Identifying material parameter distributions of fibers with extremely limited experimental efforts

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Numerous materials are essentially discrete networks of fibers, yarns or struts at length scales substantially smaller than the application scale. Some examples of these materials are foams, paper materials, printed lattices and textiles. Besides the possible geometrical randomness, many of these materials are characterized by the fact that each fiber, yarn or strut has its own set of material parameters. Incorporating this randomness in discrete mechanical models can substantially influence the predictions, compared to those of mechanical models in which no randomness of material parameters is included.

If we assume that the material parameters of each discrete constituent are realisations from a distribution, the parameters of this probability density function (PDF) must be identified. The most conventional manner of identifying the parameters of such a distribution is to experimentally identify the material parameters of hundreds of fibers, yarns or struts and subsequently, use these material parameters to identify the parameters of the distribution. This entails an enormous amount of experimental efforts, which is the reason that hardly anybody will go through these efforts.

As an alternative to testing hundreds of fibers, yarns of struts, we will present an approach that requires testing only a few fibers. We will use Bayes' theorem for this purpose, which entails the proposition of the shape of PDF, as well as a proposition of the possible values of this PDF (albeit as distributions as well). For each set of material parameters, we then assess how likely it is that it is a realisation from the proposed PDF and its proposed parameters and we update the PDF's proposed parameters such that the likelihood that the set is a realization of this PDF increases.

In order to explain the approach as gently as possible, we will not directly deal with the PDF's parameters as parameters that also originate from a PDF. Instead, we will first focus the PDF's parameters as deterministic variables [1].

[1] Rappel H, Beex LAA, Bordas SPA, 'Bayesian inference to identify parameters in viscoelasticity', Mechanics of Time-Dependent Materials, 2017, In press.