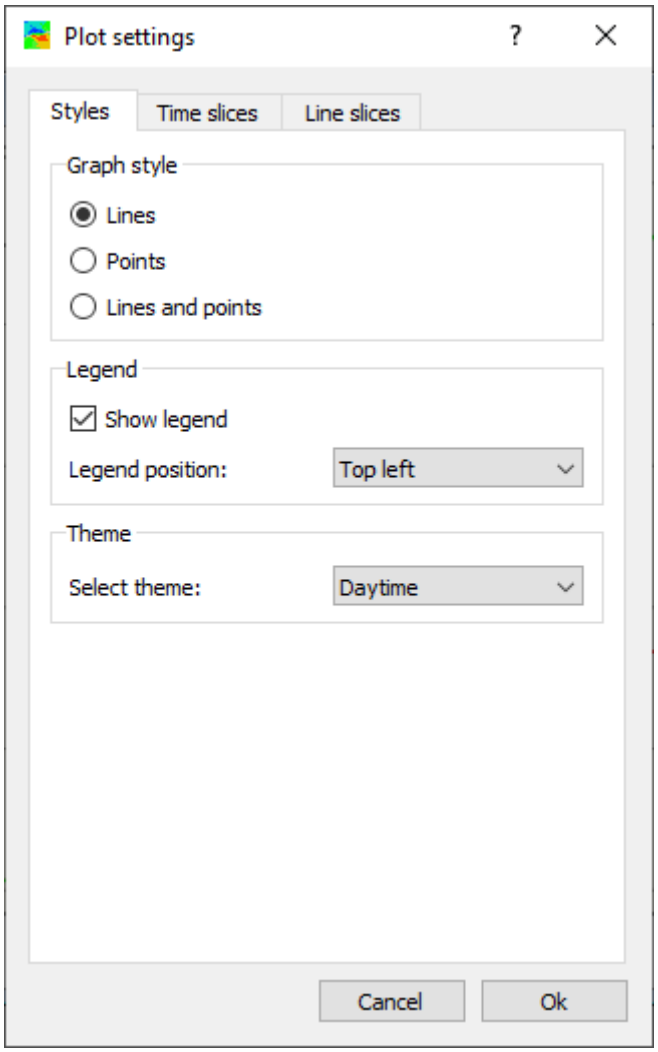



Figure 14.21: Plot settings style tab.

Extracting a limited number of data files can improve extraction speed when accessing a slow or networked drive.

### 14.9.1 Rotation angles

Rotation angles may be calculated by checking **Add rotation angles**. This computes rigid-body transformation (rotation) angles for area-type inspector items (discs, rectangles etc.). The transformation matrix can be computed from the pitch, yaw and roll angles $\alpha$, $\beta$ and $\gamma$ as follows:

$$\mathbf{R} = \begin{bmatrix} \cos(\beta)\cos(\gamma) & \sin(\alpha)\sin(\beta)\cos(\gamma) - \cos(\alpha)\sin(\gamma) & \cos(\alpha)\sin(\beta)\cos(\gamma) + \sin(\alpha)\sin(\gamma) \\ \cos(\beta)\sin(\gamma) & \sin(\alpha)\sin(\beta)\sin(\gamma) + \cos(\alpha)\cos(\gamma) & \cos(\alpha)\sin(\beta)\sin(\gamma) - \sin(\alpha)\cos(\gamma) \\ -\sin(\beta) & \sin(\alpha)\cos(\beta) & \cos(\alpha)\cos(\beta) \end{bmatrix}$$

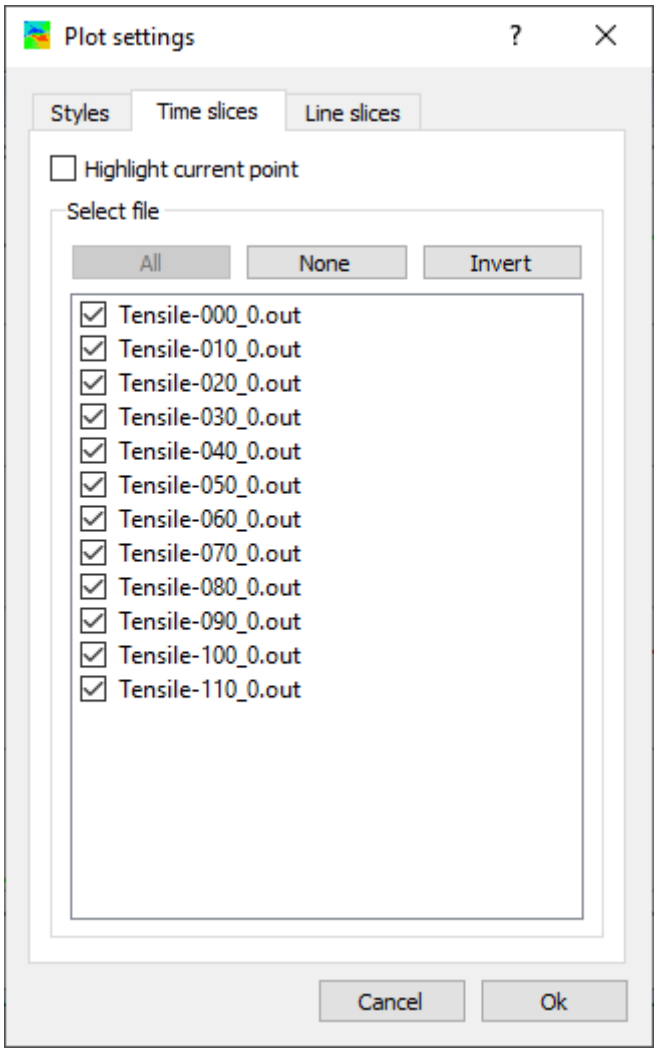



Figure 14.22: Plot settings time slice tab.

The translation component of the rigid body transformation can be computed from the location of the area's centroid $X_0, Y_0, Z_0$ and the average displacement as follows:

$$\mathbf{T} = \left\{ \begin{array}{c} \bar{U} \\ \bar{V} \\ \bar{W} \end{array} \right\} + \left\{ \begin{array}{c} X_0 \\ Y_0 \\ Z_0 \end{array} \right\} - \mathbf{R} \left\{ \begin{array}{c} X_0 \\ Y_0 \\ Z_0 \end{array} \right\}$$

Note that the transformation given by **R** and **T** transforms reference coordinates into the deformed state.

Check **Add deformation to shape** to add the variables $Xd$, $Yd$ and $Zd$ to the data set. These are the deformed values $(X+U)$, $(Y+V)$ and $(Z+W)$.

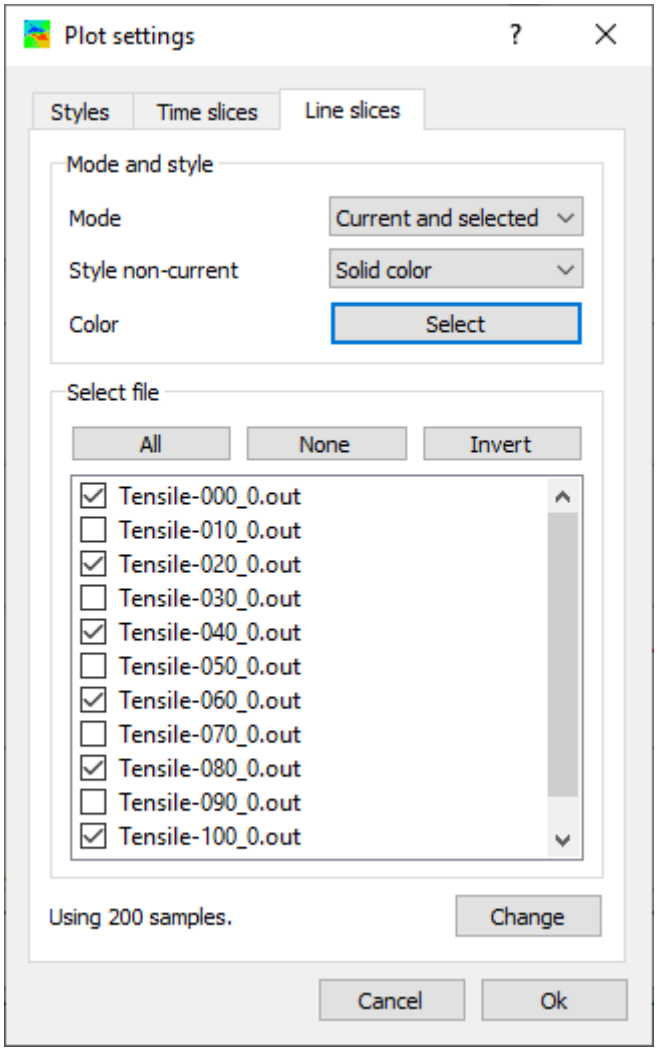



Figure 14.23: Plot settings line slice tab.

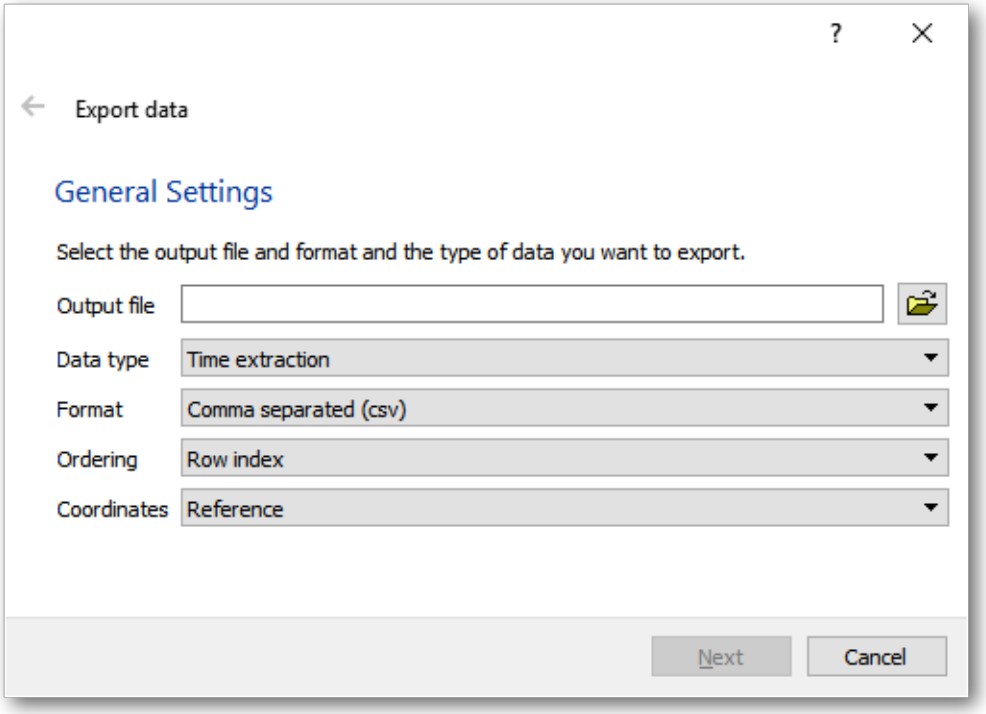



Figure 14.24: Extraction plot export wizard.

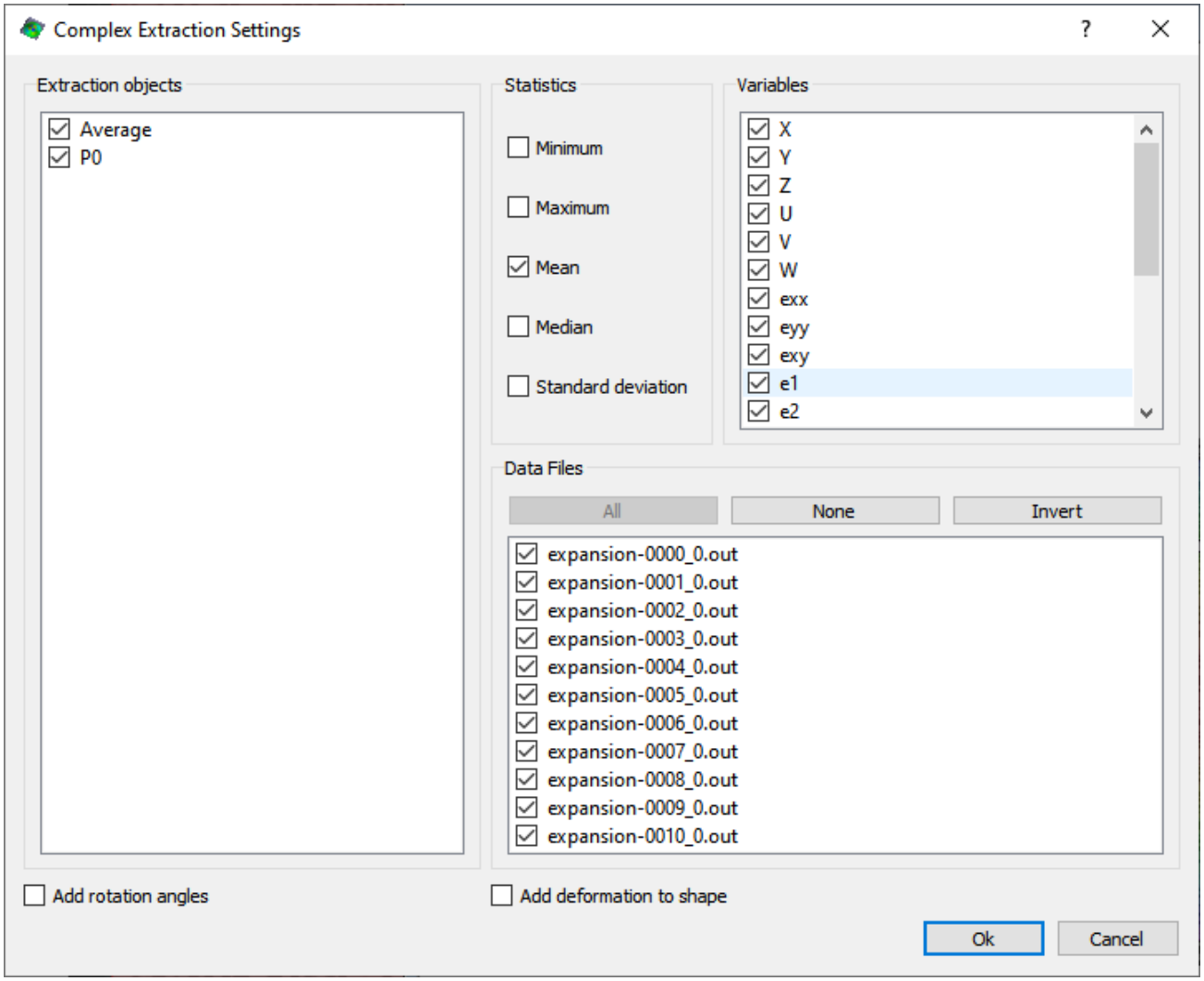



Figure 14.25: Complex extraction settings.

# Chapter 15

# Data Visualization in *iris*

The *iris* visualization framework provides a workspace for generating both static and animated plots of DIC and imported data, e.g., FE meshes. Some of the features include:

- High resolution rendering for bitmap content and scalable fonts and graphics for publication-quality output
- Most properties can be animated, e.g., position, opacity, rotation, viewing angles etc.
- Motion-tweening with a variety of easing functions
- Adaptive motion blurring for realistic video output
- Data can be interpolated in time to provide smooth high framerate video output from sparse data
- Document and page templates

To begin using *iris*, click the icon on the toolbar.
For more information, see the following topics:

- **Overview of the iris Workspace**
- **Pages, templates, and backgrounds**
- **Graphic elements**
- **Working with Sequences**
- **Working with Keyframes**
- **Document Properties**
- **Exporting iris Content**

## 15.1 Overview of the *iris* Workspace

The *iris* workspace contains all of the tools and controls for creating *iris* documents. The workspace replaces the analysis workspace when the icon is clicked in the toolbar. An overview of the workspace is shown in Fig. 15.1.

The *iris* workspace contains:

- **Main toolbar** - has controls for inserting new objects like plots and images; alignment controls; and buttons for exporting PDF and video.

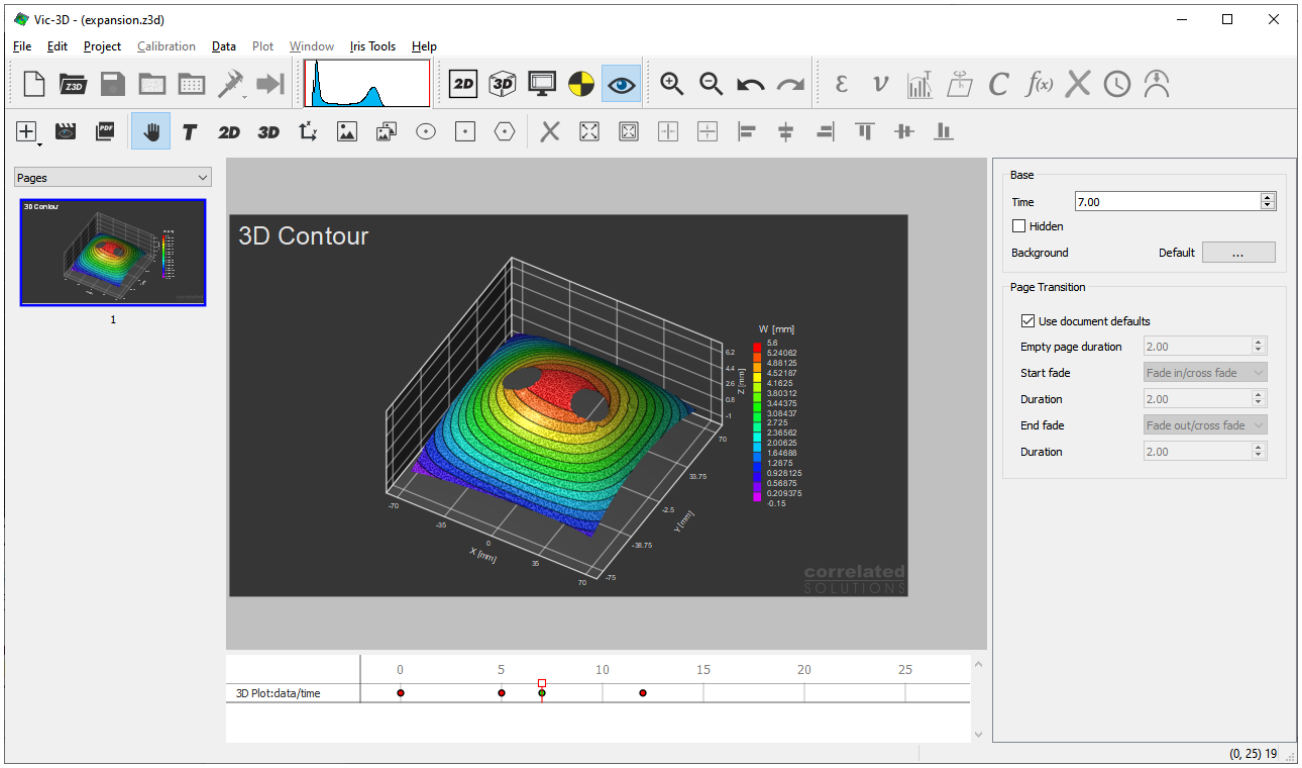



Figure 15.1: Overview of main window.

- **Page/template/backgrounds organizer** - the left sidebar shows a graphical list of pages, templates, and backgrounds, selectable from the pulldown.
- **Properties editor** - the right sidebar has a list of adjustable properties for the currently selected item.
- **Timeline** - the timeline area at the bottom of the window shows all the timelines and keyframes in the project and allows scrolling through time.
- **Main work area** - where all objects/text/graphics will be placed and manipulated.

### 15.1.1 Editor Context Menu

Right clicking inside the *iris* editor allows for quick adjustment of view, inserting of plot elements, alignment, and exporting. The context menu is shown in Fig. 15.2.

- **Fit Page** - Fits the page size to fill the screen
- **Fit to content** - Fits all of the elements in your workspace to fill the screen
- **Export video** - Opens the video export dialog
- **Export PDF** - Opens the PDF export dialog
- **Sequence Manager** - Opens the sequence manager dialog

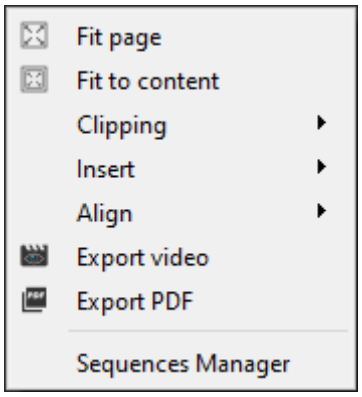



Figure 15.2: Detail of Context menu.

#### 15.1.1.1 Insert Submenu

The *Insert* submenu can be used to conveniently add objects to the page. Note that the inserted object's top-left corner will be placed where the context menu was opened by clicking. The insert menu is illustrated in Fig. 15.3.

