Identifying the “Minimum Meshable Representation” in Turbomachinery Geometries

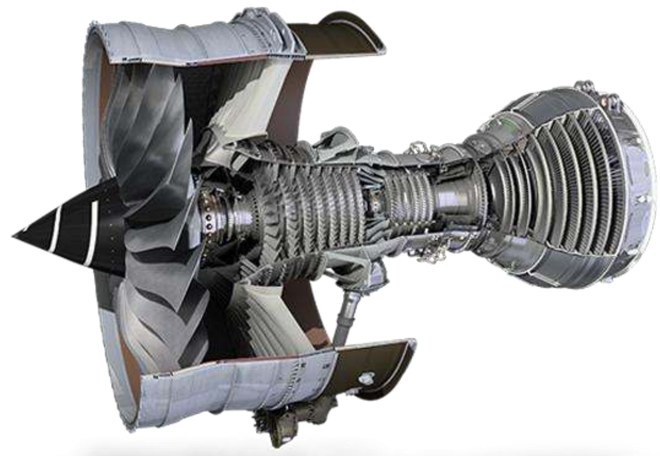
Research problem The aerospace industry is running simulation on increasingly complex geometry for product development and testing. Specified use of generally structured hexahedral meshes requires careful crafting by experienced engineers. The associated costs stimulate the desire to develop automated methods that can complement the mesh generation process.

Research ambition Develop automated geometry decomposition strategies that will facilitate rapid generation of structured hexahedral meshes by identifying the **Minimum Meshable Representation**. This will underpin the industries ambition to integrate high-fidelity analysis throughout the product development cycle.

Methodology Conventionally, decomposition strategies extract sub-domains of the model to which a known hexahedral meshing strategy can be applied. This work creates a decomposition strategy that extracts the minimum amount of geometry to a mesh must be applied, from which patterning can mesh the entire model. Advantage is taken of the cyclic nature of turbomachinery geometries, where repetitions are often exhibited around a global axis of symmetry. After the minimal meshable representation has been created, further decomposition strategies can be applied on it before manual decomposition and meshing is required. The resulting mesh may be copied and translated to the repeated sectors of the global model, thereby minimising the overall meshing effort.

Research objectives

- Interrogate the model to establish topological and geometric information
- Exploit geometric reasoning to derive additional geometric metrics from the model
- Implement logic and geometric reasoning to identify repeated sub-domains within the global model
- Incrementally decompose the model until the minimum amount of geometry for which a mesh is required has been extracted



Framework overview

Topology extraction
- Extract model topology; face, edge and vertex connections
- Extract model geometry; e.g. vertex location, edge length, face properties

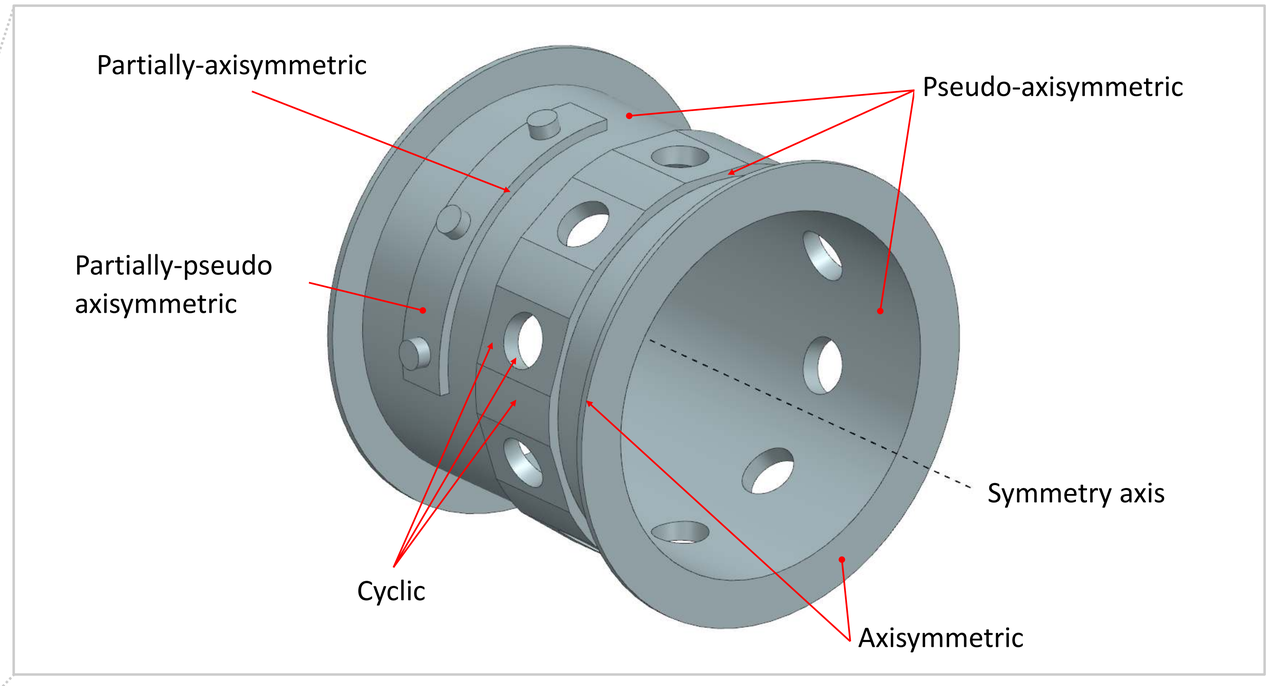
Face classification
- Classify faces in the model
- Cyclic faces mapped by a direct congruent transformation about axis of symmetry

