High-order mesh generation; current and future developments within Nektar++

High-order mesh generation

- •Very open problem.
- •Very few tools available that are robust and capable enough for complex geometries.
- •Current processes are too complex, consist of many tools.
- •This decreases robustness and usability.
- •High-order mesh generation represents the single largest bottleneck in CFD for complex geometries.

High-order mesh generation

- •Using a structured mesh or multi-block approach makes high-order mesh generation simple.
- •But that is limits on CFD to a very small number of geometries.
- High-order prism/tet unstructured mesh generation is very difficult at present.

A potential pipeline



High-order mesh generation

Goal:

Create a single executable, within the Nektar++ framework, which is capable of systematically generating optimal quality high-order meshes for viscous CFD analysis.



Achieving the desired path

- •Find or create the most robust set of tools for each stage of mesh generation.
- •Streamline into one coherent procedure.
- •Automate as much as possible.

CAD

- •Challenge in itself.
- •OpenCascade: 4 million lines of code, 17,000 functions.
- •Created a OpenCascade wrapper for Nektar++ with <10 functions.



Linear mesh generation

- •Well researched, many robust approaches.
- •Significant time consumer, ~60% of a users time.
- •Challenging to make suitably coarse meshes.
- •For Nektar++ we have automated a lot of user interaction with the linear mesh.
- •Using an octree description of the domain and relating curvature to mesh size.

Linear mesh generation



High-order manipulation

- •Addition of high-order nodes to the linear mesh.
- •Non-trivial, but simple compared to other processes.



Optimisation / correction

- •Focus of most recent research.
- Addition of high-order nodes creates invalid meshes.
- •In Nektar++ this is done with the linear elastic solver.



Where we are now

We have:

- •Nektar++ wrapper for OpenCascade.
- •Automated a significant amount of user interaction.
- •Robust linear surface mesh generator.
- •Robust linear tetrahedral mesh generator.
- •Anisotropic boundary layer splitting.
- •Linear thermo-elastic solver.

Where we are now

Where next:

•Optimised high-order surface generator.

•High-order prismatic boundary layer generation.

Meshes from Nektar++



Meshes from Nektar++



Meshes from Nektar++





When will this awesome, all singing all dancing, answer to all your prayers of a high-order mesh generator be ready for end users like yourselves?

No idea. But! It is well on its way.

Thanks for listening

m.turner14@imperial.ac.uk