correlated
SOLUTIONS

Application Note

Variable Ray Origin Calibration

VIC-3D 9

2021

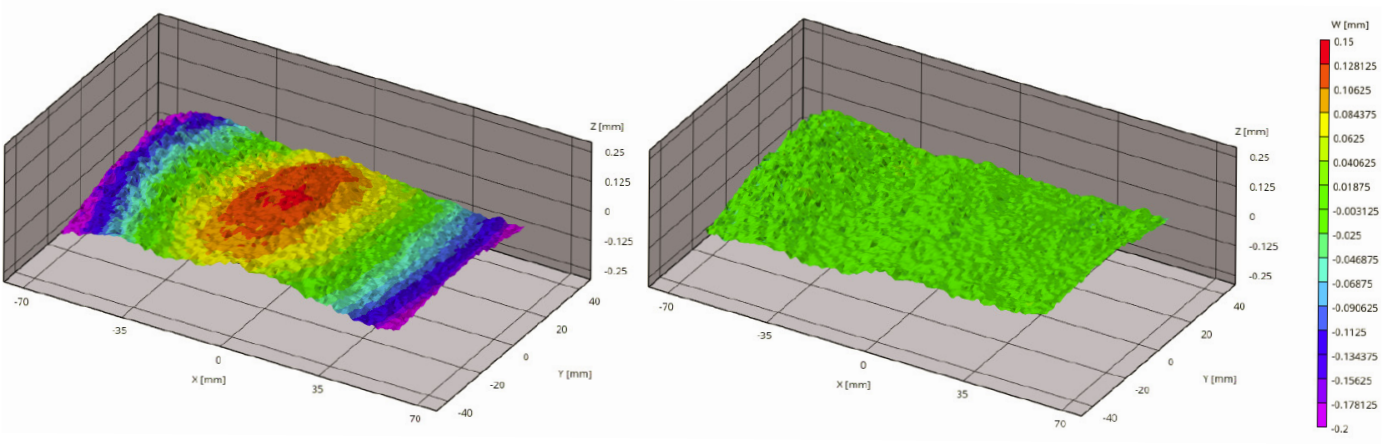
Variable Ray Origin (VRO) Calibration

Introduction

VIC-3D 9 has a calibration option using Variable Ray Origin (VRO) camera models to eliminate measurement bias when imaging through refractive surfaces. This is especially useful for setups that involve imaging through glass panes (e.g. a viewport of a heating chamber) or in bio-medical applications, where a specimen is submerged in water. This document outlines how to perform a calibration using the VRO model in VIC-3D.

VRO Camera Model

Traditionally, a pinhole camera model is used for calibration that has a singular point from which all camera rays originate. When refraction occurs at interfaces between the cameras and specimen, the pinhole model is prone to significant errors in shape, deformation, and strain measurement. The VRO camera model allows the origin of the camera to vary from pixel to pixel and eliminates the measurement bias due to imaging through optical interfaces.

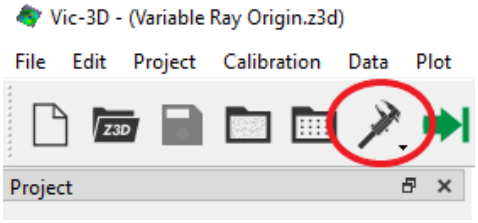


Residual errors in displacement for pinhole camera (left) and variable ray origin camera (right)