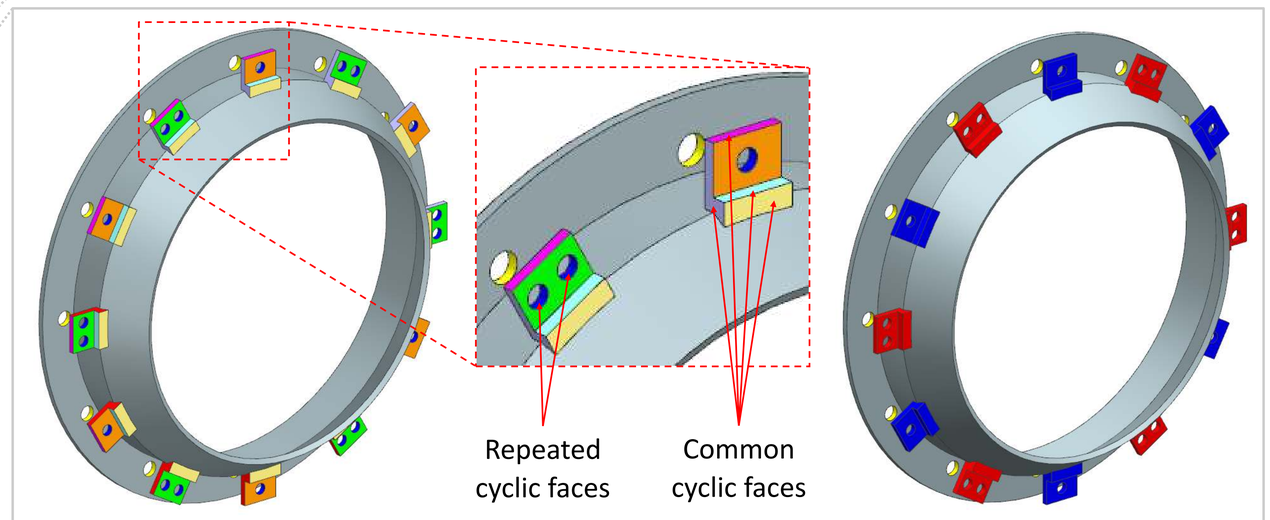
Feature construction
- Grouping adjacent faces to form cyclic and non-cyclic features
- Cognizance of cyclic faces shared between different features