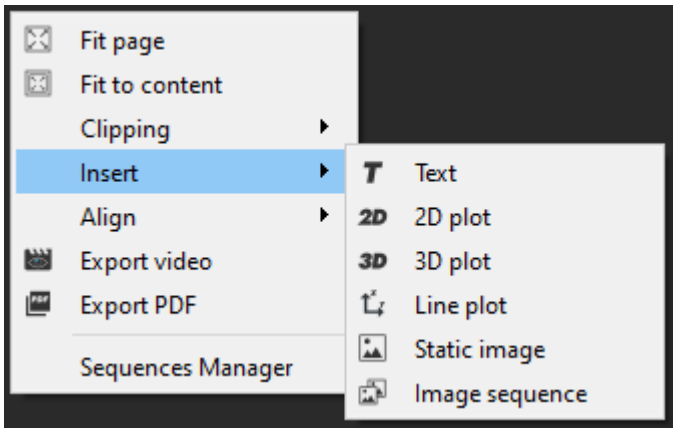



Figure 15.3: Detail of Insert submenu.

- **Text boxes**
- **2D plots**
- **3D plots**
- **Extraction plots**
- **Static images**
- **Image sequences**

#### 15.1.1.2 Align Submenu

The *Align* submenu can be used to align objects to the page or relative to each other. To align objects relative to each other, multiple objects must be selected. The last object selected will be

the stationary object, i.e., all other objects in the selection are aligned to the last object selected. The align menu is shown in Fig. 15.4.

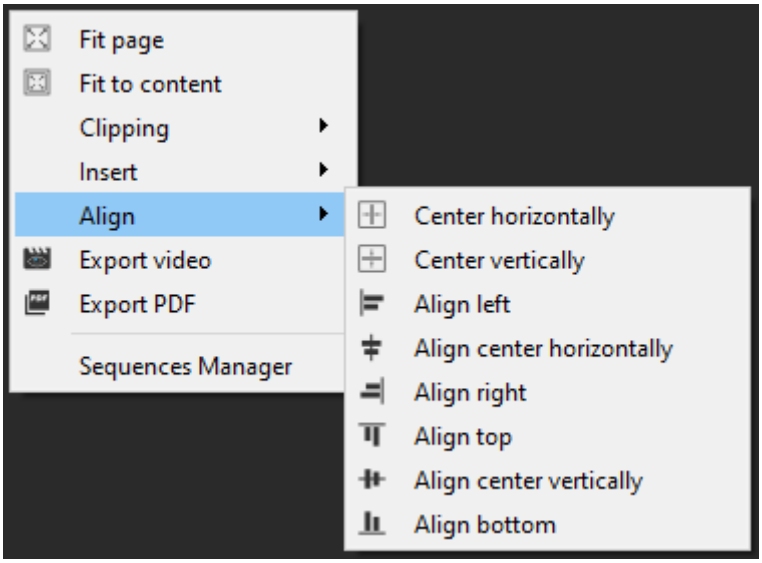



Figure 15.4: Detail of Align submenu.

- **Center horizontally** - Centers the selected objects horizontally with respect to the page
- **Center vertically** - Centers the selected objects vertically with respect to the page
- **Align left** - Aligns the left side of the selected objects
- **Align center horizontally** - Centers the selected objects horizontally with each other

- **Align right** - Aligns the right side of the selected objects
- **Align top** - Aligns the top side of the selected objects
- **Align center vertically** - Centers the selected objects vertically with each other

- **Align bottom** - Aligns the bottom side of the selected objects

### 15.1.2 Shortcut Keys in *iris*

Shortcut keys can be used to simplify common operations in *iris*.

- **Page Up**: Navigate to the previous page
- **Page Down**: Navigate to the next page
- **E**: Opens the *Export PDF* tool
- **V**: Opens the *Export Video* tool
- **</>**: Step forward or backward in timeline by the current time delta (default 0.1s). Alternate shortcuts are **,/.**.
- **t/T**: Decrease/increase time delta for stepping through timeline
- **1**: Fits the current page to the workspace
- **2**: Fits the page contents to the workspace

- #: Toggles the workspace grid
- **Backspace/Delete**: Deletes items that have been selected
- **Cursor keys**: Move selected objects by 5mm (with *Shift*: 1mm, *Alt*: 0.5mm, *Shift+Alt*: 0.1mm).

If pressing a shortcut key does not have any effect, the editor does not have keyboard focus. You can briefly zoom in and out with the wheel to give focus to the editor.

## 15.2 Pages, Templates and Backgrounds

The major elements of *iris* documents are **pages** and **backgrounds**. *iris* projects may also be made into **templates** for convenient reuse. These elements can be viewed and edited using the **page navigator** at the left of the workspace; the **page group pulldown** at the top may be used to select pages, templates, or backgrounds.

### 15.2.1 Pages

All elements in the *iris* editor are displayed on **Pages**. Through the use of multiple pages, elements like plots and images can be made to come and go from the document. All *iris* projects consist of one or more pages. Each page contains an independent set of elements and timelines.

To add, edit, and remove pages, right-click on the page in the page navigator to bring up the context menu seen in Fig. 15.5. Selecting "Page Up" or "Page Down" on the keyboard will allow users to quickly navigate through pages.

A single blank page may also be added by clicking the  icon in the toolbar.

Pages may be reordered by dragging them to the new desired position between two existing pages or before/after the first/last page.

- The **Preview size** submenu controls the appearance of the preview.
- Selecting **Hide** will minimize the page in the navigator.
- A new page can be created by selecting **Add empty page**.
- A new page can be added from an existing template by selecting **Insert template**.
- Selecting **Duplicate** will copy the selected page.
- Pages may be deleted by clicking **Delete page**.
- The background of the selected page may be chosen from the **Change background** submenu.
- The existing page may be copied for use in a **Template** or **Background**.

#### 15.2.1.1 Transitions

Transition properties for individual pages may be accessed by selecting the page in the navigator and editing the **Page Transition** settings in the sidebar at the right of the workspace.

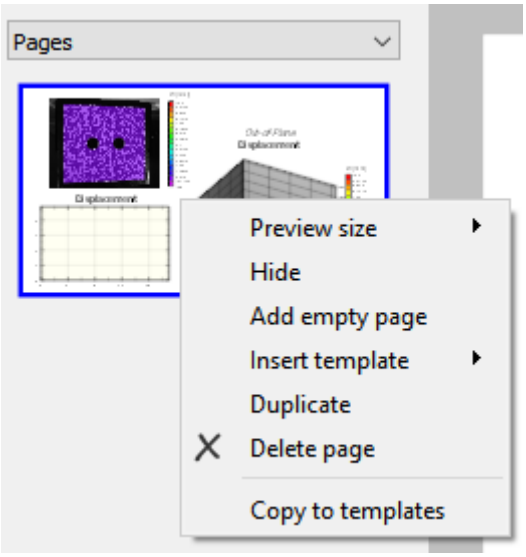



Figure 15.5: Pages context menu.

Default options for transitioning from one page to the next are accessed through the Document Properties. The duration of an empty page may also be selected there; for non-blank pages, the duration ends after the last keyframe.

The time within the page (for preview display only) may be edited with the **Time** control in the right sidebar.

### 15.2.2 Templates

Templates are used to simplify reproduction of *iris* documents for new data. Right-click on the page in the template menu to bring up the context menu seen in Fig. 15.6.

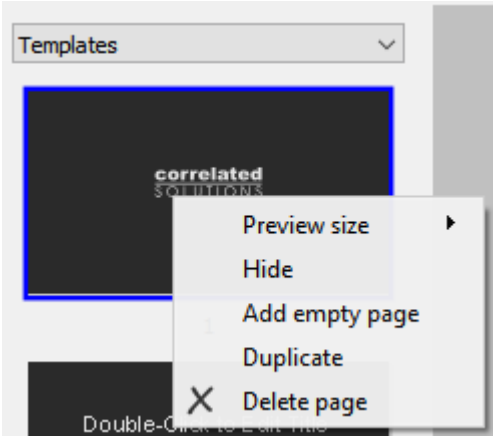



Figure 15.6: Template context menu.

To begin using templates, click the icon on the main toolbar with no existing *iris* document to view the template chooser. For more information, see Working with Templates.

### 15.2.3 Backgrounds

Backgrounds are fundamentally identical to pages, except that they are static and do not have a timeline. Backgrounds can be used to give a consistent appearance to videos through headers, logos, background graphics, etc. Backgrounds may be manipulated by right-clicking on the background in the navigator to show the context menu, illustrated in Fig. 15.7.

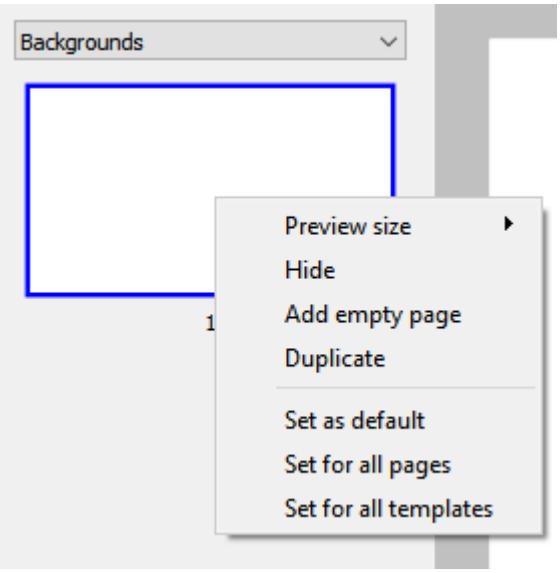



Figure 15.7: Background context menu.

Selecting **Set as default** will make the chosen background the default for new pages. To apply the selected background to all existing pages or template pages, select **Set for all pages** or **Set for all templates**.

### 15.2.4 Working with Templates

#### 15.2.4.1 Using Templates

**Templates** in *iris* are used to enable easy reuse of *iris* projects for new data set. A page template is identical to a page and contains all of the same elements - plots, images, text, etc. A document template comprises a set of page templates and some or all of the page templates may be used. When a template is used with an existing Vic-3D project, many of the elements will be populated automatically, and captions and extraction plots may be easily filled in.

When no *iris* project is present, entering the *iris* workspace will show the **Template Chooser** shown below in Fig. 15.8.

User template documents are stored in a subfolder of the user's Documents folder; both built-in templates and all templates found there will be displayed in the chooser. A template may be selected here or **Empty document** may be clicked to start a new blank project.

Alternately, selecting **New iris document from template** from the **Iris Tools** menu will replace the current document with a blank document based on the selected template.

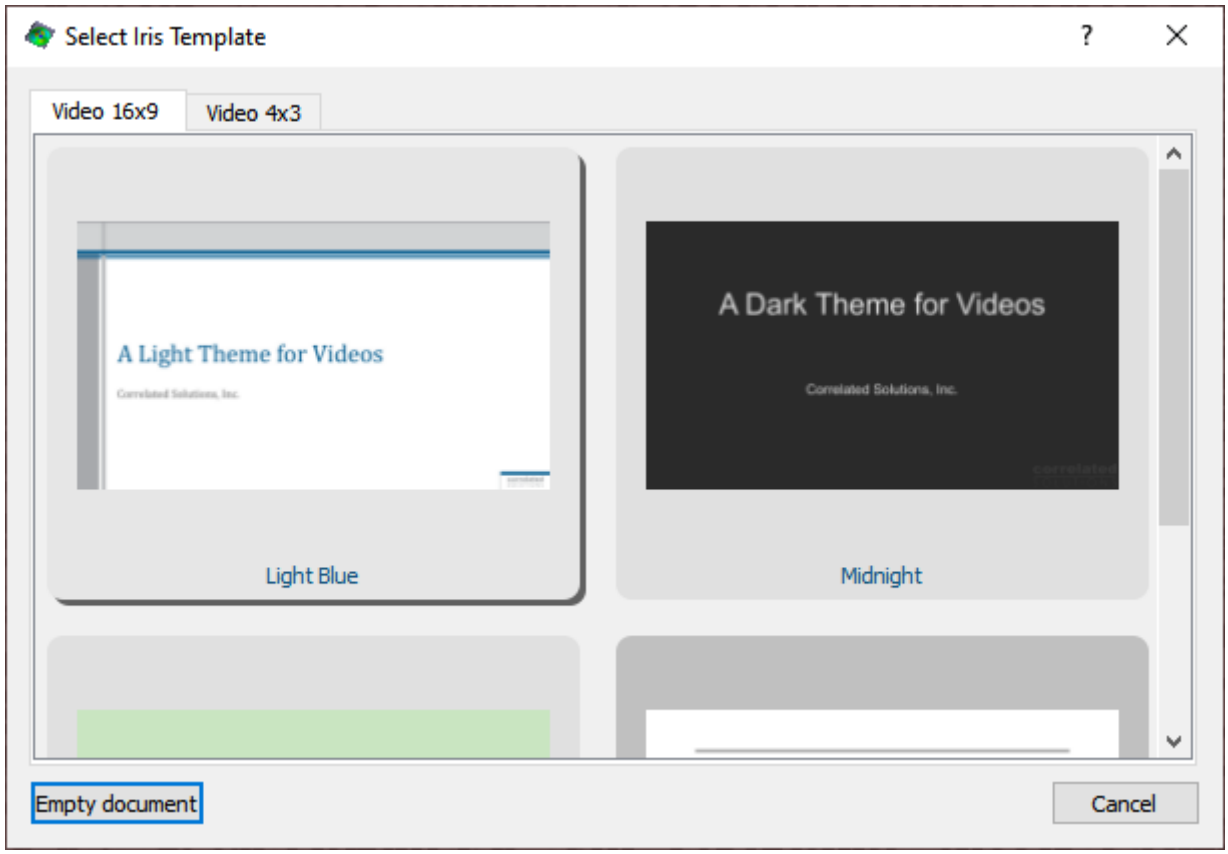



Figure 15.8: Template chooser.

Once a template document is chosen, the templates from the document will be displayed under **Templates** in the navigator view at left. The navigator pane is shown in Fig. 15.9.

To use templates, right-click in the **Pages** navigator at left to bring up the pages context menu shown in Fig. 15.10.

Selecting **Insert template** displays a submenu of available templates shown in Fig. 15.11.

Clicking a template will cause it to be added as a page.

- Any plots are filled with existing data.
- For extraction plots, an existing extraction must be chosen from the plot properties.
- Text boxes designated as template (see below) will be displayed as blank unless edited.

Multiple pages may be inserted by holding the ⊞ icon in the toolbar, this selection is shown in Fig. 15.12.

Single-clicking on a thumbnail will add it to the document; pressing Escape or clicking outside the menu will close it.

#### 15.2.4.2 Creating Templates

A new template may be created by right-clicking in the Templates navigator, shown in Fig. 15.13.


Figure 15.9: Template navigator.

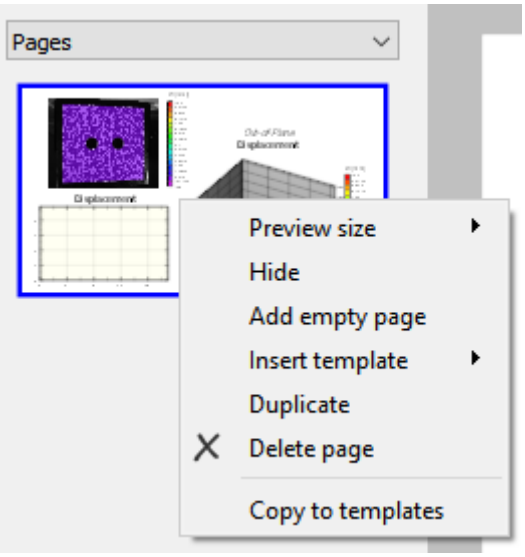



Figure 15.10: Context menu for pages.

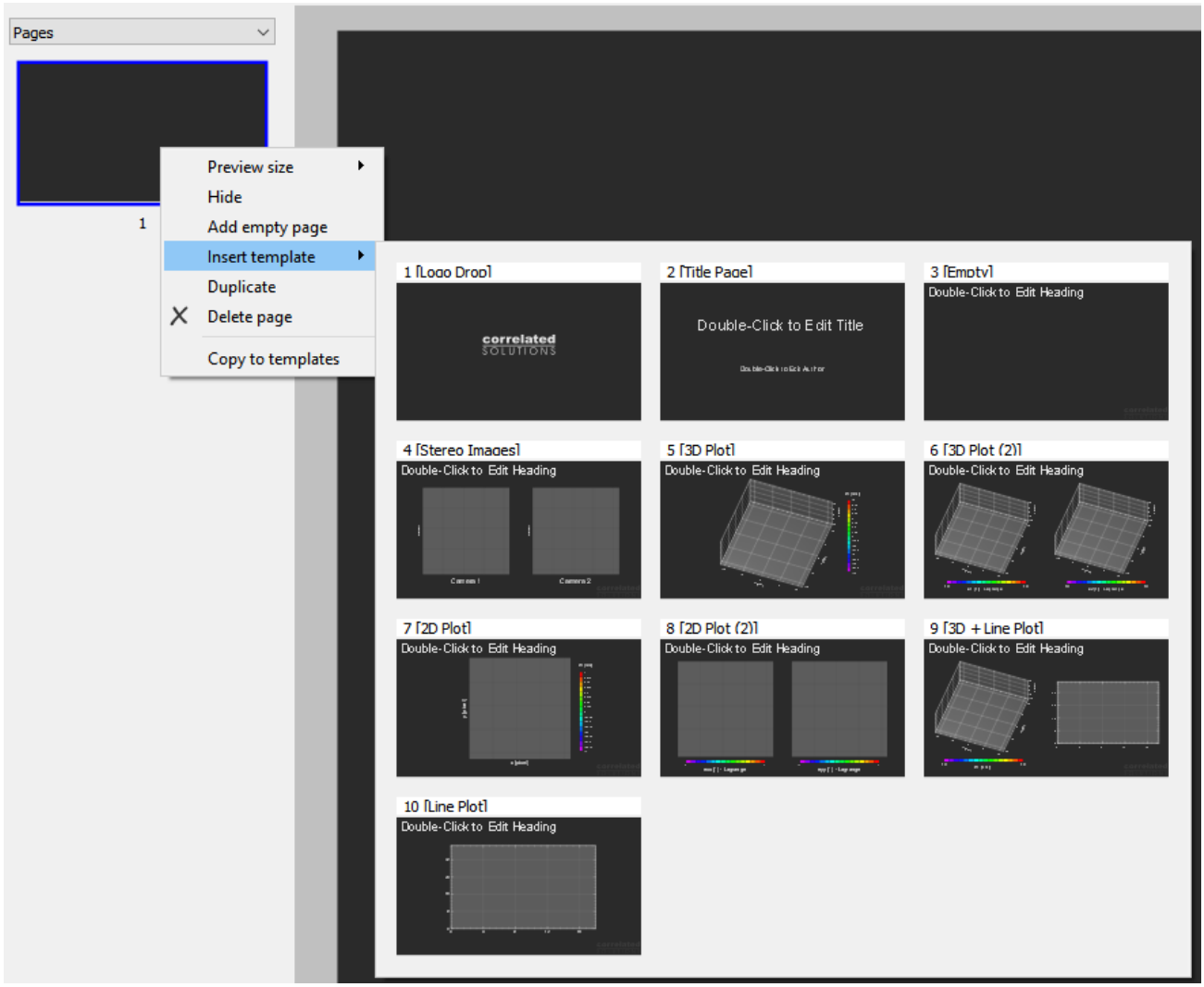



Figure 15.11: Context menu showing templates.

The template may be given a descriptive name using the **Name** field in the **Base** tools, shown in Fig. 15.14.

Editing templates is functionally identical to editing pages in most cases. For text boxes, the toolbar will contain a **Use as template** checkbox which can be seen in Fig. 15.15.

When this box is checked, the entered text becomes a placeholder, and the text will not be included in *iris* output unless edited.

The placeholder text may be used for tips to the template user, e.g., “Double-click to edit Title” or “Enter sample ID here”.