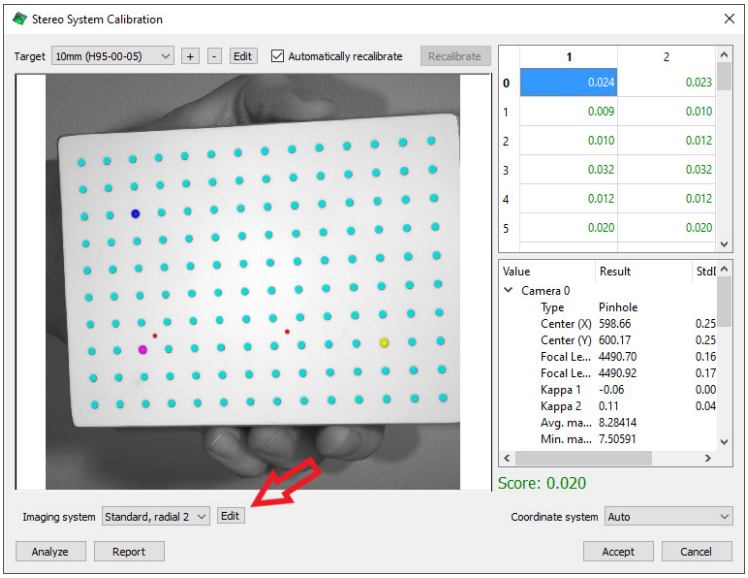
VRO Calibration Procedure

1. Acquire calibration images with the target in the same location as the test specimen will be. Any windows/liquids/etc. should be present as they will be during the test. Make sure there is no debris or air bubbles on any surface or the calibration target. Be especially careful of reflections that can be reaching the cameras. Acquire at least 30 image pairs with a good range of tilt of the calibration target.
2. Acquire the images using VIC-Snap, then import them into VIC-3D as usual.

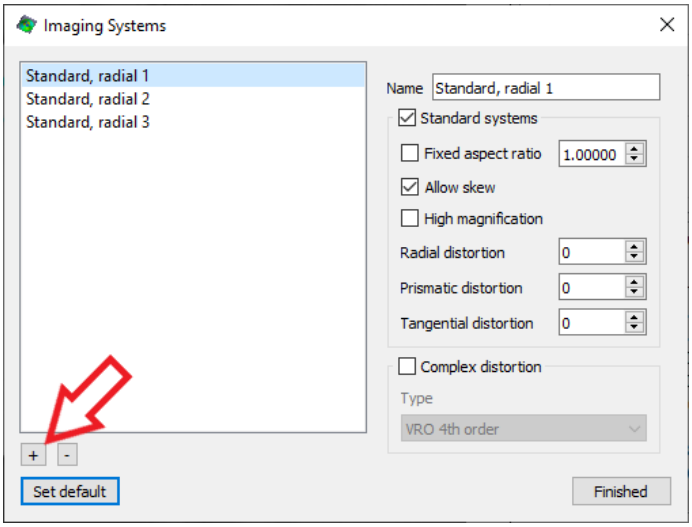
3. Click the ***Calibration button*** in VIC-3D 9.



4. If VIC-3D auto-detects the calibration target and starts analyzing, click ***Cancel***.
5. Click ***Edit*** at the lower left to edit the imaging systems.

