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A HIGH-ORDER VISCOELASTIC FRACTIONAL ELEMENT APPLIED TO MODELING OVINE ARTERIAL WALL BEHAVIOR

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Viscoelastic models have been widely used for modeling and understanding the behavior of materials, where the constitutive behavior is represented by simple models composed by springs and dashpots. However, real materials are, in general, not describable by models with a small number of springs and dashpots [1]. In order to improve the ability of these models to fit the complex behavior of materials without increasing the number of elements, it was introduced the concept of fractional response, where the stress is proportional to the fractional derivative of the strain $\sigma \propto D^{\alpha}\varepsilon$ with the fractional parameter $\alpha \in I_{\alpha} = [0, 1]$. During the twentieth century several authors made important contributions which are briefly presented in [2].

The fractional element described is called spring-pot, as it represents an intermediate behavior between a spring and a dashpot. The models that include a spring-pot are called Fractional Viscoelastic Models (FVMs) and have provided promising results for modeling materials such as polymers and living tissue [3, 4]. Our aim is to improve the accuracy of these models through the use of a modified version of the spring-pot, called high-order spring-pot. We are focused in the modeling of arterial wall behavior.

In this article we describe and implement a numerical method for characterization of mechanical properties of FVMs from σ, ε measures. We validate the implementation by solving a numerical example with artificially generated data with and without noise added. Afterwards, we apply the method to ovine arterial wall stress and strain data, obtained from *in-vitro* measurements presented in [5]. The method is applied using the spring-pot element ($I_\alpha = [0, 1]$) and the high-order spring-pot element ($I_\alpha = [0, 2]$).

The results obtained using the artificial data, show that the method is able to characterize the mechanical parameters even in presence of low-level noise. For the experimental data the results show a notable improvement using the high-order spring-pot. In Figure 1 at the left, we can see the hysteresis obtained with $I_\alpha = [0, 1]$ (experimental data is expressed with circles and model data with crosses); at the right are shown the results for $I_\alpha = [0, 2]$, where it is clearly shown the improvement in the fit.

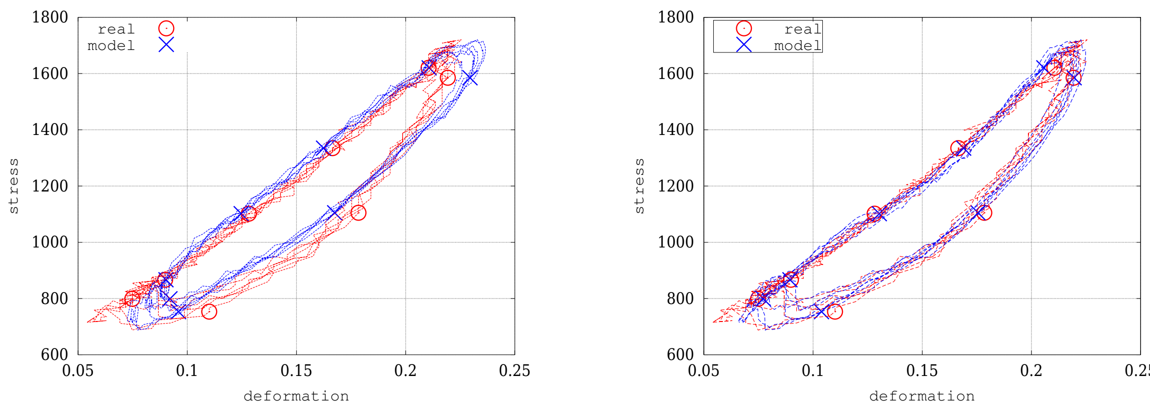

Figure 1: Left: Hysteresis results obtained for $I_\alpha = [0, 1]$; Right: results obtained for $I_\alpha = [0, 2]$

The results presented in the article allow us to conclude that the FMVs are improved when a high-order spring-pot is included. In particular, it was shown that these models are appropriate for modeling arterial wall behavior. Providing a better modeling of the behavior, will represent better results obtained in computational simulations of the arterial wall mechanics.

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