Delaundo Analysis Interface Module (AIM) Manual

Ryan Durscher
AFRL/RQVC

September 17, 2021

0.1 Introduction

0.1.1 Delaundo AIM Overview

A module in the Computational Aircraft Prototype Syntheses (CAPS) has been developed to interact with the 2D Delaunay mesh generator Delaundo, developed by J.-D. Müller. Details and download information for Delaundo may be found at http://www.ae.metu.edu.tr/tuncer/ae546/prj/delaundo/

Along with isotropic triangular mesh generation, Delaundo has limited anisotropic mesh generating capabilities. From the Delaundo website - "delaundo has also a rudimentary capability to create grids with stretched layers for viscous calculations that works well for moderate stretching factors of up to 100. Due to the simple implementation the stretched layers must completely wrap around a simply connected body such as an airfoil with a wake. It cannot do bump-like cases, where non-stretched boundaries are attached to stretched ones."

An outline of the AIM's inputs and outputs are provided in AIM Inputs and AIM Outputs, respectively.

The dealundo AIM can automatically execute dealundo, with details provided in AIM Execution.

0.1.2 Clearance Statement

This software has been cleared for public release on 05 Nov 2020, case number 88ABW-2020-3462.

0.2 AIM Inputs

The following list outlines the Delaundo meshing options along with their default value available through the AIM interface. Please note that not all of Delaundo's inputs are currently exposed.

- **Proj_Name = delaundoCAPS**
  This corresponds to the output name of the mesh.
- **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_Format = NULL**
  Mesh output format. If left NULL, the mesh is not written in the new file format. Available format names include: "AFLR3", "VTK", "TECPLOT", "STL".
- **Mesh_ASCII_Flag = True**
  Output mesh in ASCII format, otherwise write a binary file if applicable.
- **Edge_Point_Min = NULL**
  Minimum number of points on an edge including end points to use when creating a surface mesh (min 2).
- **Edge_Point_Max = NULL**
  Maximum number of points on an edge including end points to use when creating a surface mesh (min 2).

- **Mesh_Sizing = NULL**
  See Mesh Sizing for additional details.
- **Spatial_Ratio = 1.0**
  This corresponds to SPCRAT in the Delaundo manual - Ratio between the spacing gradients at the points of highest and lowest spacing. Values higher than one will cause Delaundo to interpolate with a power law to extend the regions of fine spacing further into the domain.
- **D_Tolerance = 0.65**
  This corresponds to DTOLER in the Delaundo manual - Specifies the fraction of the background mesh size that is being used as a minimum distance between nodes.
- **Q_Tolerance = 0.65**
  This corresponds to QTOLER in the Delaundo manual - specifies the minimum fraction of the maximum side length that the smaller sides must have in order to make the triangle acceptable.
- **B_Tolerance = 2.0**
  This corresponds to BTOLER in the Delaundo manual - specifies the minimum fraction of the background mesh size that is being used as a minimum distance between nodes in the background grid.
- **Delta_Thickness = 0.0**
  This corresponds to DELTAS in the Delaundo manual - specifies the thickness of the stretched layer in the scale of the other points. No stretched region will be created if the value is less than or equal to 0.0 .
- **Max_Aspect = 20.0**
  This corresponds to MAXASP in the Delaundo manual - specifies the maximum aspect ratio in the stretched layer.
- **Num_Anisotropic = 30,000**
  This corresponds to MVISRO in the Delaundo manual - specifies how many stretched, viscous rows are to be built.
- **Num_Isotropic = 30,000**
  This corresponds to MISORO in the Delaundo manual - specifies how many isotropic rows are to be built.
- **Transition_Scheme = 2**
  This corresponds to ISMOOT in the Delaundo manual - specifies how many stretched rows of cells will be opened for isotropic re-triangulation once the stretched process has terminated. 0 does not allow any re-triangulation, 1 allows re-triangulation of the outermost cells, and 2 allows re-triangulation of the neighbors of the outermost cells as well.
- **Flat_Swap = True**
  This corresponds to FLATSW in the Delaundo manual - if True this will make DELAUNDO swap diagonals in the final mesh in order to minimize the maximum angles.
- **Max_Angle = 120.0**
  This corresponds to ANGMAX in the Delaundo manual - specifies the maximum tolerable cell angle before FLATSW kicks in.
- **Num_Swap = 10**
  This corresponds to MCYCSW in the Delaundo manual - specifies how many swapping cycles will be executed.

0.3 AIM Execution

If auto execution is enabled when creating an dealundo AIM, the AIM will execute dealundo just-in-time with the command line:

```
dealundo < dealundoInput.txt > dealundoOutput.txt
```

where preAnalysis generated the file "dealundoInput.txt" which contains the input information.

The analysis can be also be explicitly executed with caps_execute in the C-API or via Analysis.runAnalysis in the pyCAPS API.

Calling preAnalysis and postAnalysis is NOT allowed when auto execution is enabled.

Auto execution can also be disabled when creating an dealundo AIM object. In this mode, caps_execute and Analysis.runAnalysis can be used to run the analysis, or dealundo can be executed by calling preAnalysis, system call, and posAnalysis as demonstrated below with a pyCAPS example:

```
print ("\n\preAnalysis......")
dealundo.preAnalysis()
print ("\n\nRunning......")
currentDirectory = os.getcwd() # Get our current working directory
os.chdir(dealundo.analysisDir) # Move into test directory
os.system("delaundo < delaundoInput.txt > dealundoOutput.txt"); # Run via system call
os.chdir(currentDirectory) # Move back to top directory
print ("\n\postAnalysis......")
dealundo.postAnalysis()
```

0.4 AIM Outputs

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

- **Area_Mesh**
  The resulting mesh that can be linked to an anlaysis input.

0.5 Mesh Sizing

NOTE: Available mesh sizing parameters differ between mesh generators.

Structure for the mesh sizing tuple = ("CAPS Mesh Name", "Value"). "CAPS Mesh Name" defines the caps↩ Mesh 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)

0.5.1 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 = 2**
  Number of points along an edge including end points. Must be at least 2.

- **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 boundary layer thickness on an edge (2D meshing)

- **boundaryLayerSpacing = 0.0**
  Initial spacing for boundary layer mesh growth on an edge (2D meshing).

0.5.2 Single Value String

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

- (NONE Currently)