Dislocation Meshing – A Credible Solution to Automatic Hexahedral Meshing

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Abstract

When the solution to the problem of Automatic Hexahedral Meshing arrives, will you recognise it?

At the **NAFEMS World Congress '97** in Stuttgart, 9-11 April 1997 Dr Bruce E. MacNeal and Dr Richard H. MacNeal gave a presentation called **"Future Issues – a Code Developer's Perspective"** where they stated: *"The "holy grail" of automatic hexahedral meshing still eludes us. Automatic meshing technology will have a long growth phase."*.

A lot of research and development efforts, resources and time have been spent on the search for the Holy Grail – Automatic Hexahedral Meshing – before and after the NAFEMS congress in 1997. So far, the software developers and the analysis community as a whole know a lot about what doesn't work.
The alternative approaches are exhausted and newcomers to the problem are encouraged to turn the stack of failed approaches over and start again, repeating the mistakes of others with the same outcome as before.

Nothing significantly has happened in this domain for a decade or more, and everybody seems resigned to live with "second best" on a permanent basis.
No one has actually asked the question **"Somehow, there must be a better way, right?"**

Dislocation Meshing is a research effort completely detached from any other effort in the search for the Holy Grail. It is based on sound scientific practice of understanding the problem at hand before a solution is proposed.
A long time was spent on understanding the behaviour of quadrilateral and hexahedral meshes until the patterns that control their behaviour emerged.

The mathemization of these patterns resulted in a system of equations that describe the flow of quadrilateral elements in the interior of 2D regions and the flow of hexahedral elements in the interior of 3D solid models.

The key characteristics of hexahedral meshes are the presence of irregular edges throughout their interior. On the outside of a hexahedral mesh there are irregular nodes (three, five or more elements meeting at an irregular node, four meeting at a regular node) used as the start of irregular edges which stretch into

the volume and emerge at another irregular node somewhere on another external face.

The breakthrough understanding of the significance of the irregular networks in a hexahedral mesh originated the choice of name Dislocation Meshing, a term taken from metallurgy.

Dislocation Meshing can create thousands of meshes for a given engineering object: first, thousands of classes of irregular edge networks, then each has thousands of instantiations as hexahedral meshes. All of them can be described uniquely by a set of underdetermined equation systems and the solutions vectors to these equations. Here is a method that can describe a super-set of solutions that are all known to exist.

Other efforts in the domain of automatic hexahedral meshing can be measured by their effectiveness in creating any subset of these known solutions. Where these methods cannot create hexahedral meshes consistently (or not at all), the theory underpinning Dislocation Meshing can be used to explain why.

Dislocation Meshing is a “jet engine” in a “propeller engine” era. Because it requires searches for a good mesh and can generate hundreds of meshes in a flash, it will come paired with Formulation, Verification and Validation technology. Comparison of results across analyses require database implementations and a new generation of post-processing tools.

The presentation will show numerous examples of hexahedral meshes created using this approach. And better, it will show results, i.e., deformed meshes with contours plotted n top in each and every example, to prove that the meshes can be used for engineering analysis.

When the solution to the problem of Automatic Hexahedral Meshing arrives, what will you the want to do?

1. References

There is an unending list of possible references for the topics covered in this paper. Instead of selecting an arbitrary reference in a long list of possibilities, here is a modern way of directing readers to authoritative sources for further reading: to use the Internet, specifically Wikipedia which gives a clear and concise presentation of most topics with a list of references for further reading.

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