Efficient Large Scale Calculations using MultiGrid (MG) Methods

N Biboulet, H Gu, M P Noutary, P Sainsot, A A Lubrecht

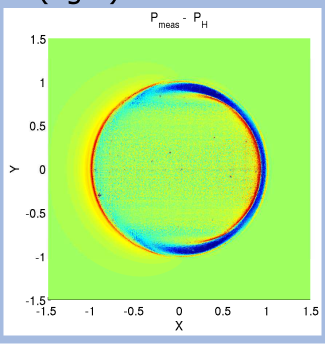
LaMCoS, INSA-Lyon, Universite de Lyon CNRS

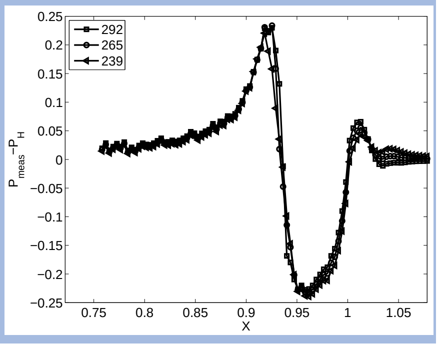
Introduction

Many of today's problems in physics and engineering require extremely fine discretisations and thus extremely large numbers of degrees of freedom (DoF). Currently, the order of magnitude is one billion DoF (10^9). As a result classical computational methods as Finite Difference (FD) or Finite Elements (FE) lead to extremely long computing times and/or require extremely large memories. This poster shows some examples of MG efficiency for FE and FD.

Pressure spike `measurement'

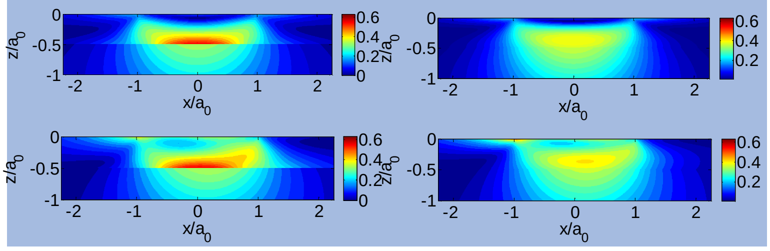
- Using very precise film thickness measurements it is possible to extract the difference with a reference (computed) film thickness profile (10^7 points).
- This difference can be de-convoluted to obtain a pressure difference, computed pressure - Hertz (left).
- Arc-averaging reduces noise and the pressure spike (right) can be reconstructed from measurements.





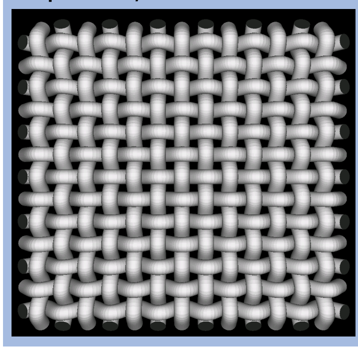
Stresses in coated materials

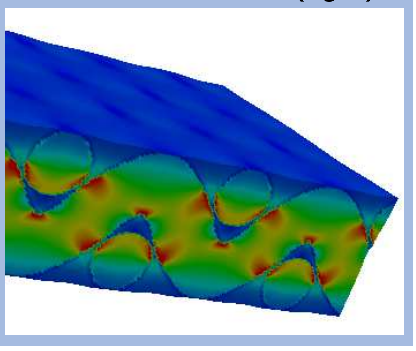
- Using a MultiGrid code the stresses in a 3d coated material are computed.
- The material properties vary abruptly (left) or gradually (right), without friction (top) or with friction (bottom).
- Load is the same for all four cases.



Solid mechanics calculation of tissue

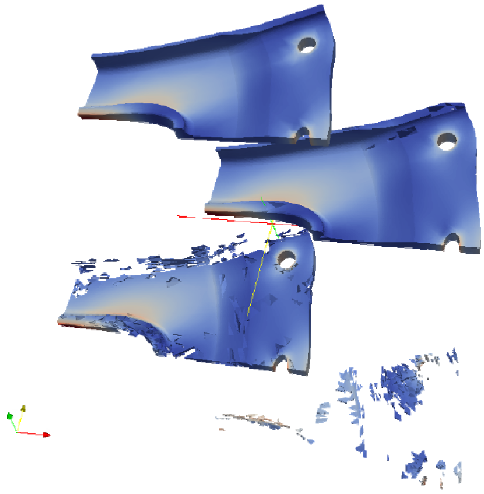
- Fiber reinforced tissues can be measured using tomography or generated mathematically (left).
- This leads to large data files with varying material properties, but allows calculation of local stresses (right).





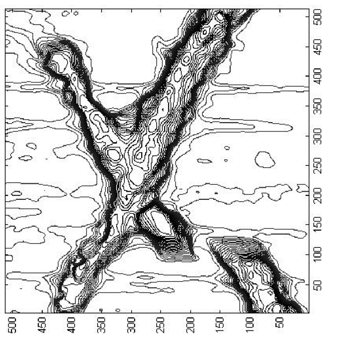
FEMG stress calculation

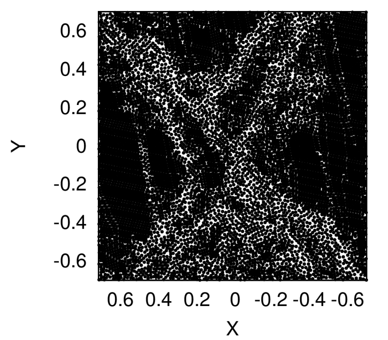
- A code mixing FEM and MG techniques was developped, that automatically refines the mesh to assure that the solution satisfies a (given) precision.
- The graph below shows the global two coarser grids (top) the partiel third grid (middle) and the very sparse finest grid (bottom). The combination of the solutions on the four grid satisfies the required precision.



Coarse grid generation using AMG

The coarse grid choice is extremely hard if the pro-blem shows rapidly varying coefficients. A flow problem with deep grooves (left) and associated coarse grid (right).





Conclusion

MultiGrid (MG) methods exhibit very efficient calculational properties, both with respect to computing time and memory requirement. A critical issue is the choice of the coarse grid points. Using AMG, this choice is automatic, but expensive. An efficient compromise is indicated by the work of Alcouffe and Brandt. Use of an FEMG code even allows an automatic grid refinement to attain a given precision.

Cooperation with MSE and Univ. Twente

LaMCoS Unité Mixte de Recherche 5259

Ton.Lubrecht@insa-lyon.fr

LaMCoS, Université de Lyon, CNRS, INSA-Lyon UMR5259, 18-20 rue des Sciences - F69621 Villeurbanne Cedex

Laboratoire de Mécanique des Contacts et des Structures