Cylinder Data With Vic-3D

Procedure Guide

correlated
SOLUTIONS

Introduction

This guide lays out the steps for imaging a cylinder with multiple encircling systems; acquiring calibration data; and merging the data to create a single dataset with the merged cylinder data.

- Preparing the specimen
- Setting up the cameras
- Stereo calibration
- Inter-system calibration
- Taking test images
- Merging data

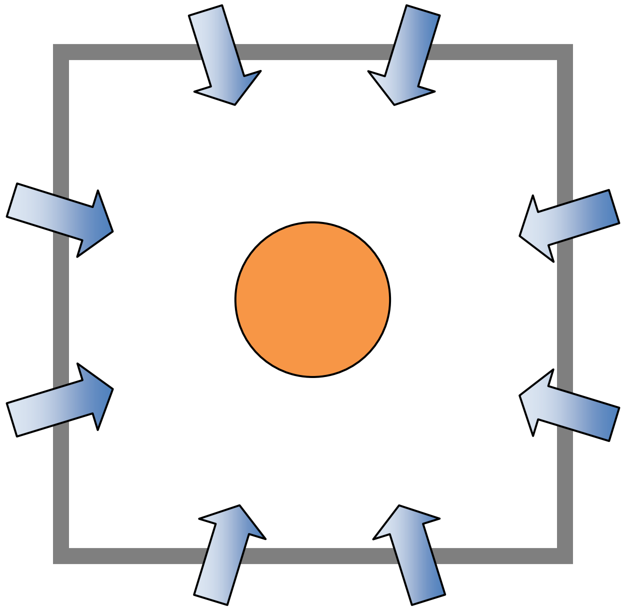
Preparing the specimen

For this test on a cylindrical 700ml pressure vessel, we begin by applying a speckle pattern with enamel paint. For larger specimens, templates are useful for creating a good speckle pattern; for very small specimens, airbrushing or powder application can work well.

Setting up the cameras

Here, we will be using 4 camera pairs to achieve 360˚ of view. Each pair will be set up as normal for a stereo camera system. Additionally, we must ensure that the stereo rigs **do not move relative to each other**. We will be determining a precise relationship between each system and this must not be disturbed during the test.

To keep the rigs rigid for our test, we are using an extruded aluminum frame that holds each camera pair as diagrammed in the top view below.



In Vic-Snap, we define each camera pair as a "System" by right-clicking in the image and selecting "Set as system...". The systems are defined as sys1 through sys4. Then, we can select Window... Tile By System to line up the systems. A large monitor or multi-monitor setup can help, here.

Stereo calibration

To begin, we calibrate each system separately, exactly as normal. For convenience, we leave all 4 systems up, so for each system, many of the calibration images show the back of the grid or no grid at all. This is a slight waste of disk space but it will be worth it to prevent mistakes or confusion later.

It's especially important to get an accurate distortion correction here since we need the images to match up at the edges, where distortion is strongest. Take a lot of calibration images (20-30) and be sure that the grid is sized to fill the field of view and that you get high tilt angles in your images.

If you leave the extraneous images (showing the back or edge of the grid), no harm will be done - the calibration routine will just ignore these images.

As you finish each calibration, save the calibration with a name that will help you find it later - here, we'll save a "sys1-cal.z3d", "sys2-cal.z3d", "sys3-cal.z3d", and "sys4-cal.z3d". Use any system that you like but be sure it makes sense! There are a lot of potential failure points here and if you need to repeat a step, being methodical now will make things much easier later.

When this part of the process is complete, we have a stereo calibration for each system.

