AFLR3 Analysis Interface Module (AIM)

Ryan Durscher
AFRL/RQVC

July 30, 2019

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1 Introduction

1.1 AFLR3 AIM Overview

A module in the Computational Aircraft Prototype Syntheses (CAPS) has been developed to interact with the unstructured, volumetric grid generator AFLR3 [2] [1].

The AFLR3 AIM provides the CAPS users with the ability to generate "unstructured tetrahedral element grids" using an "Advancing-Front/Local-Reconnection (AFLR) procedure." Additionally, an "Advancing-Normal Boundary-Layer (ANBL) procedure" may be used "to generate a tetrahedral/pentahedral/hexahedral BL grid adjacent to" specified surfaces.

An outline of the AIM's inputs and outputs are provided in AIM Inputs and AIM Outputs, respectively. The complete AFLR documentation is available at the `SimCenter`.

The accepted and expected geometric representation and analysis intentions are detailed in geomRepIntentAFLR3.

Details of the AIM's shareable data structures are outlined in AIM Shareable Data if connecting this AIM to other AIMs in a parent-child like manner.

Example volumes meshes:

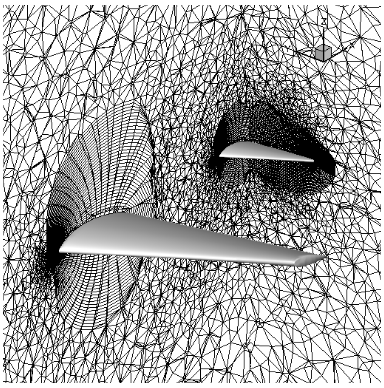

Figure 1: AFLR3 meshing example - Multiple Airfoils with Boundary Layer

1.2 Clearance Statement

This software has been cleared for public release on 25 Jul 2018, case number 88ABW-2018-3794.

2 AIM Inputs

The following list outlines the AFLR3 meshing options along with their default value available through the AIM interface. By default, these values will be linked to any parent AIMs with variables of the same name, with the exception of the ...

- **Proj_Name = NULL**
  This corresponds to the output name of the mesh. If left NULL, the mesh is not written to a file.
- **Tess_Params = [0.025, 0.001, 15.0]**
  Body tessellation parameters. Tess_Params[0] and Tess_Params[1] get scaled by the bounding box of the body. (From the EGADS manual) A set of 3 parameters that drive the EDGE discretization and the FACE triangulation. The first is the maximum length of an EDGE segment or triangle side (in physical space). A zero is flag that allows for any length. The second is a curvature-based value that looks locally at the deviation between the centroid of the discrete object and the underlying geometry. Any deviation larger than the input value will cause the tessellation to be enhanced in those regions. The third is the maximum interior dihedral angle (in degrees) between triangle facets (or Edge segment tangents for a WIREBODY tessellation), note that a zero ignores this phase.
- **Mesh_Quiet_Flag = False**
  Suppression of mesh generator (not including errors)
- **Mesh_Format = "AFLR3"**
  Mesh output format. Available format names include: "AFLR3", "SU2", "Nastran", "Tecplot", and "VTK".
- **Mesh_ASCII_Flag = True**
  Output mesh in ASCII format, otherwise write a binary file, if applicable.
- **Mesh_Gen_Input_String = NULL**
  Meshing program command line string (as if called in bash mode). Use this to specify more complicated options/use features of the mesher not currently exposed through other AIM input variables. Note that this is the exact string that will be provided to the volume mesher; no modifications will be made. If left NULL an input string will be created based on default values of the relevant AIM input variables.
- **Multiple_Mesh = False**
  If set to True a volume will be generated for each body. When set to False (default value) only a single volume mesh will be created.
- **Mesh_Sizing = NULL**
  See Mesh Sizing for additional details.
- **BL_Initial_Spacing = 0.0**
  Initial mesh spacing when growing a boundary layer that is applied to all bodies.