To copy an existing page for reuse as a template, right-click on the page in the **Pages**

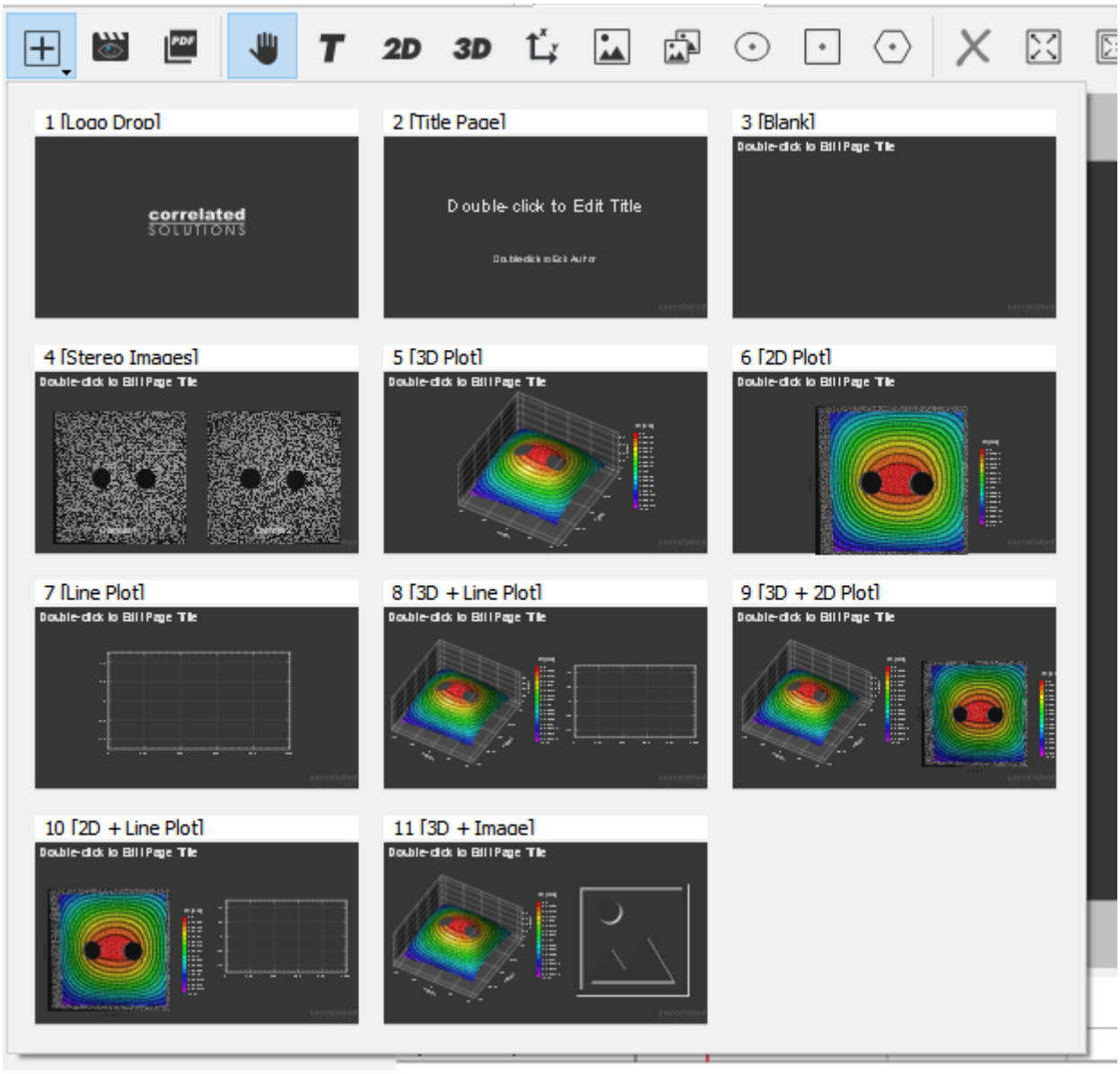



Figure 15.12: Multiple template selection.

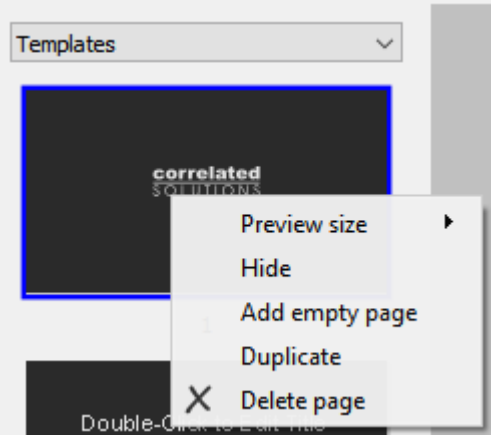



Figure 15.13: Context menu for templates.

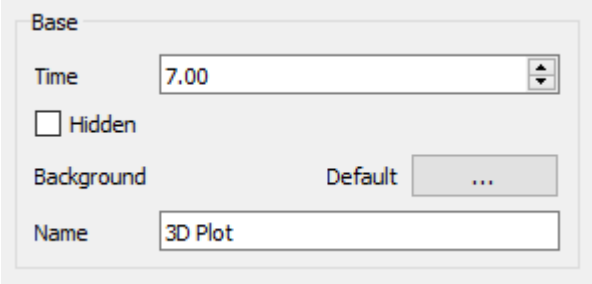



Figure 15.14: Template base tools.

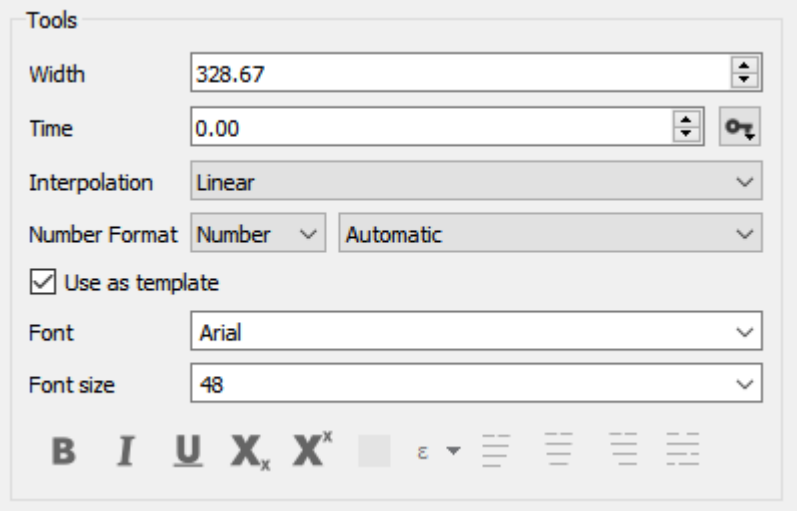



Figure 15.15: Template text tool.

navigator and select **Copy to templates**. The page is added to the template navigator and can then be chosen within the project.

To save the templates from a project as a reusable template file, select **Save as iris template** from the **Iris Tools** menu.



Templates should be saved in the folder chosen by *iris* for easy access from the Template Chooser.

## 15.3 Graphic Elements

Each page in an *iris* document comprises multiple graphical elements. Elements like drawings and plots can be placed on the page and optionally animated using keyframes. The following elements may be added to an *iris* document by clicking in the main toolbar or clicking the *Iris Tools* menu:

- **2D plots**
- **3D plots**
- **Image sequences**
- **Extraction plots**
- **Text boxes**
- **Static images and masks**
- **Mesh data sequences**
- **Ellipses, rectangles and polylines**

### 15.3.1 Element Properties

For placement, an element may be clicked once, which will cause it to be surrounded by a black border. This indicates it may then be clicked and dragged within the page. For editing, an element may be double-clicked which will show a red border. The element is then ready for editing (text editing, changing the angle of a 3D plot, etc.)

### 15.3.2 Common Properties

Many of the document elements in *iris* use a shared set of common tools. Common properties include things like base size, data sources, times, and axis controls. The following common tools are seen in *iris*:

- The **Base** tool controls positioning, alignment, scale, rotation, and depth.
- The **Data** tool controls data sources, time, and interpolation.
- The **Legend** tool sets contour variables and settings and legend settings and fonts.
- The **Variable** tool allows control of data sources and extractions.
- The **Axis** tool controls placement, format, and style of the x- and y-axes on various plots.

### 15.3.3 2D Plots

To insert a 2D plot in *iris*, click the 2D icon, and then click once in the document workspace to insert a 2D plot box. The 2D plot can be edited by clicking on the image once to move the position of the entire plot and double clicking to move the image in the 2D plot window. Clicking on the 2D plot will also bring up the 2D plot properties, which can be adjusted in the sidebar.

#### 15.3.3.1 Plot Properties

All properties of the inserted 2D plot are adjustable in the properties editor at the right side of the workspace. Properties are grouped into the following categories.

##### 15.3.3.1.1 Data

The options for the 2D plot data are set using the common data tool.

##### 15.3.3.1.2 All

The **All** box shown in Fig. 15.16 allows users to adjust the visual appearance of the plot.

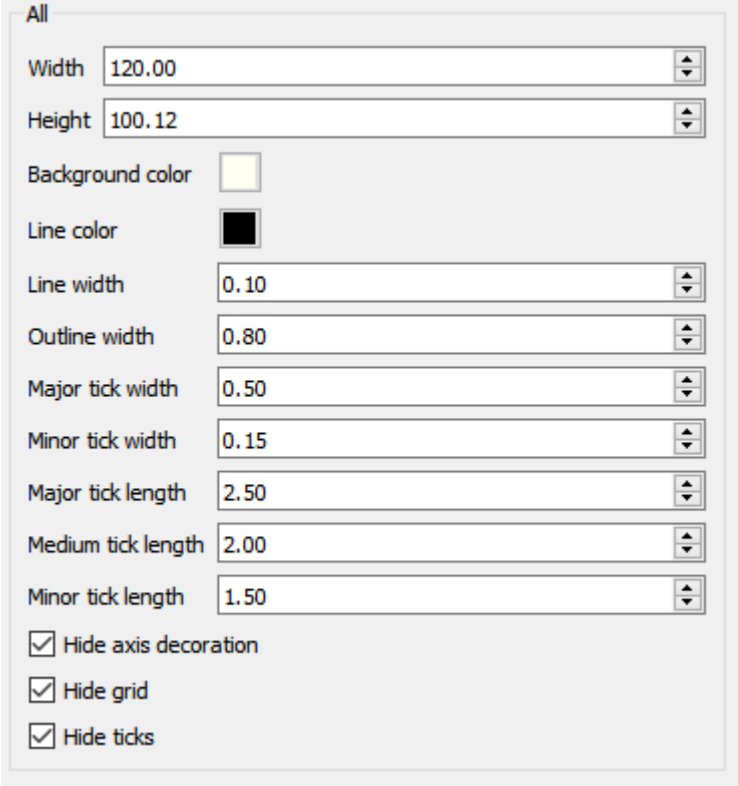



Figure 15.16: All Tool in 2D Plot

The **width** and **height** set the overall width and height of the plot (not including the legend).

The **background color** will be shown anywhere in the plot area not occupied by plot data (if the range is larger than the plot).

The **line color** is the color used for all outlines and tick marks.

The tick length and with for major and minor ticks can be adjusted here; tick spacing is set the axis tools (see below).

Select **Hide axis decoration** to hide the displayed range values.

**Hide grid** hides the grid displayed in the background along major tick lines.

**Hide ticks** hides the plot outline and all tick marks.

#### 15.3.3.1.3 X and Y-Axis

The 2D plot's X and Y-Axis properties can be set by using the common x- and y- axis tools.

### 15.3.3.2 Plot Positioning

The position and rotation of the 2D plot are set using the common base tool.

### 15.3.3.3 Legend Properties

The 2D legend properties can be adjusted from the sidebar by selecting the legend attached with the plot and using the common legend tool.

## 15.3.4 3D Plots

To insert a 3D plot in *iris*, click the 3D icon, and then click once in the document workspace to insert a 2D plot box. The 3D plot can be edited by clicking on the image once to move the position of the entire plot and double clicking to move the image in the 3D plot window. Clicking on the 3D plot will also bring up the 3D plot properties, which can be adjusted in the sidebar.

### 15.3.4.1 Plot Properties

All properties of the inserted 3D plot are adjustable in the properties editor at the right side of the workspace. Properties are grouped into the following categories.

#### 15.3.4.1.1 Data

The different options available for the 3D plot data are set using the common data tool.

#### 15.3.4.1.2 View

The view properties shown in Fig. 15.17 control the visual appearance of the 3D plot and axes.

Keyframe time can be adjusted using the **Time** control, with values ranging from 0 to 1.

If the data needs to be displayed at a time that lands between two sequential data sets, **Interpolation** will be used to calculate intermediate values. The control allows for linear interpolation as well as disabling interpolation (nearest neighbor). Interpolation is used for triangulated data (plots, VTK data) but not for images.

The overall size of the plot may be set with the **Size** control. Checking **Show coordinate system** will cause the axis planes and scales to be displayed; if **Show speckle image** is checked, the speckle pattern will appear as a texture on the surface.

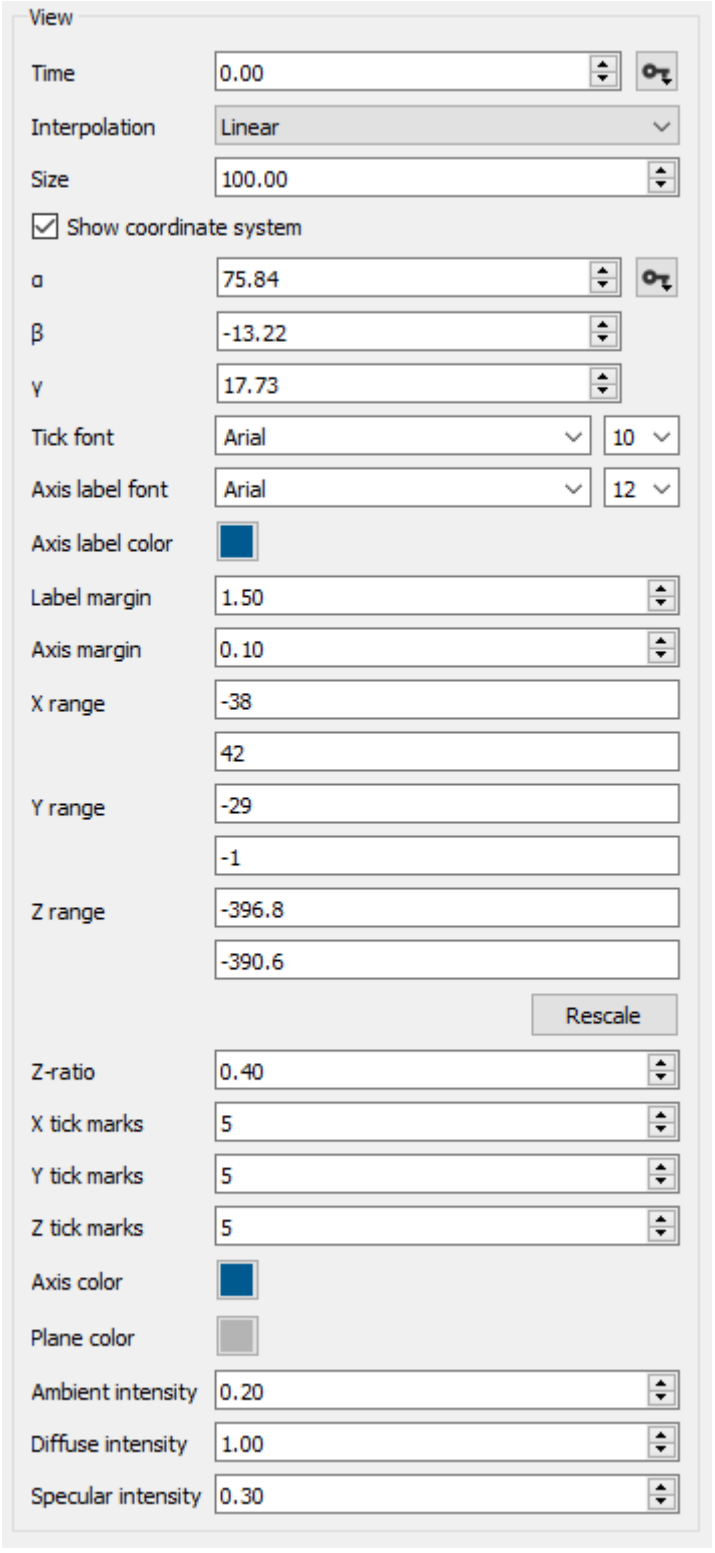



Figure 15.17: View Tool in 3D Plot

The rotation angles for the plot about the X, Y and Z axes are set with the $\alpha$, $\beta$, and $\gamma$ controls, respectively. They may also be set by double-clicking in the plot and then clicking and dragging. The rotation angles are animatable.

The font for the numbers labeled on the axis is set with **Tick font** while the font for the axis value labels (X, Y, and Z) is set with the **Axis label font**. Colors for both are set with the **Axis label color**.

Positioning of axis and tick labels can be adjusted by setting the **Label margin**. Changing the **Axis margin** affects the distance between the boundaries of the plot and the axis planes.

The boundary ranges (minimum and maximum) for each axis are set with the **X range**, **Y range**, and **Z range** controls. The X and Y axi s scales are locked; the Z axis has an independent scaling that may be set with the **Z-ratio**.

The number of ticks per axis is set by the **X tick marks**, **Y tick marks**, and **Z tick marks** controls. Colors may be chosen for the **Axis** (the grid marks displayed on the axis planes), **Plane** (the axis planes themselves), and the **Material**.

Lighting intensity may be adjusted for the **Ambient** source (the amount of light everywhere in the scene), the **Diffuse** source (a diffuse Light source pointed at the surface), and the **Specular** source (a direct light which creates shine on the surface).

> The material color is only visible if the contour overlay and speckle image display are disabled. To view **only** the object without any overlaid data, disable the contour, speckle, isolines, and coordinate system.

#### 15.3.4.2 Plot Positioning

The position and rotation of the 3D plot are set using the base tool.

#### 15.3.4.3 Legend Properties

The 3D legend properties can be adjusted from the sidebar by selecting the legend attached with the plot and using the legend tool.

### 15.3.5 Image Sequences

To add a sequence of images, click the  icon on the main toolbar. Import an image sequence from any source to use in iris animations.

The image sequence properties are set using the data tool in the sidebar. Predefined image sources (speckle images, calibration images) may be selected; an arbitrary image list may be chosen by selecting **Add Image Sequence** from the **Iris Tools** menu, or by using the sequence manager.

If you are selecting images from a DIC experiment, only one camera's images should be added for a smooth sequence.

The size and appearance of the image sequence and axes are set using the shared all tools, while the position and rotation of the image sequence are set using the base tool.

The 2D plot's X and Y-Axis properties can be set by using the common x- and y- axis tools.

The x/y axis display is off by default because an image sequence only contains pixel coordinates, not metric data.

### 15.3.6 Extraction Plots

An extraction plot may be added to an *iris* document by clicking the  icon, and then clicking once in the document workspace. Extractions available for plotting are listed under the data panel. The extraction plot can be edited by clicking on the image once to move the position of the entire plot and double clicking to move the image in the 2D plot window. Clicking on the extraction plot will also bring up the extraction plot properties, which can be adjusted in the sidebar.

#### 15.3.6.1 Plot Properties

The extraction plot properties can be adjusted from the sidebar.

Each X/Y data pair shown in the plot will be listed in the *Charts* tool box, as seen in Fig. 15.18.

To select the variables for a new or an existing X/Y pair, the X/Y data source and variable can be selected from the drop-down menus below the list box. Available data sources are:

- **Average** corresponds to the average value from the entire data set.
- **P0, R0, C0**, etc. are the values corresponding to inspector tools (points, rectangles, circles etc).
- **Analog data** corresponds to CSV data added to the project. This is normally a file generated by Vic-Snap.

After the variables for X or Y have been selected from the menus, the apply button on the right must be pressed to apply the changes. Note that the change applies to all X/Y pairs selected in the list box.

To delete an X/Y pair, the item must first be selected in the list box, followed by pressing the **Delete** button.

To add multiple X/Y pairs, select the **Multi...** button. Once selected, the *Options for New Plots* dialog will appear with selectable options and extraction objects, shown in Fig. 15.19.

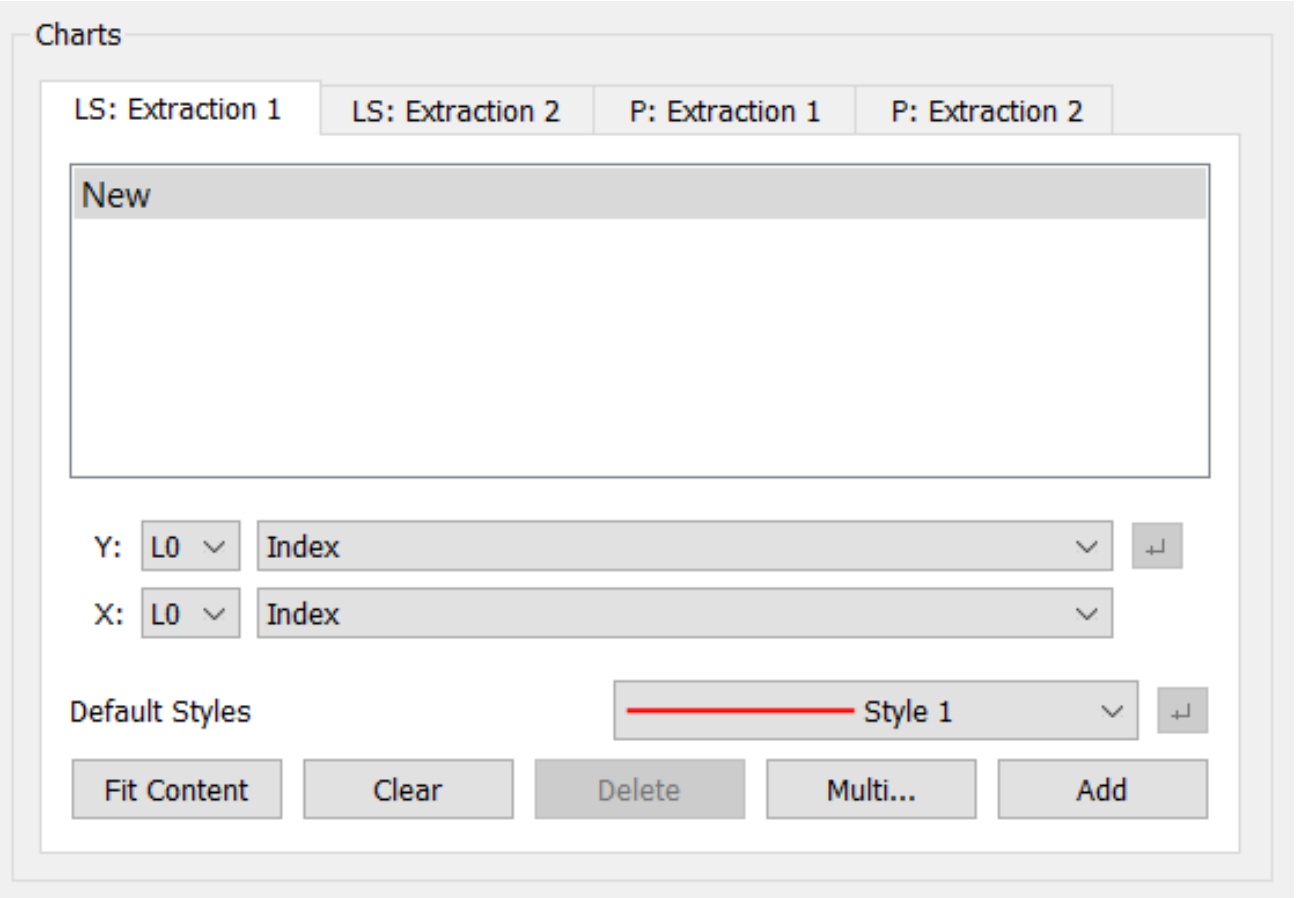



Figure 15.18: Charts Tool Box

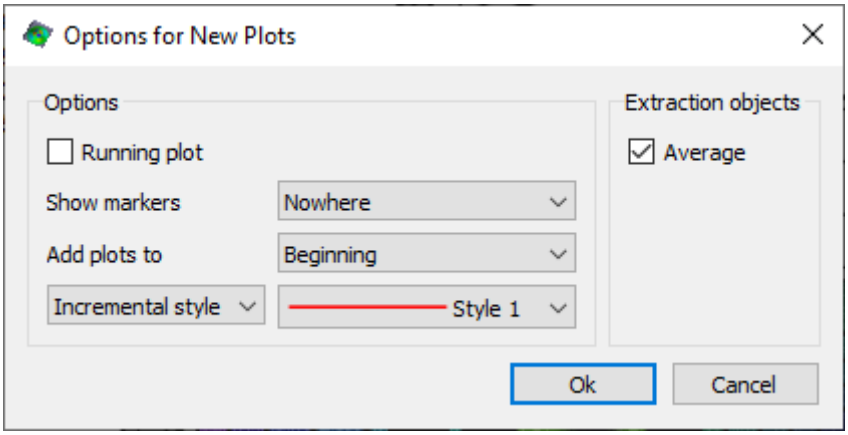



Figure 15.19: Multiple extraction options dialog.

