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SOLUTIONS

Application Note

Multi-View Registration from Rigid Motions

VIC-3D 9

2021

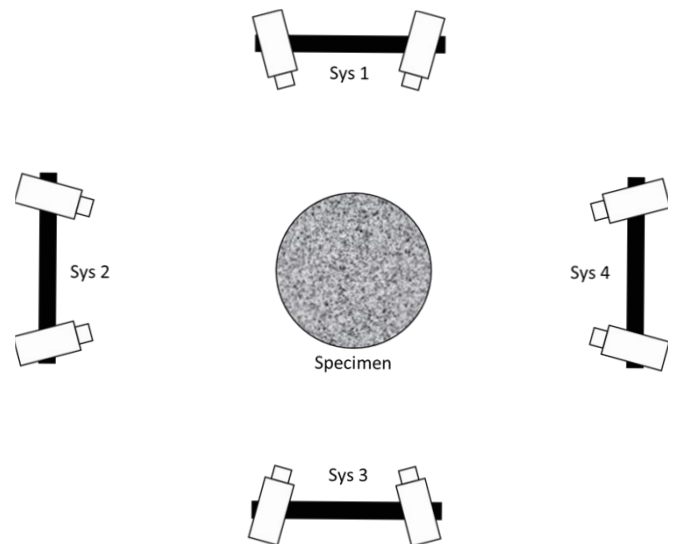# Multi-View Registration from Rigid Motions

Introduction

The principle behind using multi-view registration from rigid motions is to calibrate multiple systems separately, use rigid motions of a speckle pattern to determine the geometric transformations between each system, and use this transformation to merge data into the same coordinate system.

This application note will outline the procedure for completing a test using the multi-view registration to combine data from multiple systems.

Setup

To illustrate the capabilities and procedures of multi-view registration in Vic-3D, we will use an example of using four camera systems (8 cameras in total) to image around a cylinder. Using fewer or more camera systems will not change the process outlined here.

Plug all the cameras into your PC. Specify the camera system for each camera in Vic-Snap. Right-click on the image feed of each camera and *Select system*. Each camera pair should be a new system, starting with System 1. Doing this will add the necessary tag to the image names. For example, a four-system setup with eight cameras would have Sys1, Sys2, Sys3, and Sys4. Do not use "Primary" as one of the systems, as this will not provide the necessary file naming. It may be useful to organize the windows automatically using *Windows… Tile by System*.

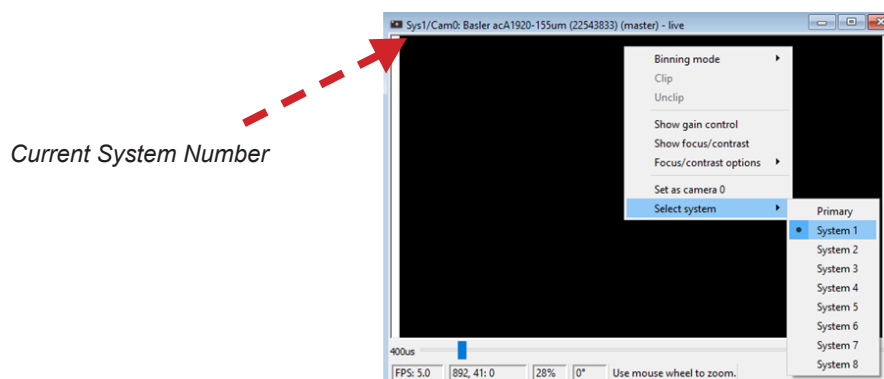*Physical setup of system used as example for this document*

Current System Number

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support@correlatedsolutions.com
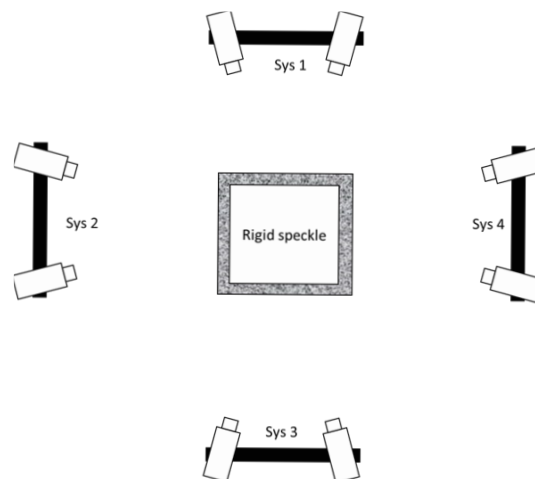1.803.926.7272

Image Capture

Calibration Images

Edit the file name prefix so that you can easily identify the images as calibration images (we used the prefix "cal"). Capture calibration images for each system individually as you would normally. You do not need to change any settings or file names in between. Take 15-20 good images of the grid with plenty of rotation visible in both system 1 cameras, then move on to system 2.

