EXCERPT: Towards Automatic Construction of 3D Shock-fitted Meshes based on Robust Shock Detection and Processing

Aiden Woodruff[1] and Onkar Sahni[2]

[1]Department of Computer Science and
[2]Department of Mechanical, Aerospace, and Nuclear Engineering &
Scientific Computation Research Center

Rensselaer Polytechnic Institute, Troy, NY

16th Jan. 2026
AIAA SciTech Forum

Motivation

- Efficient high-speed flow simulations require mesh adaptation
- Error-based adaptation needs many cycles (e.g. 10+) especially with coarse initial meshes
- An approach accounting specifically for shock geometry is desirable
- Our work can accelerate and blend with error-based adaptation

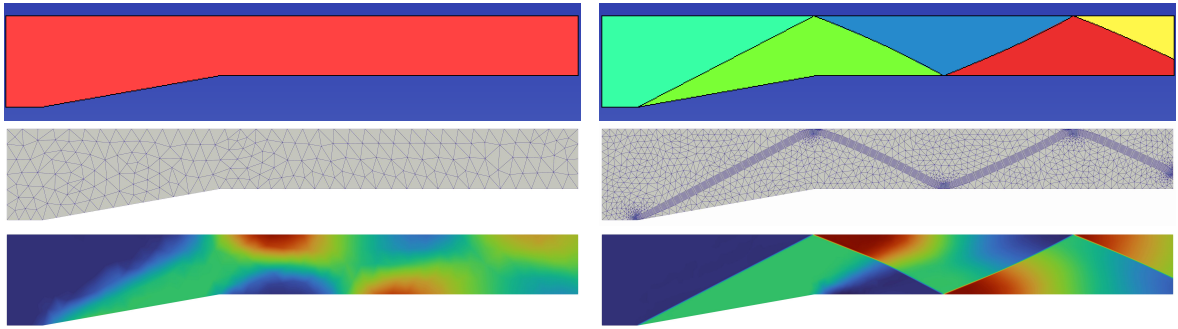
Prior Work

- Existing works mostly target single shocks or require finer initial meshes (especially in 3D)
- Automatic shock detection and processing
- Anisotropic unstructured adaptive workflow

Current Work

Current methodology is focused on automation and efficiency, and driven by shock geometry:

- A couple iterations of unstructured anisotropic adaptivity
- An iteration or two of shock-fitting in geometry and mesh

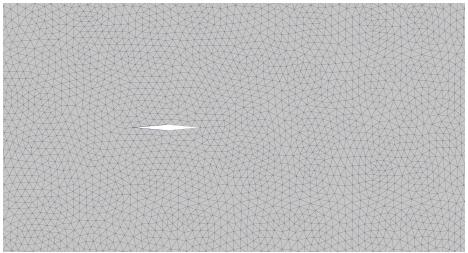


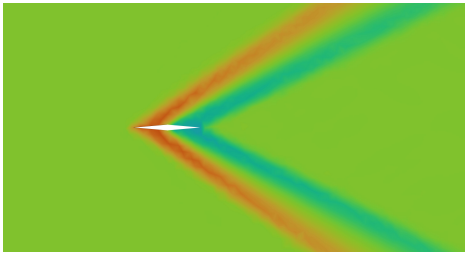
Results

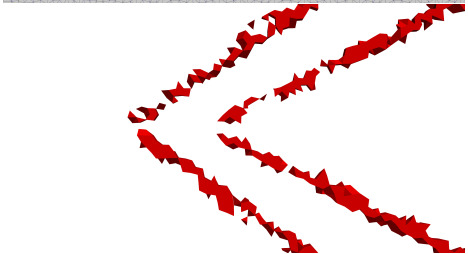
Currently we focus on inviscid cases only:

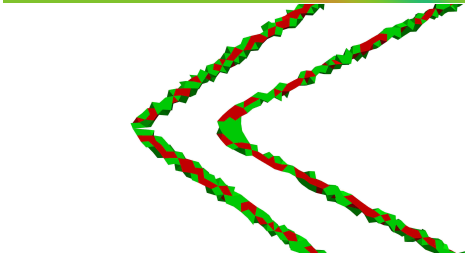
- Diamond airfoil: 2D case with external “V” shocks
- Wedge duct: 2D case with internal reflected shocks
- Blunt body: 3D (revolved) case with external bow shock

Diamond Airfoil: Mesh 0 (Initial Mesh)

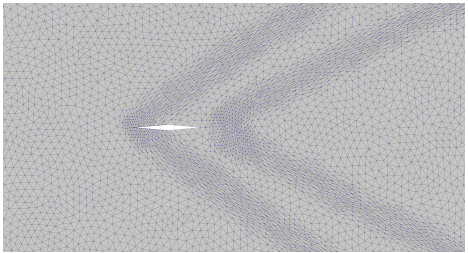


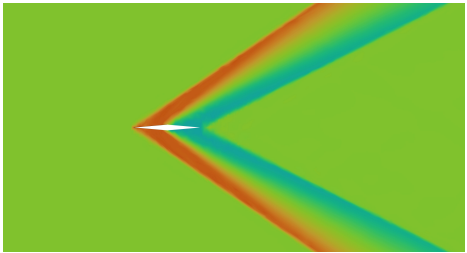


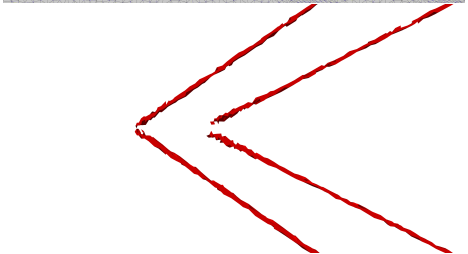


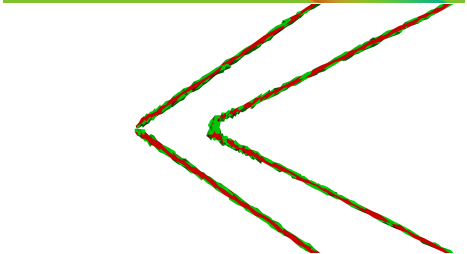


Diamond Airfoil: Mesh 1

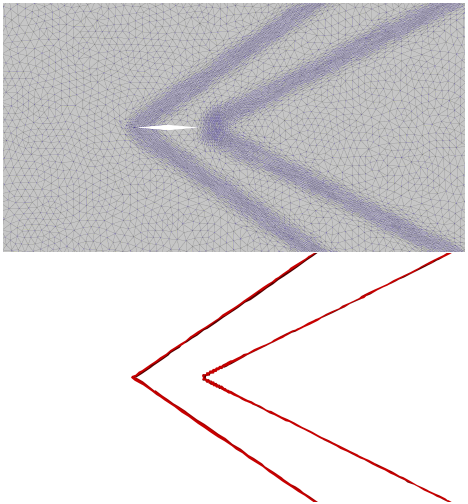


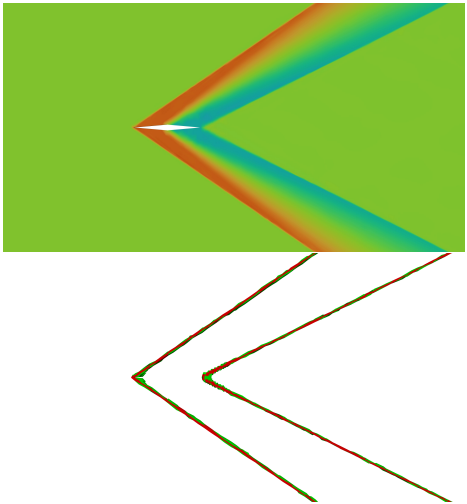




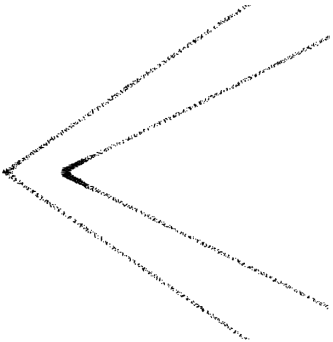