New X/Y data pairs can be added to the plot by first selecting the *New* item in the list box at the top. Then, the data source and variables can be selected from the drop-down menus and the new X/Y pair is finally created by clicking the **Add** button.

Selecting an X/Y data pair plotted will expand he *Charts* window to customize the color, line style, line width, and markers placed, as seen in Fig. 15.20.

If **Automatic Name** is selected the name will be chosen based on the data; if this is cleared a name may be entered manually and edited with the style tools. If **Show in legend** is selected the name will also be displayed in the plot legend.

The **interpolation** control selects the interpolation (linear or nearest neighbor) used when the plot is animated.

Line and marker colors, size, and style may be edited with the associated **Line** and **Marker** tools. Markers may be disabled, shown everywhere, or shown only at the end of the plot. If **Running plot** is selected, the plot will be displayed up to the current **Time**, allowing the plot to be animated.

For line slice plots, additional time controls are displayed as shown in Fig. 15.21. If **Animate Graph** is checked the graph time will be the time selected or animated via the all tools. If this box is cleared, the plot will be displayed for the static time selected in **Graph time**.

#### 15.3.6.2 Plot Legends

A plot legend may be added to allow easy identification of different data series. The legend tools are shown in Fig. 15.22.

Display of the legend is controlled by the **Show Legend** checkbox. The base position and location may be selected with the **Corner** and **Position alng axis** tools; fine adjustments to this position can be made with the **Axis offset** controls. Border appearance and style, margins, fonts, and colors may all also be adjusted here.

> The default color for the legend background has an Alpha (opacity) of 0. To make the background color visible, increase the Alpha value in the color chooser. An Alpha value of 255 corresponds to fully opaque.

#### 15.3.6.3 All

The height and width of the extraction plot within the plot window as well as the appearance of the plot and axes are controlled with the shared all tools.

#### 15.3.6.4 X and Y-Axis

The 2D plot X and Y-Axis properties can be set by using the x and y-axis tool.

#### 15.3.6.5 Plot Positioning

The position and rotation of the 2D plot are set using the base tool.

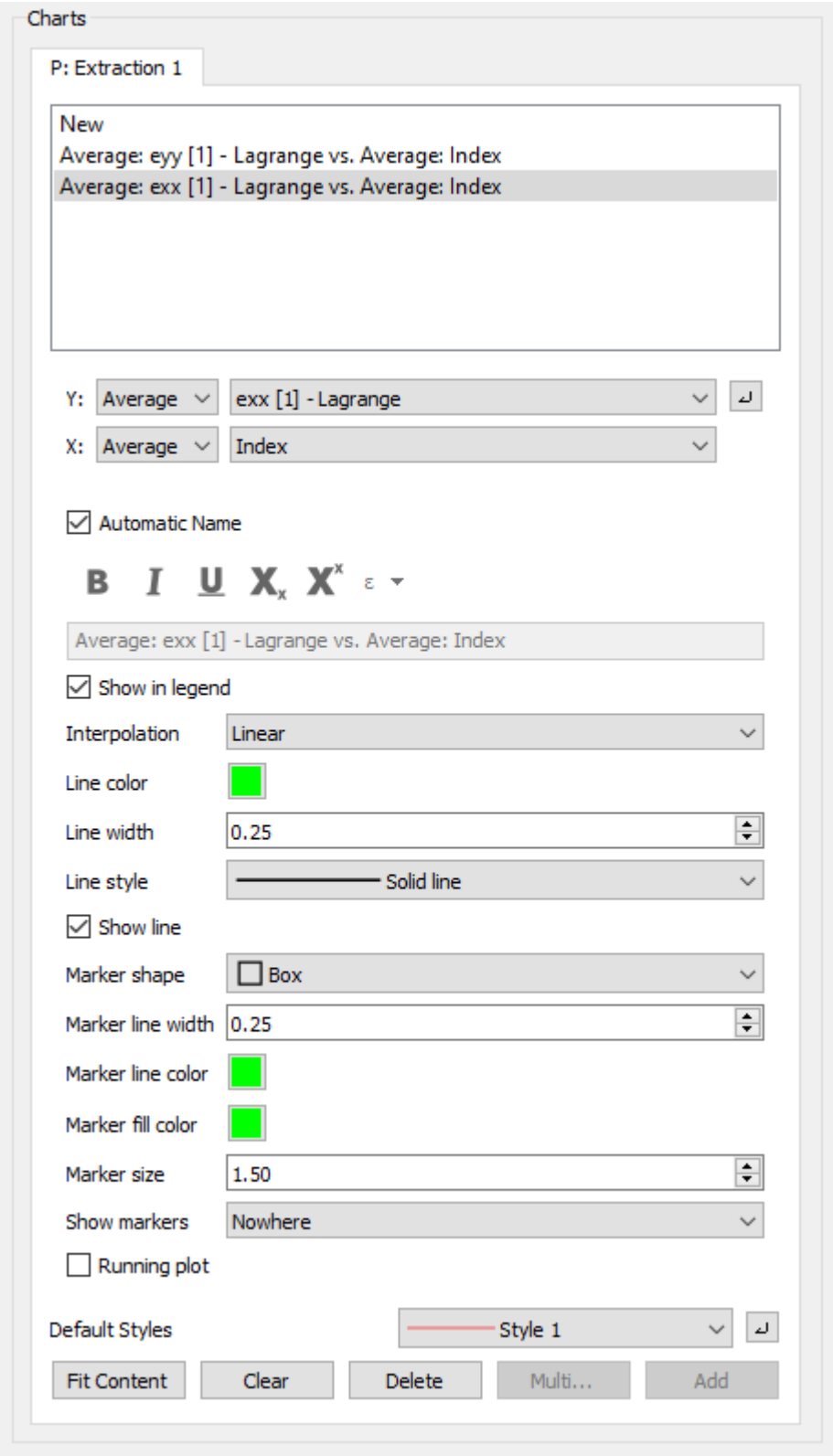



Figure 15.20: Chart style tools.

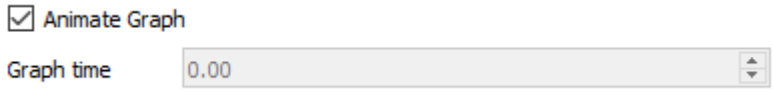



Figure 15.21: Line slice time tools.

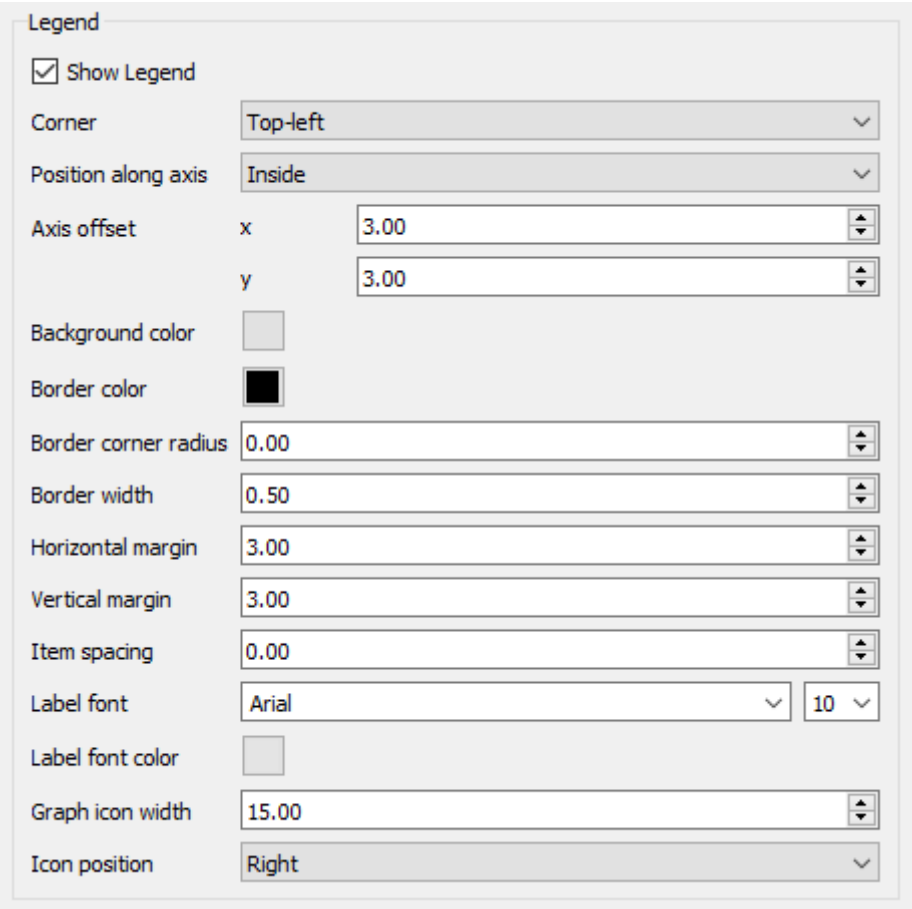



Figure 15.22: Plot legend tools.

### 15.3.7 Text Boxes

Text boxes can be used to add captions, titles, information, and extracted data values to an *iris* document. To insert a text box in *iris*, click the **T** icon, and then click once in the document workspace to insert a standard box.

#### 15.3.7.1 Text editing

The text may then be edited by double clicking on the text box. Entering a '#' at the beginning of a line will automatically create a numbered list. Entering '-' or '*' at the beginning of a line will automatically create a bullet list.

#### 15.3.7.2 Text box tools

Text box properties may be adjusted using the sidebar tools, as shown in Fig. 15.23.

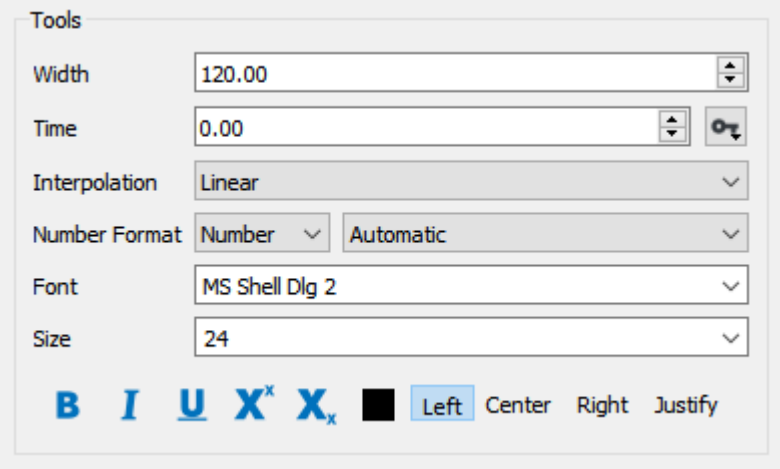



Figure 15.23: Text box tools.

The width and font size can be adjusted here, as well as the text justification.

> Select text within the box by holding Shift and using the arrow keys. When text is selected, font and style options will apply to selected text only; when no text is selected, the entire text box will be modified.

The Time control refers to the position within the data, when numerical data is present. The time control is animatable.

#### 15.3.7.3 Inserting data

To display numeric data in the text box, at least one extraction must be present in the project. You can insert the data at any location within your text by typing ${n}, replacing $n$ with the index of your desired data source. Text box variables without data shown below in Fig. 15.24.

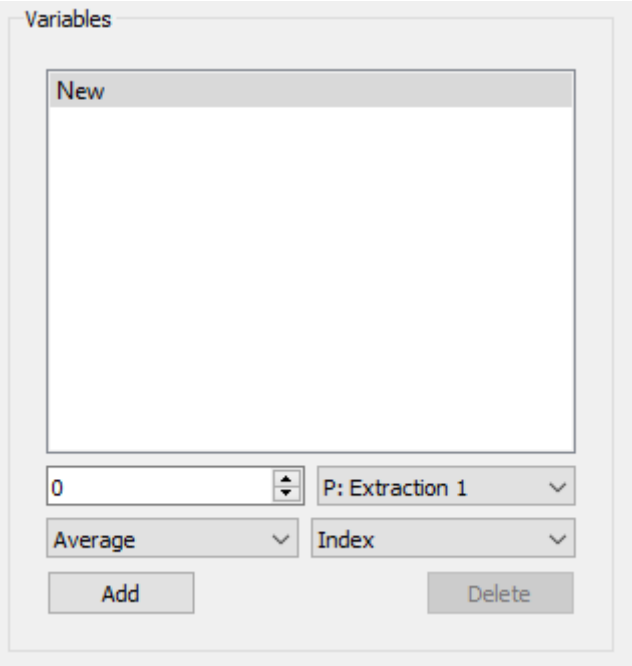



Figure 15.24: Text box variables.

Select the extraction from the pulldown, and then choose variables and click **Add** to add a data source, shown below in Fig. 15.25.

The data can now be referenced within the text by typing ${0} or ${1}.

#### 15.3.7.4 Text box positioning

The position and rotation of the text box are set using the base tool.

### 15.3.8 Static Images

To add a static image, click the  icon on the main toolbar.

The position and rotation of the image sequence are set using the base tool and are animatable. The View control at right sets the base size of the image in the workspace.

### 15.3.9 Drawing Tools

Simple graphical elements can be added using the drawing tools in *iris*. Ellipses, polylines, arbitrary polygons, rectangles, and rounded rectangles may be placed and animated as desired. These elements can also be used for clipping.

- To add an ellipse or rectangle, click the  or  icon in the main toolbar. Click and then drag in the workspace to draw the shape. Properties can be adjusted with the View tool in the toolbar shown in Fig. 15.26.

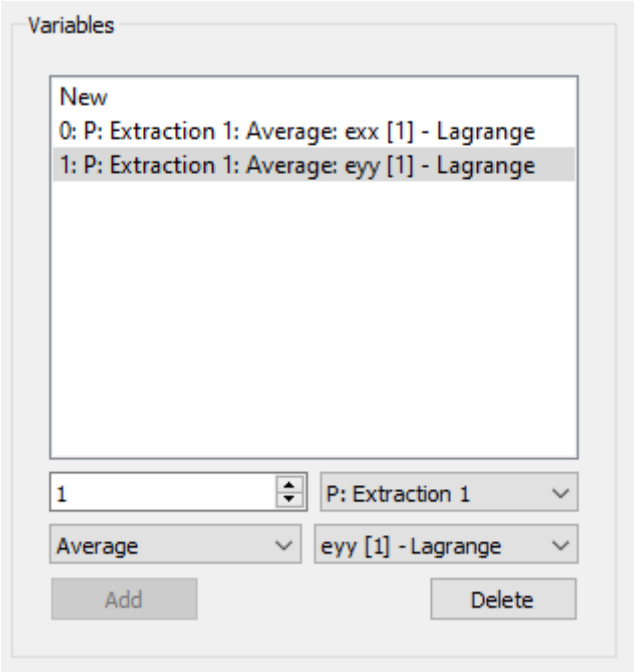



Figure 15.25: Text box variables, with data.

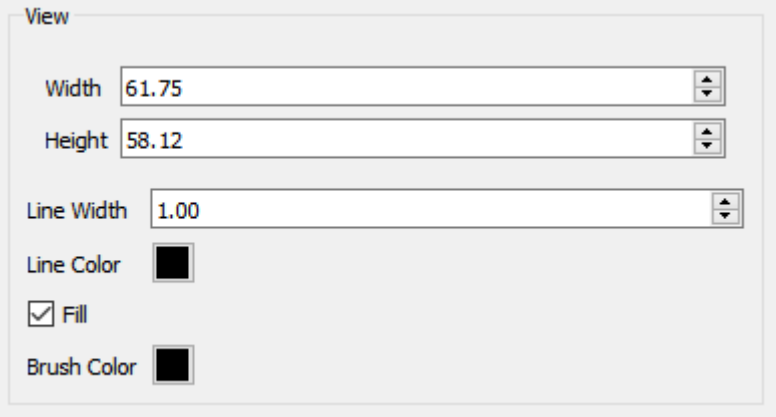



Figure 15.26: The view tool for an ellipse.

- Rectangles give one additional option for rounded corners, allowing you to adjust the radius shown in Fig. 15.27.

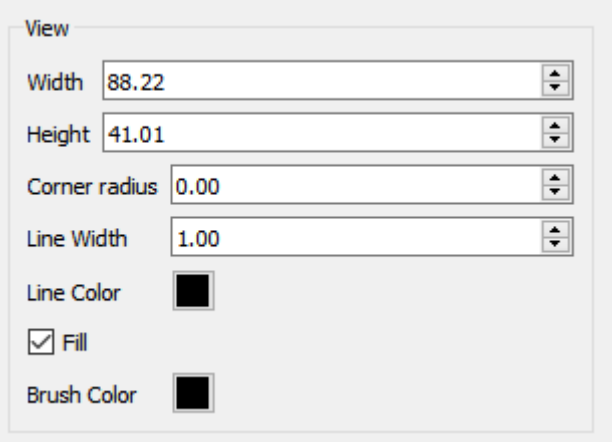



Figure 15.27: The view tool for a rectangle.

The **Line Color** controls the color of the outline; the **Brush Color** controls the fill color. The thickness of the outline is controlled by the **Line Width**.

- To add a polyline or polygon, click the icon. Click once in the workspace to define the first point; click additional points to add, and then double click to finish. Properties are adjusted with the View tool shown in Fig. 15.28.

  To force the polyline segment to 45 degree angles, hold Shift while drawing.

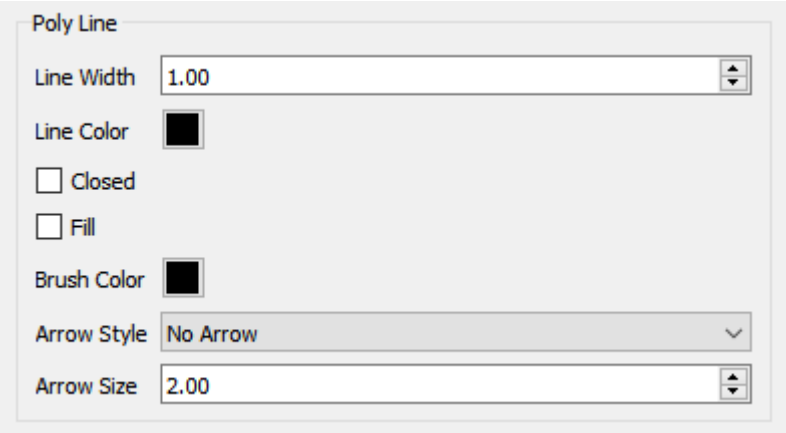



Figure 15.28: The view tool for a polyline.

A polygon may be created by selecting **Closed** to join the first and last point. Checking the **Fill** box will cause the interior area of the polyline to be filled with the **brush color**. An arrow style and size may also be selected.

### 15.3.10 Clipping *iris* Objects

- Using the ellipse or rectangle drawing tool, easily clip any *iris* objects simply by drawing a shape over the area within the object to be clipped, selecting the objects and the drawn shape, and then pressing "C" on the keyboard. Selecting any clipped objects and pressing shift +"C" will unclip the objects. Objects can also be clipped by using the context menu shown in Fig. 15.29 when right clicking on two selected objects.

