Automated Hole-Cutting in Overset Grids Using Oriented XRAYs

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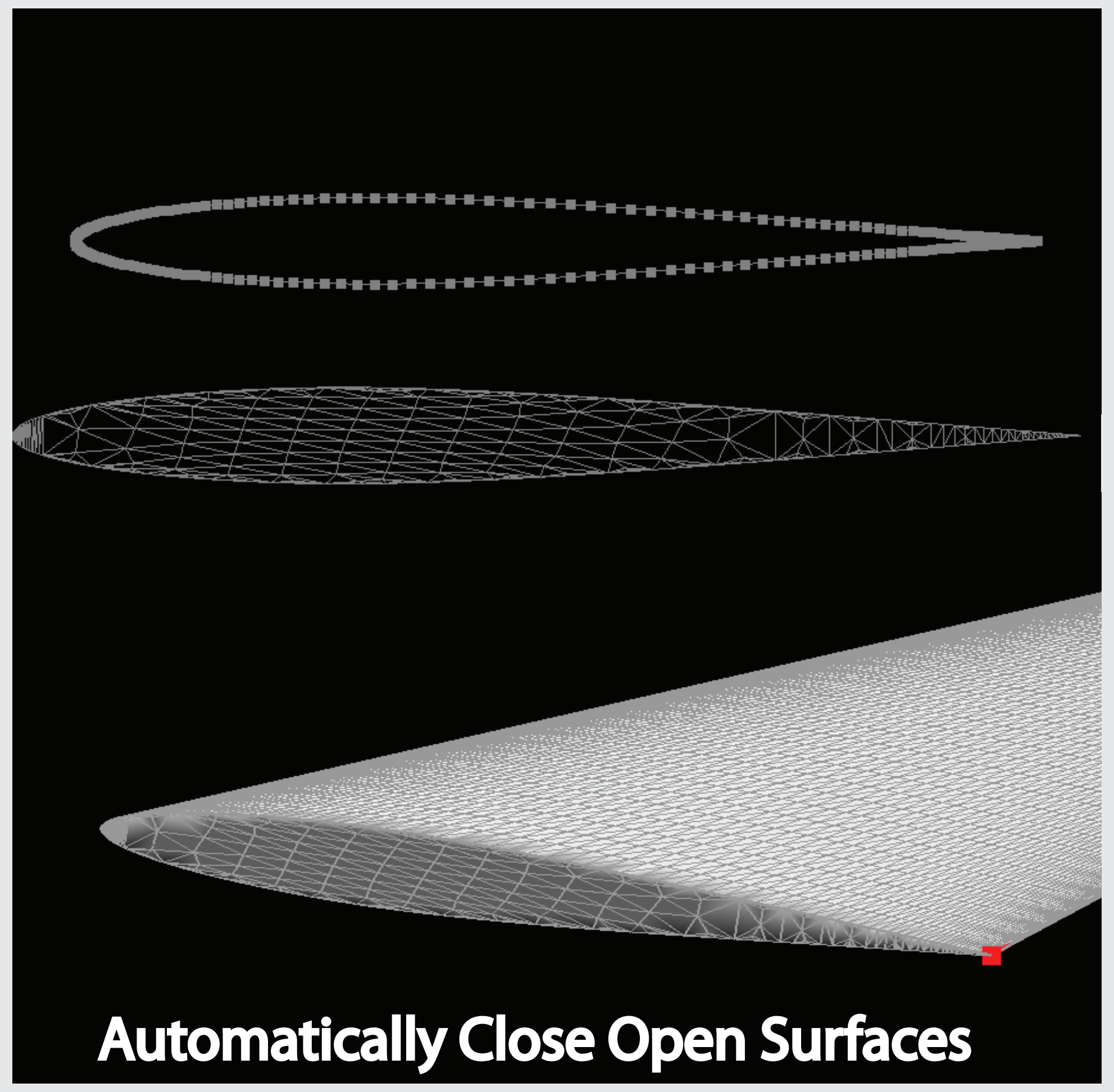
Overview

An automated approach to domain connectivity is explored, with the focus of minimizing user input. Through algorithmic changes to ray shooting, a minimum holecut can be obtained for a multi-grid system solely from component definitions.

Motivation

Domain connectivity with XRAYs is a laborious activity. A large grid system may take up to a week to complete because each grid and component interaction needs to be manually defined. The user spends majority of the time checking for errors in scripts and geometry definitions. The level of expertise and knowledge required for a mostly mechanical process makes this indeed a tedious exercise.

