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Evaluation report of habilitation thesis by Dr. Tomáš Oberhuber

The habilitation thesis written by Dr. Tomáš Oberhuber presents a good overview of his research works on high-performance numerical computation of various PDE models. His main contribution in this area is the development of numerical schemes and algorithms for many different types of PDE models on modern parallel architectures such as multi-core CPUs and GPUs, based on his deep understanding of the mathematical structures of those PDEs, for example, their geometric and variational structures, etc.

The habilitation thesis consists of four main chapters, together with the introduction, the conclusion, and his six selected papers. Each main chapter presents a brief but well-written summary of his contributions on the following topics:

Chap.2: mathematical formulations for several geometric moving boundary problems

Chap.3: level set methods for image segmentation and image registration

Chap.4: FEM formulations with parallel algorithms for incompressible Navier-Stokes equations and multiphase porous media flow

Chap.5: High-performance parallel computing with GPUs

Chapters 2-4 focus on the PDE formulations of each problem and their mathematical structures such as geometric formulation, energy equality, and variational structures. These chapters show Dr. Oberhuber's great capability in mathematics and mathematical modeling. Chapter 5 presents state-of-the-art parallel computation techniques using GPUs as his original achievement in this area. Remarkably, those parallel computation techniques are successfully applied to the various problems presented in previous chapters based on his deep mathematical insight into each problem.

I give some detailed comments on each chapter. In Chapter 2, he considers several geometric moving boundary problems, the mean curvature flow, the surface diffusion flow, the Willmore flow, and their anisotropic versions. These problems appear in various fields, in particular, crystal growth models and image segmentation problems, etc. Three different mathematical formulations by parametric method, graph representation method, and level set method, are given for each problem with their variational structures. It should be pointed out that the surface diffusion flow and the (anisotropic) Willmore flow are fourth-order nonlinear parabolic PDEs and numerical methods for these problems have not been established yet, and he and his collaborators gave significant contributions in this area [8,47,77-80,84].

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