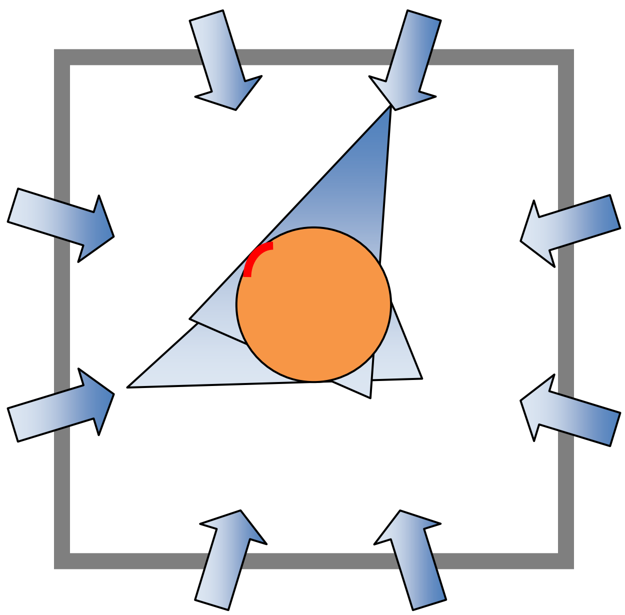
1. sys1-cal.z3d
2. sys2-cal.z3d
3. sys3-cal.z3d
4. sys4-cal.z3d

1.

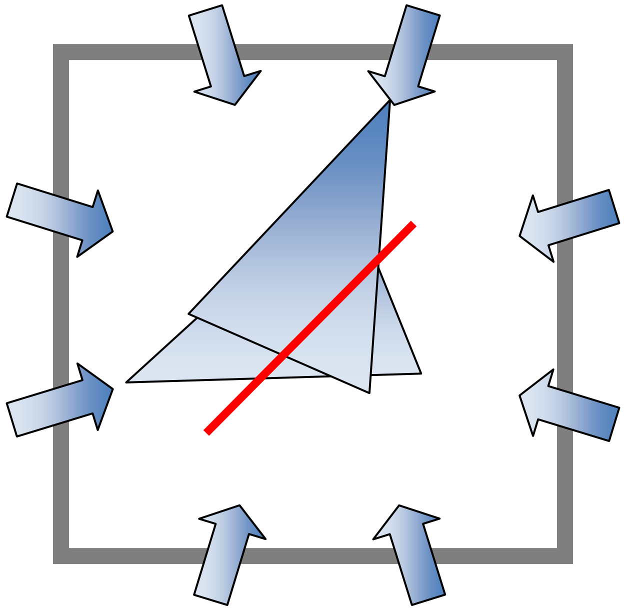
Inter-system calibration

We must now establish the geometric relationship between each system. We will do this by running a deformation analysis between an object in system 1, and the same object in system 2, etc. Since we're imaging the same thing at the same time, the measured "deformation" actually encodes the relationship from one system to the next.

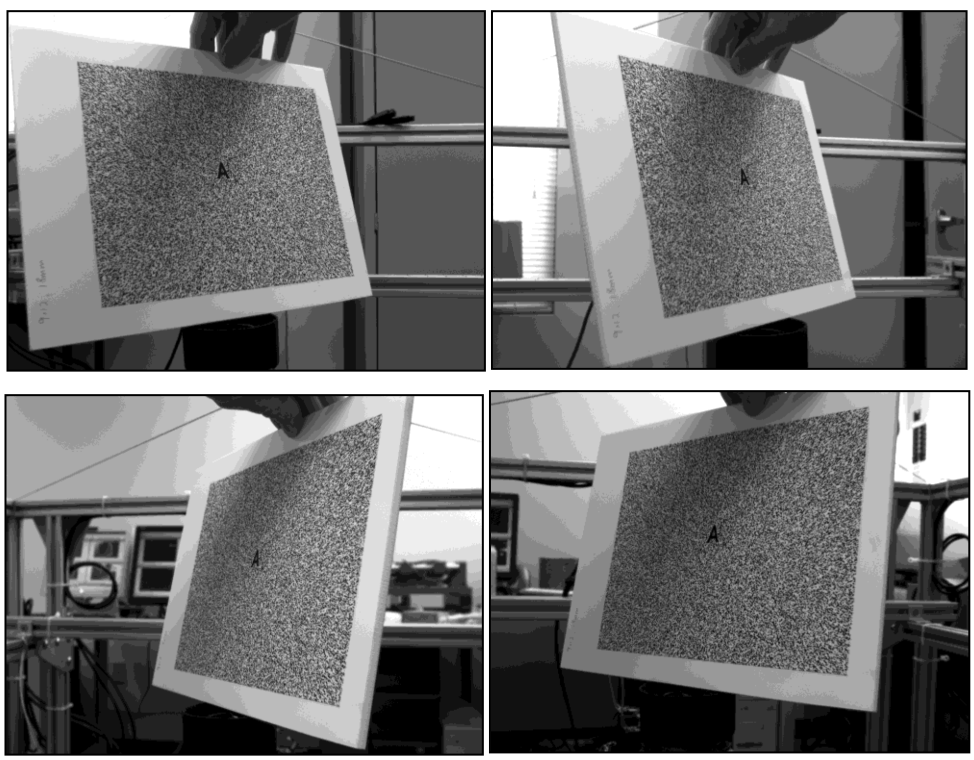
This process only requires that we have a speckled specimen that is visible in adjoining stereo pairs. We could use our already-speckled cylinder, but this can prove difficult. This is because the left edge of the left system has very little overlap with the right edge of the right system, and the overlapping area is very oblique - this makes calculation and initial guessing difficult. See illustration below, showing overlap area in red.



