CSI Application Note AN-222

Merging Multiple System Data

Introduction

Vic-3D includes the capability to merge data from multiple camera system images of the same specimen.

The process for merging involves three basic steps:

1) Calculating the geometric transform between the systems;
2) Calculating the shape/deformation fields for each system separately; and
3) Using the transform from step 1 to combine the data files from step 2.

In order to proceed, you will need to have the Multi-system module key for your Vic-3D installation.

Testing Preparation for Merging Coordinate Systems

For our test, we have two camera systems imaging a long cylindrical system. The two stereo pairs have been divided into a "System 1" and "System 2" using the multisystem features in Vic-Snap.

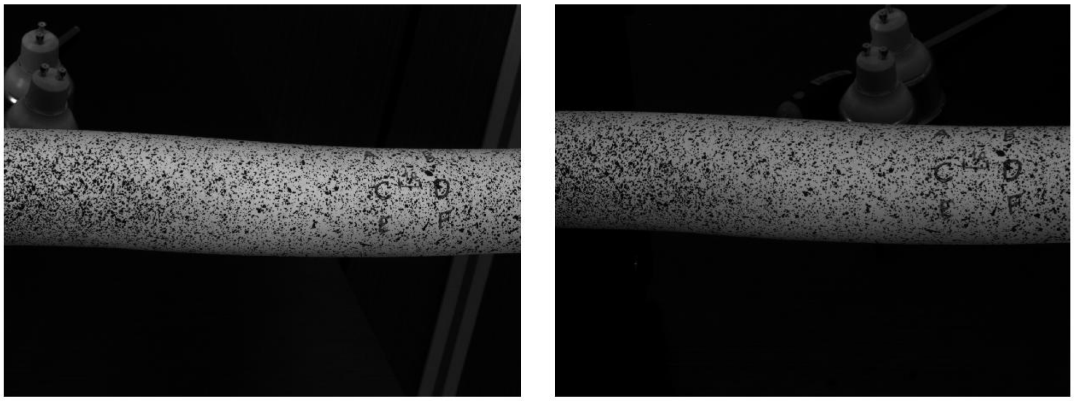


Image pair, system 1

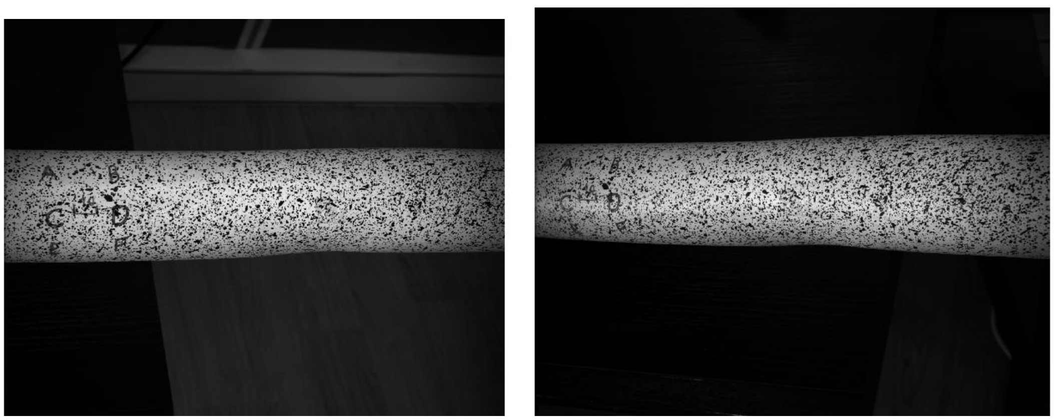
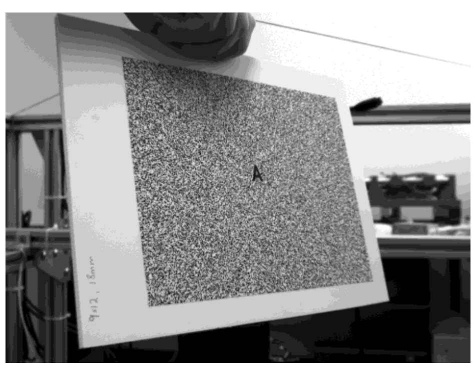


Image pair, system 2

To merge the systems, we **must** have a view of a speckle pattern that shows an overlap. This can either be the specimen itself, or of a separate target such as a flat board with a speckle pattern on it:



The board technique is very useful with cylinders/spheres where the overlap on the object itself may be very minimal.

Here, we will use the specimen itself. Note that the right edge of system 1 overlaps with the left edge of system 2.

System Calibration

To begin, we calibrate each system exactly as normal, and save a project file containing the calibration for each system. At this point it is important to be methodical and consistent about naming. Here, we save the calibration files as **sys1-cal.z3d** and **sys2-cal.z3d.**

Note: it's especially important to get a good calibration with accurate distortion coefficients, so that the data from the image edge will match well with the other system.

