correlated
SOLUTIONS

VIC-2D User Manual

Version 8
2026

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.

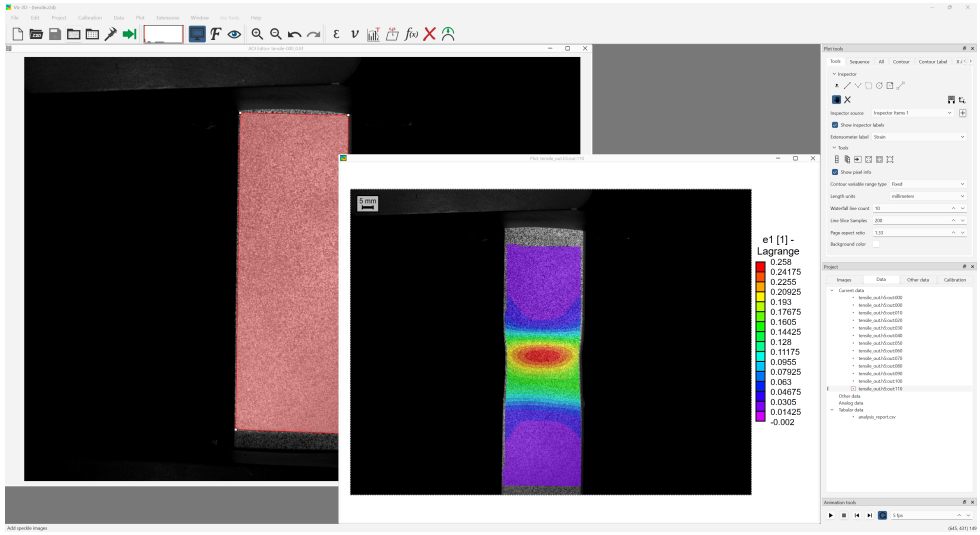

Figure 2.1: VIC-2D Application Window

2.1 File Menu

The *File Menu* provides the following functions:

- **New** - creates a new project
- **New from template** - creates a new project using selected elements of an existing one
- **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
- **Report Generation** - generate a report using a selected template
- **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.
- **Global preferences** - allows control of various defaults; more details are available at Chapter 25.

2.3 Project Menu

The *Project Menu* provides the following functions:

- **Speckle images**- adds speckle images to the project for analysis
- **Speckle image lists**- adds a specified list of 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
- **Data file groups** - add a group of pre-exiting output data files to the project
- **Analog data** - adds analog data files from VIC-Snap
- **Analysis workspace** - displays the 2D image correlation workspace
- **FFT workspace** - works with frequency-domain data, bringing up the FFT calculation dialog if necessary. This module is only visible if purchased.
- **Iris workspace** - switches to the *iris* data presentation workspace.

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
- **Set aspect ratio** - sets 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 Extensions Menu

The *Extensions Menu* provides the following functions:

- **Extension submenu** - runs the named extension; extensions are grouped by type or custom submenu. Selecting an extension opens a dialog with options, source code, help, and a preview.
- **Add new** - adds a new extension from a *.zve* file
- **Package new** - packages an extension into a *.zve* file for distribution

2.8 Window Menu

The *Window Menu* provides the following functions:

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

2.9 Help Menu

The *Help Menu* provides the following functions:

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

Figure 2.2: The main toolbar.

2.10 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

Plotting tools:

- Histogram control
- Show main Workspace
- Show FFT workspace (when module is present)
- Show *iris* workspace
- 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.

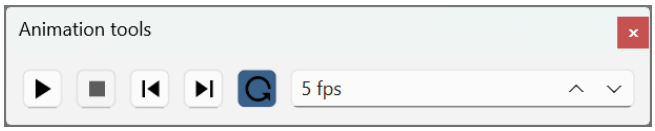

Figure 2.3: Animation toolbar.

2.11 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.

2.12 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 manual.

Chapter 3

The Start Page

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

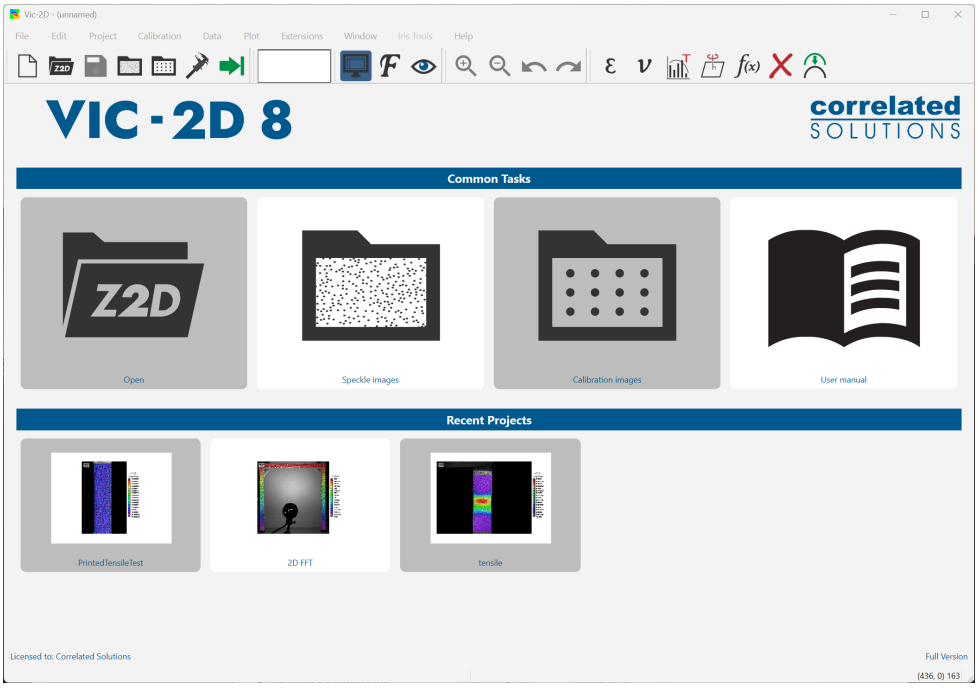

Figure 3.1: VIC-2D start page.

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 Project Organization

It is recommended that all image files are stored in the same folder as the project file. While it is possible to save project files in any directory, this may lead to problems if either the project file or any of the linked resources, such as image files, are moved. With project files in the same directory as image files, a project can be copied by simply copying the entire folder. This makes it easy and convenient to backup projects or move them from one computer to another.

Note that aside from image and data files, other imported items such as the calibration or coordinate transformations do not need to come from resources located in the same directory.

4.2 Creating a New Project from a Template

VIC-2D allows creation of a new project by importing elements of an existing project, in order to streamline repeated tests. To begin, select *File... New From Template* from the main menu, or press `CTRL-SHIFT-N`.

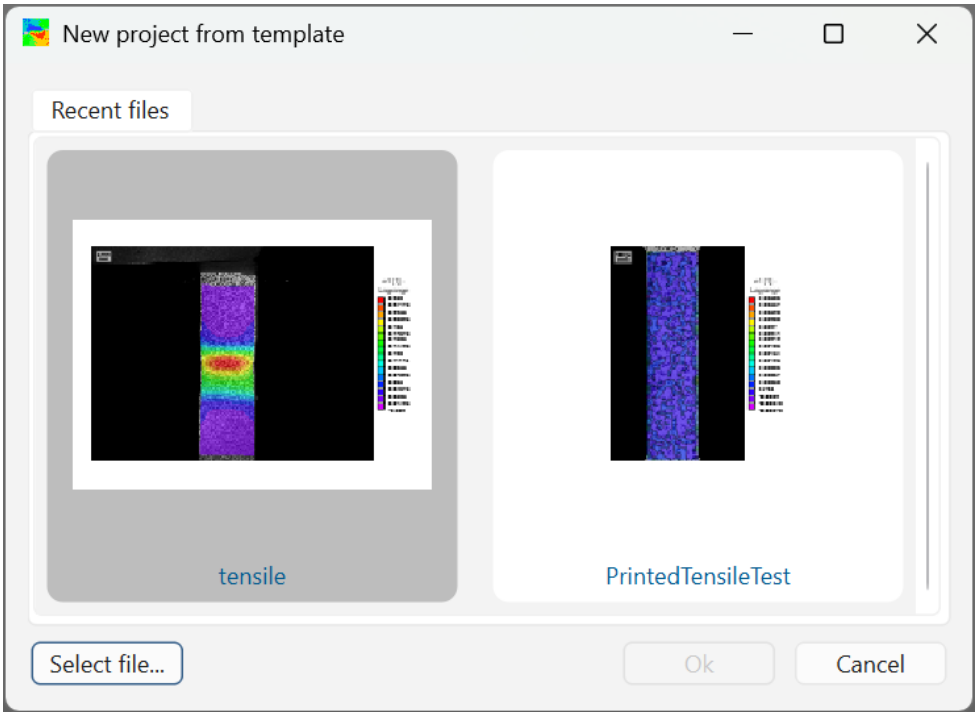

Figure 4.1: Project template dialog.

You will see a list of recent projects with previews. Single-click to select a project or mouse over to see a more detailed preview.

Checkboxes allow selection of desired elements; the **Ok** button completes the import. A blank project will be created and images may then be added. If the template contains an AOI and it was imported, it will automatically appear as soon as a reference image is selected. Note that VIC-2D allows moving an entire AOI to account for small position differences. An AOI can be moved by clicking on a selected AOI and dragging it to the desired position.

4.3 Notes

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

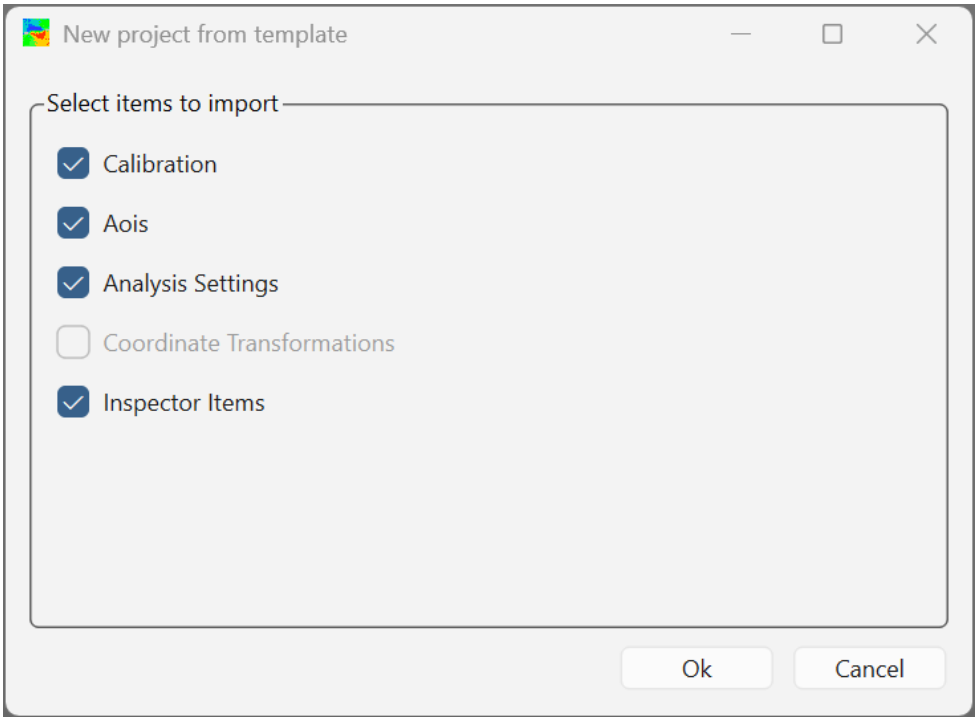

Figure 4.2: Template items available for import.

Chapter 5

The Project Toolbar

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

5.1 The Images Tab

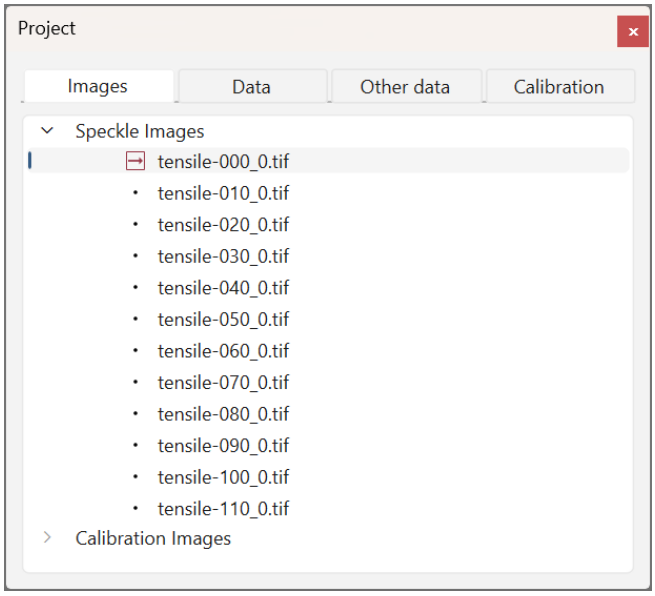

Figure 5.1: Project toolbar files tab.

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 all images from a folder in a single step, select *Images... Add speckle image groups* from the menu bar. All image files found in the selected folder will be added to the project at once.

If a single HDF5 (`.h5`) file is selected when adding images, an embedded dataset picker will appear, allowing selection of specific image datasets from within the container. HDF5 references are resolved automatically when the project is loaded.

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

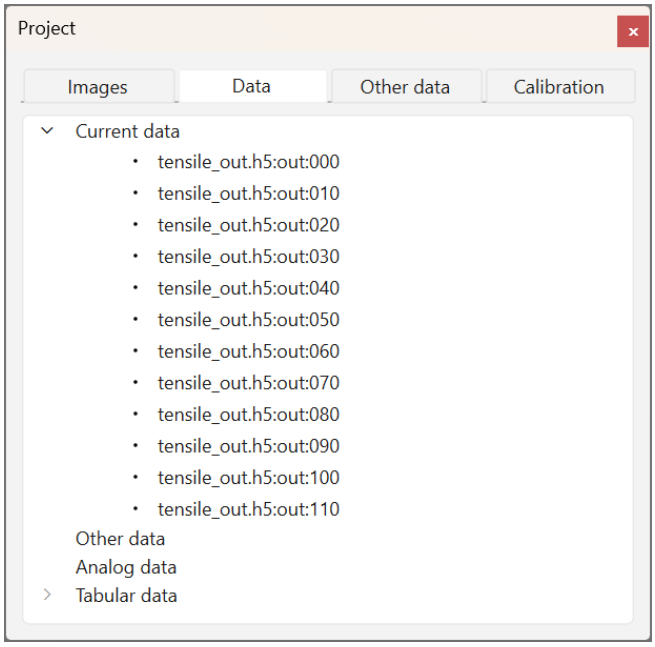

Figure 5.2: Project toolbar data tab.

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.

Tabular data from post-procesing tool in VIC is listed under *Tabular data*. Tabular data is generated automatically within VIC. To view a spreadsheet of the data, double-click the filename.

To add all data files from a folder in a single step, select *File... Add Files... Add data file groups to project* from the main menu. All data files found in the selected folder will be added at once.

If a single HDF5 (`.h5`) file is selected when adding data files, an embedded dataset picker will appear, allowing selection of specific datasets from within the container.

5.3 The Other data tab

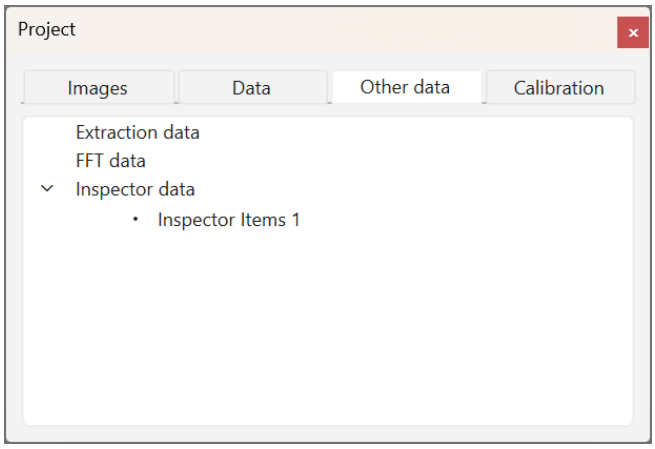

Figure 5.3: Project toolbar data tab.

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.

5.4 The Calibration Tab

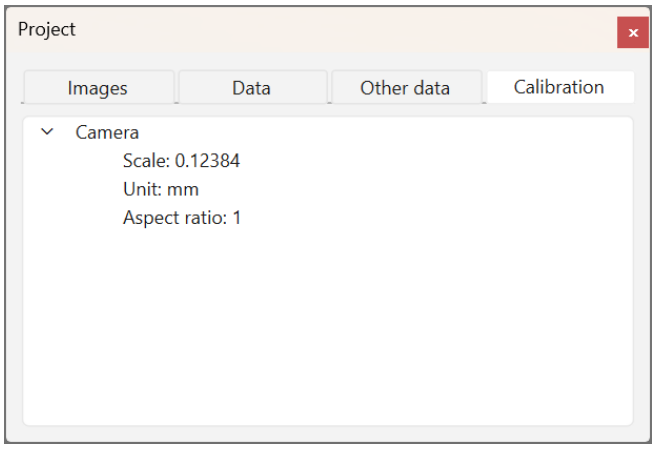

Figure 5.4: Project toolbar calibration tab.

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 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.

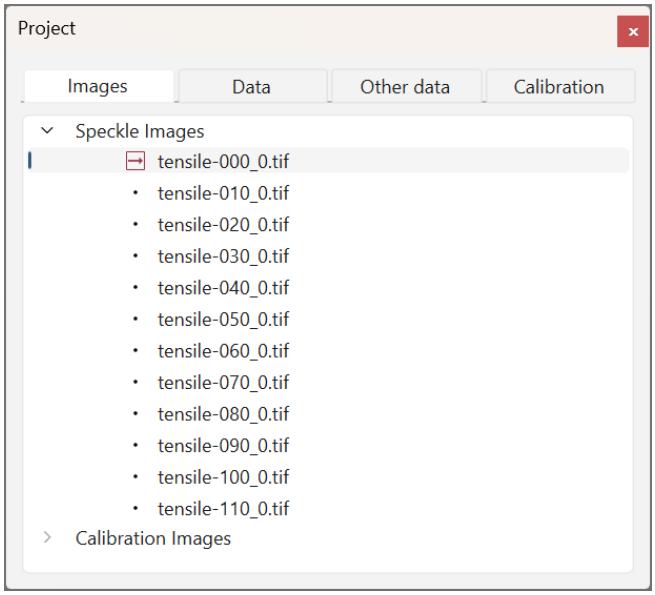

Figure 6.1: Project image panel showing speckle images.

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*.

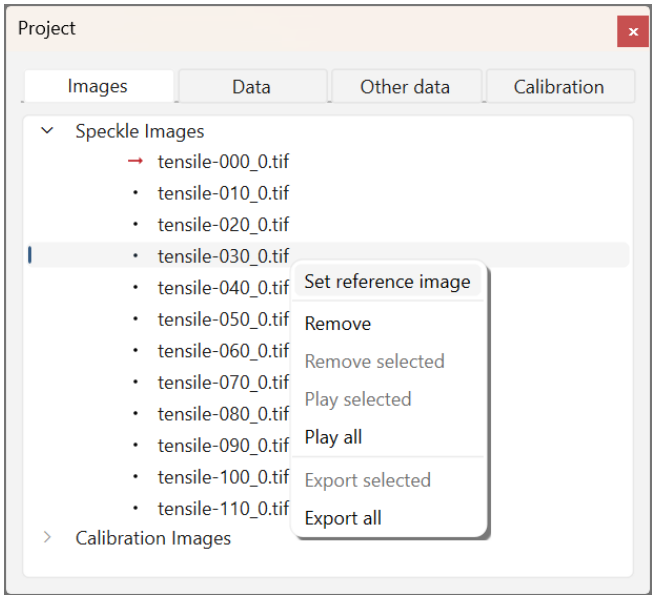

Figure 6.2: Calibration image list in project panel.

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.

6.3 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.

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.*

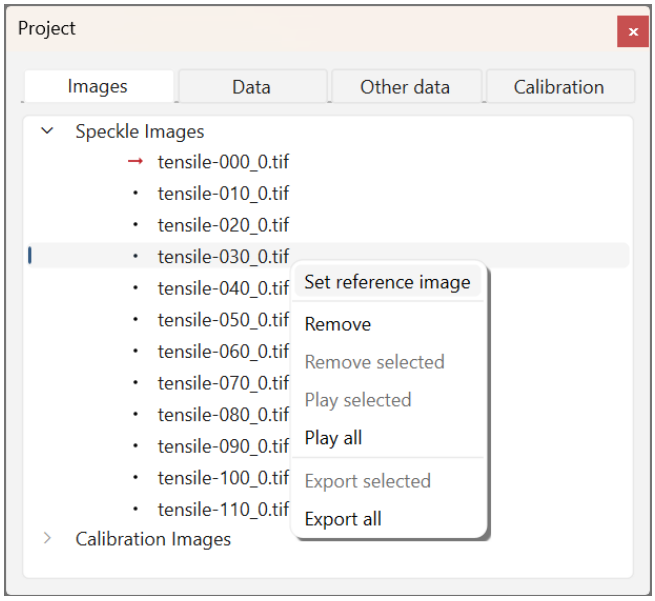

Figure 7.1: Speckle image list right-click menu.

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.

7.1 Selecting an Area-of-Interest

VIC-2D supports the following types of AOIs:

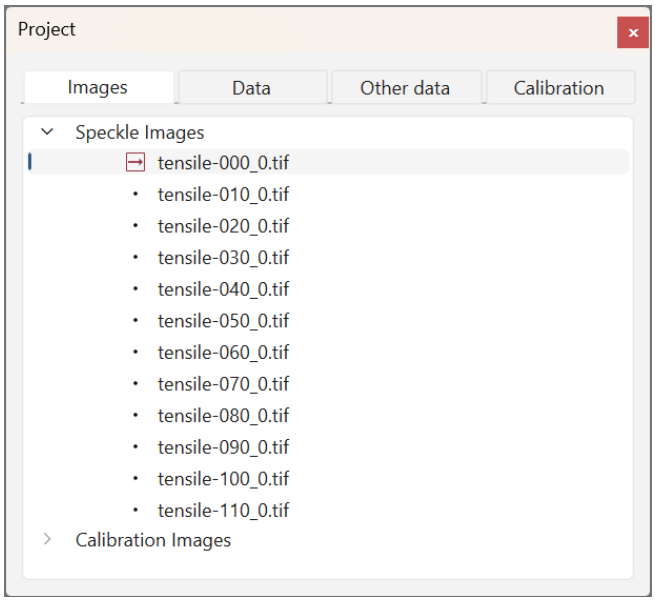

Figure 7.2: Reference image indicator

Figure 7.3: Aoi tool box.

- **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.

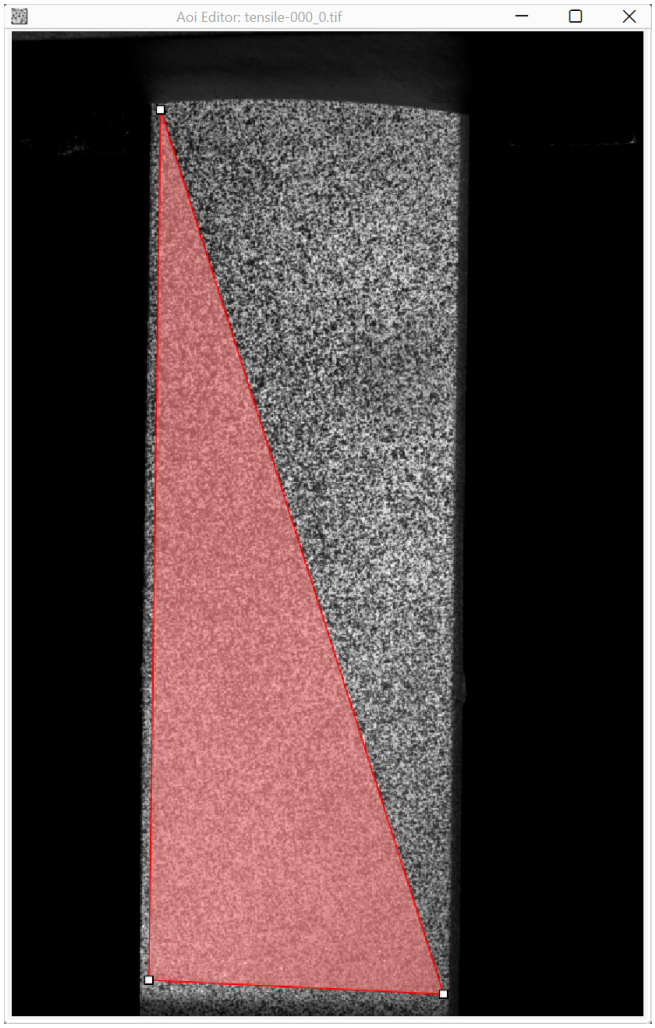

Figure 7.4: Selecting an area-of-interest.

7.2 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.

7.3 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.

7.4 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.

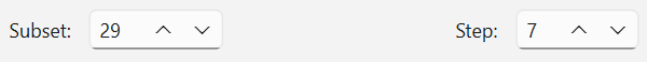

Figure 7.5: Subset and step size control.

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:

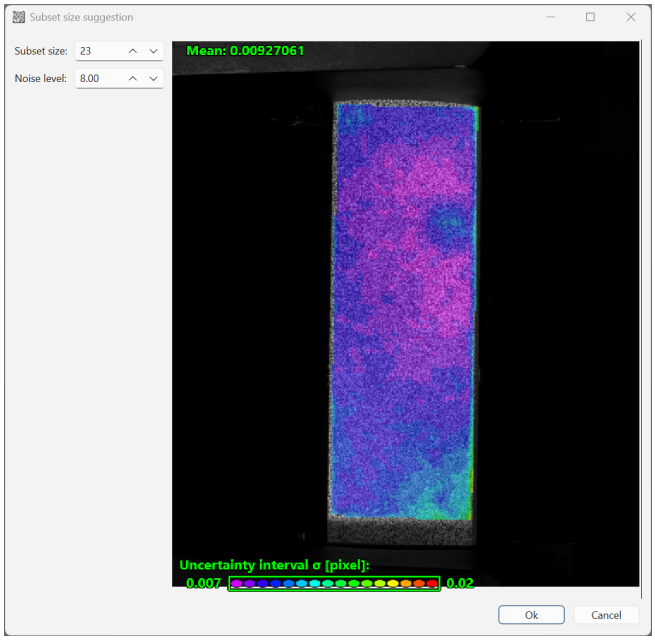

Figure 7.6: Subset size suggestion dialog.

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.

7.5 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.

- 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.

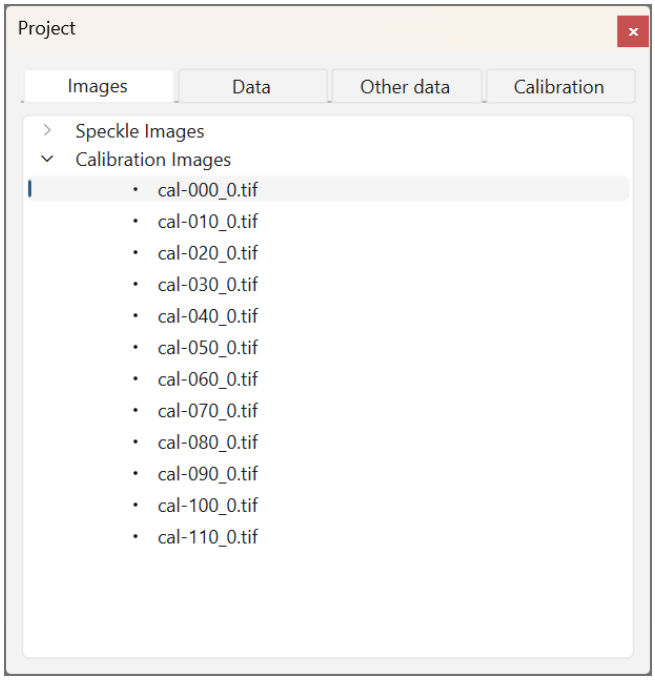

Figure 8.1: Project image panel showing calibration images.

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.

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.

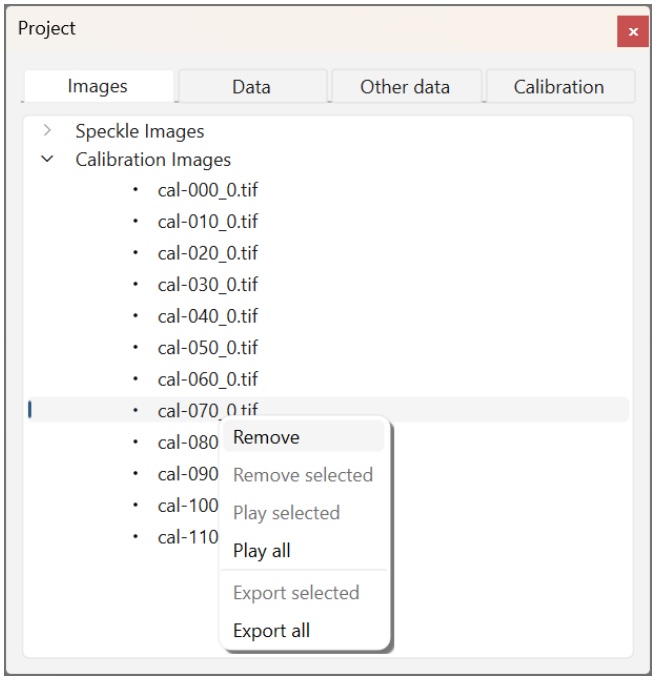

Figure 8.2: Calibration image list right-click menu.

Chapter 9

Calibration

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

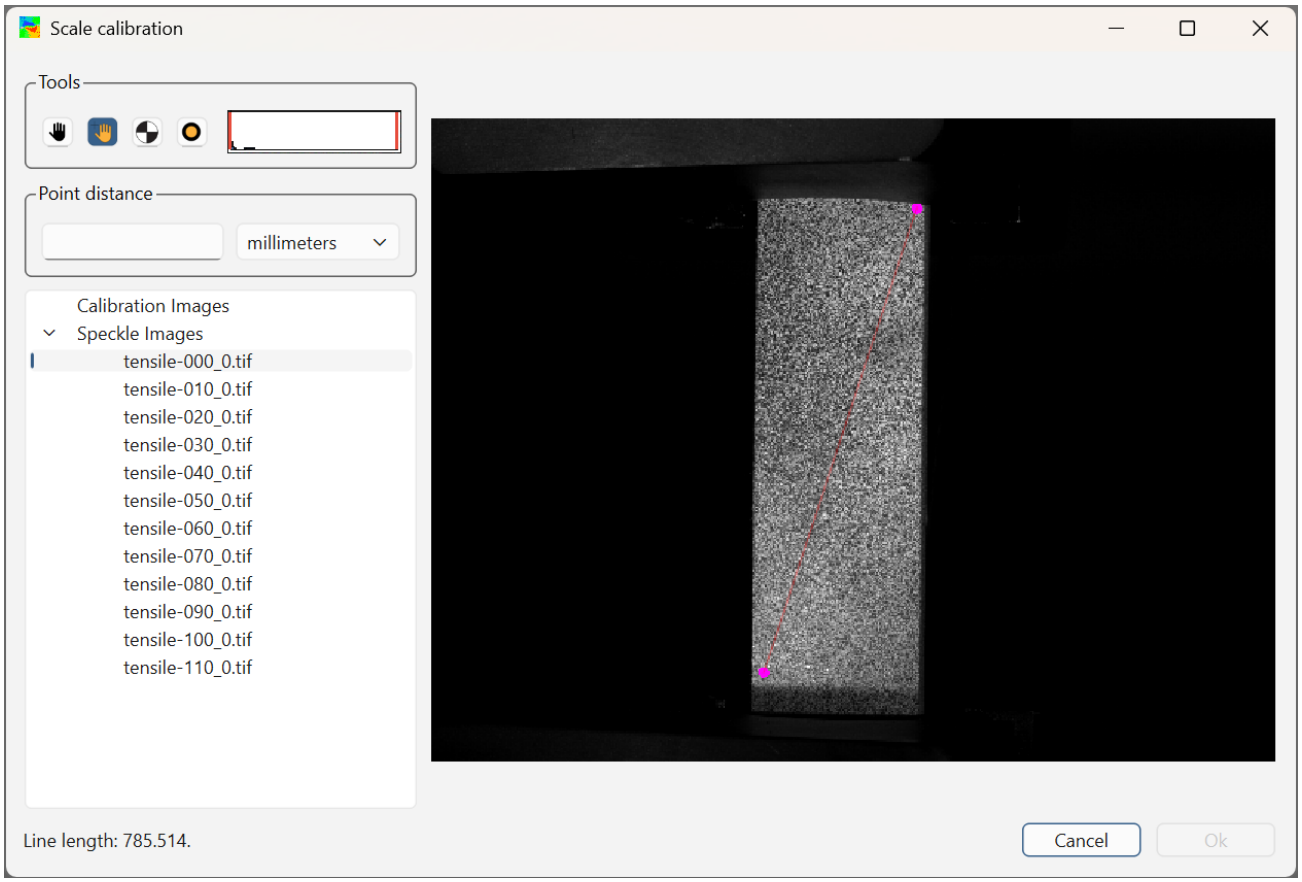

Figure 9.1: Scale calibration with manual points.

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.

9.1 Unit Selection

The unit selector displays the full standard unit list, including mm, µm, cm, inches, m, and others. The same unit list is available in both the Scale Calibration and the Distortion Correction dialogs. Select the desired unit from the dropdown before entering the known distance.

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.

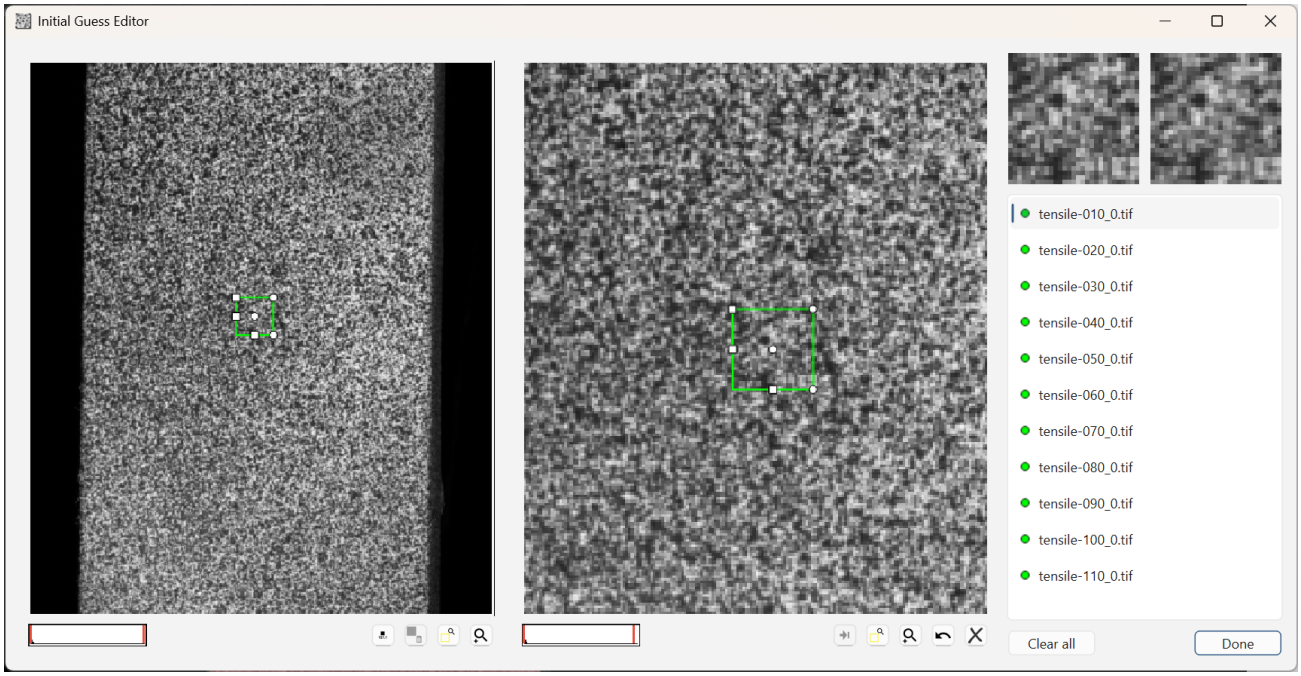

Figure 10.1: Initial guess editor.

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 collinear. 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.

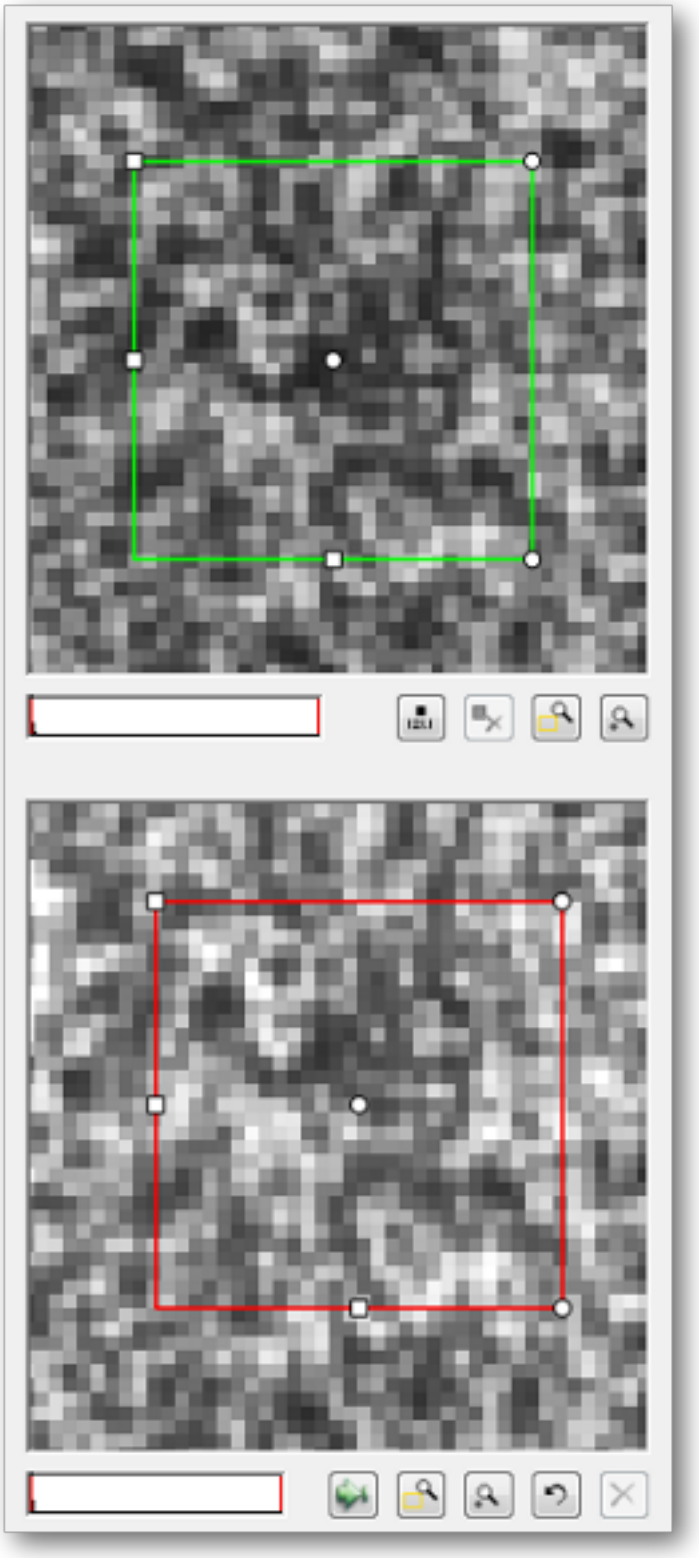

Figure 10.2: Approximate guess location.

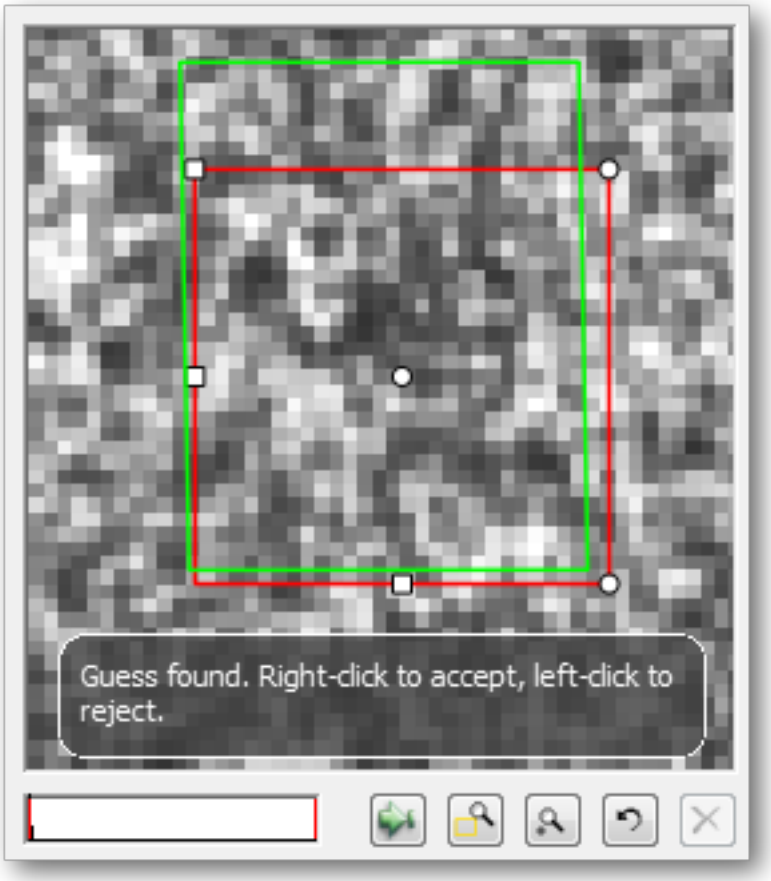

Figure 10.3: Initial guess found.

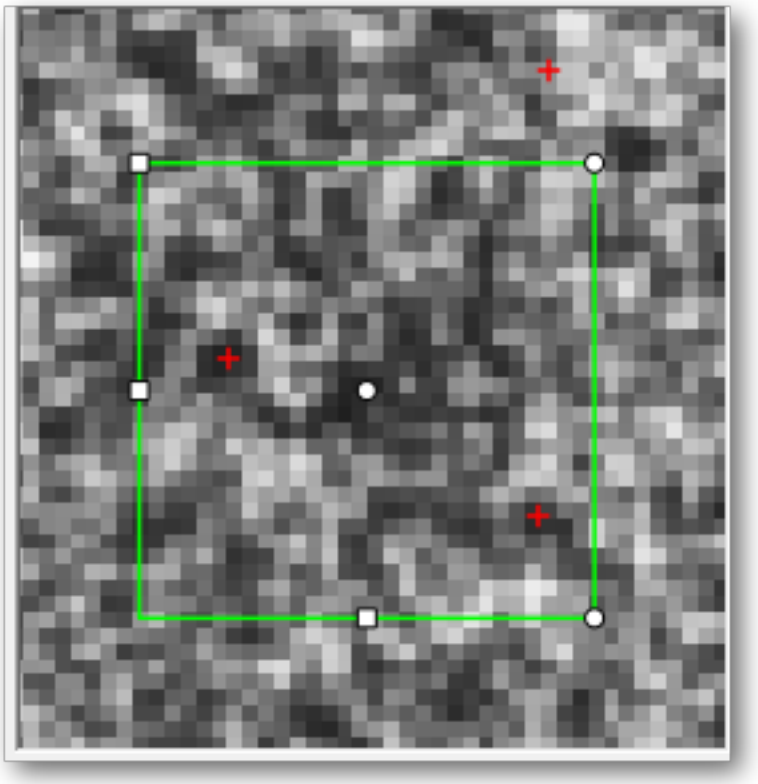

Figure 10.4: Setting control points.

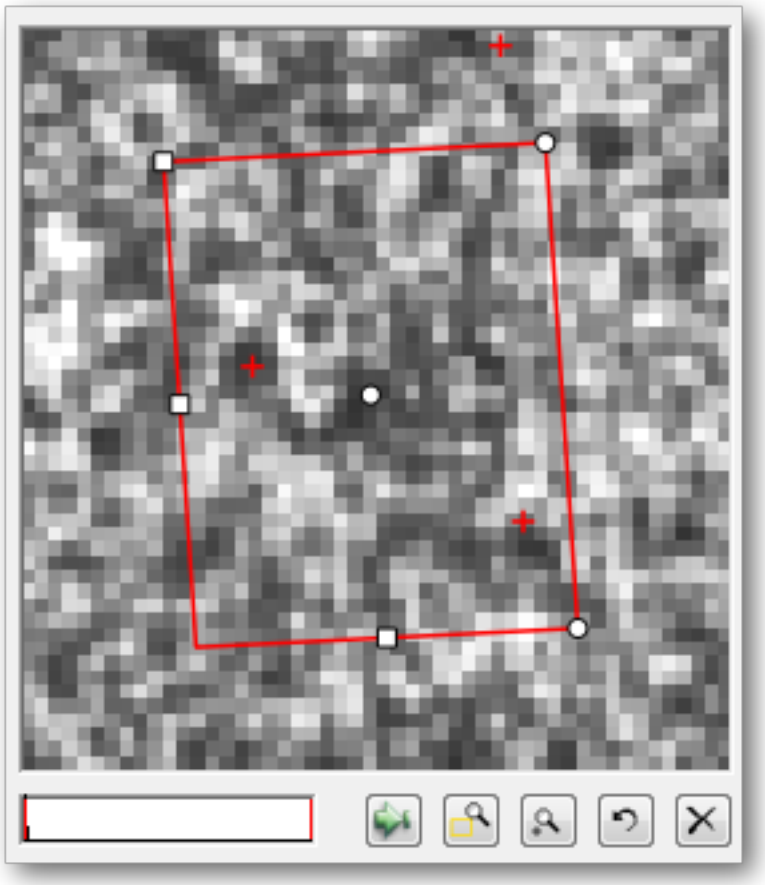

Figure 10.5: Red rectangle control points.

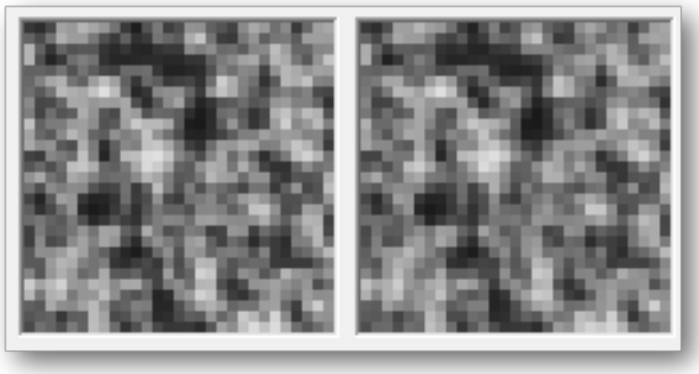

Figure 10.6: Comparison view of reference and resampled deformed subset.

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:

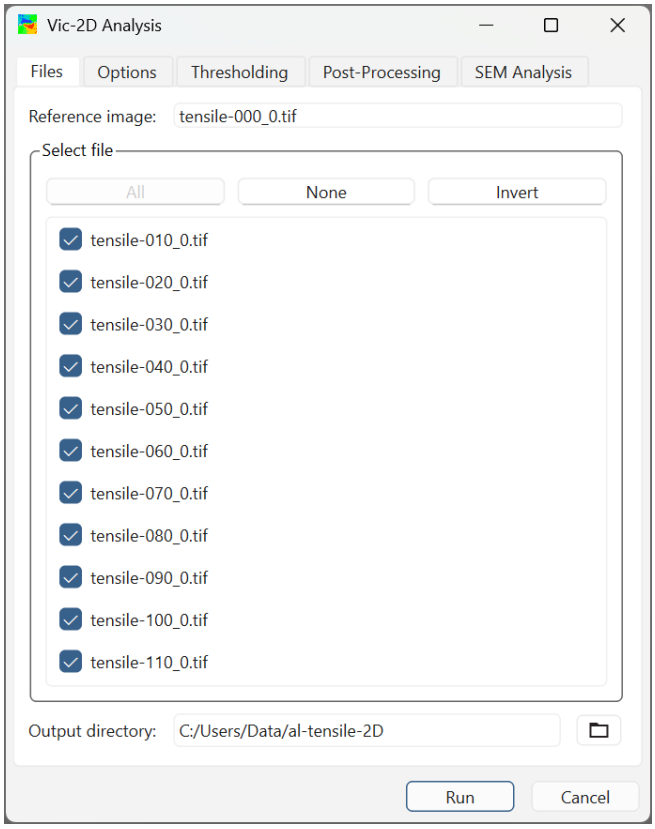

Figure 11.1: Analysis dialog file tab

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.

The analysis summary is also saved as a CSV file inside the project file, making it available whenever the project is opened.

11.5 The Options Tab

This tab displays the following options:

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.

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:

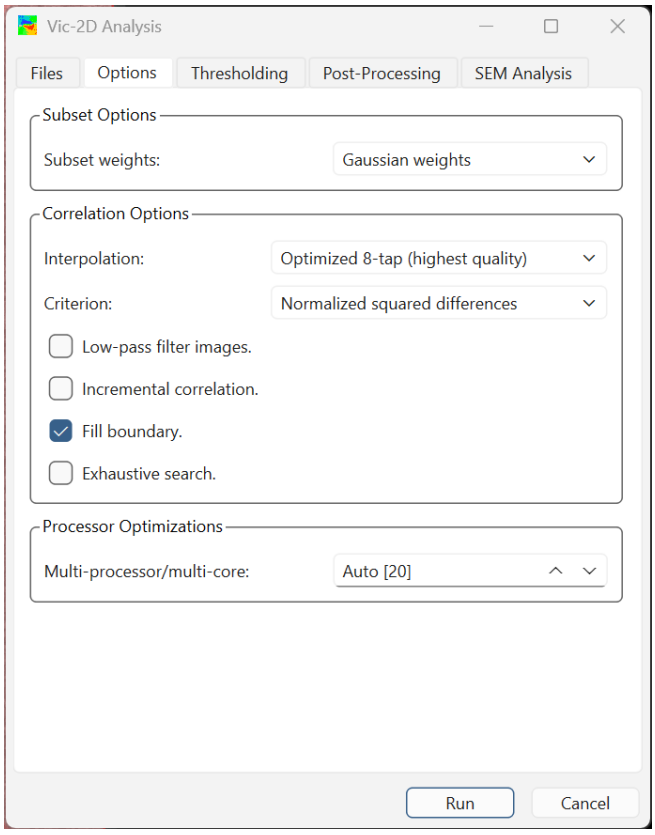

Figure 11.2: Analysis dialog options tab

- 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 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.

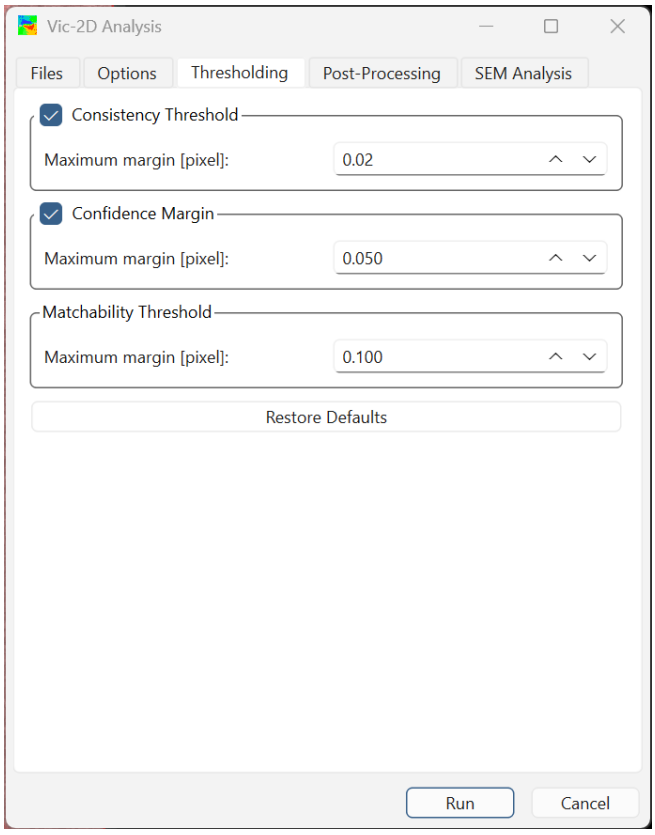

Figure 11.3: Analysis dialog thresholding tab

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:

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.