Here, rather than using the object itself, we will use a separate calibration card. Because the card is flat, the overlap area is large and not as oblique.



Additionally, we've placed a fiducial mark on the card (simply a letter "A") to make initial guesses easier. Here's the view from 4 cameras - the two "sys1" cameras, and the two "sys2" cameras:

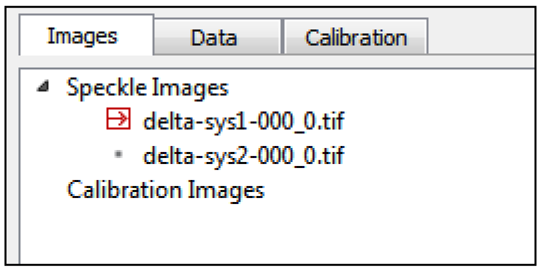


Be sure the cameras are synchronized, and give your images a descriptive name - here, we'll call them "delta". We take 4 image sets:

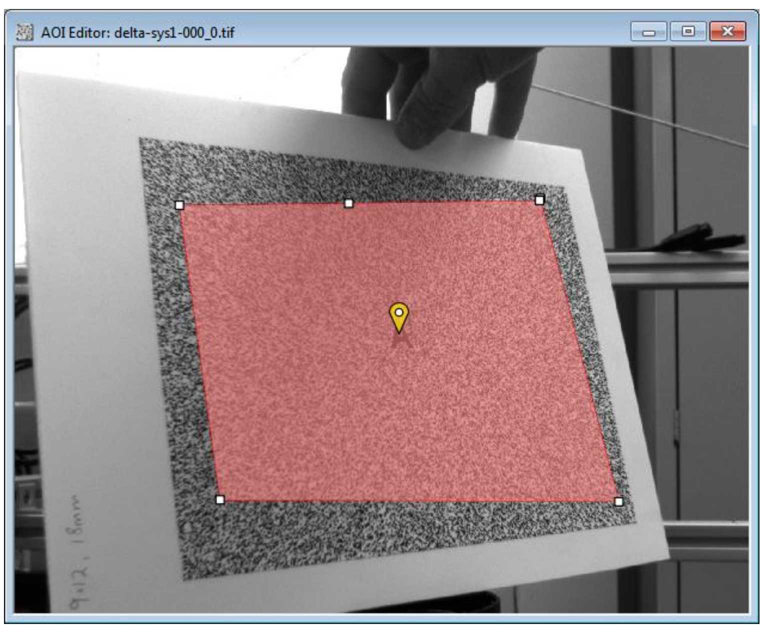
1. Card visible in system 1 and system 2
2. Card visible in system 2 and system 3
3. Card visible in system 3 and system 4
4. Card visible in system 4 and system 1

Once again, for each image set, there are several images that show the back of the card, or nothing at all. We'll take them anyway in order to keep our naming and numbering consistent.