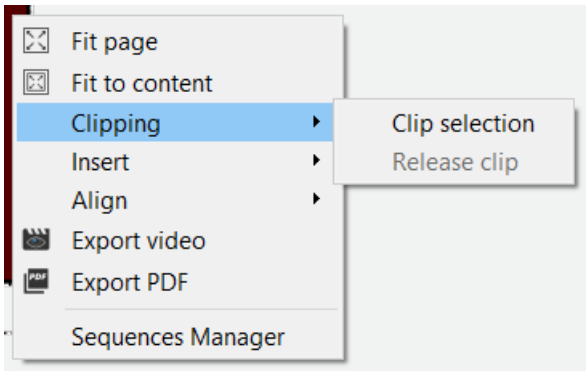



Figure 15.29: The context menu for clipping.

- The before and after effect of clipping can be seen in Fig. 15.30 and Fig. 15.31.
- When clipping objects the scale and the position are animatable.

> The clipped object can be animated to show or hide objects as well as bring focus to certain areas within a 3D plot.

### 15.3.11 The Base Tool

Each element in **iris** shares a common set of controls for location, rotation, scale, etc. These control the placement and size of the object on the page and can be animated to allow motion, rotation, and zooming. These controls are contained within the **Base** tool, shown in Fig. 15.32.

The **x** and **y** controls set the object location within the page.

The **Rotation tool** adjusts the rotation angle of the object, in degrees.

The **Scale** tool scales the object, using the object's Width and Height settings as a base.

The **Depth** controls the z-order within the page, determining which objects are displayed on top of others.

The **Opacity** control allows objects or background to be seen through the selected object, if set to less than 1.00. For a fully transparent (invisible) object the value should be set to 0.00.

The **Origin** controls are used to set the origin of the local coordinate system of the element. This is the fixed anchor within the element position, rotation, and scaling. Note that changing

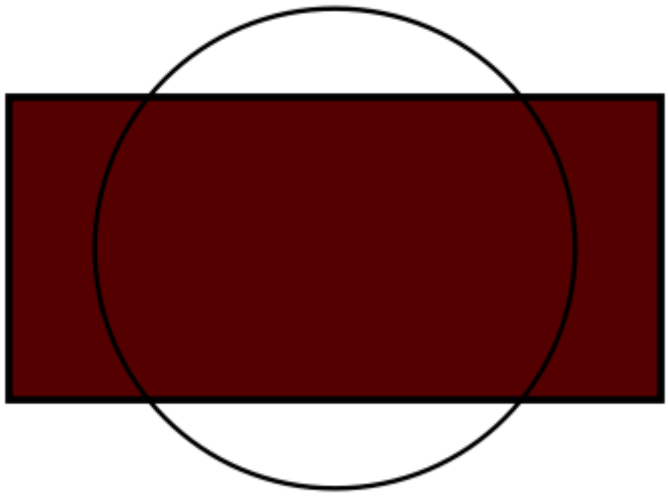


Figure 15.30: Rectangle and ellipse before clipping.

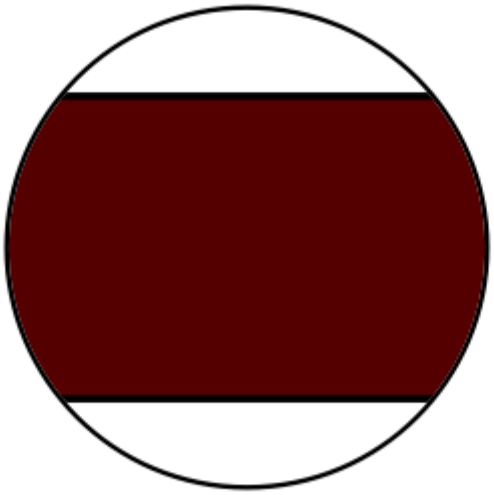


Figure 15.31: Rectangle and ellipse after clipping.

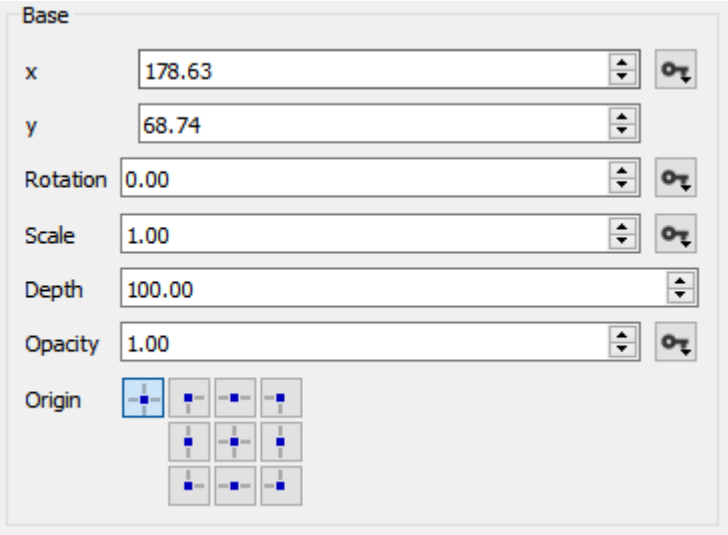



Figure 15.32: Base tool.

the origin will result in a movement of the object and it is recommended to set the origin before any animation of the object position is created. The default origin is different from the top-left corner for some objects. For instance, 3D plots use the center of the plot as the default origin to facilitate smooth interactive rotation of the plot.

All properties except depth and origin may be animated.

Since the **Depth** control is not animatable, clipping of an element may be used to allow elements behind it to be seen in an animation

For templates to work well with different data and images, it is best to set the object origin to *center* on the template pages before positioning the object. This ensures that the object remain in a reasonable position when the template is applied to different data with, e.g., different image aspect ratios or data ranges.

### 15.3.12 The Data Tool

In *iris* various elements are based on sequential, time-based data. Image sequences, VTK data sequences, text boxes containing values, and contour plots all have a time element.

Depending on the data source, the data tool will have different options available. Below, the 3D triangulated data plot menu is shown in Fig. 15.33, the 2D triangulated data plot menu is shown in Fig. 15.34, the 3D marker data plot menu is shown in Fig. 15.35, and the 2D marker data plot menu is shown in Fig. 15.36.

### 15.3.13 Data Tools for Triangulated Data

Triangulated data in *iris* refers to either correlated data (.OUT files) or to imported model data (VTP data).

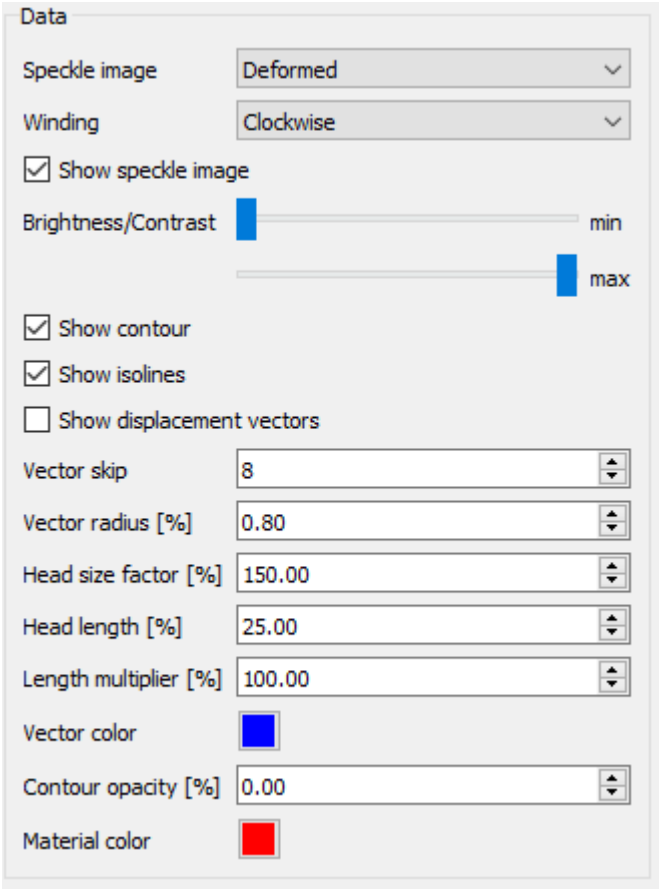



Figure 15.33: Data tool for 3D plot of triangulated data.

For 2D and 3D plots, a **Speckle image** can be selected. Either the deformed or reference speckle pattern may be chosen as a texture.

For 3D plots, a **Winding** control allows selection of clockwise or counterclockwise mesh winding, or winding direction may be ignored.

> Winding refers to the direction in which faces are defined and is used to determine the illuminated face. Vic-3D data and most mesh data is clockwise wound. If the direction is unknown, selecting Ignore usually gives a good result.

**Show speckle image** displays the speckle image along with the contour variable, unchecking this will show only the color gradient. The **Brightness/Contrast** slider allows you to adjust the top slider to control the minimum brightness, and the bottom slider to adjust the minimum

and maximum grey values. **Show contour** enables or disables the contour variable on the 3D plot. **Show isolines** enables or disables isolines on the 3D plot, individual isoline settings are found under the **Legend**.

**Show displacement vectors** enables or disables displacement vectors on the 3D plot. **Vector skip, Vector radius, Head size factor, Head length, Length multiplier, and vector color** are all settings specific to the visualization of vectors in *iris*. **Contour opacity** adjusts the opacity levels of the contour variable on the 3D plot. **Material color** is the color of the 3D model if the contour variable and speckle image overlay is not enabled.

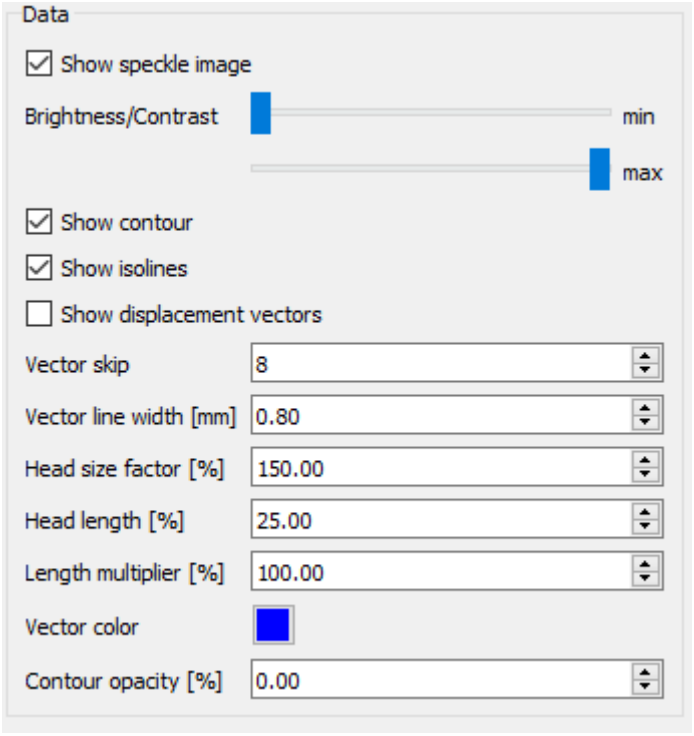



Figure 15.34: Data tool for 2D plot of triangulated data.

**Show speckle image** displays the speckle image along with the contour variable, unchecking this will show only the color gradient. The **Brightness/Contrast** slider allows you to adjust the top slider to control the minimum brightness, and the bottom slider to adjust the minimum and maximum grey values. **Show contour** enables or disables the contour variable on the 2D plot. **Show isolines** enables or disables isolines on the 2D plot, individual isoline settings are found under the **Legend**.

**Show displacement vectors** enables or disables displacement vectors on the 2D plot. **Vector skip, Vector radius, Head size factor, Head length, Length multiplier, and vector color** are all settings specific to the visualization of vectors in *iris*. **Contour opacity** adjusts the opacity levels of the contour variable on the 2D plot. **Material color** is the color of the 2D model if the contour variable and speckle image overlay is not enabled.

### 15.3.14 Data Tools for Marker Data

In *iris*, markers may represent either extracted markers (ellipse/bowtie), or plot extraction points. They are treated and displayed identically once in the *iris* workspace.

Properties for a single marker may be edited by selecting the marker in the **Markers** list and clicking **Edit**. This will display the Marker Properties dialog.

**Show markers** displays the markers on the ends of each connection. **Marker radius** adjusts the size of the markers on the ends of each connection. **Show markers contour** enables or disables the contour variable on markers. **Show connections** enables or disables the connections between the markers. **Show connection contour** enables or disables the contour variable on the connections between the markers. **Marker color** is the color of the 3D markers. **Connection color** is the color of the connection between the markers. **Connection radius** adjusts the size of the connection between the markers. **Number of tracers** adds phantom tracers in for the locations of the marker throughout time. **Tracer opacity and tracer cut-off time** adjust the opacity of tracers and the length of time they remain.

**Show speckle image** displays the speckle image along with the contour variable, unchecking this will show only the color gradient. The **Brightness/Contrast** slider allows you to adjust the top slider to control the minimum brightness, and the bottom slider to adjust the minimum and maximum grey values. **Show markers** displays the markers on the ends of each connection. **Marker radius** adjusts the size of the markers on the ends of each connection. **Show markers contour** enables or disables the contour variable on markers. **Show connections** enables or disables the connections between the markers. **Show connection contour** enables or disables the contour variable on the connections between the markers. **Marker color** is the color of the 2D markers. **Connection color** is the color of the connections between the markers. **Connection line width** adjusts the width of the connection between the markers.

The label number format and appearance may be adjusted using the Label controls. **Tracers**, **trajectory**, or both may be displayed. **Tracers** are an animatable and fading indication of the prior positions of the marker. The **Trajectory** indicates the path of the marker. To disable tracers/trajectory for a single marker, the Marker Properties dialog can be used.

#### 15.3.14.1 Data source

- For 2D, the data source will be project data (.OUT) files, extraction points and data, or both. The current project's data is selected by default. An arbitrary data set can be made available by choosing **Add Data Sequence** from the **Iris Tools** menu, or by using the or by using the sequence manager. The new data will appear in the **Data source** pulldown.

- For image sequences, a sequence source can be chosen. The Speckle and Calibration image sets are always available. An arbitrary image set can be made available by choosing **Add Image Sequence** from the **Iris Tools** menu or by using the sequence manager. The image set will then appear in the **Data source** pulldown.

  When project speckle images are the data source, a **Camera Id** control appears to allow display of images from camera 0 or 1.

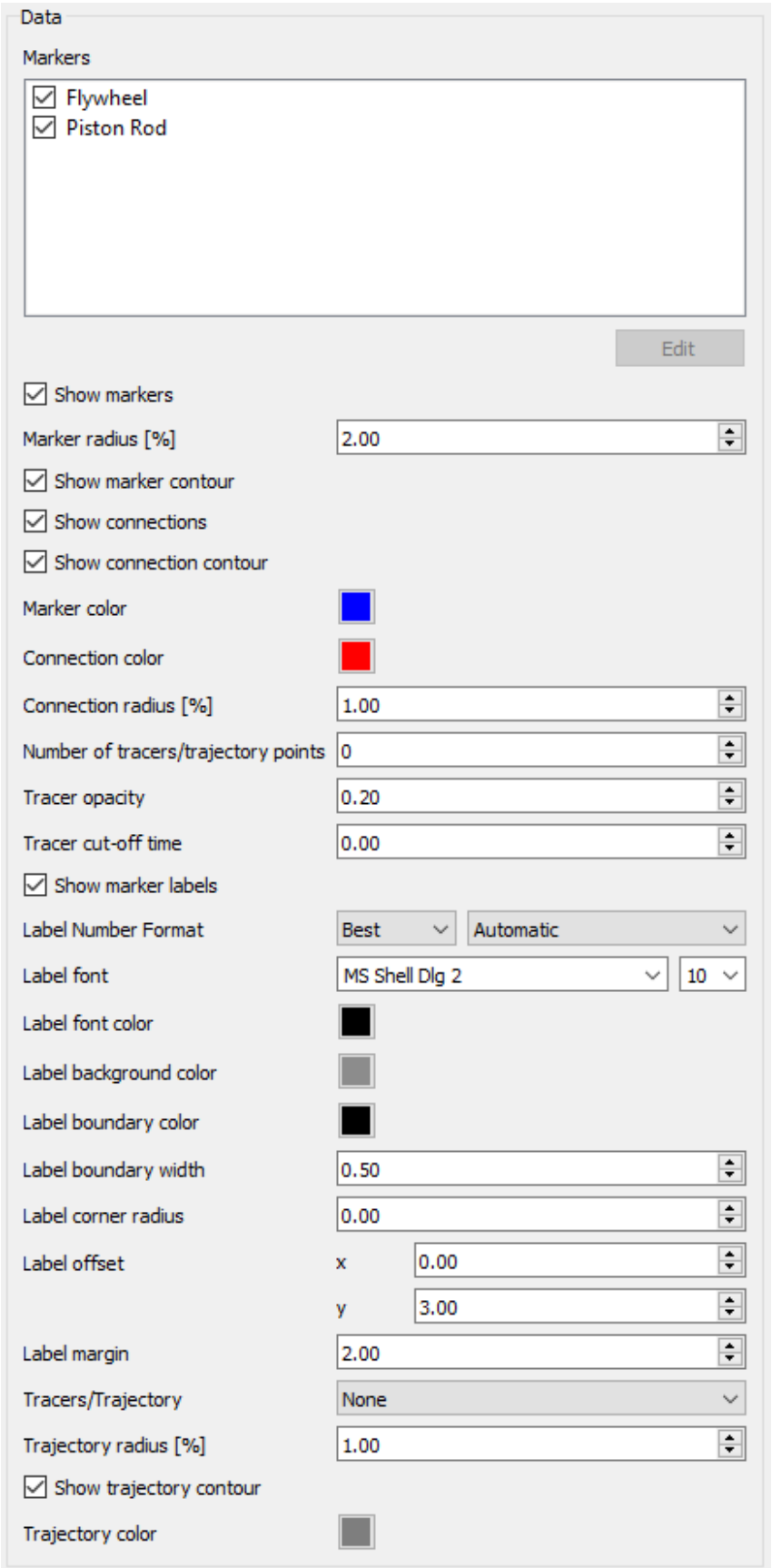



Figure 15.35: Data tool for 3D plot of marker data.

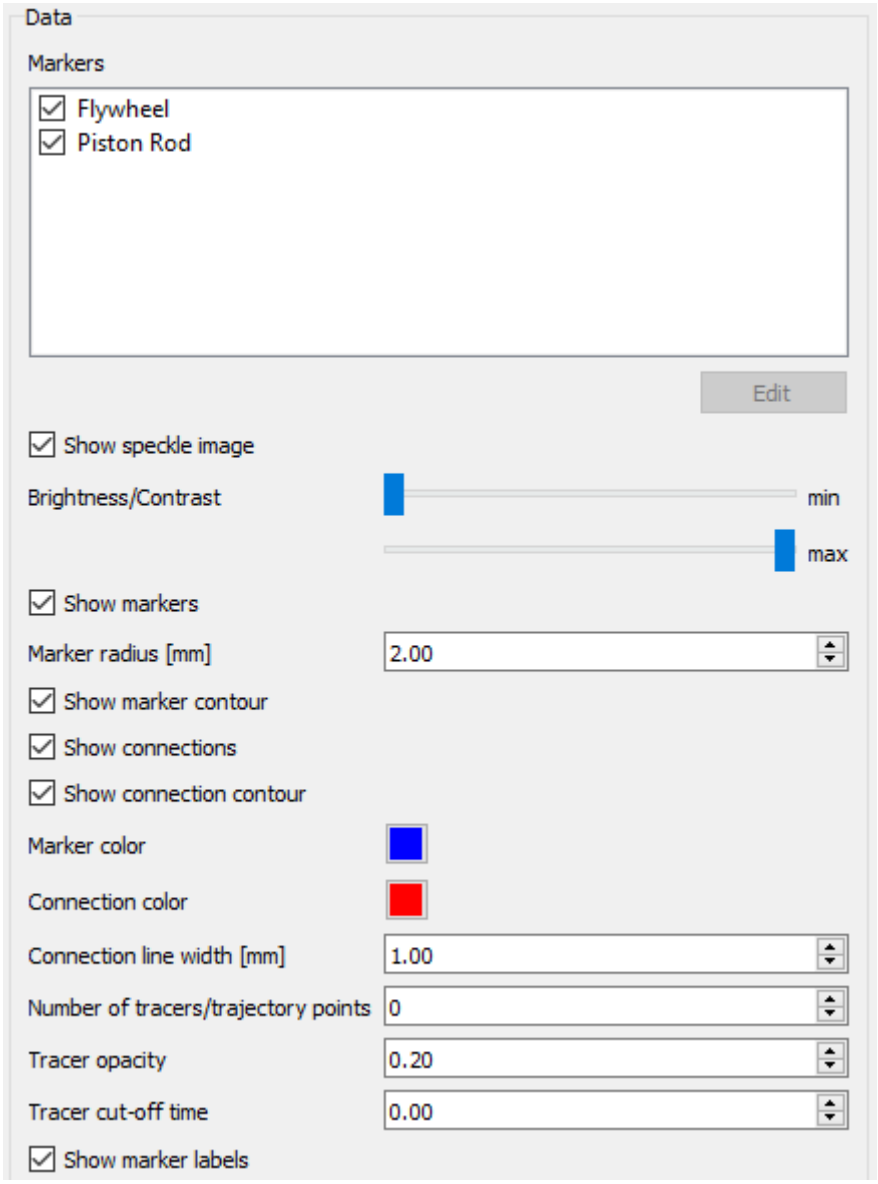



Figure 15.36: Data tool for 2D plot of marker data.