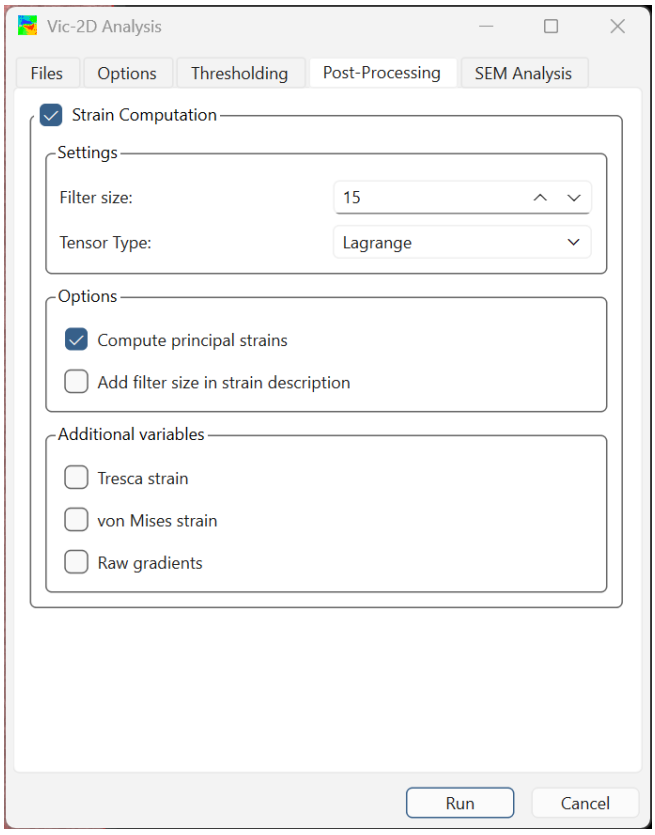

Figure 11.4: Analysis dialog post-processing tab

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.

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

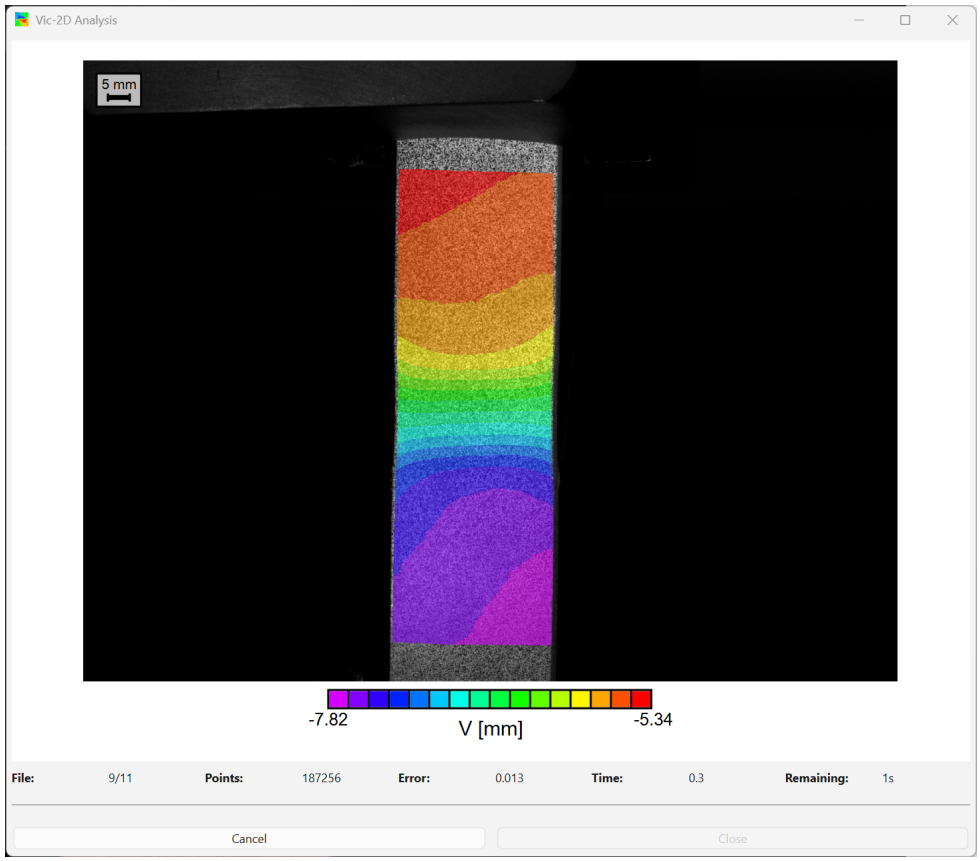

Figure 11.5: Analysis progress during correlation.

Chapter 12

Batch Processing Mode

VIC-2D has a batch processing mode for running one or more project files without user intervention. The batch processing mode can be used by starting VIC-2D from the command line with the following arguments:

```
VIC2D -R filename1 [filename2] [...]
```

This will create or append to a log in the home directory (typically c:\users\login_name) folder called VIC2D_batch_log.txt.

Alternatively, a different log file name can be specified on the command line using the *-L* switch:

```
VIC2D -R filenames -L logname
```

To automatically output a report with results, one or more report templates and output files can be specified. The number of output files must match the number of project files to process.

```
VIC2D -R filenames -L logname -T templatename -O outputnames
```

In batch processing mode, a VIC-2D icon will appear in the system tray to show progress and allows cancelling the analysis. Right-clicking on the tray icon brings up a pop-up window with progress information and an option to cancel.

For each project analyzed, the log file will contain information on start and stop times, points processed, and any associated warnings or errors. If applicable, report generator output will also be logged.

Chapter 13

Real-Time Analysis

Real-time mode may be started by first starting VIC-Snap, and then starting the real-time server (see VIC-Snap documentation for details). Then,

VIC-2D can be started and *File...* *Mode...* *Real-time 2D Analysis* should be selected.

A dialog will appear and allow entry of a server and port, or selection of a recent server and port combination, as shown in Fig. 13.1.

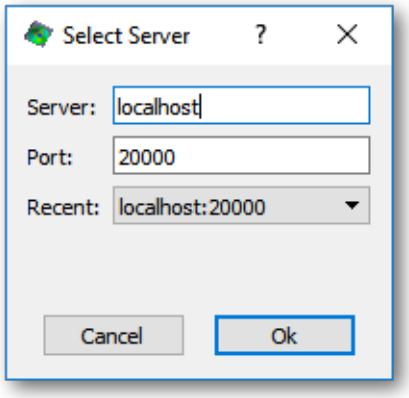

Figure 13.1: Real-time server and port settings.

If VIC-Snap is running on the local PC, *localhost* should be selected; if VIC-Snap is running remotely, the IP address of the acquisition PC can be entered. The *Port* setting should be left at the default unless there is a conflict.

VIC-2D will attempt to connect to the image server; when the connection is established, a live view will appear in the workspace, and the real-time tools will be displayed, as illustrated in Fig. 13.2.

13.1 Calibration in Real-Time Mode

Calibration must be performed outside of real-time mode. There are two possible routes:

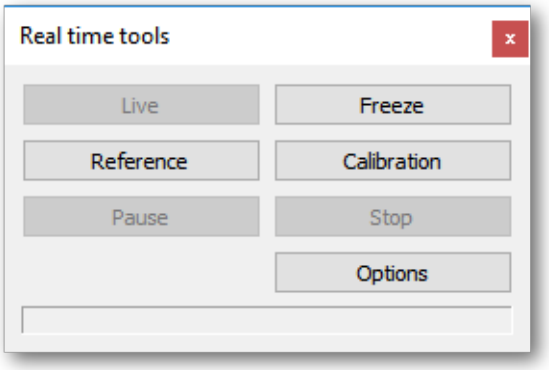

Figure 13.2: Real-time analysis tools.

- Calibration in VIC-Snap. If a scale calibration is present in VIC-Snap when real-time mode is started, it will be transferred to VIC-2D, and will appear in the Calibration tab. Clicking *Calibration* in the tool set will retrieve the latest calibration at any time.
- Calibration in VIC-2D. If the desired calibration is present in a standard project file, the *Calibration... Import calibration* main menu option may be used to import it.

13.2 Selecting a Reference Image

A reference can be set by clicking *Reference* in the real-time tool set. The currently displayed live image will be copied and used as reference. Then, AOIs may be drawn and manipulated as described in Chapter 7.

13.3 Running the Analysis

The real-time analysis is begun by clicking the green Start Analysis button in the toolbar, or selecting *Data... Start analysis*. Incoming images will be analyzed and transferred in sequence as fast as the processor and transfer speed allow.

13.4 Analysis Options

Correlation options may be adjusted before or during the analysis. If the analysis is already in process, the changes will not take place until the correlation is restarted.

13.5 Pausing the Analysis

In order to make changes to coordinates and contour levels, it may be helpful to pause the analysis by clicking *Pause*. The button text will change to *Resume* and may be clicked to resume.

- The data analyzed in real-time mode is displayed but not saved. To allow later processing and storage of data, be sure to store the images in VIC-Snap as usual (timed capture, manual capture, etc.)
- To obtain the best frame rates in real-time mode, select a large step size; this will result in fewer points being analyzed and more total updates per second.
- Select a desktop PC with many cores for maximum analysis speeds. With a fast PC and a larger step size, frame rates of 5-10 per second can be realized.
- Real-time mode is available with an optional module.

Chapter 14

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

14.1 Strain Calculation

Strain may be calculated for project data by selecting *Data... Postprocessing options... Calculate strain* from the main menu. This will show the strain computation dialog as illustrated in Fig. 14.1. Note that strains may also be computed during the correlation analysis; see Section 11.18 for details.

14.1.1 Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. Data files can be selected for processing by clicking on each data file to toggle the associated checkbox. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses the selection.

14.1.2 Preview

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

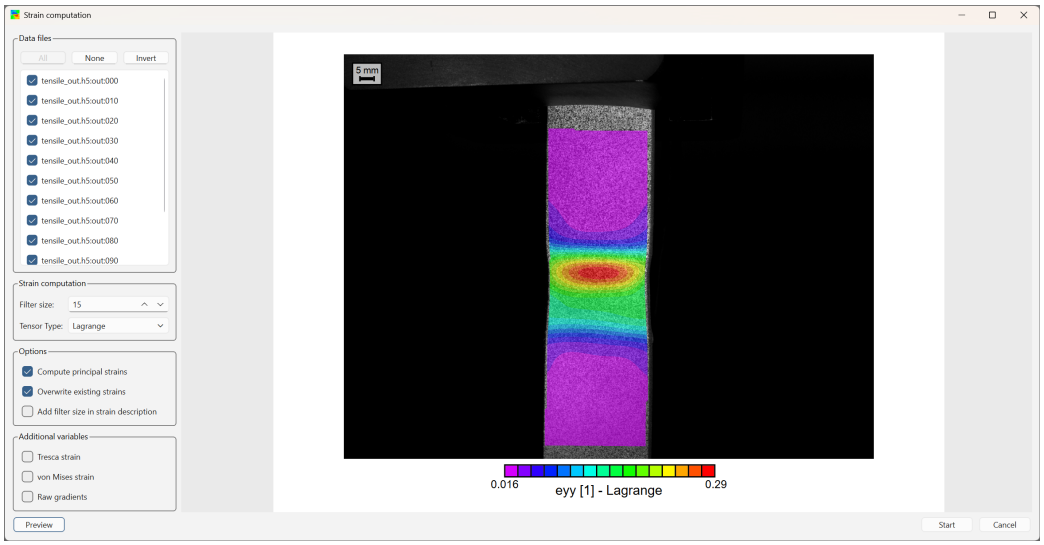

Figure 14.1: Strain dialog.

14.1.3 Compute Principal Strains

Checking this box adds principal strains and principal strain angle to the calculated output data.

14.1.4 Overwrite Variables

If this box is checked, any existing strain variables will be overwritten during the new calculation. If this box is clear, more data fields will be added to the output data set each time strain is calculated.

14.1.5 Add filter size in strain description

Checking this option will add the filter size to the text of the new strain variable description. When more than one strain result is present in the data this may help differentiate each set.

14.1.6 Compute Tresca/von Mises strain

These options may be selected to compute the Tresca/von Mises strain criterion along with the strain tensor calculation.

14.1.7 Filter size/type

Calculated strains are always smoothed using a local filter. The 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.

14.1.8 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.

14.1.9 Tensor Type

Here the desired strain tensor may be selected. 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 14.1.8 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

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

14.2 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... Postprocessing tools... Remove rigid motion.*

14.2.1 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.

14.2.2 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 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.

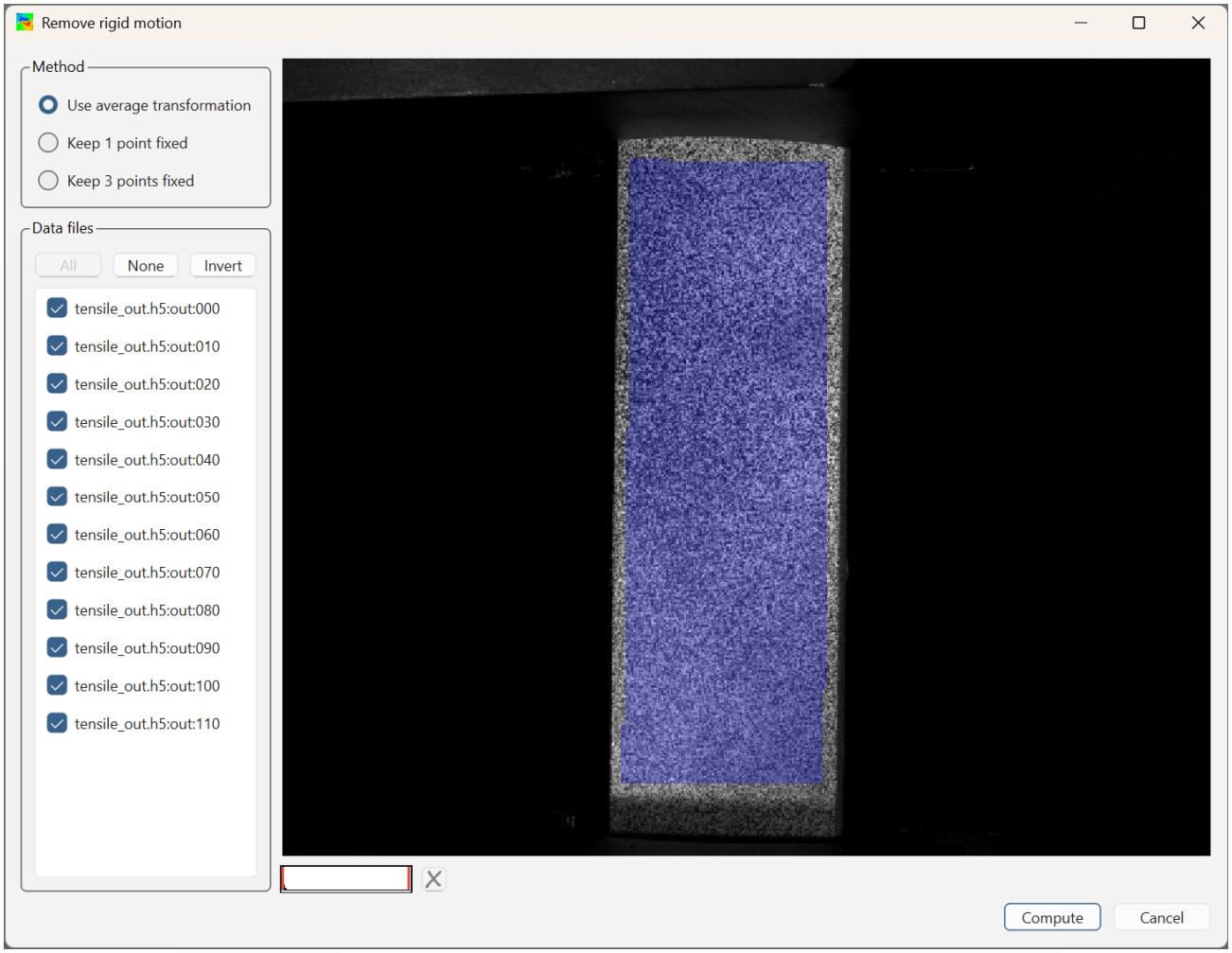

Figure 14.2: Rigid motion removal dialog.

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.

14.3 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.

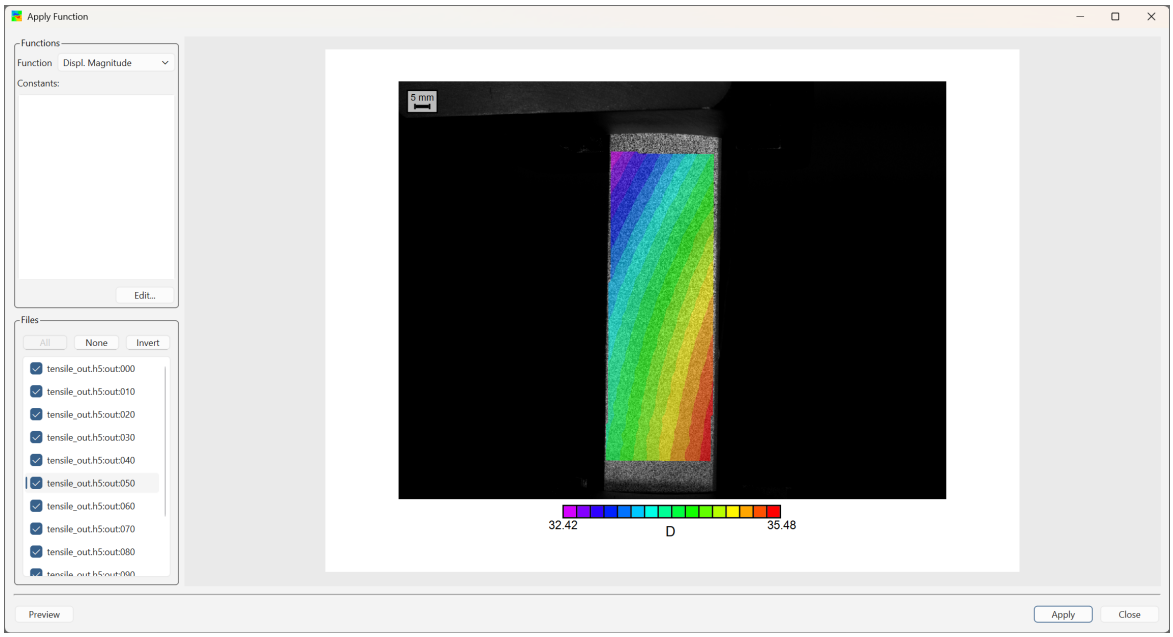

Figure 14.3: Apply function dialog.

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.

14.3.1 Creating and Editing Functions and Constants

New functions and constants may be created, and existing ones can be edited. Clicking on the **Edit...** button will open 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:

- 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.

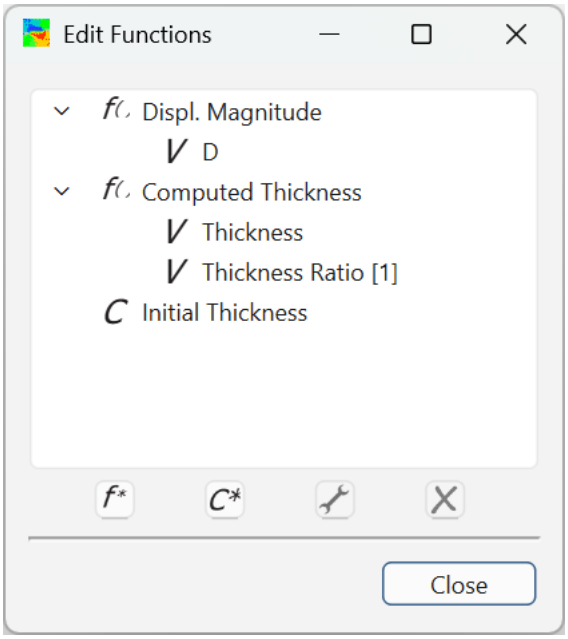

Figure 14.4: Edit functions dialog.

14.3.2 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.

14.3.3 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.

14.3.4 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.

14.3.4.1 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.

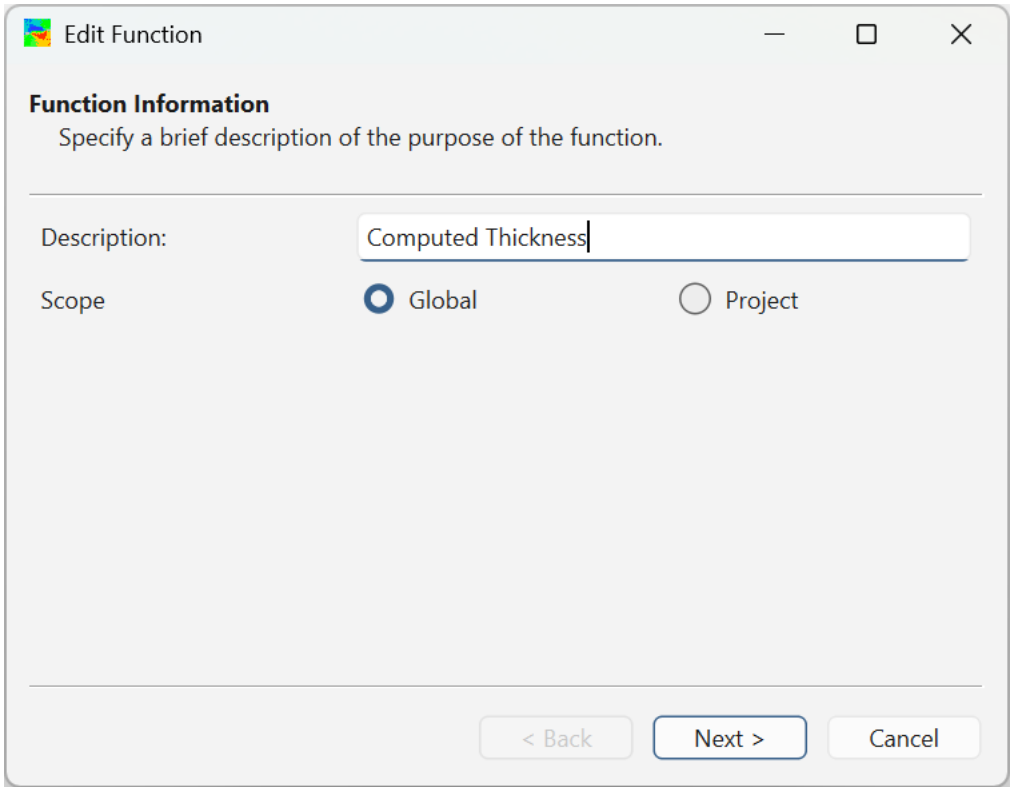

Figure 14.5: Function wizard information page.

14.3.4.2 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 14.3.6.

14.3.4.3 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.

14.3.5 The Constant Wizard

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

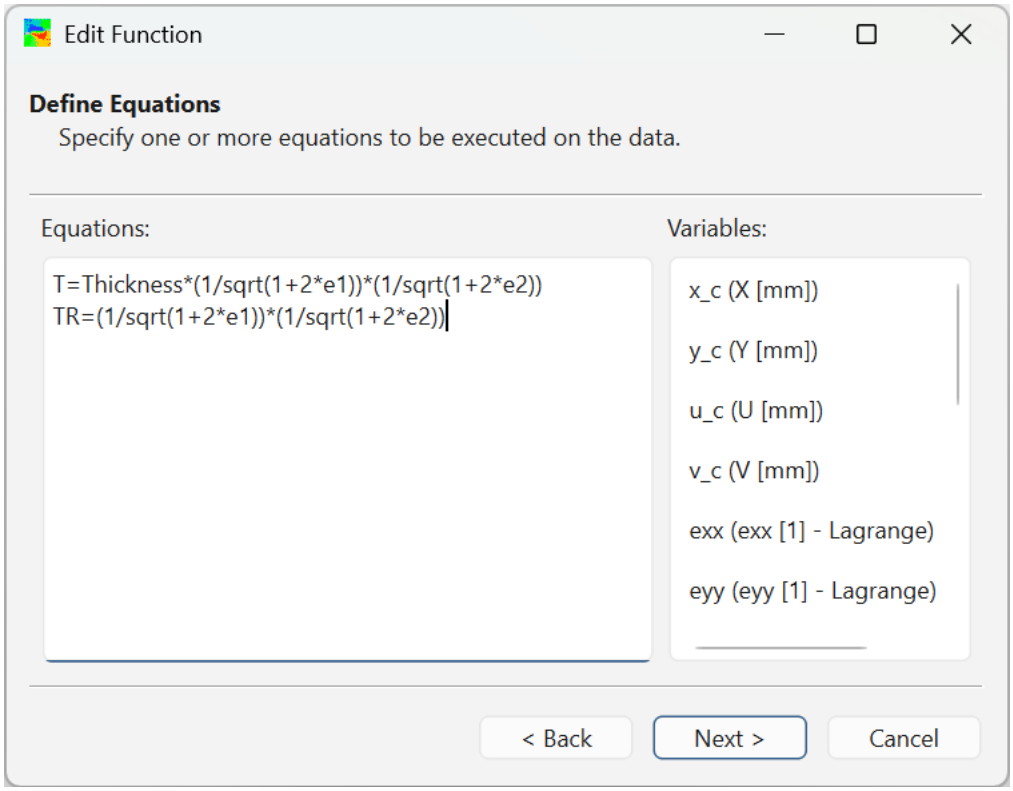

Figure 14.6: Function wizard equation page.

14.3.5.1 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.

14.3.5.2 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 description and a value.

14.3.6 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

Function name	Argument count	Explanation
`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
`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

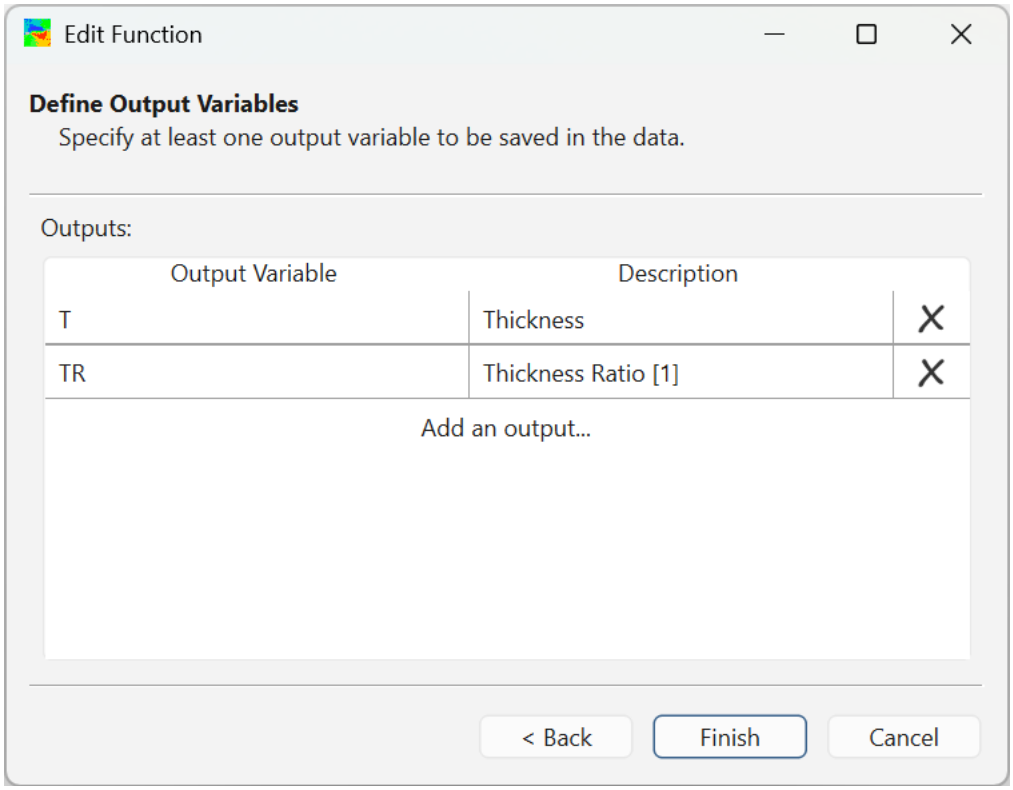

Figure 14.7: Function wizard outputs page.

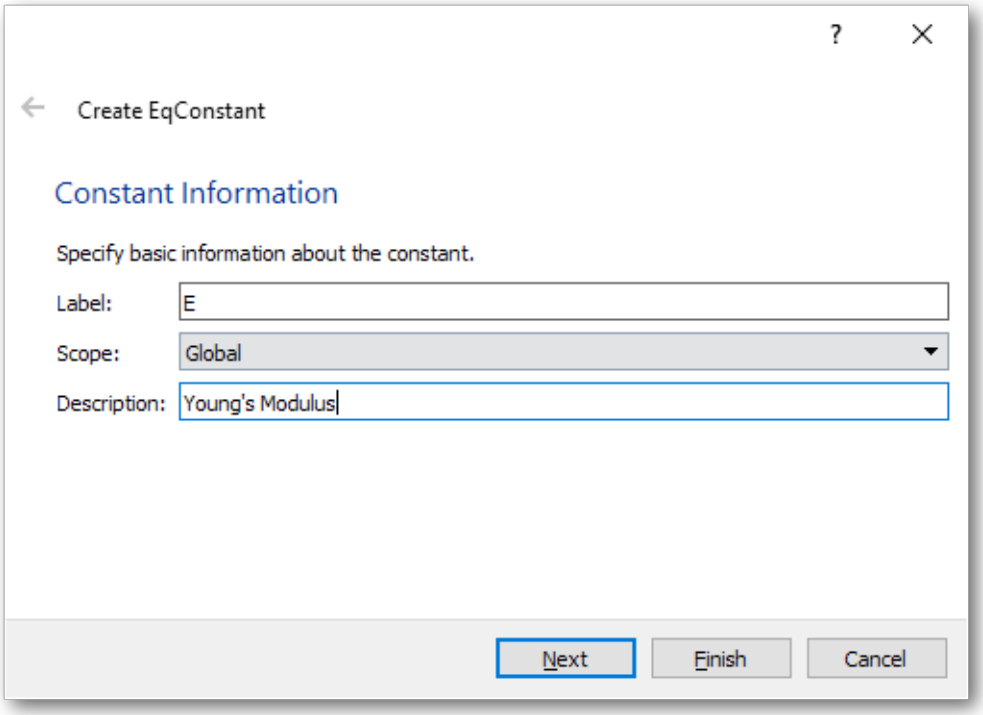

Figure 14.8: Constant wizard information page.

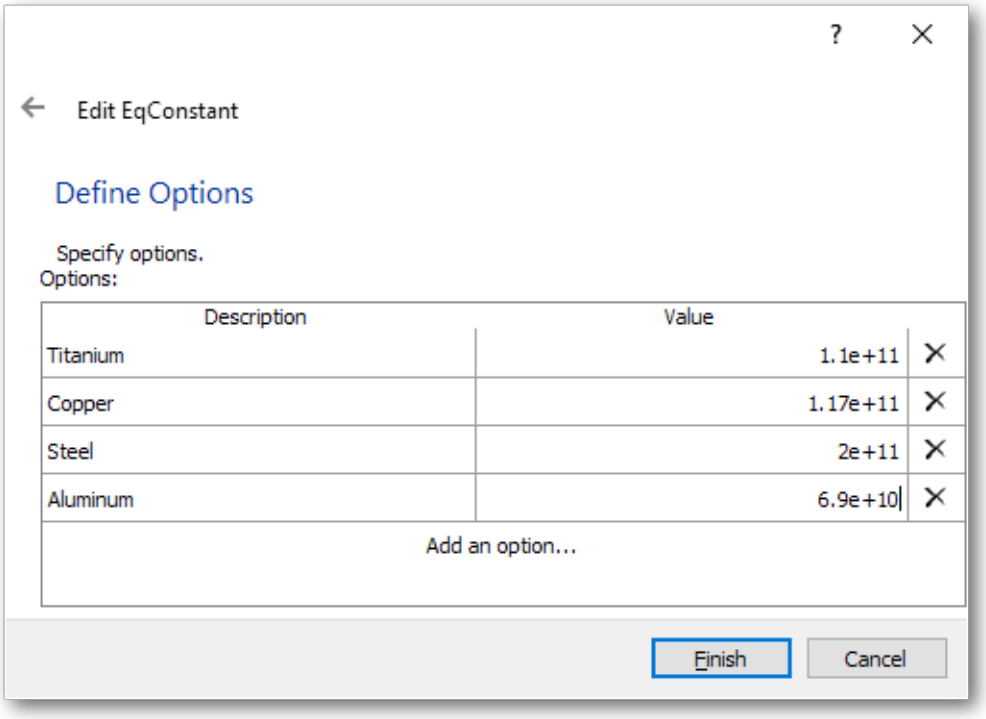

Figure 14.9: Constant wizard options page.

14.4 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. 14.10.

14.4.1 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.

14.4.2 Velocity Calculation

If a VIC-Snap .CSV log file exists for the project, *Time from file* should be selected from the dropdown. (The relevant CSV file may be selected if necessary.) Otherwise, *Constant time step* may be selected and a known time increment entered, or *Constant frame rate* may be chosen to enter a known frame rate, e.g., for data from a high-speed camera.

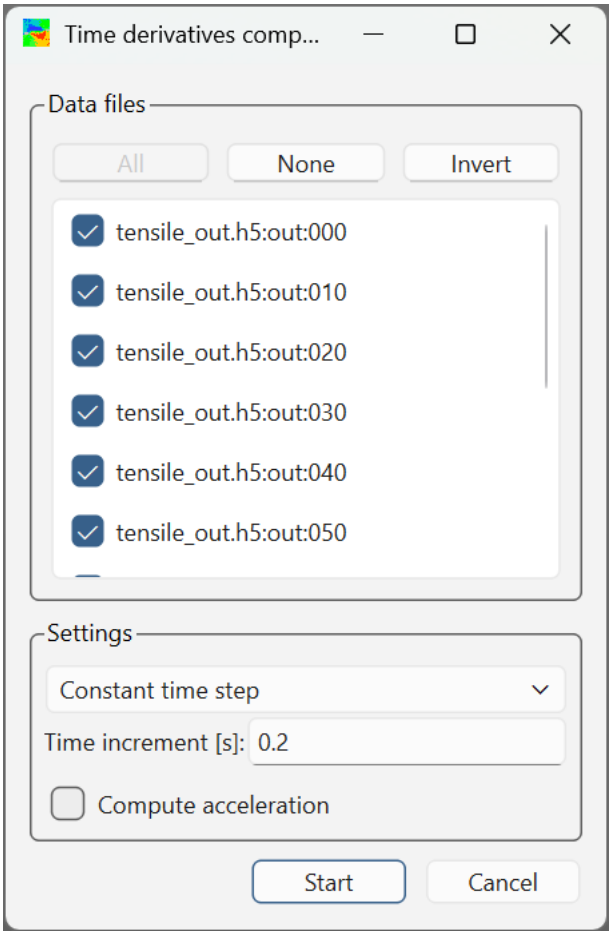

Figure 14.10: Velocity dialog.

Clicking **Start** will begin the process; a 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.

14.5 Rotation Calculation

Calculate local in-plane rotation for a set of data by selecting *Data... Postprocessing options... Calculate in-plane rotation* from the main menu. This displays the dialog illustrated in Fig. 14.11.

> 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 16.10.1.

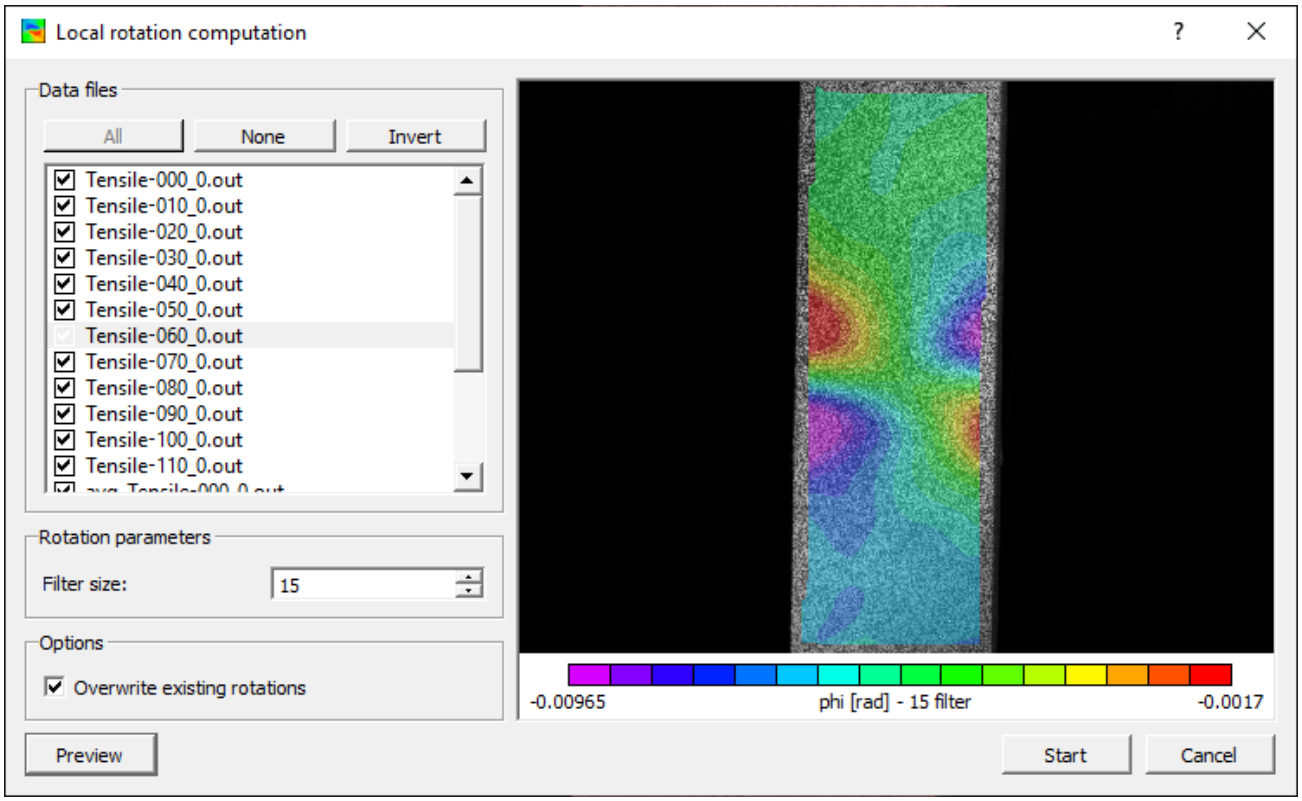

Figure 14.11: Rotation computation dialog.

14.5.1 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.

14.5.2 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.

14.5.3 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.

14.5.4 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.

14.6 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.

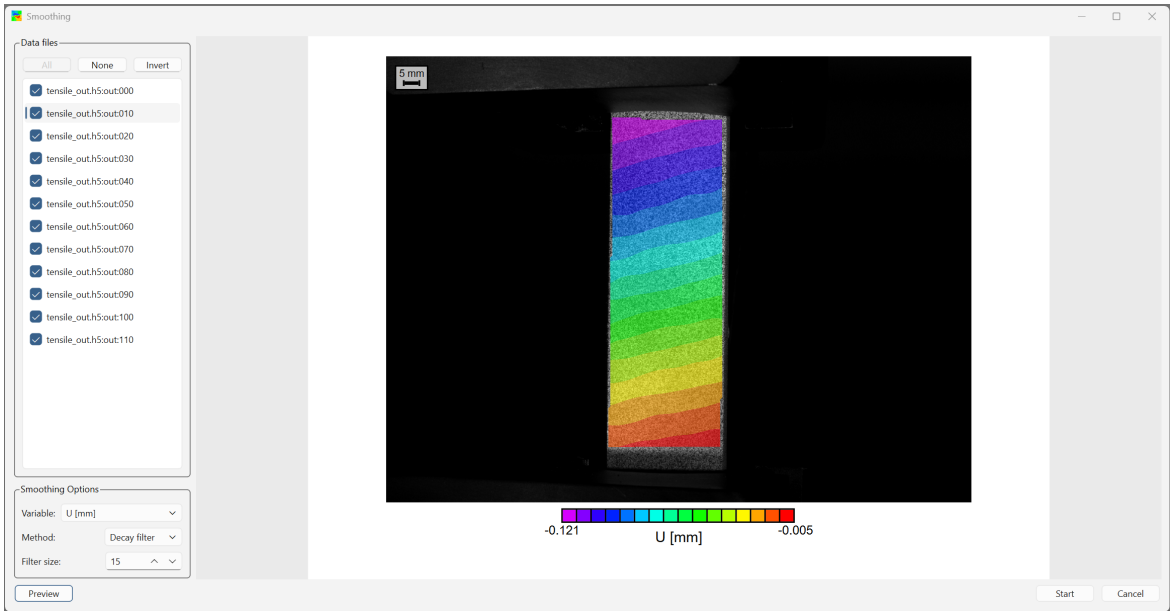

Figure 14.12: Smoothing dialog.

14.6.1 Selecting Data Files for Processing

The available data files are displayed in the *Data Files* list box. Files may be selected by clicking on each data file to select/deselect. For convenience, the buttons labeled *All* and *None* select/deselect all files, while *Invert* reverses the current selection.

14.6.2 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.

14.6.3 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.

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.

14.7 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.

14.7.1 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.

14.7.2 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.

14.8 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

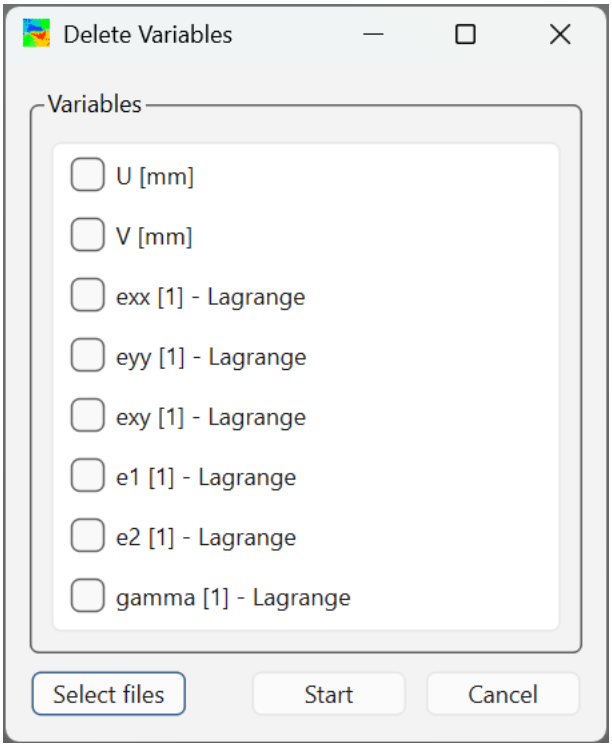

Figure 14.13: Delete variables dialog.

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.

Apply time filters to a data sequence by selecting *Data... Postprocessing options... Time filter* from the main menu.

> It is helpful to place at least one inspector point prior to opening the dialog; this will give a visualization of the filtering effect. If no inspectors are placed there will be no graphical feedback.

14.8.1 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.

14.8.2 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

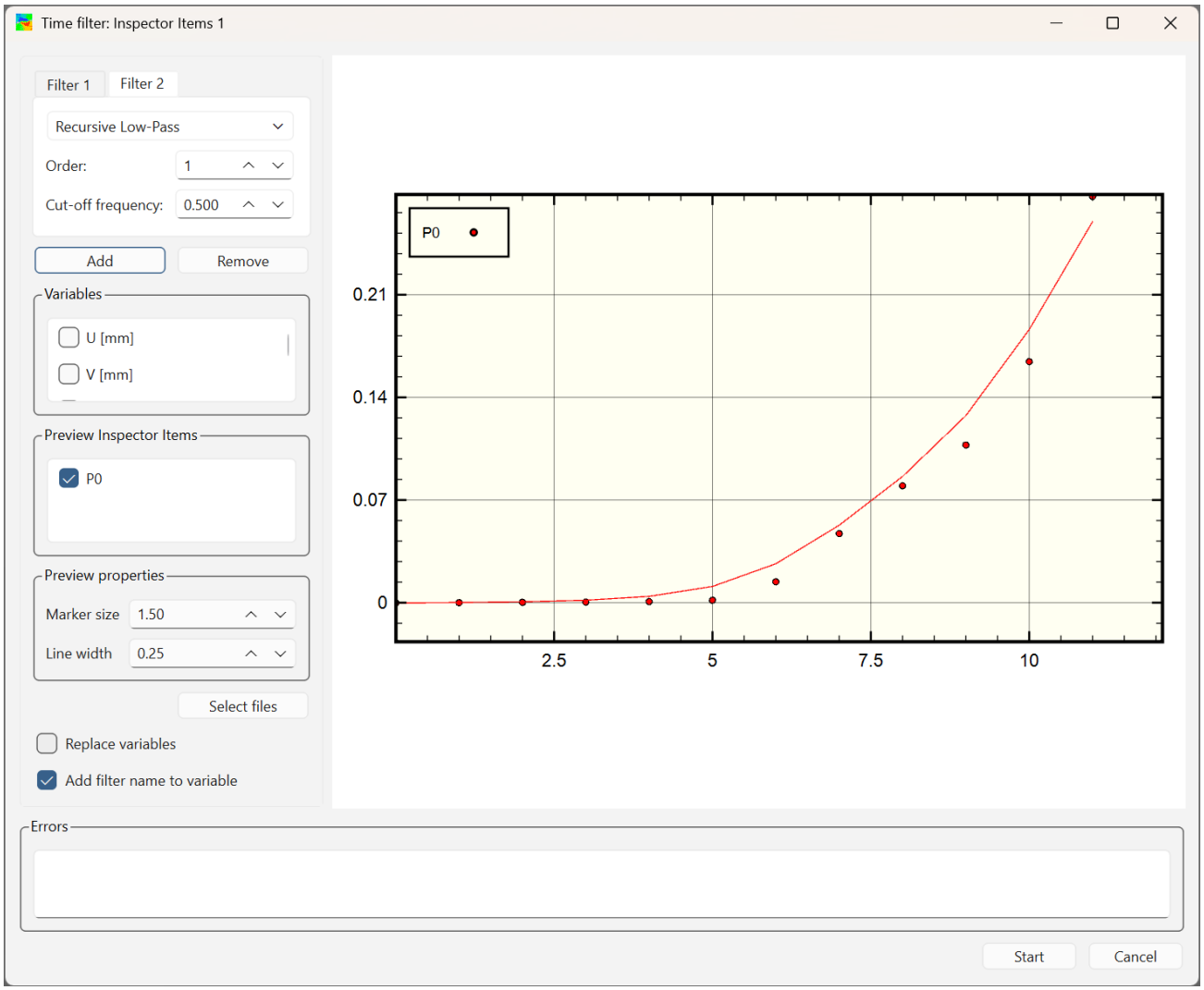

Figure 14.14: Time filter dialog

the project. Note that the preview only becomes available after validation of the input files and after a variable for filtering has been selected.

14.8.3 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 variable* check box indicates whether the variable names of the filtered data should contain a description of the filter chain or not.

14.8.4 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.

14.8.5 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.

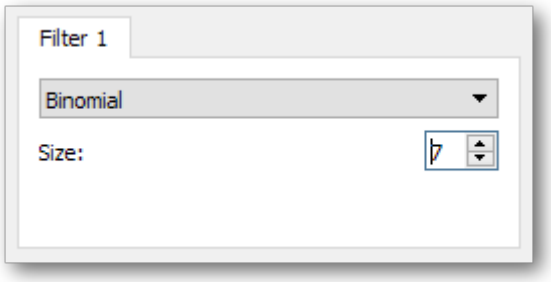

Figure 14.15: Binomial filter options.

14.8.6 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.

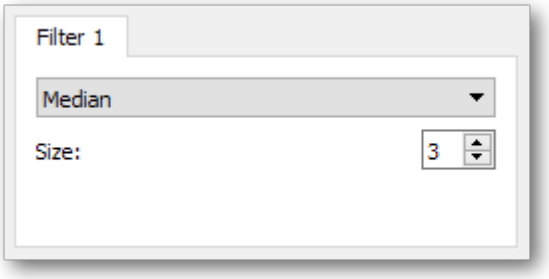

Figure 14.16: Median filter options

14.8.7 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 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.

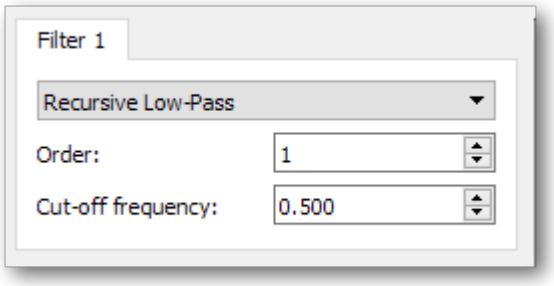

Figure 14.17: Recursive low-pass filter options.

14.8.8 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.

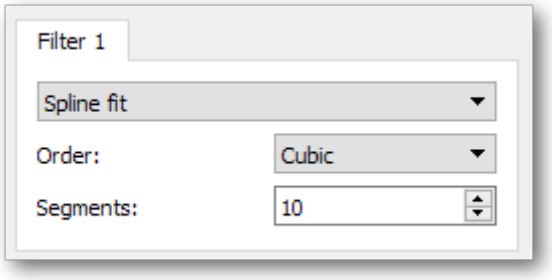

Figure 14.18: Spline fit filter options.

14.9 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.

Once the data is calculated from the speckle images, clicking *Data... Postprocessing tools... Time Average Data* on the main menu will open the dialog as shown in Fig. 14.19.

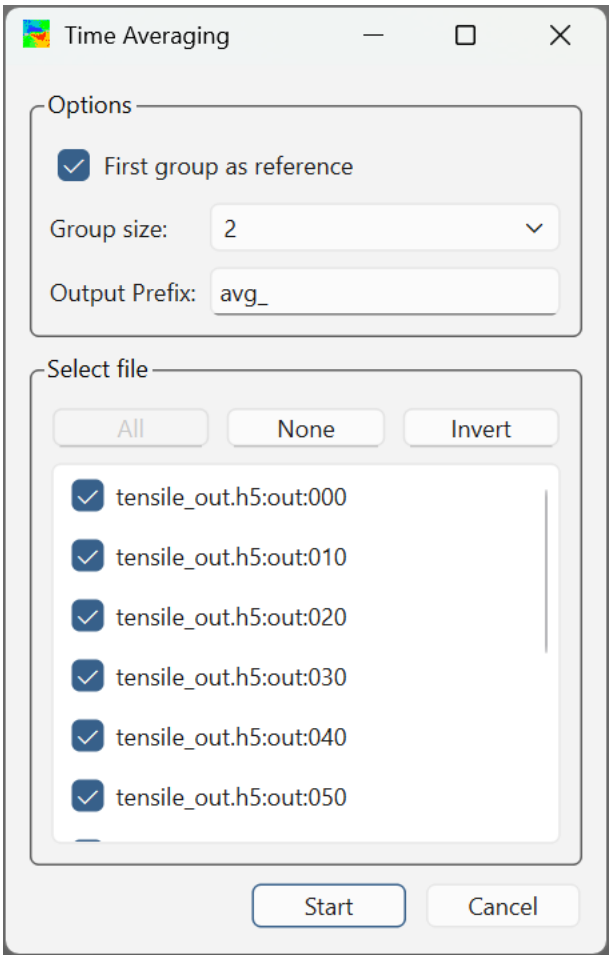

Figure 14.19: Time average dialog.