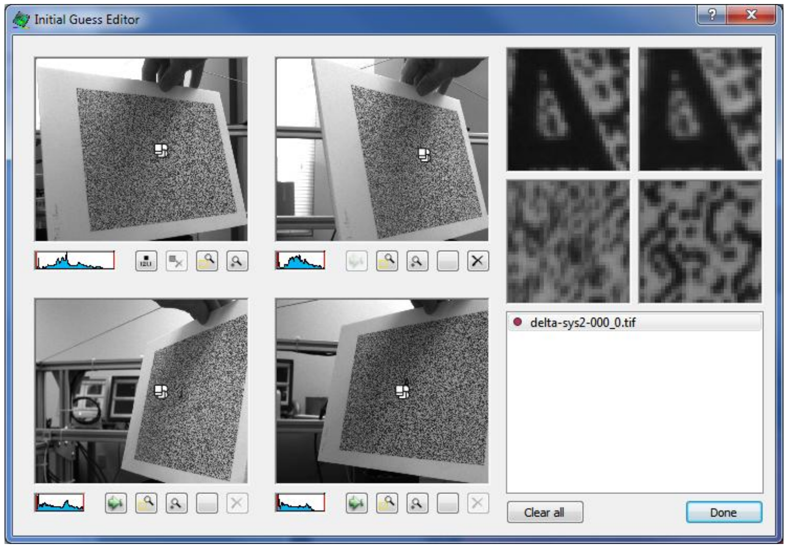
Now, we need to determine the transformations for each link above (1→2, 2→3, 3→4, 4→1). We'll start with 1→2. We create a project in Vic-3D with the **System 1** image pair of the card as a reference, and the **System 2** image pair of the card as a deformed image, and the **System 1** calibration (you can use Calibration... From Project File).



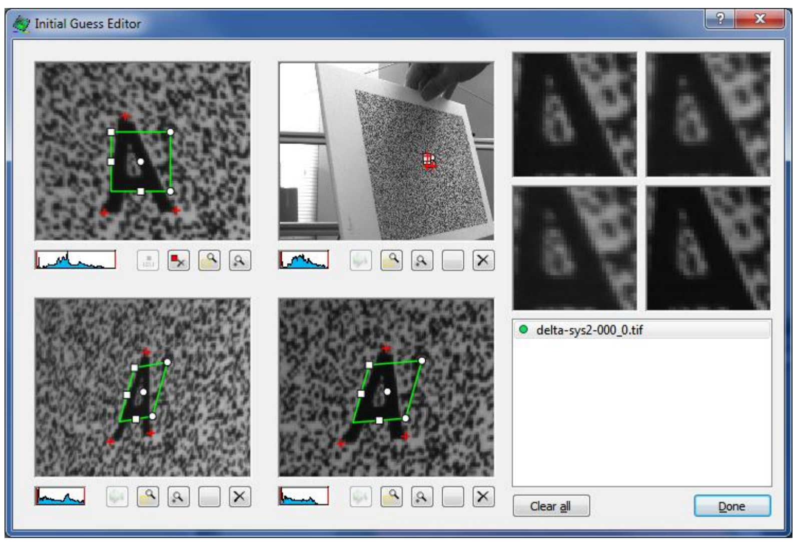
Then we define an AOI that covers a good sized patch of our card.



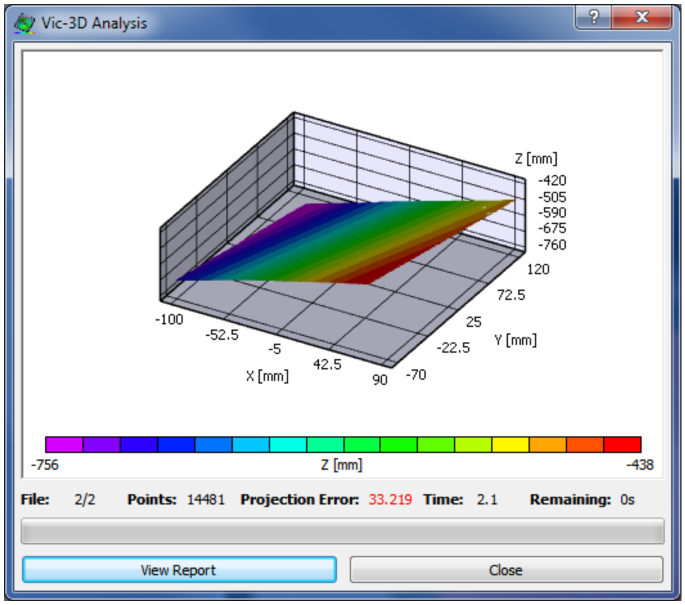
Because of the large deformation between the two systems' views, we will almost certainly need an initial guess. Here, the seed point is placed on the A to make this easier. Double-click on the seed point to set the guess:



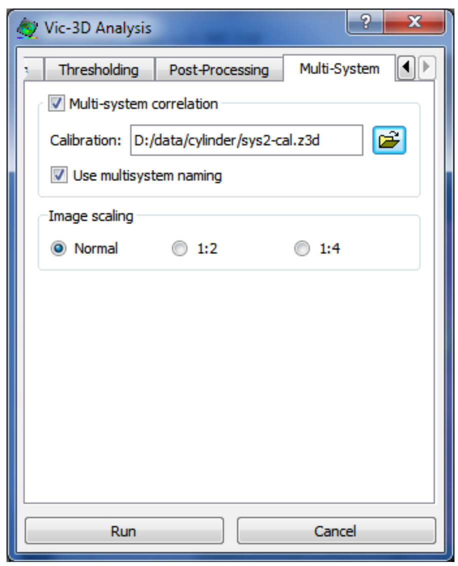
The subsets do not match, and the image is marked with a red dot - no automatic guess has been found. We'll use the control-point method to set one, placing a control point at the three corners of the A, and then matching them in the deformed images.



Once we're done, we can click Done to accept, and save the project (here, "sys1-to-sys2.z3d".) We are almost ready to run, but there's one problem - the calibration we have is from **System 1**, but the second image pair is from **System 2**. If we simply run the analysis, we get a very high projection error for the second image pair, indicating a bad calibration.

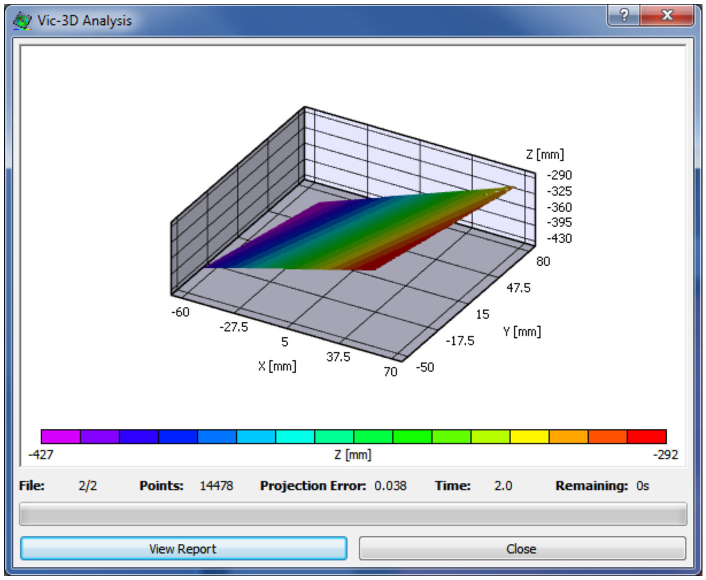


Instead, we must apply the **System 2** calibration to the **System 2** images. Click the Start Analysis button, and then go to the Multi-System tab. Check the "Multi-system correlation" box; a file dialog will pop up, and you can select the **System 2** calibration. Also, be sure the "Use multisystem naming" box is checked; more on that in a moment.



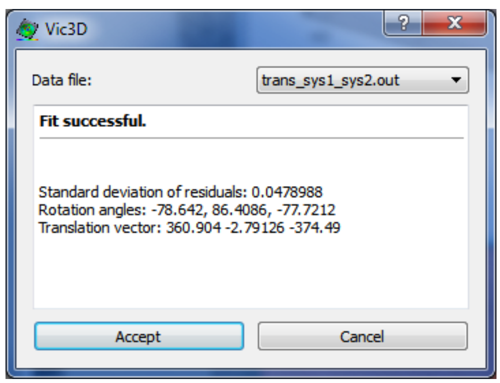
(The "Image scaling" option is only used when there is a wide disparity in image sizes - here, we ignore it.)

Now, you can run the correlation. You should see low projection errors for both images; if you see a high projection error, this is a sign that you've missed a step.