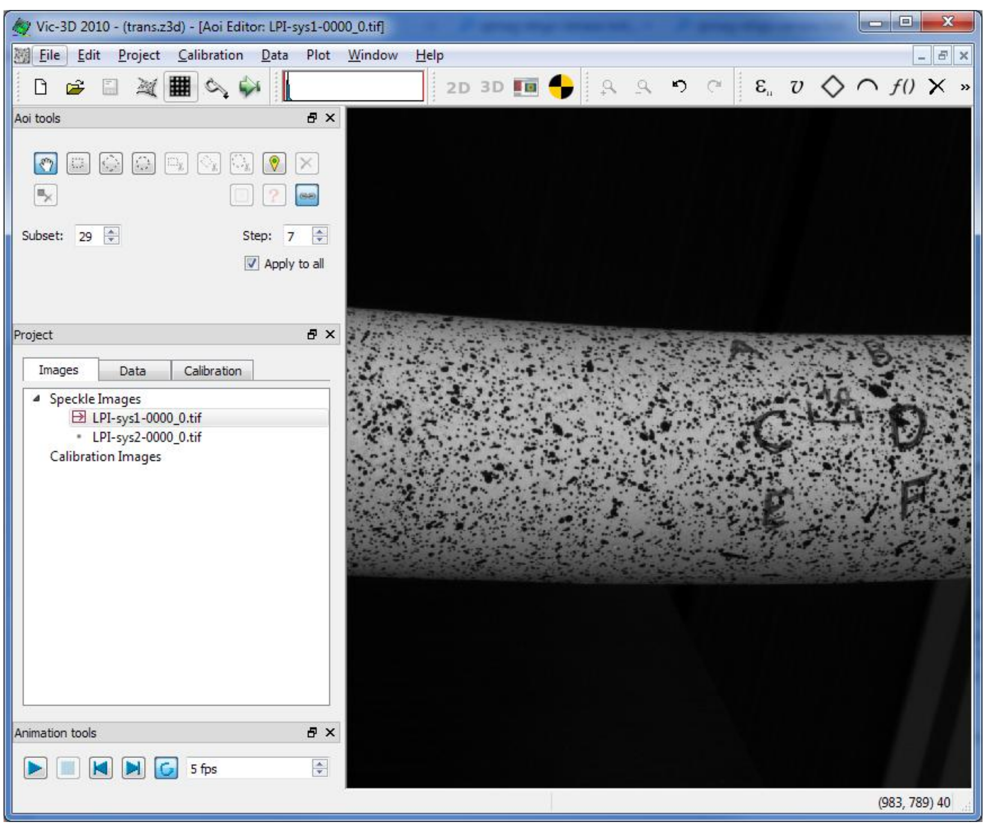
Acquiring Images

Next, we acquire a single image showing the overlap. This image needs to be either synchronized in time between the systems, or if the systems cannot be synchronized, the object needs to be very still.

Calculating the Transformation

To calculate the transformation, we will do a deformation analysis with the image from system 1 as the reference image, and the image from system 2 as the deformed image. Since the object did not move, any deformation that we see is actually the difference in geometry between the two systems.

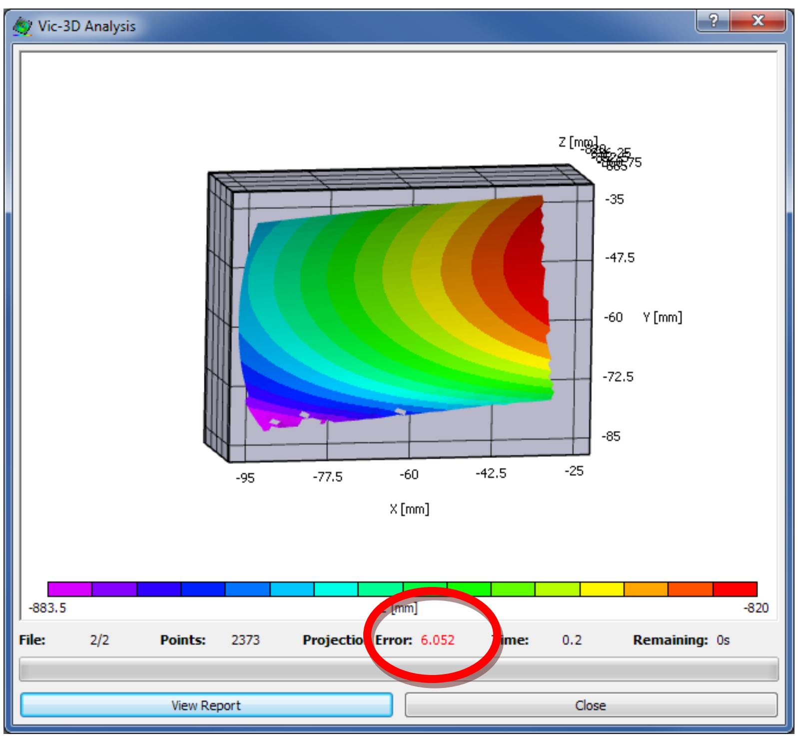
To begin, we click **Project... Speckle Images** and add the two image sets (here, LPI-sys1-0000 and LPI-sys2-0000.)



Next, we draw an AOI that covers the overlap region, and add a start point. For this step, a manual initial guess normally **will** be necessary, because of the large angles and displacements.