  Note: Both "BL_Initial_Spacing" and "BL_Thickness" must be non-zero for values to be applied. If "↩ Multiple_Mesh" is False (default value) these values will not be applied to the largest body (if more than 1 body exist in the AIM), as that body is assumed to be a bounding box (e.g. a farfield boundary in a CFD simulation). Boundary spacing and thickness specified through the use of the "Mesh_Sizing" input (see Mesh Sizing for additional details) will take precedence over the values specified for "BL_Initial_Spacing" and "BL_Thickness".
- **BL_Thickness = 0.0**
  Total boundary layer thickness that is applied to all bodies.
  This is a lower bound on the desired thickness. The height can be limited with "nbl".

  Note: see "BL_Initial_Spacing" and "BL_Max_Layers" for additional details

- **BL_Max_Layers = 10000**
  Maximum BL grid layers to generate.

- **BL_Max_Layer_Diff = 0**
  Maximum difference in BL levels.
  If BL_Max_Layer_Diff $>$ 0 then the maximum difference between the number of BL levels for the BL nodes on a given BL boundary surface face is limited to BL_Max_Layer_Diff.
  Any active BL node that would allow the number of levels to be greater is terminated.
  If BL_Max_Layer_Diff = 0 then the difference in BL levels is ignored.

3 AIM Shareable Data

The AFLR3 AIM has the following shareable data types/values with its children AIMs if they are so inclined.

- **Surface_Mesh**
  The returned surface mesh in meshStruct (see meshTypes.h) format.
- **Volume_Mesh**
  The returned volume mesh after AFLR3 execution is complete in meshStruct (see meshTypes.h) format.
- **Attribute_Map**
  An index mapping between capsGroups found on the geometry in mapAttrToIndexStruct (see miscTypes.h) format.

4 AIM Outputs

The following list outlines the AFLR3 AIM outputs available through the AIM interface.

- **Done** = True if a volume mesh(es) was created, False if not.

5 Mesh Sizing

NOTE: Available mesh sizing parameters differ between mesh generators.

Structure for the mesh sizing tuple = ("CAPS Group Name", "Value"). "CAPS Group Name" defines the capsGroup on which the sizing information should be applied. The "Value" can either be a JSON String dictionary (see Section JSON String Dictionary) or a single string keyword string (see Section Single Value String)

5.1 JSON String Dictionary

If "Value" is a JSON string dictionary (e.g. "Value" = {"edgeDistribution": "Even", "numEdgePoints": 100}) the following keywords (= default values) may be used:

- **edgeDistribution = "Even"**
  Edge Distribution types. Options: Even (even distribution), Tanh (hyperbolic tangent distribution).

- **numEdgePoints = 0**
  Number of points along an edge.

- **initialNodeSpacing = [0.0, 0.0]**
  Initial (scaled) node spacing along an edge. [first node, last node] consistent with the orientation of the edge.

- **boundaryLayerThickness = 0.0**
  Desired lower bound boundary layer thickness on a face. The minimum thickness in the mesh is is given by meshBLThickness = capsMeshLength $*$ boundaryLayerThickness

- **boundaryLayerSpacing = 0.0**
  Initial spacing factor for boundary layer mesh growth on as face.
  The spacing in the mesh is is given by
  meshBLSpacing = capsMeshLength $*$ boundaryLayerSpacing

- **tessParams = (no default)**
  Face tessellation parameters, example [0.1, 0.01, 20.0]. (From the EGADS manual) A set of 3 parameters that drive the EDGE discretization and the FACE triangulation. The first is the maximum length of an ED↩GE segment or triangle side (in physical space). A zero is flag that allows for any length. The second is a curvature-based value that looks locally at the deviation between the centroid of the discrete object and the underlying geometry. Any deviation larger than the input value will cause the tessellation to be enhanced in those regions. The third is the maximum interior dihedral angle (in degrees) between triangle facets (or Edge segment tangents for a WIREBODY tessellation), note that a zero ignores this phase.

5.2 Single Value String

If "Value" is a single string, the following options maybe used:

- (NONE Currently)

References

[1] David L Marcum. Unstructured grid generation using automatic point insertion and local reconnection. *The Handbook of Grid Generation*, pages 18–1, 1998. 1

[2] David L. Marcum and Nigel P. Weatherill. Unstructured grid generation using iterative point insertion and local reconnection. *AIAA Journal*, 33(9):1619–1625, Sep. 1995. 1