# On the use of 3D visualization for the virtual design and optimization of a structural test monitored by a multi-view system

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**Résumé**

One of the most remarkable features of full-field measurements is their ability to quantify deformations such as those resulting either from a complex shape and/or loading history or from a constitutive law leading to localized phenomena (e.g., instabilities or fracture). Experiments can be classified into two categories, namely, those aiming at the calibration of constitutive laws of a specific material and those reproducing in-service conditions for a complete industrial part. The first category seeks the most uniform stress/strain state so that either local (e.g., strain gauge) or global (e.g., extensometer) measurement devices were sufficient to characterize strains and stresses (thanks to load cells) in the region of interest. The advent of full-field measurement techniques allowed for complex sample shape to be characterized in a complete fashion, so that instead of a simple uniformity assumption, analyses can be used to "read" displacement fields and evaluate unknown components of the constitutive law, and additionally validate the numerical model and assess its relevance for the analyzed test. This opens up the possibility of using in-service tests in order to quantify and validate the selected model for the part of interest. This is a major change of perspective for experimental mechanics, which requires the development of new tools.

As soon as the specimen shape is complex, or when symmetry is broken down by an instability (be it due to geometry or to the deformation mechanism itself), displacements have to be characterized in 3D. An exhaustive characterization requires that any surface element where displacements are to be measured should be observed by at least two cameras (or two viewpoints if the imaging system is moving). Moreover, as grazing incidence gives a very poor determination, one may restrict the considered cameras observing a surface element only by those whose angle with the surface normal is less than a prescribed level. This criterion is a natural extension of the obscuration criterion. Therefore, in order to observe a given shape over its entire surfaces, a minimum of four cameras are needed, even for a simple (convex) surface. Even if it can be rightly argued that a model may allow for an appropriate interpolation for those regions where not enough viewpoints are accessible, having a global

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and redundant coverage is recommended. Hence, the positioning of the cameras and the calibration of the geometrical model that is needed in order to use all cameras simultaneously becomes key to the success of the mechanical test.

The recourse to 3D rendering software, in this case the free and open source 3D renderer *Blender*, as a way to design such complex experiments, is presented. It allows to virtually stage the experiment, by choosing and setting up cameras or light sources, with a great amount of time saved in the preparation of the real test.

Because this is a clear trend in experimental mechanics, it is of high importance to recognize it as such, and develop suited strategies to not only avoid improper test conditions (unfavorable shadows or obstructions from other objects), but rather to optimize the setup to benefit from the potentialities of full-field measurement capabilities in particular in a global framework of analysis.
Mechanical tests may be optimized by minimizing measurement uncertainties. To this end, 3D rendering softwares, at the heart of the methodology proposed herein, are extremely valuable instruments inasmuch as they can provide a reliable estimate of the uncertainties that will result from the setup and the analyzing tools. An operational route to pre-design and optimization of experimental setups is readily accessible.

**Mots-Clés:** mechanical test, multi, camera, uncertainty quantification, virtual design, computer vision, photo, realistic rendering