When you close this window, you will see a new data file name that begins with "trans". This is because of the multi-system naming option; we prepend "trans" to the filename to avoid overwriting profile data.

The "trans" data file contains the U/V/W displacement data that encodes the relationship between the two stereo rigs. We can find the transformation at this point using Data... Coordinate tools... Rigid transform from displacements:



However, this step will not be necessary in our method. The only thing we need here is the "trans" file, but be sure to save the project so you can repeat, if necessary. Be sure that your reference and deformed data sets look accurate and clean - if any junk or bad data is present, it will bias the final data.

We repeat this for all four links, each time completing the initial guesses, and confirming that we have low calibration errors. When this part is complete, we have four files:

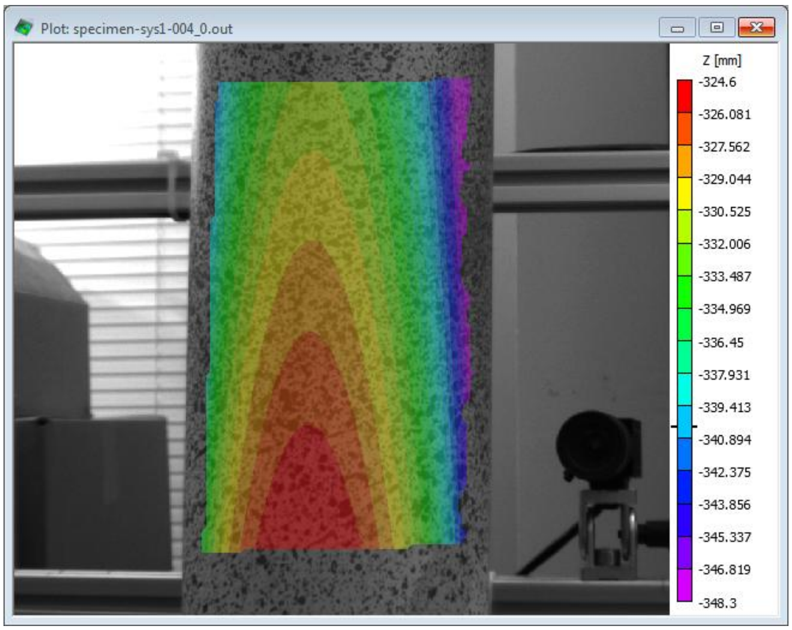
5. trans_sys1_sys2.out
6. trans_sys2_sys3.out
7. trans_sys3_sys4.out
8. trans_sys4_sys1.out

Taking test data

For the actual testing portion of our procedure, we simply have to image the specimen with all four systems and take images as usual (manual, timed capture, etc). The only point here is to be sure we use the same system setup (sys1, sys2, sys3, sys4) as during setup - this is persistent in Vic-Snap so it shouldn't usually be an issue. Here, we've taken a reference image, then some images at different pressure levels.

For each system, we run the analysis using the stereo calibration and the images from that system. This is performed exactly as normal - at this point, we treat the image sets as completely separate. The only thing you need to be sure of here is that you use camera coordinates - **the "Auto plane fit" option needs to be OFF.**

Here, we have four systems, each imaging about 100˚ of arc:



We can confirm that auto plane fit is off by noting the large Z values.

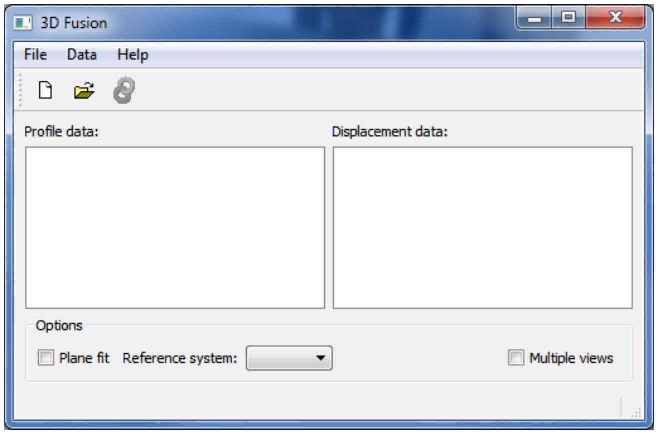
When this portion is complete, we have a sequence of individual patches of data for each system.