Diamond Airfoil: Mesh 2

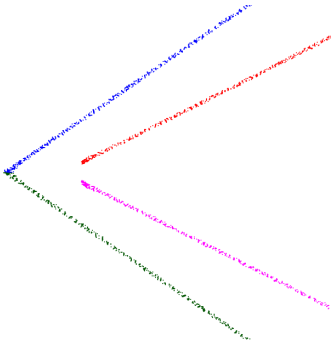




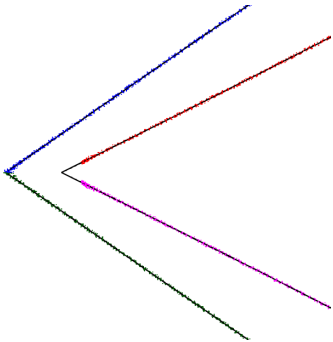
Diamond Airfoil: Shock Fitting



Processed shock points

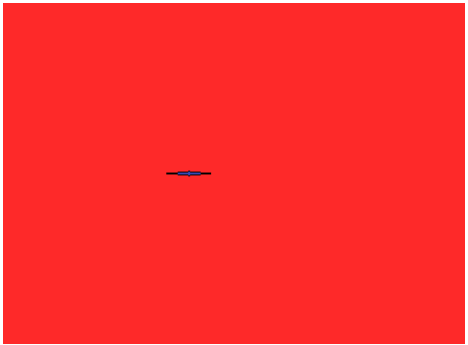


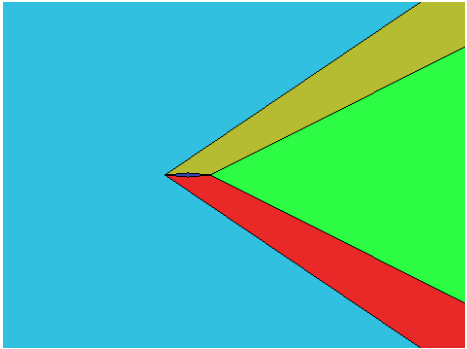
Segmented shock points



Fitted shock curves

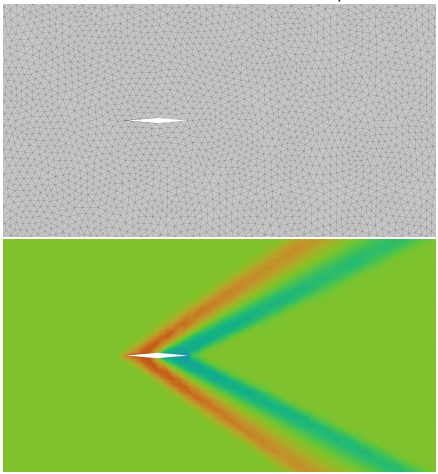
Diamond Airfoil: Initial and Shock-fitted Geometry

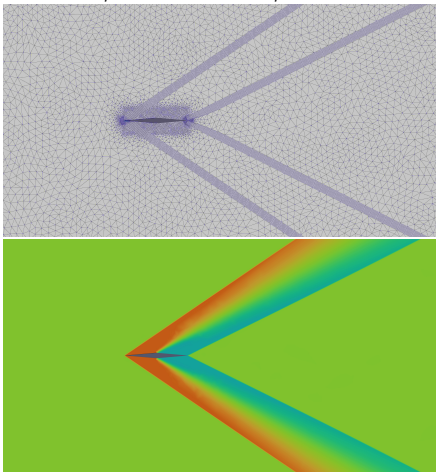




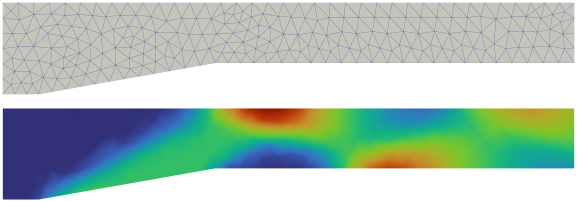
Diamond Airfoil: Initial and Shock-fitted Solutions