Since all the systems capture images at the same time, you will end up with extra images (that do not show the grid face) as you capture calibration images for the other systems. You may exclude these from the project if you wish, but they will not cause any problems since the calibration procedure will exclude them.
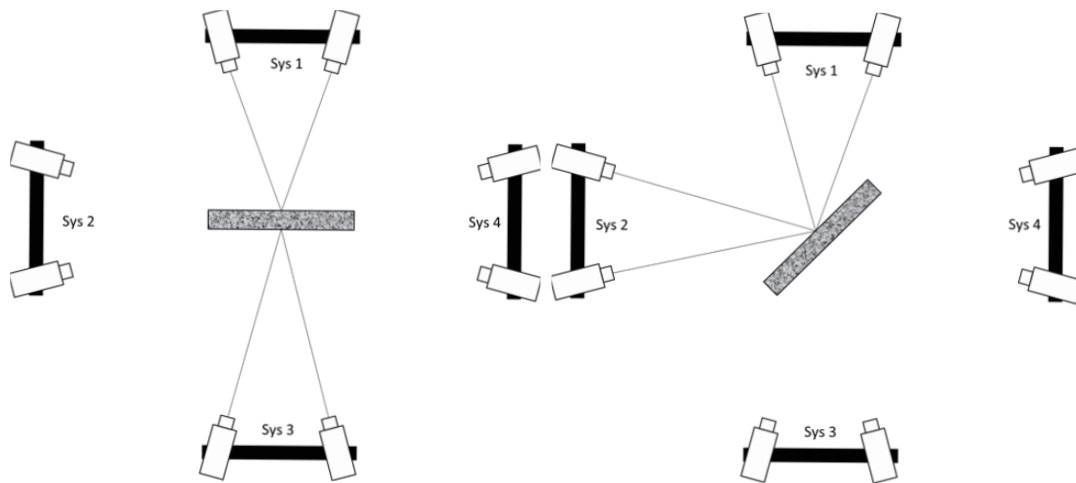
Rigid Speckle Images

Multi-view registration requires a series of rigid motions of a speckle pattern to create the coordinate transform. **It is very important that the speckle pattern remains rigid!** For the sake of example, we will be putting all the additional systems into system 1's coordinates. To do this we will need rigid motions visible in both system 1 and each of the others; in our example 1-2, 1-3, and 1-4.

The best option for obtaining rigid motion images is to have a rigid object that has a speckle pattern visible from all the cameras at once, like a cube. This allows you to rotate the cube and obtain the necessary information for all the coordinate transforms at once. Depending on the size of your field of view, what you use as a rigid object can vary. For our example, we created a cube using plywood and speckled each side with an ink roller from the Correlated Solutions Speckle Kit.

*Rigid cube with speckle pattern on each side - rotations will be visible by
all systems at once*

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S O L U T I O N S

If you cannot use a rigid object that is visible in all systems at once, you can do them separately. You must still obtain images between your system 1 and each of the others, but they may be independent (Capture rigid motions visible in sys1 and sys2, then visible in sys1 and sys3, then sys1 and sys4). For two systems adjacent to each other a rigid plate with single sided speckle pattern could be used. For systems opposite of each other you would need a plate with a speckle pattern on both sides.

Rename the file output to indicate that the images are the rigid motion images that will be used for Multiview registration (we used "rigidmotion"). Capture images with ranges of rotation and translation of the rigid speckle, similar to how you would during calibration but now with a speckle pattern.

Test Images

If your test is non-repeatable, you may want to delay this part for now and continue with the calibration and multi-view registration to make sure you have completed it properly first. If you choose to do this, be careful not to disturb/bump any of the systems as this can invalidate the calibration and multi-view transformations. When you get to the section of this document titled **Analyze Test Images**, you would take the test images then.

Rename the file output once again to signify that these are test images (we used "shape" since we are doing a shape measurement of a cylinder). Set the capture mode, options, exposure time, etc. and complete the test.

