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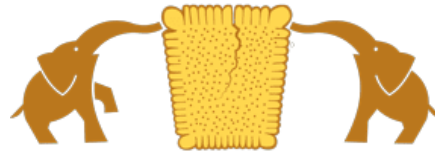
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## Identification of constitutive parameters of elastomers from one heterogeneous test

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**Abstract** — In this work, the Virtual Fields Method (VFM) and the Finite Element Updating Model (FEMU) are used for the identification of hyperelastic parameters of the Mooney, Yeoh and Ogden models from full-field kinematic measurement using Digital Image Correlation (DIC). Both method has benefited from recent development, the use of the sensitivity based virtual fields for the VFM and the use of AI for the FEMU. The AI algorithm is based on Particle Swarm Optimization (PSO) enriched with the *Page-Rank* algorithm used by Google search engine. Several comparison criteria between the two method were studied, namely the complexity encountered when formulating the method, the computation time needed to obtain the parameters and the complexity of the models that can be identified.

**Keywords** — Heterogeneous test, DIC, VFM, PSO-based FEMU

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**Introduction** The identification of the constitutive parameters of hyperelastic materials is performed classically using three homogeneous tests. These three tests are the uniaxial tension, the pure shear and the equibiaxial tension (uniaxial compression). Since 2009, these tests were replaced by one heterogeneous test of biaxial tension on a cruciform specimen [1]. In such test, all strain states corresponding to the three classical tests are present as well as several intermediate strain states with a wide distribution of the strain field. In this work, two identification procedures are investigated. The first one is the VFM based on the application of the principle of virtual work [2] with the integration of the sensitivity of the stress field to small variation of the constitutive parameters in the choice of independent virtual displacement fields [3], [4]. The second one is FEMU method with an adapted PSO optimization algorithm. Both method were used to identify hyperelastic parameters from the biaxial test.

**Experimental setup and identification methods** The experimental setup is reported in Figure 1. It is composed by a biaxial tensile machine, a CCD optical camera, the cruciform elastomeric specimen and LED lighting system to ensure homogeneous distribution of cold lighting during the test. An equibiaxial displacement is applied to the four branches of the cruciform specimen at the same loading rate (low enough to consider the equilibrium response of the material). The full kinematic fields were measured using DIC with 7D Software [5]. The first identification method VFM is based on the minimization with respect to the constitutive parameters of the difference between the internal and external virtual works using independent virtual displacement fields. Therefore for each model to be identified the principle of virtual work should be formulated. The choice of the set of independent virtual displacement fields is the crucial point of the VFM. In this work, this is done using the sensitivity based virtual fields. On the other hand, the FEMU method is based on the minimization with respect to the constitutive parameters of the kinematic fields and the force between the experiment and numerical simulation of the experiment. During the identification process, the constitutive parameters are modified by the PSO following the objective function formulated in terms of the difference of the kinematic fields and the force. The kinematic fields used in the identification are the displacement and principle in-plane stretch fields for the VFM and FEMU, respectively.

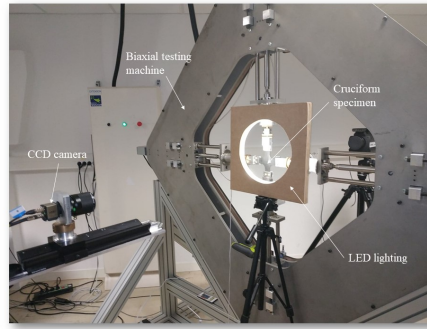


Figure 1: Experimental setup

**Results and comparison** The results of the identification procedure are the constitutive parameters for the different considered models. A first comparison is presented in Figure 2 in which the force obtained from numerical simulation of the biaxial test using the identified parameters is compared to the experimental one. Both method present an efficient option to be applied when dealing with such behavior. It should be noted, however, that the computation time and the complexity of the models that can be identified is so different between the two method. This will be fully presented in the oral presentation.

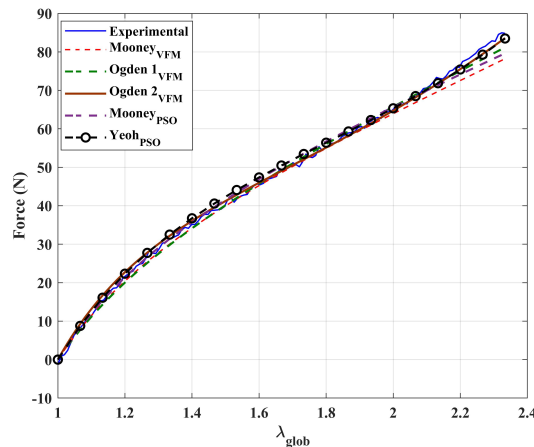


Figure 2: Force vs global stretch for the identified parameters

**Conclusion** Two identification procedures of hyperelastic parameters from one heterogeneous test are presented. Both method uses full-kinematic fields measurements ensured by DIC. The obtained results confirm the applicability of these identification methods with such mechanical behavior.

## References

- [1] N. Promma, B. Raka, M. Grédiac, E. Toussaint, J-B. Le Cam, X. Balandraud and F. Hild. Application of the virtual fields method to mechanical characterization of elastomeric materials. *International Journal of Solids and Structures*, 46(3-4):698–715, 2009.
- [2] M. Grédiac. Principe des travaux virtuels et identification. *Comptes rendus de l'Académie des sciences. Série 2, Mécanique, Physique, Chimie, Sciences de l'univers, Sciences de la Terre*, 309(1):1–5, 1989.
- [3] A. Marek, F.M. Davis and F. Pierron. Sensitivity-based virtual fields for the non-linear virtual fields method. *Computational Mechanics*, 60(3):409–431, 2017.
- [4] A. Tayeb, J-B. Le Cam, M. Grédiac, E. Toussaint, E. Robin, X. Balandraud and F. Canevet. Application of the virtual fields method to mechanical characterization of elastomeric materials. *International Journal of Solids and Structures*, submitted, 2020.

- [5] P. Vacher, S. Dumoulin, F. Morestin and S. Mguil-Touchal. Bidimensional strain measurement using digital images. In *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, 213(8):811–817, 1999.