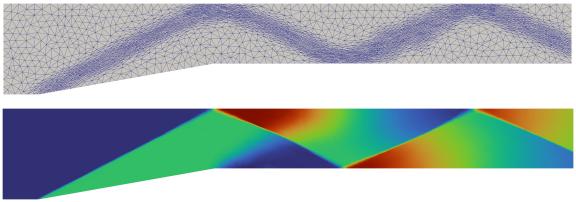
Elements: M0: 15,748 M1: 23,354 M2: 25,360 SF: 22,678



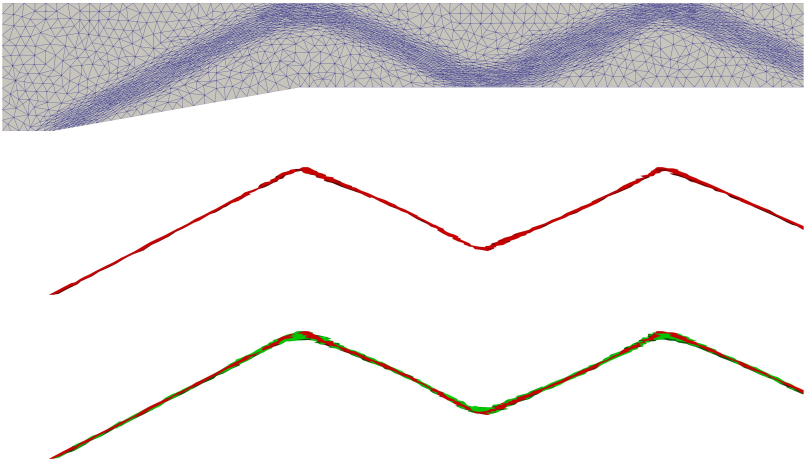


Wedge Duct: Mesh 0 and Mesh 2





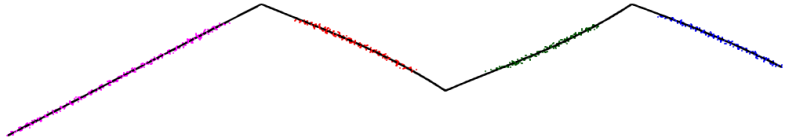
Wedge Duct: Mesh 2 Shock Processing



Wedge Duct: Shock Fitting

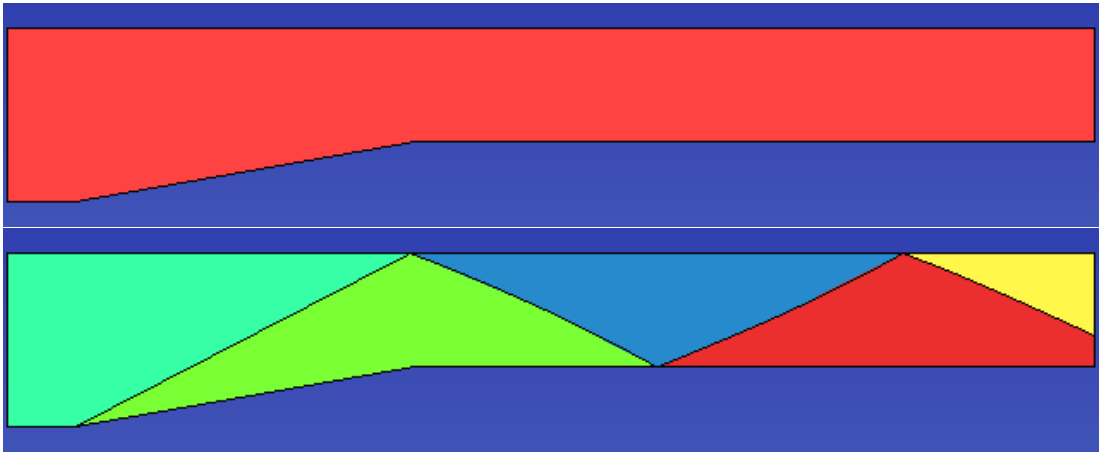
Processed shock points

