191 Evaluating measurement uncertainty in industrial environments.

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Introduction

In recent years optical full-field measuring techniques are increasingly being used in research and industry as development and design tools for improved characterization of materials and components. The digital image correlation (DIC) technique has gained in importance because this method requires grey value digital images only and measures full-field and three dimensional displacement information. For contour and displacement measurement, the image correlation technique provides material parameters far into the range of plastic deformation. Further data analysis tools allow the determination of the location and the amplitude of the maximum strain, the global strain distribution and behaviour of crack growth, which are important parameters for material testing and fracture mechanics.

However, the qualification of the measurement uncertainty is still not fully resolved and implemented. There are different approaches used to qualify the errors, associated with the measurement. These are e.g. noise floor determination, rigid body movement measurement, error propagation method, using physical reference materials and others. These different approaches have their advantages and limitations, but none is able to provide full-field 3D uncertainties covering the complete measurement chain.

Within the MOTIVATE Clean Sky project one aim was the development of a specific method for quantification of measurement uncertainty in experiments performed in industrial situations [1]. The method is based on the use of the calibration target, applied for the calibration of the DIC system combined with a rigid body translation between the object and the DIC system.

Methods

The method presented here, is based on a two-step approach. In the first step the calibration target, used for the calibration of the DIC system is utilized. After the standard calibration process and the calculation of the projection parameters, a reference calibration target with certified calibration feature positions, is placed at different positions in the measurement volume. The DIC system determines the feature's positions in the images and uses the projection parameters to calculate the 3D position of these features. These reconstructed feature positions can be compared to the known feature positions on the target. The deviation is a direct indication for the measurement uncertainty in the measurement volume. This method includes systematic and statistical error sources.

However, the DIC system may use a different correlation algorithm for the determination of feature position in in the images of the calibration target than for the correlation of the speckle pattern on an object surface. In addition, it does not take error sources into account which come from the object itself. Therefore, a second step is introduced, based on a rigid-body translation between the DIC system and the object. Introducing a known rigid-body translation with the required accuracy might be difficult. Hence, before introducing the rigid-body translation, images of the object are captured and afterwards a reference calibration target is positioned in front of the object and images of the target are captured. Then, a rigid body translation in the range of the expected object deformation, between the DIC system and the object, is applied. Again, images of the target are captured. The target is removed and images of the object are captured.

Using the calculated feature positions of the reference calibration target before and after the rigid-body translation, the amount of translation can be determined. Using the images of the object before and after the translation, the translation measured using the object can be compared with the translation calculated from the target. The deviations are a direct measure of the uncertainty

Test Case

The described method was applied during a test case for the measurement of compression loading test on a fuselage large panel. The panel had a size of about 1x1m and curvature in one direction. The panel was potted at the top and bottom in order to be placed in the compression frame. In figure 1 the measured surface contour of the panel and potting frame are shown. By using the two-step approach for the uncertainty quantification of the DIC measurement for each point on the object, an uncertainty for each coordinate direction can be determined. These uncertainty data are scaled by 1000x and overlaid on the contour information.

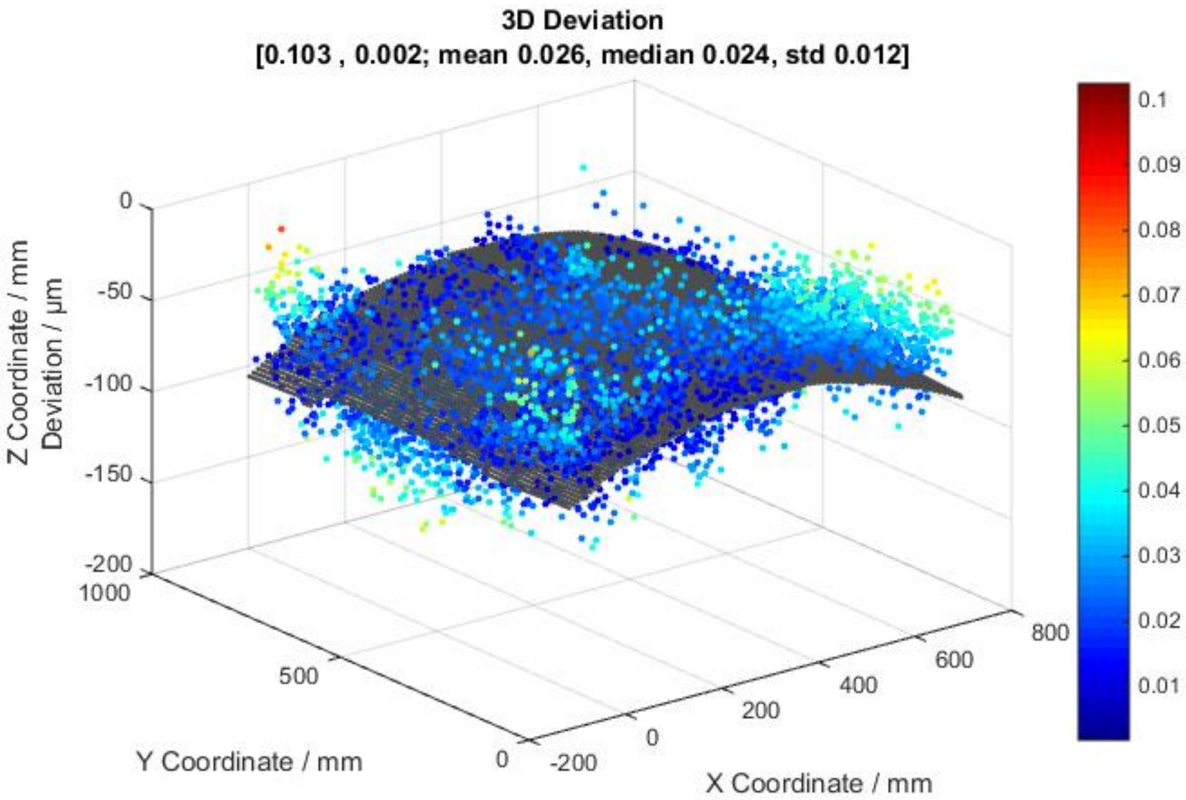

Fig. 1: Contour of the test panel and 3D uncertainty (scaled 1000x) calculated by the proposed method for uncertainty quantification.

Conclusion

The proposed method is based on using standard DIC parts and does not require any additional equipment. By the combination of the positions of features of a known calibration target and a rigid body translation, the displacement uncertainty of the DIC system in the specific environmental condition of the actual experimental can be determined. In this way, error sources from the DIC system, the environment and the object are combined. The usability of the method was successfully demonstrated on a compression panel test.

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