Model order reduction for complex ocular simulations inside the human eyeball

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Résumé

In recent years, we have developed the Eye2brain project, an international collaboration aiming to develop a reliable and efficient mathematical and computational framework to simulate and predict the functioning and the connection between the eye and the brain. The ocular contribution is devoted to modeling the complex interplay between tissue perfusion, biomechanics, fluid dynamics, and heat transfer within the eye. These different aspects of the same physical problem have to be properly connected and every step has to be verified and validated in the interest of a medical application. The models require the knowledge of various parameters and some may be important factors in the development of pathologies. However, despite recent significant advances in medical data acquisition, only some parameters and their variability are known, but others cannot be directly measured. To identify the main factors that influence the biomechanical behavior of the eye, we, therefore, need to study the influence of these parameters through an uncertainty quantification (UQ) process which requires many evaluations of the models. Since 3D models are not amenable directly to UQ, a reduction step is needed to mitigate the computational cost. In (2), the team conducted on a complete UQ analysis on the 0D models developed in (3). In the present presentation, we propose a strategy to carry out further analysis using reduced order methods and in particular the reduced basis method.

We discuss then the implementation with the library Feel++ (1). Finally, we apply the methodology to some advanced ocular models and report our findings.

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