NATIONAL INSTITUTE OF AEROSPACE

Making Your Own Mesh

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JOINT NATIONAL INSTITUTE OF AEROSPACE (NIA) & SU2 FOUNDATION
USER WORKSHOP, August 9, 2019

Updated on 08-05-19

Grid format

SU2 accepts the following grid formats:

- Native format (.su2) https://su2code.github.io/docs/Mesh-File/
- CGNS (.cgns) https://cgns.github.io

Any software that can produce a grid file in either .su2 or .cgns format serves as a grid generator for SU2.

Grid Generation Software

which generate .su2 and/or .cgns files.

- Pointwise https://www.pointwise.com
- ICEM CFD https://en.wikibooks.org/wiki/ICEM_CFD
- CENTAUR Grid Generator https://www.centaursoft.com/grid-generator
- SC/Tetra (available in MSC ONE) https://www.cradle-cfd.com/products/sctetra/

  scFLOW (also in MSC ONE) in 2021 or later, https://www.cradle-cfd.com/products/scflow/

Open-source software:

- Gmsh http://gmsh.info
- Salome https://www.salome-platform.org
- refine https://github.com/nasa/refine (3D mixed-element grid adaptation framework)
- Custom grid generation codes

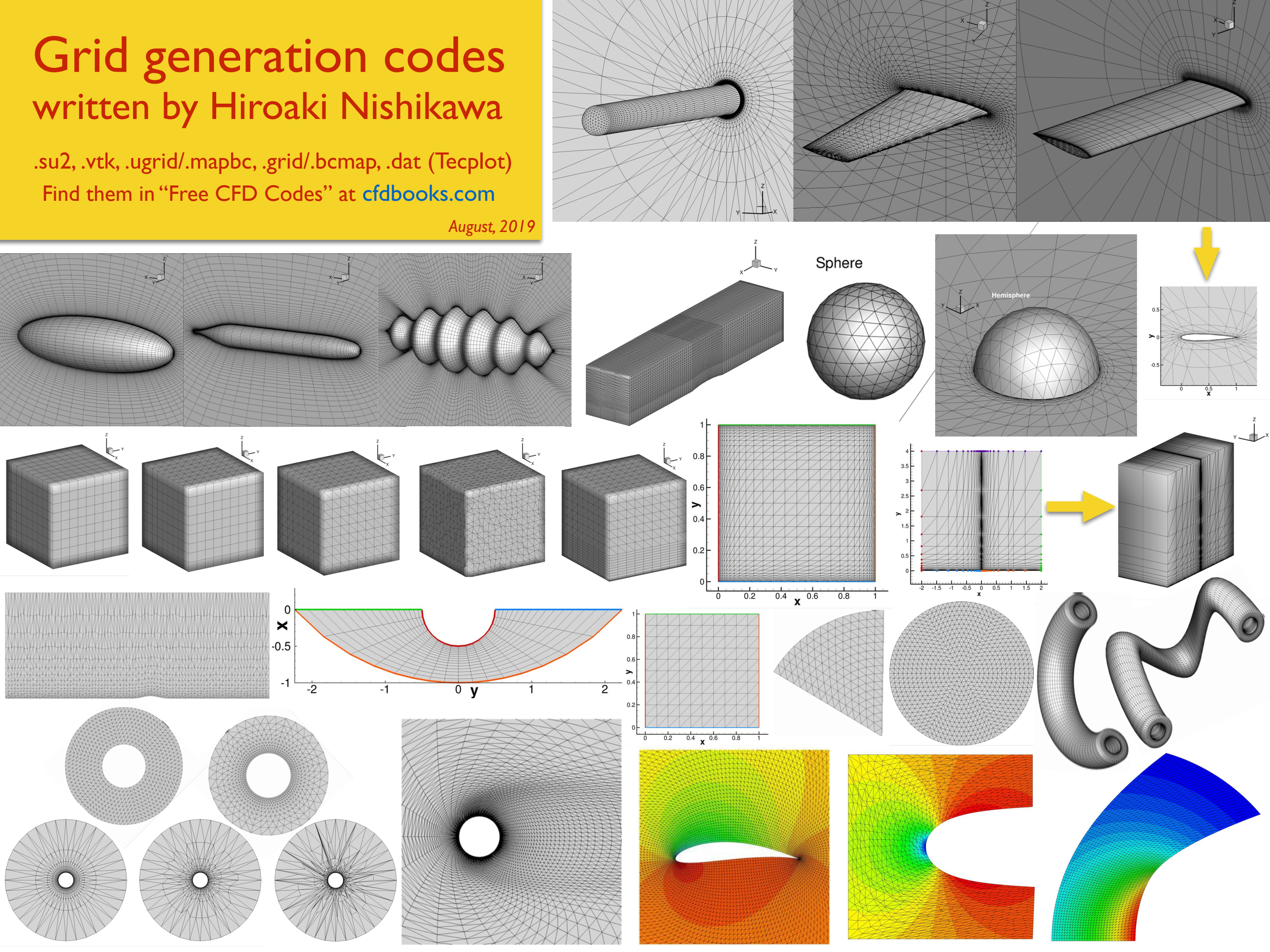
This talk focuses on custom codes (written by Hiro Nishikawa) that generate .su2 files.

