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On the Construction of Constitutive Manifolds from Experimental Data

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ABSTRACT

The use of constitutive equations calibrated from data collected from adequate testing has been implemented successfully into standard FEM solvers for a variety problems encountered in simulation based engineering sciences. However, the complexity of modelling requirement is unceasingly increasing due to the high complexity of the physics problems to be solved.

Data-Driven simulation constitutes in our opinion a real change of paradigm in simulation-based engineering sciences – SBES-. Standard simulation in classical mechanics is based on the use of two very different types of equations. The first one, of axiomatic character, is related to balance laws (momentum, mass, energy...), whereas the second one consists of models that scientists have extracted from collected, natural or synthetic data. Data-driven simulation consists of directly linking data to computers in order to perform numerical simulations. These simulations will employ universal laws while minimizing the need of explicit, often phenomenological, models. They are based on manifold learning methodologies able to extract the uncorrelated behavior of constitutive relations [1]. This approach is especially interesting when considering complex engineered materials (metamaterials) for which constitutive relations become with difficulty accessible. The main drawback of such an approach is the large amount of required data, some of them inaccessible form the nowadays testing facilities. Such difficulty can be circumvented in many cases, and in all cases alleviated, by considering complex tests, collecting as many data as possible (e.g. by using image correlation) and then using an inverse approach in order to generate the whole behavior manifold from few complex experimental tests.

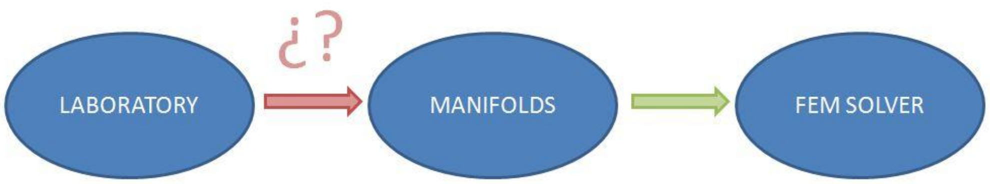

Fig. 1 Data-driven simulation chain.

REFERENCES

[1] R. Ibanez, E. Abisset-Chavanne, J.V. Aguado, D. Gonzalez, E. Cueto, F. Chinesta, A manifold-based methodological approach to data-driven computational elasticity and inelasticity, Archives of Computational Methods in Engineering, DOI 10.1007/s11831-016-9197-9