CARTESIAN-CELL BASED GRID GENERATION AND ADAPTIVE MESH REFINEMENT

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MOTIVATION

Wouldn't it be nice to just define the geometry and the free-stream conditions, and let the grid generation/adaptive refinement do the rest?

Objectives

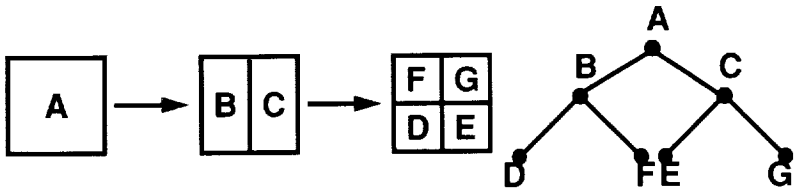
- Automated Grid Generation for Complex Bodies
- Automated Grid Refinement (Convergence?)
- Alternative to Triangular/Tetrahedral Meshes

A Cartesian-Mesh Approach

- Use Cartesian Cells of Unit Aspect Ratio to Create Background Mesh
- "Cut" Bodies Out of Background Mesh, Creating Irregularly Shaped Boundary Cells
- Arbitrary Numbers of Arbitrarily Shaped Bodies Are Allowed
- Geometry Defined With Sets of General Basis Functions Along Surfaces
- Background Mesh Created By Recursively Refining Cartesian Cell Into Four Cells

GRID GENERATION

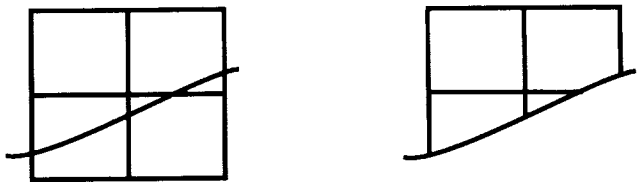
- Grid Generation Process Creates Binary Tree



- Binary Tree Allows Quad and Binary Refinement
- Connectivity/Tree Hierarchy Closely Related

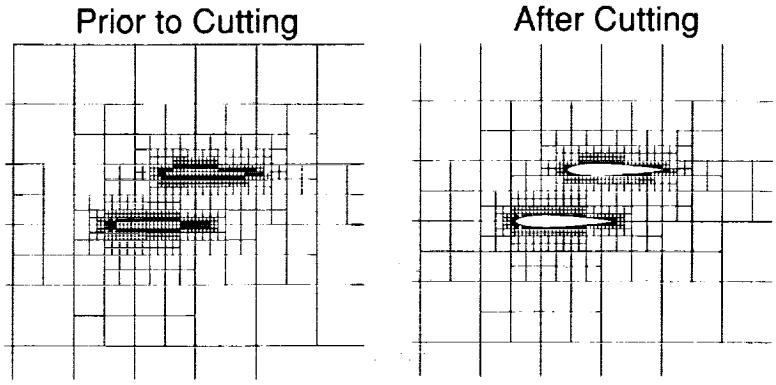
GRID GENERATION

- Recur to Leaves of Tree and Determine Intersections (if any) with Bodies
- Use Simple Set of Rules to Determine If It is Legal to Cut Leaf into Cell: Recursively Refine if Illegal
- Vertex Locality Used to Determine Cut Cell Geometry