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Multi-View Registration

Calibration

Create a new Vic-3D project for each system. Name the projects intuitively; sys1.z3d, sys2.z3d, etc. works well. Import the respective calibration images to each project. Following the example set up here, the system 1 project should contain the calibration images ending with the suffix "-cal-sys1-XXXX_0.tif" and "-cal-sys1-XXXX_1.tif". Calibrate and save the projects.
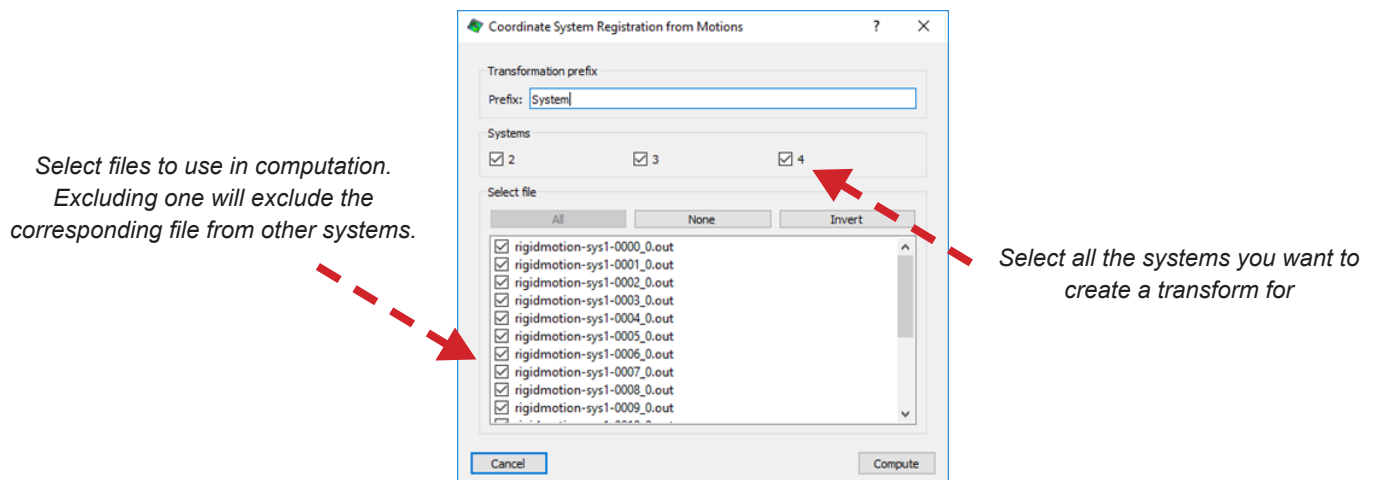
Analyze Rigid Speckle

Import the rigid motion images into each respective project. Define an AOI over as much of the speckle as visible. You may need to supply an initial guess (start point) because of large motions. Run the analysis, making sure **Auto Plane Fit is turned off** in the post-processing options tab.

Hybrid Calibration (optional)

To improve results, we can use the rigid motion images we have already captured and perform a hybrid calibration. Go to *Calibration…. Hybrid Stereo System Calibration* and use the "Rigid speckle and scale from grid" option. This can do a better job determining geometric and camera model parameters than grid calibration alone. Run the procedure and click *Accept* if you are satisfied with the calibration. Re-analyze the rigid speckle images with the new calibration.

Multi-View Registration

Open the system 1 project file (or whichever system you want to merge the data into) and run the multi-view registration from *Data… Coordinate Tools… Multi-View Registration from Rigid Motions*. If the data files contain the correct system prefix and are found in the same directory, they will be automatically recognized. You may choose which system transforms to compute and the data files to use. Compute the transform for all the systems.

Select files to use in computation. Excluding one will exclude the corresponding file from other systems.

Select all the systems you want to create a transform for

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Viewing the plot tab is a useful way to confirm that the transform is correct, showing the surfaces in their physical orientation. Click *Accept* to store the computed coordinate transforms in the current project file, and then save the project file.
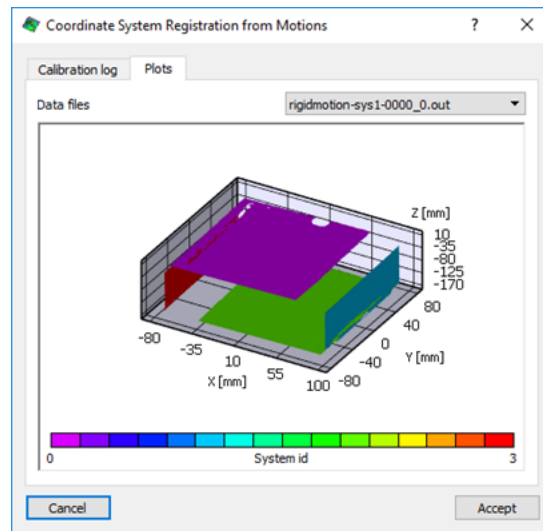
Set-Up Coordinate Systems

For each system **other than the first**, open the original system file with the grid calibration. Select *Data… Coordinate Tools…. Set Coordinate System*. You will be prompted to import a transform:

Select the project file form the previous step; it should contain transforms for system 2 through 4. Select relevant transform (matching the system you are working with) and click *Accept*.