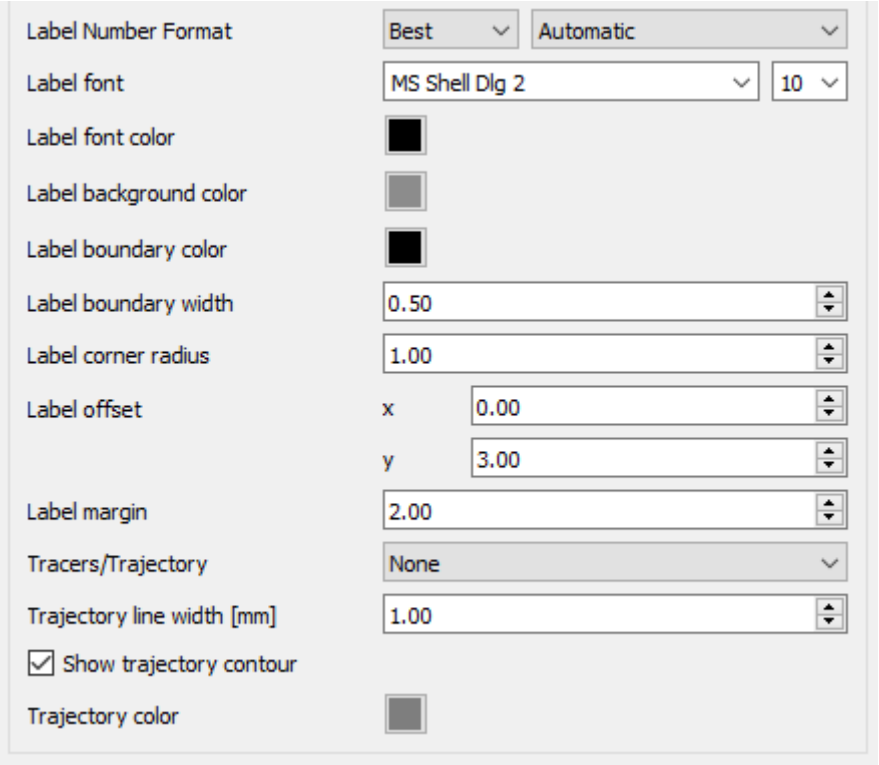



Figure 15.37: Data tool for 2D plot of marker data.

### 15.3.15 Marker Properties

The marker properties dialog is used to edit marker appearance and labels. It can be displayed by selecting a marker from the data tool and clicking Edit.

The marker color and radius may be adjusted using the controls at the top of the dialog. Checking **Show contour** will cause the marker to be colored in the contour color according to its value rather than the selected color. Checking **Enable tracers/trajectory** will enable the display of tracer and trajectory decorations for the marker; clearing the box will override the global settings in the Data Tool and hide decorations for this marker.

#### 15.3.15.1 Text editing

The default label for the marker may be edited or overriden using the line editor. Standard tools are present for bold, italic, underline, sub/superscript, and Greek characters.

The default marker display is *marker name : marker value*. The formatting and displayed values may be changed, added, or removed. A list of possible escape codes is displayed at the bottom of the dialog; double-clicking will insert the appropriate code at the cursor position. During rendering, the code will be replaced with the evaluated value.

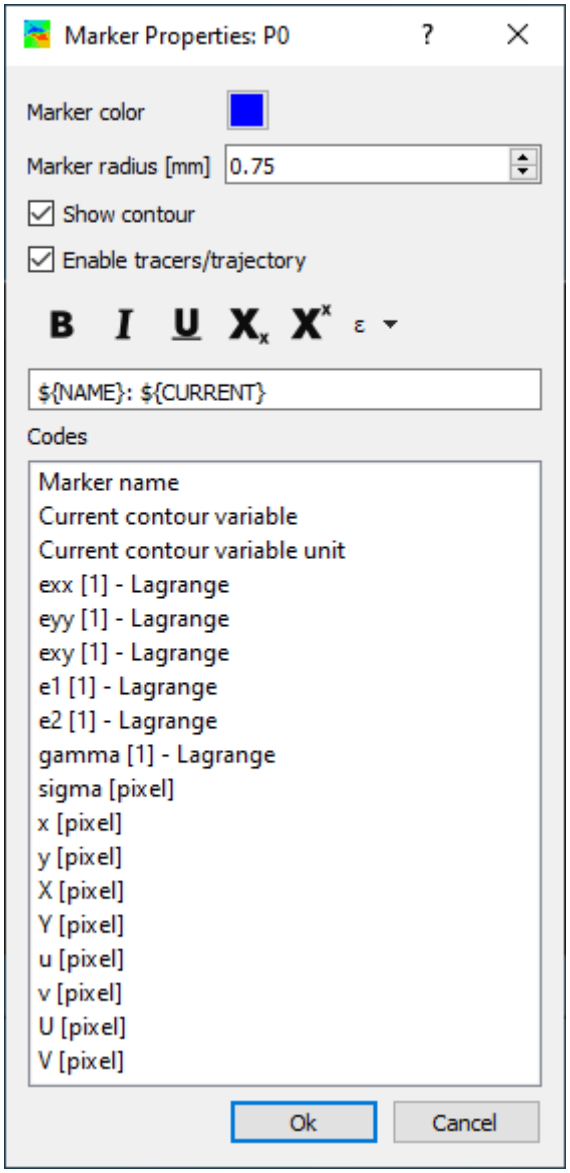



Figure 15.38: Marker properties dialog.

### 15.3.16 The Legend Tool

The legend tool controls the legend properties for both 2D and 3D plots in *iris*. This tool affects the legend itself and also contains controls for the appearance of the attached plot. A 2D legend is shown below in Fig. 15.39:

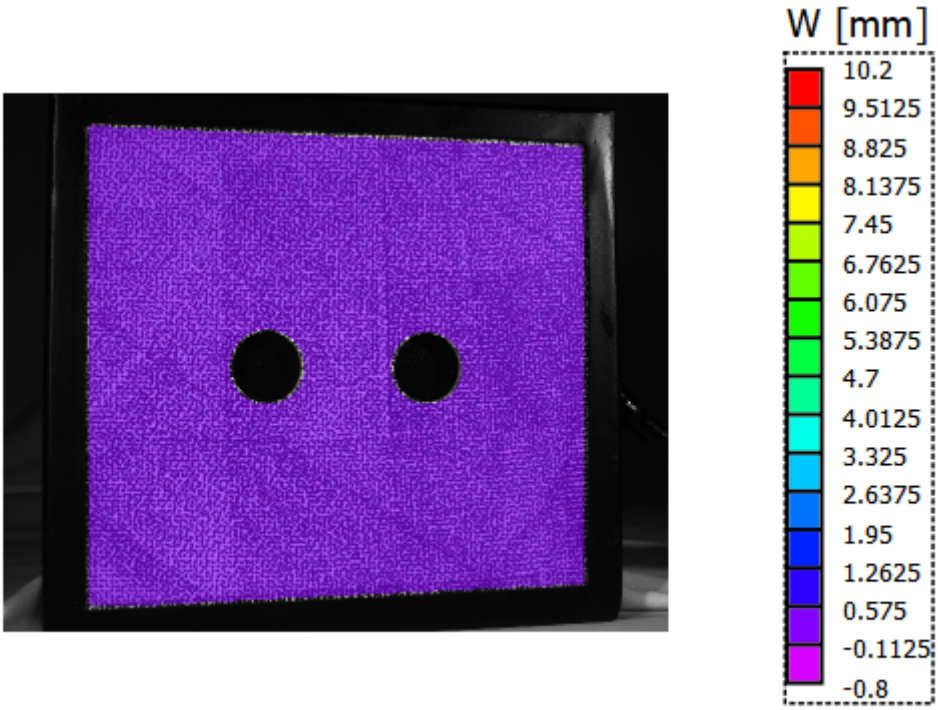



Figure 15.39: Plot with legend selected.

Clicking the relevant legend will highlight it with a black border; settings shown in Fig. 15.40 may then be edited using the toolbar at the right.

#### 15.3.16.1 Legend Properties

**Contour**

The contour properties may be adjusted from the sidebar by selecting the legend attached to the plot.

The **Variable** pulldown determines which variable to overlay as a contour plot. The contour overlay may be hidden by clearing the **Show contour** box, and the isolines may be hidden by clearing the **Show isolines** box.

The range of contour variables (minimum and maximum) is set with the **Range** controls. The opacity of the overlay is set with the **Opacity** control; 0.00 is invisible and 1.00 is fully opaque.

A variety of color maps may be chosen from the **Color map** pulldown. The number of levels is set with the **Colors** control, and the number of isoline levels is set with the **Isolines** control.

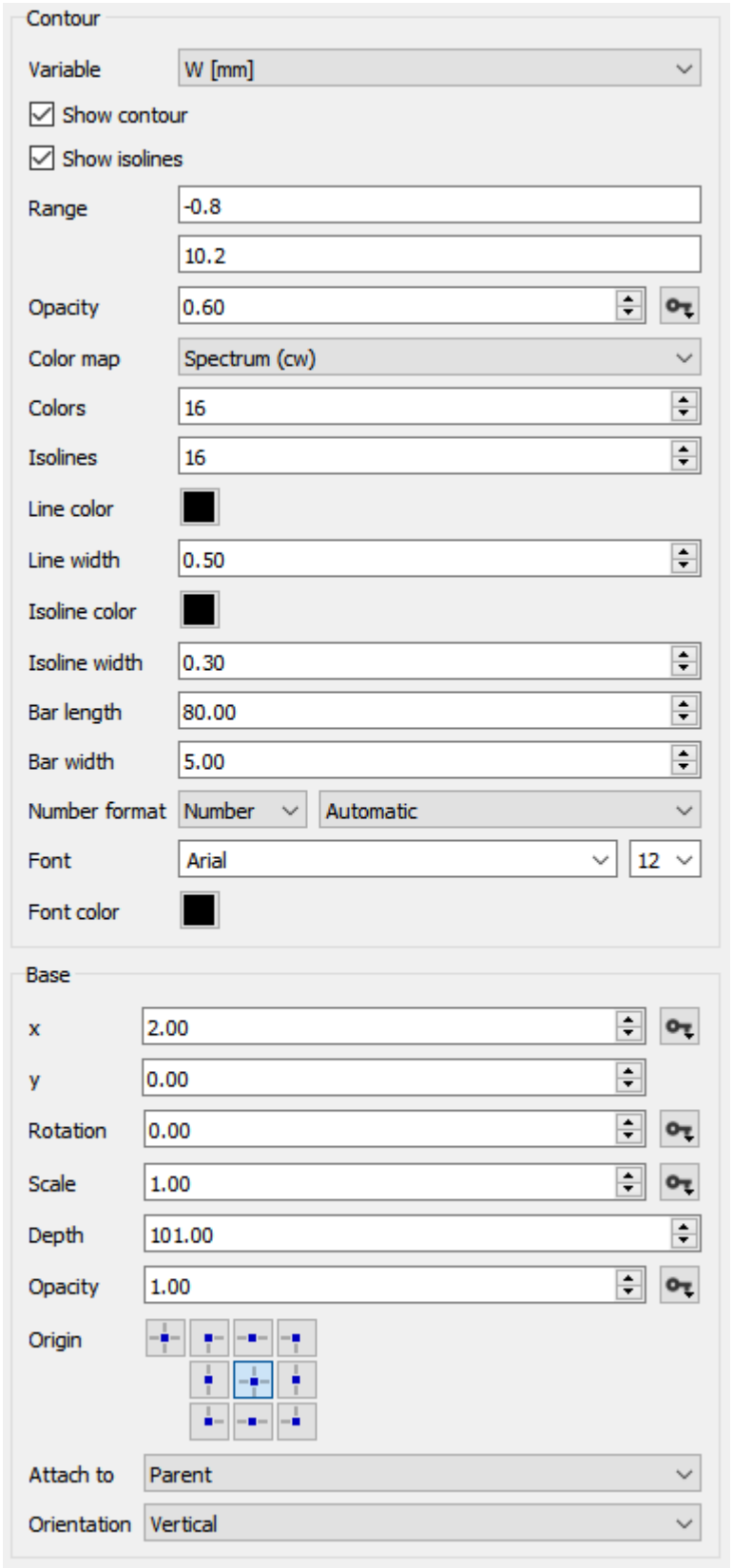


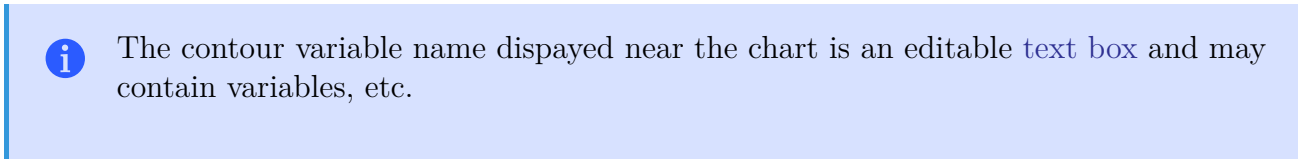

Figure 15.40: Legend tool for 3D plot.

The **Line color** and **Line width** affect the appearance of the contour legend; the **Isoline color** and **Isoline width** control the appearance of the isolines. The size of the color scale bar is controlled by the **Bar length** and **Bar width**.

The format, color, and font of the contour legend labels are set with **Number format**, **Font**, and **Font color**.

**Legend Positioning**

The position and rotation of the legend are set using the base tool.



The contour variable name dispayed near the chart is an editable text box and may contain variables, etc.

### 15.3.17 The Variable Tool

The variable tool shown in Fig. 15.41 controls the variable properties for both 2D and 3D plots in *iris*.

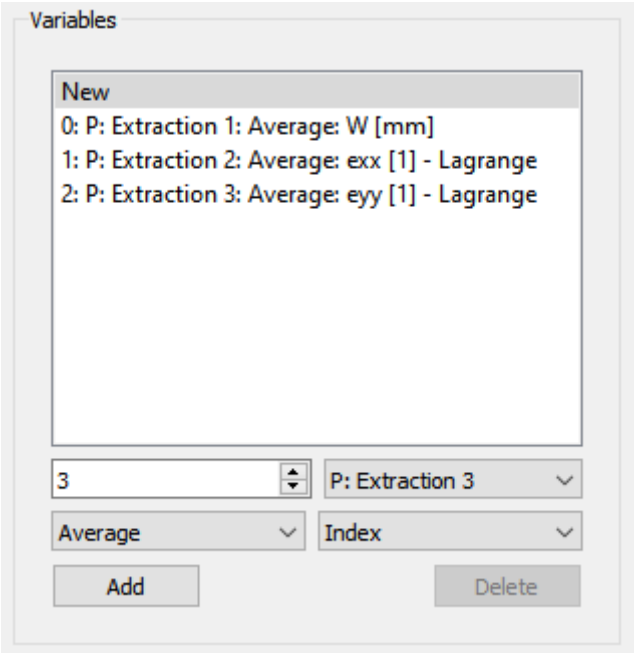
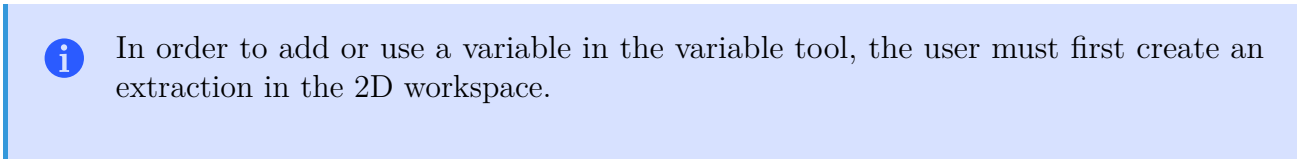



Figure 15.41: Variable tool for 3D plot.

The **Variable** tool allows users to add different variables from the extractions created in the 2D workspace. To add a new variable, first select the extraction plot of interest from the extraction drop down menu. Once selected, the data source drop down will be populated with inspect tools used in the extraction. Simply select the inspection tool of interest, the variable from the variable drop down menu, and select *Add*. The variables will then be available for use in the text box. To delete any unwanted variables, simply select the variable to remove and click *Delete*.

To call on a variable from the variable tool, double click the text box and replace the text with ${...}, making sure to put the number corresponding with the variable being recalled from the variable tool. Once the text has been replaced, click outside the text box to confirm. The data from the called variable will now appear in the text box.




### 15.3.18 The Axis Tool

In *iris*, 2D plots, images, and extractions have associated x- and y-axis ticks and labels. The placement, format, and style of these axes are controlled with a common **Axis** tool as shown in Fig. 15.42.

The **Range** control sets the axes ranges. For extraction plots, this will be in data units; for 2D plots, the value is in pixels.

To reverse the given axes, check **Invert axis**

The **Ticks label margin** adjusts the distance between the plot and the numbered tick labels.

The **Major ticks** and **Minor ticks** boxes control the number of major ticks for the entire range, and the number of minor ticks between each major tick.

The **Tick Font**, tick font size pulldown, and **Tick Font Color** controls affect the numbers displayed alongside each tick.

Formatting of numerical values is selected with the **Ticks Number Format** control; select Scientific notation, Number for positional notation, or Best to select based on data. Precision can be selected with the adjoining pulldown.

The **Label Position** pulldown allows top/bottom or left/right placement of the tick label depending on axis.

The **Label Alignment** pulldown allows the option of left, right, or center alignment for the label along the axis. The **Label Margin** control adjusts the margin between the numbered tick labels and the axis label.

Checking **Hide Label** hides the axis label.

IF **Automatic Label** is selected, the label will match the data. A custom label can be entered by clearing the checkbox and entering the text in the text edit at the bottom of the axis control.

The **Label Font**, font size pulldown, and **Label Font Color** controls affect the appearance of the associated axis label. Controls are also available for text formatting and symbol entry, when using a custom label.

## 15.4 Working with Sequences

All time-based data in *iris* is considered to be a **sequence**. Existing sequences can be viewed and edited by clicking **Sequences Manager** under the **Iris Tools** menu. The sequence manager

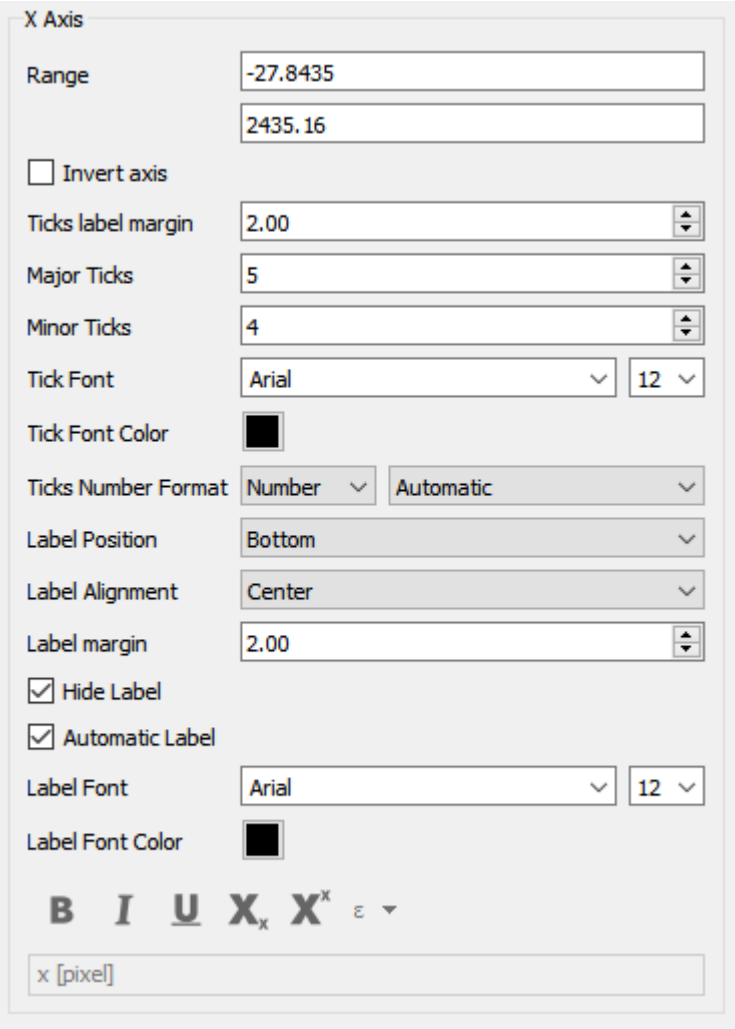



Figure 15.42: X and Y Axis Tools.

can be seen below in Fig. 15.43.

Examples of sequence types include:

- Speckle and calibration images
- Triangulated data (output files, VTK data)
- Extraction data
- Image sequences
- Marker tracking data

Sequences may be added by selecting "New". Once a sequence is added to the *iris* project, it may be selected as a data source for the relevant element (images for image sequences, triangulated data for 3D plots, etc.)