CELL CUTTING

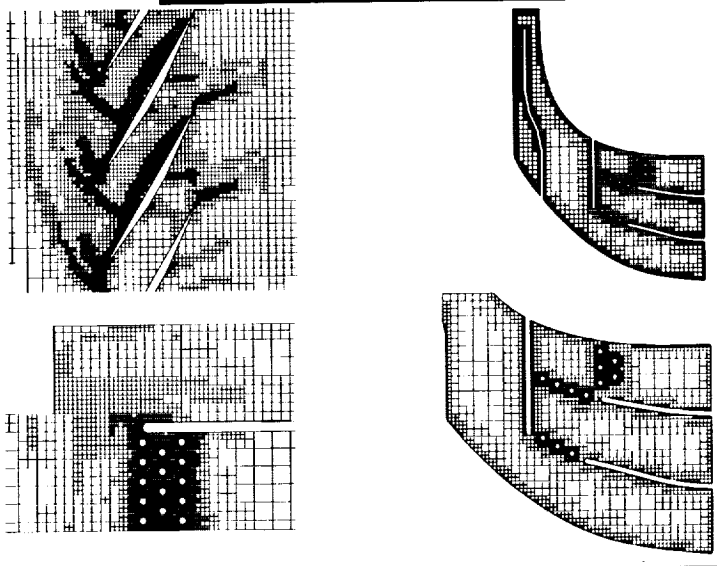
- Example: Staggered Biplane Configuration of Clarke, Salas and Hassan (AIAA J. 1986)



DATA STRUCTURE(S)

- Cartesian Cell Geometric Data Inferred From Tree
- Cut Cell Geometric Data From (Local) Ordered List of Pointers to (Global) List of Vertices
- Connectivity Is Inferred Directly From Tree By Logical Tree Traversals (Centroid Compares, Face Matching)
- Code Written in ANSI C: Dynamic Memory Allocation/Deallocation, Self-Referential Data Structures

SAMPLE GRIDS



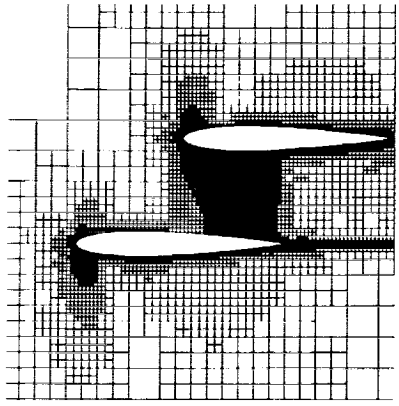
FLOW SOLVER FORMULATION

- Cell Centered, Finite Volume, Upwind Based Scheme
- Linear Reconstruction (Minimum-Energy) of Primitives Used to Compute Left/Right Interface States as Input to Approximate Riemann Solver
- Adaptive Mesh Refinement Using Cell Size Weighted Criterion Based on Velocity Divergence and Curl (Compressibility and Rotation)
- Perform Flow Solve/Adaptation Set Number of Times

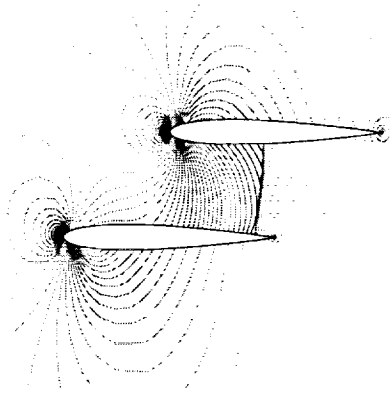
ADAPTIVE MESH REFINEMENT

- Staggered Biplane Case

Grid



Pressure Contours

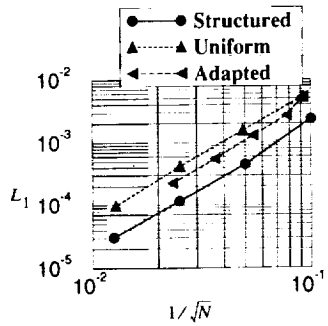


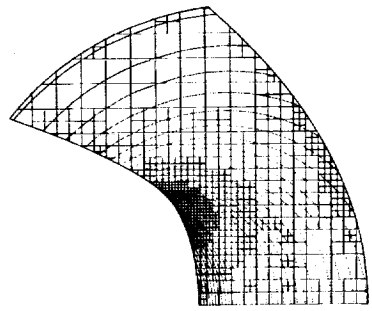
ACCURACY ASSESSMENT

- Use Exact, Analytic Solution (Ringleb's Flow)
- Infer Order of Error From Uniform and Adaptive Refinement
- Infer Magnitude of Error by Comparing to Structured Solver
- Asks Question:

Can Adaptive Mesh Refinement Beat Uniform Refinement and/or Structured Uniform Refinement?