This will reconfigure the coordinate system for the project so that the data will be in the correct Cartesian coordinate system immediately upon running. Complete this step for system 2, 3, and 4, being sure to save the project.

Analyze Test Images

At this point we can begin to analyze the actual test's images. Import the images into each system's respective project file, set the reference image, AOI, options, and run the analysis on the test images. Again, **make sure Auto Plane Fit is turned off**. Do this for all systems before combining data.

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Combine Data

Bring the data files from all systems into the system 1 project file (or the project you compute transforms in). Go to *Project… Data Files* and import the data files from the other systems. They will now appear in the data tab under "Other data".

We now have all of the data in a single coordinate system, but we cannot view it as a single file. To fix this, we combine the newly transformed data: *Data… Postprocessing Tools… Combine Data Files*. Select the data files to merge and check the Group by index option. Provide a name for the output files by the Combined prefix. You can preview the result by clicking on a file name. If everything looks correct, click *Start*.
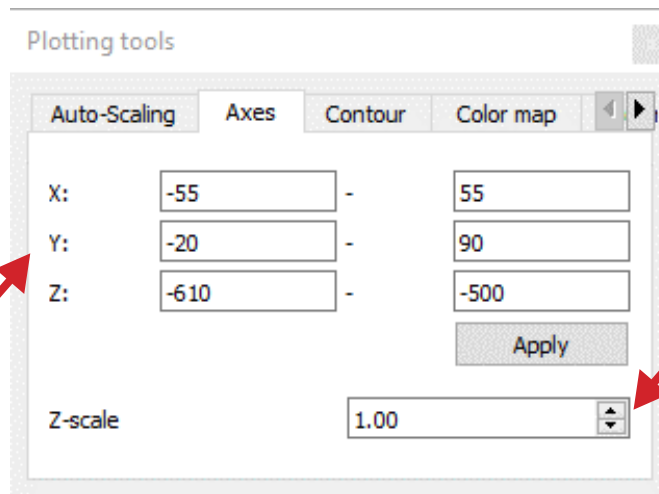

Select the test data files

Group by index selected
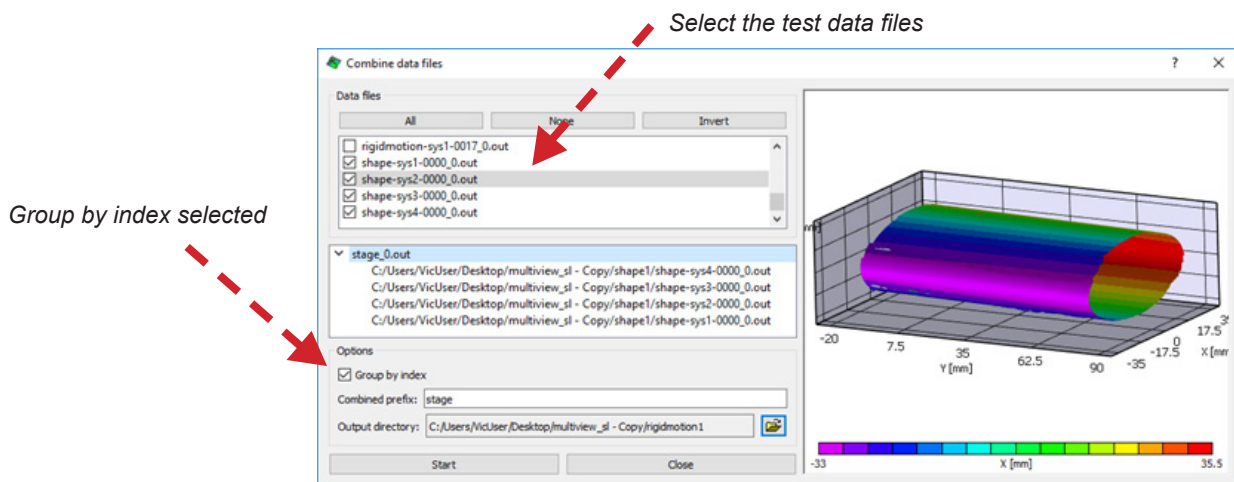
Viewing Combined Data

The newly combined data files will also appear under "Other data" of the project data tab. There are several plotting options that may make it easier to view the data. By default, the Z-scale of the plot is likely set to 0.3, making the shape appear flattened. A Z-scale of 1 should be used if you are interested in viewing a closer representation of the actual 3-d shape. It is also likely that Auto-rescale coordinates will make some of the coordinate ranges different sizes. To view a true 1:1:1 shape each of the axes should cover the same range. Uncheck Auto-rescale coordinates and set the axes limits such that they encompass the entire data set and have the same span.