Grid generation codes
written by Hiroaki Nishikawa

.su2, .vtk, .ugrid/.mapbc, .grid/.bcmap, .dat (Tecplot)

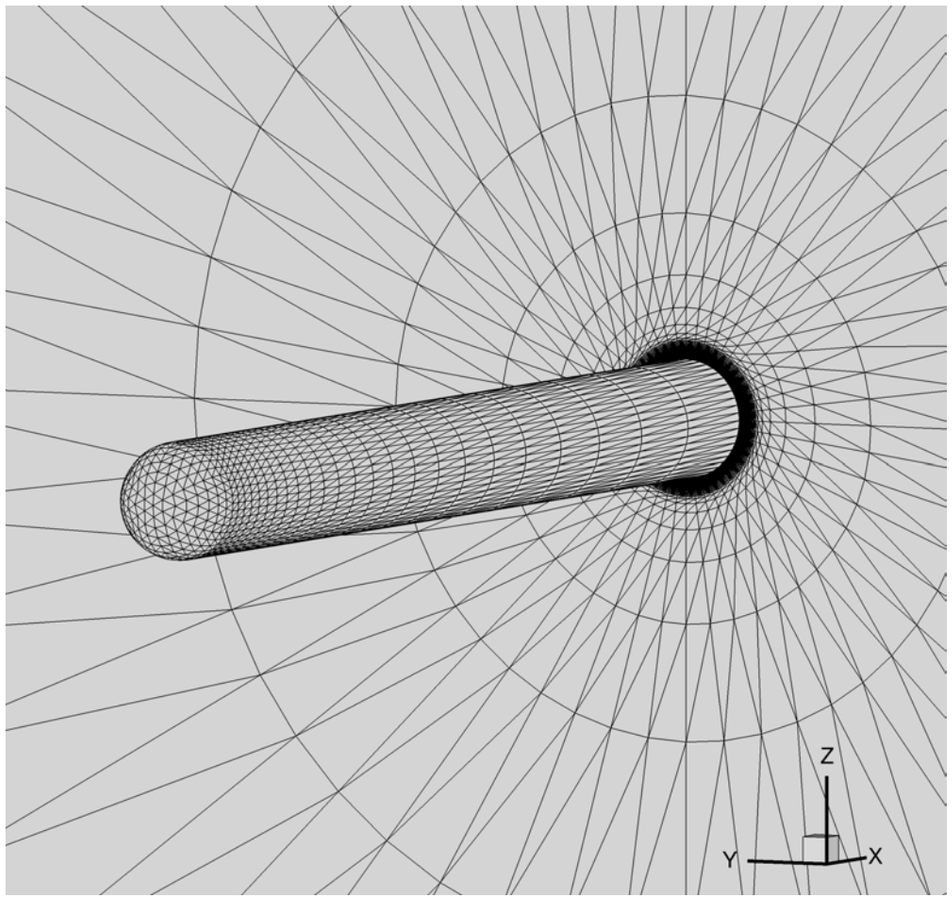
Find them in "Free CFD Codes" at cfdbooks.com