14.9.1 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**.

14.9.2 Selecting files

The available data files are displayed in the list box. Files may be selected or deselected using the checkbox next to each. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

The computation can be executed by clicking the **Start** button.

14.9.3 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. 14.20. 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.

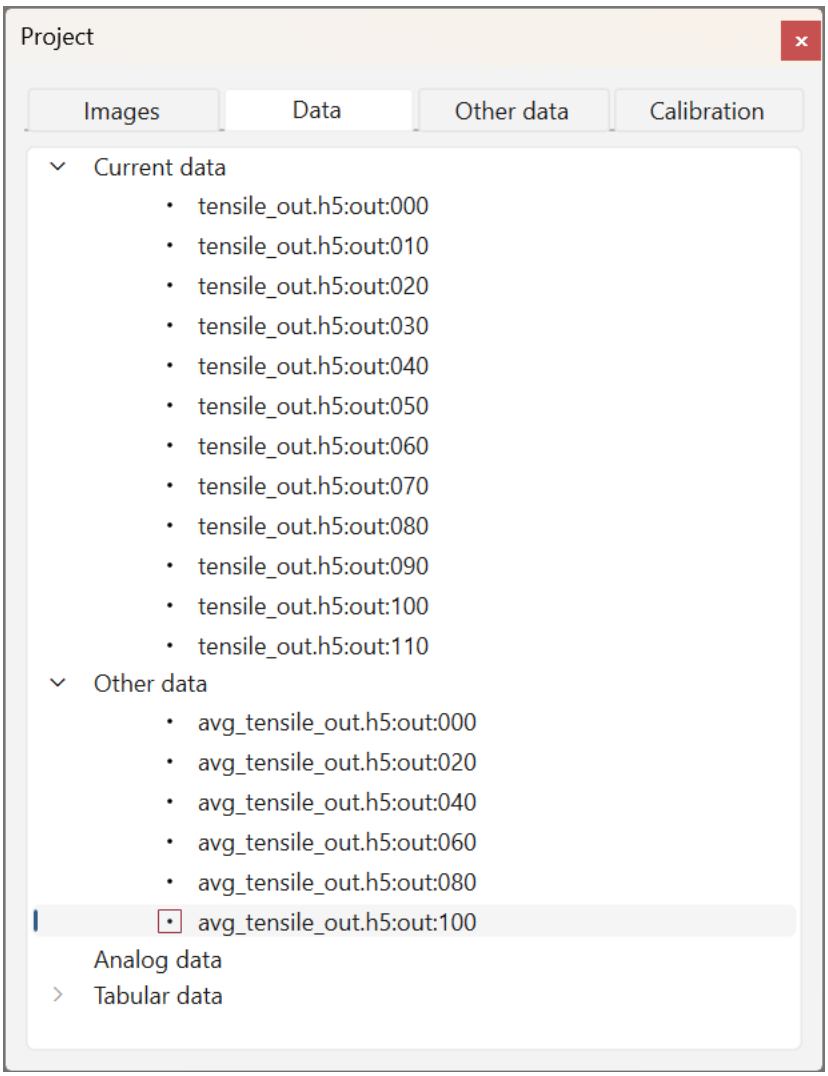

Figure 14.20: Project data panel showing time average data.

14.9.4 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.

14.10 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.

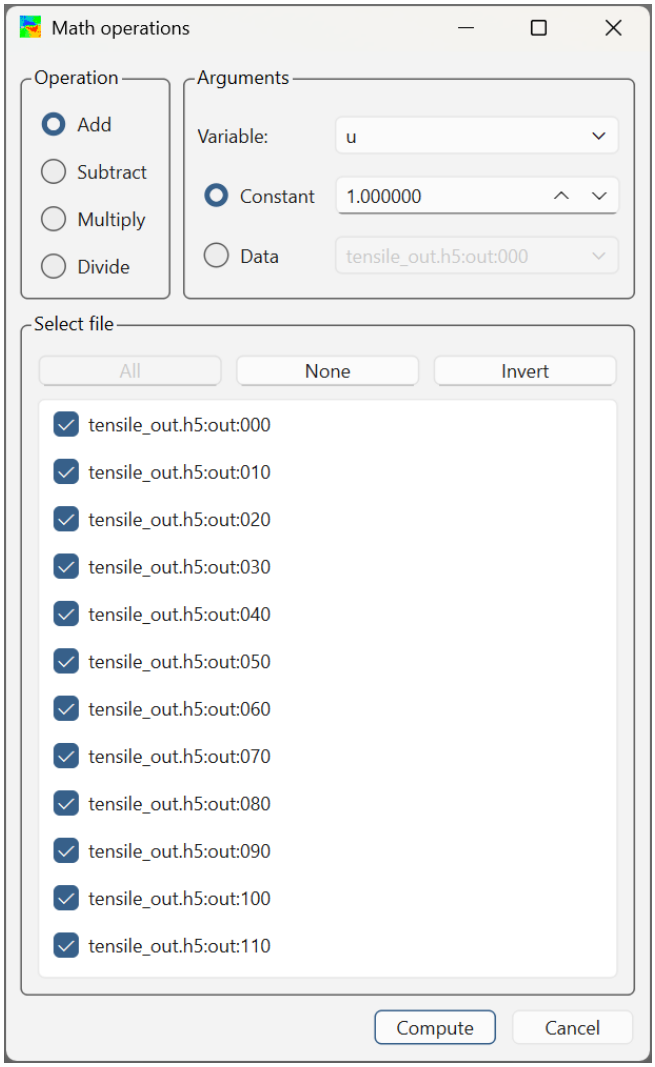

Figure 14.21: Math operations dialog.

14.10.1 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.

14.10.2 Operation

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

14.10.3 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 v variable 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.

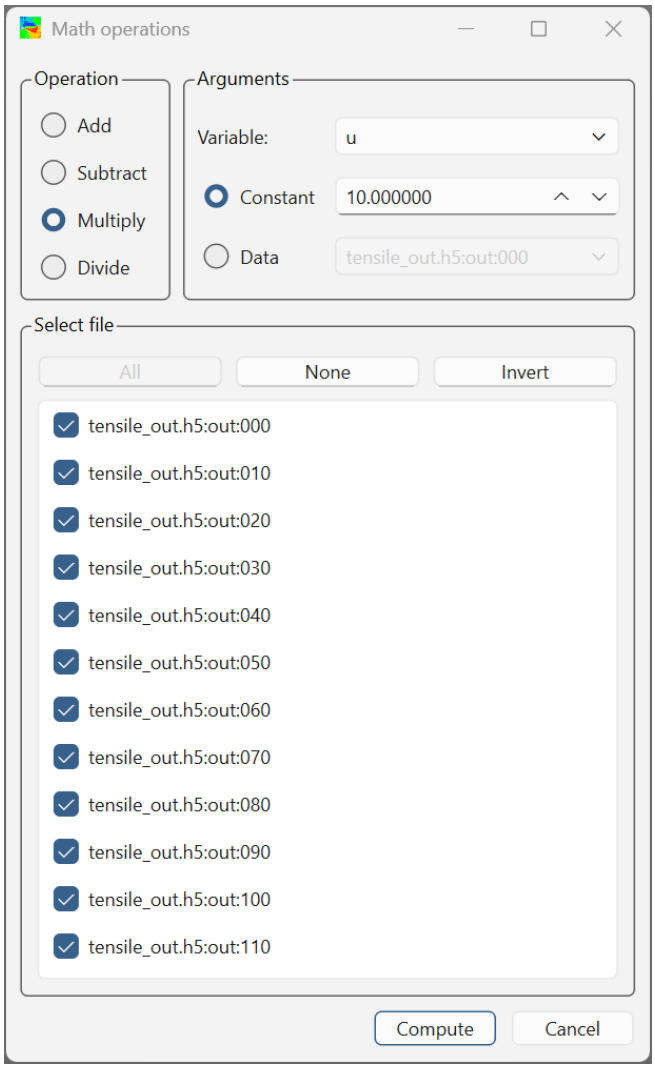

Figure 14.22: Math operation using a constant input.

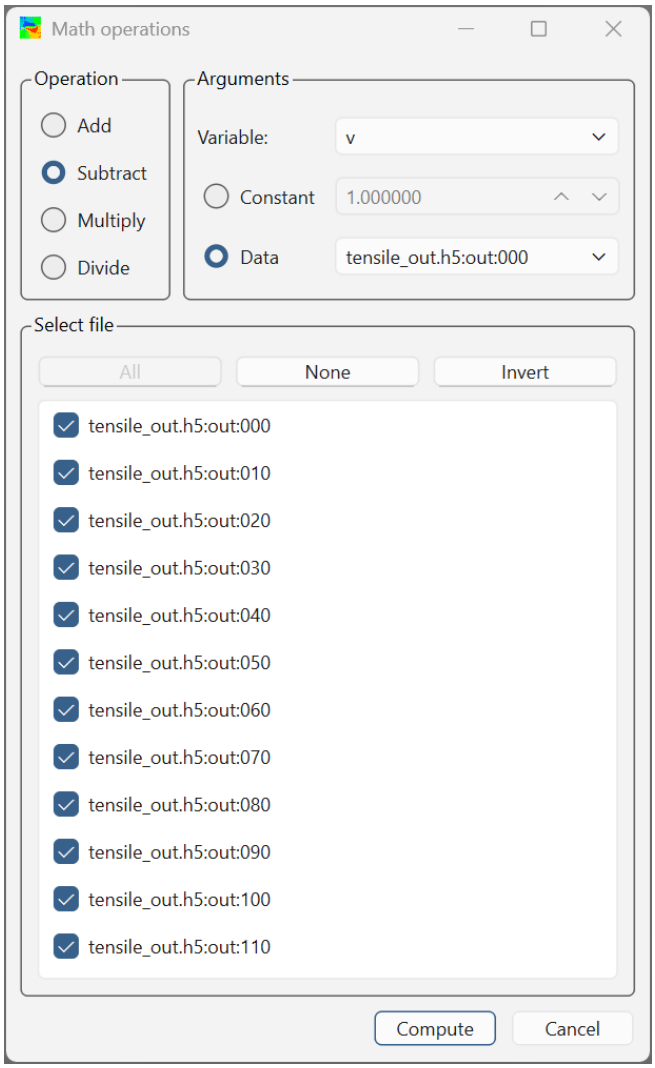

Figure 14.23: Math operation using a data file as input.

Chapter 15

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.

15.1 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. 15.1 will appear.

15.1.1 Selecting Files for Exporting

The available data files are displayed in the list box. Each file may be selected or deselected by toggling the adjacent checkbox. For convenience, the buttons labeled *All* and *None* select/deselect all files.

15.1.2 File Formats

The data files can be exported to the following formats:

Comma-Separated Variable
Data entries are separated by commas. This format is understood by most spreadsheet

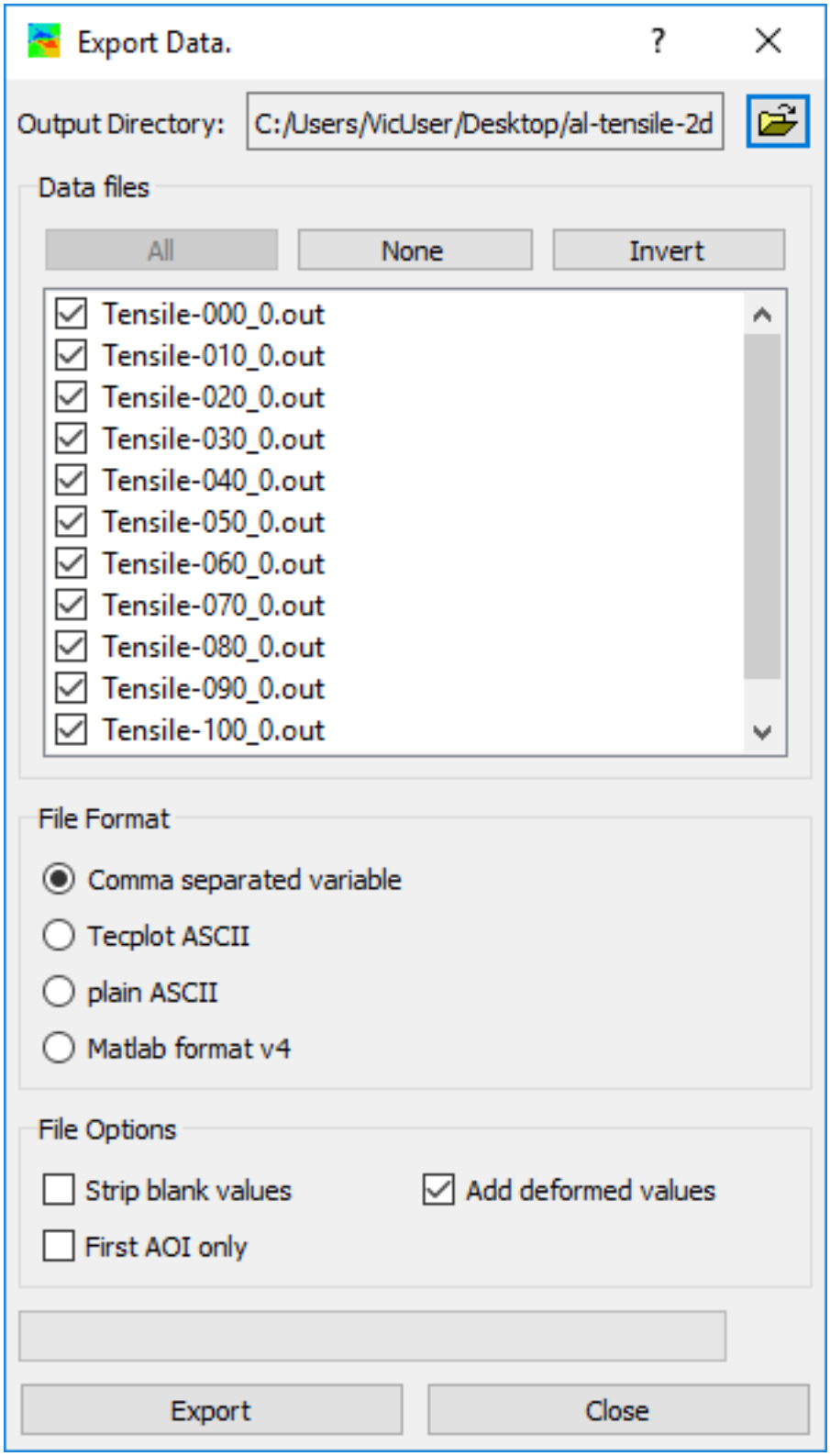

Figure 15.1: Export data dialog.

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 to discuss implementation either inside VIC-3D or using a Python script.

15.2 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.

15.2.1 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.

15.2.2 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.

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.

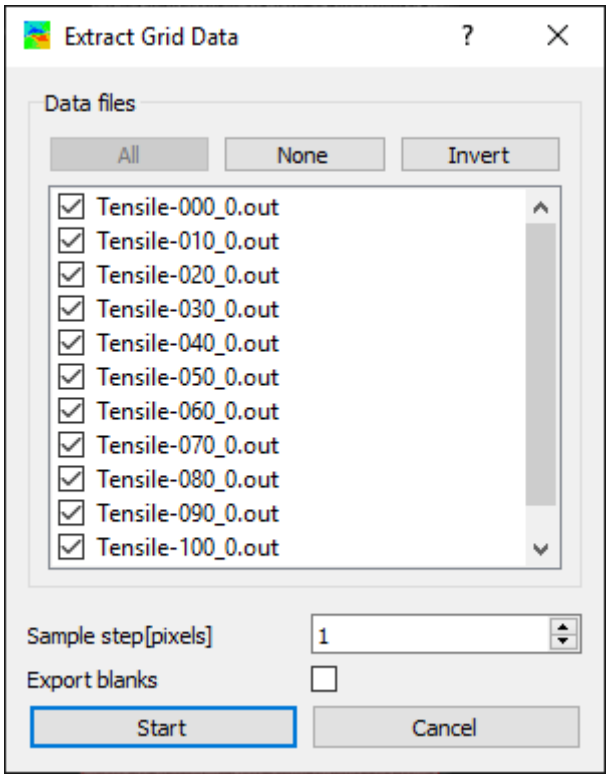

Figure 15.2: Extract grid data dialog.

15.2.3 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.

15.3 Calculating Statistics

A full set of statistics for calculated variables and data files may be exported by selecting *Data. . . Statistics* from the main menu bar.

15.3.1 Statistics

The desired measures may be checked or cleared to include or exclude them from the statistics file.

15.3.2 Variables

In this section the desired variables may be selected. By default, all metric variables are included, while correlation and pixel variables are excluded.

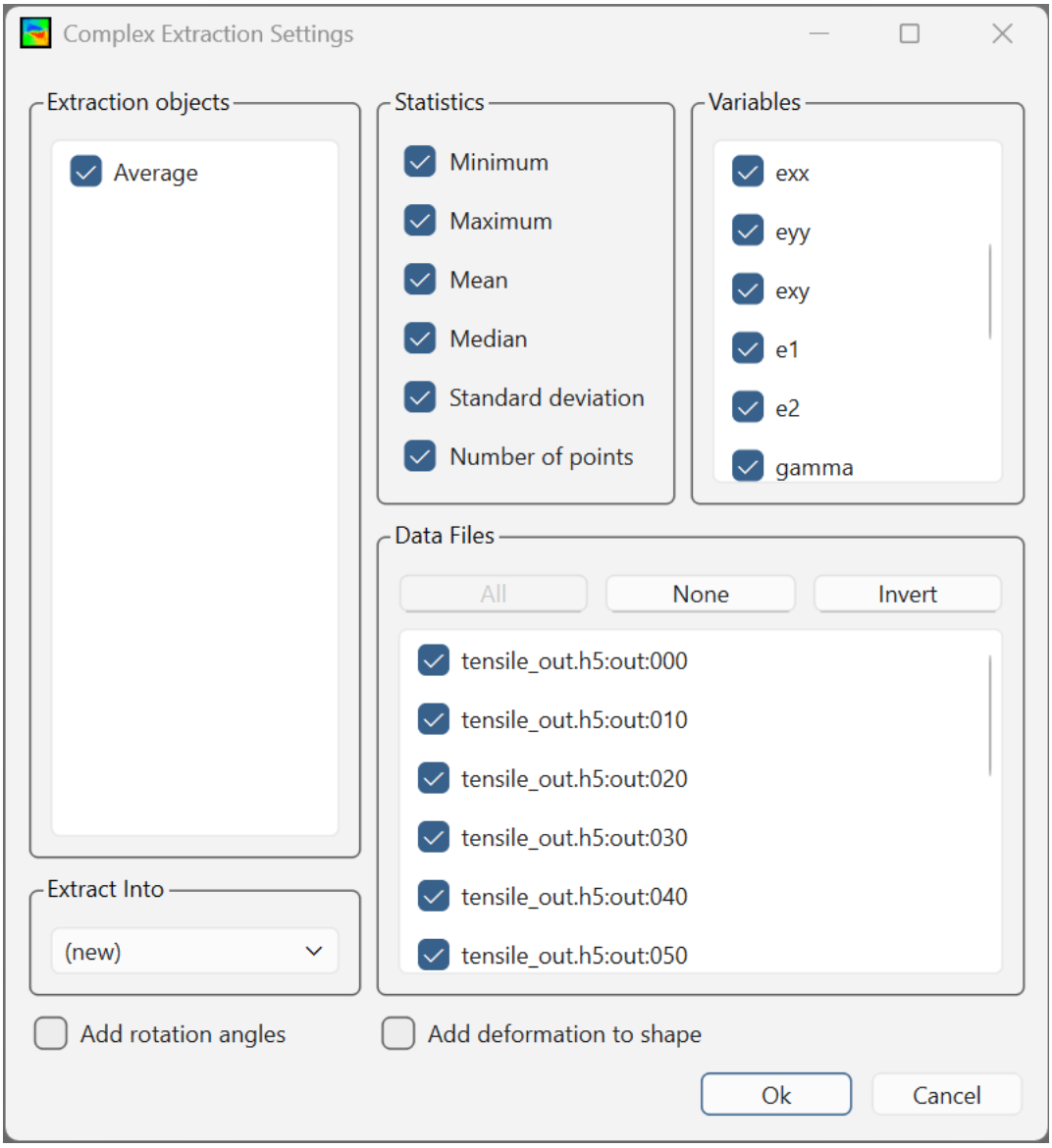

Figure 15.3: Statistics dialog.

15.3.3 Data File Selection

The available data files are displayed in the list box. Files may be included or excluded by toggling the adjacent checkbox. For convenience, the buttons labeled *All* and *None* select/deselect all files; the *Invert* button inverts the selection.

15.3.4 Exporting

The calculation can be executed by clicking **Ok**. A file dialog will appear, and the data will be exported to the selected .CSV file.

Chapter 16

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.

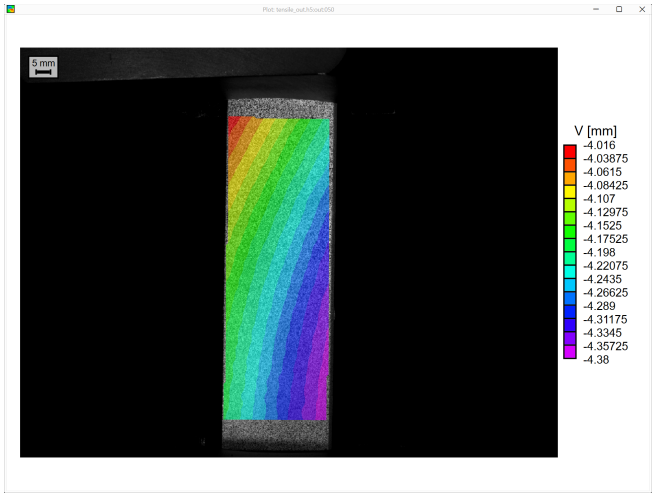

Figure 16.1: 2D contour plot display.

16.1 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.

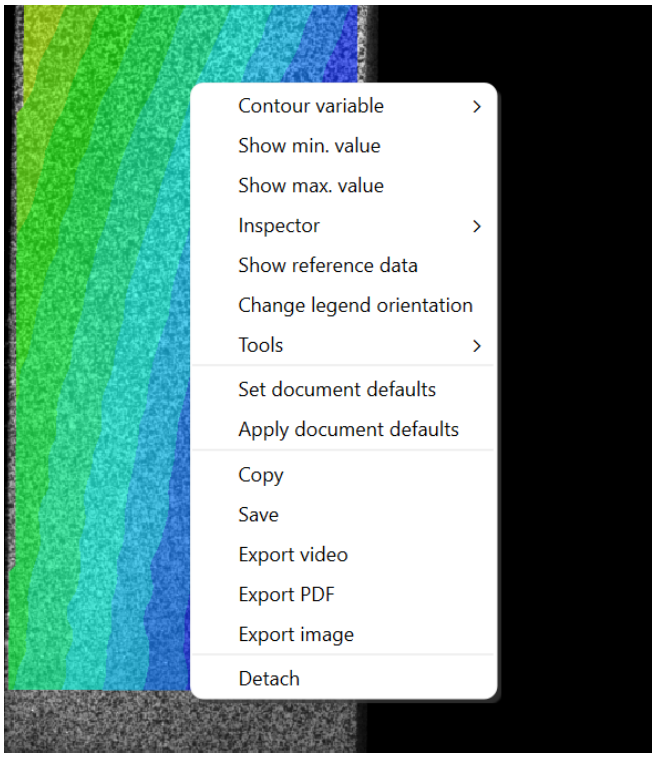

Figure 16.2: 2D plot context menu.

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.

16.2 Editing Plot Parameters

To edit other plot parameters, use the plot toolbar.

16.3 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.
- 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.

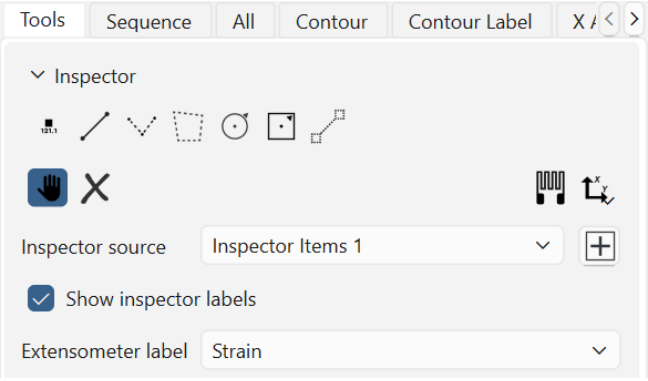

Figure 16.3: Inspector tools

- 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.

16.4 Animating Plots

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

16.5 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*.

16.6 The Plot Toolbox

The plot toolbox is displayed at the top left edge of the work area by default. It contains options and controls for both the 2D and 3D plots.

16.6.1 Tools Tab

The **Tools** tab (illustrated in Fig. 16.4) contains basic tools for controlling the plot view. The icon bar has buttons to:

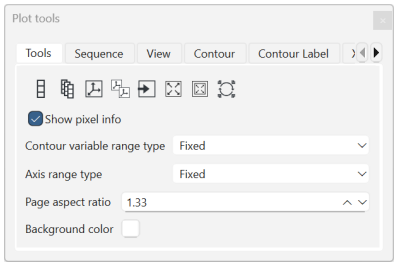

Figure 16.4: Tools tab.

- Adjust the contour scale to that of the *current* data file
- Adjust the contour scale to that of the *global* data set
- Adjust the axis scale to that of the current data set
- Adjust the axis scale to that of the global data set
- Center the plot on the page
- Fit the plot to the page
- Fit the page contents to the window
- Force the data sequence to update

If **Show pixel info** is checked, an inset will display data when the mouse is moved over the plot contents.

Three **Range types** may be selected for the *Contour variable* and the *Axis range*:

- *Fixed* range uses a static range that may be selected with the tool buttons above (global or current) or entered manually.
- *Expanding* adjusts to each image but will only get larger.
- *Local* range adjusts to each image.

The **Page aspect ratio** can also be controlled here, while the **Background color** picker sets the color of the page background.

When viewing a 2D plot, the *Inspector tools* shown in Fig. 16.4 will be present.

The **hand** tool may be used to pan in the plot.

The **point**, **polygon**, **disc**, and **rectangle** tools are used to create point extractions that extract data for a point or area, over time.

The **line** and **polyline** tools are used to draw lines for line extractions.

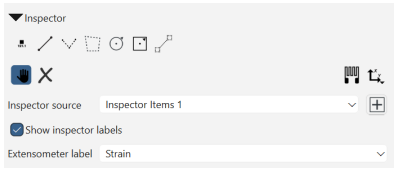

Figure 16.5: Inspector tools.

The **extensometer** tool creates a virtual extensometer for point-to-point measurement.

After any tool is used, the **Extract** button to the far right will process the data and produce an extraction plot.

If one or more extraction lines is present, the **Virtual Strain Gauge** tool will be enabled; clicking it starts the Virtual Strain Gauge analysis dialog.

16.6.2 Sequence Tab

The **Sequence** tab (Fig. 16.6) controls the display of sequence data.

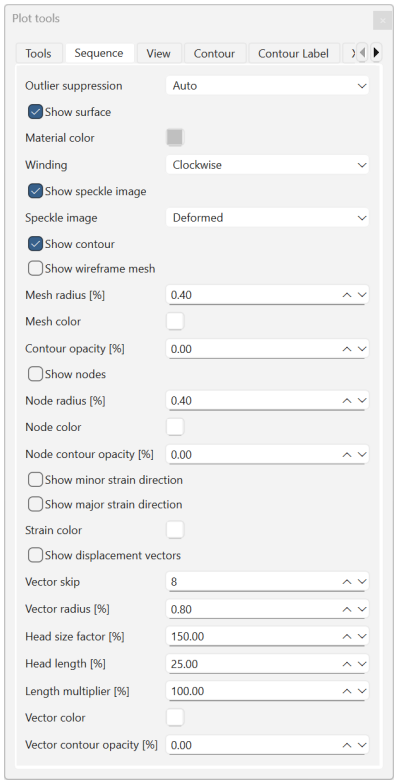

Figure 16.6: Sequence tab.

The **Outlier suppression** pulldown allows scaling to include or remove outliers; the *Auto* selection will use the full scale unless outliers are present.

Material color sets the base color for the surface plot. **Winding** determines the direction of the mesh winding, for shading.

The **Speckle image** may be toggled and the selected image and image brightness may be controlled.

If **Show contour** is checked the data will be overlaid on the surface; the opacity is adjustable as well.

Display of the material mesh can be toggled with **Show wireframe mesh**, and the color and radius of the mesh are adjustable.

The **Show nodes** control causes data nodes to be displayed; the color and radius of the nodes is also user-adjustable.

Minor and **major** strain direction vectors may be displayed, as well as **displacement** vectors. Various vector parameters may be adjusted here.

16.6.3 View Tab

The *View* tab (Fig. 16.7) is present for 3D plots and controls the appearance of the plot.

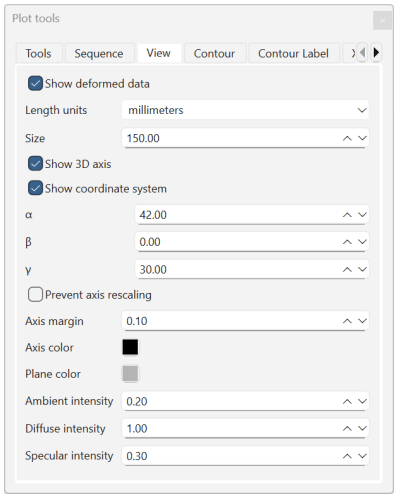

Figure 16.7: View tab.

If **Show Deformed Data** is checked the deformed state of the data set will be plotted; otherwise, the reference state of the data will be used.

A variety of **Length units** may be selected for plotting.

The **Size** controls sets the size of the displayed plot within the page.

The axis plane display may be toggled with the **Show coordinate system** check.

The exact angle of the view perspective (in degrees) is set with the alpha, beta, and gamma controls.

If **Prevent rescaling** is checked, the axis limits will *not* be automatically adjusted when the sequence is updated (e.g., by reprocessing the data).

Controls are also available to set the size of the **Axis margin**; to control the color of the axes and planes; and to adjust the lighting intensity for each source.

16.6.4 Contour Tab

The *Contour* tab (Fig. 16.8) controls the appearance of the contour overlay.

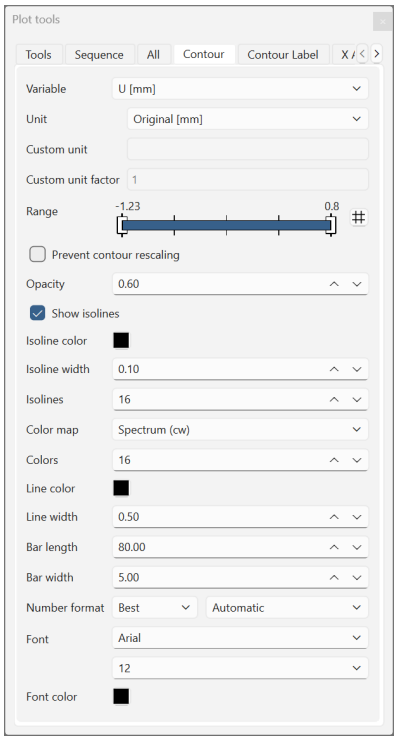

Figure 16.8: Contour tab.

The **Variable** and **Unit** (inches, mm, etc) may be selected here. If *Custom* is selected from the pulldown, a custom unit name and factor may be entered. The custom factor is in terms of the original unit [mm].

The **Range** bar has draggable controls for adjusting the contour limits; clicking the # button allows direct entry of the limits.

If **Prevent rescaling** is checked, the contour limits will *not* be automatically adjusted when the sequence is updated.

Controls are available for the opacity of the overlay as well as the color map choice and number of color levels to render.

> Custom color maps may be created in Global Preferences.

Controls are also available to toggle the display of isolines and set their thickness and color, as well as to set the appearance of the legend bar. The font and color of the text as well as the number format are set with the controls at bottom.

16.6.5 Contour Label Tab

The *Contour Label* tab (Fig. 16.9) controls the appearance of the contour bar caption adjacent to the contour bar. Font, style, alignment, and color may be set here.

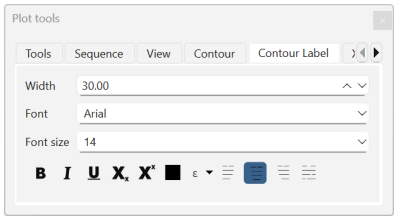

Figure 16.9: Contour Label tab.

16.6.6 Axis Tab

The *Axis* tab (Fig. 16.10) is present for each axis. The range and appearance of each axis is set in this tab.

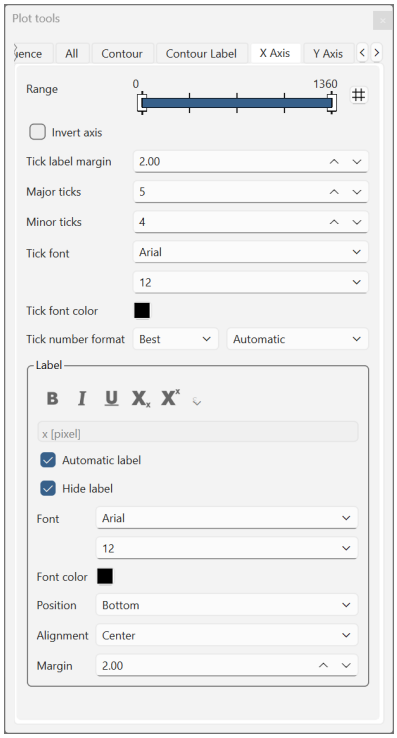

Figure 16.10: Axis tab.

The **Range** may be set with the range bars, or numerically by clicking #.

Controls are available for the number and labeling of the ticks; there are also controls for the font and style of the axis title. If the **Automatic label** checkbox is cleared, an editor appears and custom text may be entered.

If the **Attach to** pulldown is set to *Parent*, the indicator will move when the plot is repositioned. If the pulldown is set to *Page*, it will remain where it was placed when the plot is moved.

16.6.7 Scale Tab

The *Scale* tab (Fig. 16.11) appears when a 2D plot is selected. It controls the small linear scale display associated with the plot. If **Show scale** is checked, the inset display will be shown.

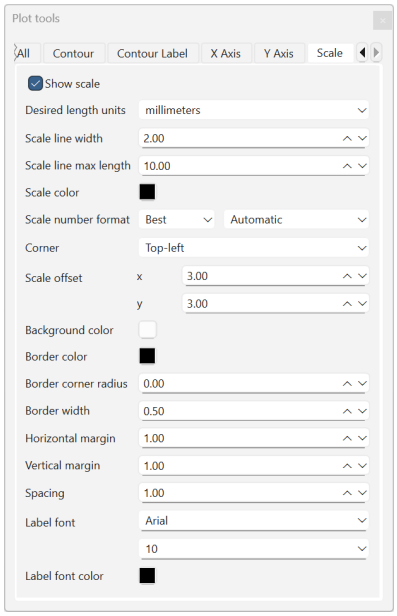

Figure 16.11: Scale tab.

The exact position and appearance may be set using these controls. If the **Border corner width** is above zero then the inset box will have rounded corners.

16.7 Exporting Videos

When right clicking in the 2D plot window and selecting *Export Video* the following dialog appears:

16.7.1 File

Click the icon to select a filename for saving.

16.7.2 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.

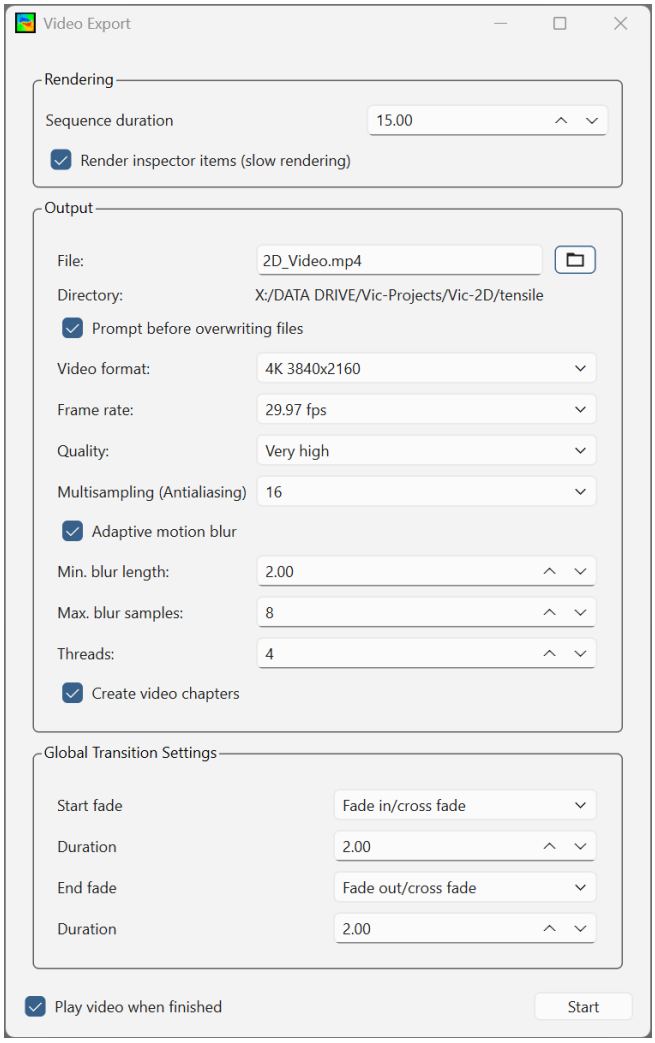

Figure 16.12: Video export dialog

16.7.3 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.

16.7.4 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.

16.8 The Virtual Strain Gauge Dialog

The Virtual Strain Gauge (VSG) Extraction dialog is used to help determine the optimum filter size for a given test. A range of VSG sizes may be quickly and visually compared to help determine the balance between strain filtering and spatial resolution.

The dialog may be opened by clicking the icon in the Inspector Tools. One or more line inspectors must be present to enable the tool.

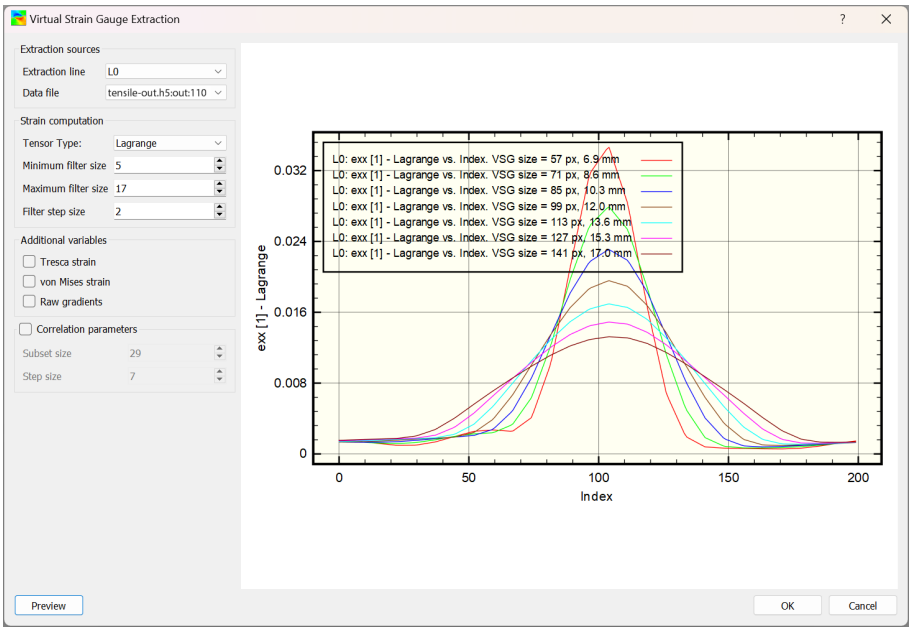

Figure 16.13: Virtual Strain Gauge dialog.

The VSG tool generates data extractions along an inspection line for a specific data file. The line may be chosen with the **Extraction line** pulldown at the top left, and the data file may be specified with the **Data file** pulldown.

The strain computation **tensor type** can be selected, as well as the minimum and maximum filter sizes. The **Filter step size** sets the increment between analyzed filter sizes for the waterfall plot. Additional strain variables (Tresca strain, von Mises strain, raw gradients) can also be incorporated into the extractions using the relevant checkboxes.

Some correlation parameters (**subset size** and **step size**) are shown and available to edit as well. These parameters are important for determining the final VSG size. For simple AOIs, the parameters shown by default will be the ones used in data analysis. However, when there is more than one AOI, or there are AOIs with different subset size and step size, the controls should be enabled and the values should be edited to match the parameters of the specific relevant AOI.

The extraction process generates a series of graphs for the chosen inspection line and file, with each graph corresponding to a filter size within the selected range, using the chosen step. A preview of the extracted data can be viewed by pressing the preview button. The user can select the displayed strain variable by right clicking on the preview plot and using the strain variable menu.

The legend on the plot displays the VSG size in pixels. If the average pixel magnification is available, it will also indicate the size in millimeters.

Analysis settings may be adjusted and the result viewed by clicking **Preview**. Once the settings are finalized, clicking **OK** will generate a plot and display it in the analysis workspace. The plot data may also be viewed in the *iris* workspace.

> The VSG plot may easily be duplicated in *iris* by using the **Multi...** tool in the line plot controls.

16.9 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. 16.14 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.

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

16.9.1 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. 16.15) and shown in the plot's legend (if configured, see Section 16.9.8). The X/Y data that is shown in the plot can be edited in the 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.

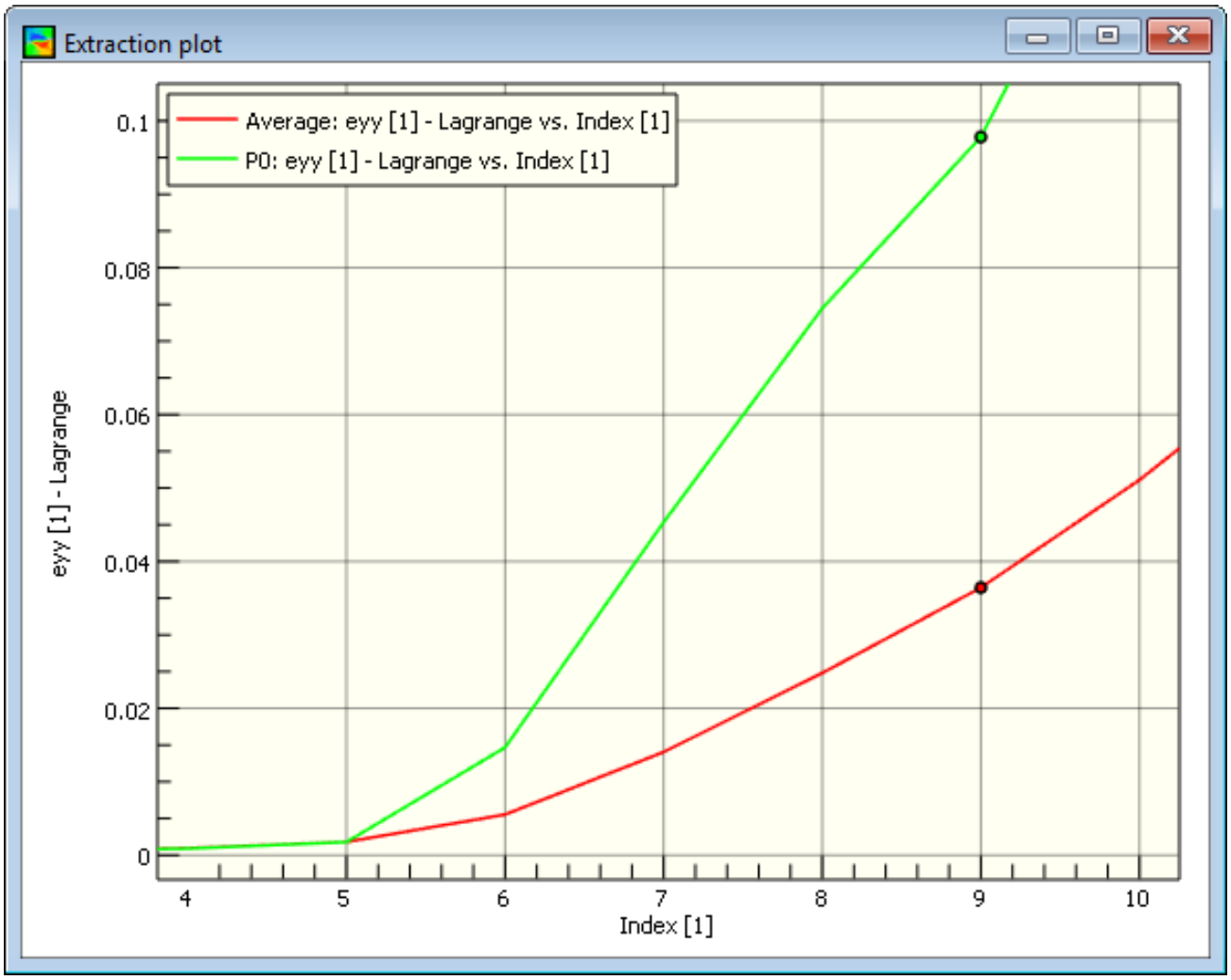

Figure 16.14: Extraction plot.

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.

16.9.2 The Extractions Menu

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.

16.9.3 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.

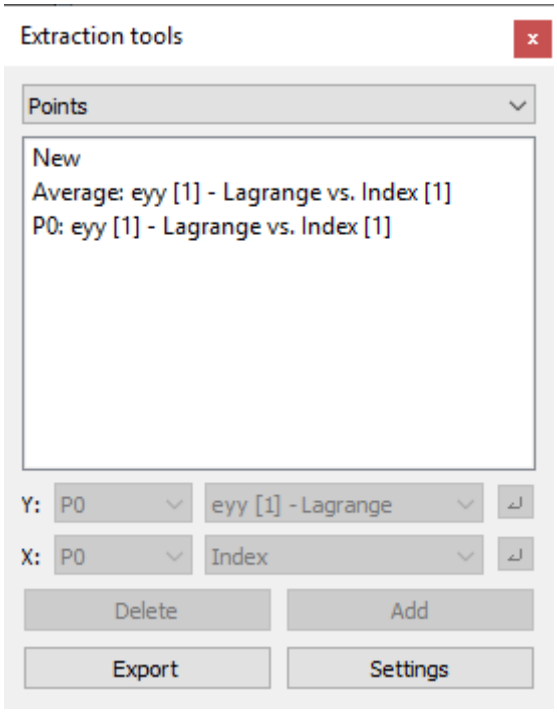

Figure 16.15: Extraction plot tool box.

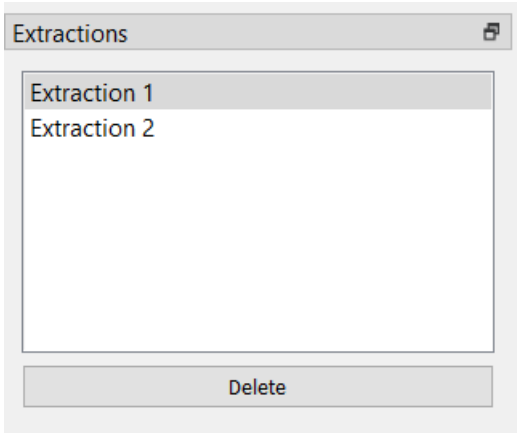

Figure 16.16: Extractions menu.

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.

16.9.4 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.

16.9.5 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. 16.15.

16.9.6 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 or polylines to a 2D contour plot. An example of a line slice inspector item is illustrated in Fig. 16.17.

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. 16.18.

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. 16.19. The number of lines that are shown in the plot can be configured in plot settings, see Section 16.9.8.

16.9.7 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. 16.20.

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. 16.21. 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.

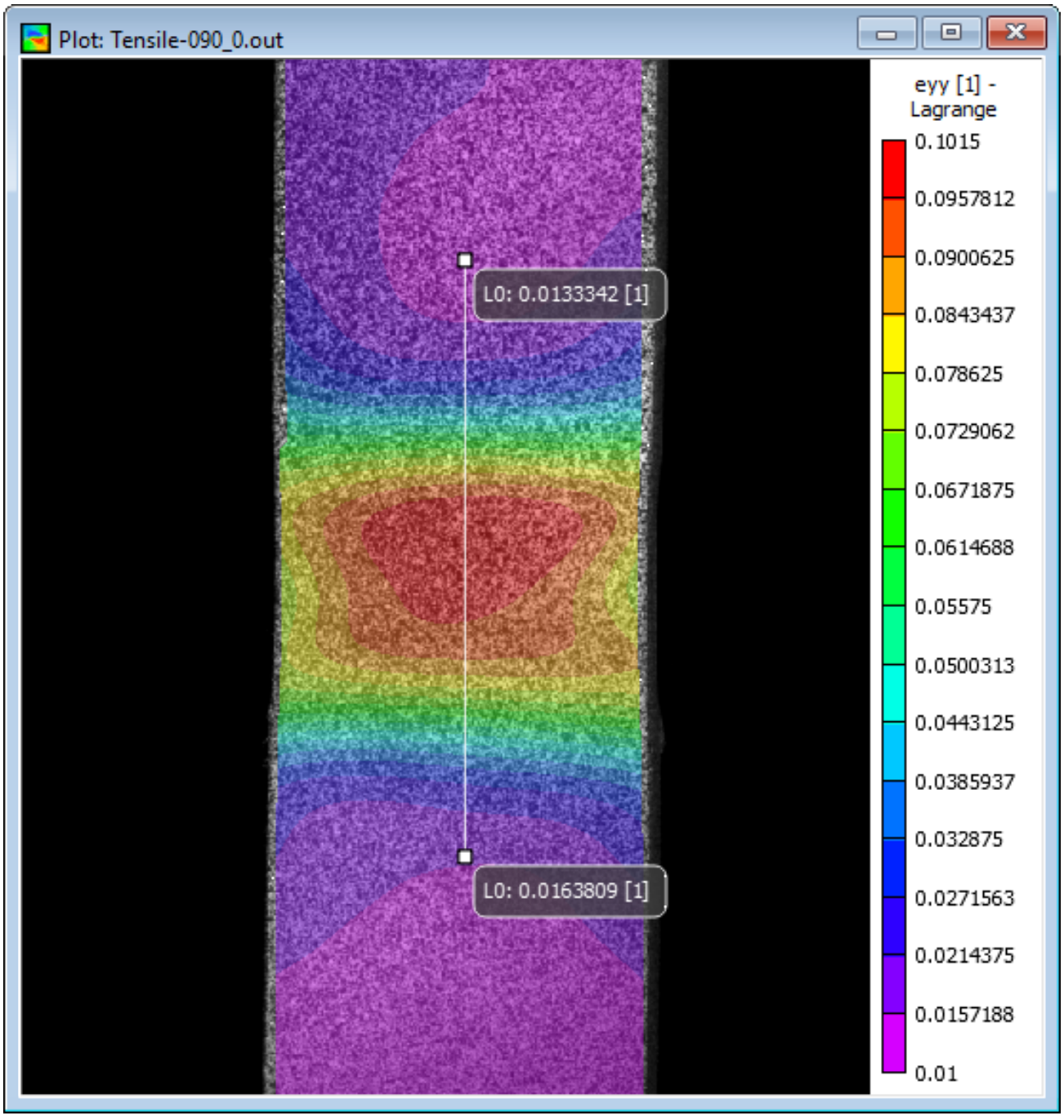

Figure 16.17: Line slice in contour plot.

