Geodynamics Workshop
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UT-Austin

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CUBIT 10.2, Released Oct 15 2006

Product of Over 15 years R&D at Sandia, NM

Most used Meshing software at Sandia (300+ users, 500+ external licenses)

CAD-Based Meshing Toolkit

Specializes in all-hex meshes for complex assemblies

CAD Geometry diagnostics, clean-up and decomposition tools

Automatic Hex, tet, quad, tri meshing

Element quality diagnostics and mesh improvement

Professional cross-platform GUI

Command/script driven interface

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CUBIT Usage up 5X over 2 years

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CUBIT 8.1 → CUBIT 9.0 → CUBIT 9.1 → CUBIT 10.0 → CUBIT 10.1

FY03 FY04 FY05 FY06


Sandia Usage

External Usage

CUBIT Usage up 5X over 2 years
CUBIT Licensing

• **Academic and Government Use License**
  – $300 Distribution Fee (One Time)
  – No per/license fee
  – Includes Government Contractors
  – Instructions at cubit.sandia.gov/licensing
  – About 2 weeks turnaround
  – Password to downloads site (includes all platforms and CAMAL)
  – Usage Tracking: Please help!

• **Commercial License**
  – Sandia does not offer directly
  – Non-exclusive distribution: CSimSoft
CUBIT Geometry

Meshing Algorithms

Geometry/CAD Abstraction

3rd Party Geometry Kernels Commercially Licensed

Mesh-based geometry

ACIS PRO/E CATIA MBG
Mesh Based Geometry

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Facet File Format

Import Facet Definition

Import [Facets|AVS|STL] "<filename>"
[Feature_Angle] [LINEAR||Spline] [MERGE|no_merge]
[make_elements] [stitch] [improve]

- **feature_angle**: defines curves, surfaces
- **spline**: smooth Bezier patches
- **make_elements**: create tri elements
- **stitch**: create tri elements
- **improve**: collapse small edges at curves

Watertight connectivity needed to form volumes

Smooth triangulation

Smooth <surface_list> facets [iterations
<value>] [free] [swap]

STL and AVS formats supported
Mesh Based Geometry

Exodus II Format

Binary Format
Standard format used by Sandia FEA codes

Open Source Library

Includes:
Hex, Tet, Quad, Tri, Beam
Linear and Quadratic Elements
Boundary Conditions: Nodesets, Sidesets, Blocks, Attributes, Distribution factors
Results: Can contain vector and/or scalar results at multiple time steps

Import Command

Import Mesh Geometry
'<exodusII_filename>'
[Block <id_range>|ALL] [Start_id <id>]
[Use [NODESET]no_nodeset]
[SIDESET]no_sideset [Feature_Angle <angle>]
[LINEAR|Gradient|Quadratic|Spline]
[Deformed {Time <time>|Step <step>|Last} [Scale <value>]]
[MERGE|No_Merge] [merge_nodes <tolerance>]

Geometry from feature angle, boundary conditions and deformations at timestep
Example
CUBIT Adaptive Meshing Algorithm Library

- CUBIT’s core meshing algorithms
- Available as DLL or compiled library
- C or C++ style API
- Included in standard CUBIT license
- Could be used for remeshing during analysis

Requires boundary definition
Geometry queries defined by calling application
Opportunities

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Geometric Modeling

GOCAD

Meshing

CUBIT

Triangulated surfaces

Solid Model

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Opportunities

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Geometric Modeling

- GOCAD

Meshing

- CUBIT

Triangulated surfaces

Solid Model
Opportunities

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• **Scripting**
  - Geometric reasoning/Human interaction on triangulated surfaces
  - Write CUBIT commands OR python scripts to guide CUBIT in creating solid model

• **Build into CUBIT**
  - CUBIT reads GOCAD data directly
  - Does geometric reasoning internally to create solid model

• **Use CAMAL/CUBIT inside geometric modeler**
  - Integrate CAMAL meshers into geometric modeler
  - GM handles all geometry definition
Opportunities

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• **Scripting**
  - **Advantage**: Independence - Little or no interaction with CUBIT or GOCAD needed.
  - **Disadvantage**: No access to real data. Have to duplicate geometry by geometric reasoning. Inefficient

• **Build into CUBIT**
  - **Advantage**: Have access to CUBIT data. Can customize for GOCAD data. More efficient
  - **Disadvantage**: Requires source code licensing and interaction with CUBIT developers

• **Use CAMAL/CUBIT inside geometric modeler**
  - **Advantage**: Full access to geometric data. Single application. Most efficient
  - **Disadvantage**: Would require licensing and software agreements with GOCAD.
Opportunities

Parallel

– Current Approach

• *Subdivide geometry into simple blocks*
• *Generate CUBIT script to generate mesh on each block*
• *Run CUBIT on each node (1 node per block)*
• “Embarassingly parallel”
• **Advantage:**
  – Use of existing CUBIT technology.

• **Disadvantage:**
  – Managing interfaces to ensure conforming hexes: Relies on script to generate common interfaces

– Proposed Approach

• *Parallelize sweep algorithm*
• *Manage interfaces and balancing internally*
Opportunities

• All-hex algorithms
  – General for arbitrary geometry
  – Unconstrained Plastering

• Adaptive hex meshes
  – Refinement and coarsening based upon a sizing function
  – Conforming meshes

• Specific Capability Requests
  – …