

CADfix API for Meshing Research

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1 Introduction

CADfix is widely used for advanced geometry processing. Among other functions CADfix enables the user to repair and simplify models for the purpose of meshing the geometry, using either meshing tools that are built into CADfix or third-party mesh generators. In addition to an interactive desktop application with a graphical user interface, the core functionalities can be accessed through an API. This enables researchers and developers to build their own applications based on CADfix, as well as modifying and extending the existing core functions to meet specific requirements. In this research note we outline how the CADfix API can be used to create, interrogate and mesh geometry.

2 The CADfix API

The CADfix API (CFI), shown schematically in Fig. 1, provides access to a vast array of functions for geometry interrogation and manipulation, as well as meshing capabilities. Therefore it can be used to develop applications that require the ability to

- create, modify and interrogate geometry, model structure and attributes;
- perform geometric calculations such as curvature, medial axis transform, projection and mass properties;
- create and store surface and volume meshes with associativity to the parent CAD entities;
- tessellate curves and surfaces for display.

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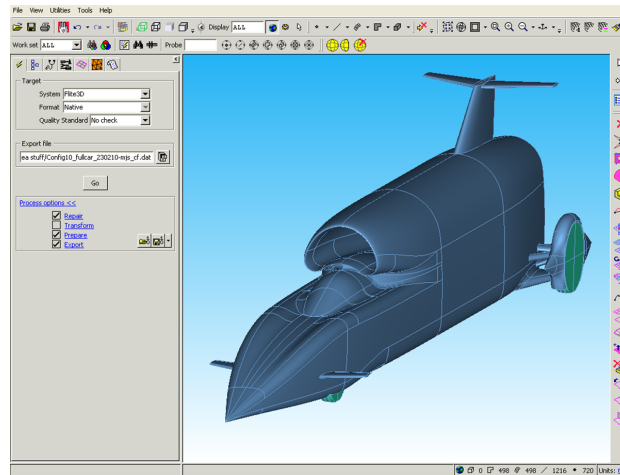


Fig. 2: The Bloodhound SSC in the interactive desktop application of CADfix.

This is where the team at Swansea University used CFI to integrate the CADfix geometry handling functionality with their FLITE surface mesh generator [2]. They used the full CADfix tool, as shown in Fig. 2, to access a comprehensive set of geometry manipulation functions, including the removal of small, unwanted features on the model and the repair of poor surface parameterisations. Once the geometry had been prepared, CFI was used to read in the geometry, provide geometric evaluations, projections and ray-firing to support the FLITE meshing algorithm. In summary, the integration of CFI ensured an optimum geometry for the subsequent meshing and analysis with FLITE.

3.2 *Queen's University Belfast*

Queen's University Belfast (QUB) is conducting research into bio-inspired designs. These are organically growing CAD models subject to external stimuli, such as gravity, stress or energy. Based on a set of growth rules and an underlying algorithm a CAD model is gradually built up that satisfies the applied boundary conditions and supports the specified loads. At each step of the growth process QUB uses the Python interface to CFI to extract information from the current state of the model to then calculate forces, energies, stresses etc. With this input the growth algorithm computes the preferred growth direction, length and thickness. Using the geometry creation and modification features of CADfix through CFI, the model is updated accordingly.

Another application of CFI within Queen's University Belfast is the use of geometric reasoning to generate efficient meshes. The aim is to match the element shape to the geometry. For this purpose, the CADfix tool is used to partition the

