STOCHASTIC MODELING OF 3D FIBER SYSTEMS WITH FIBER BUNDLES AND PARAMETER ESTIMATION FROM CT IMAGE DATA

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Keywords

Fiber system model, Fiber bundle, CT image, Image analysis, Fibrous media.

Introduction

Non-woven materials are used in various applications such as surgical gowns, surgical masks, oil and air filters, vacuum cleaner bags, canal constructions, erosion control, shopping bags, etc. The physical properties like strength or efficacy of these products are highly influenced by the micro structure of the materials used. Realistic 3D models for a fiber system are required to analyze the micro structure of these products. These models help to study the influence of the micro structure on its macroscopic properties.

Materials and Methods

There are several stochastic models for fiber systems with individual fibers proposed in the literature. Particularly, the model introduced in Altendorf et al. (2011) is a non-overlapping fiber system model with densely packed curved fibers. However, non-woven fibrous materials prominently feature fiber bundles rather than individual fibers only (see Figure 1). Hence, in this work, we incorporate fiber bundles in the dense bending fiber system model of Altendorf et al. (2011).

Figure 1: Visualization of CT image (550 nm pixel spacing and approximately 0.5 mm side length) (Data provided by MANN+HUMMEL GMBH, Ludwigsburg , CT imaging by RJL Micro & Analytic GmbH)

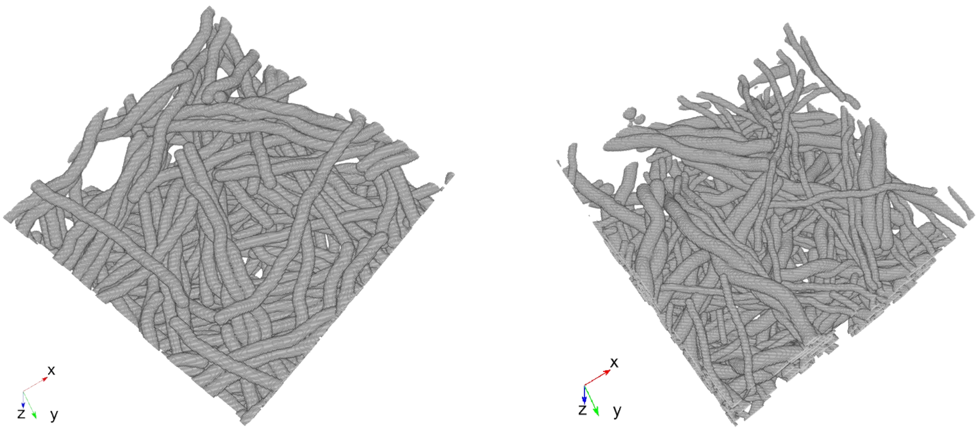

Figure 2: Realizations of the new fiber system model with fiber diameter 10 pixels and with fiber diameter 6 and 12 pixels

Results and Discussion

Models of fiber systems with fiber bundles generated by our new approach are shown in Figure 2. In order to fit our fiber bundle model to real data, we estimate the model parameters such as fiber thickness distribution and fiber orientation distribution from computed tomography (CT) images of the real non-woven filter media. Precisely, we used the morphological segmentation method from Altendorf et al. (2010) to compute fiber thickness and fiber orientation distribution. In addition to that, we also estimate parameters of the fiber bundles such as total number of fiber bundles and number of fibers in each bundle from the CT data. Then, we use these parameters to achieve a realistic 3D fiber model for real filter media.

Conclusion

Since our proposed approach incorporates fiber bundles as in the real non-woven filter medium, it can be used to improve the accuracy in filtration simulation.

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