Also note that the combined data exists as 3D data only. Plotting and analysis that requires a 2D overlay cannot be used here. It can, however, still be used on the individual data files after transforms have been applied.
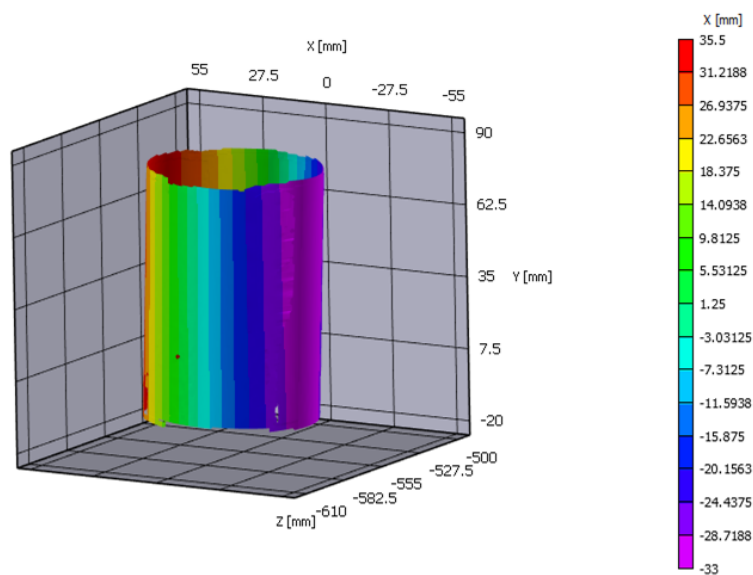
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Auto-Rescale Off

All axes have same range
(110mm here)

Set Z-scale to 1

Combined data with plotting options listed above -- 1:1:1 scale

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Troubleshooting

Transformations

If your combined data ends up looking wrong or something like this:

It is likely that one of three things has occurred:

First, the auto plane fit option may have been left on during the analysis of one or more image sets. Check if this was the case, and if so, retriangulate that data with auto plane fit off (*Data… Postprocessing Tools… Restore Data*, select the files to restore and turn auto plane off this time), restore any data that had a transformation applied, recompute the multi-view registration, and then apply the transforms.
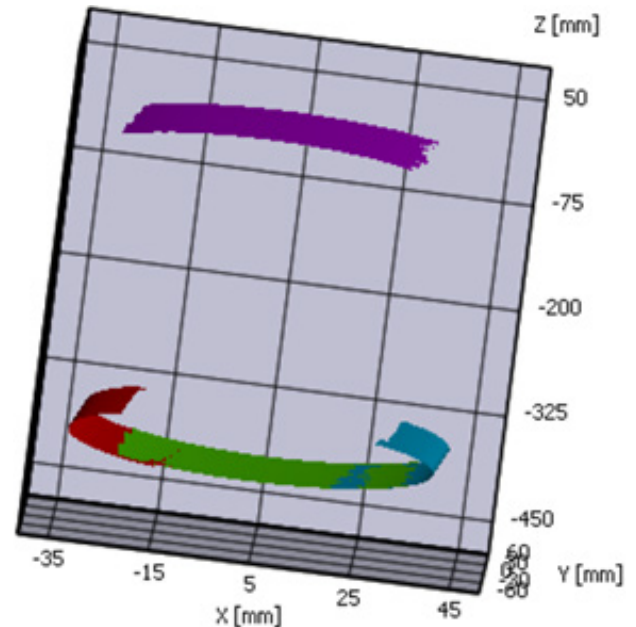
A second option is that the transforms were not applied/were applied to the wrong data. You should be applying the corresponding transform to each set of additional data brought into the main (system 1 in our case) project file. For example, the system 2 transform takes system 2 data and puts it into the system 1 coordinates. Retriangulate data files and retry applying the transforms to the correct data.

A third possibility is that the transform itself is inaccurate. Assuming that the procedure was complete correctly, this could be a result of a poor calibration or not enough information being provided as part of the rigid motion images. Check calibration and that the rigid motion images have wide ranges of rotations and are correctly analyzed in each system project file.

Strains

After applying any coordinate transform to data strains must be recalculated. They should be based on the new coordinate directions. Do this through *Data… Postprocessing Tools… Calculate Strain*.

Support

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