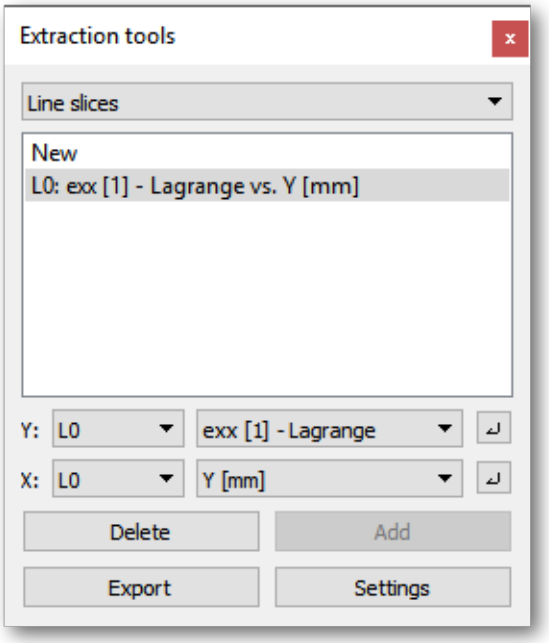

Figure 16.18: Extraction tool box for lines slices.

16.9.7.1 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. 16.22.

The available extensometer variables are:

- 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.

16.9.8 Plot Settings

The plot settings can be accessed from the context menu of the plot (see Section 16.9.4). This displays a dialog with different options to control the plots as illustrated in Fig. 16.23.

The first tab controls graph display settings.

- Graph style: select from lines, points, or both. If Points is selected, you can use the snap cursor to evaluate values at specific locations in the plot. With Lines selected, the snap cursor will give an interpolated value.

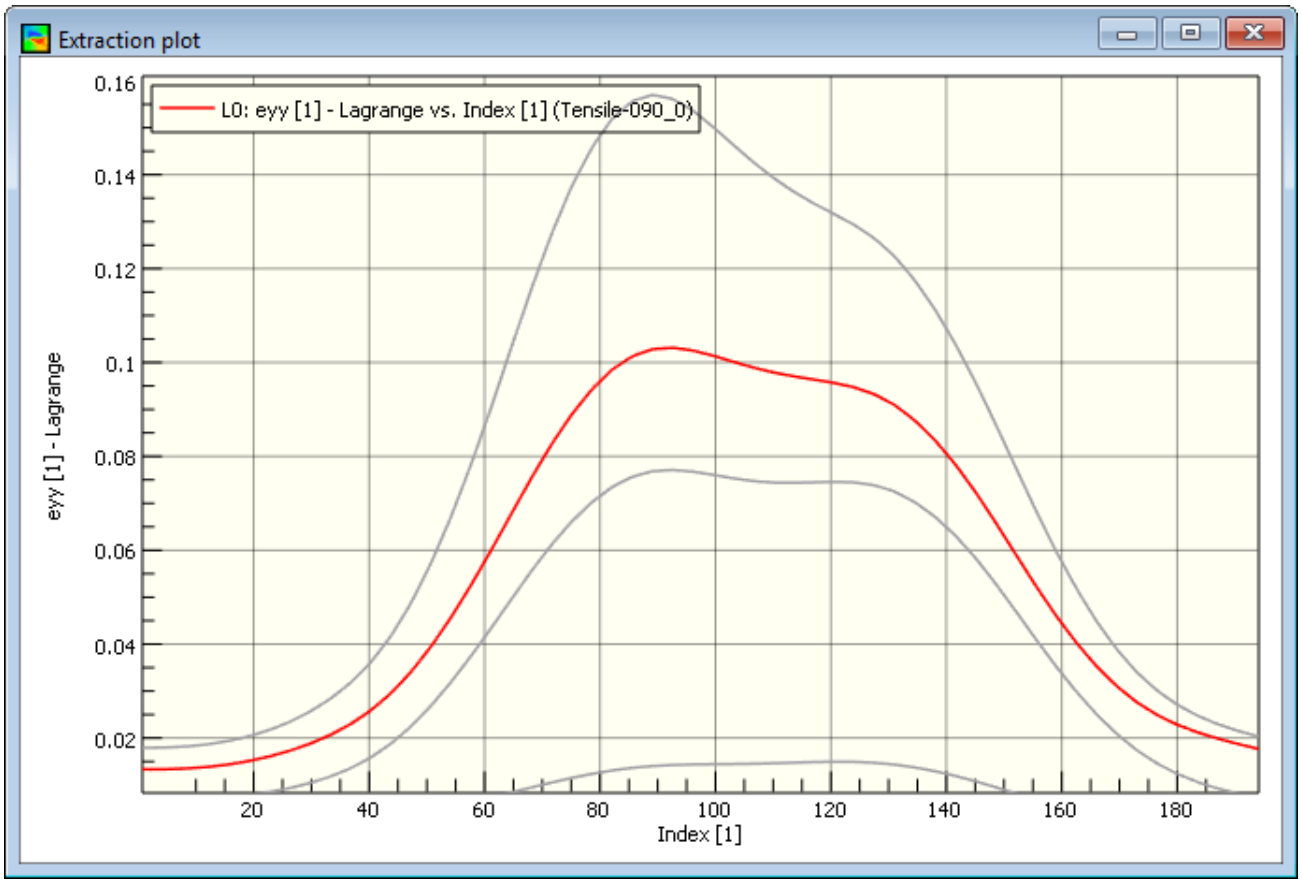

Figure 16.19: Line slice plot.

- 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.

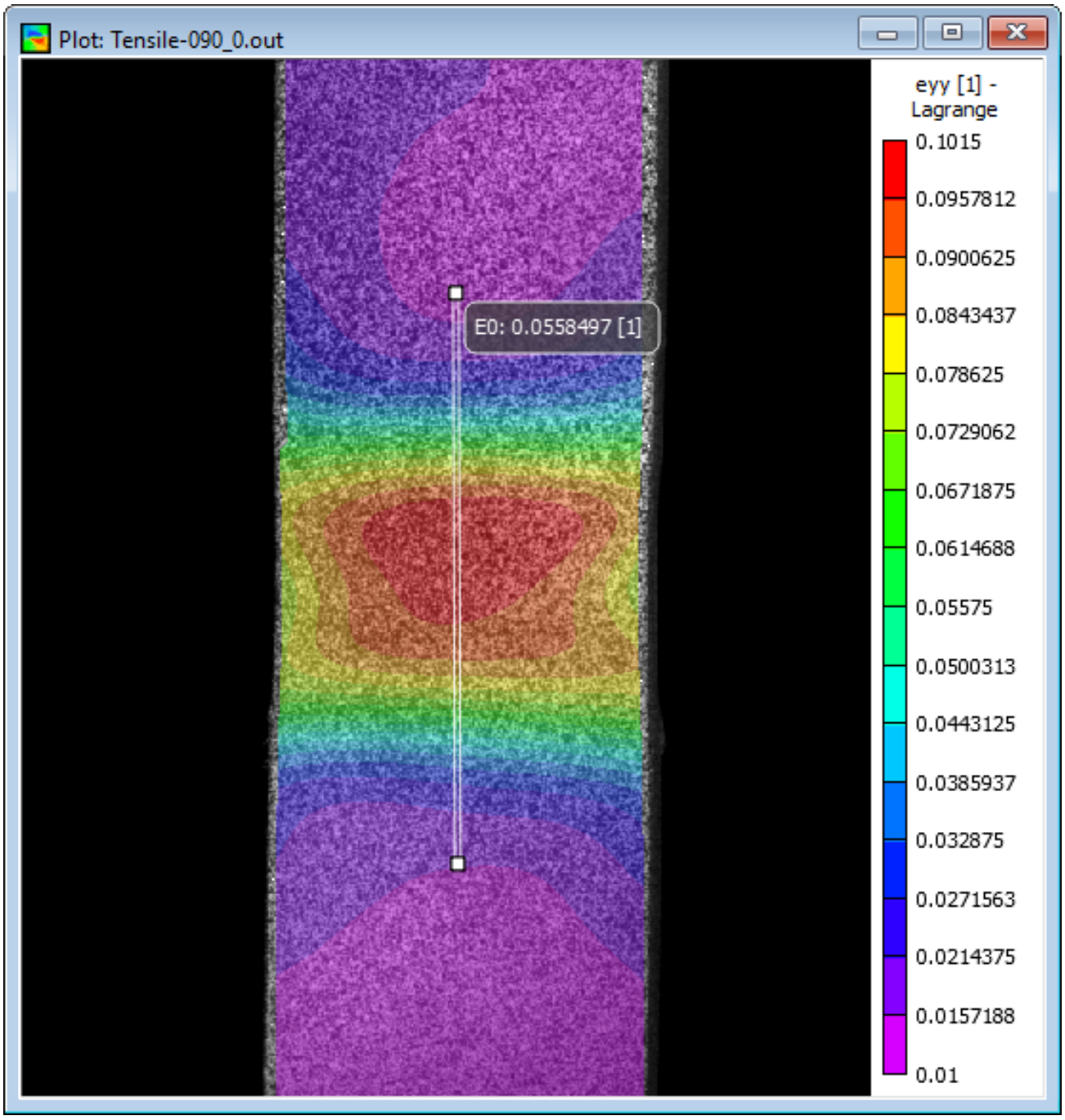

Figure 16.20: Extensometer in contour plot.

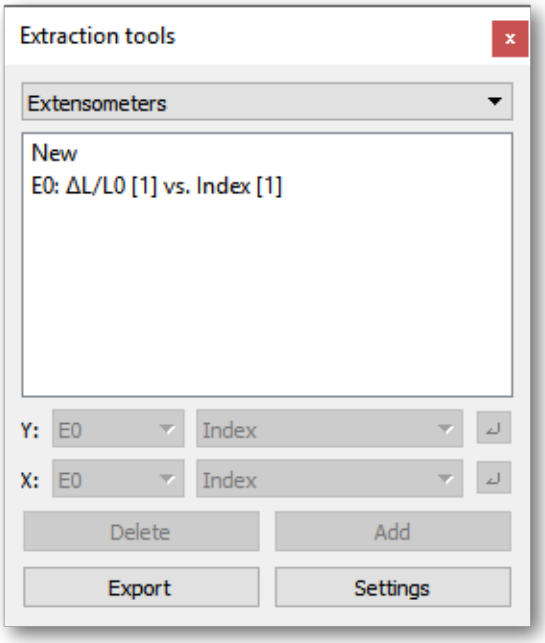

Figure 16.21: Extraction plot tool box for extensometers.

16.9.9 Exporting Slice Data

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

- 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.

16.10 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.

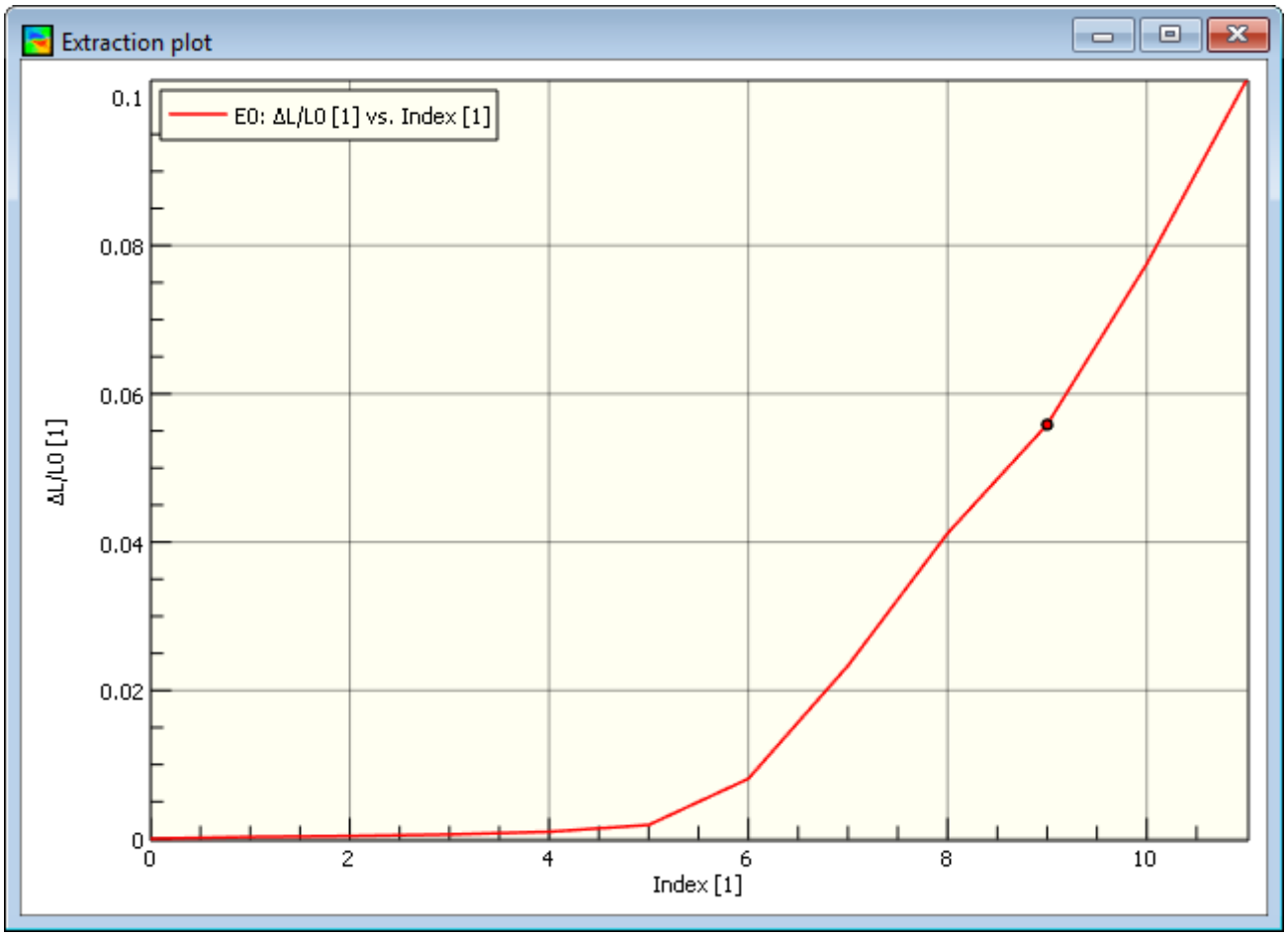

Figure 16.22: Extensometer extraction plot.

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

16.10.1 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 α, β and γ as follows:

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

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:

$$\mathbf{T} = \begin{Bmatrix} \bar{U} \\ \bar{V} \\ \bar{W} \end{Bmatrix} + \begin{Bmatrix} X_0 \\ Y_0 \\ Z_0 \end{Bmatrix} - \mathbf{R} \begin{Bmatrix} X_0 \\ Y_0 \\ Z_0 \end{Bmatrix}$$

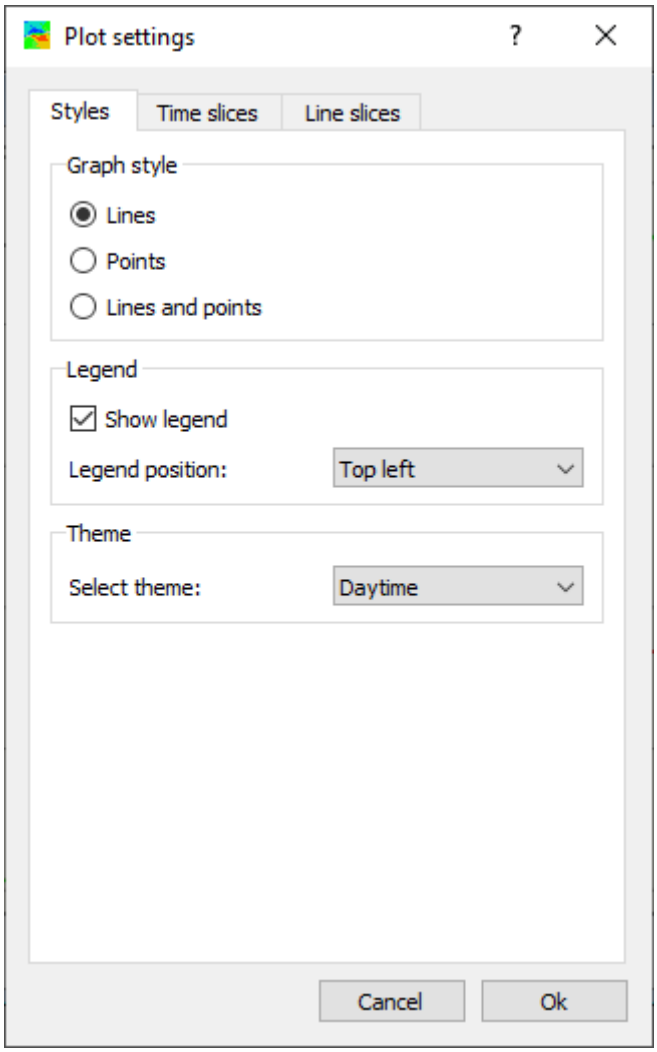

Figure 16.23: Plot settings style tab.

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 $(Z+W)$.

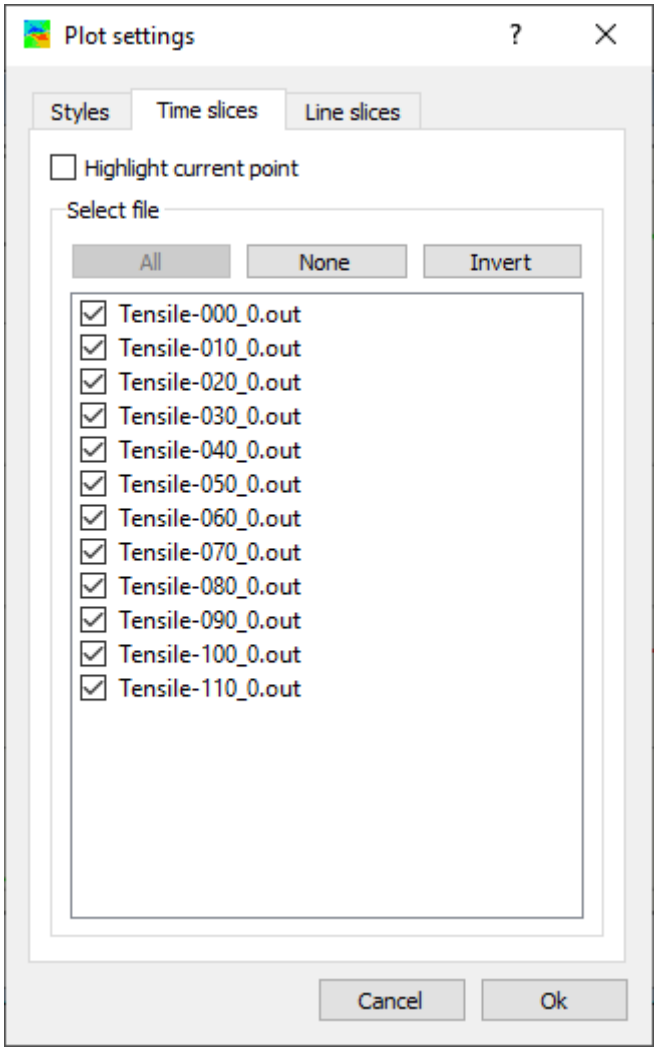

Figure 16.24: Plot settings time slice tab.

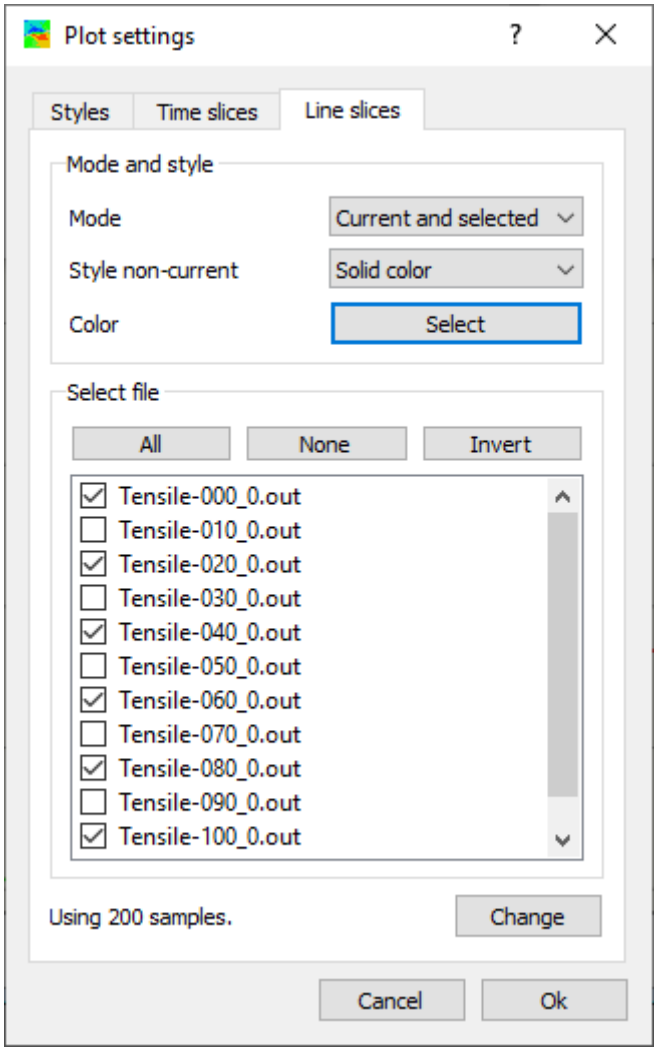

Figure 16.25: Plot settings line slice tab.

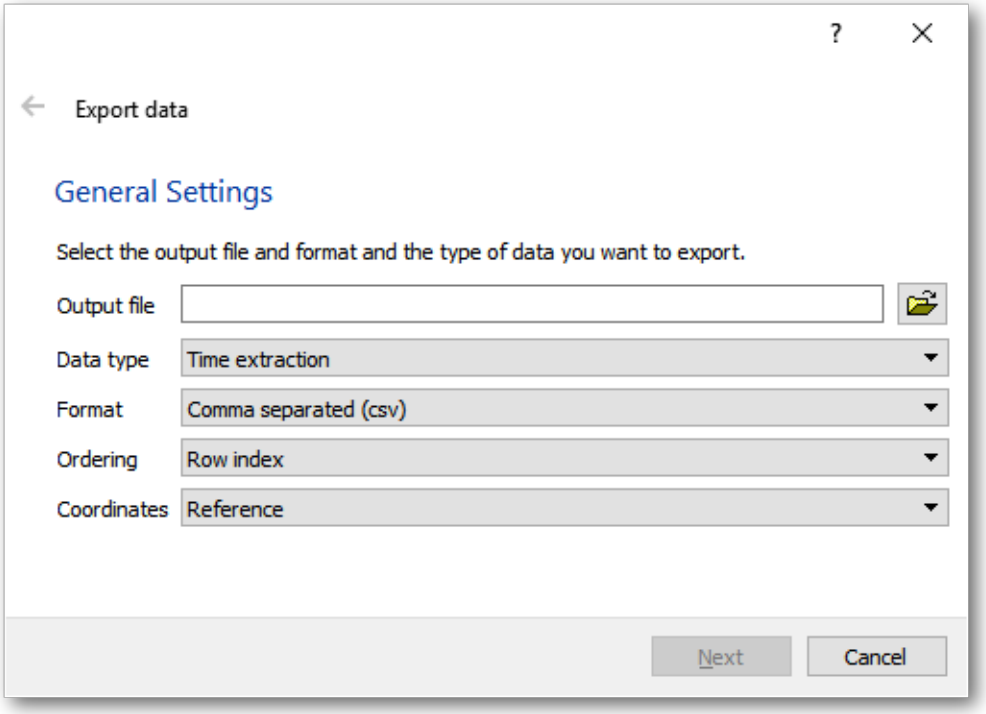

Figure 16.26: Extraction plot export wizard.

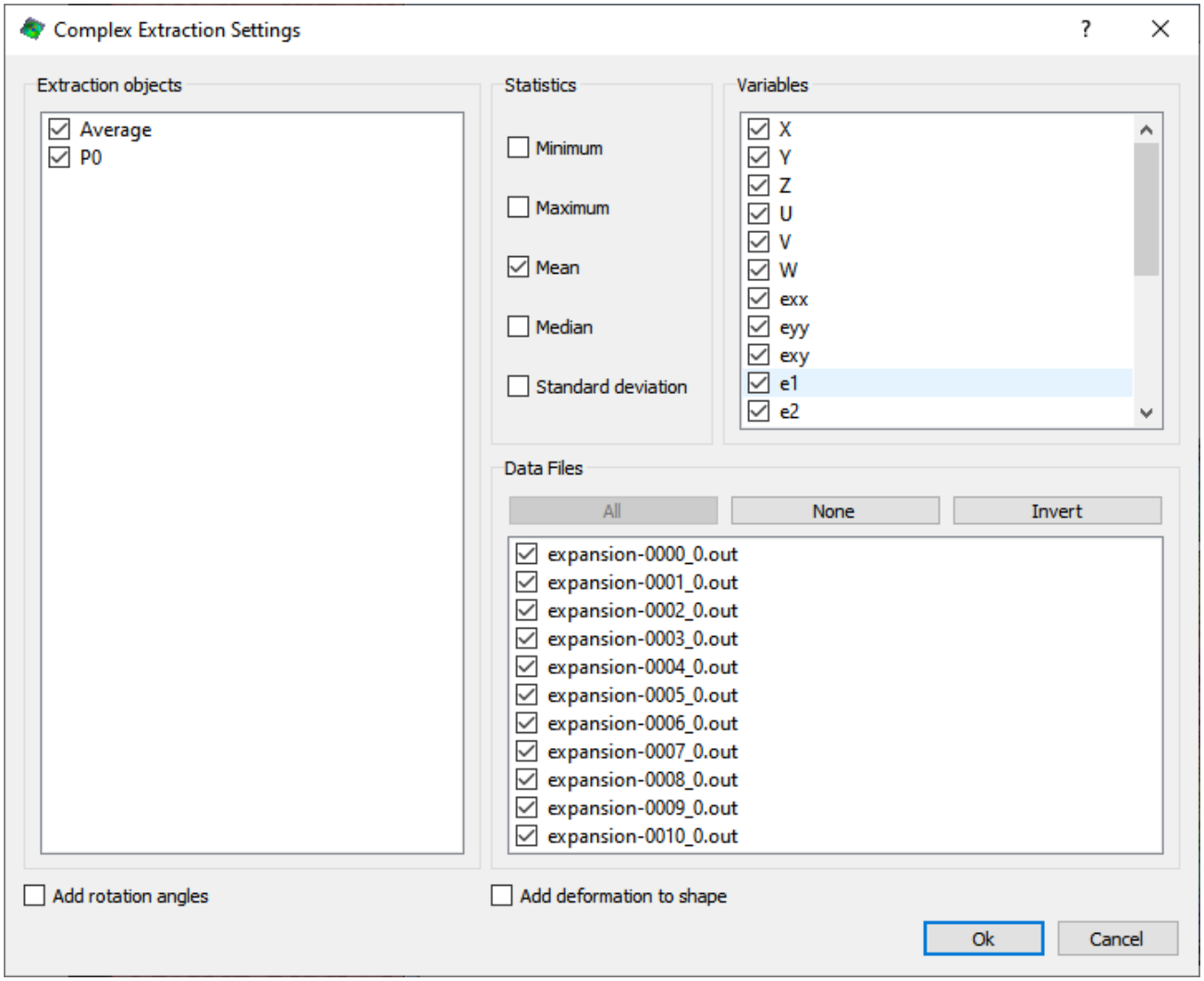

Figure 16.27: Complex extraction settings.

Chapter 17

FFT Analysis

VIC-2D incorporates a mode for transforming time-domain displacement and strain into the frequency domain. Using a known time step, the time-domain data is transformed to frequency-domain data for plotting and analysis. If input data is available, frequency response metrics may also be calculated.

The data can be analyzed using the FFT Dialog. After analysis, the data can be viewed, probed, and exported from the FFT Workspace.

17.1 FFT Analysis Dialog

Clicking *Data... Postprocessing tools... Frequency analysis* will open the Frequency Analysis dialog.

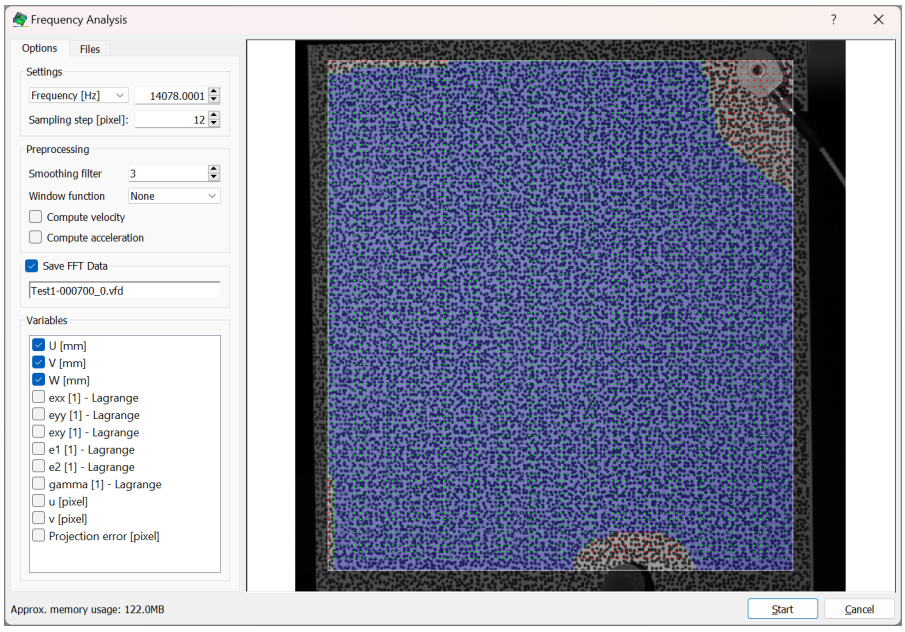

Figure 17.1: Frequency analysis dialog.

The available data set is displayed on the right. The default FFT analysis window is displayed as a box; the area may be redefined by clicking and dragging within the data plot. The mouse wheel is used to zoom; holding the `SHIFT` key will toggle pan mode.

17.1.1 The Settings Panel

- Overlaid on the data is a grid of analysis points. Each of the green points will be analyzed and converted to the frequency domain for later plotting; red points indicate areas where no data is present. The sample step may be adjusted with the **Sampling step** spin box; smaller sample steps will require more memory and slightly more analysis time.
- For the frequency to be calculated correctly, the correct image time step must be entered in the **Time step** spin box; this can be specified in terms of frequency by pulling down to **Frequency** [**Hz**].
- Data to be used for frequency analysis often involves very small displacements which may be difficult to resolve; because of this, a smoothing filter can be applied during the FFT analysis. The radius for the filter is set using the **Smoothing filter** spin box; a value of 1 applies no smoothing.

17.1.2 The Files tab

The **Files** tab contains selections for choosing a set of files to analyze as well as a list of analog values for frequency response function (FRF) calculation.

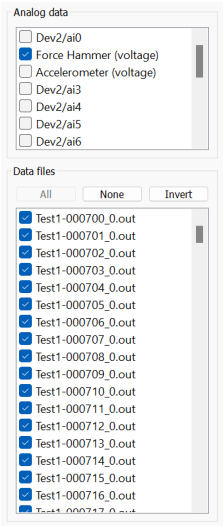

Figure 17.2: Files tab of Frequency analysis dialog.

- The relevant analog channel(s) to be used as an input for response calculation may be selected in the **Analog data** group. The data must be present in the project, and can be added by clicking *Project... Analog data* in the main menu.

- If one or more files are to be excluded they may be unchecked in the **Data files** group. This is standard VIC-3D file list and multiple items may be selected and toggled; a right-click in the list allows detailed selections.

> ⚠ When selecting files to analyze, there must be a consistent time step between every file and the next, or the FFT calculation will give incorrect results.

17.1.3 The Preprocessing Panel

- Optionally, a **window function** can be applied to the data. The Hann and Hamming window functions are supported.
- Velocities can be computed by checking the **compute velocity** check box. The velocities will be computed for the selected displacement variables.
- Similarly, checking **compute acceleration** will compute the accelerations for the selected displacement variables.

When the **Save FFT Data** box is checked (default), the FFT data will be saved to disk. A custom filename may also be specified. If this box is cleared, the analysis will need to be re-run to recreate the data again. When multiple different output files are created, they may be added to the project using the Sequence Manager.

Additional or fewer variables may be selected for extraction in the **Variables** list. Selecting more variables will use more memory.

When the settings are correct, clicking the **Start** button will start the analysis (this can be time consuming for large data sets). After the data has been processed, the frequency workspace will be displayed.

17.2 Frequency Workspace

FFT results are displayed in the dedicated Frequency workspace. The frequency workspace may be accessed by clicking the $\mathcal{F}$ icon in the main toolbar; if computed frequency data is not already present in the project, a prompt to open the FFT Analysis Dialog will appear.

The main part of the workspace shows contour and line plots of computed FFT data. Various key data can be selected by using Pages.

The FFT control toolbox is displayed at the side of the screen and may be used for controlling display and export of the data.

17.2.1 Working with plots

The initial display plots the FFT contour data to the left, and a line plot of amplitude vs. frequency to the right.

The FFT plot tools are always displayed in the tool area.

The top buttons allow animation control.

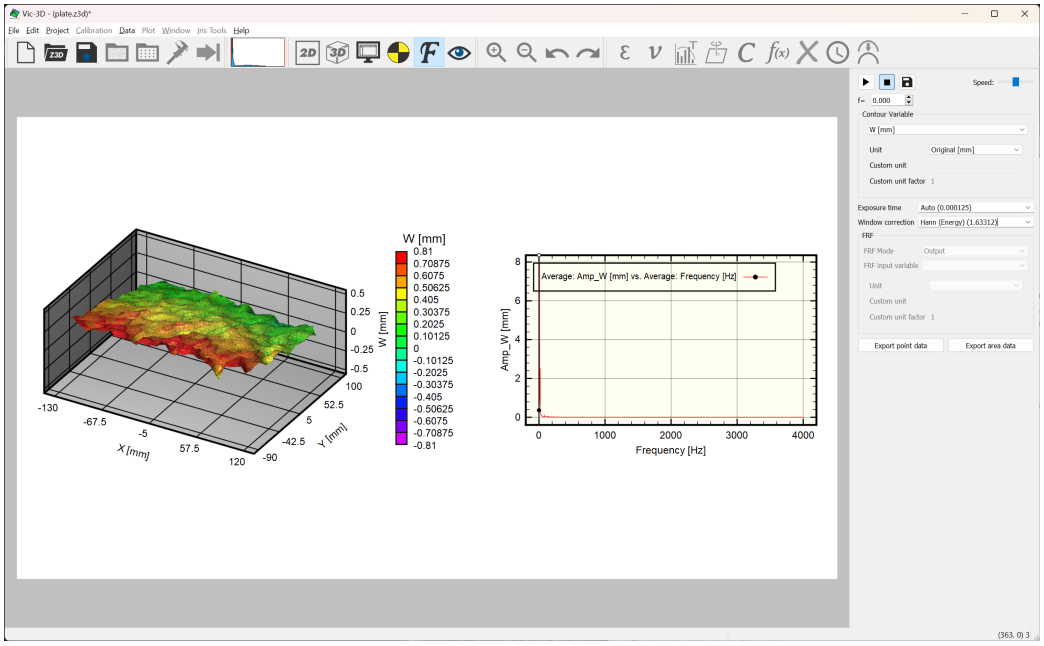

Figure 17.3: Frequency workspace.

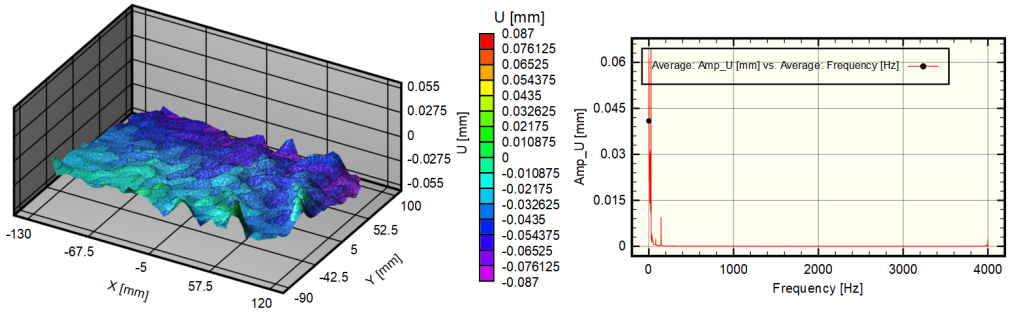

Figure 17.4: Frequency workspace.

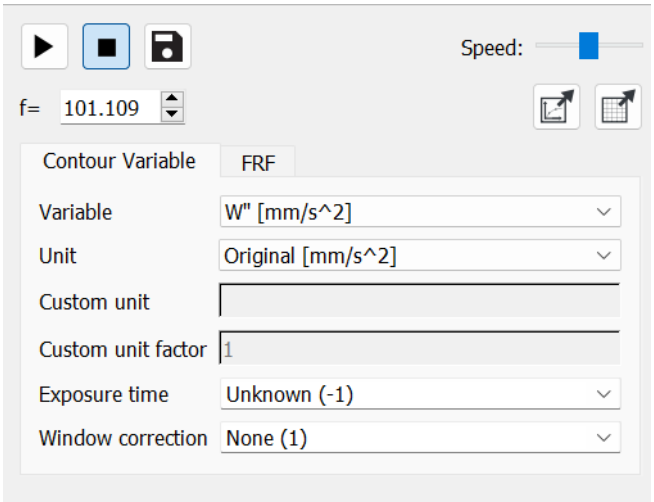

Figure 17.5: FFT toolbox.

- **Play** - start the phase animation.
- **Stop** - stop the phase animation.
- **Save** - export the phase animation as a video.
- **Speed** - control the looping speed.

The **f=** spin box controls the currently displayed frequency.

The button opens the Export Point Data dialog, allowing export of pointwise amplitude and phase data.

The button opens the Export Area Data dialog, which contains the controls for exporting area-based data.

The **Contour variable** area controls the currently displayed FFT component. Changing the variable here changes all of the displayed contour and line plots.

The **Unit** control allows the selection of a variety of units for length, velocity, acceleration, and strain. If the desired unit is not available, a **Custom unit** may be entered along with a **Custom unit factor**.

The **Exposure time** control sets the exposure time used for phase correction calculations. This value is taken from the analog data file for high speed cameras or TIFF metadata for low speed cameras, the newest versions of VIC-Snap 10 automatically handle this. Analog data files from older versions of VIC-Snap may require manually updating the analog data file.

The **Window correction** control chooses the correction factor for the currently applied FFT windowing function, if any.

17.2.1.1 The FRF tab

Where analog impulse data has been included from the FFT Analysis Dialog, the **FRF** tab will be selectable.

- The **FRF Mode** may be selected from Output, Output over input, or Input over output.

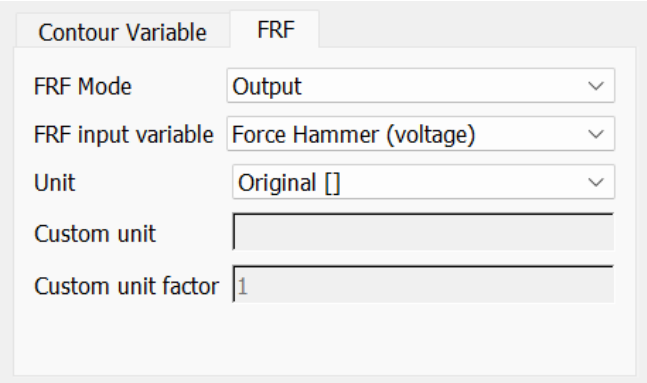

Figure 17.6: FFT toolbox.

- The **FRF input variable** may be selected from among the variables included during analysis.
- The **Unit** control may be usd to select a custom unit for the input. The name of the **Custom unit** and the multiplying **Custom unit factor** may be entered directly below.

17.2.1.2 Phase animations

Displacement amplitudes may be animated to display deflection shapes in an intuitive visual manner. Clicking the **Play** button will start a looping animation of the deflection shape for the current frequency. To change the current frequency, the **f=** tool in the FFT plot tools may be used; alternately, if the amplitude vs. frequency line plot is selected, the small square at the top of the current frequency line may be dragged to visually locate frequencies of interest.

17.2.2 Plotting tools in the FFT workspace

For 2D or 3D plots in the FFT workspace, a full set of adjustments is available in the tool area. For the most part, the plot tools duplicate the ones found in the 2D or 3D plot toolbox, with certain additions.

- **Mode** - this control allows selection of the component to be plotted. *Amplitude* displays the calculated amplitude for the current frequency, and *Phase* displays the calculated phase at the current frequency. *Modulated amplitude* plots the amplitude as an animatable modulated value which will change then the **Play** button is clicked in the FFT toolbox
- **Z-axis** - in FFT plots, the Z-axis may be replaced with the out-of-plane displacement by selecting *W*, or by the currently selected contour variable by selecting *Contour*.

  Selecting *Shape* plots the standard deformed shape.
- **Count** - this control specifies the number of full-phase (360°) cycles plotted with each animation.
- **X/Y/Z multiplier** - for ease of visualization, the displacement in each axis will be multiplied by this factor, exaggerating (or attenuating) the motion.

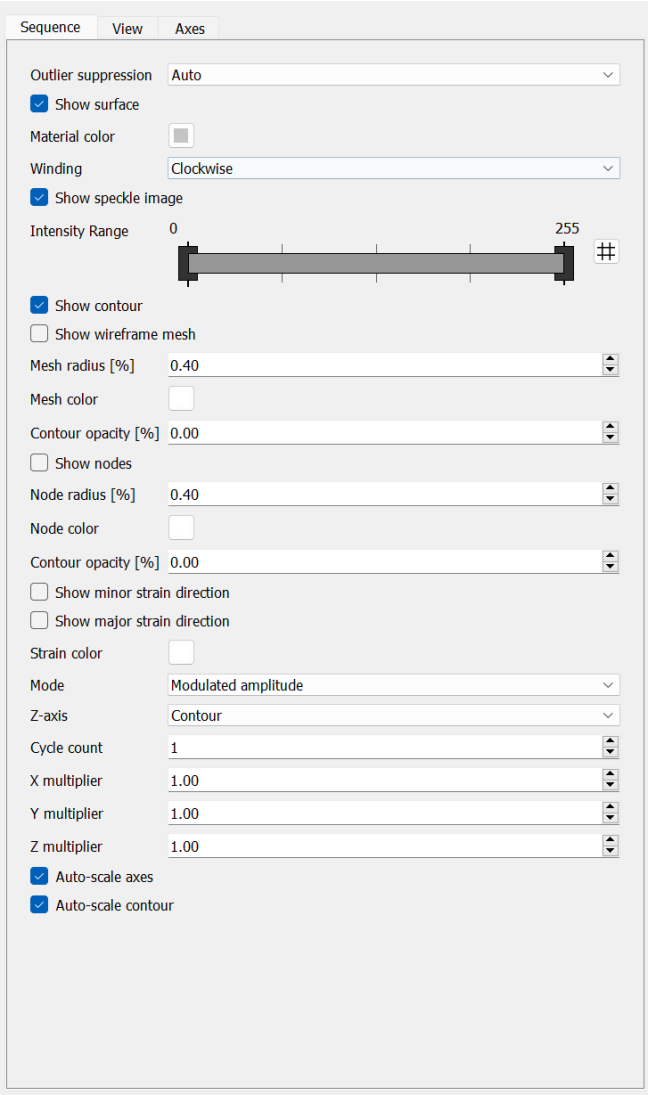

Figure 17.7: FFT toolbox.

For 2D plots, a **Tools** tab is added. The tools are, in order:

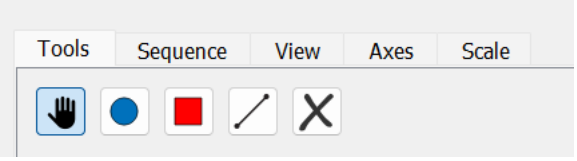

Figure 17.8: 2D FFT plot tools.

- **Hand tool** - allows panning of the image.
- **Add point** - add a point for extraction plotting and exporting.
- **Reference point** - set a point as the zero degree phase reference.

- **Add line slice** - draw a line slice for slice plotting.
- **Delete point** - delete an existing point, reference point, or line slice.

17.2.3 Probing individual points

The amplitude vs. frequency and phase vs. frequency plots for a given *point* may be viewed by clicking the **add point** button ( ) in the FFT tools, and then clicking in the plot. Additional lines will appear on any line plots that are present.

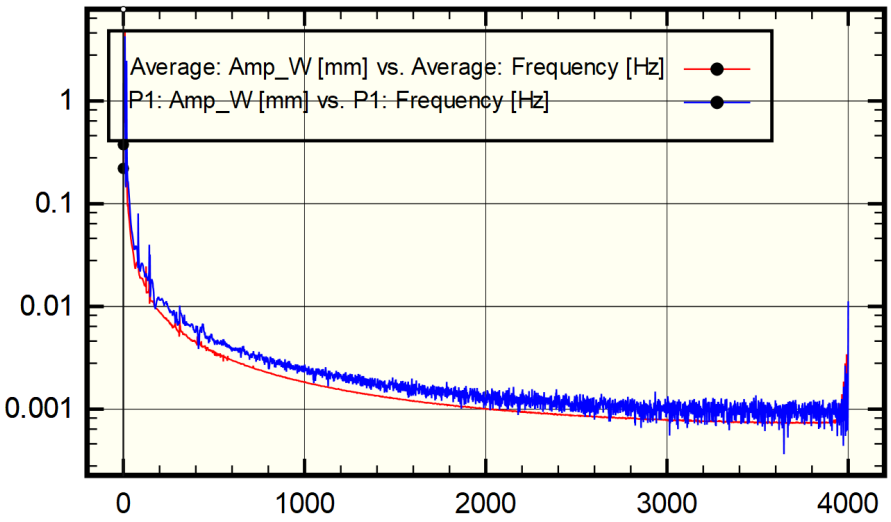

Figure 17.9: Selecting line slices for plotting.

Probe points can be removed by clicking the ✕ button in the FFT tools, and then clicking on the point.

A reference point (which will become the point where phase=0) may be specified by clicking the ■ button, and then on the reference point. The extract lines in the phase plot at the lower right will re-reference to this point.

17.2.4 Probing line slices

Amplitude vs. frequency and phase vs. frequency plots for a given *line* may be plotted by clicking the **add line** button ( ) in the FFT tools. The line is drawn by clicking the start and endpoint in the plot.

Right-clicking in the document and choosing *Show line slices* will switch the view to the lines slice data.

Probe lines can be removed by clicking the ✕ button in the FFT tools, and then clicking on either endpoint.

17.2.4.1 Line plots in the FFT workspace

Line plots such as the frequency vs. amplitude plot may be selected by double-clicking. The plot boundary will turn into a dotted red line to indicate the selection.

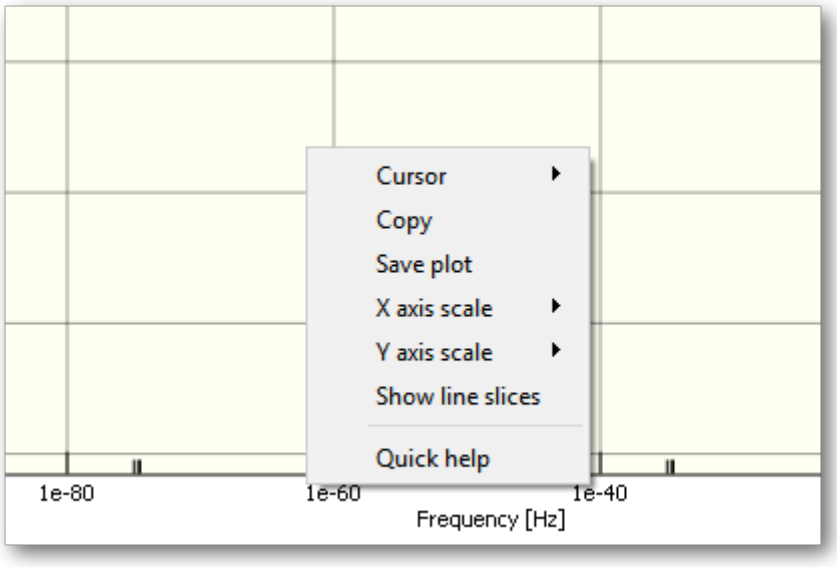

Figure 17.10: Selecting line slices for plotting.

When a plot is selected, the mouse may be used to drag the plot, and the mouse wheel will zoom. Right-clicking in the plot allows changing plot settings and exporting. Detailed plot settings are available in the tool area; each control here is describe in more detail in the line plots section.

In many situations a logarithmic axis scale will be most useful for locating interesting frequencies. Axis scales may be selected by right-clicking in the plot and choosing *X axis scale* or *Y axis scale*.

17.2.5 Working with pages

Various functional displays may be selected by right-clicking in the document and choosing the **Pages** submenu.

Each page contains a different combination of 2D and 3D plots of phase and amplitude along with line plots of phase or amplitude vs. frequency.

17.2.6 Exporting data

Computed FFT data may be exported either as extracted point data or as array area data.

17.2.6.1 Exporting point data

Point and average FFT data is exported by clicking **Export point data** in the tool area. The Export FFT Data dialog will appear.

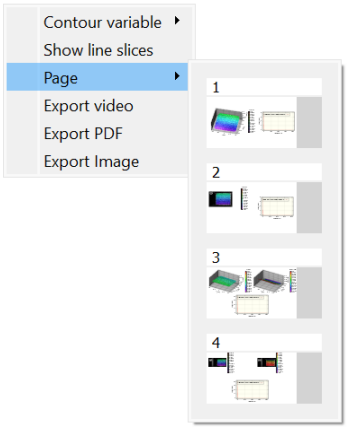

Figure 17.11: Context menu for pages.

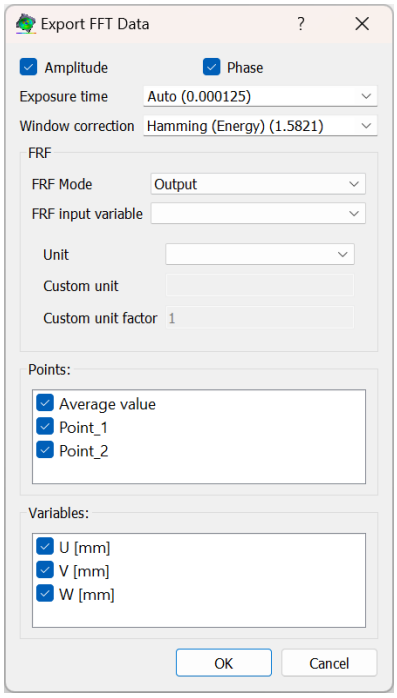

Figure 17.12: Exporting point data.

Amplitude, phase, or both may be selected for export. Exposure time and window correction may also be applied at this time.

If inspection points have been added, they will be available in the *points* selection box; otherwise, only the average will be given. Relevant variables may also be selected or cleared from the *variables* box. Clicking **OK** allows selection of an output file name and completion of the export.

17.2.6.2 Exporting area data

Area data may be exported as a UFF (Universal File Format) file by clicking **Export area data** in the tool area.

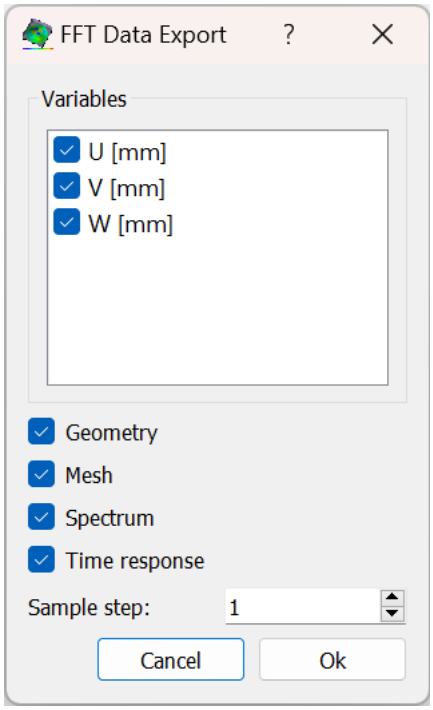

Figure 17.13: Exporting point data.

