On the efficient use of lattice models

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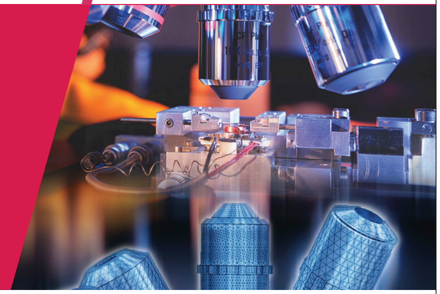

On the Efficient Use of Lattice Models

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1. Introduction

Technological interest in fibrous materials is increasing since they are used in more and more applications (see Fig. 1). Lattice models are appropriate to investigate their material behaviour because they directly incorporate mesoscale phenomena of the fiber network. A drawback is that lattice models come with high computational costs and the challenge is therefore to reduce the lattice models such that they become manageable without losing accuracy. The quasicontinuum (QC) method is proposed as a starting point for model reduction.

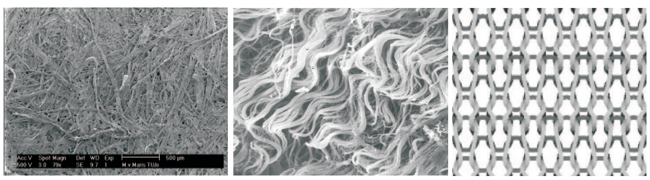

Figure 1: Three fibrous materials: cardboard, collagenous fibers [1] and knitted electronic textile [2].

2. Lattice model

The lattice model in Fig. 2, containing elastic trusses, can be regarded as a discrete representation of the microstructure of a fibrous material. In order to find the nodal displacements, the potential energy of the lattice model must be minimized. This is however computationally expensive for two reasons:
1. lattice models contain many degrees of freedom, since every truss node corresponds with two unknown displacements
2. all truss nodes of the lattice model must be 'visited' to determine the internal potential energy of the lattice model.

3. The QC method

The QC method [3] introduces two reduction steps in order to allow a more efficient use of lattice models:
1. Finite elements are used to interpolate the displacements of the truss nodes and thus to reduce the number of degrees of freedom (see the first step in Fig. 2).
2. Instead of visiting all nodes, only a small number of so-called sampling nodes is visited to estimate the potential energy (see the second step in Fig. 2).

4. Results

A new summation procedure has been established that uses the location of neighboring nodes to determine if a truss node can be summed or must be discretely modeled (see Fig. 3). This procedure makes the error due to summation $E(summation)$ vanishes completely.

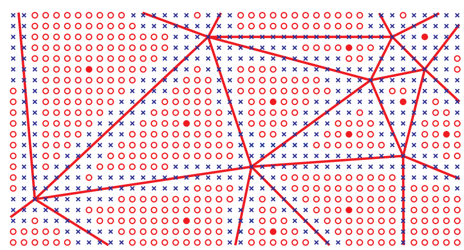

Figure 3: Result of the new selection procedure: discretely modeled nodes (crosses) and sampling nodes (full circles) that represent all other truss nodes (open circles) in an FE.

References
1. www.udel.edu
2. Falconnet et al., 2002, Comp: Part B, 33, 579-588.
3. Tadmor et al., 1996, Philos. Mag. A, 73, 1529-1563.

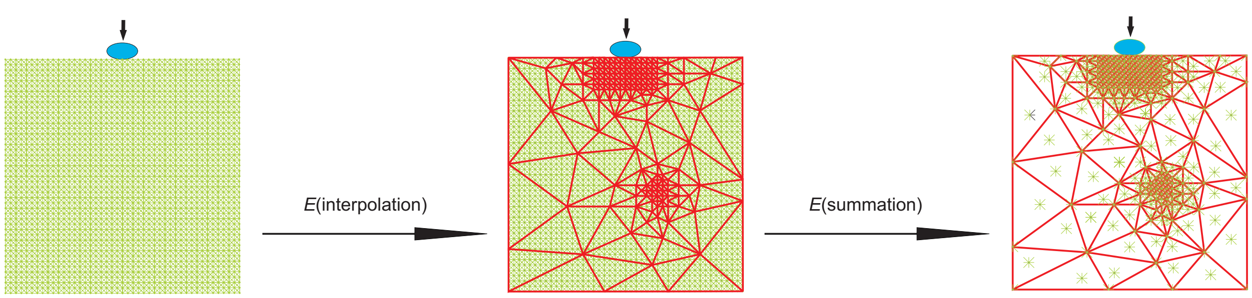

Figure 2: (From left to right) The exact lattice model, the interpolated lattice model and the QC lattice model. During each of the two reduction steps an error may be introduced.