August, 2019



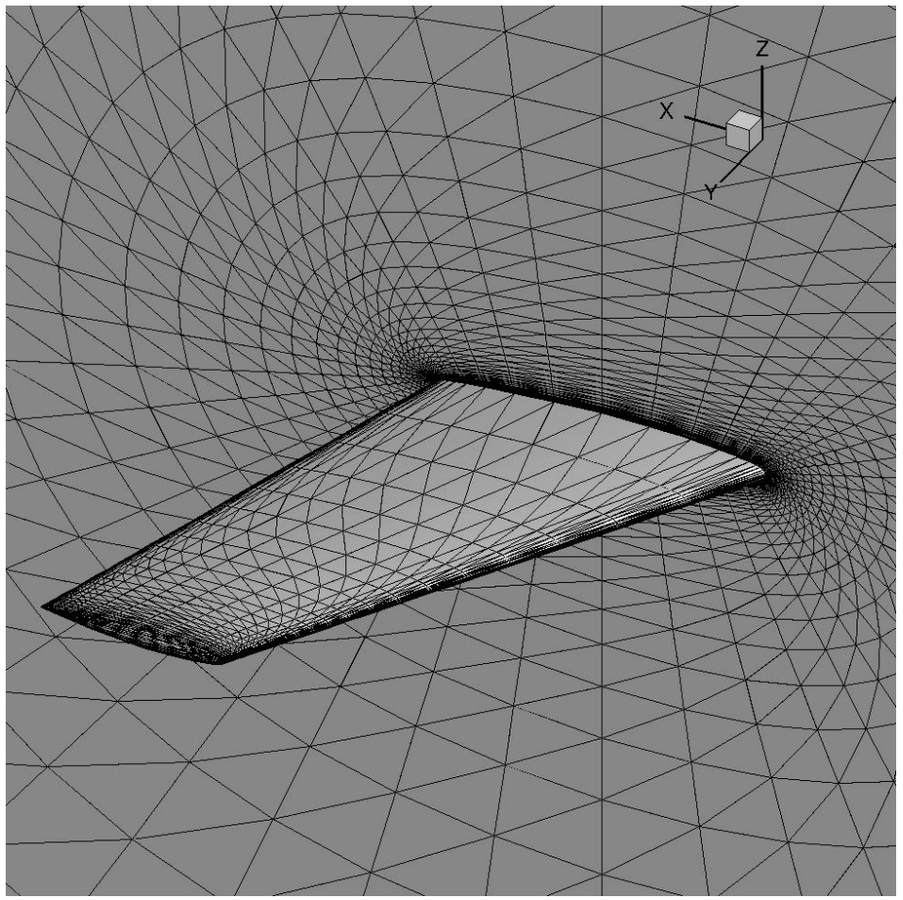
Special grid generation codes

Hemisphere-Cylinder



NASA TMR (HC)

Wing



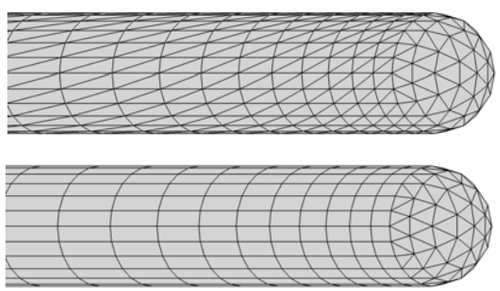
NASA TMR (OM6)

Code packages are available NASA Turbulence Model Resource website (click "NASA TMR" above).

Special grid generation codes:

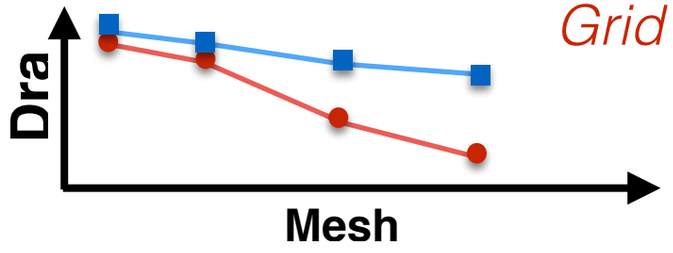
- **Structured/unstructured grids**

  with the same (or very similar) point distributions.



- **Generate a family of regularly-coarsened grids**

  suitable for grid convergence studies.