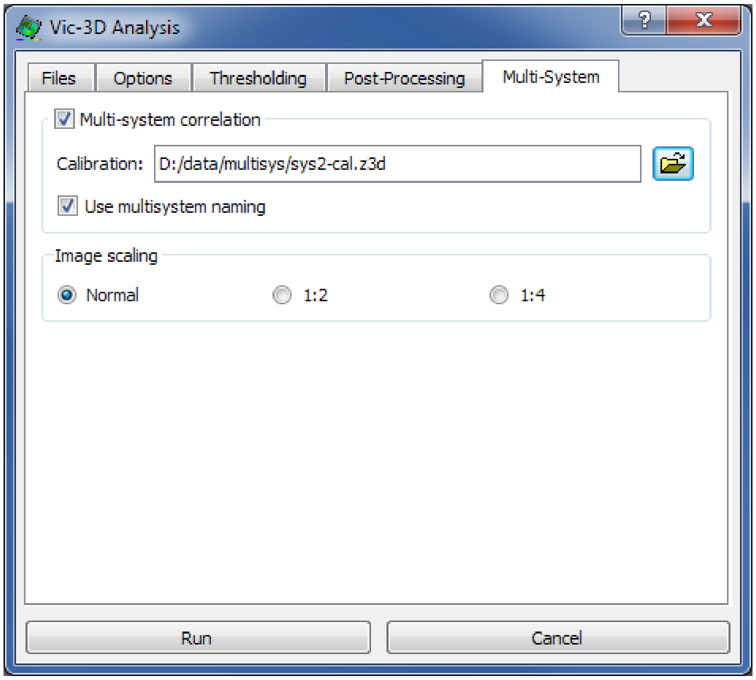
For the calibration, we will import the calibration for the *reference* image - here, system 1 - using **Calibration... From project file**.

At this point, we can run the analysis - but an extra step is necessary. The calibration for the project is for system 1; but this calibration is not appropriate for system 2, which has a different camera geometry. If we were to run without changing further options, we would see this for the second file:

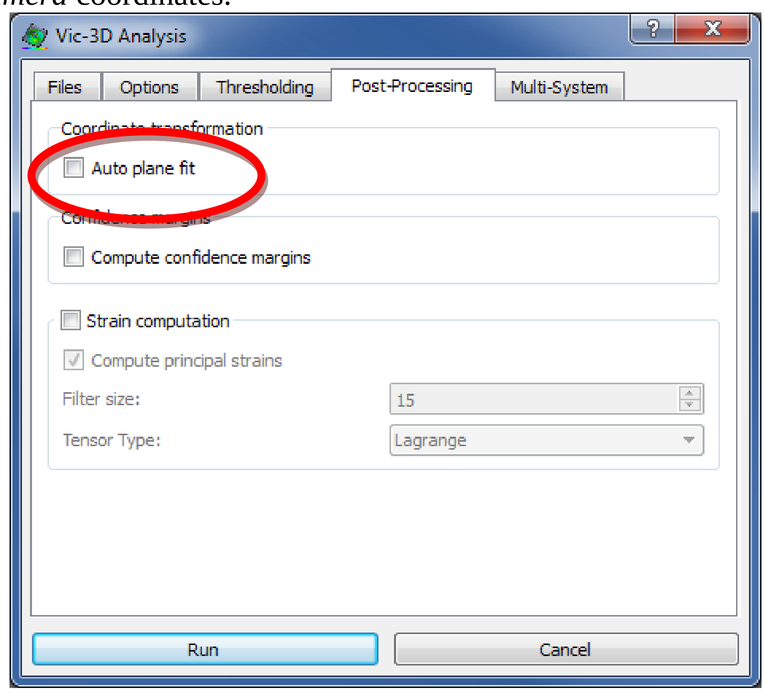


The projection error is **very** high - because the calibration was incorrect.

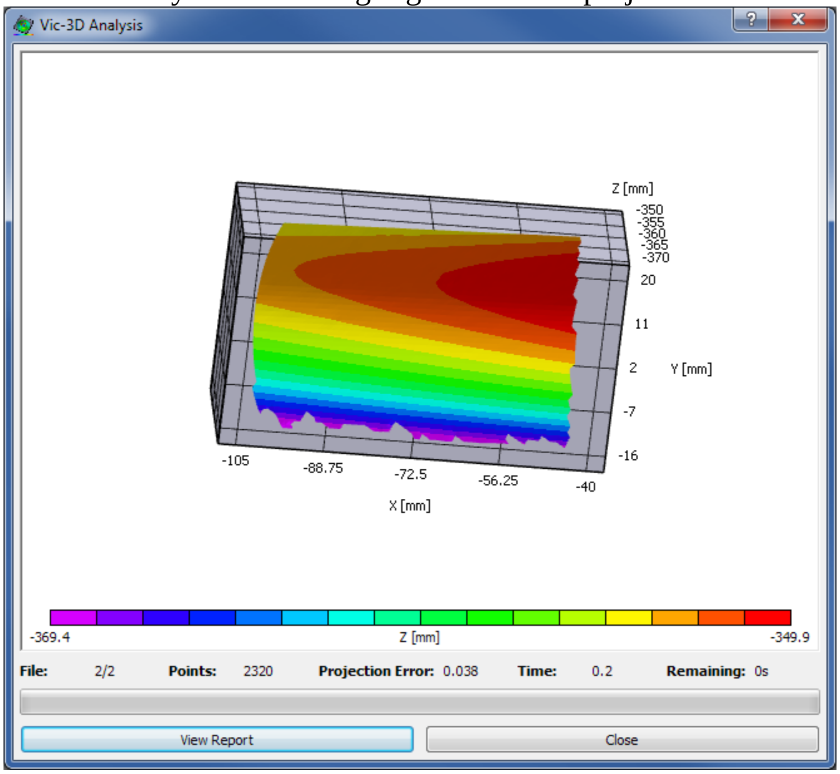
Instead, we will specify the deformed calibration using the **Multi-system** tab in the Run dialog.