The desired variables for export can be selected in the Variables list box. The following UFF data set types are supported for export:

- Geometry (data set 2411) exports the 3D location of nodes.
- Mesh (data set 2412) exports thin shell triangular elements (ID 91) for the data set. Note that there might be nodes that do not belong to triangles, particularly for larger sampling steps (see below).
- Spectrum (data set 58) exports the spectrum for each node. & Time response (data set 58) exports the time response for each node. Note that any spatial filtering and windowing applied during FFT computation is reflected in this data.

In addition, a header (data set 151) is always exported with the data. The dialog offers the option to skip data points through increasing the Sample step in order to reduce file size. Note that the node IDs remain the same if this option is used.

Chapter 18

Data Visualization in *iris*

The *iris* visualization workspace provides a specialized set of tools for generating both static and animated plots of DIC and imported data (e.g., FE meshes), along with graphics, image sequences, and text elements. 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
- An updated set of presentation templates for different formats each of which includes a range of DIC-specific layouts for efficient production of professional reports.

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

- **Overview of the iris Workspace**
- **Pages, Layouts, and Backgrounds**
- **Working with Templates**
- **Graphic Elements**
- **Working with Sequences**
- **Working with Keyframes**
- **Document Properties**
- **Exporting iris Content**

18.1 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. 18.1.

The *iris* workspace contains:

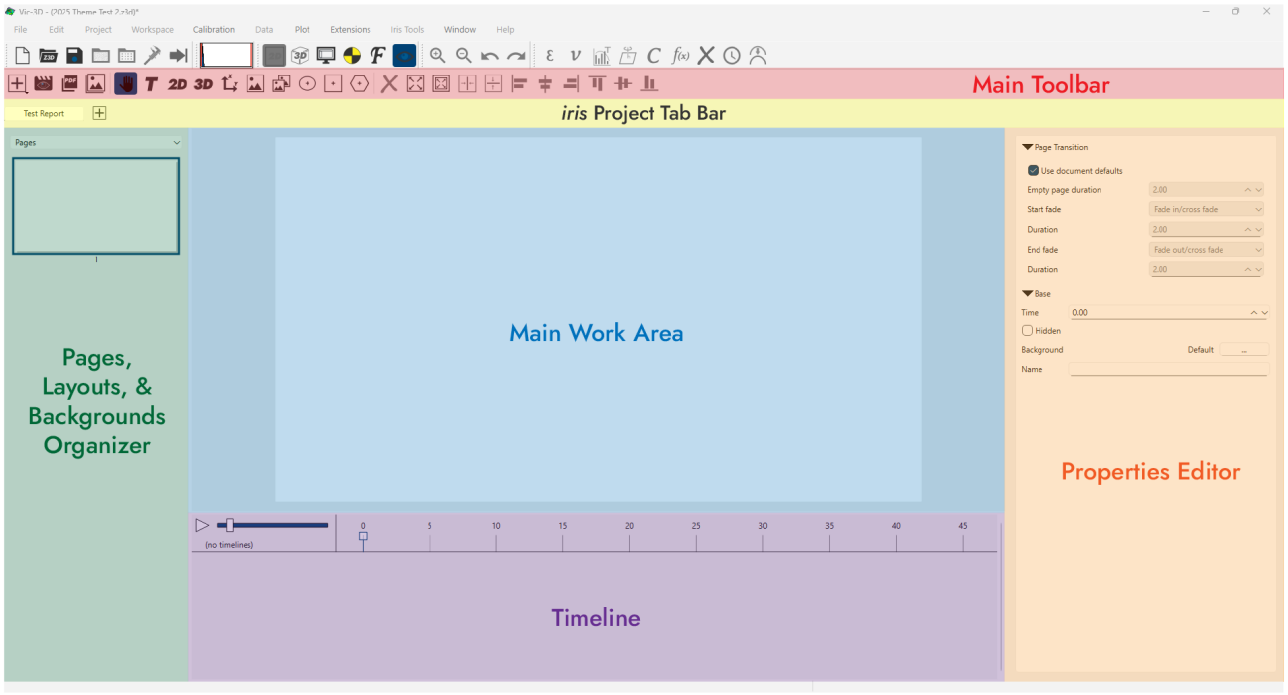

Figure 18.1: Overview of main window.

- **Main toolbar** - has controls for inserting new objects like plots and images; alignment controls; and buttons for exporting PDF and video.
- **Pages/Layouts/Backgrounds organizer** - the left sidebar shows a graphical list of pages, layouts, 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.
- ***iris* project tab bar** - keep multiple *iris* projects open simultaneously and switch between projects using tabs

18.1.1 Editor Context Menu

Right-clicking inside the *iris* Main Work Area allows for quick adjustment of view, inserting of plot elements, object alignment, and exporting. The context menu is shown in Fig. 18.2.

- **Fit to Page** - Fits the page size to fill the screen
- **Fit to content** - Fits all of the elements in your workspace to fill the screen
- **Clipping** - Allows for isolation and emphasis on particular parts of objects
- **Insert** - Conveniently adds new objects to the current page
- **Align** - Conveniently arranges objects to the page or relative to each other
- **Export video** - Opens the video export dialog

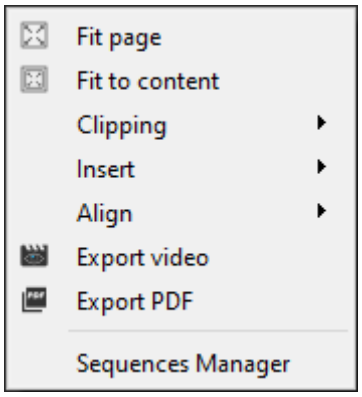

Figure 18.2: Detail of Context menu.

- **Export PDF** - Opens the PDF export dialog
- **Export image** - Opens the PDF export dialog
- **Sequence Manager** - Opens the sequence manager dialog

18.1.1.1 Clipping Submenu

Using the ellipse or rectangle drawing tool, easily clip any iris object 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.

18.1.1.2 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. 18.3.

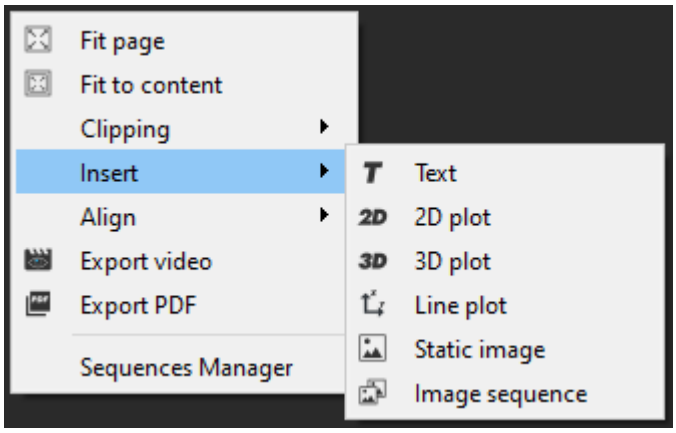

Figure 18.3: Detail of Insert submenu.

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

18.1.1.3 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. 18.4.

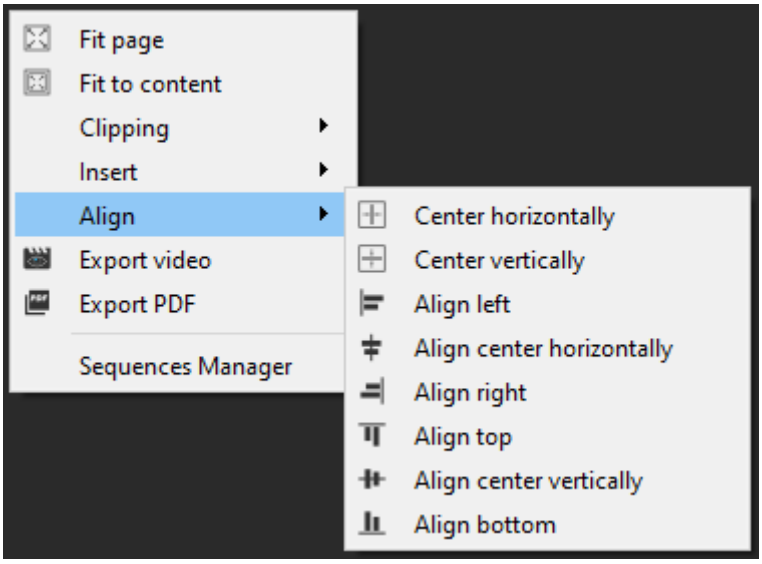

Figure 18.4: Detail of Align submenu.

- **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

18.1.2 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
- **I**: Opens the *Export Image* 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.

18.2 Pages, Layouts and Backgrounds

The central elements of *iris* documents are **pages**, **layouts**, 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.

18.2.1 Pages

At the most basic level, objects can be added to a **Page**, edited in the Properties Window and exported for presentation. All *iris* projects consist of one or more pages. Pages use background and layout slides as building blocks to build the final, exportable presentation. Each page contains an independent set of elements and a timeline. Through the use of multiple pages and a keyframe-based timeline, objects like plots and images can be animated.

To add, edit, and remove pages, right-click on the page in the page navigator to bring up the context menu seen in Fig. 18.5. 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 layout by selecting **Insert layout**.

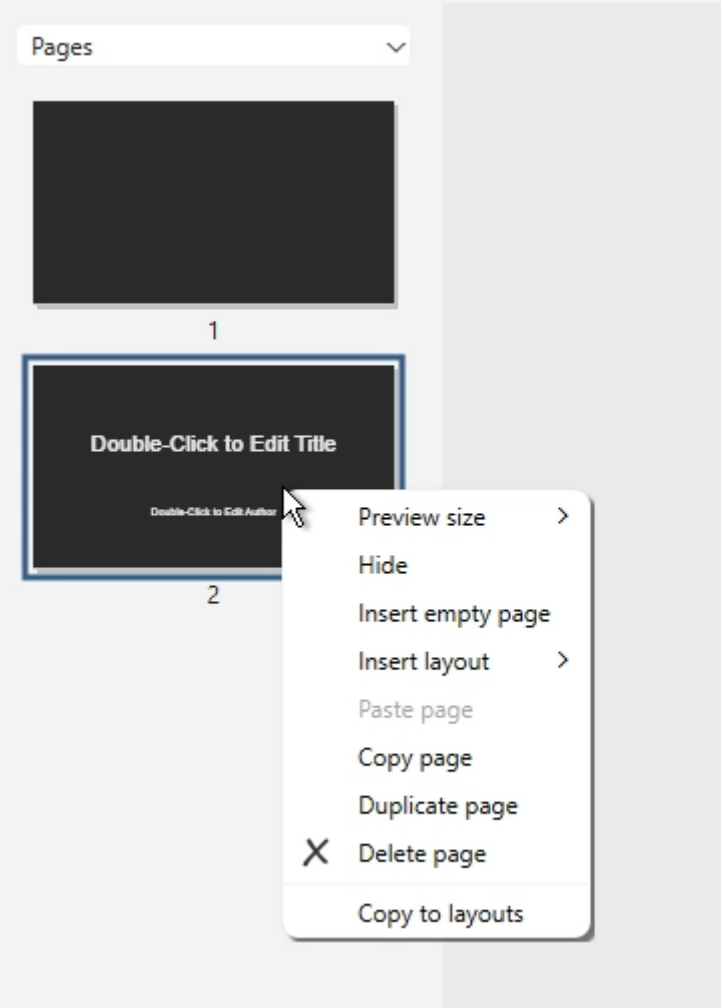

Figure 18.5: Pages context menu.

- 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 **Layout** or **Background**.

18.2.1.1 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.

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.

18.2.2 Layouts

In each pre-installed template, there are a range of layout slides with common DIC-specific arrangements of plots and other objects. Layout slides can also be built from scratch or added from different *iris* projects. Right-click on the page in the layout menu to bring up the context menu seen in Fig. 18.6.

Figure 18.6: Template context menu.

Layouts are used to simplify reproduction of DIC data in subsequent tests with similar results. Quickly add layouts to the **Pages** tab by right-clicking or using the button in the Main Tool bar.

18.2.3 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. 18.7.

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**.

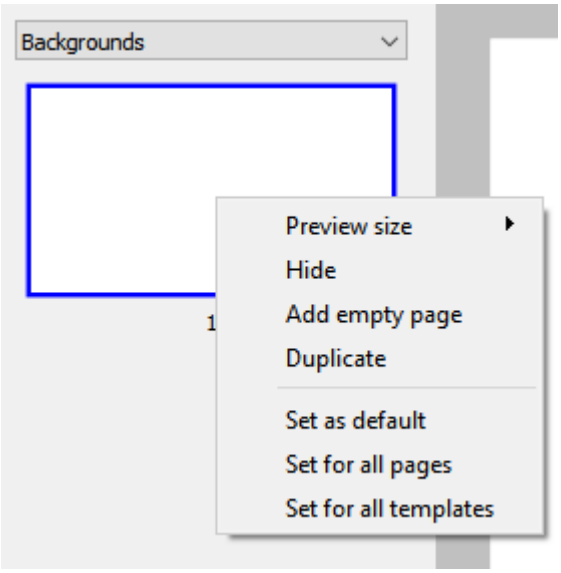

Figure 18.7: Background context menu.

18.2.4 Working with Templates

18.2.4.1 Using Pre-Installed Templates

Templates in *iris* are used to enable easy reuse of *iris* projects for new data set. These pre-installed collections of layout and background slides can be deployed as-is with little editing, or they can be comprehensively edited to match corporate or institutional branding.

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. 18.8.

User template documents are stored in a subfolder of the user's Documents folder; both built-in templates and all user-created 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.

To use one of the pre-installed **Templates**, populate the **Pages** navigator at left by right-clicking to bring up the pages context menu shown in Fig. 18.9.

Start with an empty page (which will use the default background design) or select **Insert layout** which displays a submenu of available layouts shown in Fig. 18.10.

Clicking a layout 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.

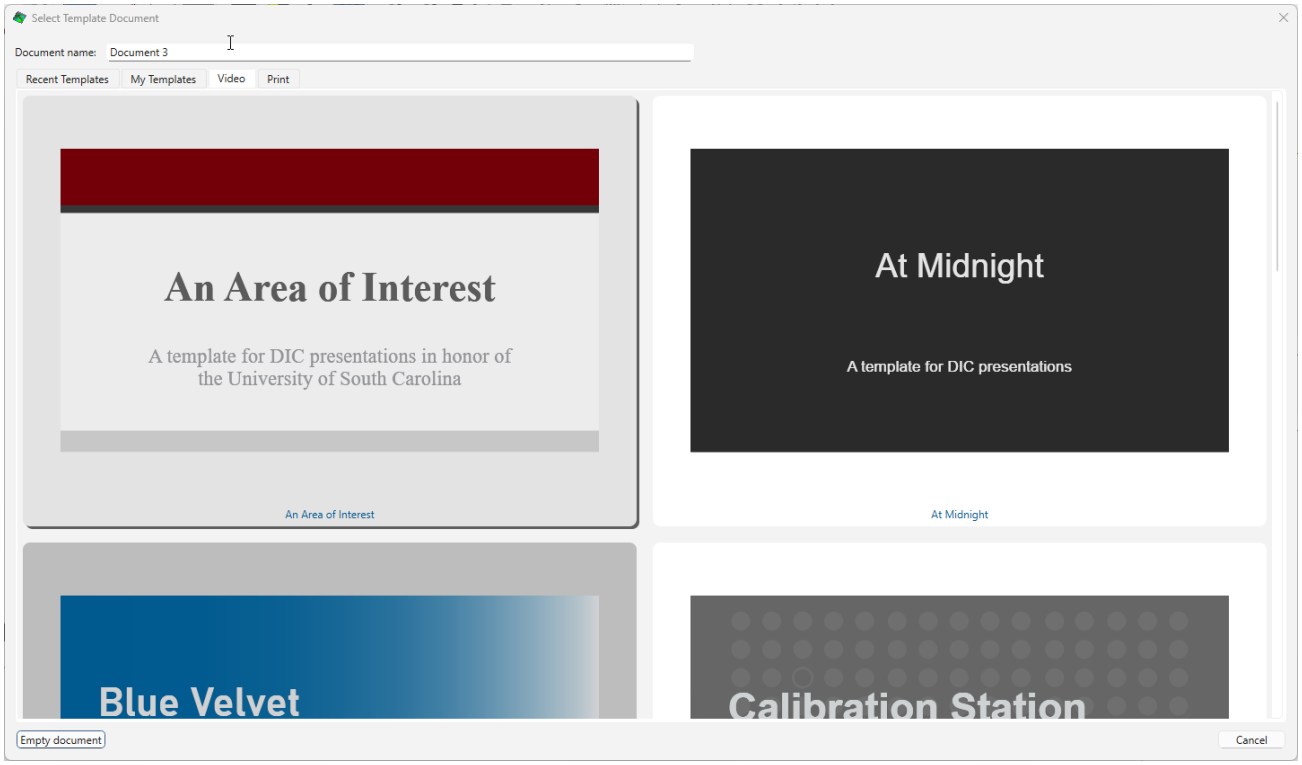

Figure 18.8: Template chooser.

Multiple layout slides may be inserted by holding the ⊞ icon in the toolbar, this selection is shown in Fig. 18.11.

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

18.2.4.2 Creating New Templates

A new **Template** can be created in two ways: editing an existing template or starting with an "Empty Document" from the Template Chooser.

may be created by right-clicking in the Layouts navigator, shown in Fig. 18.12.

The template may be given a descriptive name using the **Name** field in the **Base** tools, shown in Fig. 18.13.

Editing layouts is functionally identical to editing pages in most cases. For text boxes, the toolbar will contain a **Use as layout** checkbox which can be seen in Fig. 18.14.

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".

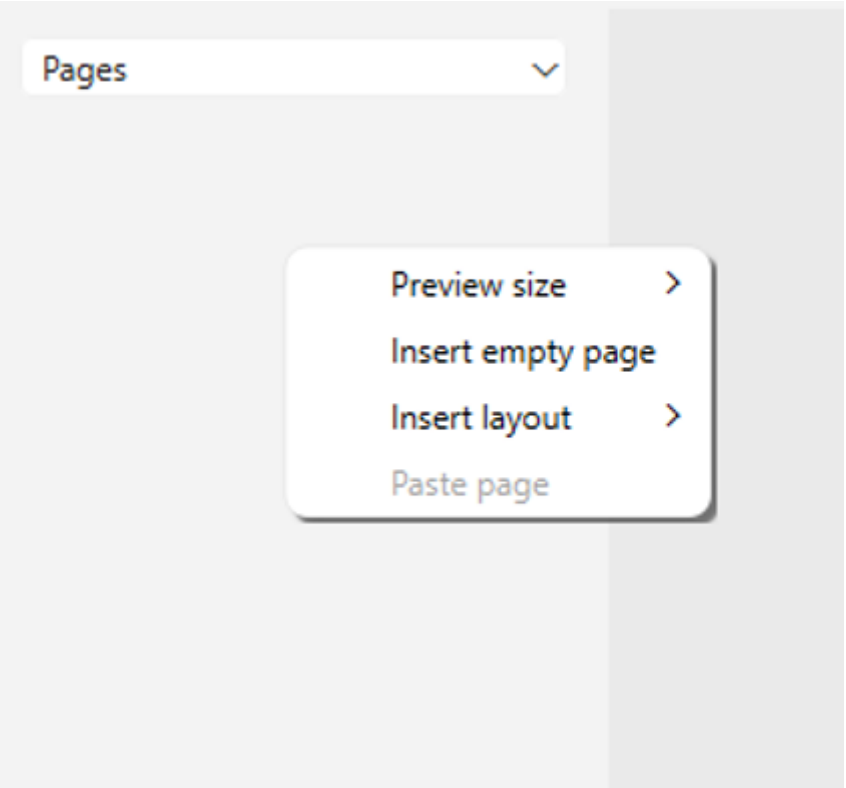

Figure 18.9: Context menu for pages.

To copy an existing page for reuse as a layout, right-click on the page in the **Pages** navigator and select **Copy to layouts**. The page is added to the layout navigator and can then be chosen within the project.

To save a group of layouts 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.

18.3 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**

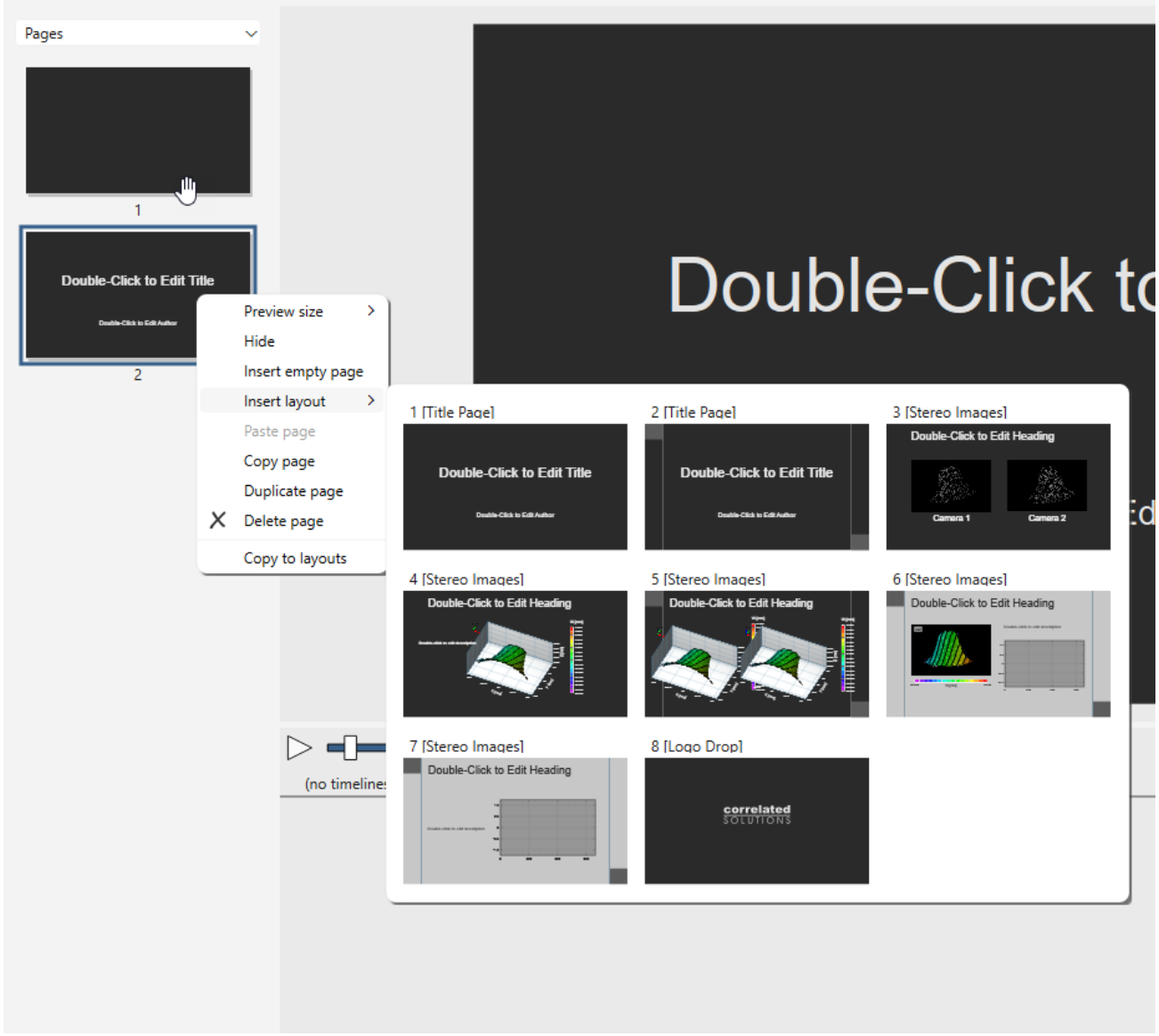

Figure 18.10: Context menu showing layouts.

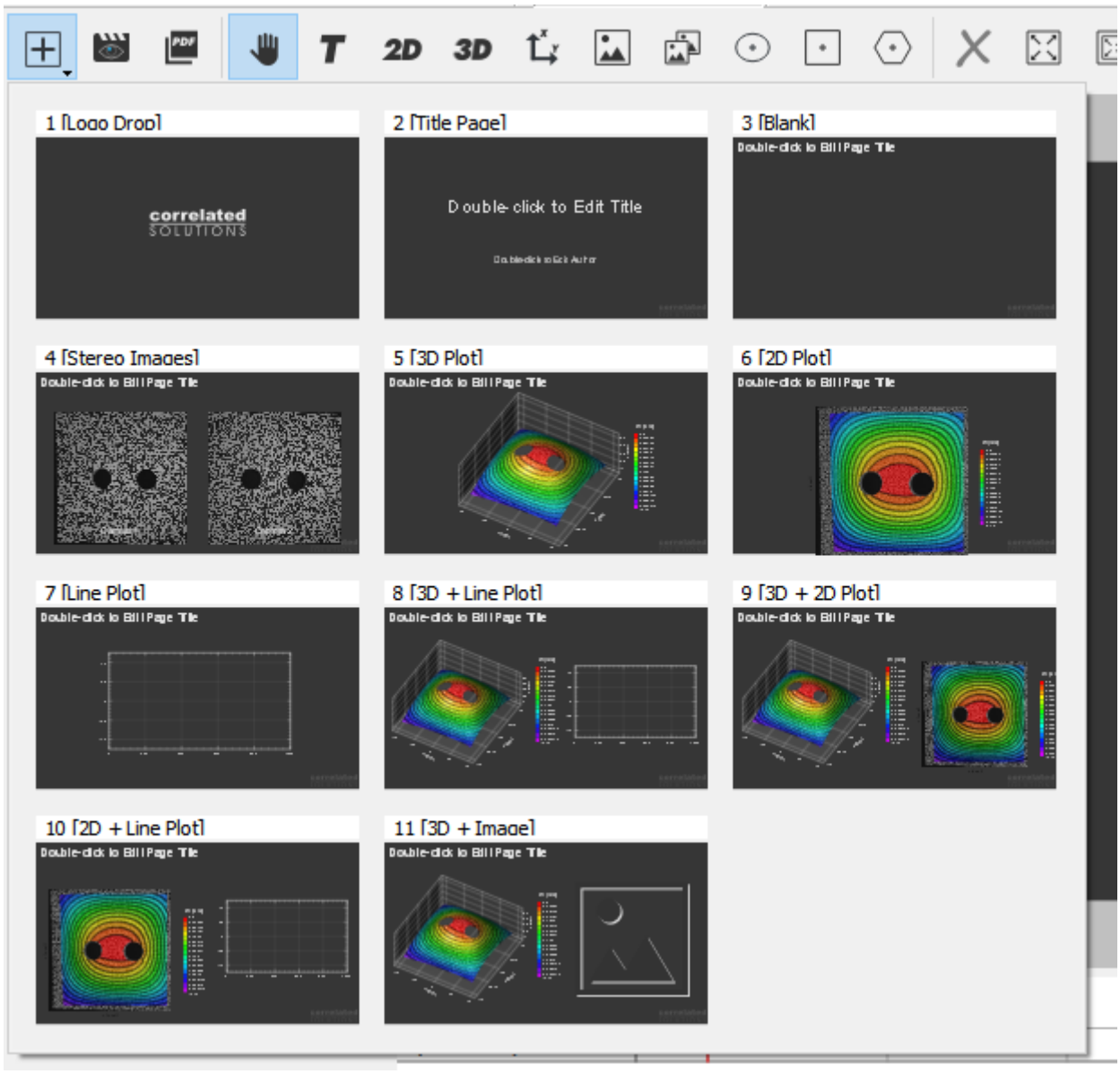

Figure 18.11: Multiple template selection.

Figure 18.12: Context menu for templates.

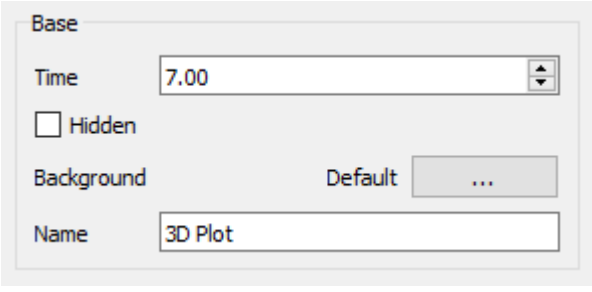

Figure 18.13: Template base tools.

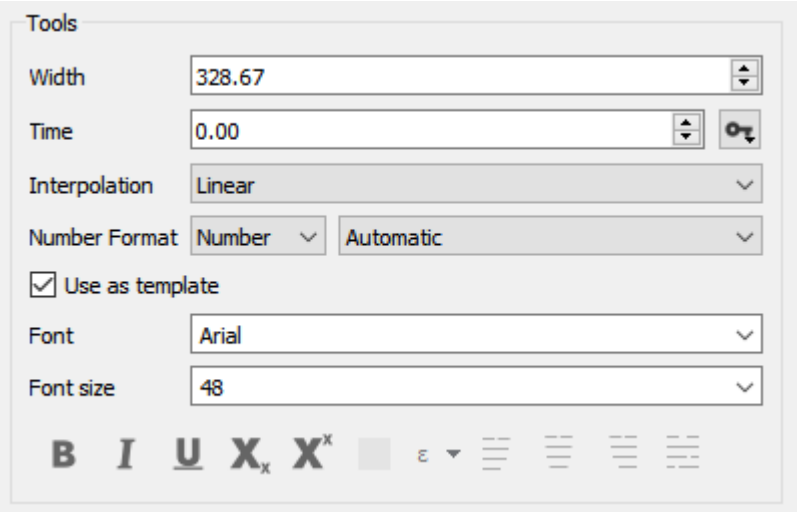

Figure 18.14: Template text tool.

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

18.3.1 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.)

18.3.2 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.

18.3.3 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.

18.3.3.1 Plot Properties

All properties of the inserted 2D plot are adjustable in the properties editor at the right side of the workspace. Each property is detailed in Section 23.1.

18.3.4 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.

18.3.4.1 Plot Properties

All properties of the inserted 3D plot are adjustable in the properties editor at the right side of the workspace. Details for all properties are detailed in Section 23.2.

18.4 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.

18.4.1 Line 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.

18.4.1.1 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. 18.15.

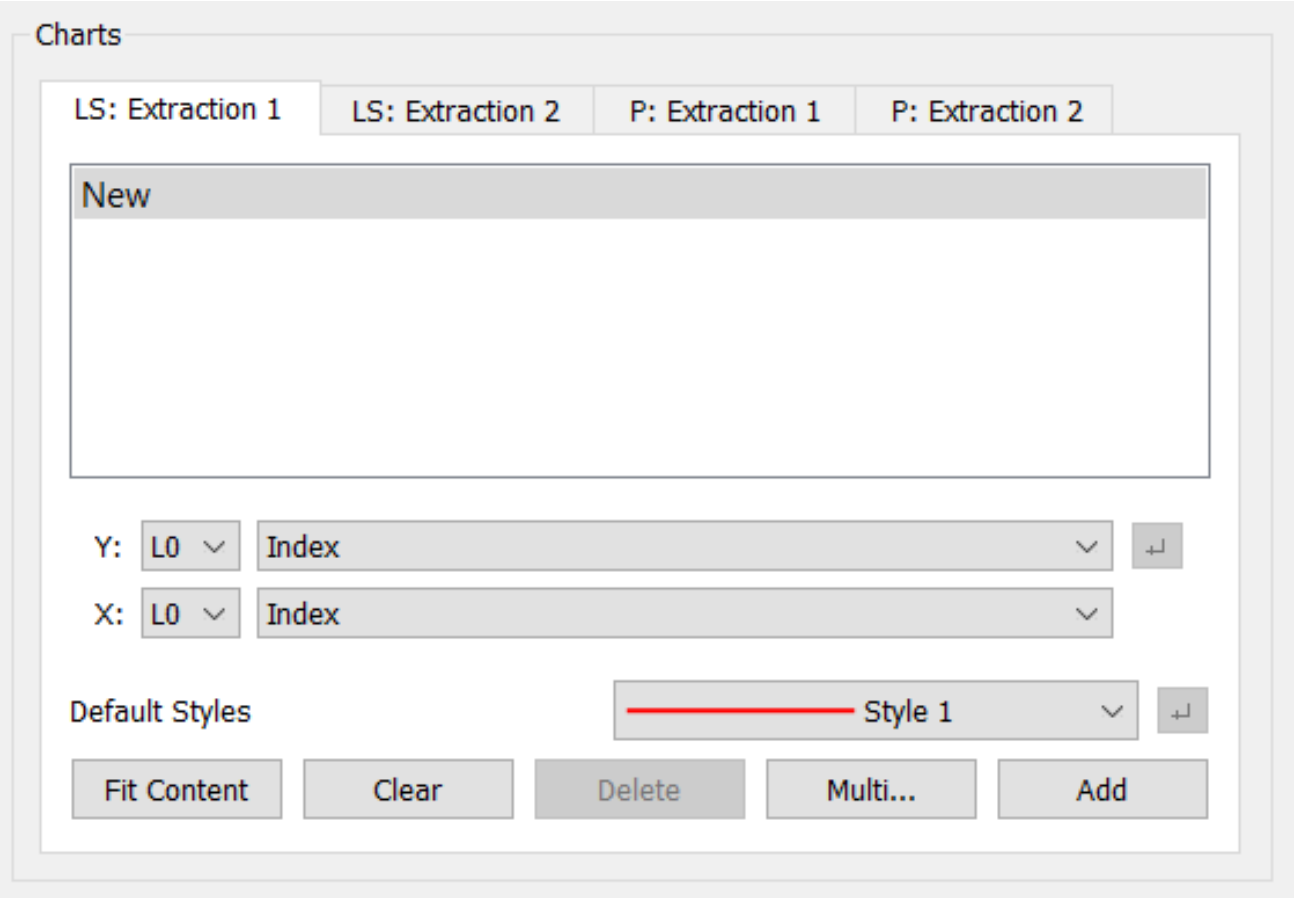

Figure 18.15: Charts Tool Box

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.

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. 18.16.

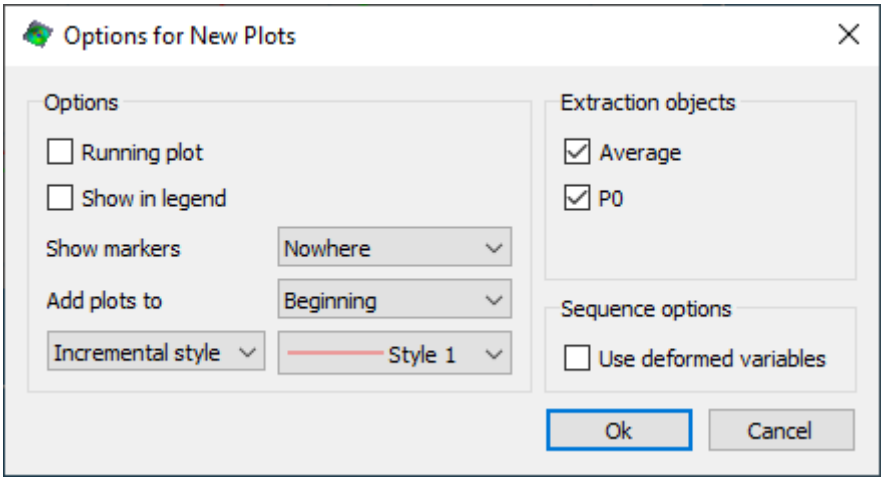

Figure 18.16: Multiple extraction options dialog.

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 the *Charts* window to customize the color, line style, line width, and markers placed, as seen in Fig. 18.17.

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. If **Use deformed variables** is checked, the position variables X, Y, and Z will have deformation (U, V, and W) added before plotting.

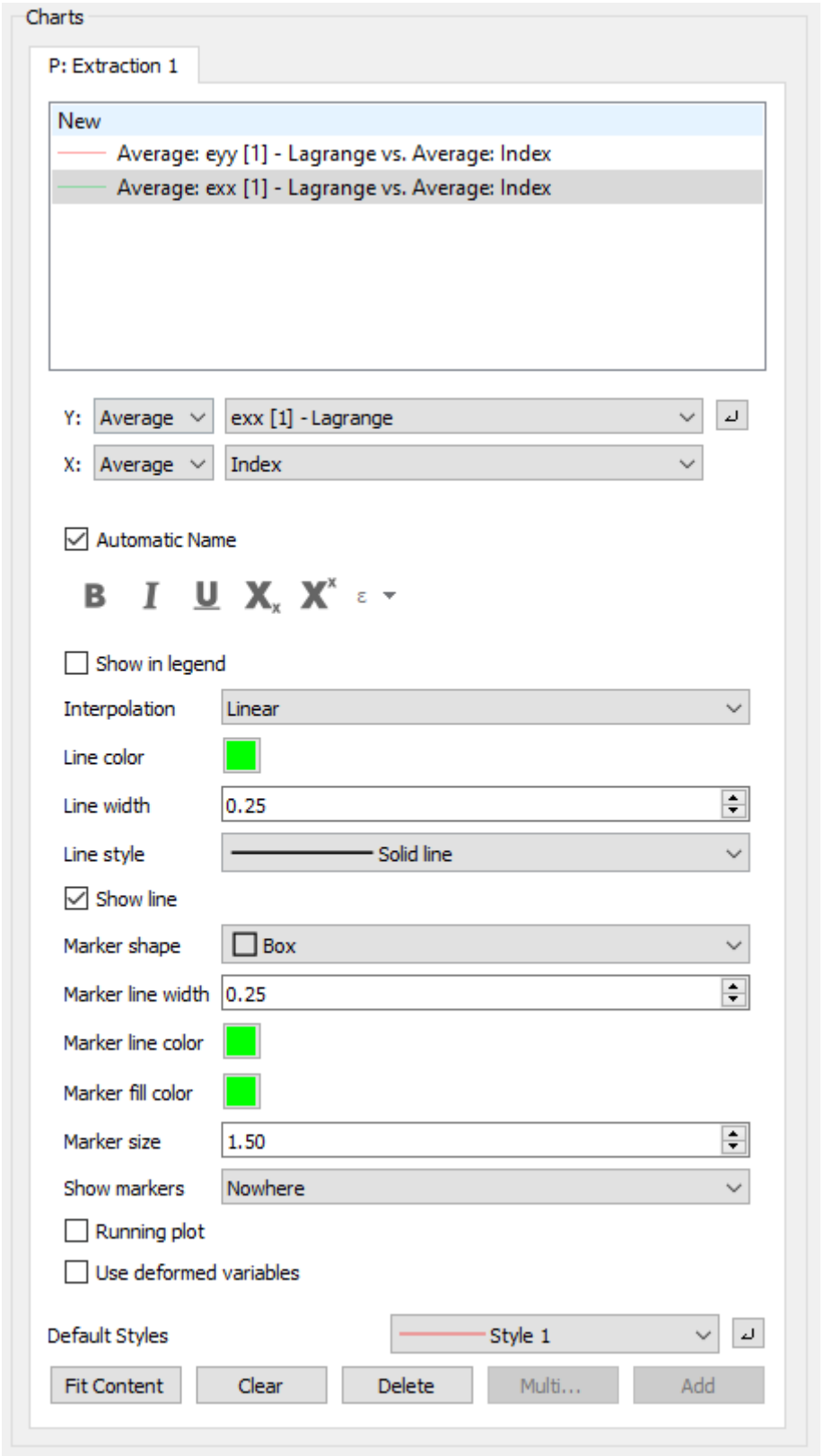

Figure 18.17: Chart style tools.

For line slice plots, additional time controls are displayed as shown in Fig. 18.18. 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**.

Figure 18.18: Line slice time tools.

18.4.1.2 Plot Legends

A plot legend may be added to allow easy identification of different data series. The legend tools are shown in Fig. 18.19.

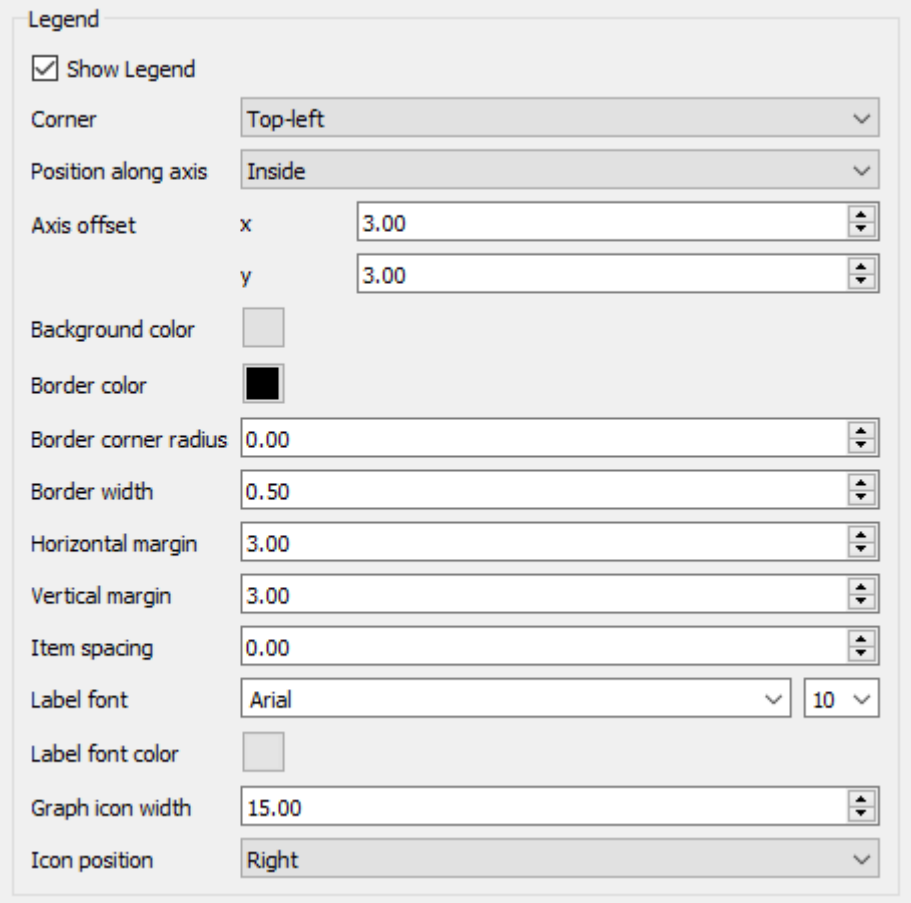

Figure 18.19: Plot legend tools.

Display of the legend is controlled by the **Show Legend** checkbox. The base position and location may be selected with the **Corner** and **Position along 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.

18.4.1.3 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.

18.4.1.4 X and Y-Axis

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

18.4.1.5 Plot Positioning

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

18.5 Secondary Axis

There is the option to add and modify a secondary axis for an extraction plot. The options are similar to those of the primary axis outlined in the x and y-axis tool. The secondary axis can be toggled via the "Disable" checkbox under the "Secondary Axis" tab in the workspace.

18.5.1 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.

18.5.1.1 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.

18.5.1.2 Text box tools

Text box properties may be adjusted using the sidebar tools, as shown in Fig. 18.20.

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

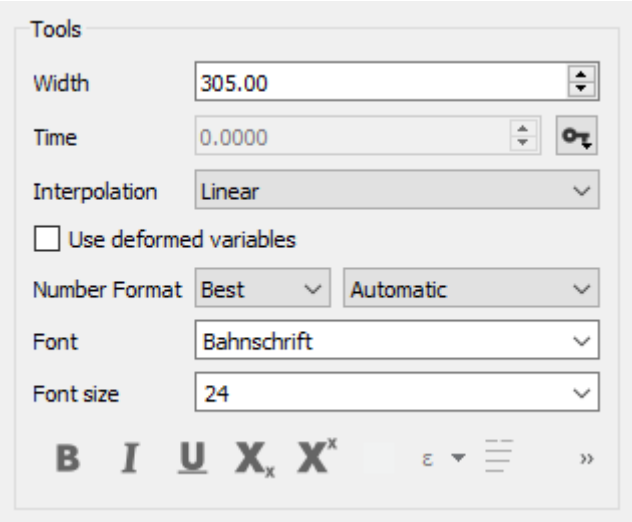

Figure 18.20: Text box tools.

> 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.

If **Use deformed variables** is checked, the position variables X, Y, and Z will have deformation (U, V, and W) added before display.

18.5.1.3 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. 18.21.

Select the extraction from the pulldown, and then choose variables and click **Add** to add a data source, shown below in Fig. 18.22.

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

18.5.1.4 Text box positioning

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

18.6 Static Images

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

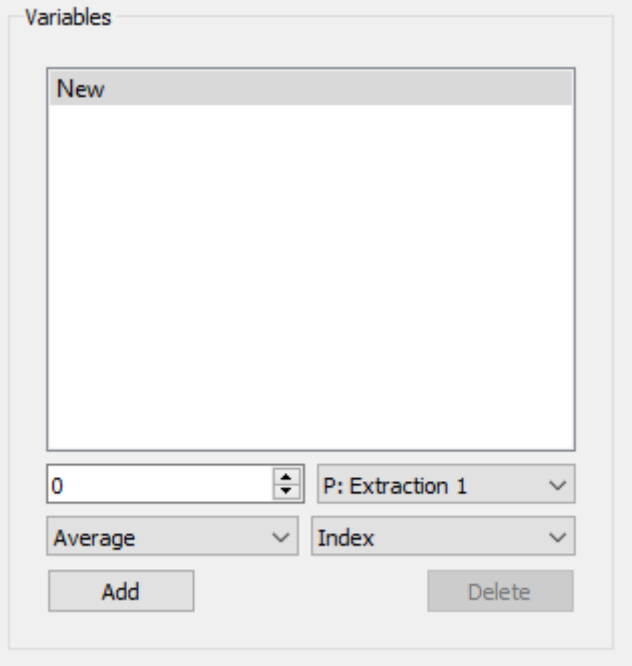

Figure 18.21: Text box variables.

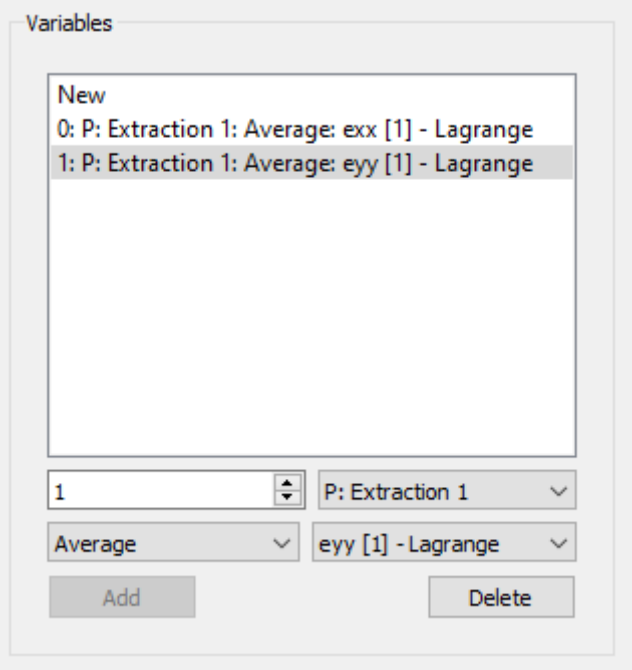

Figure 18.22: Text box variables, with data.

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.

18.6.1 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. 18.23.

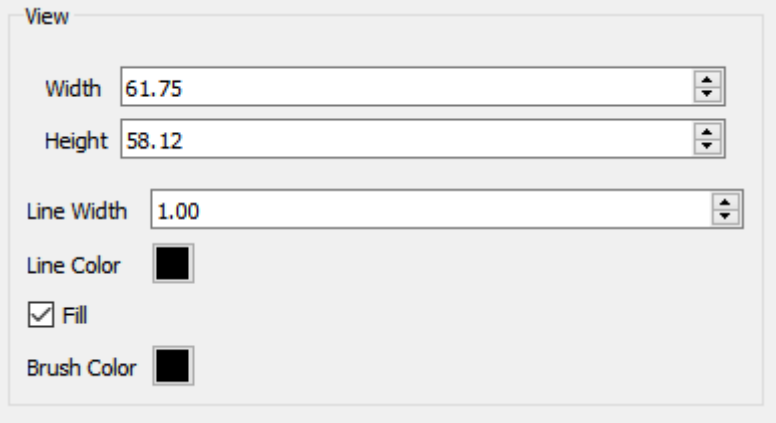

Figure 18.23: The view tool for an ellipse.

- Rectangles give one additional option for rounded corners, allowing you to adjust the radius shown in Fig. 18.24.

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. 18.25.

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

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.

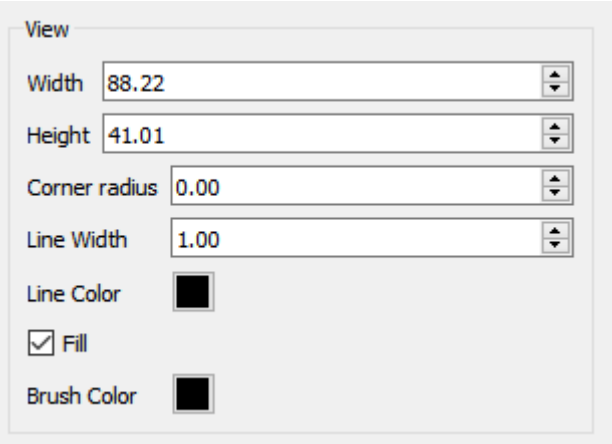

Figure 18.24: The view tool for a rectangle.

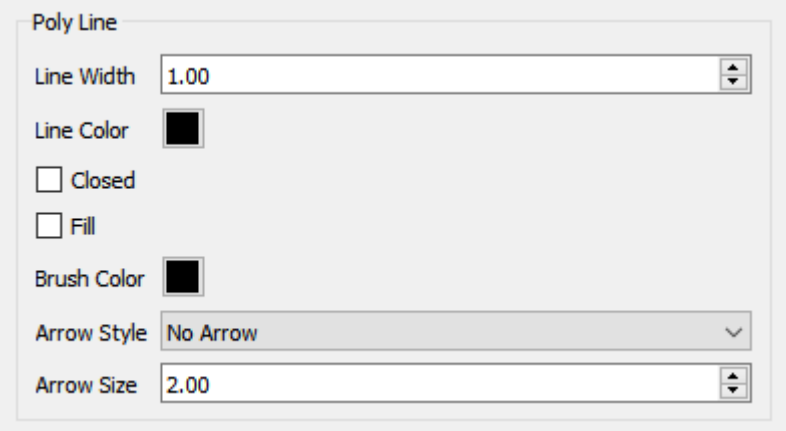

Figure 18.25: The view tool for a polyline.

18.6.2 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. 18.26 when right clicking on two selected objects.

- The before and after effect of clipping can be seen in Fig. 18.27 and Fig. 18.28.
- 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.

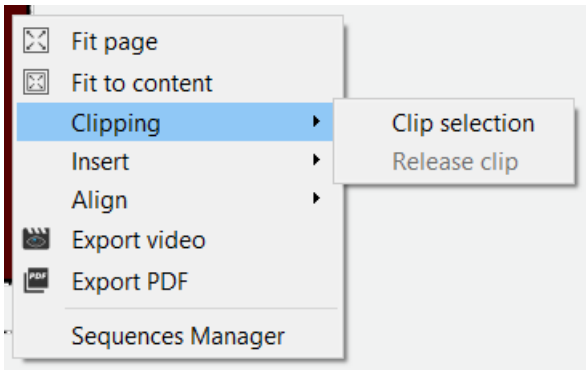

Figure 18.26: The context menu for clipping.