Segmented shock points



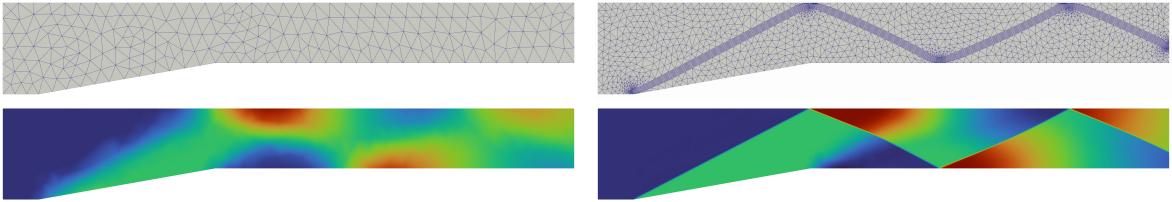
Fitted shock curves

Wedge Duct: Initial and Shock-fitted Geometry

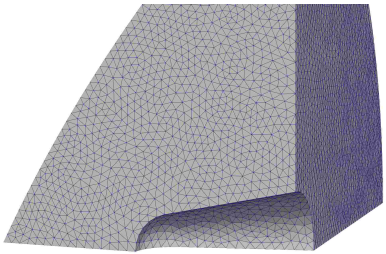


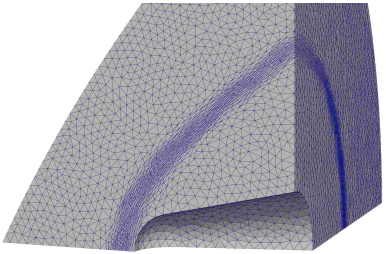
Wedge Duct: Initial and Shock-fitted Solutions

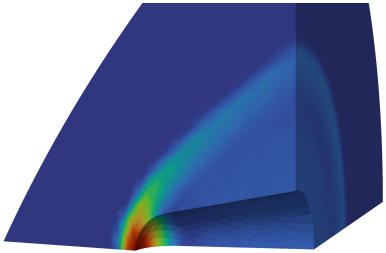
Elements: M0: 416 M1: 4,676 M2: 5,440 SF: 4,178

