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A virtual/real dialogue to set up, control and optimize a single camera digital image stereo-correlation test

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ABSTRACT

The term "digital image stereo-correlation" (DIC) refers to the non-contacting technique based on the acquisition of digital images of an object which, through image registration, extracts 3D shapes and full-field motion measurements [1]. It is a recent method that relies on a projection model at different viewpoints and their consistency with a single 3D shape. The significant benefits that the full-field character entails as compared to the use of strain gauges make its use very appealing in the industry: the information gathered is global and continuous rather than local and discrete. Its implementation requires at least two cameras that are fixed and each calibrated [2]. The positioning of those cameras is chosen in order to offer a correct angle of view but in practice remains mostly empirical. Such a setup lacks flexibility, may be time consuming and shows no tolerance to imperfection. Tests involving multiple view points are feasible but very demanding.

It is proposed in this study to develop and optimise the stereo-correlation method with a single camera mounted on a robot arm to gain flexibility in its positioning (Figure 1, left). This setup enables the camera to capture the specimen to be tested under a large variety of angles but it leads to new issues, among them the accuracy and the repeatability of the positioning of the robot. Tests are made to assess these characteristics. The robot arm is a source of positioning uncertainties but the position of the camera can be calculated with a dynamic calibration on a target provided for that purpose. It is set up next to the test piece in order to constantly be in the field of view. This calculated position is therefore chosen over the commanded position for the stereo-correlation method.

The test piece was designed to maximise out-of-plane deformations during a tensile test (Figure 1, right). By minimising the bending elastic energy of the surface, an exact analytic solution has been obtained for the out-of-plane buckled geometry as a function of the imposed elongation. The calculation is based on the assumption that the membrane is inextensible. That solution is used as a reference of the 3D displacement of the test piece.

The software *Blender* [3], which can simulate the real experimental environment, is used to shorten the test development time by virtually setting up the test within a 3D environment

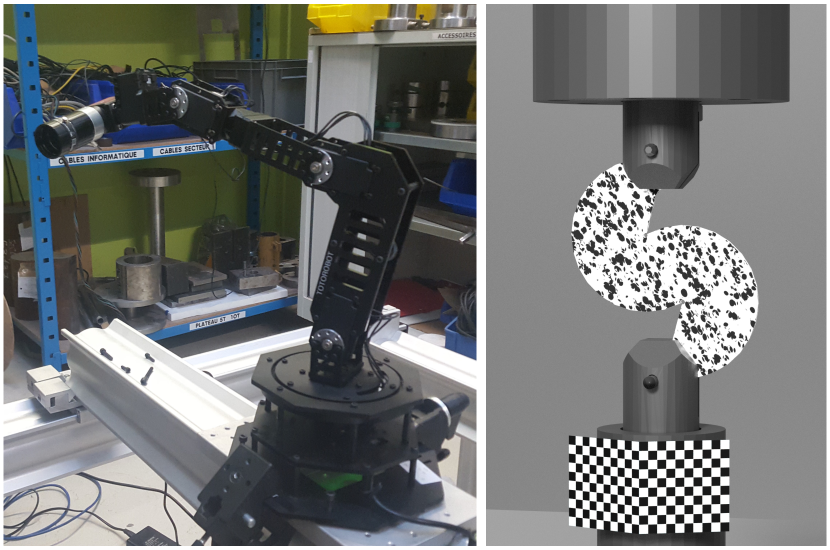

Figure 1: Camera mounted on a robot arm (left) and *Blender*-generated render of the specimen designed in *CATIA* and target for the tensile test (right).

(using the virtual design approach [4]) and then avoiding a trial and error method. A 3D virtual model of the test is generated and the camera positions are optimised, in the software, in order to offer a wide coverage and to minimise the measurement uncertainty. Rather than adjusting the test setups on the real system, they are adjusted in *Blender* offering a faster and more accurate algorithm. The objective criteria that are implemented solve the problem of empirical positioning.

Finally a tensile test was performed to determine the displacement of the test piece. The software *EikoTwin* provides this information from pairs of images taken with the robot arm. These displacements are compared to the analytic solution. This comparison assesses the effect of errors in robot positioning that were calculated with a calibration.

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