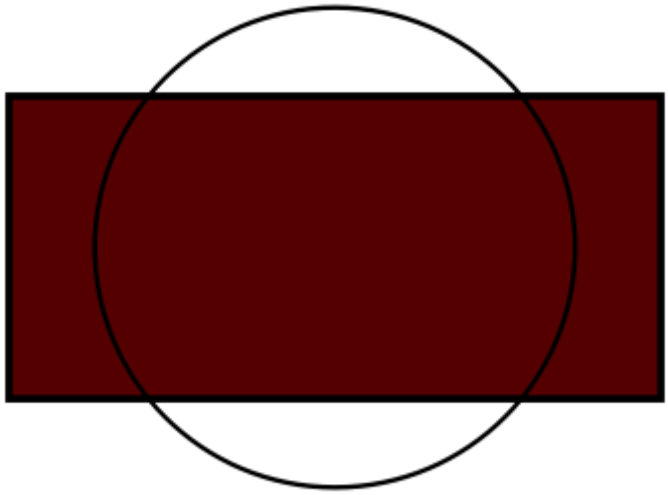

Figure 18.27: Rectangle and ellipse before clipping.

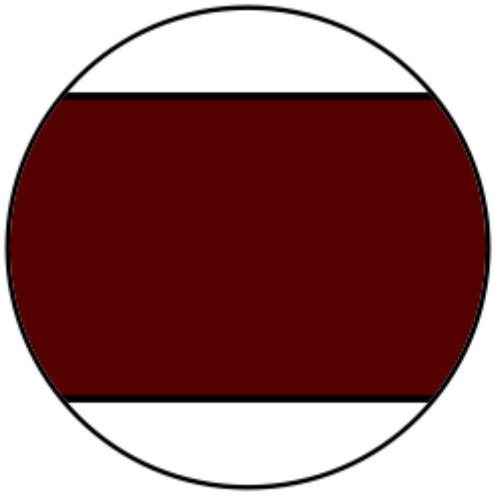

Figure 18.28: Rectangle and ellipse after clipping.

18.6.3 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 *triangulated* data plot menu is shown in Fig. 18.29, and the *marker* data plot menu plot menu is shown in Fig. 18.30.

18.6.3.1 Data Tools for Triangulated Data

Triangulated data in *iris* refers to either correlated data (.OUT files) or to imported model data (VTP 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. If **Show speckle image** is unchecked, the surface will be a solid color rather than the speckle pattern.

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.

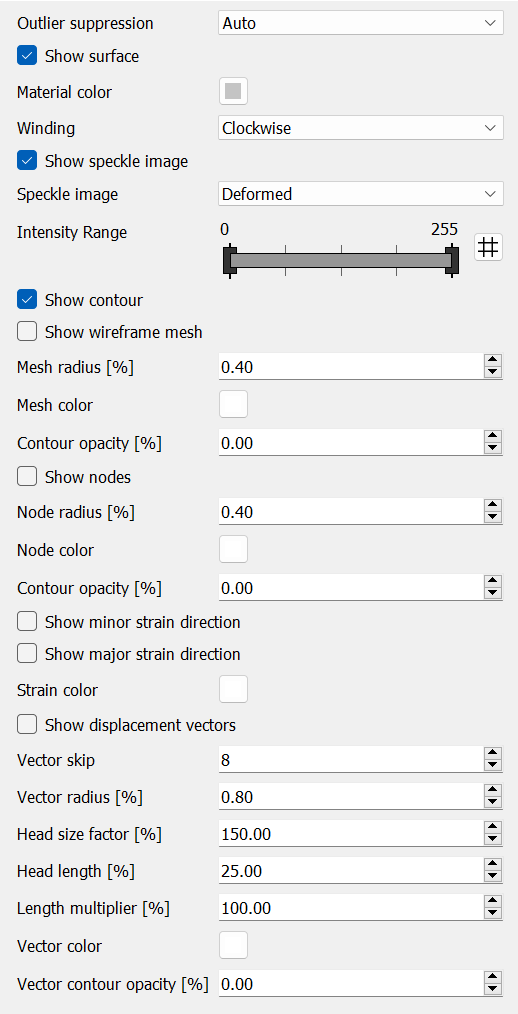

Figure 18.29: Data tool for 3D plot of triangulated data.

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 3D plot.

If **Show wireframe mesh** is checked, a mesh of data points will be displayed. The **radius** and **color** of the wireframe may also be adjusted. The **Contour opacity** control sets the opacity of the contour coloring applied to the wireframe

When **Show nodes** is checked, individual data points will be individually drawn as spheres. The **radius** and **color** controls below affect the display of the nodes. The **Contour opacity** control adjusts the opacity of the color overlay.

A variety of vectors may be displayed on the plot. The **Show minor strain direction** and **Show major strain direction** checkboxes toggle the display of minor and major strain direction ticks. Checking **Show displacement vectors** will show arrows indicating displacement of the data points.

For these vectors, the **Vector skip** control adjusts the density of displayed vectors; a value of 1 displays a vector at every data point. The **radius** (thickness) of the vector may be adjusted; the **Head size** and **Head length** adjust the appearance of the arrowheads on displacement vectors. The **Length multiplier** control scales the overall length of the displayed vector. THe **color** and **contour opacity** are also selectable.

18.6.4 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.

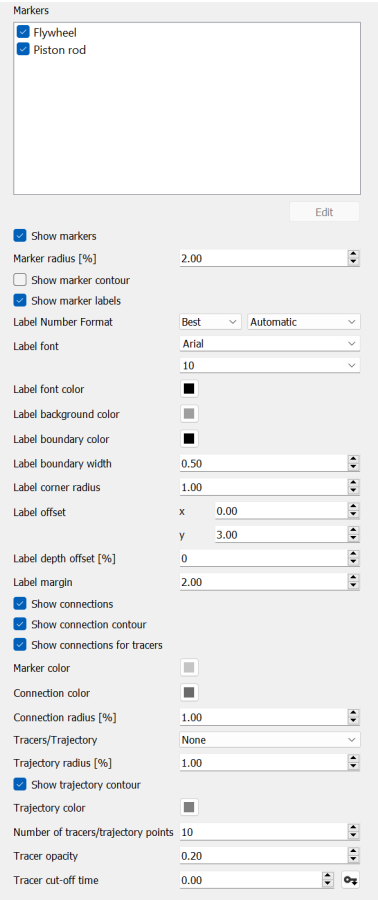

Figure 18.30: Data tool for 3D plot of marker data.

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 marker contour** enables or disables the contour overlay on displayed markers, while **Show marker labels** toggles the display of the associated marker name.

When marker labels are displayed, the **Label** controls affect their appearance and font.

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.

18.6.4.1 Data sources

- 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.

18.6.5 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.

18.6.5.1 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.

18.6.6 The Variable Tool

The variable tool shown in Fig. 18.32 controls the variable properties for both 2D and 3D plots in *iris*.

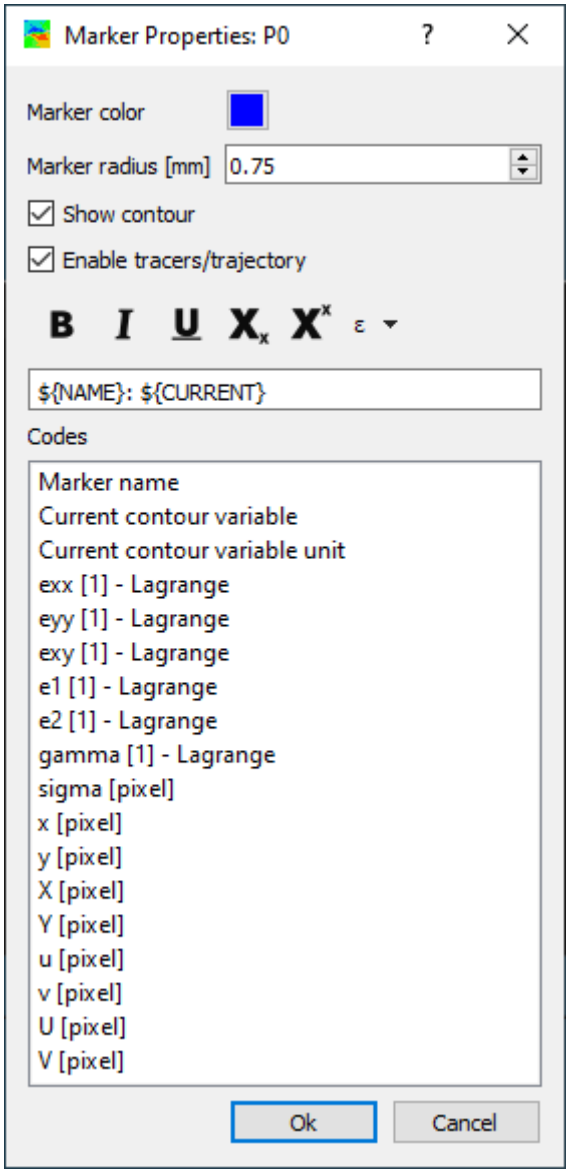

Figure 18.31: Marker properties dialog.

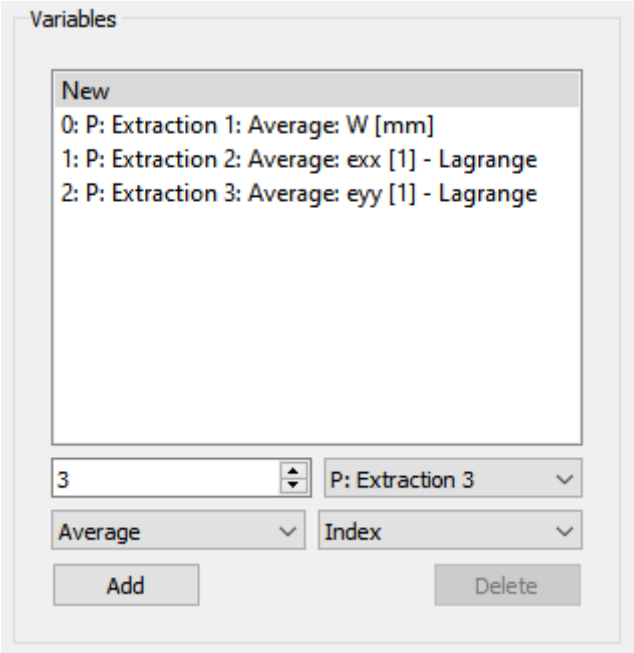

Figure 18.32: Variable tool for 3D plot.

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.

In order to add or use a variable in the variable tool, the user must first create an extraction in the 2D workspace.

18.7 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 can be seen below in Fig. 18.33.

Examples of sequence types include:

- Speckle and calibration images

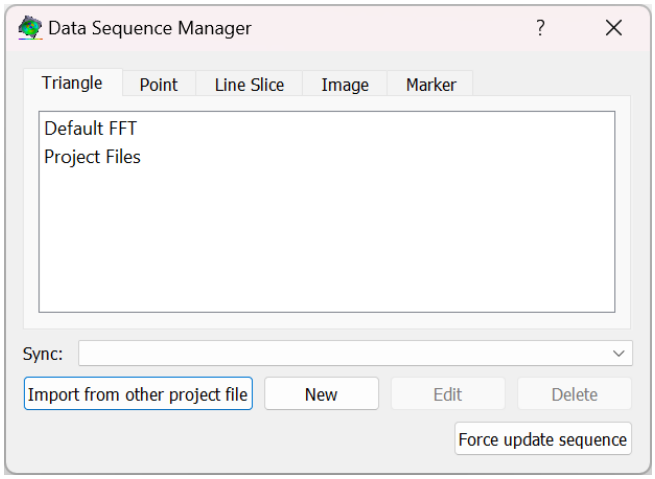

Figure 18.33: The sequence manager.

- Triangulated data (output files, VTK data)
- Extraction data
- Image sequences

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.)

Sequences may be imported from a different *iris* project file by clicking **Import from other project file**.

Where data has been recalculated or processed, **Force update sequence** will cause the data to be reloaded and new scaling applied.

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 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.

18.7.1 Mesh Data Sequences

iris supports import of a wide range of 3D mesh file formats, including VTP files (VTK polygon data), VIC-3D OUT files, OBJ, STL, PLY, and many more. VTK is a very flexible package that allows import and conversion of these and other FE mesh and CAD formats.

Mesh files are added under iris tools dropdown box at the top toolbar, by using "Add File Sequence" shown in Fig. 18.34. 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. 18.35. This sequence name will be the data source recalled for the 3D plot.

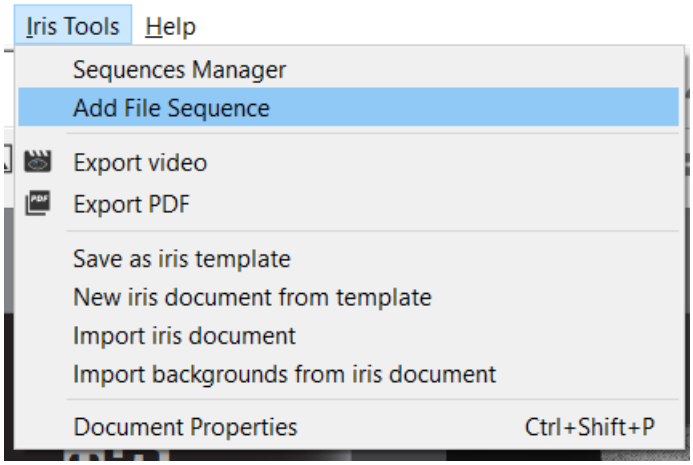

Figure 18.34: Add File Sequence menu.

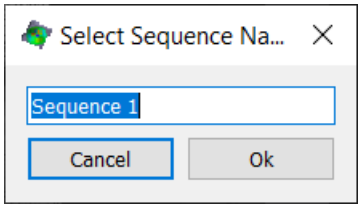

Figure 18.35: Selecting sequence name.

Once the sequence name is given, the dialog window shown in Fig. 18.36 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.

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.

18.7.1.1 Plot Properties

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

18.7.1.2 View

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

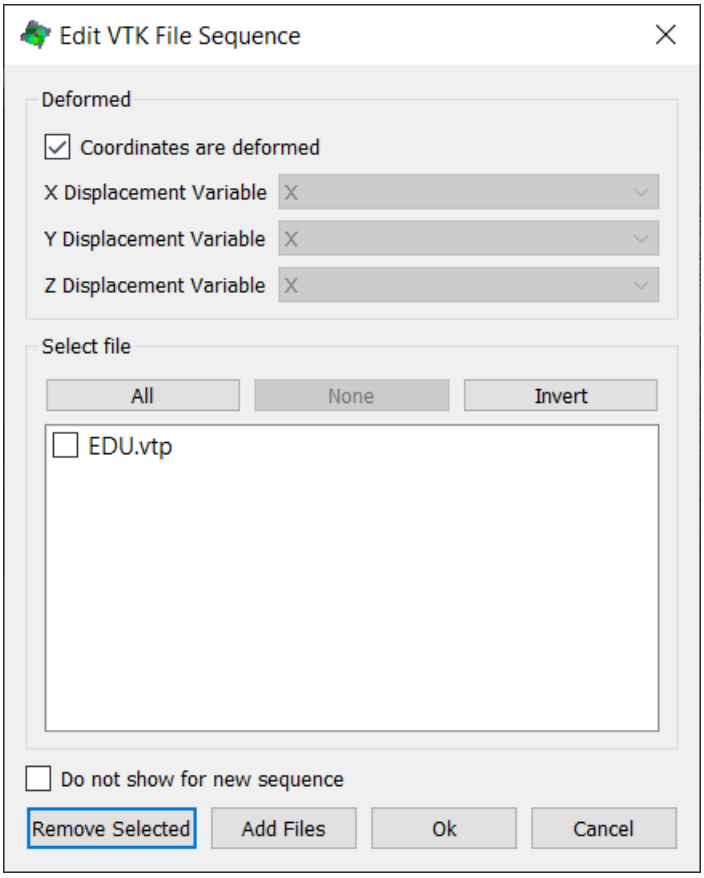

Figure 18.36: Edit VTK File Sequence dialog.

18.7.1.3 Plot Positioning

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

18.8 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.

18.8.1 Adding Keyframes

Keyframes are added by clicking the icon next to the desired value (Here in Fig. 18.37 the **Time** attribute for a 3D plot), and selecting *Add keyframe* from the dropdown.

Figure 18.37: Time control showing keyframe icon.

A keyframe indicator will appear in the timeline at the bottom of the workspace, shown in Fig. 18.38.

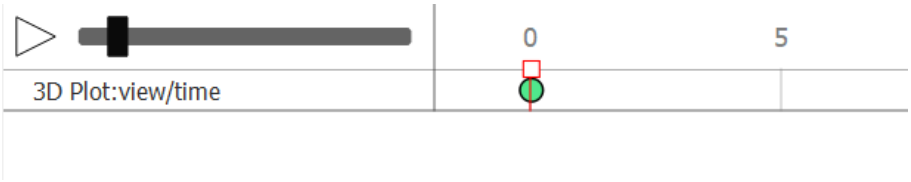

Figure 18.38: Timeline showing single keyframe.

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. 18.39:

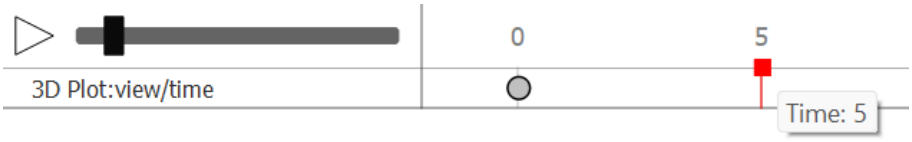

Figure 18.39: Timeline showing dragging.

On returning to the **Time** control, the key attribute has been disabled because the timeline is not currently at a keyframe, shown in Fig. 18.40:

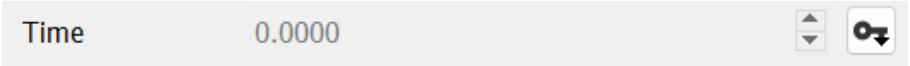

Figure 18.40: Disabled time control.

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. 18.41:

The new keyframe also appears on the timeline, shown in Fig. 18.42. A line connects any consecutive keyframes of the same attribute and its color indicates the interpolation or easing effect used for the transition.

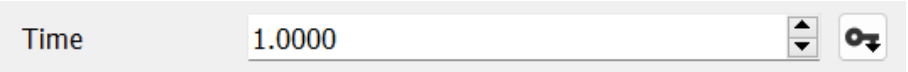

Figure 18.41: Enabled time control.

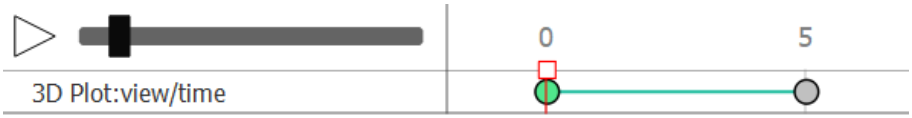

Figure 18.42: Timeline showing second keyframe.

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.

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.

Clicking on the play button on the top left corner plays through the animation for the current page. Clicking on the stop button or pressing the `K` key stops the animation. The animation speed can be adjusted using the slider next to the play/stop button or by pressing the `J` and `L` keys. The `J` and `L` keys will respectively lower and increase the animation speed, setting it at some predefined value.

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.

18.8.2 Editing timelines

A timeline can be edited by moving the keyframes. A keyframe can be selected by clicking on it, and can be moved by dragging it. Multiple keyframes can be selected by either clicking on them while holding the `CTRL` key or by drawing a selection box by holding the `SHIFT` key. Dragging any of the selected keyframes will move all of them. Since multiple keyframes for an attribute cannot occupy the same time frame, when moving keyframes, moves that would cause overlaps are not allowed.

18.8.3 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. 18.43, an animated rotation has been added after the time animation.

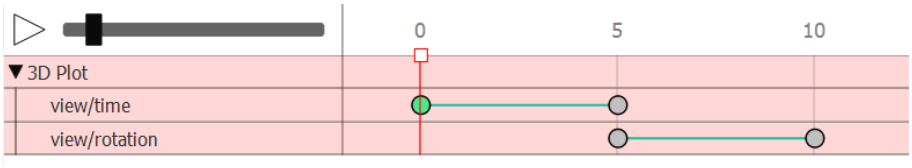

Figure 18.43: Timeline showing multiple animated attributes.

18.8.4 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 rows will be highlighted in red, shown in Fig. 18.44. A document item can be selected when clicking on the left of any of its animated attributes.

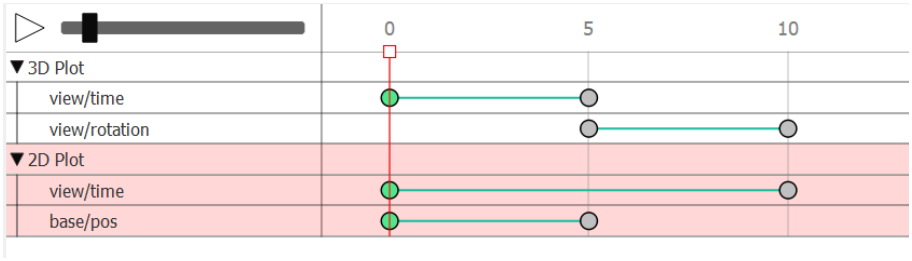

Figure 18.44: Timeline showing multiple objects.

All the attributes of the same drawable are grouped under the drawable's name. Clicking on the drawable name collapses or expands the list of animated attributes for the drawable. When the list is collapsed, a black line with a diamond at each end point is shown, indicating the time span of all animated attributes for the drawable as shown in Fig. 18.45. The collapsed timeline cannot be edited.

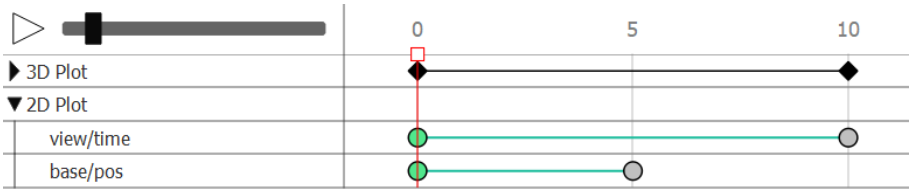

Figure 18.45: Timeline showing collapsed timelines for object.

Clicking on an animated attribute will open the editor for the selected attribute and adjust the highlight for its timeline as shown in Fig. 18.46. When an attribute is selected, pressing the

`Left` and `Right` arrow keys will move the time to the closest keyframe for that attribute in the selected direction.

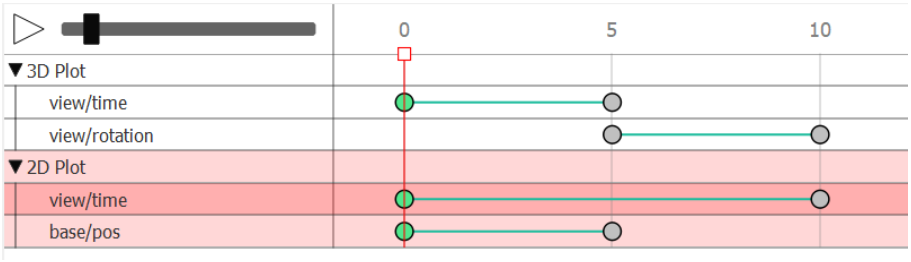

Figure 18.46: Timeline showing selected attribute.

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

18.8.5 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.

18.8.5.1 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.

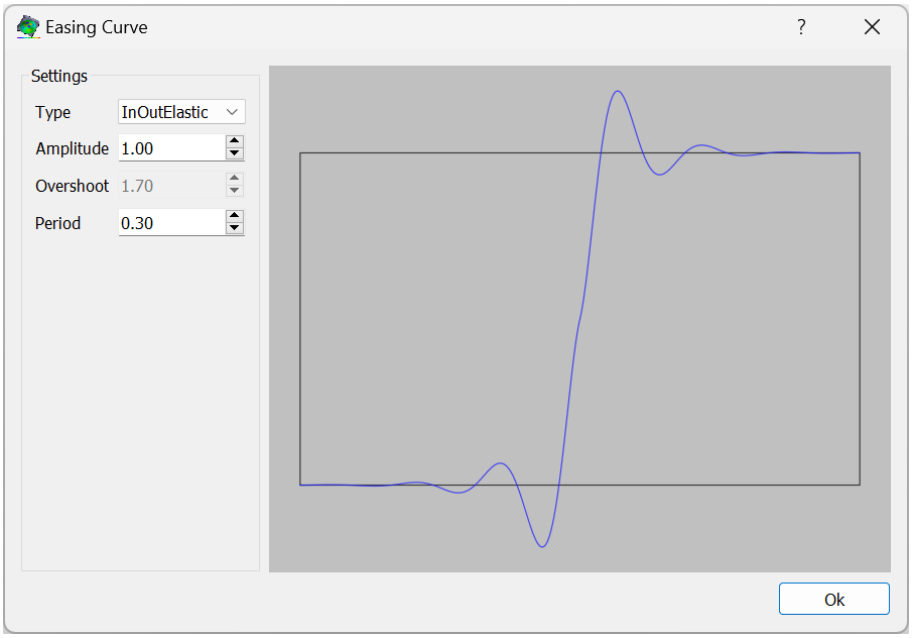

Figure 18.47: Customize easing options.

18.9 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`.

18.9.1 Page size

A list of standard page sizes can be selected as shown in Fig. 18.48, or a **Width** and **Height** can be entered in the desired units (selected using the pulldown).

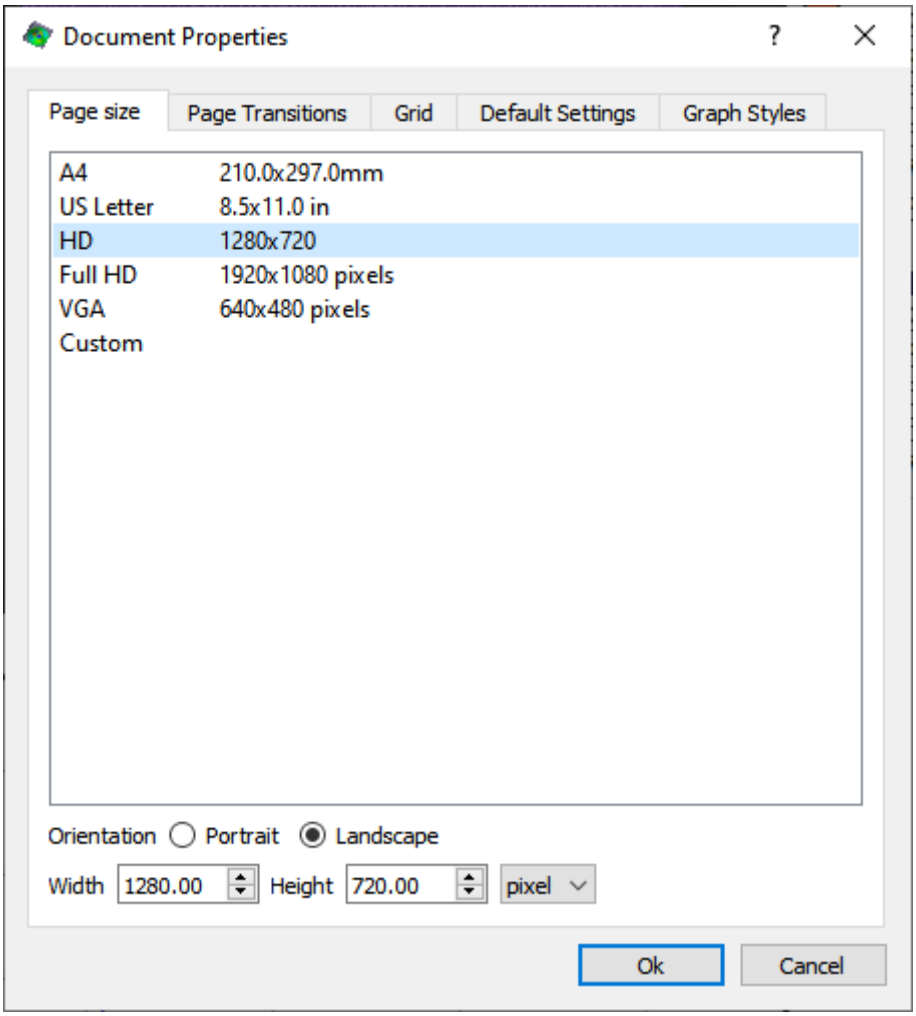

Figure 18.48: Page size tab.

18.9.2 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. 18.49.

18.9.3 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. 18.50.

18.9.4 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. 18.51.

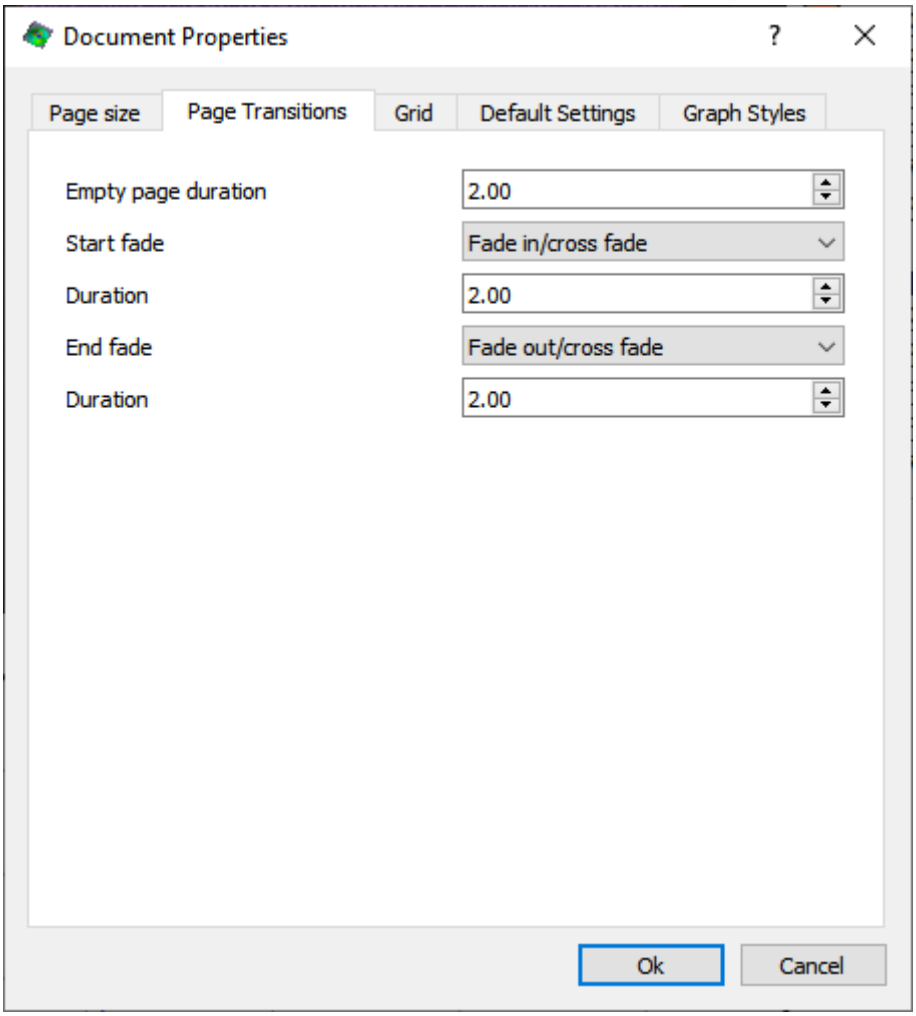

Figure 18.49: Page transitions tab.

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.

18.9.5 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. 18.52.

Graph style 12 is reserved for background traces.

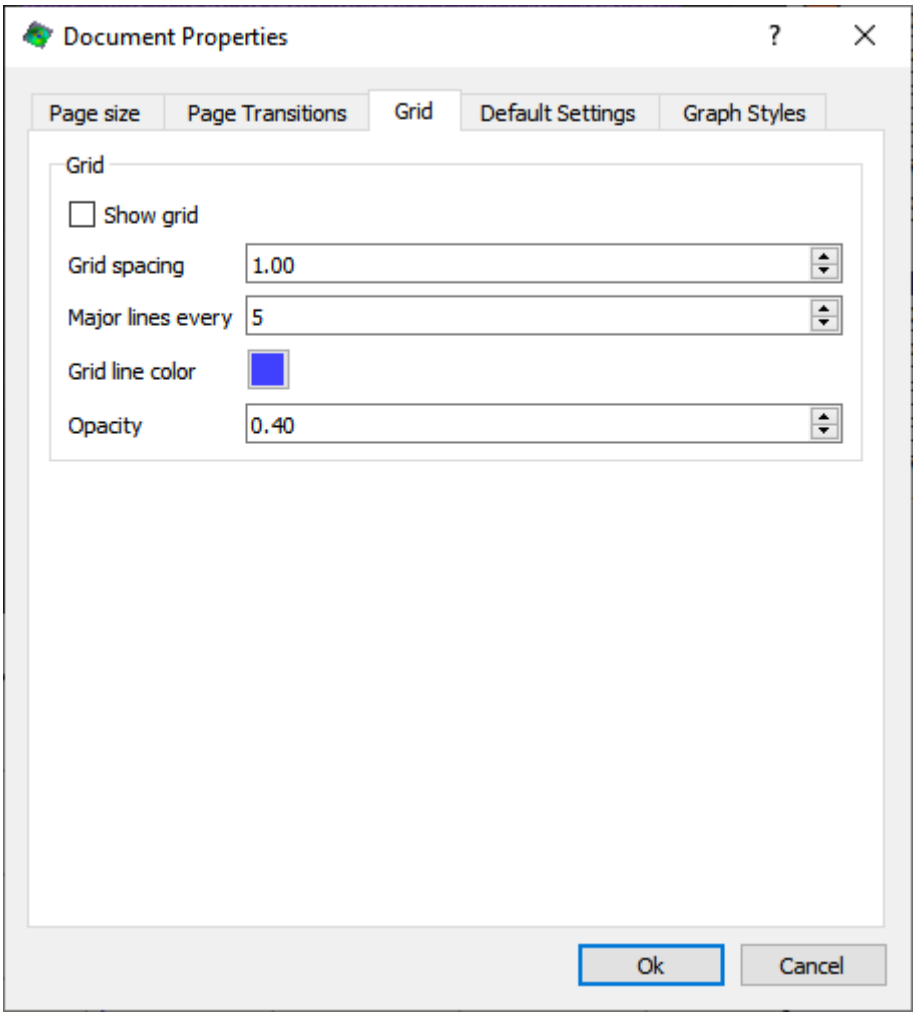

Figure 18.50: Grid tab.

18.10 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. 18.53.

18.10.1 Output

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

The resolution of the output is selected from the **Video format** pulldown; **Frame rate** allows selection from standard frame rates for video, and **Quality** controls the compression factor and resulting video quality.

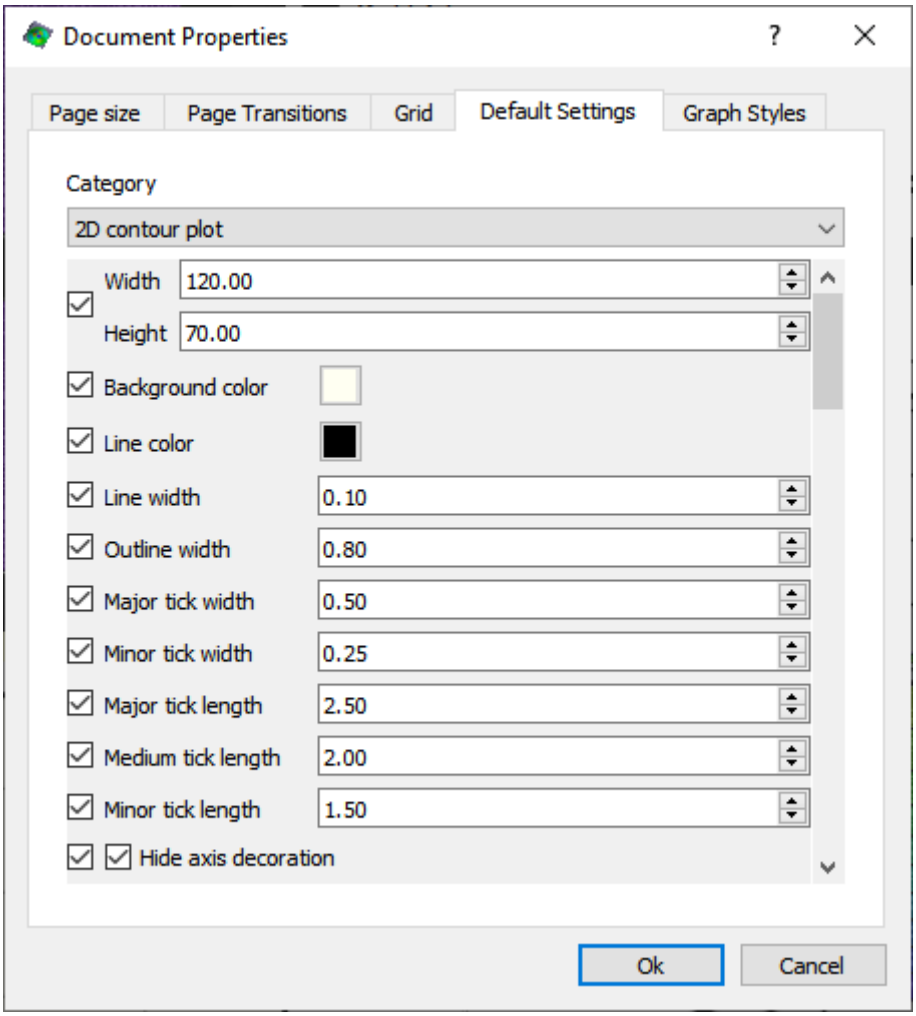

Figure 18.51: Default settings tab.

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.

The number of processes used for rendering is controlled by the **Threads** selection.

18.10.2 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.

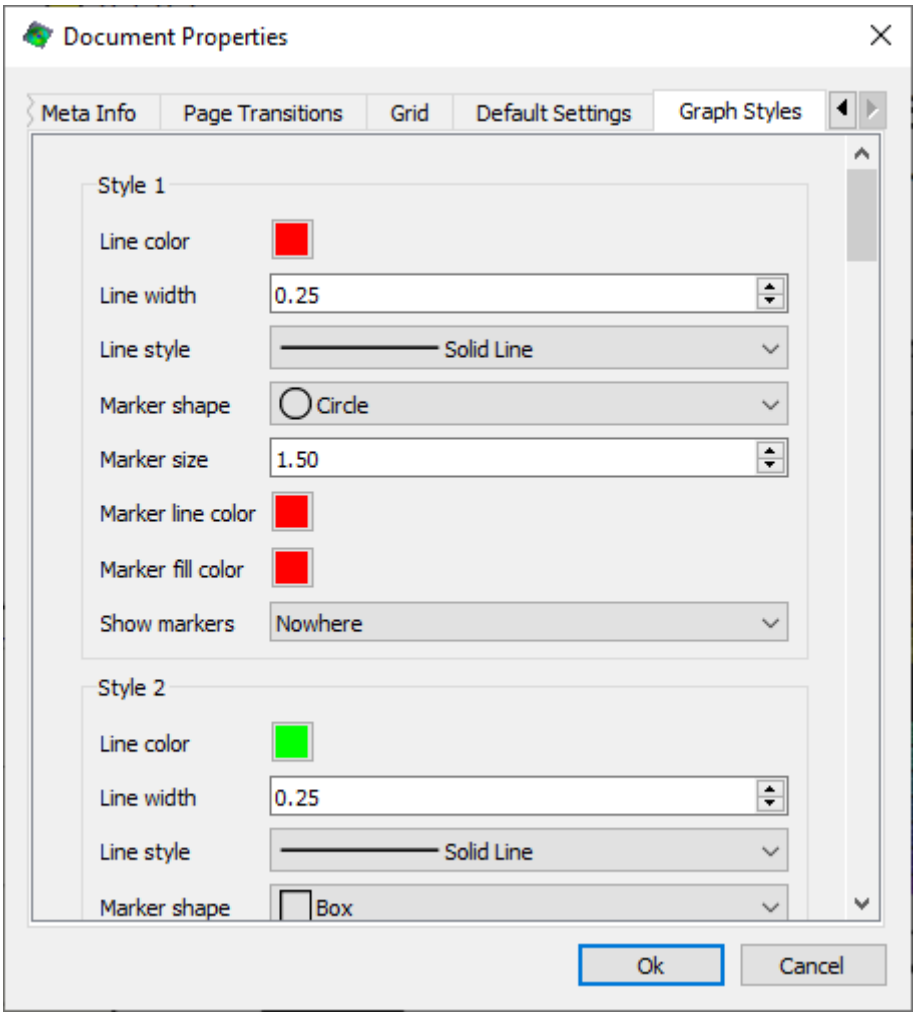

Figure 18.52: Graph styles tab.

18.10.3 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 icon in the main *iris* toolbar, or by pressing the "E" key on the keyboard. The export dialog is shown in Fig. 18.54.

18.10.3.1 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.

18.10.3.2 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.

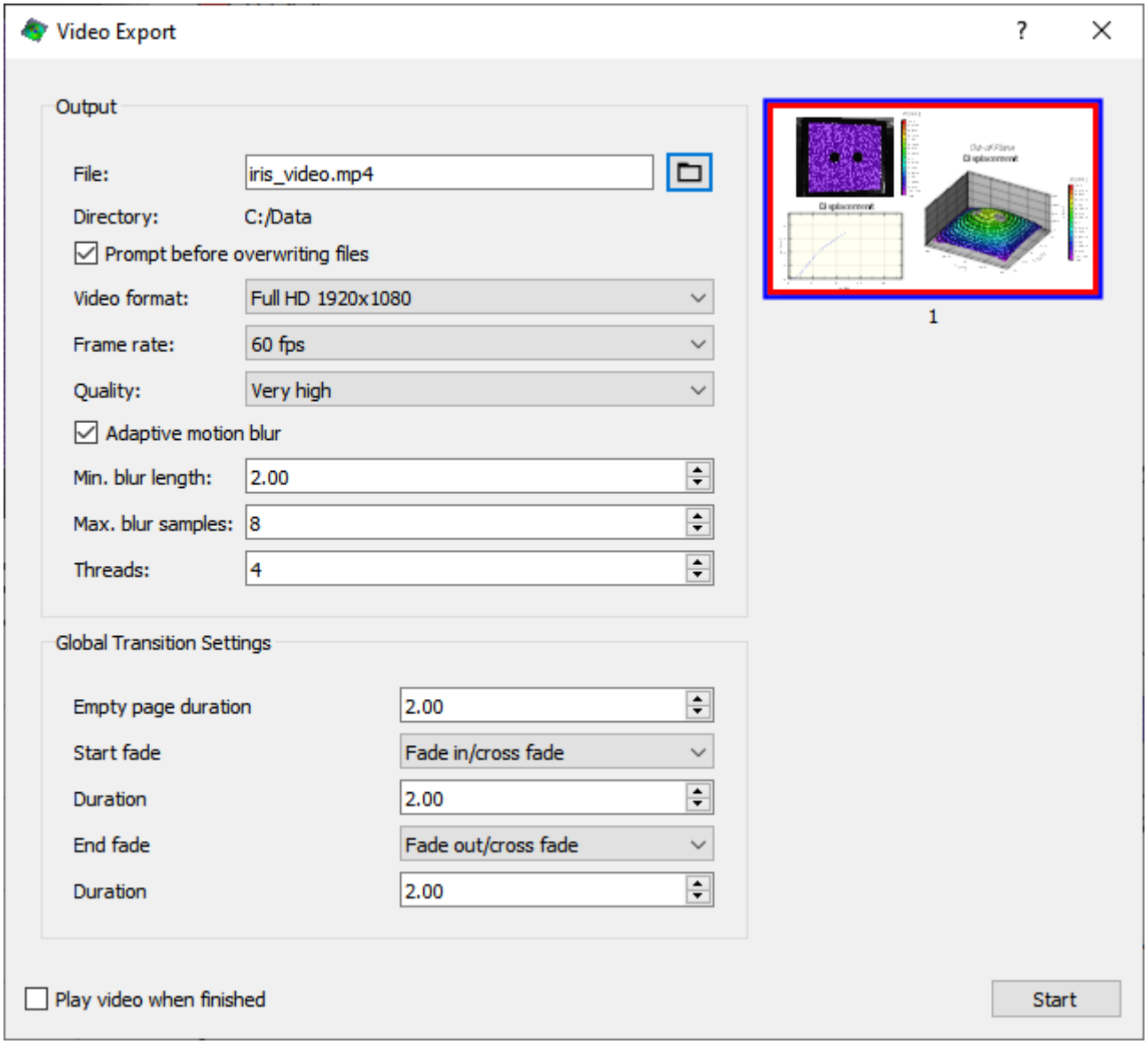

Figure 18.53: *iris* Export dialog.

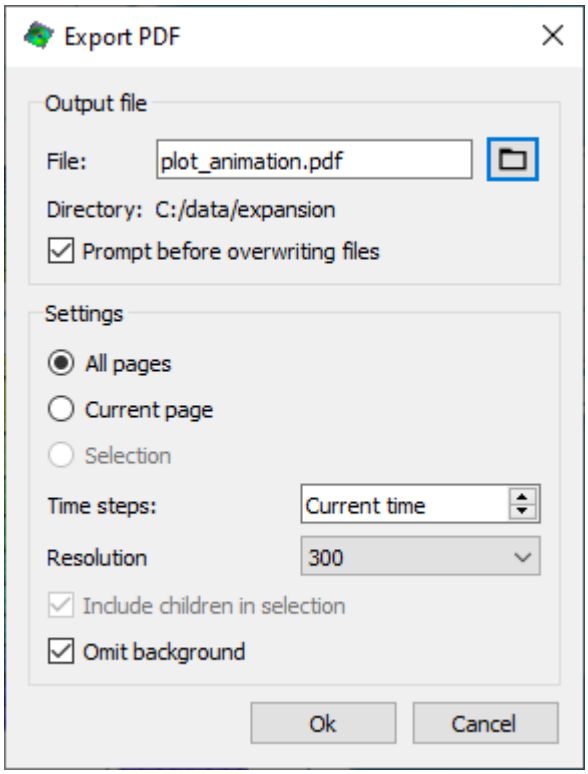

Figure 18.54: *iris* PDF Export dialog.

By default, the output will be generated for the current time set for each page. It is also possible to automatically sweep the timeline on each page and generate one page for each time step. The number of time steps can be controlled via the spin box labeled **Time steps**.

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 19

Report Generation

VIC-2D can generate reports from template documents. Special tags are used in the documents as placeholders for project-specific data such as calibration values, analysis settings, images or plots. During report generation, VIC-2D fills in the template with the data from the current project and writes a new document to the hard drive. VIC-2D supports additional template tags specific to 2D projects, including scale factor, measurement unit, and pixel aspect ratio. See the Report Template Tags reference for details.

19.1 Report Generator Dialog

To create a report after running an analysis, click *File... Report* from the main menu.

You can choose from installed Text documents or Presentations by selecting the tab at the top. The preset location for these templates is under your Documents folder in the VICReport-Templates subfolder. Supported filetypes are:

- **.odt:** OpenDocument document.
- **.docx:** Microsoft XML document (Word).
- **.odp:** Open Document presentation.
- **.pptx:** Microsoft XML presentation (PowerPoint).

You can add to the template library by placing new templates in this folder. Click on a template to continue, or click **Other** to select any other file.

Important note: if a tag is broken up by formatting, revision tracking, or spell checking, it will not be processed. It is usually best to turn off all change tracking and spelling/grammar checking in your word processor.

19.2 Report Options

Image resolution:

- Screen: for plots/images, uses the same resolution as the display, for viewing on screen.
- Print: upscales images for a better printed image.

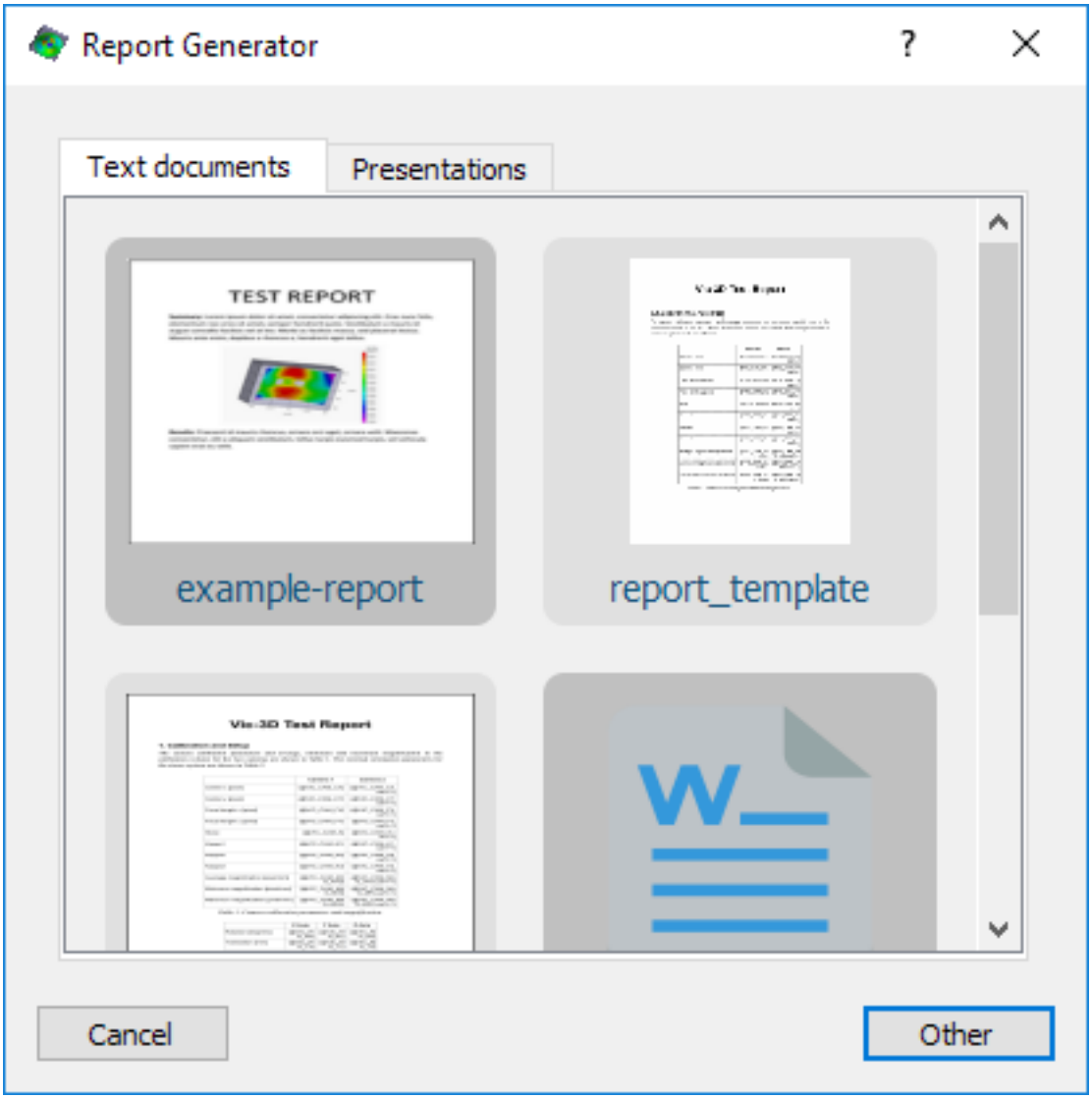

Figure 19.1: Report dialog

Scaling:

- In Print image resolution, choose nearest neighbor (faster) or smooth (better quality).

Video settings:

- Encoder: choose encoding method (built in AVI or external convertor).
- Format: choose a preset format (faster, higher quality, etc).
- Frame rate: select a frame rate for video display.

To open the report after completion, leave the checkbox selected. Click Ok to begin; the document will be filled out, replacing tags with quantities, images, tables, and videos. For more detail on available tags, consult the Report Template Tags reference.