ACCURACY ASSESSMENT

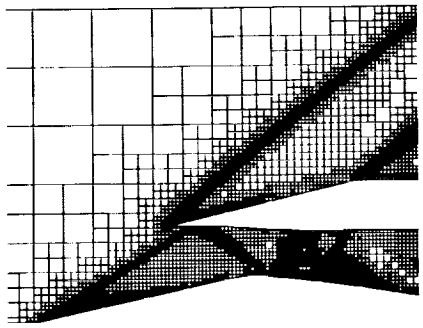


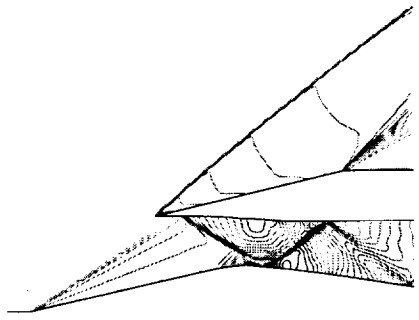


- Approach is 2nd Order (Global), Better than 1st (Local)
- **Smooth Flow:** Can't Beat Uniform Refinement or Structured

ADAPTIVE MESH REFINEMENT

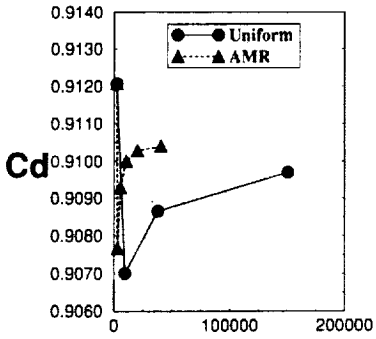
- What About Non-Smooth Flows?
- Grid Convergence Study on Supersonic, Axi-Symmetric, Mixed-Compression Inlet





ADAPTIVE MESH REFINEMENT

- Compare Uniform and Adapted Drag Coefficients

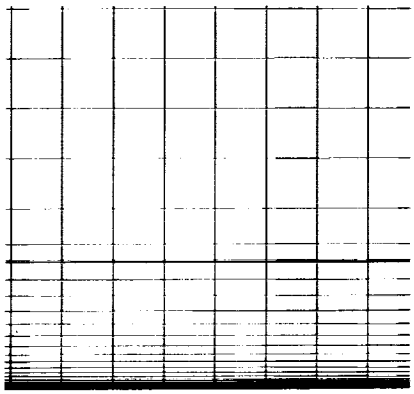


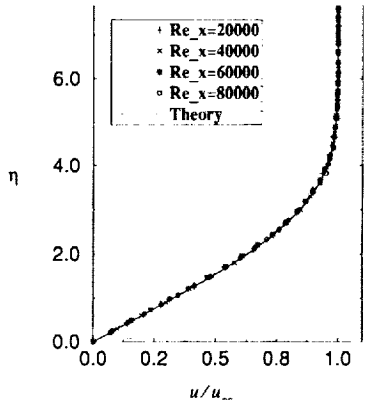
Conclusion

- AMR Grid Converged
- Uniform Not Converged (150,683 Cells!)
- Adaptive Mesh Refinement Best For Non-Smooth Flows With Multiple Length Scales

VISCOUS FLOWS

- Presently Extending to Viscous Flows
- "Cut" Level Distance Lines From Bodies





CONCLUDING REMARKS

- Proven to be an Accurate Alternative to Triangular/Tetrahedral and Structured Grids
- Adaptive Refinement Best on Flows With Widely Varying Length Scales

FUTURE DIRECTIONS

- Can This Approach Work Well For Viscous Flows? (Grid Smooth Enough With Distance Cutting?)
- What About 3D?
- WYSIWYG Front End?