Application Note AN-1703
# Strain Filter Selection

**correlated**
SOLUTIONS

Introduction

Strain filters in Vic-2D and Vic-3D are user-defined so that users can select how localized or how averaged the strains will be presented in the data. The strain filter helps determine the strain gauge size for all of the individual points on the contour plot. Small strain filters provide better resolution and more localized data. However, large strain filters increase accuracy because they contain more data which will result in less uncertainty. This document provides the stain calculation background, explains the effects of different strain gauge filter sizes, and provides filter selection advice for different instances.

Background: Strain Calculation

The strain calculation in Vic-2D and Vic-3D is similar to the algorithm generally used by FEA software. The input for the strain calculation is the grid of data points from the correlation – a cloud of X, Y, Z points and U, V, W displacement vectors.
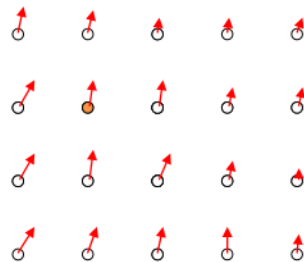
The separation between these points (in pixels) is dictated by the step size. The separation between the points in physical space will vary depending on magnification and the shape of the specimen. With this grid as the input, we consider each point separately, and create a local mesh of triangles; here, we consider the highlighted point from above:
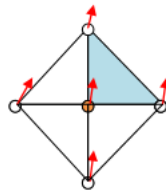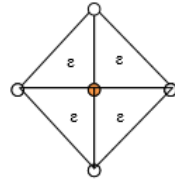
Next, we consider each triangle separately:

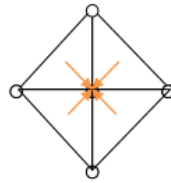Vector data   Reference triangle   Deformed triangle
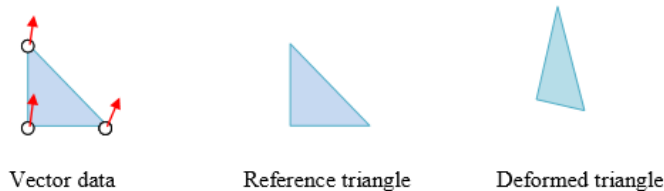
Rigid body motion is easy to remove at this point:
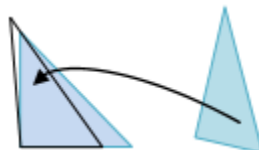
The remaining deformation of the triangle gives us exactly enough data to compute a strain tensor for this triangle. We repeat this for each triangle:


Since we want a strain for each existing data point, we interpolate from the surrounding strains:

We repeat this process for each point until we have a strain tensor at each initial data point.
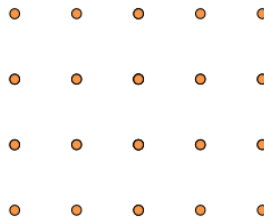
Because the local triangles are very small, the directly calculated strain tensors can be noisy, so at this point we smooth over a group of points. The size of this smoothing group is dictated by the user ("Strain Filter size") and is a decay filter, worth 10% at the edges.
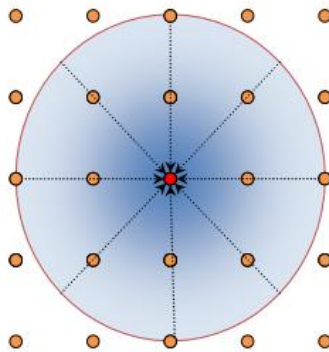

Note that since the data points are already separated by step size pixels, and we smooth over filter size data points, the total smoothing diameter is step size filter size. This smoothing diameter may also be considered the virtual strain gauge size. Because each triangle is considered to be locally planar, it is important that we sample the surface densely enough that each triangle covers an approximately planar surface. For a flat surface, any step size will work, but for a curved surface such as a cylinder, it is important to use a small step size.

Effects of Changing Strain Filter

Strain filter selection can be a balance because if we average over a larger area, we will reduce the noise but will lose spatial resolution.

