Leveraging DegenGeom for Multi-Fidelity Analysis

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Outline

- Introduction
- Motivation and Goal
- Discrete Data Mapping
- Implementation
- Subsonic Transport Example
- Concluding Remarks
Introduction

- Early conceptual design studies traditionally performed using lower-order analysis methods on simplified geometrical representations.
- Transition to higher-order analysis using a more representative geometry as the design becomes more refined.
- This transition typically requires complete recreation of the geometry.
- Discontinuities in geometrical representation are even more of a problem in newer multi-fidelity approaches.
Motivation

• Nodes of degenerate models are consistent with the geometric abstraction of the analysis method, therefore they could also serve as repositories for the resulting analysis data.

• These results can be made available to subsequent analyses in other disciplines, always maintaining the link to the master geometry.

• This internal data storage capability can greatly facilitate the creation of multi-disciplinary, multi-fidelity analysis, design and optimization processes.
Goal

• Extend the functionality of OpenVSP's degenerate geometric models to also store analysis results associated with the geometry.

• Implement a method to simultaneously map analysis results onto the nodes of all the other degenerate models.

• Make stored data available to subsequent higher- and lower-order analyses in whatever level of abstraction they require, regardless of the degenerate model on which the original analysis was based.
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Discrete Data Mapping

Analysis results are mapped onto discrete nodes of degenerate models in three ways:

1. Results mapped onto nodes of the same order as the analysis.
2. Results mapped onto lower-order degenerate models (aggregation).
3. Results mapped onto higher-order degenerate models (disaggregation).
Aggregation and Disaggregation

Degenerate Type

Aggregation
• Integration
• Differencing
• Averaging

Disaggregation
• Shape function
• Scaling
• Interpolation
• RSEs
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Implementation

• Mapping process implemented as a Java™ class name DegenGeom.

• DegenGeom object instantiated by parsing a Degenerate Geometry file exported by OpenVSP.

• Application program interface (API) makes data access and mapping methods available to wrappers for individual analysis methods.

• Aggregation and disaggregation operations performed automatically when analysis results are processed.

• DegenGeom objects are serializable and can be passed as output, carrying all analysis results for use by subsequent analysis methods.

• DegenGeom object is typically the only output needed.
Wrapper and API

Analysis method based on the degenerate Stick model

Existing results → Analysis → Results

Flight conditions → User options

get variables

put variables

interpolate
disaggregate
aggregate

DegenGeom

Stick

Point

Plate

Surface

Wrapper

API
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Single-Aisle Transport in OpenVSP
Analysis Process

- **FRICTION**: profile drag of fuselage
- **XFOIL**: sectional aerodynamic coefficients of lifting surfaces
- **ASWING**: aero-structural analysis of full configuration
ModelCenter® Process Model

OpenVSP
Parse degenerate models
FRICTION analysis
XFOIL analysis
Define material properties
ASWING analysis
Tecplot
$M_\infty = 0.3$, $h = 10,000$ ft, $\alpha = 0$
XFOIL Sectional Polars

\[ M_\infty = 0.3, \ h = 10,000 \text{ ft} \]
Quasi-steady 2.5-g pull-up at $V_{eas} = 250$ kt, $h = 10,000$ ft
ASWing Deflections

Quasi-steady 2.5-g pull-up at $V_{eas} = 250$ kt, $h = 10,000$ ft
Quasi-steady 2.5-g pull-up at $V_{eas} = 250$ kt, $h = 10,000$ ft
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Concluding Remarks

• Aggregation and disaggregation processes currently formulated in a mostly ad-hoc manner depending on the specific analysis method.

• It should be possible to further automate these processes, defining universal mapping algorithms that automatically enforce consistency and reversibility.

• Surface model components are maintained as separate, non-intersected surfaces. We could extend these capabilities by also applying them to the intersected, unstructured surface mesh exported by OpenVSP.
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