Introduction to Student Projects

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Towards web modeling of geometric data

Introduction

- New problems in science and technology require solid modeling and multiphysics simulation on big data sets,
- using the computational infrastructure provided by web-as-a-platform and platform-as-a-service paradigms
- Most of the methodologies underlying solid and physical modeling to be rethought from scratch
- Going towards the availability of simple, general-purpose, dimension-independent geometric data structures and computational methods

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and therefore requiring

- pre-processors (Delaunay triangulations) towards PDE solvers
- post-processors towards graphics renderers and user interfaces

New challenges

are posed by old and new application fields, namely

material science

- engineered surfaces,
- nanomaterials and
- metamaterials

biomedicine

where modeling and simulation issues range from the molecular/protein level to multiscale modeling of

- subcellular organelles,
- cellular structures,
- tissues and
- organs.

Integrative biomedicine

- Technological advances have made it possible to acquire large sets of biomedical data at a fast rate with affordable costs.

- The ease of producing and collecting data over the Internet is causing a shift of paradigm in the approach to science and technology:

- from physical prototyping and testing

- to virtual prototyping and mathematical modeling

- to simulate and predict behavior and performance

Towards novel solid and physical modeling

Conventional geometric modeling

Conventional geometric modeling is rather limited in scope,

being typically restricted to certain classes of triangulations or tensor-product domains in 2D or 3D, and most often confined to boundary representations.

Contrariwise, we need out-of-the-box computational representations and methods that support geometrical and physical computations on meshes of any sort.

Modeling inside boundaries: cellular complexes

All meshes—partitioning either the boundary or the interior of the model domain—and all physical quantities associated with them, may be properly represented by chain/cochain complexes.

A chain complex is a sequence of linear spaces of d-chains, $0 \leq d \leq n$, together with a sequence of linear boundary operators ∂, each mapping the space of d-chains into the space of $(d-1)$-chains.

Cochain complexes are dual to chain complexes; the coboundary operators δ, mapping the spaces of d-cochains into the spaces of $(d+1)$-cochains are dual to the boundary operators *partial*.