Long Term Stability of Stereo-DIC Calibration

R. Spencer[1a], A. Tayeb[1], L. Fletcher[1]

[1]UKAEA, Culham Campus, Abingdon, Oxfordshire, OX14 3DB

[a]Rory.Spencer@UKAEA.UK

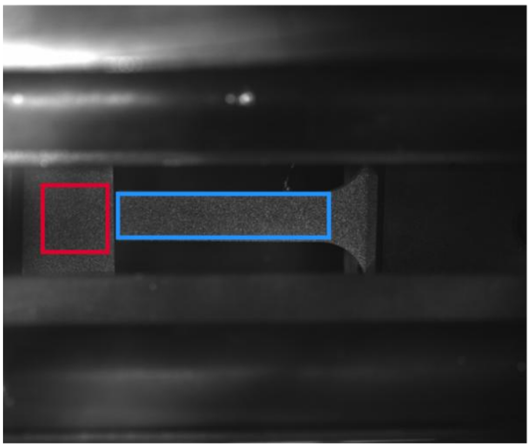
Abstract Accurate full-field measurements during creep tests are essential for robust inverse identification of constitutive models. Creep tests can take 100's to 1,000's of hours, or more, and stability of the stereo camera setup over this duration is often not considered. Experimental data is presented that demonstrate an impact of stereo camera drift. An approach to correct for the drift is proposed using stereo calibrations derived from the experimental images.

Introduction

Two camera stereo (3D) Digital Image Correlation (DIC) is preferred over 2D DIC as it can detect out-of-plane movement. Stereo DIC requires calibration, typically using a plate with a grid of dots with known size and spacing. This calibration determines the parameters for the transformation of the camera coordinates to world coordinates. Once calibrated, provided there is no interference from the experimenter, it is assumed that the system does not change and the calibration remains valid. However, our experiments suggest that over the long durations of creep tests, small changes can occur to the camera setup which manifests as spurious out-of-plane displacements and biaxial strains that pollute the real data.

Experimental Observations

Fig. 1 shows the start of a creep test on Gr91 steel at 550°C in vacuum. After temperature stabilisation, the specimen (blue) was subject to a 250MPa tensile load, whereas the dummy plate (red) was unloaded. Despite there being no mechanical load, the dummy specimen appears to creep. Assuming this is non-physical, it can be used to correct the apparent strain on the specimen (green). This gives a significant change in the apparent creep on the specimen by a factor of ~6.



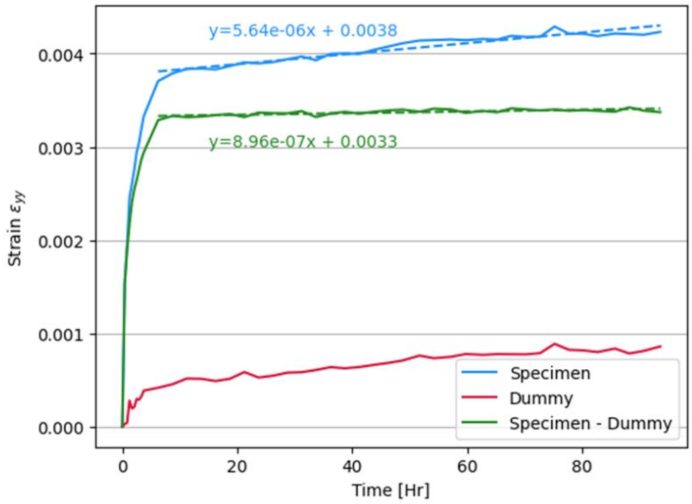


Figure 1: Specimen (blue) and unloaded dummy (red) of the same material during a 550°C creep test nominally at the same temperature (left), strain developed on the specimen and dummy over time (right).

To isolate the effect, further testing was performed on a static target, outside the vacuum chamber, with no applied load or temperature. Cameras were turned on and warmed up prior to testing. The same effect was observed, shown in Fig. 2. The apparent shift in the out-of-plane position of the specimen suggest that the stereo angle is changing after the calibration. The spurious strain values are biaxial and correspond to the apparent change in magnification, i.e. $\varepsilon_{xx} = \varepsilon_{yy} = \frac{\Delta Z}{Z}$, where Z is the stand-off distance when the system was originally calibrated.