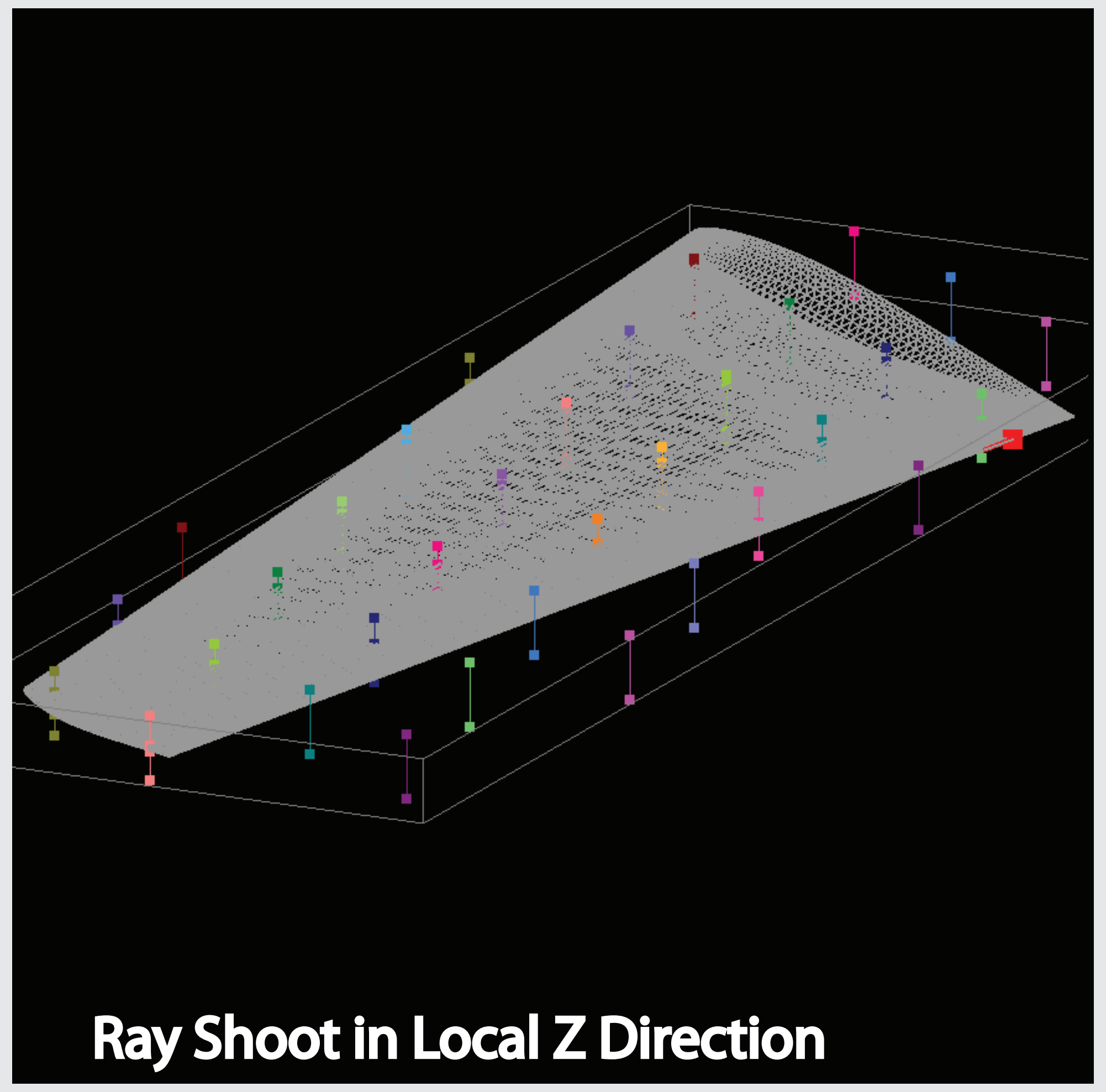


Automatically Close Open Surfaces

Identify and extract open curve
Project points on curve to best fit plane
Populate curve interior with Cartesian points
2D delaunay triangulation to generate surface
Laplacian transformation to smooth in 3D