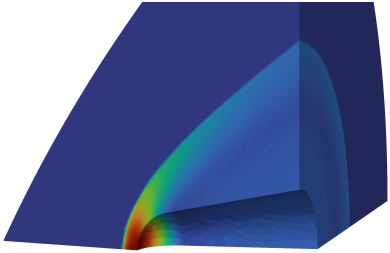


Blunt Body: Mesh 0 and Mesh 2

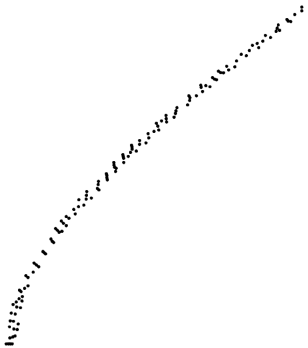




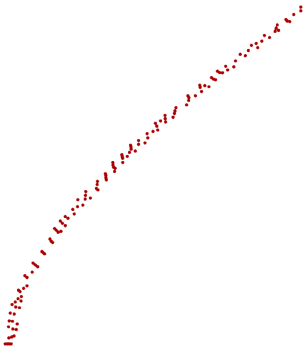




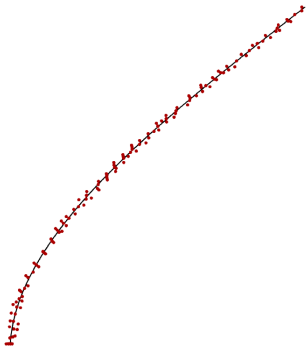
Blunt Body: Shock Fitting



Processed shock points

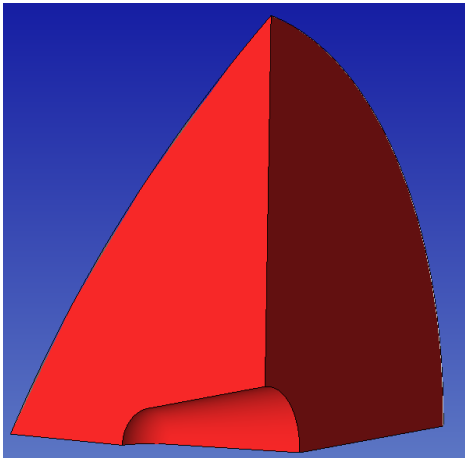


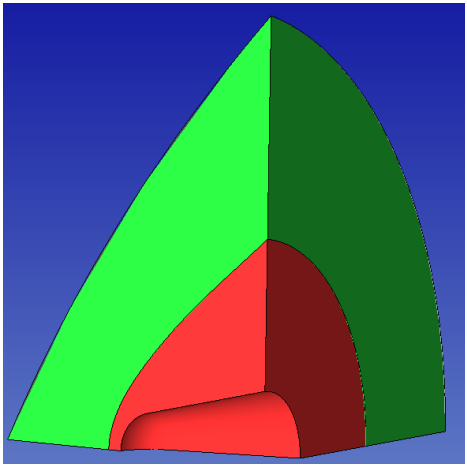
Segmented shock points



Fitted shock curves

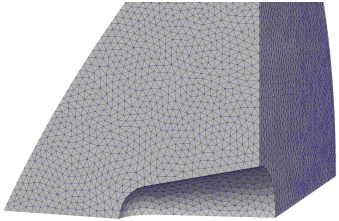
Blunt Body: Initial and Shock-fitted Geometry

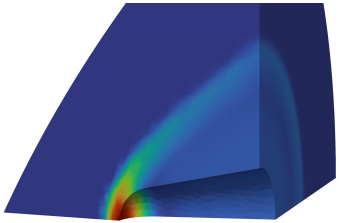


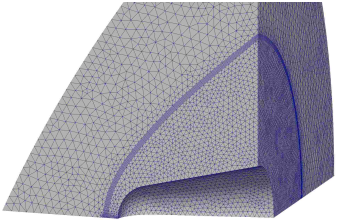


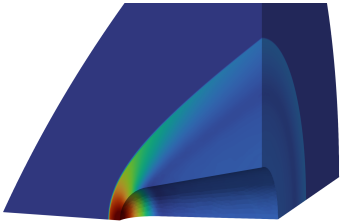
Blunt Body: Initial and Shock-fitted Solutions

Elements: M0: 118,879 M1: 225,321 M2: 245,971 SF: 307,073 (178,816)









Closing Remarks and Acknowledgments

Summary:

- Extended robust shock processing with shock system segmentation
- Developed geometry/mesh shock-fitting procedure
- Showcased crisp shocks in 3 iterations even with very coarse initial meshes

Future directions:

- Other solution features and more complex shock interactions
- Viscous and transient cases
- Combine with error-based adaptation

Acknowledgments:

- Mr. Steven Spreizer and Isaac Tam for their initial efforts
- Mr. Soumyanil Sadhu Deep for providing some Ansys Fluent CFD simulation data
- Simmetrix, Inc. for providing geometry and mesh libraries

References

More details can be found in the conference paper:


Woodruff, Aiden and Onkar Sahni (2026). "Towards Automatic Construction of 3D Shock-fitted Meshes based on Robust Shock Detection and Processing". In: *AIAA SCITECH 2026 Forum*. _eprint: https://arc.aiaa.org/doi/pdf/10.2514/6.2026-2680. American Institute of Aeronautics and Astronautics. DOI: 10.2514/6.2026-2680. URL: https://arc.aiaa.org/doi/abs/10.2514/6.2026-2680 (visited on 01/19/2026).