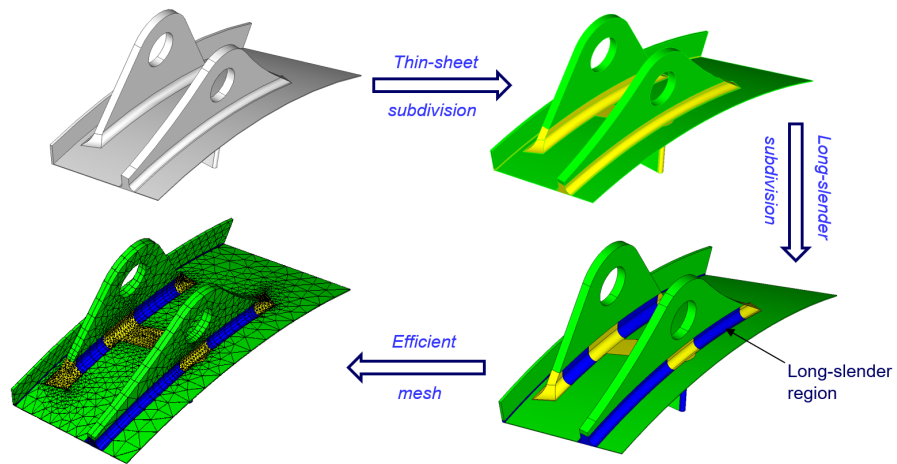


Fig. 3: Illustration of the thin/thick subdivision process and the resultant mesh.

CAD model, either using the medial axis transform [7] or thin/thick partitioning [6, 3]. The former is used to identify areas which are suitable for sweep meshing, while the latter is used to locate thin sheet and long slender regions, as illustrated in Fig. 3. Following partitioning in CADfix, CFI is used to interrogate and evaluate the resulting partitions in order to assign different element types to the partitions and eventually create the mesh.

3.3 Imperial College London

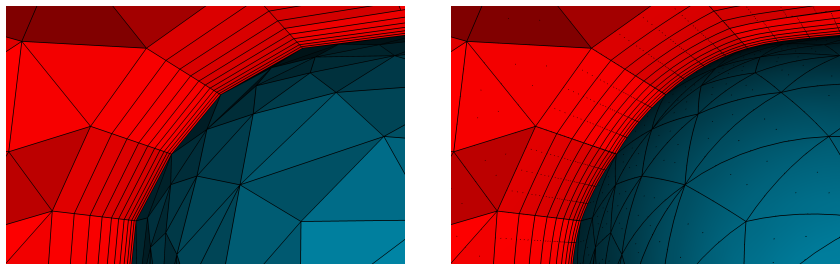


Fig. 4: Linear mesh, generated by CADfix (left) and upgraded higher order mesh (right). The higher order mesh was set up to respect the curved boundary of the parent geometry which was accessed through CFI.

Imperial College London (ICL) integrated CADfix into their own meshing tool, NekMesh, using CFI. NekMesh is part of the Nektar++ Spectral/HP element frame-

work project [1] and enables the creation of higher order meshes from linear meshes, as illustrated in Fig. 4. NekMesh has the ability to read in both geometry and meshes and can then generate both surface and volume meshes. CFI enables access to both the geometry and the linear meshes stored in CADfix. Using CFI the research group at ICL designed a geometry and mesh processing system that is based on the CADfix geometry kernel [4, 8]. The CAD geometry is interrogated using CFI and then mapped into NekMesh objects. In addition to this parsing of geometry, the coarse linear meshes generated by the CADfix meshing tools are also parsed into NekMesh. For this purpose, node and element definitions are extracted and the CAD parenthood information, associating the mesh and geometry, is established. Once the geometry and linear mesh are parsed into NekMesh, CFI is used further to support the isoparametric splitting process [5]. This process requires information from the original geometry such as parameter values and derivatives on edges and faces, face normals and curvatures. Through the use of CFI this information can be directly computed from within NekMesh, accessing the original CADfix geometry.

4 Summary

In this research note we have presented some of the geometry and meshing capabilities of the CADfix kernel and how they are accessed through the CADfix API (CFI). With the examples of three use cases, we have outlined how different research groups use CFI to solve unique and challenging research problems. CFI provides a comprehensive set of functions to create, interrogate and modify geometry as well as the capability to mesh this geometry. Therefore it provides a very flexible, CAD-connected research platform that can support the development of advanced mesh generation applications.

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