We check the **Multi-system correlation** box, and select the calibration applying to the *deformed* image. We also check the **Use multisystem naming** box - more on this in a bit. Finally, we confirm that the **Auto plane fit** option is cleared. It's important that all our results be in *camera* coordinates.



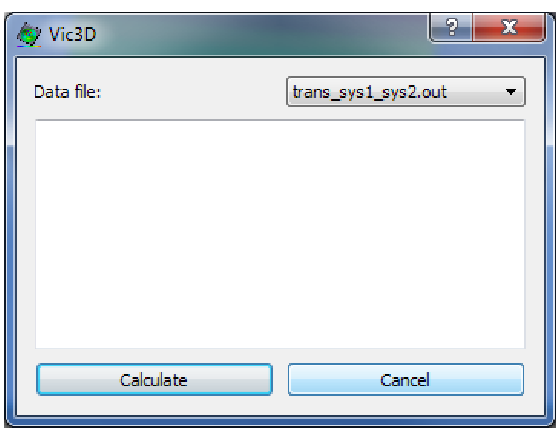
Now, we can run the analysis. Both images give us a low projection error.



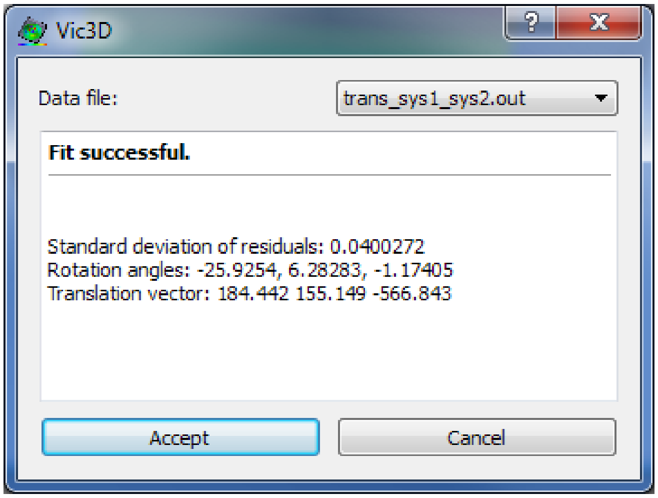
After closing the analysis window, we see a new file in our Data tab called **trans_sys1_sys2.out**. This is the deformed data file, and it has been named this way because we selected the **Use multisystem naming** checkbox. (Otherwise, the deformed image could be overwritten by a profile analysis, and we would need to manually copy and move the files to keep them).

The **trans** data file contains the deformation between system 1 and system 2. Since the images are of the same specimen, we can assume that any deformation present is actually a rigid transformation between the two systems.

To calculate this rigid transformation, we use **Data... Coordinate Tools... Rigid transformation from displacements**.



Select the deformed data file (normally, the only one available) and click **Calculate**. You will see some data about the calculated transform:



We have a rotation and translation between the two systems (the actual values may be a bit difficult to interpret because of the way we deal with the two cameras in the two systems), and, more importantly, a standard deviation. This number is given in mm and should be quite low - it indicates the average motion in each point that was left over *after* fixing the transformation. If it's *slightly* high, it may indicate that our cameras moved a little bit, or our distortion wasn't calculated perfectly; if it's *very* high, it means that we missed a step earlier, or selected the wrong image at some point.

Here, we click **Accept** and name the transformation. This transform will transform data *from* system 2 *to* system 1, so we will name it as "sys2-to-sys1".

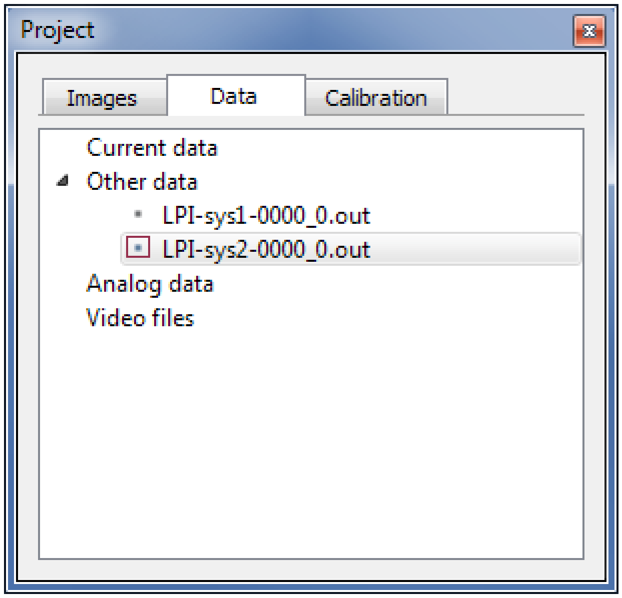
Finally, we save this project with an appropriate name - here, "sys1tosys2.z3d". This will make it easier to recreate the transform and the data in the future, if need be.