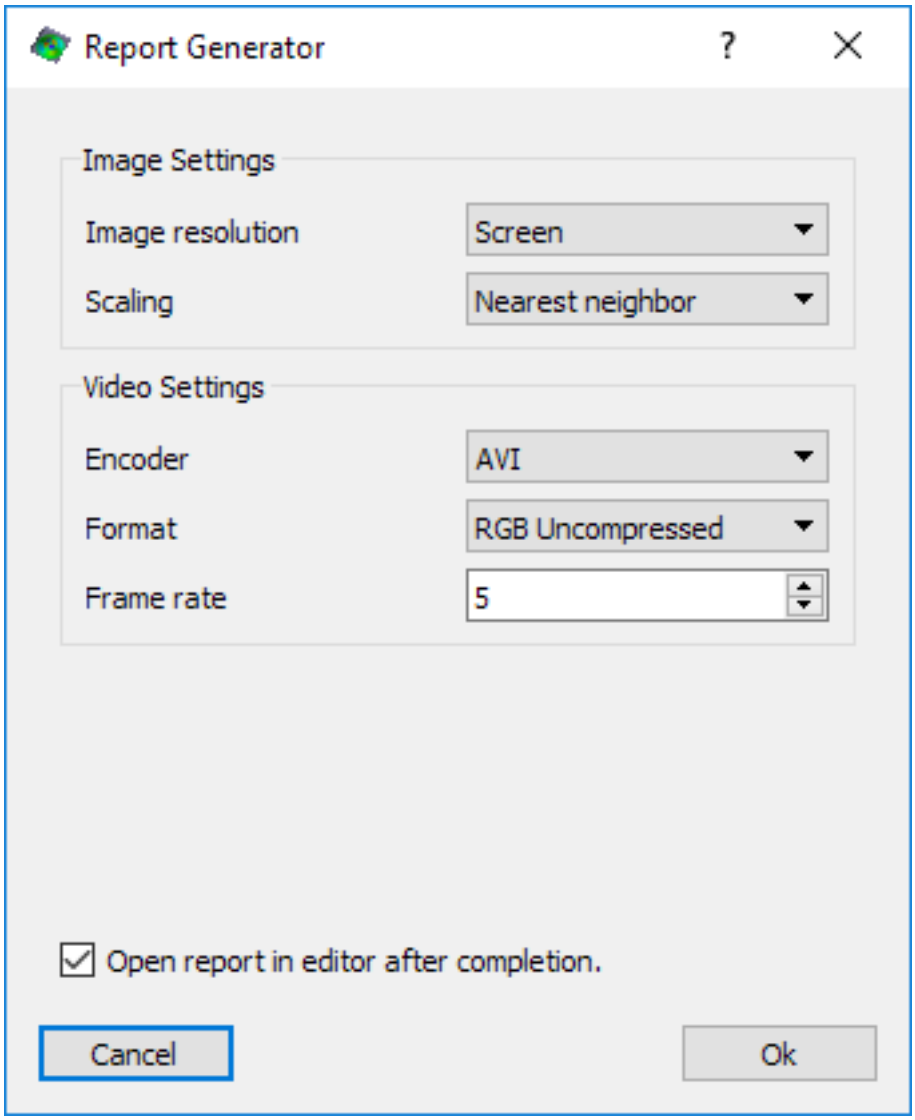

Figure 19.2: Report options page

19.3 Template Tag Reference

19.3.1 Basics

To insert a text tag, place the tag and any parameters, separated by commas, inside braces. The tag will be replaced by the appropriate value without changing the font, position, etc. For example, *{@VIC_RIG_TX}*.

To insert a graphic tag, create a blank or placeholder image and then add the tag and any parameters as the **alternative text**. The image will be replaced by the requested plot. For example, *{@VIC_PLOT_3D,var=e1,idx=-1}*.

Important note: if a tag is broken up by formatting, revision tracking, or spell checking, it will not be processed. It is usually best to turn off all change tracking and spelling/grammar checking in your word processor.

19.3.1.1 Format specifiers

Many tags have format specifier flags.

- fmt: floating point format
  - 'f': display as 7.7
  - 'g': uses either regular format, or scientific notation (e.g., 1e+3) if more concise
- prec: precision specifier (number of digits after decimal for 'f' or total number of floating point digits for 'g')

Spreadsheet column specifiers have the format COL_ID:FMT:PREC, where

- COL_ID: spreadsheet column (A, B, C, ..., AA, AB etc.)
- FMT: number format 'f', 'g' (optional)
- PREC: number of digits (optional)

List indeces:
Any time a list index *idx* is present, you may specify integer values starting from 0, or negative values to count down from the end; e.g., -1 refers to the last element. Alternatively, indeces can be specified as a percentage, e.g., 33.33%. If indeces are specified as percentages, the closest integer value is used.

19.3.2 Analog or Spreadsheet Data Tags

19.3.2.1 VIC_ADATA

Used to insert data from the project's analog data file (CSV) for time, load, etc.

- idx: Index value
- col: column (A, B, C, ..., AA, AB)
- fmt: floating point format ('g', 'f')
- prec: precision specifier (number of digits)

Example: *{@VIC_ADATA, idx=100%, col=B, fmt='f', prec=1}* shows the second column (normally Time_0) from the analog data file for the last image in the test, floating point, 1 digit of precision.

Example: *{@VIC_ADATA, idx=10, col=H}* shows the 8th column (i.e., Load, in a given setup) from the 10th image in the test.

19.3.2.2 VIC_CSV_DATA

Used to insert data from external csv files. Can be used either to look up spreadsheet cell entries (e.g., cell=B3) or for key-value pair lookups. In the latter usage, one column in the csv file is used as the key column and should hold unique descriptors of the values in the value column. For instance, the key column could have entries 'modulus', 'poisson', 'sample_id" and the value column would contain the numerical values for the elastic modulus, the poisson ration and the sample's identification number.

- file: path to csv file on disk
- cell: spreadsheet cell (e.g., A1, C32)
- key_col: column that holds keys for key-value pair lookups
- val_col: column that holds values for key-value pair lookups
- key: string in key column
- fmt: floating point format ('g', 'f')
- prec: precision specifier (number of digits)

Example: *{@VIC_CSV_DATA, file=testinfo.csv, cell=B3}* - shows the value from cell B3 of the specified spreadsheet.

Example: *{@VIC_CSV_DATA, file=testinfo.csv, key_col=D, val_col=E, key=modulus}* - scans row D for the keyword "modulus" and pulls the matching value from row E.

19.3.3 Calibration values

The following calibration values support the `prec` option to control the number of significant digits in the output (default: 6).

19.3.3.1 VIC_CAL_SCALE_FACTOR

The scale factor of the calibration (units per pixel).

Example: *{@VIC_CAL_SCALE_FACTOR, prec=4}* – shows the scale factor with 4 significant digits.

19.3.3.2 VIC_CAL_UNIT

The measurement unit string (e.g., mm, µm, inches).

Example: *{@VIC_CAL_UNIT}* – inserts the unit string.

19.3.3.3 VIC_CAL_ASPECT_RATIO

The pixel aspect ratio of the calibration.

Example: *{@VIC_CAL_ASPECT_RATIO, prec=6}* – shows the aspect ratio with 6 significant digits.

19.3.4 Analysis Settings

19.3.4.1 VIC_STRAIN_FILTER_SIZE

size of strain filter used (pixels)

19.3.4.2 VIC_STRAIN_TENSOR

type of tensor

19.3.4.3 VIC_SUBSET_SIZE

subset size (pixels)

19.3.4.4 VIC_STEP_SIZE

step size (pixels)

Example: *{@VIC_SUBSET SIZE}* – show the subset size for the analysis.

19.3.5 Tables (VIC_TABLE_CSV)

The template generator supports generation of tables from comma-separated variable files using the tag VIC_TABLE_CSV. This tag has to be added to the name field (ODT) of an existing table. The last row of the table in the template must contain spreadsheet column specifiers. The following options are supported:

- file: path to csv file on disk
- start: integer value for start row
- end: integer value for end row, or -1 to use entire table

19.3.6 Plots

19.3.6.1 @VIC_PLOT_2D

Inserts a 2D plot. 2D plots support the following options:

- idx: the image index (default 0)
- cam: the camera to view (default 0)
- var: the name of the variable to plot (default "W")
- c_range: the contour range, separated by a colon

19.3.6.2 @VIC_PLOT_3D

Inserts a 3D plot. 3D plots support the following options:

- idx: the image index (default 0)
- cam: the camera to view (default 0)
- var: the name of the variable to plot (default "W")
- c_range: the contour range, separated by a colon
- view_angles: the 3 viewing angles, separated by colons (default 60:0:30)

19.3.6.3 @VIC_IMG_EXTERNAL

Inserts an arbitrary image. External images support the following option:

- file: the file name

19.3.6.4 @VIC_IMG_REFERENCE

Inserts the reference speckle image. The reference image tag supports the following options:

- cam: the camera to view (default 0)

19.3.6.5 @VIC_IMG_SPECKLE

Inserts a speckle image. The speckle image tag supports the following options:

- idx: the actual image number (not a percentage or negative number)
- cam: the camera to view (default 0)

19.3.6.6 @VIC_IMG_AOI

Inserts the reference image with the AOI overlaid. The AOI image tag supports the following options:

- subset: set "subset=true" to show the subset grid overlaid on the AOI.
- startpoints: set "starpoints=true" to show start points overlaid on the AOI.

Chapter 20

Python Extensions

The *Extensions* framework allows users to apply customizable post-processing to their project data using Python scripts and the vicpyx module. An extension allows the user to apply any function to their data, edit existing variables or add new ones, get line and point extractions, and export data in a desired format. Since extensions are based on the Python language, any module available in Python can be used in an extension. Extensions can access the project's datasets and other information like inspector items. Finally, extensions are designed to be multithreaded by default, allowing parallel processing of the data.

The *Extensions* framework as well as the *vicpyx* Python module that powers it are open, so any user can create their own extension.

20.1 Running an extension

Installed extensions are available in the **Extensions** menu. Individual extensions are grouped by type. Selecting an extension opens a new dialog for that extension. The available options are shown on the left side, while on the right side there are tabs displaying the Python source code, help file, log messages, and any available preview.

20.2 Adding a new extension

The VIC-2D installation includes several extensions. Additional extensions can be added at any time by selecting "Add new" from the **Extensions** menu.

20.3 Creating a new extension

An extension requires two files. First, the Python script that implements the extension and then a configuration file written in JSON. While not required, a help file written in HTML or Markdown and a `requirements.txt` file are highly recommended. An extension can have more files, like images for the extension help file.

The extension needs to be implemented in a single, standalone file. However, any external Python module can be imported and used.

20.3.1 Configuration file

The extension configuration is formatted as a JSON file. This file specifies the rest of the files included in the extension, the type of data and information required from the project as well as the user interface for the extension.

The properties that can be set in the JSON file are:

Property	Required	Description
name	Yes	The name of the extension
type	Yes	The type of the extension
app-type	No	The application type that can use the extension
script	Yes	The Python script that implements the extension
help	No	Documentation for the extension as an HTML or Markdown file
description	No	A short description of the extension
menu-group	No	Custom submenu name in the Extensions menu
preview-variable	No	The contour variable that will be used as the default for preview
x-variables	No	Variables used for previews and initial display in extractions
y-variables	No	Variables used for previews and initial display in extractions
required-args	No	Required arguments for the extension
required-variables	No	Variables that must be present in the project data
argument-groups	No	Additional arguments that will be added in the UI

A detailed description of the properties follows:

20.3.1.1 `name`

A *String* with the name of the extension. This name needs to be unique and will be the one displayed in the Extensions menu.

20.3.1.2 `type`

The type of the extension. Available types are:

- **"full-field"**: An extension that will modify or add new full-field variables
- **"full-field-export"**: An extension to export the dataset in another format
- **"line-slice-generator"**: An extension that will generate a new line slice extraction
- **"point-data-generator"**: An extension that will generate a new point extraction
- **"single-processor"**: An extension that generates a new project object (e.g., a file sequence or a set of inspector items)

20.3.1.3 `app-type`

The type of the application that can use the extension. If omitted, the extension is available in all applications. Available types are:

- **"Common"**: Any VIC application
- **"VIC-3D"**: VIC-3D
- **"VIC-2D"**: VIC-2D

20.3.1.4 `script`

The Python file that implements the extension.

20.3.1.5 `help`

An HTML or Markdown file that provides detailed documentation for the extension that will be displayed in the *Help* section.

20.3.1.6 `description`

A *String* with a short description for the extension.

20.3.1.7 `preview-variable`

The default preview variable. It can be an existing one or one that will be added by the extension. Defaults to `"W"`.

20.3.1.8 `x-variables`

Only applicable to **"line-slice-generator"** and **"point-data-generator"** extensions. A list of *Strings* specifying the x-axis variables that the extension is expected to add to the extraction. These variables are used for previews in the extension dialog and as the default variables shown when the results are first displayed in the main workspace. This serves a similar role to `preview-variable` but for extraction-type extensions.

20.3.1.9 `y-variables`

Only applicable to **"line-slice-generator"** and **"point-data-generator"** extensions. A list of *Strings* specifying the y-axis variables that the extension is expected to add to the extraction. These variables are used for previews in the extension dialog and as the default variables shown when the results are first displayed in the main workspace. This serves a similar role to `preview-variable` but for extraction-type extensions.

20.3.1.10 `menu-group`

A *String* naming a custom submenu in the Extensions menu. Extensions that share the same `menu-group` value are grouped together under that submenu. If omitted, the extension appears in the default submenu for its type.

20.3.1.11 `required-args`

A list of project attributes that are required by the extension. The available attribute types are:

- **"aoi-mask"**
- **"subset-size"**
- **"reference-data"**

20.3.1.12 `required-variables`

A list of *Strings* with variable names that must be present in the project data for the extension to be available. If any listed variable is missing from the project, the extension cannot be opened.

20.3.1.13 `argument-groups`

Any additional options can be configured, grouped and positioned here. These are additional arguments that will be passed to the Python script. The parts of an argument group are:

- **"name"**: The argument group name
- **"ui-options"**: This has three fields:
  - **"no-group"**: A boolean indicating if the argument widgets should be grouped in a named box.
  - **"tab"**: A string with the title of the tab where the argument group should be placed. Argument groups sharing the same tab title are placed in the same tab. If not specified, a default "Options" tab is created.
  - **"stretch"**: An integer stretch factor. When greater than zero, the argument group's widget expands to fill available vertical space proportionally. Defaults to *0* (no expansion). Useful for groups that contain tall widgets such as file lists.
- **"args"**: The list of the additional arguments for the group:

Each argument is defined by a list of attributes. The required attributes are `type`, `name` and `ui-text`. The `name` must be a unique string and should match what is specified in the Python script and the `ui-text` is what will be shown in the UI next to the argument's widget.

Individual arguments also support the optional **`"app-type"`** array attribute, which works the same way as the top-level `app-type` property. When specified, the argument is only shown for the listed application types (`"VIC-3D"`, `"VIC-2D"`, or `"Common"`). If omitted, the argument is available in all applications.

Most argument types also support the optional **`"store-default"`** boolean attribute. When set to `true`, the user's last-used value for this argument is persisted and restored the next time the extension is opened. Supported on: `checkbox`, `integer`, `double`, `combobox`, `string`, `input-file-select`, and `output-file-select`. When any argument has this enabled, a "Store default values" checkbox appears at the bottom of the extension dialog.

Most argument types also support the optional **`"stretch"`** integer attribute. When greater than zero, the argument's widget is given extra vertical space in the layout. Defaults to *0*.

The supported types of arguments and their additional, optional attributes are:

20.3.1.13.1 `checkbox`

This argument type represents a boolean and the only additional attribute is the default value specified by **"default"**. The default can be either *true* or *false* and if not specified it defaults to *false*.

20.3.1.13.2 `integer`

This represents an integer value and the additional attributes are:

- **"default"**: The default value. If not specified defaults to *0*.
- **"min"**: The minimum value. If not specified defaults to *-99*.
- **"max"**: The maximum value. If not specified defaults to *99*.
- **"step"**: The step value. If not specified defaults to *1*.
- **"optional"**: Whether this is an optional argument. If not specified defaults to *false*. When `true`, a checkbox is shown next to the spin box. The argument is only passed to the script when the checkbox is checked.
- **"default-check-state"**: Only used when `"optional"` is `true`. Sets the initial checked state of the optional checkbox. Defaults to *false*.

20.3.1.13.3 `double`

This represents a floating value and the additional attributes are:

- **"default"**: The default value. If not specified defaults to *0.0*.
- **"min"**: The minimum value. If not specified defaults to *-99.0*.
- **"max"**: The maximum value. If not specified defaults to *99.0*.
- **"step"**: The step value. If not specified defaults to *1.0*.
- **"digits"**: The number of decimal digits. If not specified defaults to *2*.
- **"optional"**: Whether this is an optional argument. If not specified defaults to *false*. When `true`, a checkbox is shown next to the spin box. The argument is only passed to the script when the checkbox is checked.
- **"default-check-state"**: Only used when `"optional"` is `true`. Sets the initial checked state of the optional checkbox. Defaults to *false*.

20.3.1.13.4 `combobox`

This represents a list of distinct options for an argument and the additional attributes are:

- **"default"**: The default value. Should be one of the values specified in **options**.
- **"options"**: Pairs of values and ui-text specifying the argument options
  - **"value"**: The value for the option as it would be used in the Python script.
  - **"ui-text"**: The string that will be shown in the UI in the argument's widget.

20.3.1.13.5 `string`

This represents a string value and the additional attributes are:

- **"default"**: The default value.
- **"can-be-empty"**: A boolean. When `false` (the default), the extension cannot be started if this field is left blank. Set to `true` to allow an empty string.

20.3.1.13.6 `input-file-select`

This represents a file selection widget for input files.

- **"default"**: The default filename.
- **"file-extensions"**: A dictionary of file filters, where the key is the description and the value is a list of allowed extensions (e.g., `{"JSON": [".json"]}`).
- **"can-be-empty"**: A boolean. When `false` (the default), the extension cannot be started if no file is selected. Set to `true` to allow an empty selection. When empty, the argument is omitted from the script command line.

20.3.1.13.7 `output-file-select`

This represents a file selection widget for output files.

- **"default"**: The default filename.
- **"file-extensions"**: A dictionary of file filters, where the key is the description and the value is a list of allowed extensions (e.g., `{"CSV": [".csv"]}`).

20.3.1.13.8 `variable-list`

This represents a variable selection widget that allows the user to select which data variables should be processed by the extension. The additional attributes are:

- **"ui-text"**: The label displayed above the variable list widget.
- **"ui-style"**: The widget style. Can be `"list"` for a multi-selection list (default) or `"combobox"` for a single-selection dropdown. When `"combobox"` is used, the argument is passed to the script as a single string (the selected variable name) rather than a list. `"preselection"` and `"multiselection"` are not applicable with `"combobox"`.
- **"preselection"**: A list of *Strings* specifying the variables that should be selected by default. If not specified, defaults to `["U", "V", "W", "exx", "eyy", "exy"]`. Not used when `"ui-style"` is `"combobox"`.
- **"multiselection"**: A boolean indicating if multiple variables can be selected. Defaults to `true`. Not used when `"ui-style"` is `"combobox"`.
- **"variable-types"**: A list of *Strings* specifying the variable types that should be shown in the widget. When specified, only variables matching one of the listed types are displayed. If not specified, all variables are shown. The available type names are:

Type name	Description
`"pixel-coordinates"`	Pixel coordinates
`"global-coordinates"`	Global coordinates
`"pixel-displacements"`	Pixel displacements
`"global-displacements"`	Global displacements
`"strain"`	Strain
`"correlation"`	Correlation

Type name	Description
`"disparity"`	Disparity
`"cylinder-coordinates"`	Cylinder coordinates
`"cylinder-displacements"`	Cylinder displacements
`"pixel-velocities"`	Pixel velocities
`"global-velocities"`	Global velocities
`"strain-rate"`	Strain rate
`"curvature"`	Curvature
`"angle"`	Angle
`"angular-velocity"`	Angular velocity
`"global-accelerations"`	Global accelerations
`"pixel-accelerations"`	Pixel accelerations
`"stress"`	Stress
`"angular-acceleration"`	Angular acceleration

When using `VariableListMixin`, the argument `name` must be `"variable-list"`. To use a custom name, define the argument in the JSON configuration with the desired name and `"type": "variable-list"`, then add a matching argument in `add_arguments()` using `VariableListMixin.read_variable_list` as the type converter. The application passes the selected variables as a colon-separated string, and the reader parses it into a Python list. For example:

```
{
  "name": "strain-variable",
  "type": "variable-list",
  "ui-style": "combobox",
  "ui-text": "Strain variable"
}
```

```
def add_arguments(self, parser):
    parser.add_argument(
        '--strain-variable',
        type=VariableListMixin.read_variable_list,
        required=True,
        help='Strain variable to use',
    )
```

The selected variable is then available as `self.options.strain_variable`.

20.3.1.13.9 `inspector-items`

This represents an inspector item selection widget that allows the user to select inspector items from the project. The additional attributes are:

- **"ui-text"**: The label displayed above the inspector item widget.

- **“inspector-types”**: A list of *Strings* specifying the types of inspector items that should be listed. Available types are: `"point"`, `"line"`, `"circle"`, `"rect"`, `"polygon"`, `"extensometer"`.
- **“multiselection”**: A boolean indicating if multiple inspector items can be selected. Defaults to `true`.

When using inspector item mixins such as `InspectorLineMixin`, the argument `name` must be `"inspector"`. To use a custom name, define the argument in the JSON configuration with the desired name and `"type": "inspector-items"`, then add matching arguments in `add_arguments()`. The application appends the item type to the argument name when passing it to the script: `--{name}-line`, `--{name}-rect`, `--{name}-circle`, `--{name}-point`, `--{name}-extensometer`, or `--{name}-polygon`. In Python, add a separate argument for each item type that the argument accepts, using the corresponding mixin reader as the type converter. For example:

```
{
  "name": "reference",
  "type": "inspector-items",
  "inspector-types": ["rect", "circle"],
  "multiselection": false,
  "ui-style": "combobox",
  "ui-text": "Reference inspector item"
}
```

```
def add_arguments(self, parser):
    parser.add_argument(
        '--reference-circle',
        type=InspectorCircleMixin.read_inspector_circle,
        required=False,
        help='Reference inspector circle',
    )
    parser.add_argument(
        '--reference-rect',
        type=InspectorRectangleMixin.read_inspector_rect,
        required=False,
        help='Reference inspector rect',
    )
```

20.3.1.13.10 `project-files`

This represents a project file selection widget that allows the user to select data or image files from the project. The additional attributes are:

- **“ui-text”**: An optional label displayed above the widget.
- **“file-type”**: The type of project files to list. Can be `"data"` or `"images"`. If not specified defaults to `"data"`.

- **"ui-style"**: The widget style. Can be `"combobox"` for a dropdown or `"list"` for a multi-selection list. If not specified defaults to `"list"`.
- **"single-selection"**: A boolean. When `true`, the list widget allows only a single file to be selected. If not specified defaults to *false*.
- **"preselection"**: A boolean. When `true` (the default), all files are selected if **"single-selection"** is `false`, or the first available file if **"single-selection"** is `true`. When `false`, no file is pre-selected. Not applicable when `"ui-style"` is `"combobox"`. If not specified defaults to *true*.
- **"filter-size"**: A positive integer specifying the filter size. If not specified defaults to *1*.
- **"filter-padding"**: A boolean enabling padding. If not specified defaults to *true*.

20.3.2 Requirements file

An extension can include a `requirements.txt` file listing the Python packages it depends on. This follows the standard pip requirements format. The `vicpyx` module should be listed with a minimum version constraint (e.g., `vicpyx>=0.8.0`).

Example `requirements.txt`:

```
numpy
scipy
vicpyx>=0.8.0
```

20.4 Packaging an extension

Extensions are packaged in *.zve* files. These are archived files that include everything needed to run an extension, making it easier to manage and share them. To package a new extension, any zip software can be used to create a zip file with all the required files and then rename it to change the extension to *.zve*.

This can also be achieved by selecting "Package new" from the **Extensions** menu. This will also check the config file and report any issues if the structure is wrong or if the Python script and help files are missing.

20.5 Example

Here is a very simple example to illustrate what can be achieved with the extensions framework and how the files involved are structured.

20.5.1 Config file

```
{
  "name": "Displacement magnitude",
  "type": "full-field",
  "app-type": [
    "VIC-3D",
```

```
    "Vic-2D"
  ],
  "script": "displacement_magnitude.py",
  "help": "help.md",
  "description": "Compute the displacement magnitude",
  "preview-variable": "D",
  "argument-groups": [
    {
      "name": "Options",
      "ui-options": {
        "no-group": true,
        "tab": "Options"
      },
      "args": [
        {
          "name": "create-new-var",
          "type": "checkbox",
          "default": false,
          "ui-text": "Create new variable"
        }
      ]
    }
  ]
}
```

Breaking down the different parts:

```
  "name": "Displacement magnitude",
  "type": "full-field",
  "app-type": [
    "VIC-3D",
    "Vic-2D"
  ],
  "script": "displacement_magnitude.py",
```

First, the required properties are set. These specify that the name of the extension is *"Displacement magnitude"* and that it is a *"full-field"* extension meaning that it will add or modify full-field variables. Also, this extension is available for both VIC-3D and VIC-2D. Finally, the script that implements the extension is *"displacement_magnitude.py"*.

```
  "help": "help.md",
  "description": "Compute the displacement magnitude",
```

This extension has some documentation that will be displayed in the extension dialog. The documentation is contained in the "help.md" file. Also, a short description is provided. This will be displayed in the status bar when selecting an extension.

```
  "preview-variable": "D",
```

This property specifies the default preview variable. In this case, it's the variable added by this extension. When any dataset is previewed or processed, this is the variable that will be shown by default. This can be changed by selecting a different variable from the contour variable menu.

```
  "argument-groups": [
    {
      "name": "Options",
      "ui-options": {
        "no-group": true,
        "tab": "Options"
      },
      "args": [
        {
          "name": "create-new-var",
          "type": "checkbox",
          "default": false,
          "ui-text": "Create new variable"
        }
      ]
    }
  ]
```

The last part of the configuration file sets up the argument groups that will be displayed in the UI and used in the script. An argument group named *"Options"* is added, placed in a tab titled *"Options"*. Since the "no-group" property is set to *true*, the group box frame won't be displayed in the UI. The group has a single argument *"Create new variable"* of type *"checkbox"* that defaults to false.

20.5.2 Python script

```
import numpy as np
from vicpyx import *


class Extension(FullFieldProcessor):
    """
    This script computes the displacement magnitude D=sqrt(U^2+V^2+W^2).
    """

    def add_arguments(self, parser):
        parser.add_argument(
            '--create-new-var',
```

```
            action='store_true',
            help='Force creation of a new variable. By default, '
            'the script re-uses the variable "D" if it exists.',
        )

    def process_data(self, data):
        if data.current_data_type() == CsDataSystemType.Type3d:
            d = data.get_values(['U', 'V', 'W'])
            dd = np.sqrt(d['U'] ** 2 + d['V'] ** 2 + d['W'] ** 2)
        else:
            d = data.get_values(['u_c', 'v_c'])
            dd = np.sqrt(d['u_c'] ** 2 + d['v_c'] ** 2)

        var_name = 'D'
        add_var = not var_name in data.variables()
        if self.options.create_new_var == True:
            add_var = True
        if add_var:
            var_name = data.add_variable('D', 'D [mm]',
                           VICDataVariableType.GlobalDisplacement)
        # store computation result in data set
        data.set_values({var_name: dd})
        # save the data
        data.save()


if __name__ == "__main__":
    Extension().run()
```

Breaking down the different parts of the script:

```
import numpy as np
from vicpyx import *
```

First, the required modules are included. This extension uses *numpy* in addition to *vicpyx*.

```
class Extension(FullFieldProcessor):
```

Then the Extension class is defined. This class inherits from FullFieldProcessor since it will modify or add full field variables.

```
    def add_arguments(self, parser):
        parser.add_argument(
            '--create-new-var',
            action='store_true',
            help='Force creation of a new variable. By default, '
```

```
            'the script re-uses the variable "D" if it exists.',
        )
```

Since this extension has additional arguments, they need to be added to the extension script as well. The argument name needs to match the *"name"* property in the config file, in this case *"create-new-var"*.

```
    def process_data(self, data):
        if data.current_data_type() == CsDataSystemType.Type3d:
            d = data.get_values(['U', 'V', 'W'])
            dd = np.sqrt(d['U'] ** 2 + d['V'] ** 2 + d['W'] ** 2)
        else:
            d = data.get_values(['u_c', 'v_c'])
            dd = np.sqrt(d['u_c'] ** 2 + d['v_c'] ** 2)

        var_name = 'D'
        add_var = not var_name in data.variables()
        if self.options.create_new_var == True:
            add_var = True
        if add_var:
            var_name = data.add_variable('D', 'D [mm]',
                           VICDataVariableType.GlobalDisplacement)
        # store computation result in data set
        data.set_values({var_name: dd})
        # save the data
        data.save()
```

The method that processes the data follows. Here, the values for the required variables are first collected and the values for the new variable are computed. Then, it checks if the displacement variable already exists in the data. If not, or if the *"create-new-variable"* option is true, a new variable is added to the dataset. Finally, the values for the variable are set and the dataset is saved.

Chapter 21

The vicpyx Python Module

The *vicpyx* python module permits loading and saving of VIC-3D data files in python. This allows custom post-processing and data reduction algorithms to be implemented very quickly and efficiently. Since the python module can write results in VIC-3D's native output format, the post-processing results can then be used in VIC-3D for visualization.

Moreover, the vicpyx modules powers the *Extensions* found in VIC-3D.

The vicpyx module is not compatible with the old VICPy module. Scripts written for VICPy need to be updated for vicpyx. The new module introduces several optimizations, enabling users to write more efficient code that also executes faster. Users of the VICPy module are encouraged to update their scripts to take advantage of the new one.

21.1 Installation

The vicpyx module is available on *The Python Package Index* and can be installed with the following pip command:

```
pip install vicpyx
```

If you'd like to test the module, install the examples from this link: Python Examples. A short instruction file is in the ZIP.

21.1.1 Running vicpyx Scripts

1. If you are comfortable with the console you can simply use the console Python application to run .py and .pyw modules.
2. To run directly, you will have to associate .py and .pyw modules with the relevant applications. To do this, navigate to the file; right-click, and select **Open with...**.
3. Select **More apps**.
4. Scroll all the way to the bottom, and select **Look for another app on this PC**
5. Navigate to the folder path\to\your\python.exe.

6. Select python.exe for .py files, and pythonw.exe for .pyw files. (For applications with a graphical interface, PYW files will show the application without the unnecessary console window.)
7. After this, if you double click on another script, it should run directly.

21.2 Example

To illustrate what can be done with the vicpyx module, here is a very simple example that loads a data file, computes the magnitude of the displacement for all data points, and saves the data file under a new filename.

```
import sys
from os import _exit as exit

import numpy as np
from vicpyx import *
if len(sys.argv) != 3:
    print(f"Usage: {sys.argv[0]} infile.out outfile.out\n")
    exit(-1)

dataset = VICDataSet()

if dataset.load(sys.argv[1]) == False:
    print("Could not load data set\n")
    exit(-1)

var_names = ["U", "V", "W"]
values = dataset.get_values(var_names)

D_values = np.sqrt(values["U"] ** 2 + values["V"] ** 2 + values["W"] ** 2)

vars = dataset.variables()

d_var = "D"
if d_var not in vars:
    d_var = dataset.add_variable("D", "Δ [mm]")

dataset.set_values({d_var: D_values})

if dataset.save(sys.argv[2]) == False:
    print("Could not save the dataset\n")
    exit(-1)
```

Breaking down the different parts of the script:

21.2.1 Imports

```
import sys
from os import _exit as exit

import numpy as np
from vicpyx import *
```

The beginning of the script imports the required modules for the script. The `sys` module provides access to the command-line arguments and the `exit` function is imported from the `os` module. The `numpy` module is imported so that the square-root function can be used and finally the `vicpyx` module is imported so that its classes become available for use.

21.2.2 Checking the arguments and loading the Dataset

```
if len(sys.argv) != 3:
    print(f"Usage: {sys.argv[0]} infile.out outfile.out\n")
    exit(-1)

dataset = VICDataSet()

if dataset.load(sys.argv[1]) == False:
    print("Could not load data set\n")
    exit(-1)
```

The program checks that an input and output file are specified on the command line and displays a usage message if not and then exits. If two arguments are given, a `VICDataSet` is created and the script attempts to read the specified input file. If an error occurs, the program displays an error message and exits.

21.2.3 Computing and adding the new variable to the Dataset

```
var_names = ["U", "V", "W"]
values = dataset.get_values(var_names)

D_values = np.sqrt(values["U"] ** 2 + values["V"] ** 2 + values["W"] ** 2)

vars = dataset.variables()

d_var = "D"
if d_var not in vars:
    d_var = dataset.add_variable("D", "Δ [mm]")

dataset.set_values({d_var: D_values})
```

Here, the values of the displacement on each axis are first retrieved from the dataset. Then the values for the new variable is calculated. This is done for all points in the dataset. Then, a check is performed to see if the dataset already contains a variable with the same name, and if not, it is then added. Note here, that the 'add_variable' method returns the name of the variable just added to the dataset. This ensures that all variable names in VIC data files remain be unique. The values for the new variable are then set in the dataset.

21.2.4 Writing the dataset

```
if dataset.save(sys.argv[2]) == False:
    print("Could not save the dataset\n")
    exit(-1)
```

Finally, the script saves the dataset in the output file specified on the command line.

21.3 Detailed vicpyx Python Module documentation

21.3.1 Module vicpyx.extensions.aoi_object

21.3.1.1 Class AOIObject

```
def set_image_size(self, width, height)

def add_polygon(self, poly)

def as_dictionary(self)
```

21.3.2 Module vicpyx.extensions.extension_base

21.3.2.1 Class FullFieldExporter

Extension for exporting full-field data, one output file at a time.

```
def process(self)

def process_data(self, data)
```

21.3.2.2 Class FullFieldProcessor

Extension for processing full-field data, one output file at a time.

```
def process(self)

def process_data(self, data)
```

21.3.2.3 Class LineSliceGenerator

Extension for generating line (slice) data from Vic output files.

```
def process(self)
```

```
def process_data(self, data, line_data)
```

21.3.2.4 Class PointDataGenerator

Extension for generating point data from Vic output files.

```
def process(self)
```

```
def process_data(self, data, point_data_set)
```

21.3.2.5 Class SingleProcessor

Extension that runs only once and can return a SingleObjectSet.

```
def process(self)
```

```
def process_data(self, obj, data, image)
```

21.3.2.6 Class VicExtension

Base class for Vic extensions. Provides argument parsing.

```
def add_arguments(self, parser)
```

Add extra arguments to the extension. For instance, use

```
def add_arguments(self, pars):
    pars.add_argument('--radius', help='Circle radius', type=float, default=2.0)
```

The radius will be available as self.options.radius.

```
def enable_shuffle_data(self, enable)
```

```
def read_text_args(self, args)
```

```
def run(self, args=None)
```

Run the extension.

```
def process(self)
```

21.3.3 Module vicpyx.extensions.extension_mixins

21.3.3.1 Class AoiMaskAction

21.3.3.2 Class AoiMaskMixin

Mixin for AOI mask. Adds –aoi-mask to the argument parser.

21.3.3.3 Class DataSequenceAction

21.3.3.4 Class DataSequenceMixin

Mixin for DataSequence. Adds –input to the argument parser.

21.3.3.5 Class FilterCenterMixin

Mixin for the –filter-center argument. Shared by DataSequenceMixin and ImageSequenceMixin.

21.3.3.6 Class ImageSequenceAction

21.3.3.7 Class ImageSequenceMixin

Mixin for ImageSequence. Adds –image to the argument parser.

21.3.3.8 Class InspectorCircleMixin

Mixin for inspector circle. Adds –inspector-circle to the argument parser.

```
def read_inspector_circle(obj)
```

21.3.3.9 Class InspectorExtensometerMixin

Mixin for inspector extensometers. Adds –inspector-extensometer to the argument parser.

```
def read_inspector_extensometer(obj)
```

21.3.3.10 Class InspectorLineMixin

Mixin for inspector lines. Adds –inspector-line to the argument parser.

```
def read_inspector_line(obj)
```

21.3.3.11 Class InspectorPointMixin

Mixin for inspector points. Adds –inspector-point to the argument parser.

```
def read_inspector_point(obj)
```

21.3.3.12 Class InspectorPolygonMixin

Mixin for inspector polygons. Adds –inspector-polygon to the argument parser.

```
def read_inspector_polygon(obj)
```

21.3.3.13 Class InspectorRectangleMixin

Mixin for inspector rectangle. Adds –inspector-rect to the argument parser.

```
def read_inspector_rect(obj)
```

21.3.3.14 Class JsonOutputMixin

Mixin for JSON output. Adds –output to the argument parser.

21.3.3.15 Class ReferenceDataAction

21.3.3.16 Class ReferenceDataMixin

Mixin for reference data. Adds –reference-data to the argument parser.

21.3.3.17 Class SubsetSizeMixin

Mixin for subset size. Adds –subset-size to the argument parser.

21.3.3.18 Class VariableListMixin

Mixin for variable list. Adds –variable-list to the argument parser.

```
def read_variable_list(vars)
```

21.3.4 Module vicpyx.extensions.extension_sequences

21.3.4.1 Class DataSequence

```
def data(self, index=0)
```

21.3.4.2 Class DataSet

```
def set_port(self, port)
```

```
def set_block_saving(self, block)
```

```
def load(self, filename)
```

```
def save(self, filename=None)
```

21.3.4.3 Class FileSequence

```
def set_file_list(self, files)
```

```
def file_list(self)
```

```
def number_of_files(self)
```

```
def file_name(self, index=0)
```

21.3.4.4 Class ImageSequence

```
def image(self, index=0)
```

21.3.5 Module vicpyx.extensions.extension_socket

21.3.5.1 Class ExtensionSocket

```
def get_data(self, req)
```

21.3.6 Module vicpyx.extensions.inspector_item_set

21.3.6.1 Class InspectorItemSet

```
def set_forbidden_names(self, ii_names)
```

```
def enable_average(self, enable)
```

```
def add_point(self, x, y, name=None)
```

```
def add_line(self, points, name=None)
```

```
def add_extensometer(self, x0, y0, x1, y1, name=None)
```

```
def add_polygon(self, points, name=None)
```

```
def add_disc(self, x, y, radius, name=None)
```

```
def add_rectangle(self, width, height, cx, cy, name=None)
```

```
def as_dictionary(self)
```

21.3.7 Module vicpyx.extensions.line_data

21.3.7.1 Class LineData

```
def add_line(self, var_name, var_desc, data)
```

```
def variable_names(self)
```

21.3.7.2 Class LineDataSet

```
def set_port(self, port)
```

```
def set_file_name(self, filename)
```

```
def append(self, line_data)
```

```
def as_dictionary(self)
```

```
def save(self, filename=None)
```

21.3.7.3 Class VicLineSliceEncoder

```
def default(self, obj)
```

21.3.8 Module vicpyx.extensions.point_data

21.3.8.1 Class PointData

```
def set_data(self, name, variables, descriptions, values)
```

21.3.8.2 Class PointDataSet

```
def set_port(self, port)
```

```
def set_file_name(self, filename)
```

```
def append(self, point_data)
```

```
def as_dictionary(self)
```

```
def save(self, filename=None)
```

21.3.8.3 Class VicPointDataEncoder

```
def default(self, obj)
```

21.3.9 Module vicpyx.extensions.single_object

21.3.9.1 Class SingleObjectSet

```
def set_port(self, port)
```

```
def set_file_name(self, filename)
```

```
def set_aoi(self, aoi)
```

```
def set_inspector_forbidden_names(self, ii_names)
```

```
def add_inspector_point(self, x, y, name=None)

def add_inspector_line(self, points, name=None)

def add_inspector_extensometer(self, x0, y0, x1, y1, name=None)

def add_inspector_polygon(self, points, name=None)

def add_inspector_disc(self, x, y, radius, name=None)

def add_inspector_rectangle(self, width, height, cx, cy, name=None)

def enable_inspector_average(self, enable)

def set_transformation(self, transformation)

def add_startpoint(self, startpoint)

def add_line_dataset(self, line_dataset)

def add_point_dataset(self, point_dataset)

def add_file_sequence(self, files)

def as_dictionary(self)

def save(self, filename=None)
```

21.3.10 Module vicpyx.extensions.start_point_set

21.3.10.1 Enum GuessType

- Reference
- User

21.3.10.2 Class StartPoint

```
def add_guess(
    self,
    image,
    pos_x,
    pos_y,
    du_x=0.0,
    du_y=0.0,
    dv_x=0.0,
    dv_y=0.0,
    type=<GuessType.Reference: 0>,
)

def as_dictionary(self)
```

21.3.10.3 Class StartPointGuess

```
def set_guess(self, image, pos_x, pos_y, du_x, du_y, dv_x, dv_y, type)

def as_dictionary(self)
```

21.3.11 Module vicpyx.extensions.transformation_object

21.3.11.1 Class TransformationObject

```
def as_dictionary(self)
```

21.3.12 Module vicpyx.vicpy

21.3.12.1 Function change_file_extension

```
def change_file_extension(full_file_name, extension)
```

Returns the Vic data file name with the requested extension.

Changes the file extension to the requested one. It supports file names for both out files and dataset saved in HDF5 files.

Args:

- full_file_name: The file name of the Vic data file. Also supports H5 name encoding
- extension: The desired file extension

Returns:

- The file name with the requested extension

21.3.12.2 Enum AngleType

- Rad
- Deg

21.3.12.3 Enum CsDataSystemType

- Type2d
- Type3d

21.3.12.4 Enum RTClientMessageType

- DATA
- ANALOG_DATA

21.3.12.5 Enum TensorType

- LagrangeStrainTensor
- HenckyStrainTensor
- EulerStrainTensor
- LogarithmicEulerTensor
- EngineeringStrain
- BiotStrainTensor

21.3.12.6 Enum VicDataVariableType

- PixelCoordinate
- GlobalCoordinate
- PixelDisplacement
- GlobalDisplacement
- Strain
- Correlation
- Unknown
- Disparity
- CylinderCoordinate
- CylinderDisplacement
- PixelVelocity
- GlobalVelocity
- StrainRate
- Curvature
- Angle
- AngularVelocity
- GlobalAcceleration
- PixelAcceleration
- Stress
- AngularAcceleration

21.3.12.7 Class AOIPolygon

Implements a polygon with cutouts used to define AOIs.

This class is used to define an AOI polygon that can include holes. It also defines the subset and step sizes used during correlation.

```
def set_outline(self, outline)
```

Sets the polygon outline.

Args:

- outline: A list of x, y coordinates that define a point in the outline of the polygon

```
def set_cutouts(self, cutouts)
```

Sets the polygon cutouts.
Args:

- cutouts: A list of lists of x, y coordinates that define a point in the outline of a cutout

```
def add_cutout(self, cutout)
```

Adds a cutout to the polygon.
Args:

- cutout: A list of x, y coordinates that define a point in the outline of a cutout

```
def set_subset_size(self, subset_size)
```

Sets the subset size for the AOI.
Args:

- subset_size: The subset size. Should be between 9 and 151

```
def set_step_size(self, step_size)
```

Sets the step size for the AOI.
Args:

- step_size: The step size. Should be between 1 and 30.

21.3.12.8 Class ProjectCalibration

Holds a Vic-3D project's calibration data.

```
def read_calibration(self, project_file)
```

Reads the project calibration from an xml etree object
Args:

- project_file: The project file as an xml.etree.Element

```
def write_calibration(self, project_file)
```

Writes the project calibration to an xml etree object.
Args:

- project_file: The project file as an xml.etree Element

```
def triangulate(self, position_left, position_right)
```

Triangulates a 3D point from its image coordinates
Args:

- position_left: A tuple or a list of size 2 representing the pixel position in the left image
- position_right: A tuple or a list of size 2 representing the pixel position in the right image

Returns:

- A tuple or list of size 3 representing the triangulated position in world coordinates

```
def project(self, world_position)
```

Computes the projection of a 3D point into the camera coordinate systems
Args:

- world_position: A tuple or a list of size 3 representing a world position

Returns:

- A tuple or list of size (2, 2) representing the camera positions. Left camera first followed by the right

```
def ray(self, camera_id, pixel_position)
```

Computes the ray for a specific pixel position and camera
Args:

- camera_id: The camera id. Should be either 0 or 1
- pixel_position: A tuple or a list of size 2 representing the pixel position

Returns:

- A tuple or list of size (2, 3) representing the origin and direction of the ray

```
def intrinsic_matrix(self, camera_id)
```

Returns the intrinsic matrix for the selected camera
Args:

- camera_id: The camera id. Should be either 0 or 1

```
def extrinsic_matrix(self, camera_id)
```

Returns the extrinsic matrix for the selected camera
Args:

- camera_id: The camera id. Should be either 0 or 1

```
def radial_distortion(self, camera_id)
```

Returns the radial distrortion coefficients for the selected camera. Only valid for pinhole camera models
Args:

- camera_id: The camera id. Should be either 0 or 1

```
def tangential_distortion(self, camera_id)
```

Returns the tangential distrortion coefficients for the selected camera. Only valid for pinhole camera models
Args:

- camera_id: The camera id. Should be either 0 or 1

```
def prismatic_distortion(self, camera_id)
```

Returns the prismatic distrortion coefficients for the selected camera. Only valid for pinhole camera models
Args:

- camera_id: The camera id. Should be either 0 or 1

21.3.12.9 Class ProjectFile

Implements reading and writing some basic components of a Vic-3D project.

```
def reset(self)
```

Resets the state of the object.

```
def is_empty(self)
```

Checks if the object is initialized.

```
def create_project_file(self, file_name, project_directory=None)
```

Creates a new project file.
The file is only created in memory. Call save_project to save it.
Args:

- file_name: The file name for the project file
- project_directory: The porject directory. If not set, it will default to the directory of the file_name

```
def set_project_file_name(self, file_name)
```

Sets the project file name.
Args:

- file_name: The project file name.

```
def load(self, source)
```

Loads a project from a Vic-3D project file.
Args:

- source: The Vic-3D project file.

```
def save_project(self, file_name=None)
```

Saves the project file
Args:

- file_name: Optional file name used for saving. If not set it will use the existing file name.

```
def get_data_files(self)
```

Returns the list of data files.

```
def set_data_files(self, data_files)
```

Sets the list of data files.
Args:

- data_files: The data file list.

```
def get_deformed_images(self)
```

Returns the list of deformed images.

```
def set_deformed_images(self, deformed_images)
```

Sets the list of deformed images.
Args:

- deformed_images: The list of deformed images.

```
def get_reference_image(self)
```

Returns the reference image.

```
def set_reference_image(self, reference_image)
```

Sets the reference image.
Args:

- reference_image: The reference image.

```
def get_project_calibration(self)
```

Returns the project calibration.

```
def set_project_calibration(self, project_calibration)
```

Sets the project calibration.
Args:

- project_calibration: The project calibration as a ProjectCalibration object.

```
def get_startpoints(self)
```

Returns the list of startpoints.

```
def add_startpoint(self)
```

Adds a new startpoint.
Returns:

- The name of the new startpoint.

```
def set_startpoint_guess(
    self,
    start_point,
    image_name,
    position,
    du,
    dv,
)
```

Sets a startpoint guess for the image
Args:

- start_point: The name of the startpoint. This should be either from get_startpoints or add_startpoint.
- image_name: The image for the guess.
- position: The position of the guess in the image coordinates as a tuple or list.
- du: The u derivative as a tuple or list
- dv: The v derivative as a tuple or list

```
def get_aoi_polygon_masks(self)
```

Returns the list of AOIPolygon masks.

```
def set_aoi_polygon_masks(self, masks, width, height)
```

Sets the AOIPolygon masks
Args:

- masks: The list of AOIPolygon masks.
- width: The image width.
- height: The image height.

```
def get_analog_data_csv(self)
```

Returns the analog data csv as a dictionary.
The dictionary has a key 'header' that contains the csv header and then a key for each element in the header.

21.3.12.10 Class RTClient

Implements a real time server client.
This class is used to connect to a Vic-3D/Vic-2D instance working in realtime mode and forward the desired data to any connected handlers.

```
def register_handler(self, message_type, handler)
```

Register handler for different message type.
Usage example: client.register_handler(RTClientMessageType.DATA, lambda data_i, cs_data_set: print(f"Received data: {data_i}"))
Args:

- message_type: Message type to handle.
- handle: Function to handle the specified message type.

```
def connect(self)
```

Connects to the server.

```
def disconnect(self)
```

Disconnects from the server.

```
def request_start_data_streaming(self)
```

Request start streaming VicDataSet files.

```
def request_stop_data_streaming(self)
```

Request stop streaming VicDataSet files.

```
def request_analog_data_while_streaming(self)
```

Request streaming analog data (in JSON format) along with data files.

21.3.12.11 Class RigidTransformation

Implements a three dimensional rigid transformation.

```
def rotation(self)
```

Returns the rotation for this rigid transformation.

```
def translation(self)
```

Returns a tuple of the translation for this rigid transformation.

```
def set_rotation(self, rotation)
```

Sets the rotation for this rigid transformation.
Args:

- rotation: The rotation.

```
def set_translation(self, translation)
```

Sets the translation for this rigid transformation.
Args:

- translation: The translation as a tuple or list.

```
def matrix(self)
```

Returns the 4x4 rigid transformation matrix.

```
def apply(self, point)
```

Applies the rigid transformation to the point
Args:

- point: A tuple or list, with a size of 3.

Returns:

- A tuple or a list of the transformed point.

```
def invert(self)
```

Inverts this rigid transformation.

```
def plane_fit(self, dataset, ignore_displacement=False)
```

Computes the best plane fit for a dataset.
If successful, this rigid body transformation object will be set to the computed transformation.
Args:

- dataset: The VicDataSet to process.
- ignore_displacement: If True, the displacement will be ignored.

Returns:

- True if successful

```
def from_displacement(self, dataset)
```

Computes the rigid transformation between the reference and deformed state of the dataset.
If successful, this rigid body transformation object will be set to the computed transformation.
Args:

- dataset: The VicDataSet to process.

Returns:

- A tuple with a boolean to show operation success and the residual

21.3.12.12 Class Rotation

Implements a three dimensional rotation.

```
def angles(self, angle_type=AngleType.Deg)
```

Get the angles of the rotation object.
Args:

- angle_type: Type of angle output

Returns:

- A tuple of the Cardan-Bryant angles.

```
def set_angles(
    self,
    alpha=0,
    beta=0,
    gamma=0,
    angle_type=AngleType.Deg,
)
```

Sets the rotation angles.
Args:

- alpha: Rotation around x
- beta: Rotation around y
- gamma: Rotation around z
- angle_type: Type of angle input

```
def matrix(self)
```

Returns the 3x3 rotation matrix.

```
def set_matrix(self, mat)
```

Sets the rotation using a 3x3 rotation matrix.
Args:

- mat: The 3x3 rotation matrix

```
def load_identity(self)
```

Sets the rotation to identity.

```
def apply(self, point)
```

Applies the rotation to the point
Args:

- point: A tuple or list, with a size of 3.

Returns:

- A tuple or a list of the rotated point.

21.3.12.13 Class VicData

Holds all the data for an AOI in a VicDataSet.

This class should be used if you want to work on a specific AOI only. In most cases, working with a VicDataSet is prefered since that includes and affects the whole dataset.

```
def clear(self)
```

Clears this object of all data.

```
def copy(self)
```

Returns a copy of this.

```
def num_rows(self)
```

Returns the number of rows in the data matrix.

```
def num_columns(self)
```

Returns the number of columns in the data matrix.

```
def num_variables(self)
```

Returns the number of variables in the data matrix.

```
def matrix_size(self)
```

Returns the size of the data matrix.

```
def current_data_type(self)
```

Returns the type of the data.

```
def variable_name(self, n)
```

Returns the name of a variable.
Args:

- n: The index of the variable to look up.

Returns:

- The name of the variable.

```
def variable_description(self, n)
```

Returns the description of a variable.
Args:

- n: The index of the variable to look up.

Returns:

- The description of the variable.

```
def variable_type(self, n)
```

Returns the type of a variable.
Args:

- n: The index of the variable to look up.

Returns:

- The type of the variable.

```
def variable_index(self, variable)
```

Returns the index of a variable specified by its name.
Args:
variable: The variable to search for.
Returns:

- int : Position in the array if found, else -1.

```
def find_minimum(self, variable_index)
```

Returns the minimum value and its position for a given variable in the dataset.
Args:

- variable_index: The variable to search over. Can be the variable name or index.