In cases where sequences have a differing number of frames (e.g., if data was only run for every other image), the **Sync:** pulldown may be used to synchronize the animation. The relevant sequences should be synchronized to the sequence with the *fewest* frames. When objects based

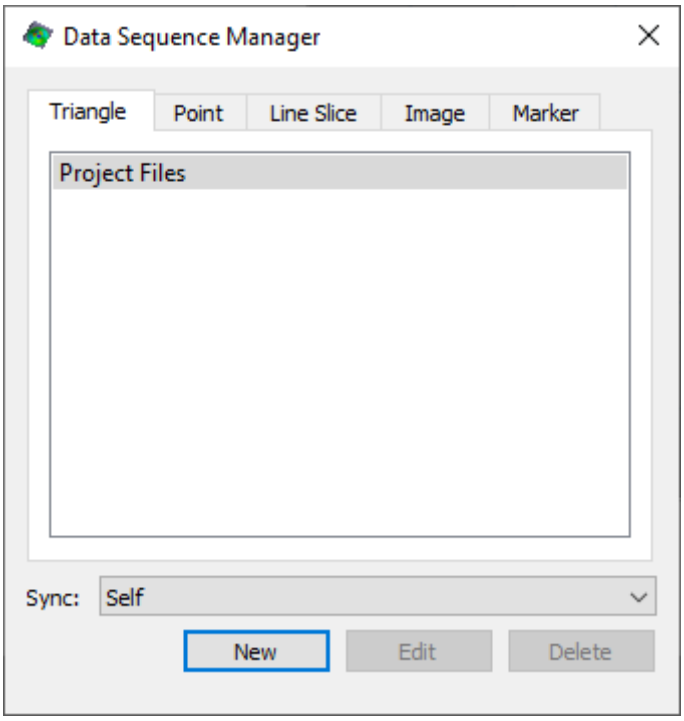



Figure 15.43: The sequence manager.

on the synchronized sequences are added to the workspace and given the same keyframes and easing, they will be synchronized to each other in time.

Synchronization is accomplished by referencing associated camera 0 filenames. Because of this, the synchronization feature is mainly useful with data files (.OUT files) and corresponding images and extractions.

### 15.4.1 Mesh Data Sequences

iris supports import of several 3D mesh file formats, including VTP files (VTK polygon data) and Vic-3D OUT files. VTK is a very flexible package that allows import and conversion of STL, OUT, or FE mesh files.

Mesh files are added under iris tools dropdown box at the top toolbar, by using “Add File Sequence” shown in Fig. 15.44. Once selected, the user will be prompted to select a file and then name the sequence in the “Select Sequence Name” window shown in Fig. 15.45. This sequence name will be the data source recalled for the 3D plot.

Once the sequence name is given, the dialog window shown in Fig. 15.46 will appear. Prompting the user for additional information regarding the data source. If “Coordinates are deformed” is selected, then the displacement variable selection will be disabled.

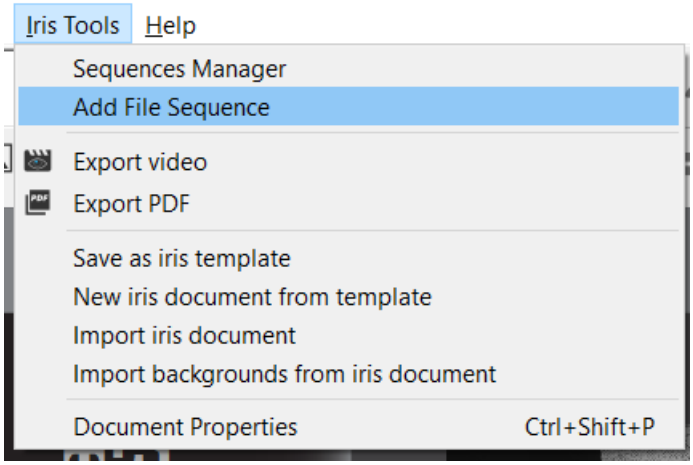



Figure 15.44: Add File Sequence menu.

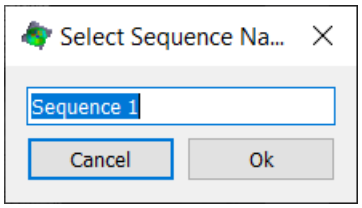



Figure 15.45: Selecting sequence name.

To insert a 3D VTK plot in *iris*, click the 3D icon, and then click once in the document workspace to insert a 3D plot box. The 3D plot can be edited by clicking on the image once to move the position of the entire plot and double clicking to move the image in the 3D plot window.

> The data source of the 3D plot may be changed in the plot properties.

#### 15.4.1.1 Plot Properties

The source, interpolation, time, and winding for the mesh data are set using the common data tool.

#### 15.4.1.2 View

The visual appearance of the 3D plot and axes are set using the shared view tool.

#### 15.4.1.3 Plot Positioning

The position, size, and rotation of the 3D plot are set using the shared base tool.

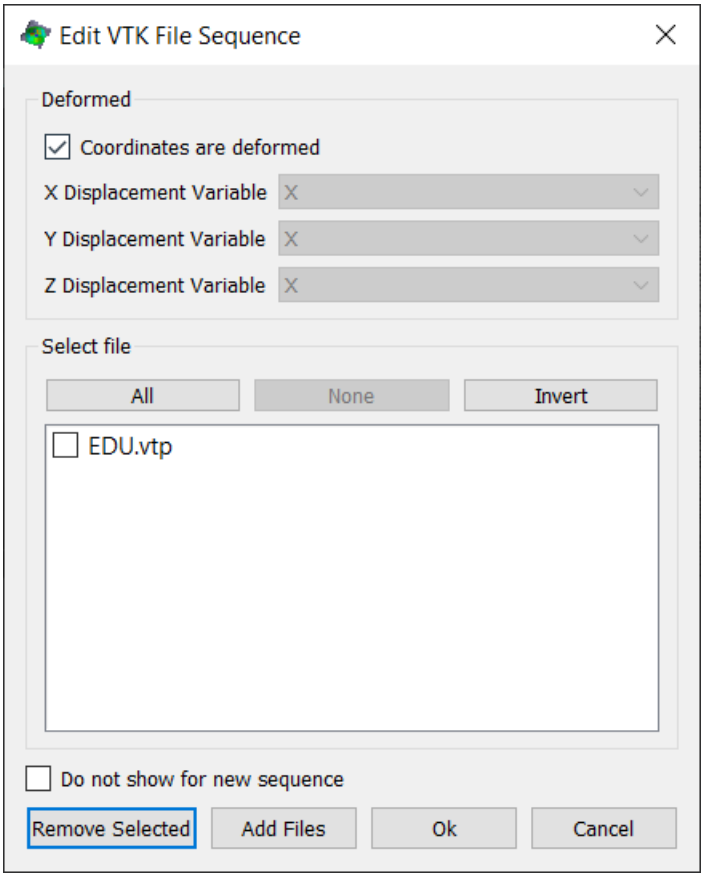



Figure 15.46: Edit VTK File Sequence dialog.

## 15.5 Working with Keyframes

A **keyframe** in *iris* is a position within the timeline where a user-defined value is specified. Examples of values that can be specified are:

- The position within the page of a text box
- The size of a graphic
- The 'time' parameter of a data plot

If a property value is specified at two or more keyframes, *iris* will smoothly interpolate the value between keyframes to create an animation of text moving, a graphic zooming in, a plot animating through time, etc. The Interpolation can be linear, or easing options can be selected for more natural appearing transitions.

Every value or attribute that can be animated using keyframes is indicated with an icon next to the relevant control, and these attributes are referred to as *animatable* in this manual.

### 15.5.1 Adding Keyframes

Keyframes are added by clicking the icon next to the desired value (Here in Fig. 15.47 the **Time** attribute for a 3D plot), and selecting *Add keyframe* from the dropdown.


Figure 15.47: Time control showing keyframe icon.

A keyframe indicator will appear in the timeline at the bottom of the workspace, shown in Fig. 15.48.

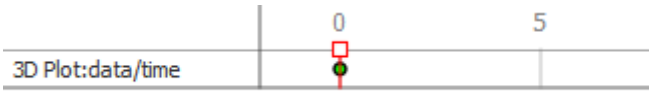



Figure 15.48: Timeline showing single keyframe.

The keyframe is indicated by time (here, 0 seconds) as well as the element and keyed property (3D plot, data/time). The entire timeline can be scrolled by clicking and dragging the times at the top. The current position *within* the timeline can be adjusted by dragging the small square, shown in Fig. 15.49:

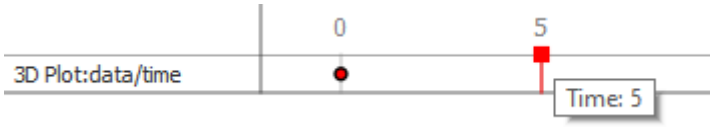



Figure 15.49: Timeline showing dragging.

On returning to the **Time** control, the key attribute has been disabled because the timeline is not currently at a keyframe, shown in Fig. 15.50:

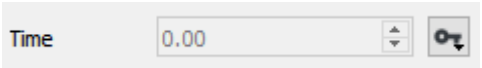



Figure 15.50: Timeline showing dragging.

To insert another keyframe at the new position in the timeline, the icon can be clicked again and *Add keyframe* selected. The time attribute becomes editable; here, it has been set to 1.00, shown in Fig. 15.51:

The new keyframe also appears on the timeline, shown in Fig. 15.52.

The document now contains a single element: an animation of a 3D plot of the test data, from the first frame to the last, with a duration of 5 seconds.


Figure 15.51: Timeline showing dragging.

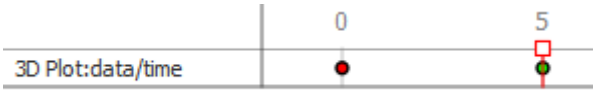



Figure 15.52: Timeline showing dragging.

When exporting video, the animation will always begin at the first keyframe regardless of its position on the timeline. If the first keyframe is placed at 10 seconds, the video will start immediately there rather than being blank for 10 seconds. Blank video and transitions may be managed with the Page Transition settings.

There is no limit on the number of keyframes; a third keyframe could be added to show the data returning to the start position, etc.

### 15.5.2 Adding more timelines

Multiple different attributes can be animated; each time a new attribute is keyed, a new timeline is added to the editor. In Fig. 15.53, an animated rotation has been added after the time animation.

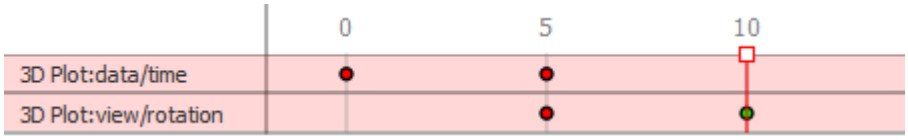



Figure 15.53: Timeline showing dragging.

### 15.5.3 Animating other items

Multiple items can be animated, and these too will be added to the timeline. If an object with keyframes is currently selected, the relevant row will be highlighted in red, shown in Fig. 15.54.

A document item may be selected by double-clicking it at the left of the timeline.

Objects which are invisible or behind other items may be easily selected in this way.

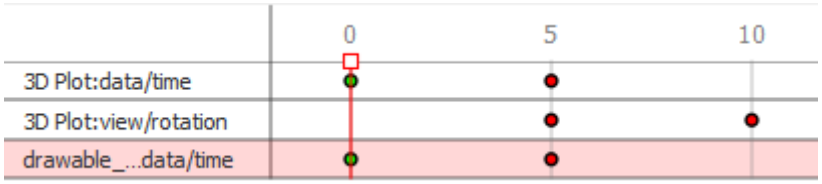



Figure 15.54: Timeline showing dragging.

### 15.5.4 Keyframe shortcuts

For common operations, adding keyframes can be simplified by selecting a shortcut from the pulldown.

- For data plots, a simple forward, reverse, or forward-then-reverse animation of the data can be selected. For instance, "Forward 5s" repeats the operation described above to animate a 3D plot over 5 seconds, with a single click.
- For most position and miscellaneous attributes, a simple placement of keyframes at common time intervals can be selected. The values must be adjusted manually.
- For the opacity control, there are predefined fade-in and fade-out settings.

The shortcuts will not overwrite or interfere with existing keyframes; if not enough blank space is available on the timeline, a warning will be displayed and the timeline will remain unchanged.

#### 15.5.4.1 Easing Options

To control the interpolation and resulting visual effect for each animation, right-clicking on the keyframe at the *end* of the specified animation will allow selecting an easing option.

In animation, *easing* is used to make motion look more natural. A linear motion with an instaneous start and stop will appear artificial; adding smooth start and stop, acceleration, or "bounce" effects can remedy this.

Easing options may be selected by right-clicking the keyframe indicator at the end of the relevant animation and choosing from the **Easing** submenu. Six main categories of predefined easing options are available:

**Linear** - motion uses linear interpolation only (no easing).
**Quad** - quadratic curves for motion.
**Cubic** - cubic curves for motion.
**Elastic** - 'spring' effects.
**Bounce** - 'bounce' effects with rebound.
**Back** - adds an overshoot.

Each easing option can affect the beginning motion (**In**), the end motion (**Out**), both (**InOut**), or work from the center out (**OutIn**).

Selecting **Customize** allows further customization of the exact parameters of the easing curve, as well as being a convenient way to preview the nature of each easing curve.

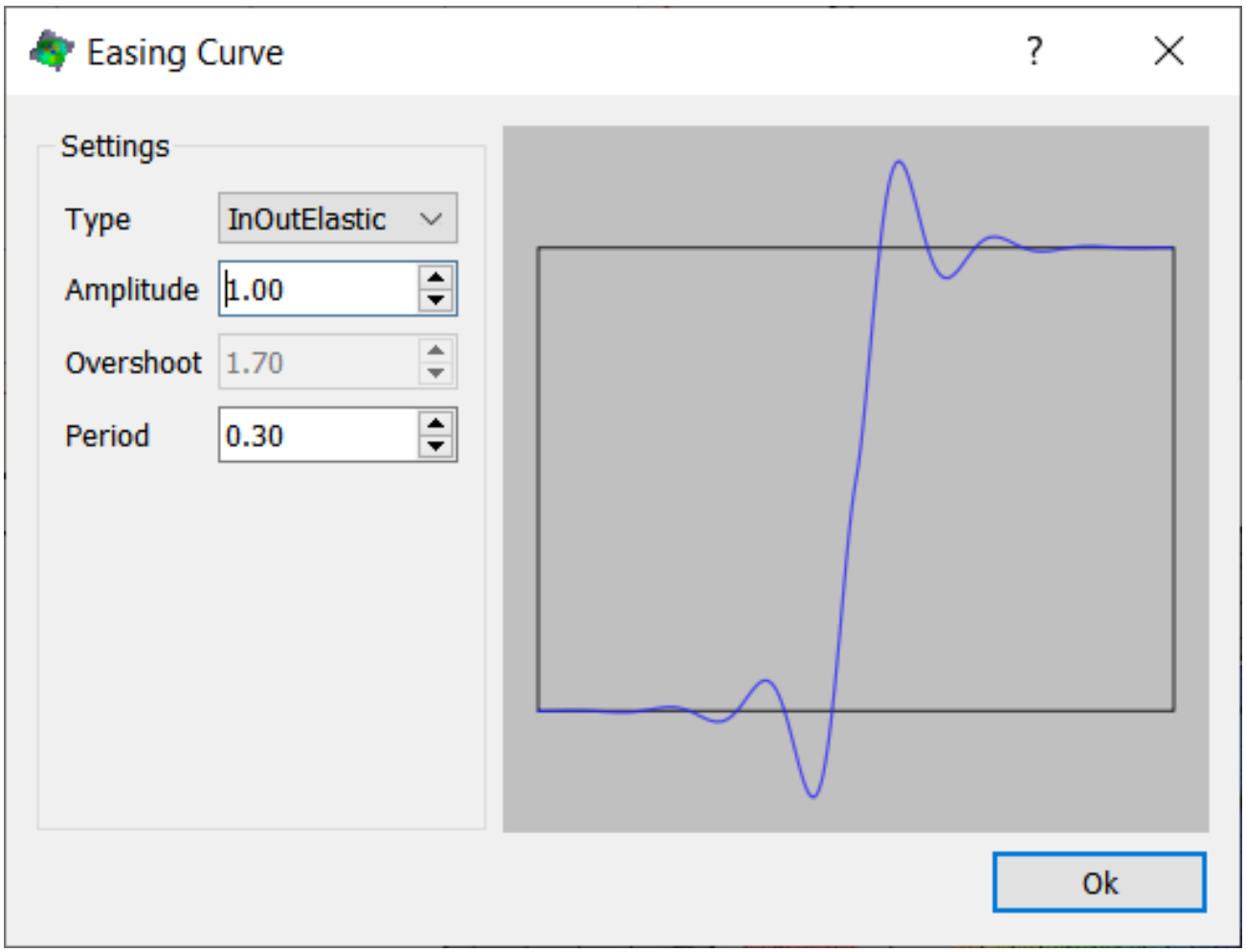



Figure 15.55: Customize Easing Options.

## 15.6 Document Properties

Each *iris* document has a set of global properties that control page size, transitions, grid settings, document defaults, and graph styles. These document properties may be edited by clicking **Document Properties** in the **Iris Tools** menu, or by pressing Ctrl+Shift+P.

### 15.6.1 Page size

A list of standard page sizes can be selected as shown in Fig. 15.56, or a **Width** and **Height** can be entered in the desired units (selected using the pulldown).

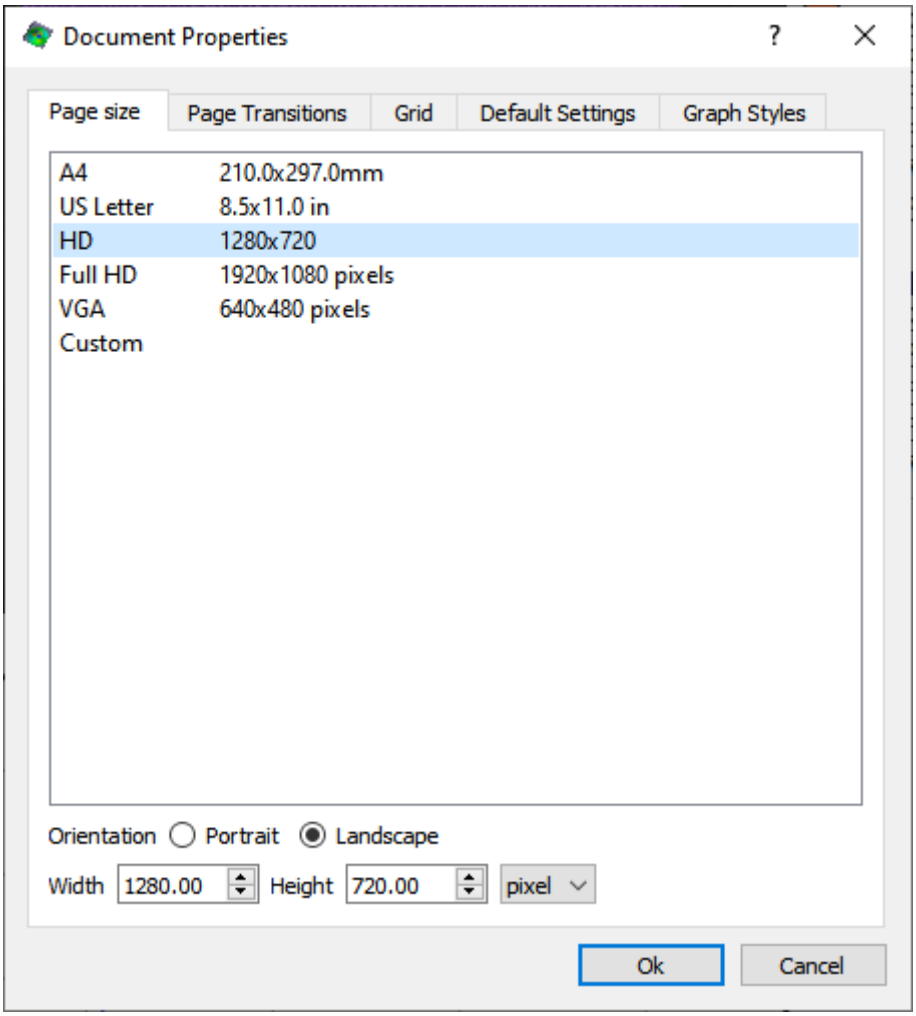



Figure 15.56: Page size tab.

### 15.6.2 Page transitions

The duration of each blank page is controlled with the **Empty page duration** value. For each transition, a start and end fade style can be chosen, along with a fade duration. These selections are shown in Fig. 15.57.

### 15.6.3 Grid

A grid can be overlaid on the main workspace by checking **Show grid**, or pressing the "#" key on the keyboard. Grid spacing and appearance is set by using the controls shown in Fig. 15.58.

### 15.6.4 Default Settings

Default settings for each *iris* element may be modified by selecting the desired element from the **Category** pulldown. These options are shown in Fig. 15.59.