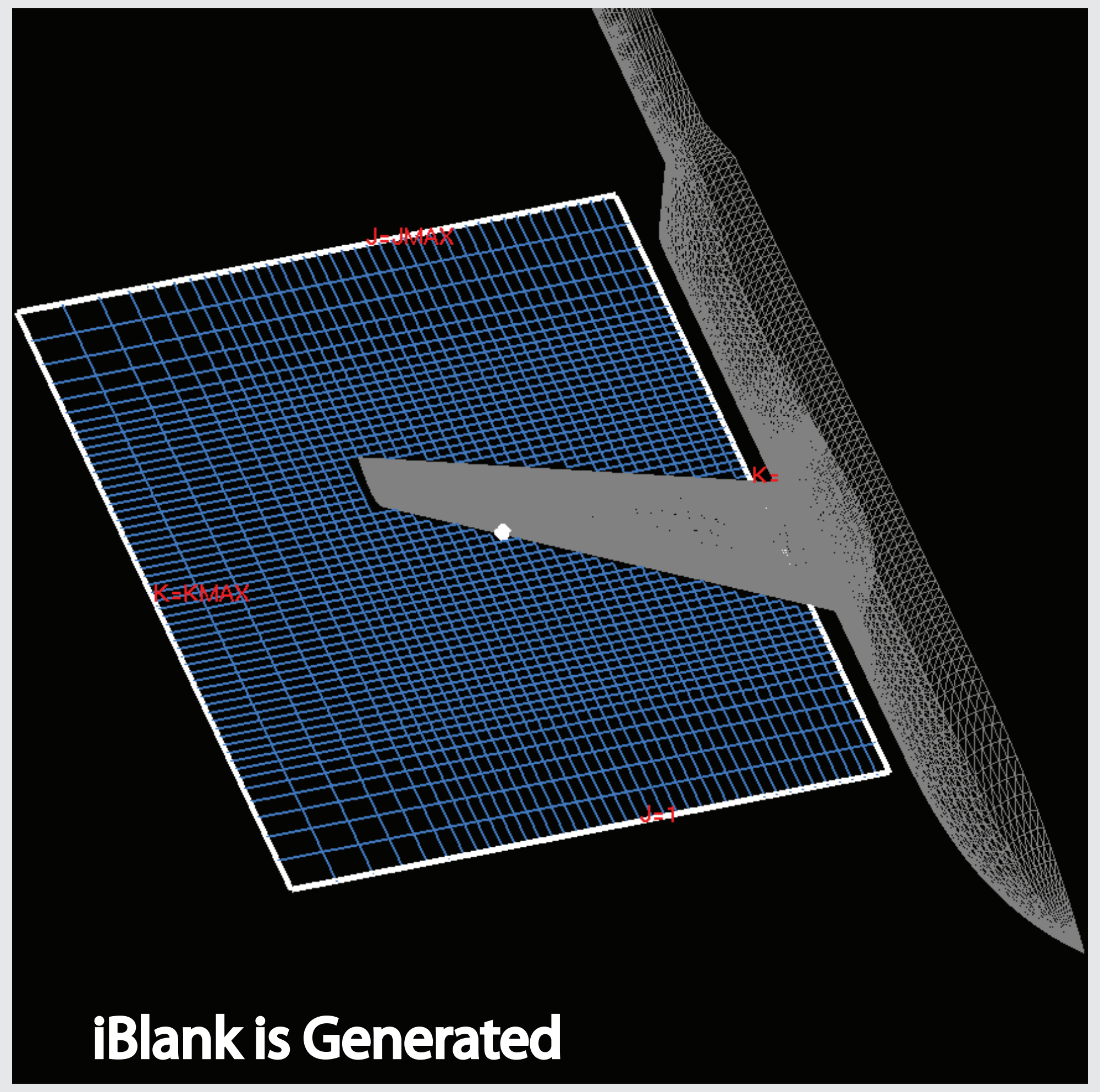
Generate Oriented Bounding Box

Take triangle areas as weights to reduce bias in principal direction caused by point clustering
Find the weighted covariance matrix
Find principal directions via matrix eigenvectors
Set Z direction in max component projected area



Ray Shoot in Local Z Direction

Identify points inside oriented box
Shoot rays in local Z direction
Mark intersection points
Perform inside vs outside test



iBlank is Generated

Blank Points Inside Component
Generate Minimum Holecut

On Demand XRAY Process

🟦 Manual Process　■ Automatic Process

Identify Components → Automatically Close Open Surfaces → Generate Cartesian Bounding Box → Generate Oriented Bounding Box → Eliminate Points outside the Box → Rayshoot in Z Direction for Points Inside Box → Generate iBlanks