Running the individual data files

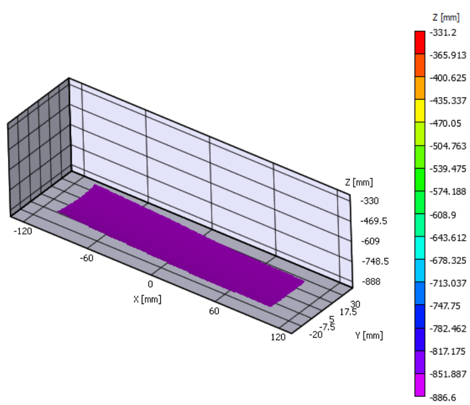
Next, we run the data files for system 1 and system 2, exactly as normal, using their respective calibrations. Here, we just have one file for each system - a shape analysis.

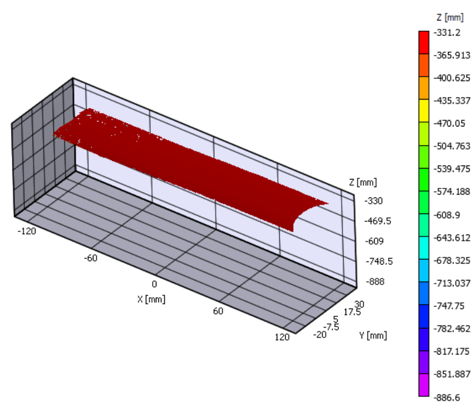
Putting everything together

At this point, we can create a new project, and bring in our two shape data files using **Project... Data File.**



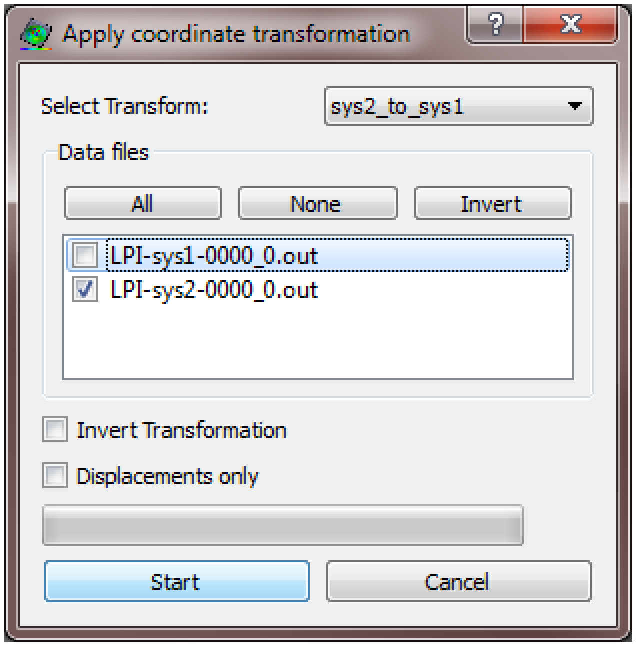
If we look at our two shapes, we can see that they are not in the same coordinate system.



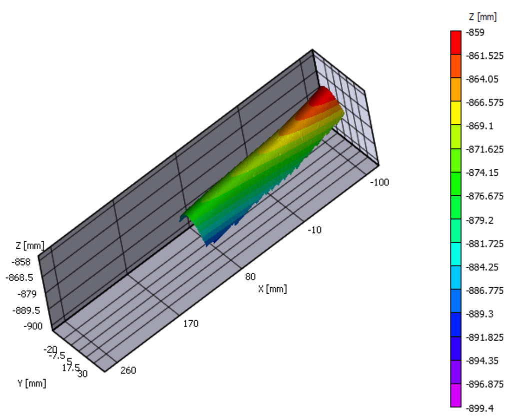


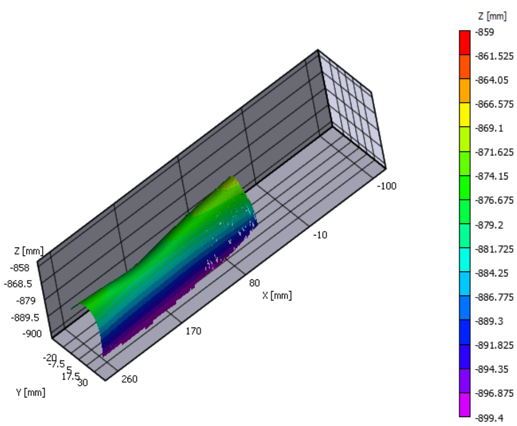
We need to retrieve the transform which will put the data from system 2 in the coordinate system from system 1. We use **Data... Coordinate tools... Import from project file**, and select the "sys1tosys2.z3d" project file we saved previously, then the "sys2-to-sys1" transform. (The names are reversed because the calculated transform *reverses* the deformation. So we go from sys1 to sys2, and then the transform brings sys2 back into the sys1 coordinate system.)