Returns:

- A tuple with the minimum value and the position of the minimum for the variable.

```
def find_maximum(self, variable_index)
```

Returns the maximum value and its position for a given variable in the dataset.
Args:

- variable_index: The variable to search over. Can be the variable name or index.

Returns:

- A tuple with the maximum value and the position of the maximum for the variable.

```
def value(self, n, variable_index)
```

Returns the value of a variable at a specific position.
Args:

- n: The position to look up.
- variable_index: The index of the variable.

Returns:

- The value of the variable at position n.

```
def as_array(self, variables)
```

```
def get_values(self, variables)
```

Returns a numpy array of a set of variables.
Args:

- variables: List of variable names.

Returns:

- A numpy array of the values found.

```
def values(self, n, variable_ids)
```

Returns the values of a set of variables at a specific position.
Args:

- n: The position to lookup.
- variable_ids: The variables to lookup specified by index.

Returns:

- A list of the values found.

```
def set_value(self, n, variable_index, value)
```

Sets the value of a variable at a specific position.
Args:

- n: The position to set the value.
- variable_index: The variable to change. Can be the variable name or index.
- value: The value to set

```
def set_values(self, variable_index, values)
```

Sets all the values of a variable.
Args:

- variable_index: The variable to change. Can be the variable name or index.
- values: The values to set.

```
def clear_search_trees(self)
```

Clears the search trees used in at_global_xy. Call this method if you edited any data in this VicData

```
def at_global_xy(self, x, y, variable_list, use_tree=False)
```

Returns the values of a set of variables at a specific global position.
Args:

- x: The x coordinate of the global position to lookup.
- y: The y coordinate of the global position to lookup.
- variable_list: The variables to lookup. Can be the variable name or index.
- use_tree: If true, the first call will construct a search tree to speed up future searches.

Returns:

- A list of the values found or None if nothing is found.

```
def lookup_variables(self, x, y, variable_list)
```

Returns the values of a set of variables at a specific pixel position.
Args:

- x: The x coordinate of the global position to lookup.
- y: The y coordinate of the global position to lookup.
- variable_list: The variables to lookup specified by their name.

Returns:

- A list of the values found or None if nothing is found.

21.3.12.14 Class VicDataSet

Holds all the Vic data in a data file.

This is the main data class. It has access and can modify all the different AOIs in a dataset. It is an iterable class that returns all VicData for each AOI in the dataset.

```
def copy(self)
```

Returns a copy of this.

```
def current_data_type(self)
```

Returns the type of the data.

```
def load_from_data(self, buffer, file_name)
```

Loads data from a byte array into this object.
Args:

- buffer: The memory buffer data to load from.
- file_name: Dataset file name.

```
def load(self, file_name)
```

Loads a Vic-3D data file into this object.
Args:

- file_name: The file to load. Can be the path to an out file or a dataset in an HDF5 file

```
def save(self, file_name=None)
```

Saves the VicDataSet to an out file or HDF5 dataset.
Args:

- file_name: The name of the file to save this VicDataSet. To save in an hdf5 file, the file name
- should follow the format 'path/to/file.h5:out:index', where index is the dataset index.

```
def variables(self)
```

Returns a list of variables.

```
def variable_descriptions(self)
```

Returns a list of variables descriptions.

```
def variable_types(self)
```

Returns a list of the variables types.

```
def set_variable_description(self, variable, variable_description)
```

Changes the description for the specified variable
Args:

- variable: The variable whose description to change
- variable_descritpion: The variable description

```
def export_raw(self)
```

Returns the raw data of the VicDataSet in the Vic-3D format.

```
def file_name(self)
```

Returns VicDataSet file name or None if empty.

```
def set_file_name(self, file_name)
```

Sets the file name of this VicDataSet.

```
def reference_image(self)
```

Returns the reference image file name.

```
def set_reference_image(self, file_name)
```

Sets the reference image file name.

```
def deformed_image(self)
```

Returns the deformed image file name.

```
def set_deformed_image(self, file_name)
```

Sets the deformed image file name.

```
def num_data(self)
```

Returns the number of AOI in the dataset.

```
def data(self, n)
```

Returns the data for the requested AOI.
Args:

- n: The index of the AOI to access.

Returns:

- A VicData object for the selected AOI in the dataset.

```
def matrix_size(self)
```

Returns the combined size of all AOIs.

```
def get_values(self, variables)
```

Returns a numpy array for the variables for all AOIs.
The triangulation() function returns indices into this array.
Args:

- variables: List of variable names.

Returns:

- A numpy array of the values found.

```
def set_values(self, variables)
```

Sets the values for an existing variable in the dataset.
Args:

- variables: Dictionary or numpy structured array of variables with the values to set

```
def triangulation(self, sub_sample=1)
```

Returns a triangulation for the dataset.
Args:

- sub_sample: Sub-sampling value for data reduction.

Returns:

- A n-by-3 numpy array of triangle indices, where n is the number of triangles.

```
def range(self, variable)
```

Returns the range of values for a variable.

```
def sum_range(self, variable_0, variable_1)
```

Returns the range of the sum of two variables.

```
def add_variables(self, variables)
```

Adds new variables to every AOI contained in the dataset.
Args:

- variables: Name to description dictionary of the variables to add.

Returns:

- A list of the unique variable names assigned to the variables.

```
def add_variable(
    self,
    variable_name,
    variable_description,
    variable_type=VicDataVariableType.Unknown,
    values=[],
)
```

Adds a variable to all AOIs in the dataset.
Args:

- variable_name: Name of the variable to add.
- variable_description: Description of the variable to add.
- variable_type: Variable type.
- values: List of values for the new variable.

Returns:

- The unique variable name assigned to the variable.

```
def delete_variable(self, variable_name)
```

Deletes variable from all AOIs in the dataset.
Cannot delete any of the required variables:
['X', 'Y', 'Z',
'U', 'V', 'W',
'sigma',
'x', 'y',
'u', 'v',
'q', 'r',
'q_ref', 'r_ref',
'x_c', 'y_c',
'u_c', 'v_c']
Args:

- variable_name: Name of the variable to delete

```
def compute_strain(
    self,
    window_size=15,
    tensor_type=TensorType.LagrangeStrainTensor,
    compute_principal_strain=True,
    reuse_variables=True,
    compute_tresca=False,
```

```
    compute_von_mises=False,
    output_gradient=False,
    add_size_to_decription=True,
    displacement_variables=[],
    suffix=None,
)
```

Computes the strain over all AOIs in the dataset.
Args:

- window_size: The window size
- tensor_type: The tensor type
- compute_principal_strain: If True, principal strains will also be computed
- reuse_variables: If True and the dataset has the strain variables computed, the old ones will be replaced
- compute_tresca: If True, the Tresca strain will also be computed
- compute_von_mises: If True, the Von Mises strain will also be computed
- output_gradient: If True, the gradients will also be computed
- add_size_to_decription: If True, the window size is added to the description of the strain variables
- displacement_variables: A vector of two or three that defines the variables that should be used as the displacement variables. The order must be X, Y and Z-axis displacements
- suffix: Optional suffix to be used in variable names and descriptions. Should only contain alphanumericals and underscores Returns:
- A dictionary with all the variables created. The possible dictionary keys are
- [exx, exy, eyy, fxx, fxy, fyx, fyy, e1, e2, gamma, tresca, vonmises]

```
def compute_curvature(
    self,
    window_size=15,
    compute_principal_curvature=True,
    reuse_vars=True,
    weighted_filter=True,
)
```

Computes the curvature over all AOIs in the dataset.
Args:

- window_size: The window size

- compute_principal_curvature: If True, principal curvature will also be computed.
- reuse_variables: If True and the dataset has the curvature variables computed, the old ones will be replaced
- weighted_filter: If True, a weighted filter will be used

```
def smooth(self, variable, window_size=15, weighted=True)
```

Applies smoothing to a variable
Args:

- variable: The variable to smooth
- window_size: The window size
- weighted: If True, a weighted filter will be used

```
def transform(self, rigid_transformation, displacement_only=False)
```

Applies a transformation to all AOIs in the dataset.
Args:

- rigid_transformation: The transformation that will be applied
- displacement_only: If True, it will only apply the displacement and will ignore any rotation

```
def clear_search_trees(self)
```

Clears the search trees used in at_global_xy. Call this method if you edited any data in this VicDataSet

```
def at_global_xy(self, x, y, variable_list, use_tree=False)
```

Returns the values of a set of variables at a specific global position.
Args:

- x: The x coordinate of the global position to lookup.
- y: The y coordinate of the global position to lookup.
- variable_list: The variables to lookup. Can be the variable name or index.
- use_tree: If true, the first call will construct a search tree to speed up future searches.

Returns:

- A list of the values found or None if nothing is found.

```
def lookup_variables(self, x, y, variable_list)
```

Returns the values of a set of variables at a specific pixel position.
Args:

- x: The x coordinate of the pixel position to lookup.
- y: The y coordinate of the pixel position to lookup.
- variable_list: The variables to lookup specified by their name.

Returns:

- A list of the values found or None if nothing is found.

21.3.12.15 Class VicDataSetIO

Holds a pair of a VicDataSetReader and a VicDataSetWriter.

This class provides the functionality of both a VicDataSetReader and a VicDataSetWriter. By default, the writer will overwrite the data in the reader source.

```
def set_reader(self, reader)
```

```
def get_data_source(self)
```

Returns the data source.

```
def get_dataset_list(self)
```

Returns the list of all dataset in the source.

```
def load_from_hdf5(self, h5_file_name)
```

Loads all available dataset in an HDF5 file.
Args:

- h5_file_name: The path to the HDF5 file.

```
def load_from_directory(self, directory)
```

Loads all available dataset in a directory.
Args:

- directory: The path to the directory.

```
def load_from_project(self, project)
```

Loads all available dataset in a project.
Args:

- project: The path to the Vic-3D project file.

```
def dataset(self, dataset_id)
```

Returns the VicDataSet with the specified name.
Args:

- dataset_name: The dataset name as in the get_dataset_list().

Returns:

- A VicDataSet for the data file.

```
def set_output(self, output_dest)
```

Sets the output destination.
Args:

- output_dest: The output destination. It can be either a directory or an HDF5 file.

```
def set_output_prefix(self, output_prefix)
```

Sets a string to be used as prefix when saving data
Args:

- output_prefix : The prefix

```
def save(self, data)
```

Saves a VicDataSet
Args:

- data: The dataset to save

21.3.12.16 Class VicDataSetReader

Holds a set of VicDataSet from a source.

This class holds all available datasets from a supported source. Supported sources include directories with out files, HDF5 files, and project files. It also supports global patterns. If the source is a project file, the source will be set to either the directory or HDF5 holding the data.It is an iterable class that returns all VicDataSet in the source.

```
def get_data_source(self)
```

Returns the dataset source.

```
def get_dataset_list(self)
```

Returns the list of all dataset in the source.

```
def load_from_hdf5(self, h5_file_name)
```

Loads all available dataset in an HDF5 file.
Args:

- h5_file_name: The path to the HDF5 file.

```
def load_from_directory(self, directory)
```

Loads all available dataset in a directory.
Args:

- directory: The path to the directory.

```
def load_from_project(self, project)
```

Loads all available dataset in a project.
Args:

- project: The path to the Vic-3D project file.

```
def dataset(self, dataset_name)
```

Returns the VicDataSet with the specified name.
Args:

- dataset_name: The dataset name as in the get_dataset_list().

Returns:

- A VicDataSet for the data file.

21.3.12.17 Class VicDataSetWriter

Writes VicDataSet to a specified output.

This class provides some convenience methods to write a set of VicDataSet. The output directory or HDF5 file can be set here and will be applied to any VicDataSet saved through this class.

```
def set_reader(self, reader)
```

Sets a VicDataSetReader.
The VicDataSetWriter will overwrite the data in the reader.
Args:

- reader: A VicDataSetReader that will specify the output for this writer.

```
def set_output(self, output_dest)
```

Sets the output destination.
Args:

- output_dest: The output destination. It can be either a directory or an HDF5 file.

```
def set_output_prefix(self, output_prefix)
```

Sets a string to be used as prefix when saving data
Args:

- output_prefix : The prefix

```
def save(self, data)
```

Saves a VicDataSet
Args:

- data: The dataset to save

Chapter 22

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.

22.1 What's New in VIC-2D 8

- Fully integrated Python extension system for easy execution of scripts directly from within VIC-2D.
- Real-time 2D analysis for live analysis with the appropriate license.
- Batch analysis via command line is now supported.
- Report generation from document templates, with VIC-2D-specific tags for scale factor, unit, and aspect ratio.
- FFT workspace now supports Frequency Response Function (FRF) analysis.
- Analysis and FFT workspaces now use the Iris-based plot engine, making plots fully configurable with templates, styles, and property editors.
- Images and data files stored in HDF5 containers can be added to a project via an embedded dataset picker.
- Multiple Iris documents in a single project.
- Dark mode capable.
- All new Iris templates, including dark mode variants.
- Video files can be used as image sequences in the Iris workspace.
- Add all data files from a selected folder to the project in a single step.
- Additional support for mesh data files including OBJ, STL, PLY, and many more formats.

- New project from template option for starting pre-configured projects.
- Independent secondary axes for line plots.
- Significant expansion of global preferences.
- Inspector element improvements.
- Analysis summary CSV is now saved inside the project file.
- Chinese language support is now complete.
- Calibration unit selector now shows the full standard unit list.
- Virtual strain gauge tool for computing averaged strain values over a user-defined gauge area.

22.2 Transitioning from Earlier Versions

- Projects saved in VIC-2D 8 use a new project structure and **cannot be loaded** in VIC-2D 7.

Chapter 23

Appendix: Controls and Elements

23.1 2D Plot Controls

Properties for 2D plots are grouped into the following categories.

23.1.1 Sequences

The **Sequences** control allows selection from existing data sources (triangulated data, extraction locations) for display. This control is only available in the *iris* workspace; in the analysis workspace, each plot has fixed source data.

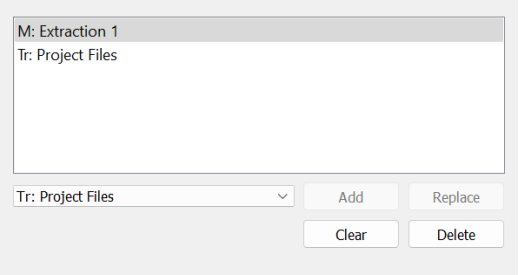

Figure 23.1: Sequence selector in 2D Plot

More information about sequence data sources is available in Section 18.6.4.1.

The Sequences tab also contains controls for the appearance of the plot; these controls are detailed in Section 18.6.3.1.

23.1.2 View

The 2D **View** group pictured in Fig. 23.2 controls the basic parameters of a 2D plot.

The current plot **Time** is controlled with a spin box and is animatable.

For reference, the frame associated with the selected time is displayed immediately below.

The **Interpolation** pulldown allows selection of *Nearest*, which will cause display of the data from the frame closest to the selected decimal time, or *Linear*, which will result in a data overlay that is interpolated from the data before and after the selected time.

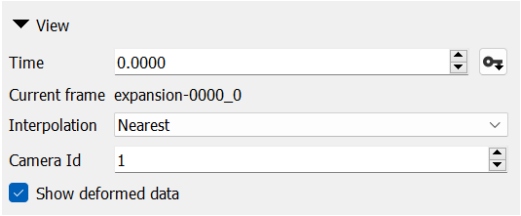

Figure 23.2: Sequence selector in 2D Plot

The **Camera Id** control allows selection of the background image view. If **Show deformed data** is checked, the background image will be of the *current* frame; otherwise, it will be of the *reference* frame.

23.1.3 All

The **All** controls shown in Fig. 23.3 are used to adjust the size and appearance of plot elements in 2D plots.

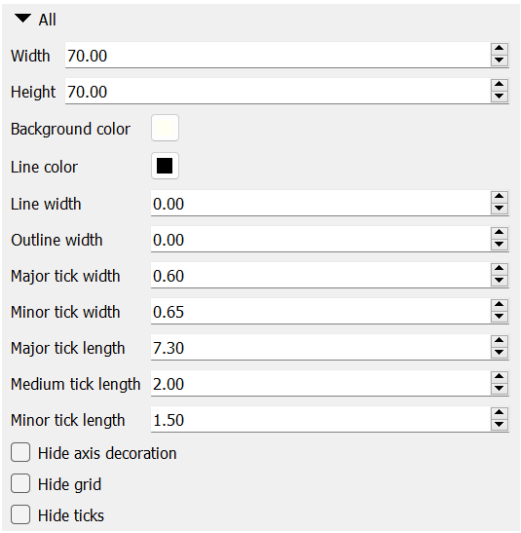

Figure 23.3: All Tool in 2D Plot

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, grid lines, and tick marks. The **Line width** sets the thickness of the background grid lines, and the **Outline width** controls the width of the plot border.

The background, grid, and ticks will only be visible if the plotted data does not fill the plot area.

The tick **width** and **length** for major and minor ticks can be adjusted here; tick *spacing* is set with the axis tools.

Selecting **Hide axis decoration** will 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.

23.1.4 Axes

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

23.1.5 Scale

For each 2D plot a visual scale indicator, as pictured in Fig. 23.4, is displayed by default:

Figure 23.4: 2D scale example.

The **Scale** tab pictured in Fig. 23.5 contains controls for the appearance of the indicator.

The **length units** may be specified with the pulldown. A complete set of controls for the positioning and appearance of the scale bar and label are also available.

23.1.6 Plot Positioning

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

23.1.7 Legend Properties

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

23.2 3D Plot Controls

23.2.1 Sequences

The Sequences control allows selection from existing data sources (triangulated data, extraction locations, markers) for display. This control is only available in the *iris* workspace; in the analysis workspace each plot is associated with a fixed data source.

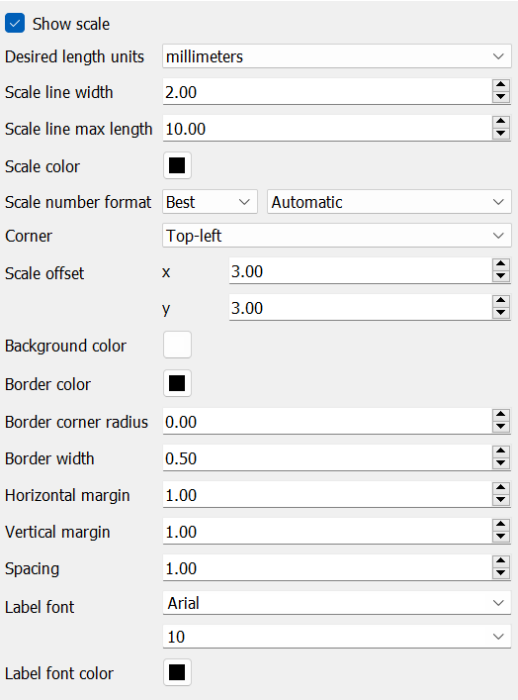

Figure 23.5: Scale controls

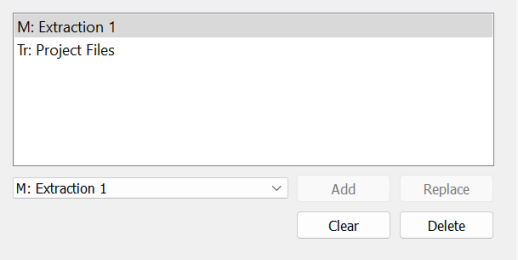

Figure 23.6: Sequence selector in 3D plot

More information about sequence data sources is available in Section 18.6.4.1.

The **Sequence** tab also contains controls for the appearance of the plot; these controls are detailed in Section 18.6.3.1.

23.2.2 View

The view properties shown in Fig. 23.7 control the visual appearance of the 3D plot and axes.

Frame time can be adjusted using the **Time** control, with values ranging from 0 to 1. The frame time is animatable.

The frame associated with the selected time is displayed immediately below.

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

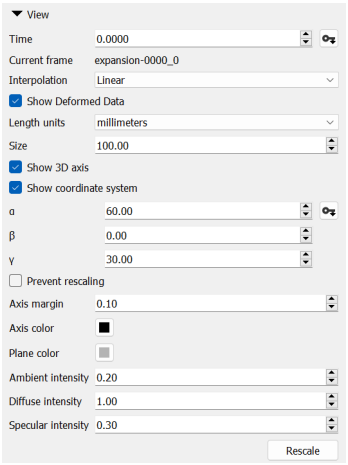

Figure 23.7: View tool in 3D plot

interpolation as well as disabling interpolation (nearest neighbor). Interpolation is used for triangulated data (plots, VTK data) but not for images.

The **Length units** pulldown may be used to select the unit for the axis scales.

The overall size of the plot may be set with the **Size** control.

The axis direction indicator may be enabled or disabled with the **Show 3D axis** checkbox.

Checking **Show coordinate system** will cause the axis planes and scales to be displayed.

The rotation angles for the plot about the X, Y and Z axes are set with the α, β, and γ controls, respectively. They may also be set by double-clicking in the plot and then clicking and dragging. The rotation angles are animatable as a group.

If **Prevent rescaling** is checked, the plot's scale will be maintained when the underlying data changes.

Changing the **Axis margin** affects the distance between the boundaries of the plot and the axis planes.

The color of the axis grid may be set with the **Axis color** control, and the color of the axis background planes with the **Plane color** control.

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.

23.2.3 Axes

The range and appearance of each axis is adjusted with the **X/Y/Z Axis** groups.

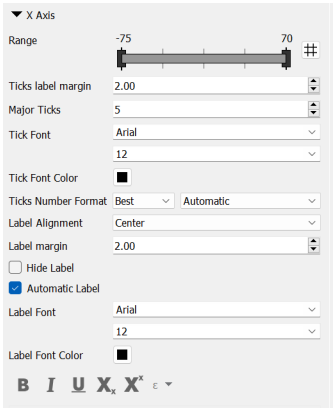

Figure 23.8: 3D X axis controls.

The range of the axis is set with the **Range** controls. Clicking the # icon allows direct entry of the minimum and maximum values; clicking again returns the sliders with the newly entered limits.

The **Ticks label margin** control sets the distance of the labels from the axis boundary.

The number of **Major Ticks** may be set here, as well as the **Font**, **Color**, and **Number Format**. The **Label alignment** and **Label margin** control the position of the main axis label. There is also a checkbox to **Hide** the label and **font** controls.

If **Automatic label** is checked, a label such as "X [mm]" is applied. If it is cleared, a text box appears below, and a custom label may be entered.

23.2.4 3D Axis

For each 3D plot, a Cartesian axis indicator as pictured in Fig. 23.9 is displayed by default:

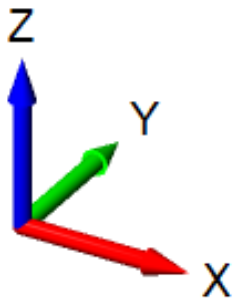

Figure 23.9: 3D axis example.

The appearance of the indicator may be controlled either by clicking on the indicator (*iris* workspace) or selecting the **3D Axis** tab (analysis workspace).

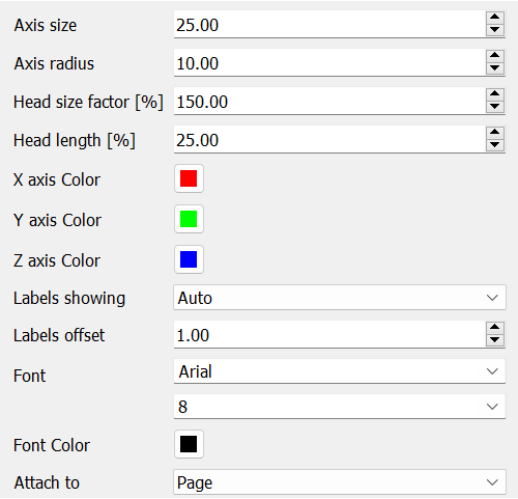

Figure 23.10: 3D Axis tool.

The size and radius of the 3D arrows may be controlled here, as well as each arrow's color. The label display may be set to *Off*, *On*, or *Auto* (each label will only be displayed if it is not obscured.) The font and color of the label text is also adjustable.

The 3D Axis tab also contains a base tool which allows position, rotation, scaling, and animation.

23.2.5 Plot Positioning

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

23.2.6 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.

23.3 Contour Legend Properties

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 in Fig. 23.11.

Clicking the relevant legend will highlight it with a black border; settings shown in Fig. 23.12 may then be edited using the toolbar at the side of the work area.

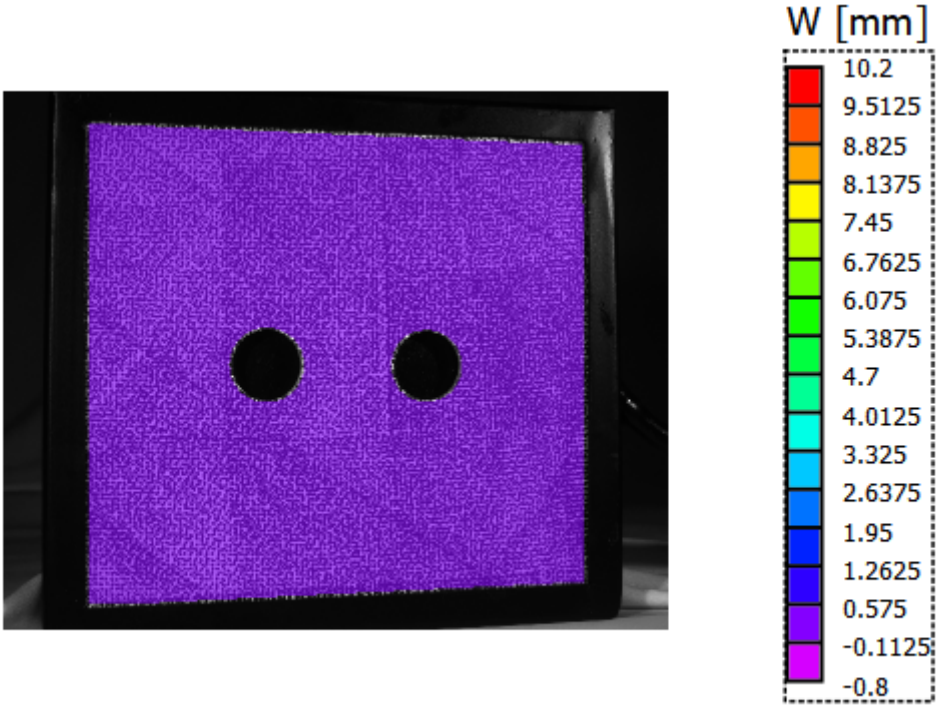

Figure 23.11: Plot with legend selected.

23.3.1 Legend Properties

23.3.1.1 Contour

The **Variable** pulldown determines which variable to overlay as a contour plot. A range of relevant units may be selected, or a custom **unit** and associated **factor** may be entered.

The range of contour variables (minimum and maximum) is set with the **Range** controls. Clicking the # icon allows direct entry of the minimum and maximum values; clicking again returns the sliders with the newly entered limits.

If **Prevent rescaling** is checked, the plot scale will not change if the underlying data is processed or modified.

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 **Show isolines** checkbox toggles the display of isolines in the plot. The number of isoline levels is set with the **Isolines** control. 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 in the legend 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**.

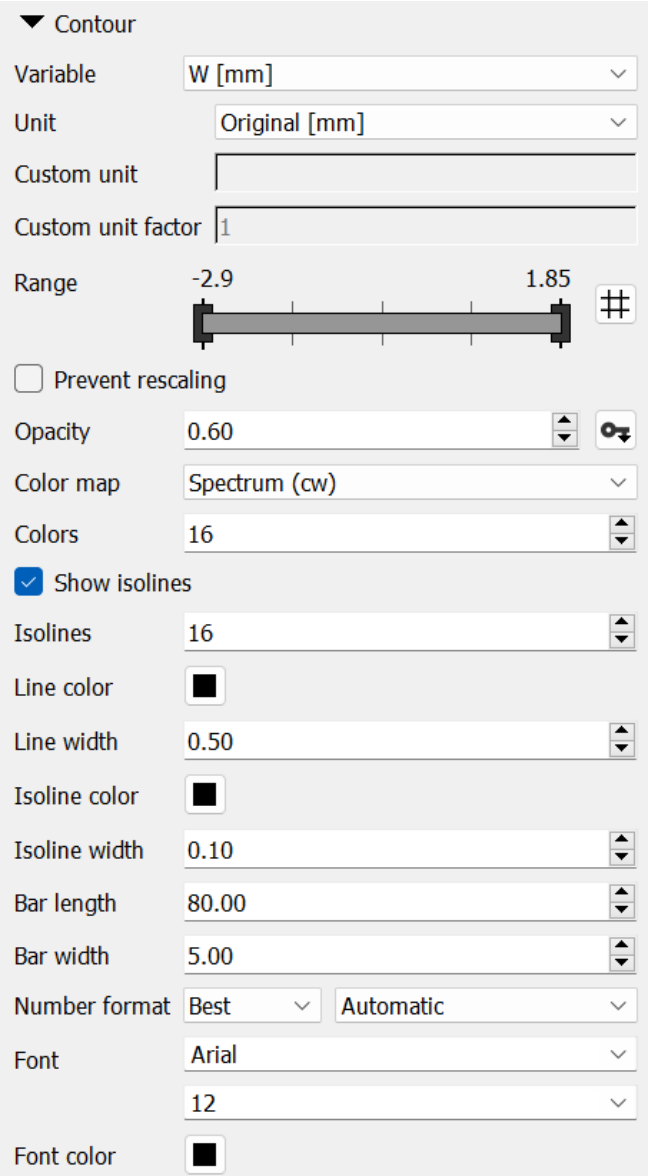

Figure 23.12: Legend tool for 3D plot.

23.3.2 Legend Positioning

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

> The contour variable name dispayed near the legend is an editable text box and may contain variable tags or custom text.

23.4 Line Plot Controls

This set of tools controls the plot data and appearance for line/extraction plots.

23.4.1 Charts controls

The **Charts** controls, pictured in Fig. 23.13, allow selection of data plot sources.

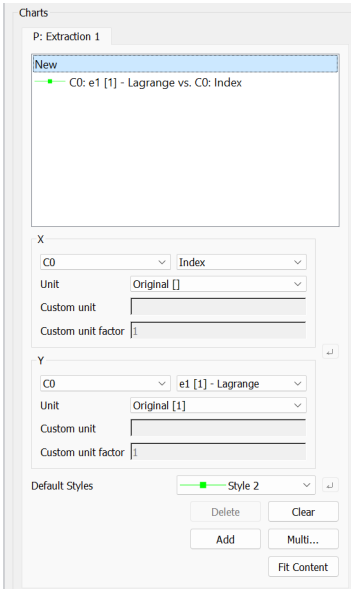

Figure 23.13: Charts data controls.

A new data series may be added by selecting **New** and choosing extraction nodes and components for each axis. A **Custom unit** and associated multiplying factor may also be applied, if desired. The style for the new series can be picked with the **Default Styles** control. Finally, clicking **Add** will add the series to the list above.

An existing data series may be edited by clicking on it to select and then adjusting the parameters below. To apply any changes, click the ↩ button to the right.

An individual series may be deleted by clicking the **Delete** button or by pressing the *Delete* key; clicking **Clear** removes all data series.

Clicking **Fit Content** will automatically fit the boundaries of the chart area to fit all plotted data.

Clicking the **Multi...** button will enable the addition of multiple data series or multiple objects at once, using the dialog pictured in Fig. 23.14.

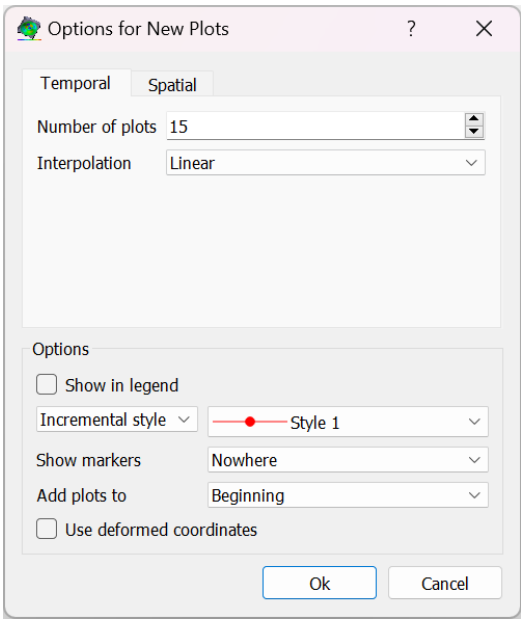

Figure 23.14: Multi series dialog for line extractions.

- For the case of *line* extraction, a **Temporal** and **Spatial** tab are available. The **Temporal** tab has controls for the number of waterfall lines displayed and the interpolation method; the **Spatial** tab has selections for the lines to extract from and the desired variables to plot. Data series options are shown below; each of these properties is individually described in the data series controls section.
- For the case of *point* (or disc, rectangle, etc.) extraction, the dialog in Fig. 23.15 is displayed. The desired extraction elements are selectable to the right, and other plot options to the left.

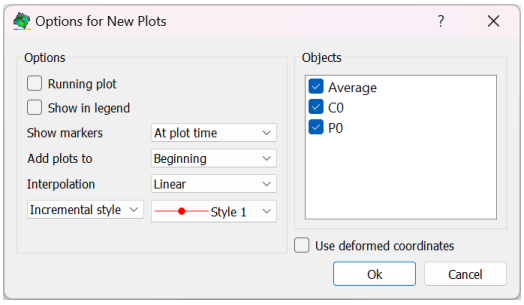

Figure 23.15: Multi series dialog for point extractions.

23.4.2 Data series controls

If a data series is selected from the list, properties for this series will be presented in the tool box as pictured in Fig. 23.16.

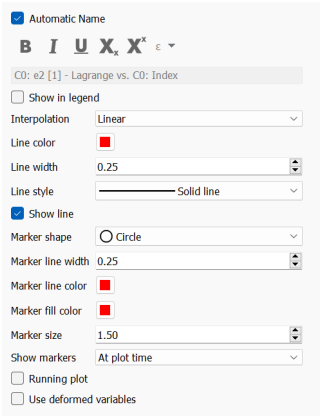

Figure 23.16: Charts data controls.

If **Automatic Name** is checked, a name will be assigned based on the extraction source and axis selections. If the box is cleared, a custom name may be entered.

The selected series may be included in or omitted from the plot legend by toggling the **Show in legend** checkbox.

If **Interpolation** is set to *linear*, time data will be computed between existing data points with linear interpolation. If it is set to *nearest*, the nearest data point will be used.

The **color**, **width**, and **style** of the line may be set below, or the line may be hidden by clearing the **Show line** checkbox.

Controls are also available for the **shape**, outline **width**, outline **color**, **fill color**, and **size** of the data markers. The **Show markers** pulldown may be used to select between showing all markers; showing no markers; showing a marker only at the end of the plot (for running plots); and showing the marker at the plot time (selected from the time control in the base tool, or animated.)

If **Running plot** is selected the plot will end at the base time.

Checking **Use deformed variables** will add deformation to the X/Y/Z variables, when present in the plot.

23.4.3 Base/All controls

In the *iris* workspace the Base controls are available for line plots; see Section 23.5.2 for details. (In the analysis location the base controls for line plots are fixed.)

The **Time** control in the base control may be used to create animated plots, either by using running plots or by using the **At plot time** marker selection.

23.4.4 Legend controls

The **Legend** tab seen in Fig. 23.17 allows adjustment of the plot legend appearance and location.

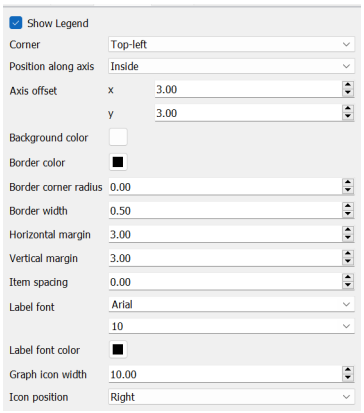

Figure 23.17: Line plot legend controls.

The **Corner** pulldown allows placement of the legend in any of the four corners of the plot.

The legend may be placed either inside or outside the plot by changing the **Position along axis** control.

The position of the legend relative to the selected corner may be increased or reduced with the **Axis offset** property.

The colors for the **background** and **border** of the legend are selectable below.

The legend outline may be given rounded corners by increasing the **Border corner radius**. The thickness of the outline is set with the **Border width** property.

The inside margins of the legend box are set with **Horizontal margin** and **Vertical margin**. Spacing between each item is set with **Item spacing**.

A **font** and text **color** may also be chosen for the legend.

The **Graph icon width** property controls the size of the examplar for each series; the **Icon position** adjusts the location of the examplar with respect to the text.

23.4.5 Axis controls

The X and Y axis controls for line plots are detailed in Section 23.5.1.

23.5 Common Controls

23.5.1 XY axis tools

Images, 2D plots, 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. 23.18.

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

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

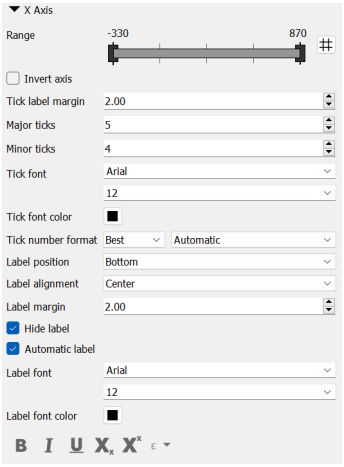

Figure 23.18: X and Y Axis Tools.

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.

23.5.2 The Base tool

Each element placed in the *iris* workspace 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. 23.19.

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

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

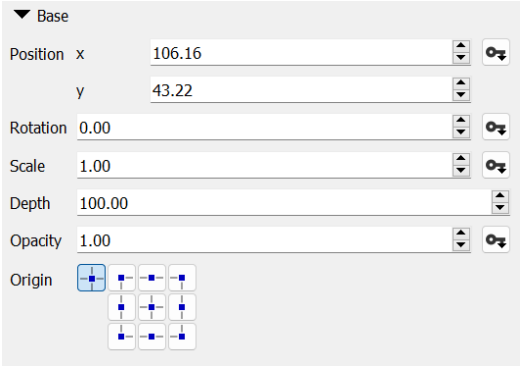

Figure 23.19: Base tool.

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 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.

23.5.3 The Color Selector

In each location where a color is customizable, a common Select Color dialog (Fig. 23.20) is employed.

At the top left is a palette of basic colors. Clicking **Pick Screen Color** will allow a second click anywhere on the screen to detect and use the color at that location.

Colors may be selected directly via their Hue/Saturation/Value definition or via Red/Green/Blue values. An alpha channel (transparency) is also available and applies to certain graphic elements. Alternately, the HTML color code may also be entered directly.

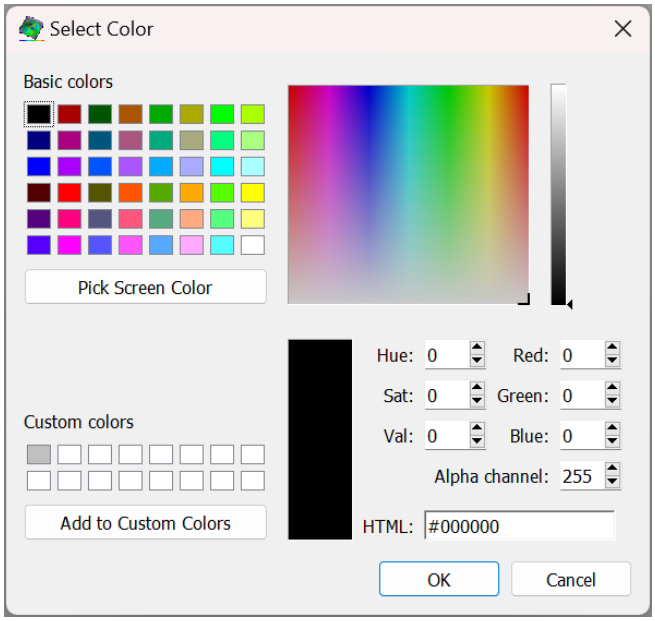

Figure 23.20: Color select tool.

Once a color is selected it may be saved to a set of favorites by clicking **Add to Custom Colors**.

When selection is complete, clicking **OK** will apply the color to the relevant control.

Chapter 24

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

24.1 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.

Chapter 25

The Global Preferences Dialog

Options and plot template defaults may be set with the Global Preferences dialog. The dialog is accessed by selecting **Edit... Global Preferences** from the main menu.

25.1 Visual Preferences

The Visual preferences are shown in Fig. 25.1.

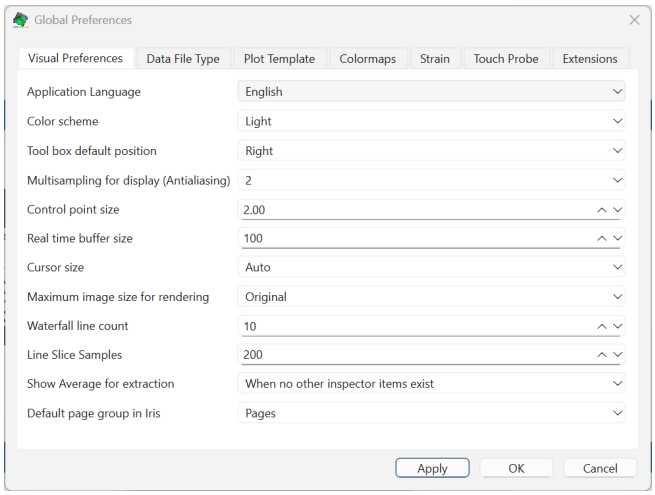

Figure 25.1: Visual preferences.

Application Language - Select the application language. It defaults to the system language if supported, but it can be overridden here.

Color scheme - Select between light and dark mode. Defaults to the system selection.

Tool box default position - Used to select the position of the tool area (left or right).

Multisampling for display (Antialiasing) - Can be used to lower multisampling for display purposes on systems with limited graphics. Multisampling for media exports are not affected by this setting.

Control point size - The size of inspector item control points in scaled pixels.

Real time buffer size - The buffer size for real time mode.

Cursor size - The size of the cursor in scaled pixels.

Maximum image size for rendering - Can be used to lower the resolution of images used in graphics on systems with limited graphics.

Waterfall line count - The default number of lines used in waterfall extraction plots.

Line Slice Samples - The default number of line slices used in extractions.

Show Average for extraction - Used to select if the average extraction will always be included or only when no other inspector items exist (default).

Default page group in iris - Used to select if the default page group for each opened Iris document will be Pages (default), or if the last opened for each document.

25.2 Data File Type

The Data File Type preferences are illustrated in Fig. 25.2.

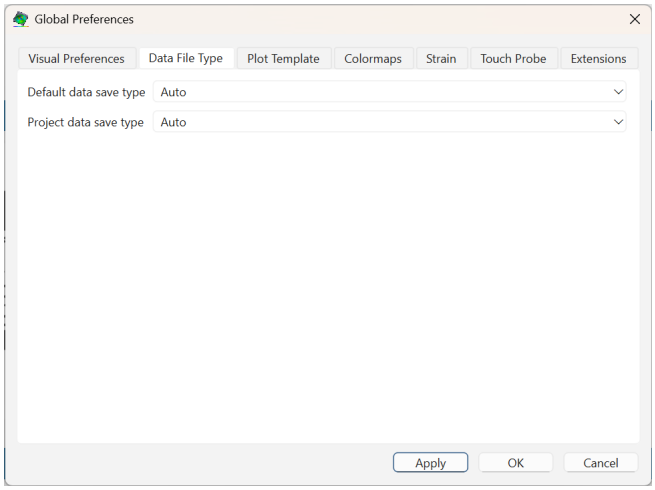

Figure 25.2: Data File Type preferences.

The pulldown may be used to choose the default format for data storage during analysis:

- **Auto** - this will use HDF5 if images are added as an HDF5 file and Out files if the images are added as individual image files.
- **Out files** - these are individual files for each frame of data and maintain compatibility with older VIC-2D versions.
- **HDF5 file** - this is a single hierarchical data file containing all output data for enhanced speed and portability.
- **HDF5 compressed file** - this option enables compression of the data stored in the HDF5 file, which can significantly reduce file size, though it may result in slower read and write operations.

25.3 Plot Template Settings

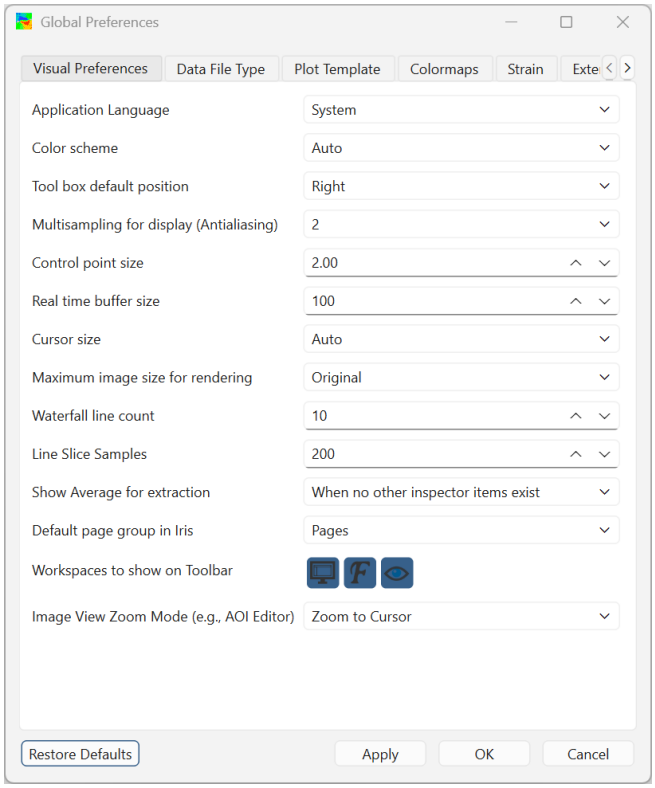

Figure 25.3: Plot Template Settings.

Each customization setting for plots and graphs may be controlled with the *Plot Template Settings* tab, as seen in Fig. 25.3.

The pulldown can be used to choose from Document, 2D contour plot, and 2D line plot settings.

To the left of each setting is a checkbox; when this box is filled, the specific setting will be applied as a default.

The **Graph Styles** tab allows customization of series styles including marker and line color and style.

A certain set of defaults may be saved using the **Save** tool button, or set for the current project using the center tool button. Defaults can be deleted using the **Delete template** tool button.

25.4 Colormaps

This tab, pictured in Fig. 25.4, may be used to create, edit, and import custom color maps for data visualization.

- A new color map can be created by clicking **Create New** and selecting a name.

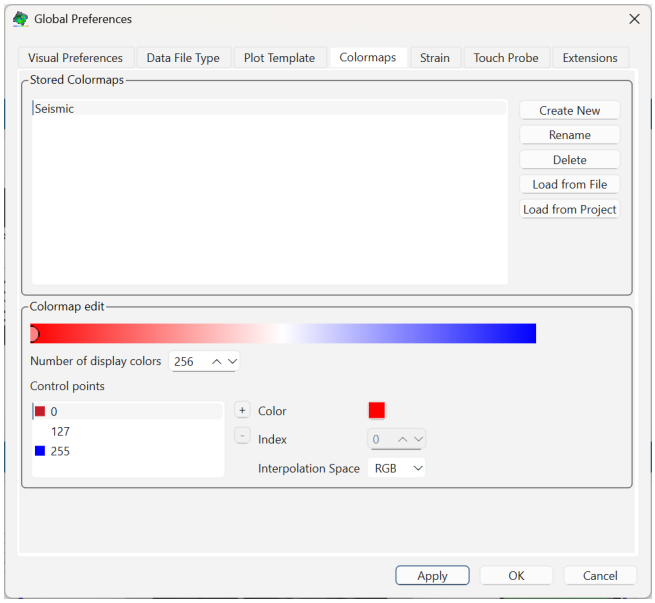

Figure 25.4: Colormaps editor.

- Color maps have two or more *control points* at specified indices. Colors are linear interpolated between control points in either **RGB** or **HSV** color space. The color at each control point can be selected by clicking on the **Color** sample to show the color chooser dialog (Fig. 25.5).

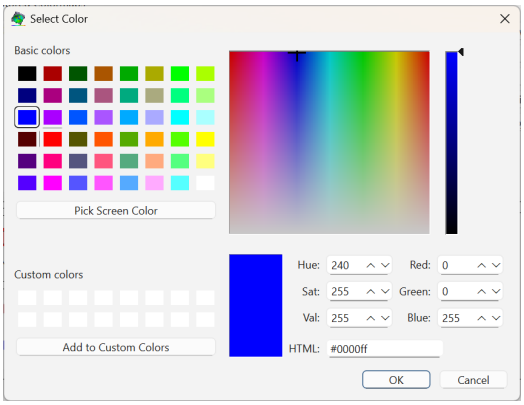

Figure 25.5: Color chooser.

  Colors may be selected using the *Basic colors* palette or from the HSV chooser to the right. Clicking **Pick Screen Color** will allow the sampling of a color from anywhere on the screen. Color values may be entered directly using HSV, RGB, or hex color codes. Clicking **OK** will finalize the color selection.

- Buttons are available to **Rename** or **Delete** the selected color map.

- Stored color maps in JSON format may be loaded using the **Load from File** button.

- When a color map has been used in a project file, it may be imported using the **load from Project** button and selecting the project.

25.5 Strain Defaults

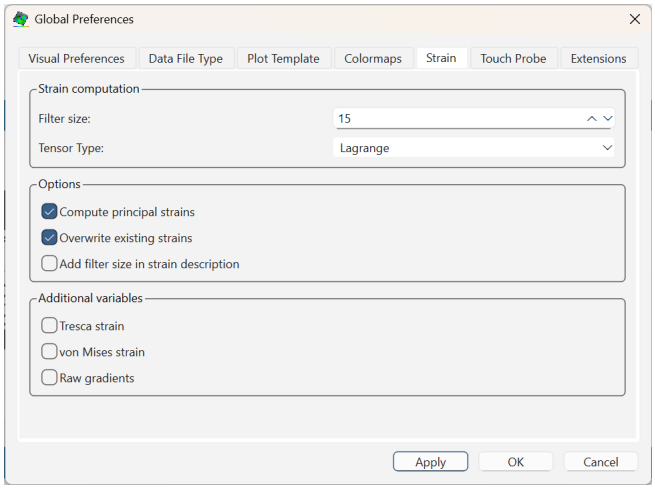

Figure 25.6: Strain default settings.

This tab (Fig. 25.6) controls default settings for strain computation. More details on each setting are available in Section 14.1.

25.6 Extension Settings

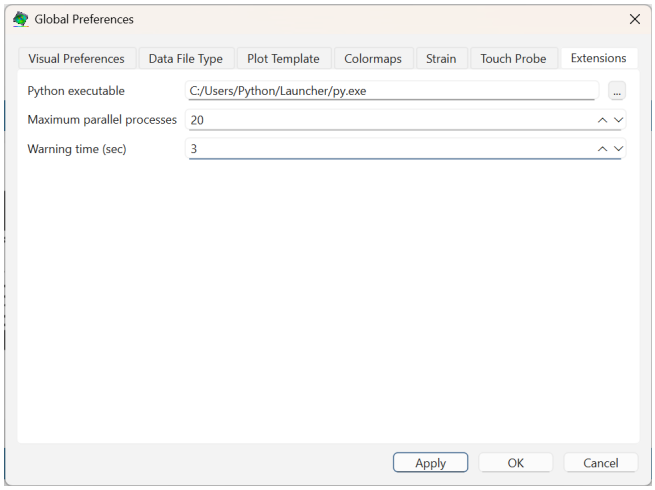

Figure 25.7: Extension settings.

This tab controls defaults for vicpyx extensions.

The *Python executable* editor allows selection of a preferred Python executable; the filename can be entered directly or the executable can be selected by clicking the `...` control.

The *Maximum parallel processes* spin box can be used to change the maximum number of processes that are spawned for computation.

The *Warning time* spin box controls the time allowed before a process is deemed to be stuck and the user is given an option to cancel.

Chapter 26

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