Merging data

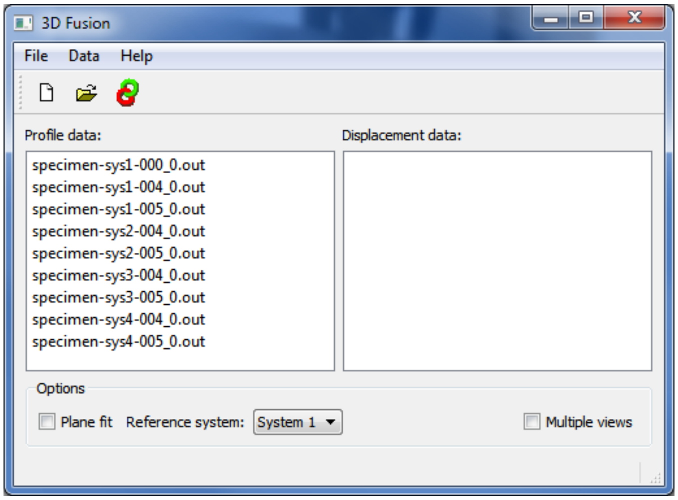
Once we have

- The individual patches of data from each system, and
- The "trans..." files connecting each system to the next,

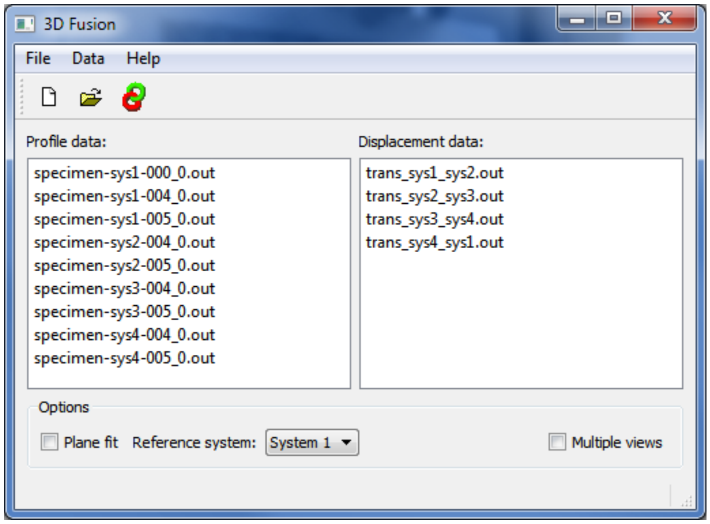
We can merge the files. This will be accomplished using the **3D Fusion** utility.



Click File... Add Data Files. Then, select all of your **test data**. Here, we have 3 .out files from each system. Click open:



The data has been sorted into the "Profile data" side because it only contains information for one system. Then, click Add Data Files again, and select the **"trans..." files**.

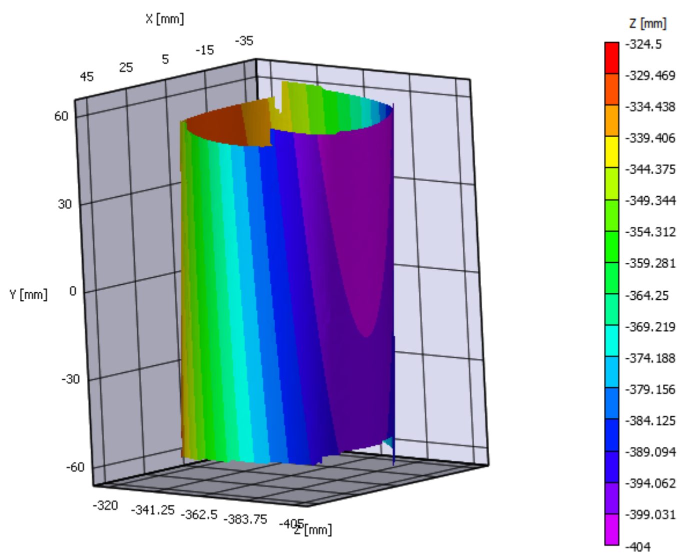


These files are sorted into "displacement data" because they contain a displacement between one system and the next. Note that you can add all these files at once - they will be placed in the right spot automatically.