Now, use **Data... Coordinate tools... Apply Transformation to** apply the transform to the sys2 image *only*. (The sys1 image is already in the sys1 coordinate system.)

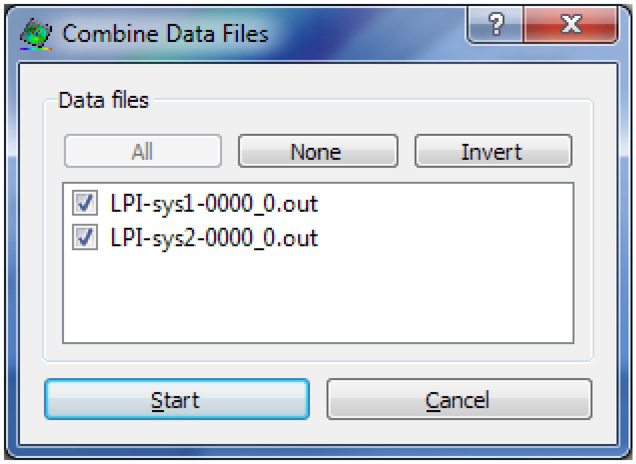


Now, our data looks to be in the same coordinate system.

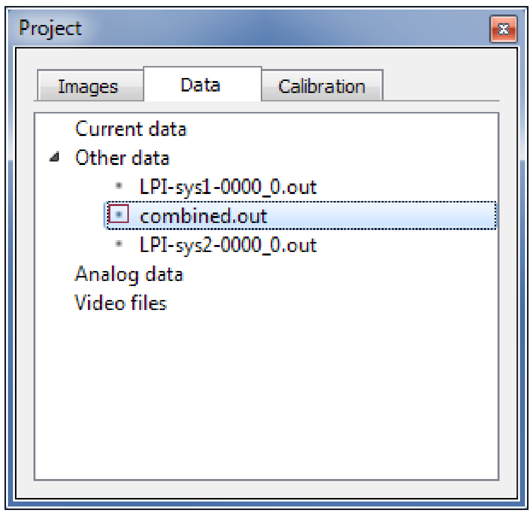




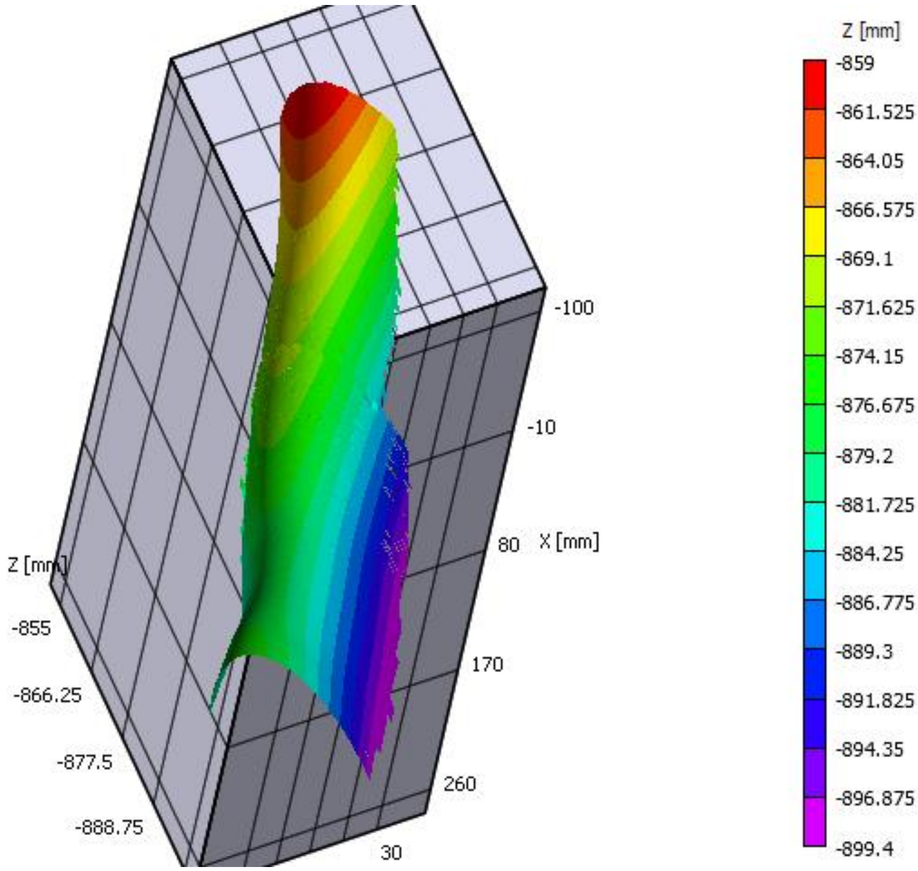
If desired, we can use **Data... Postprocessing tools... Combine data files** to put these two patches into one .out file.