In the example below, a small filter size of 5 allows for very localized strains, but the contour plot is noisy due to the increased uncertainty of using a small filter.
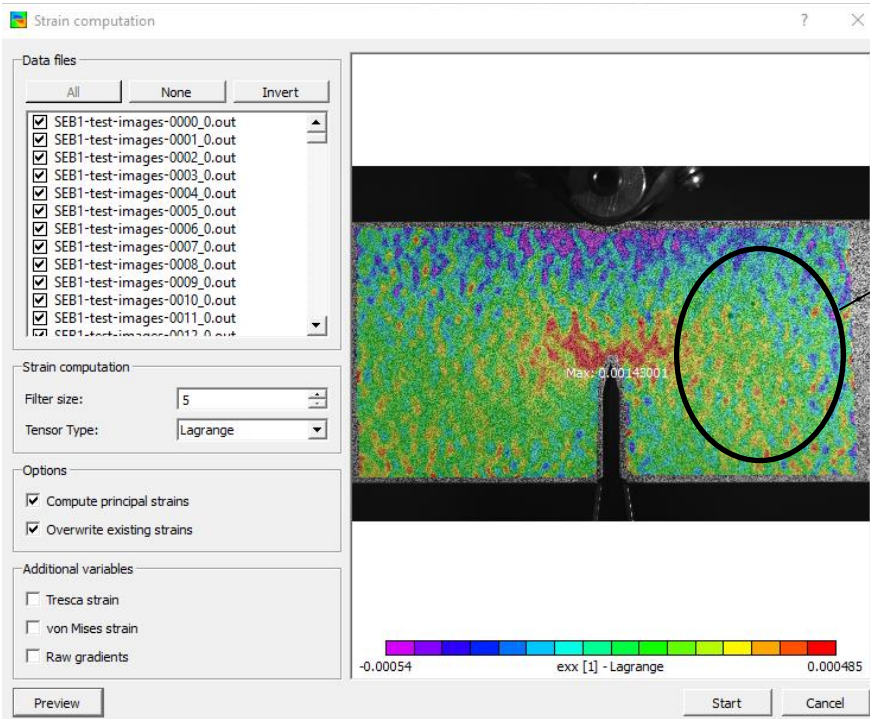
- Filter Size: 5
- Data appears noisier
- Strain can be seen in more localized areas

When using a larger strain filter, the strains will be cleaner, however we lose some resolution for local strains. The same data as above list shown below with a larger filter size of 35.
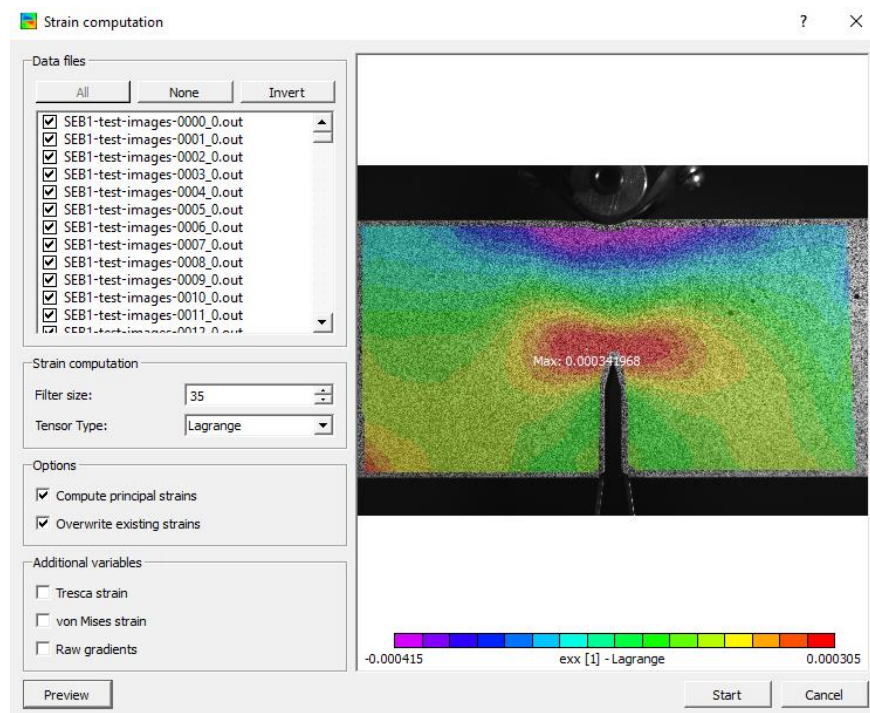
- Filter Size: 35
- Data appears smoother throughout area of interest
- Reduces spatial resolution