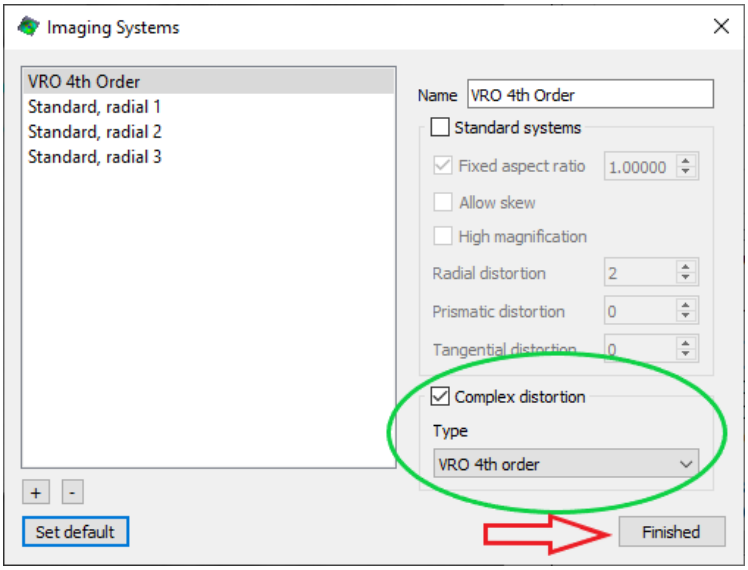


6. Click the "**+**" to add a new imaging system.

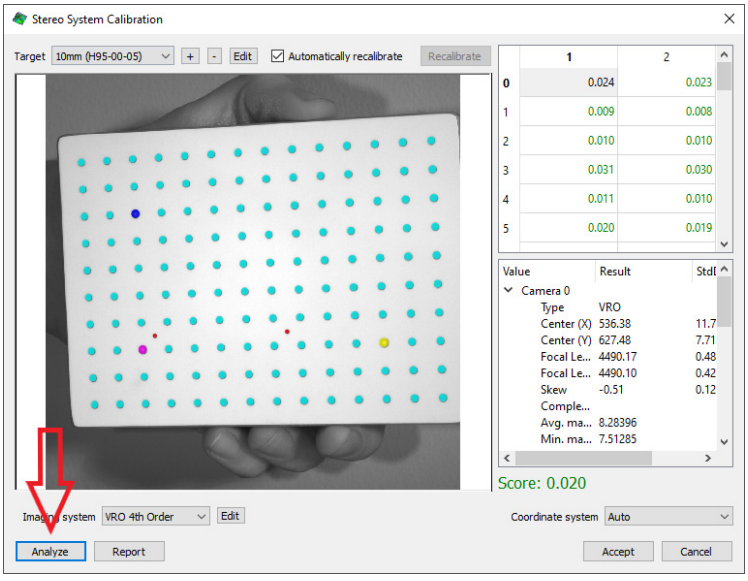


7. Name the new ‘imaging system’ calibration. In this example, the file is named “VRO 4th Order”. Check the box labeled ***Complex Distortion*** and select ***VRO 4th order***. Click ***Finished***. This calibration setting will be saved for future use.

Note: It is best to use the 4th order as much as possible, because fewer variables are required to optimize the model. This model works for most setups. The 5th order may be used if the setup is more complicated, such as viewing through multiple refractive interfaces (e.g. camera->air->glass->water->glass->air->specimen).



8. Select the system that was just created from the imaging system drop-down.
9. Select the appropriate calibration target in the top left and click ***Analyze***.



10. Click ***Accept*** to use the calibration.
11. Examine the remaining noise and bias of the setup before performing the test. As with any VIC-3D system, take images of a rigid speckle pattern undergoing translation and/or rotations. Analyze these images as normal and compute strain in VIC-3D. Observe the mean and standard deviation of strain values by viewing the 2D data plot and selecting a strain contour variable. Right-click the contour and click *Statistics*. The closer the mean is to zero and the lower the standard deviation, the better the setup and calibration. If *Hybrid Calibration with Rigid Images* (which is recommended for VRO setups) is used, simply analyze those images after the hybrid calibration is completed.

Hybrid Stereo Calibration

In addition to the VRO camera model, it is also recommended to use the hybrid stereo calibration procedure. This allows for an improved calibration because it uses many more data points than just the grid points of a traditional calibration grid. To do this, another set of images should be captured in which a rigid speckle pattern is rotated and translated similar to how calibration grid images are acquired. Import these images as speckle images into the project and open the hybrid calibration dialog (***Calibration > Hybrid stereo system calibration***). Select the rigid speckle method and the desired point limit. Larger numbers of data points can increase processing time but may improve confidence in calibration parameters. Select the image files of the rigid speckle and click ***Calibrate***. Click ***Accept*** to use the calibration.

Support

If you have any questions about this document or any other questions, comments, or concerns about our software, please contact us at support@correlatedsolutions.com, or visit our website at support.correlatedsolutions.com.