We select both files, click **Start**, and specify a filename. The new combined file is added to the project.



Double-clicking this file gives us both patches at once. Note that this can only be viewed as a 3D plot as there is no single image file which can be used as a background.



If the patches do not look right *at all*, then it may be necessary to recheck your steps. Confirm that the correct data files were used; that the auto-plane fit option was off at each step; and that the correct calibrations were applied.

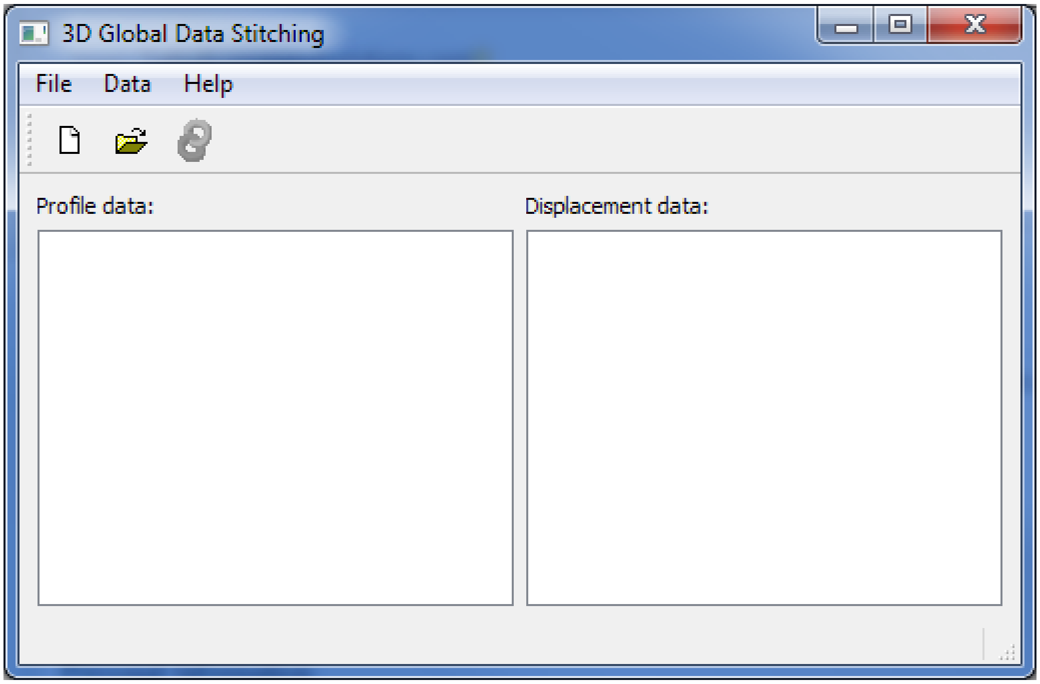
If the patches show a *slight* mismatch, it may be due to either an imperfect calibration (leading to some slight distortion at the images edges), or a slight motion between systems. Depending on the scale, a slight motion of one system's mounting might lead to a significant mismatch in your patches; be sure to use the most rigid practical mounting method, preferably with the two systems mounted rigidly together.

Using the Global Data Stitching software

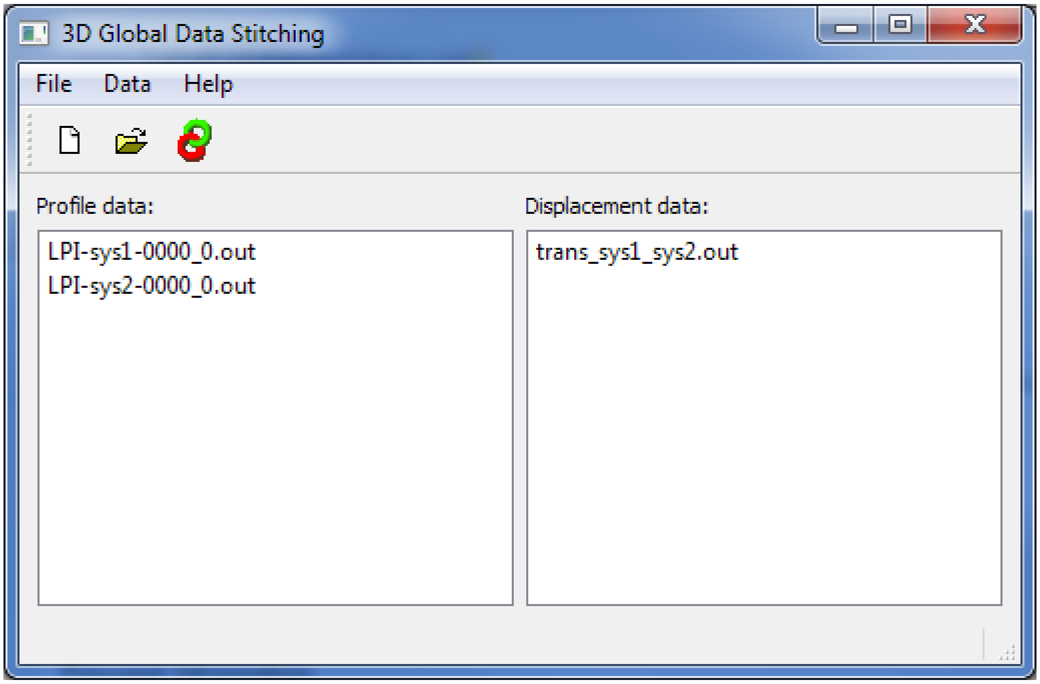
For more complicated configurations with more than 2 stereo systems or multiple deformed files, applying the procedure above can become extremely time consuming. The 3D Global Data Stitching software (available on request) can but used to simplify the process.