When comparing strains in the two examples above, the peak strains for the smaller filter size are higher. This is because the peak strains are more local and are not averaged over areas with lower strains. If virtual strain gauge size is larger than the physical area that the peak strain covers, it will be reported lower since it contains areas with lower strains.

To further illustrate this point, we can investigate data from two extensometers for the simple tensile test below. Here we see a contour plot of the last image next to the strain as it develops throughout time for two gauge sections.
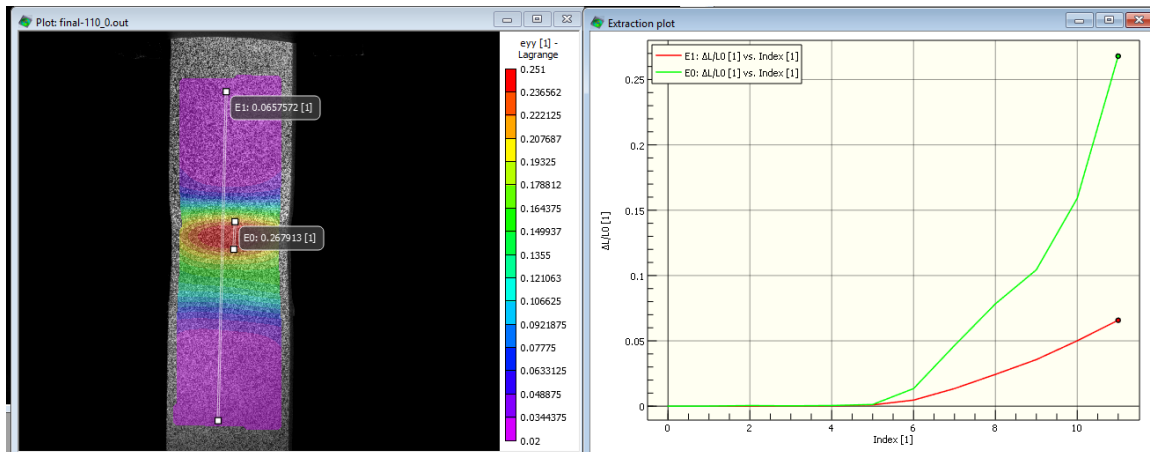
There is a necking region, in where the strain is very high. The other regions have very low strain. Let's assume that this sample has two extensometers, and the lines drawn on the sample below represent each extensometer. The extracted strain throughout time shows a green line for the shorter gauge length and the red line is for the longer gauge length. We can see the difference in strain results based on how long the gauge length is. The extensometer that is placed on the necking region shows very high strain. But if we put a gauge along the entire length of the sample, the strain is lower because the percent change in length is much lower when the gauge has two points that are on either end of the sample and contain regions that do deform that much.

The difference in extensometer gauge length here is more exaggerated than what we see for the localized virtual strain gauge sizes, which are controlled by the strain filter. However, it does demonstrate how different strains can look if averaged over larger or smaller areas.

How to decide what filter to use?

Strain Level

If the strains are very high, small filters may be used without increasing the noise (our noise floor is typically around 100 microstrain, so strains of several percent will likely appear clean no matter what filter is chosen). Lower strains might need larger filters.

Local Features/strains

Smaller filters will allow for more local strains. In the above example with the crack, a smaller filter allows us to investigate the peak strain at a location is not smoothed into the rest of the data with a higher filter.

Homogenous Strains

If strains are homogenous, a higher strain filter will make the contour plot cleaner. Small filters are not necessarily needed if there are no local strains to evaluate.

Support

If you have any questions about this Application Note or any other questions, comments, or concerns about your CSI system, please feel free to contact us at support@correlatedSolutions.com or visit our web site at www.correlatedsolutions.com.