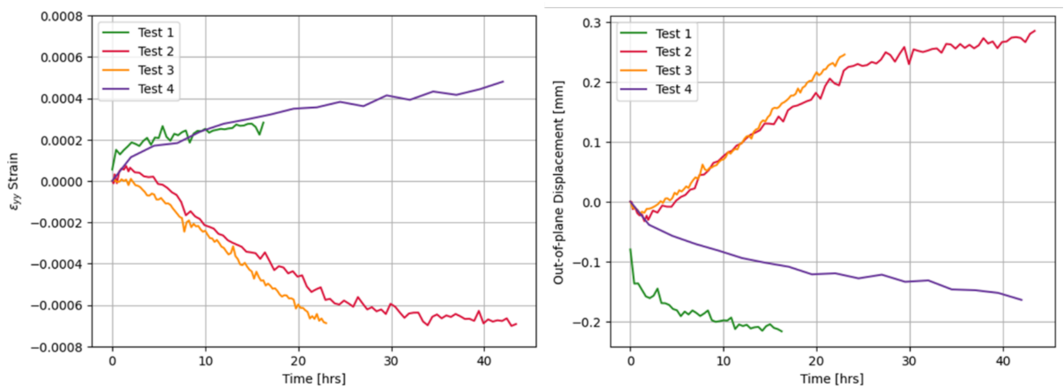


Figure 2: Results from multiple stereo DIC observations of a static target. The strain should be zero, but drifts either up or down (left), which is associated with an apparent movement away or towards the cameras (right).

Correction Methodology & Results

Fig. 3. shows our experimental setup used to replicate changes to the stereo angle. Both cameras are mounted on micrometer-controlled rotation stages. The right camera was rotated after calibration, whilst the left remained fixed, inducing the effect observed in Figs 1. and 2. Intermediate calibrations were obtained using the Independent Calibration feature in MatchID. These calibrations were used to recalculate the stereo projection and formulate a correction based on the difference between the original and updated projections.

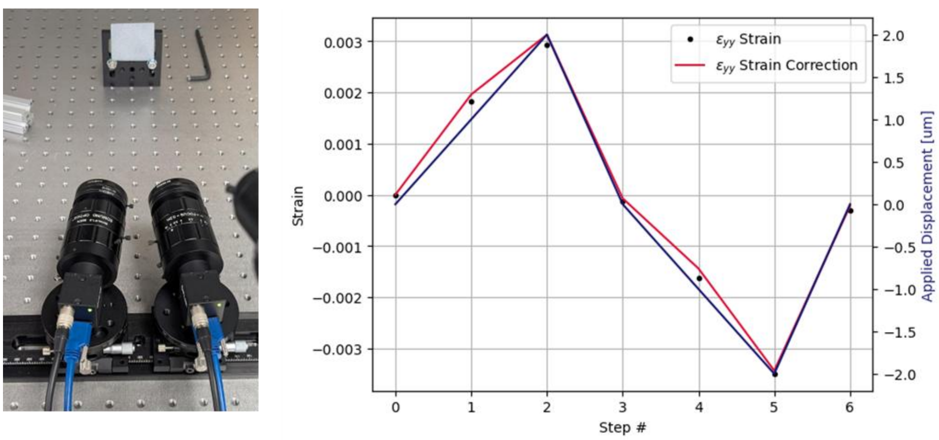


Figure 3: Stereo setup with cameras on micrometer-controlled rotation stages (left), spurious strain developed on the target (black dots) with the calculated correction based on intermediate calibrations (red) (right).

The results shown in Fig. 3. suggest that the correction can handle complex changes in stereo angle. However, the correction is reliant on the accuracy of the intermediate calibrations calculated from the images.

Conclusions

Changes in the stereo DIC setup have been observed over long duration creep tests. These are associated with spurious biaxial strains and out-of-plane displacements. The effect has been replicated experimentally and a correction formulated using calibrations based on the captured images.

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