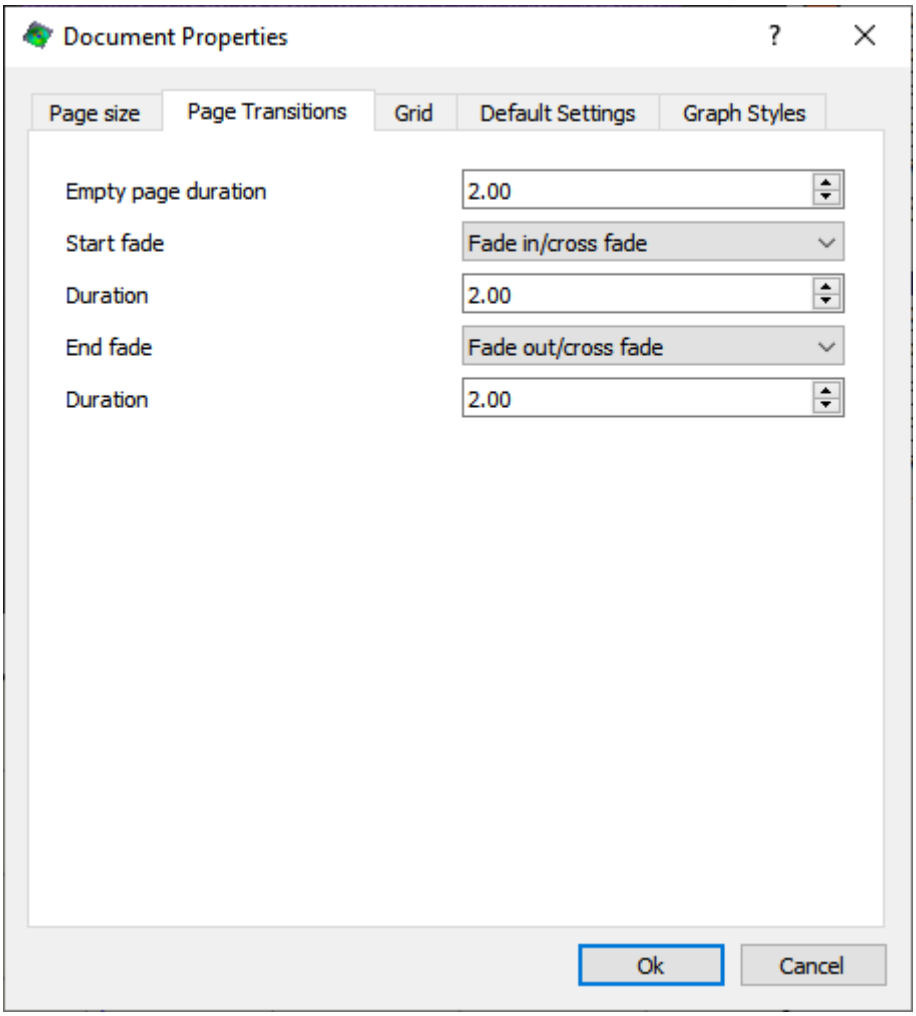



Figure 15.57: Page transitions tab.

If the checkbox to the left of a property is clear, a global default will be used. If it is checked, the value entered will be used for the property for new objects.

### 15.6.5 Graph Styles

Default settings for each graphing style may be modified within the graph styles tab. Select *Ok* to save the changes. These options are shown in Fig. 15.60.

Graph style 12 is reserved for background traces.

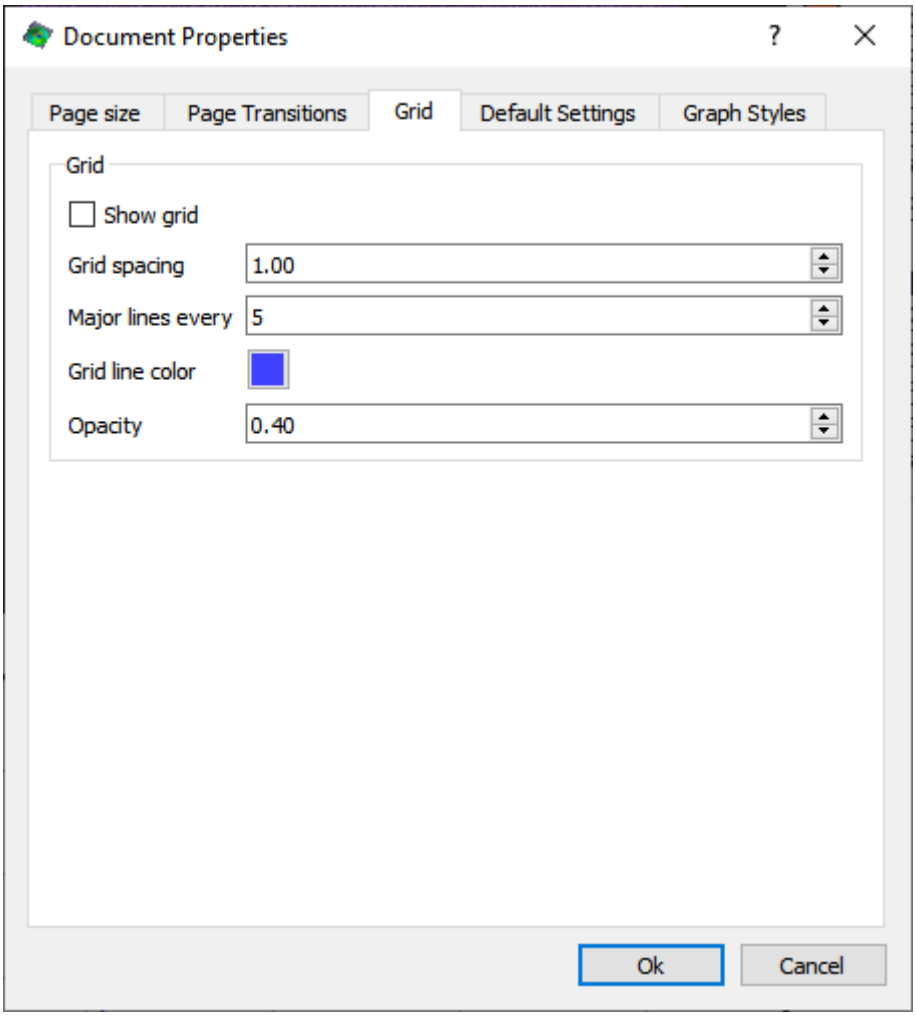



Figure 15.58: Grid tab.

## 15.7 Exporting *iris* Content

*iris* documents may be exported to video by selecting *Export video* from the *iris tools* menu, by clicking the icon in the main *iris* toolbar, or by pressing the "V" key on the keyboard. The export content dialog box can be seen in Fig. 15.61.

### 15.7.1 Output

A filename and folder may be chosen by clicking the folder icon.

Choose a video resolution by selecting from the **Video format** pulldown; **Frame rate** allows selecting from standard frame rates for video, and **Quality** controls the compression factor and resulting video quality.

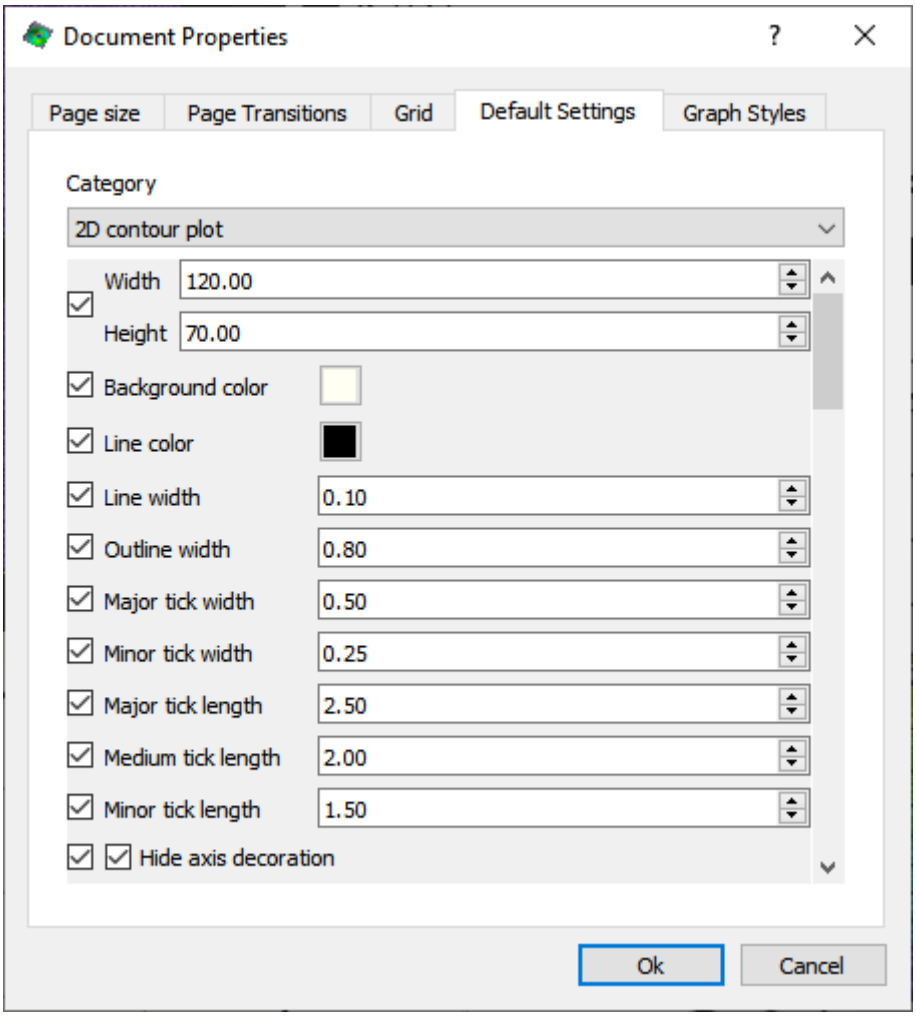



Figure 15.59: Default settings tab.

Higher resolutions and frame rates will take longer to render and result in larger file sizes.

The **Adaptive motion blur** checkbox enables a motion blur for realistic appearing motion. This is calculated by interpolating a number (**Max. blur samples**) of frames between each existing frame. The blurring will be applied when motions greater than the **Min. blur length** are present anywhere in the frame.

### 15.7.2 Global transition Settings

These settings control the display length of an empty page, and the duration and style of the start and end fades. Clicking the **Fade background** checkbox will cause the selected background to be faded in and out as well, rather than static.

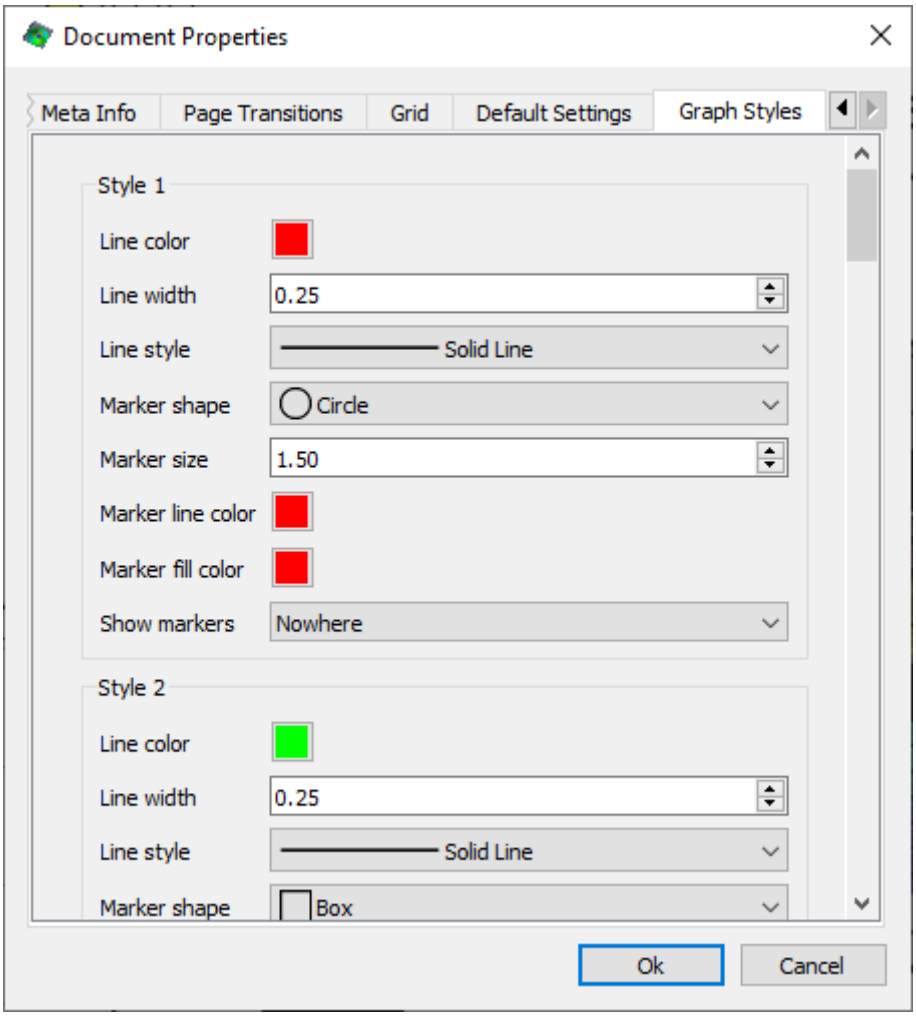



Figure 15.60: Graph styles tab.

### 15.7.3 Exporting *iris* Content as a PDF

A PDF of the content created with *iris* can be exported by selecting *Export PDF* from the *iris tools* menu, by clicking the PDF icon in the main *iris* toolbar, or by pressing the "E" key on the keyboard. The export dialog is shown in Fig. 15.62.

#### 15.7.3.1 Output File

The filename for the exported PDF can be entered in the **File** input box. Clicking the folder icon allows selection of the output folder.

#### 15.7.3.2 Settings

The **Settings** box in the export window allows export of **All pages**, the **Current page**, or the current **Selection**. The resolution for export (in dots per inch) can also be found here.

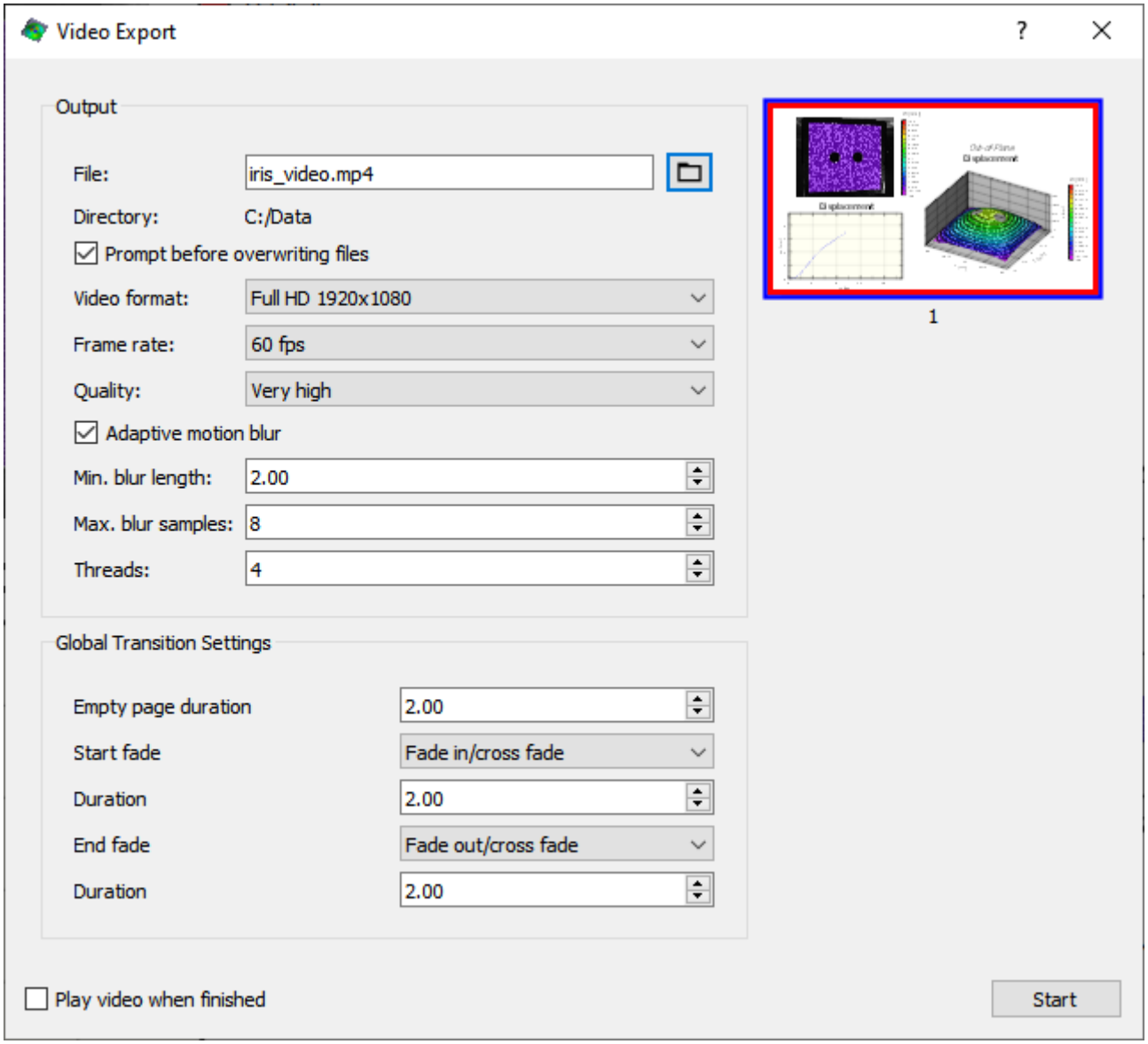



Figure 15.61: *iris* Export dialog.

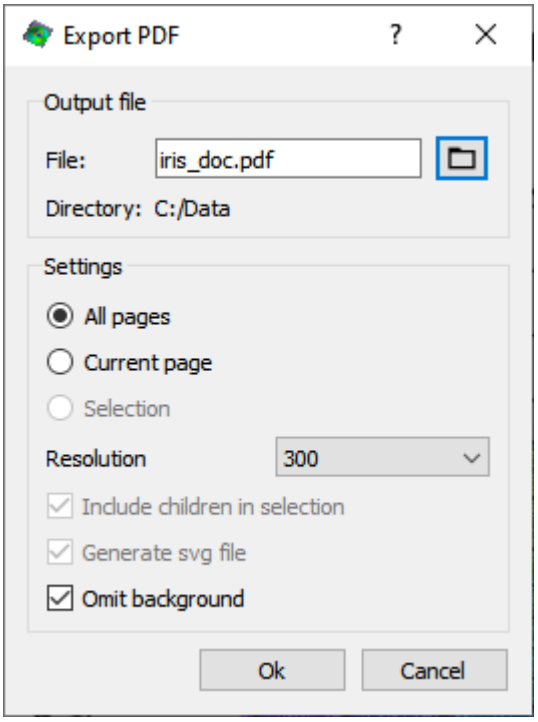



Figure 15.62: *iris* PDF Export dialog.

The maximum selectable resolution depends on the rendering capability of the PC and the size of the document.

When **Selection** is chosen, a scalable SVG file may be created by checking **Generate svg file**.

SVG files are scalable and are the best choice for inclusion in Word® documents, etc.

To omit any background present in the page, check **Omit background**. For SVG export and when **Selection** is chosen, the background is always omitted.

If **Include children in selection** is checked any child objects of the selected object will also be exported (e.g., contour legends for a data plot.)

To enable SVG export, *Inkscape* must be installed. Information about Inkscape as well as the latest installer may be found at inkscape.org.

# Chapter 16

# Quick Start

There are only a few steps involved in obtaining shape and deformation measurements from your images. If you are using Vic-2D for the first time, take a look at the example provided with the program. Then, try to go through the following steps yourself to quickly familiarize yourself with the program usage:

1.  Add a reference image and select your area of interest.
2.  Add more speckle images, if applicable.
3.  Run the correlation analysis.
4. Plot the results

If you encounter any difficulties, please do not hesitate to contact our technical support department.

## 16.1 What's New in Vic-2D 7

The all-new Iris graphics engine brings a host of new functionality to the already versatile Vic-2D software. It delivers extremely high resolution still and moving images with multiple page PDFs or MP4 presentations, all from within. Some of these exciting new features are listed below:

- Create multiple-page, high-resolution, publication-ready plots in PDF and ultra-high-definition video formats (from 720p to 4K)
- View high-resolution isolines on plots with scalable fonts
- Edit labels with Unicode support
- All new user-friendly graphics engine for animating object position, scale, opacity, rotation, and much more
- Create high-quality videos using the multi-threaded rendering engine (see iris export)
- Create life-like animations using integrated adaptive motion blurring for fast-moving objects
- Animate object position, scale, opacity, rotation, and much more with an all-new user-friendly graphics engine

- Import Finite Element data for visualization and comparison to measurement data into new graphics framework

# Chapter 17

# Technical Support

If you cannot find an answer to your question in this manual, please do not hesitate to contact our technical support at support@correlatedsolutions.com. You can also find contact information at our web site at www.correlatedsolutions.com.

We will be happy to assist with topics such as:

- Designing digital image correlation experiments
- Calibration
- Troubleshooting errors
- Interpreting test data
- Achieving optimal results

## 17.1 Bug Reports and Feature Requests

If you encounter a bug in Vic-2D, please let us know about it. Send a short description of the problem to support@correlatedsolutions.com, along with any project or image files you think may help us reproduce the bug.

Also, if you think Vic-2D can be improved by adding a particular feature you would find helpful, let us know about it. We will try to incorporate your requests in our future updates of the software.