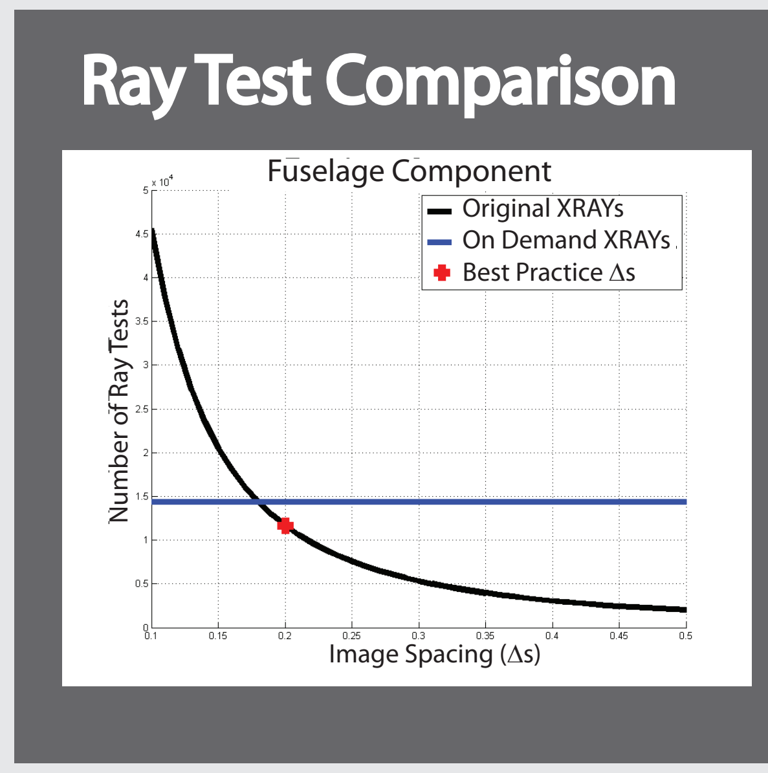
Original XRAYs Process

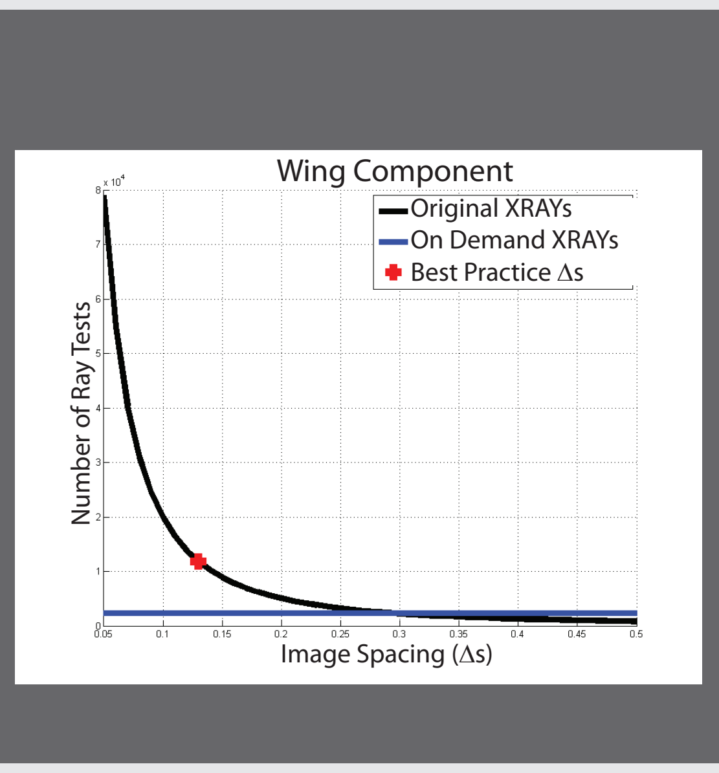
1. Manually identify components
2. Manually close open surface
3. Generate Cartesian bounding box
4. Manually identify image spacing
5. Rayshoot in Z direction of Cartesian box
6. Manually identify XRAY-grid interaction
7. Generate iBlanks

On Demand XRAYs Process

1. Manually identify components
2. Automatically close open surface
3. Generate Cartesian bounding box
4. Generate oriented bounding box
5. Eliminate points outside oriented box
6. Rayshoot in Z direction for points inside box
7. Generate iBlanks

Ray Test Comparison





Difference between On Demand XRAYs and original Xrays is shown. Traditional XRAYs require the user to define an image-plane spacing(Δs) to shoot a predetermined number of rays. This number can vary dramatically based on Δs. By testing only the points that are inside the bounding box, the user no longer needs to define and iterate on Δs. This eliminates another step that required the user's attention previously.

Conclusion and Future Works

This work sets the framework for an automatic domain connectivity. Additional tests will be done by expanding to more complicated geometries, and optimal holecut algorithms will also be explored.