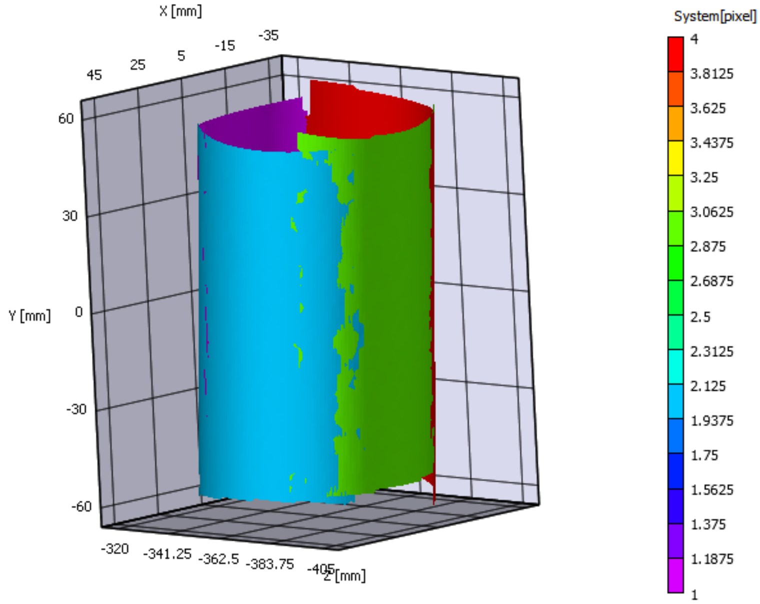
You can select the "Plane fit" check to re-fit the data to a new coordinate plane; or, select a "Reference system". This selection controls the coordinate system of the new data; whichever patch is selected as the Reference system will be **unchanged.**

The "Multiple views" checkbox is used when we have a single system taking several views of the same object as it rotates; we will ignore it, here.

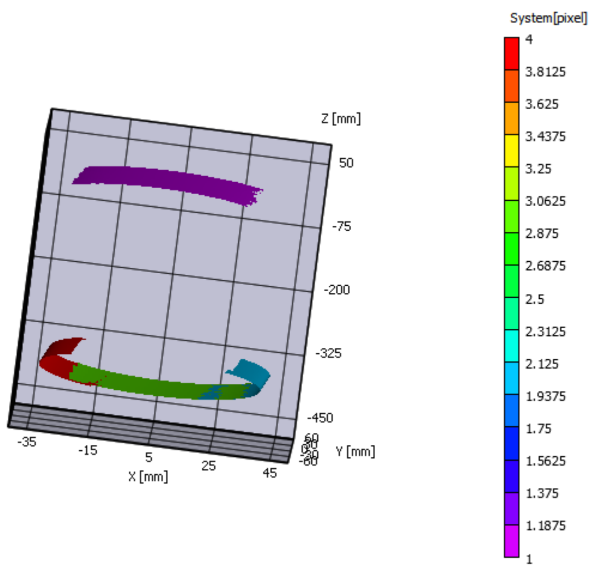
Finally, click the Fuse Data button or select Data... Fuse Data. You will see a progress bar as each file is processed. When complete, there will be a set of new .out files in the folder called "stage-*nnnn*.out". There will also be a new project called fused.v3d; this project is for convenience and it simply points to the fuse out files. If you open it you will see a new set of fused files:



This is your original data, placed into a common coordinate system. It also contains a new variable called "System" which indicates the integer system number that each data point came from:



If you see something like this:



Then either one of the transforms was incorrect, or, you accidentally left "auto plane fit" on for one of the image sets. At this point you will have to trace back through and repeat each step, which is why careful naming and saving is important.

Note: this data exists as 3D data only; many plotting and analysis functions that require a 2D overlay won't work, here.

Global optimization

For this example, we had a "closed loop" of system links: 1→2→3→4→1. This procedure will run just fine without the last link (just 1→2→3→4), but the fit might not be quite as good because of the minor errors at each link. When the loop is closed, we can globally optimize to minimize the error at each step.

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.