To prepare to use the software, you should create the transformation file as above - add the reference and deformed image, select the multisystem calibration, and run to get the "trans" data file. It is *not* necessary to calculate the transformation - only the deformed data file is necessary.

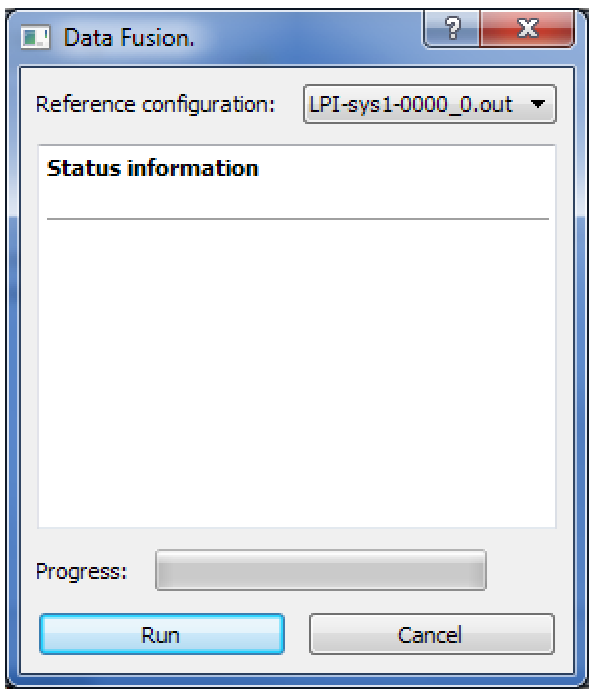
Once you have a set of data files from the individual systems, as well as the transformation files to connect each system, you can start the software.



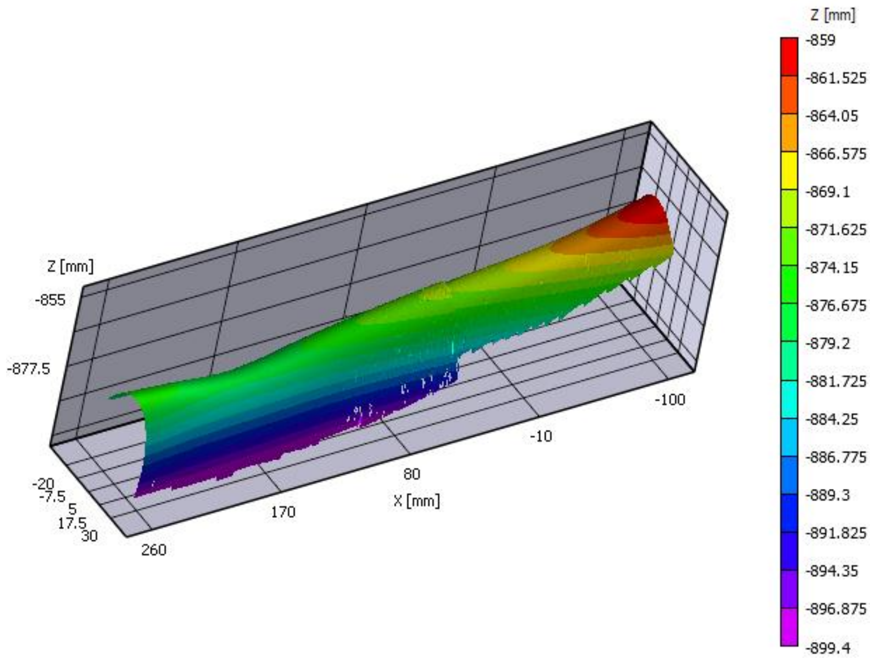
Click the "Add data files" button and add all the profile/deformation .out files, and all the connecting "trans" files. They will be added and sorted - individual system files on the left, inter-system files on the right.



Click the **Fuse Data** icon at the right to run.



Select a reference configuration (the data will be moved into this coordinate system), and click **Run**. The software will then generate one or more fused files called **stage_nnn.out**.



These file contains the combined data as before. It also contains a new variable called "System" which indicates the system number each AOI came from.

Note that for systems which completely encircle a system or sphere, the software will connect each system, and then perform a global optimization to minimize gaps all around. In order for this to work, you will need to connect the systems in a full loop. That is, for the example of 4 systems, you will need to connect 1 to 2, 2 to 3, 3 to 4, and 4 to 1 again. If you omit the 4 to 1 link, you can still connect all 4 systems, but there may be a slight gap where 4 connects to one because of the slight errors at the other 3 links.

Support

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