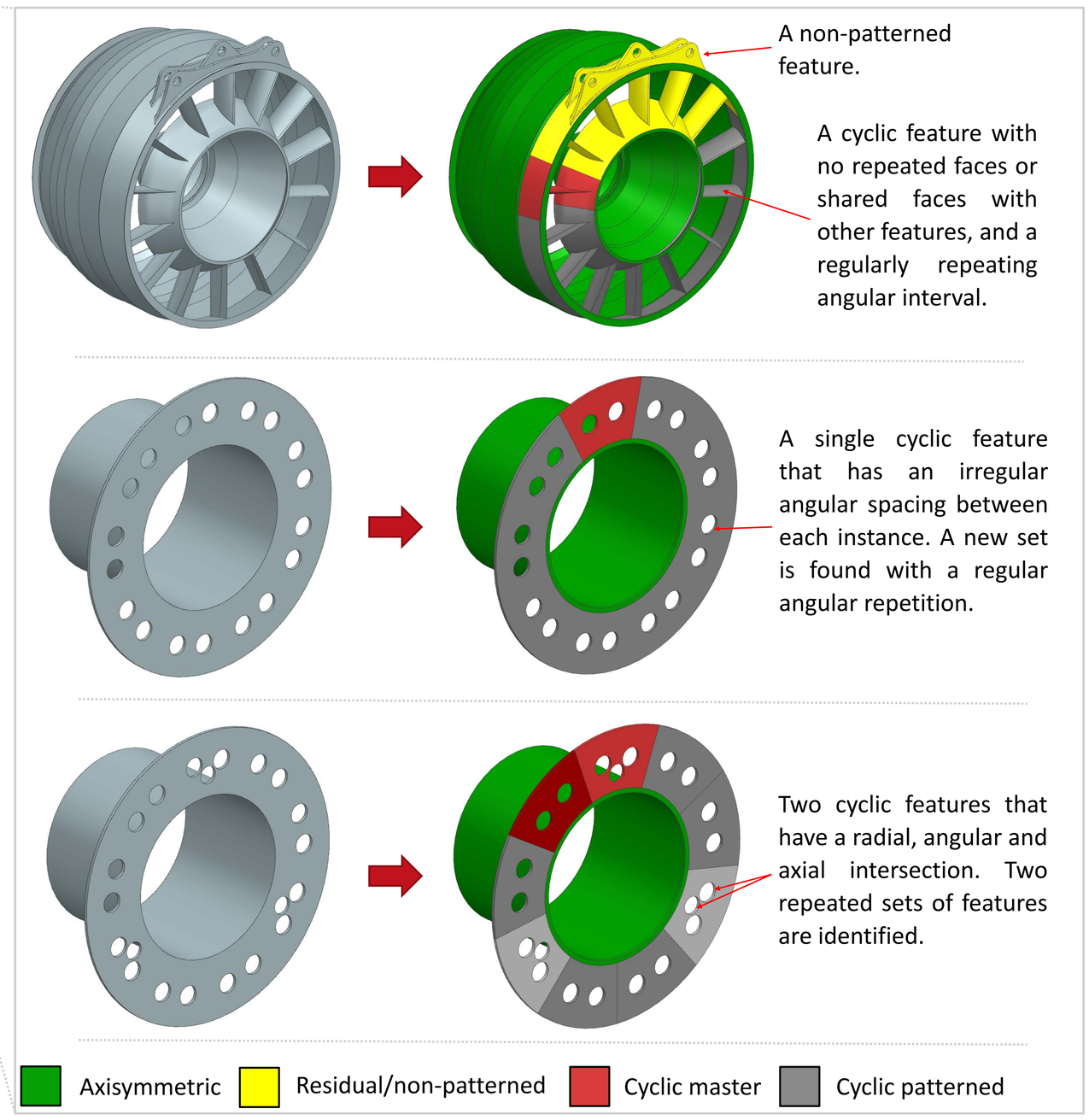
Axisymmetric decomposition
- Extract regions with a 2D profile revolved around the axis of symmetry by 2π radians

Cyclic decomposition
- Group irregular or intersecting cyclic features to form cyclic sets
- Identify when splits can be inserted to extract the minimal sector

Further decomposition
- Apply further decomposition strategies (e.g. thin sheet or long slender) to the extracted minimal meshable representation







Conclusions Turbomachinery geometries often exhibit repeated sub-domains around a global axis of symmetry. This has been exploited to reduce the amount of geometry for which a mesh is required, hence minimising the manual effort required to achieve a structured hexahedral mesh.

Future work The initial results from the minimal meshable representation decomposition strategy have provide confidence for further developments to:

- Target increasingly complex geometries
- Maintain cognizance of meshing requirements when decomposing the geometry
- Identify “almost cyclic” features where the same mesh topology can be assumed

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