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A MULTISCALE MODEL DERIVATION AND SIMULATION TOOL FOR MEMS ARRAYS

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Introduction We are currently developing software Memsalab dedicated to asymptotic multiphysic model derivation applied to arrays of micro and nanosystems. An asymptotic model is needed when the original model, a PDEs system, is defined on a periodic structure (small ratio of cell size to global size) or on a thin structure (small thickness) by taking into accounts its complexity and the present computer techniques. Generally, the asymptotic model can be solved much faster than the original one with an acceptable relative error. In the field of asymptotic models, a lot of literature and techniques have been developed. However, none of them have been implemented in a systematical approach to render it available to engineers as a design tool. In fact, each published paper focus on the asymptotic model for a given geometry and physics, little of them tried to propose an approach for asymptotic model derivation with general geometries and physics. Considering the constant need for faster and more reliable simulations, as well as the variety of geometrical and physical features of micro and nanosystems, it becomes essential to find a general and systematic approach. Ours starts from a reference model (asymptotic model of a PDE system on a single one dimensional domain) derivation, and then extend it to adapt new features and physics. Since the extensions can be combined, thus model derivation with different geometries and physics be generated by combining the existing and new extensions. It is grounded in the mathematical tool called Two-Scale Transform, see [1], together with formal specification techniques in computer science, namely term rewriting and rewriting strategies [2, 3]. The software is written in the symbolic computation language Maple™ The end of this abstract presents our methodology regarding software design.

Software Design Methodology The software kernel consists of the rewriting based language *Symbtrans* [4]. In our approach, a multi-scale model derivation is characterized by the features taken into account in the asymptotic analysis. Its formulation consists in a derivation of a reference model associated to an elementary nominal model, and in a set of transformations to apply to this proof until it takes into accounts the wanted features. In addition to the reference model proof, the framework includes the first order rewriting principles designed for reference model derivations, and the second order rewriting principles dedicated to transform the model derivations. Rewriting operates on expressions whose level of abstraction accurately reflects the mathematical framework. Their description follows a well defined grammar in order that they carry enough information allowing for the design of the rewriting rules and the strategies. Put together all these concepts can express a lemma proof as a strategy, i.e. a first order strategy, and therefore provide a framework of symbolic computation. The concept of the generalization of a proof is introduced as second order rewriting strategies, made with second order rewriting rules, operating on the first order strategies. They transform the first order rewriting rules and strategies and, where appropriate, remove or add new ones. Summing up, proofs for complex models are incrementally constructed by extending already existing proofs starting from the reference model. It is applied to simulate an elastic system for AFM's cantilever arrays by combining model derivation and numerical simulation. These concepts are partially reported in [5].

Conclusion This software is designed to dramatically reduce model derivation effort, avoid human errors and cover complex models.

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