Towards Real Earth Models — Computational Geophysics on Unstructured Tetrahedral Meshes?

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Outline:

Geological models!

Advantages of unstructured tetrahedral meshes.

EM geophysics on unstructured tetrahedral meshes.

Disadvantages, difficulties, challenges.

Conclusions.
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Courrioux et al. (Tectonophysics, 2001)
Zanchi et al.  
*(Comps. & Geosci., 2009)*
Paradigm/GOCAD (web-site, 2014)
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**Advantages of unstructured tetrahedral meshes ...**

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Unstructured meshes:

→ geological and geophysical models can share the same mesh;
→ they can, in essence, be the same model;
→ a single, unified Earth model.
Constrained inversion ...
Constrained inversion ...
Constrained inversion ...
Constrained inversion ...
Contact surface inversion ...

Sprague & de Kemp (GeoInfo., 2005)
Contact surface inversion ...
Numerical/computational benefits:
Inversion, sensitivity computations (MT):
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EM geophysics on unstructured tetrahedral meshes:

Börner et al. (GJI, 2008);
Um et al. (GEOPHYSICS, 2010);
Mukherjee & Everett (GEOPHYSICS, 2011);
Schwarzbach et al. (GJI, 2011);
Puzyrev et al. (GJI, 2013);
Ren et al. (GJI, 2013);
Schwarzbach & Haber (GJI, 2013);
Um et al. (GJI, 2013).

Also ...

➔ $\mathbf{A} - \phi$ decomposition;
➔ linear edge elements & nodal elements;
➔ total field;
➔ magnetic & electric sources.
We E108 02 - Forward Modelling of Geophysical Electromagnetic Data on Unstructured Grids Using a Finite-volume Approach - Jahandari & Farquharson.

- staggered grid finite difference;
- total field;
- magnetic & electric sources;
- $\mathbf{E}$ field; $\mathbf{A} - \phi$ decomposition.
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Unstructured meshes:

→ specialized mesh generation;

e.g., TetGen (Hang Si, http://wias-berlin.de/software/tetgen/)
Unstructured meshes:

→ **specialized** mesh generation;

→ **quality** mesh generation;
Unstructured meshes:

→ *specialized* mesh generation;

→ *quality* mesh generation;

→ *quality* mesh generation *between tessellated surfaces*...
Pellerin et al. (Comps. & Geosci., 2014)
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A single, unified Earth model.

Surface and volumetric meshing of Earth models is an active area of research.
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