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AN IMAGE DECOMPOSITION APPROACH TO VALIDATION

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Innovative approaches to the design of engineering structures need to be validated in order to demonstrate their reliability. It is generally accepted that a comparison of the simulated to measured data provides a substantial piece of evidence for that assessment. In solid mechanics, the stress-induced deformation or strain in a structure or component is related to potential damage. While from a fundamental point of view a comparison of the full 3D-data set were desirable, in practice, only surface strain or stress fields are readily accessible outside the laboratory.

Advanced optical techniques based on full-field measurement are increasingly used to measure surface strain fields as they offer the unique possibility for a holistic comparison of the simulation data to data fields from an actual experiment. A huge amount of data is created both from the detailed finite element prediction and from the full-field measurements. A quantitative comparison can be based on taking the difference point-by-point and calculating an average or maximum deviation. However, with such an approach redundancy is expected, and the challenge is to reduce the data to a meaningful sub-set which still reflects the essentials of the structural behaviour but allows a quantitative comparison with reasonable effort.

Instead of comparing a million points, matched onto a common coordinate grid by interpolation, we propose a hierarchical comparison of image descriptors to provide evidence for consistency of the data. One of the most common procedures is the Fourier transform in which the original data field is represented by a superposition of periodic base functions. Based on this hierarchical comparison, a quantitative measure of validation can be obtained and be compared to a confidence limit or acceptance interval set beforehand which is an indispensable step in solid mechanics model validation. This approach was developed in the ADVISE project [1], and promising applications have been reported since, see e.g. [2].

We will review the basics of validation and image decomposition based on, for example, Zernike or Tchebichef polynomials. While application of the technique to a simple geometrical object is straightforward, the robustness of the process and its limitation in view of experimental influences such as noise and measurement uncertainty will be discussed. Figure 1 shows the image decomposition of a simulated and measured deformation field.

While the residual of reconstruction is zero for the (smooth) simulation data, reconstruction quality of the experimental data is limited by the noise level.

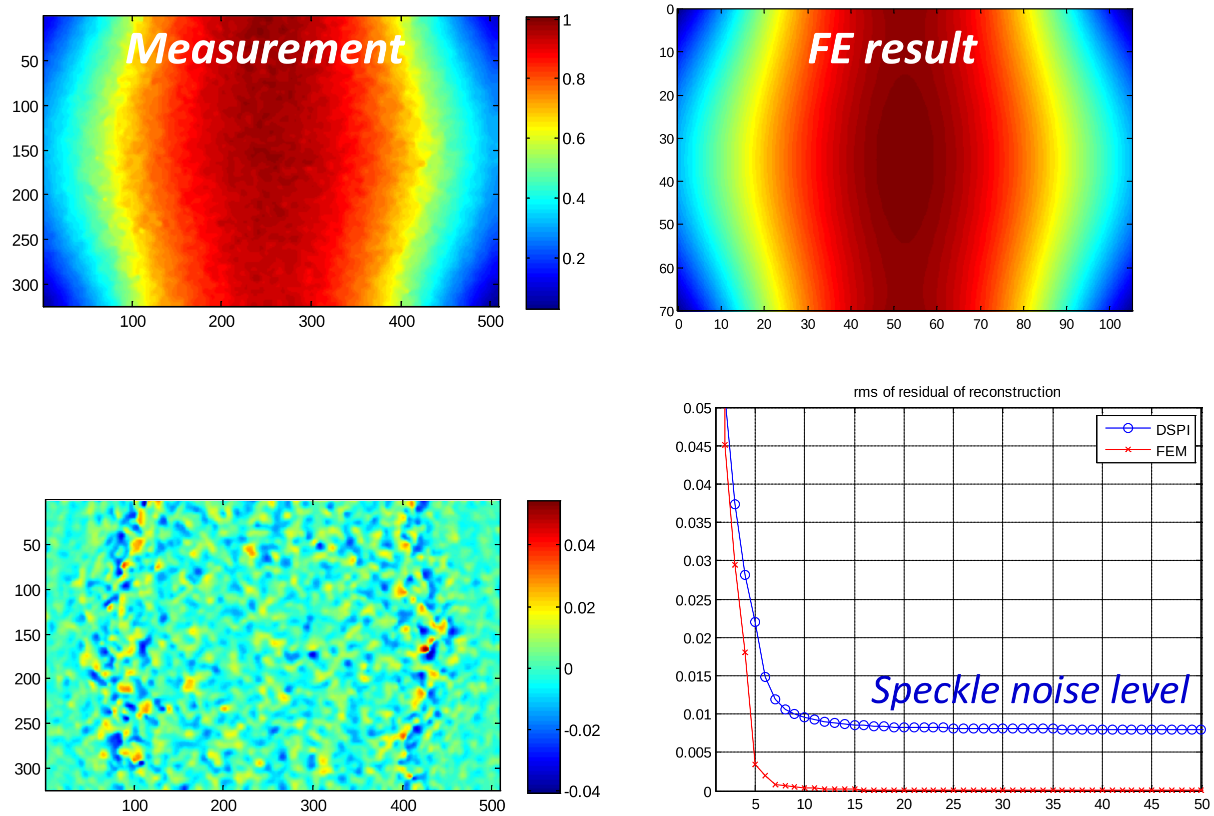

Figure 1: Measured and simulated deformation field (top), the residual of a 20 term Tchebichef polynomial reconstruction (bottom left), and rms residual for both FE and measurement results (bottom right).

In addition to the influence of experimental deficiencies more fundamental issues of the comparison and the definition of the acceptance band will be addressed. These include the influence of a possible mismatch of the areas to be compared, robustness against a randomised selection of points inside the data field, as well as correct normalisation in view of the actual number of points.

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