- **Grid generation code, not grid files**

  easy to share large-size grids, which can be difficult

- **Other special features**

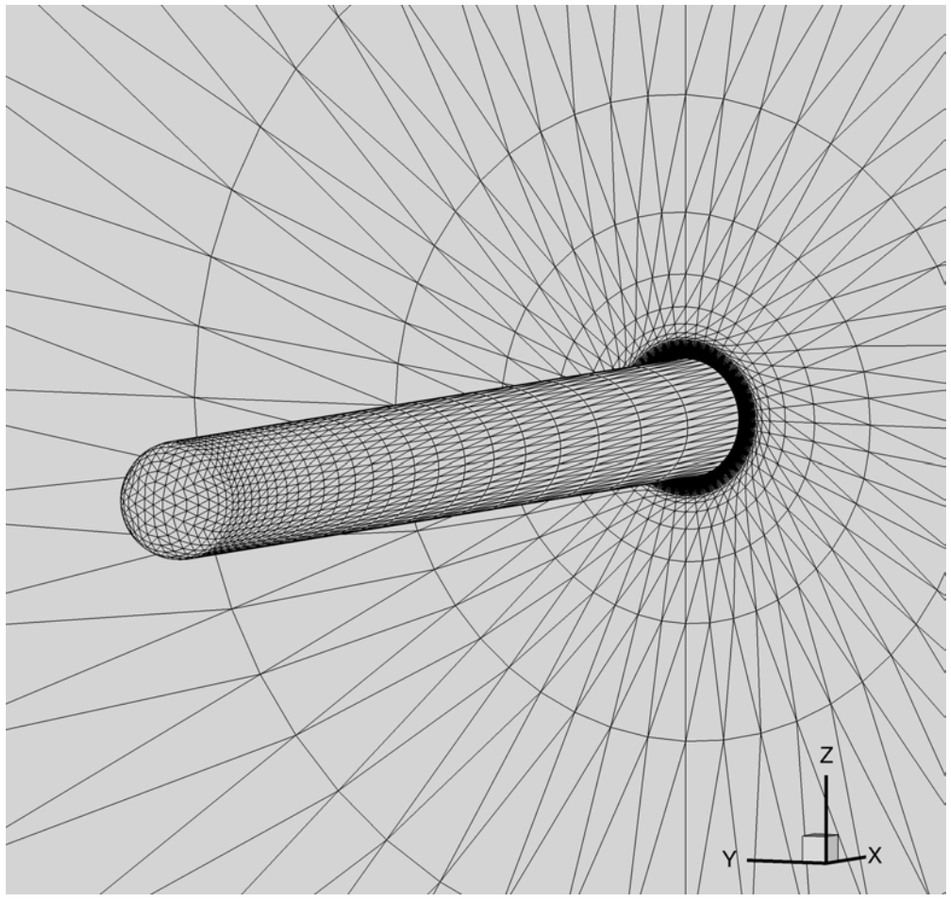
  Inter-grid operators, line information, removed points (to construct high-order grids, natural partitions.

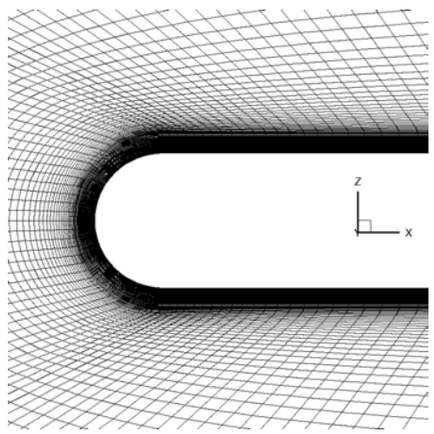
Hemisphere-Cylinder

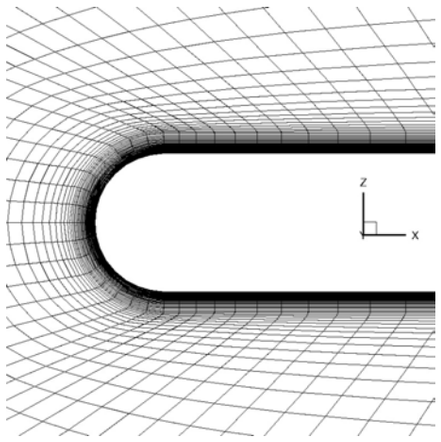
Grid generation code package:

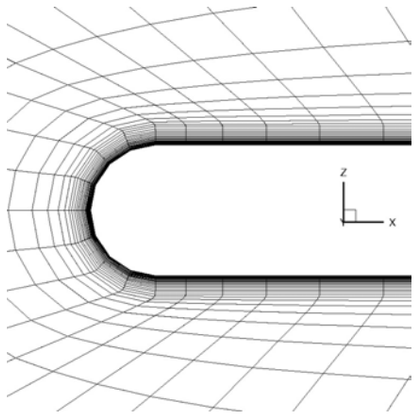
`hc_release_072319.tar.gz` (Updated)

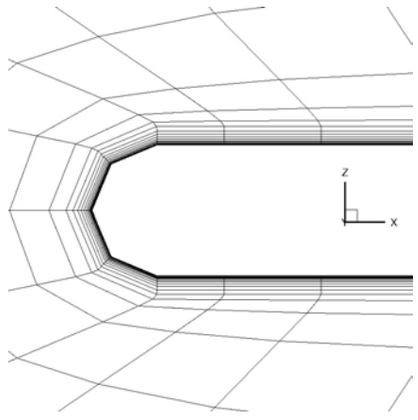
See "readme_release.txt" included in the package.

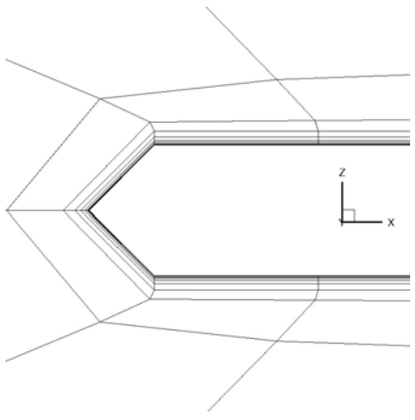








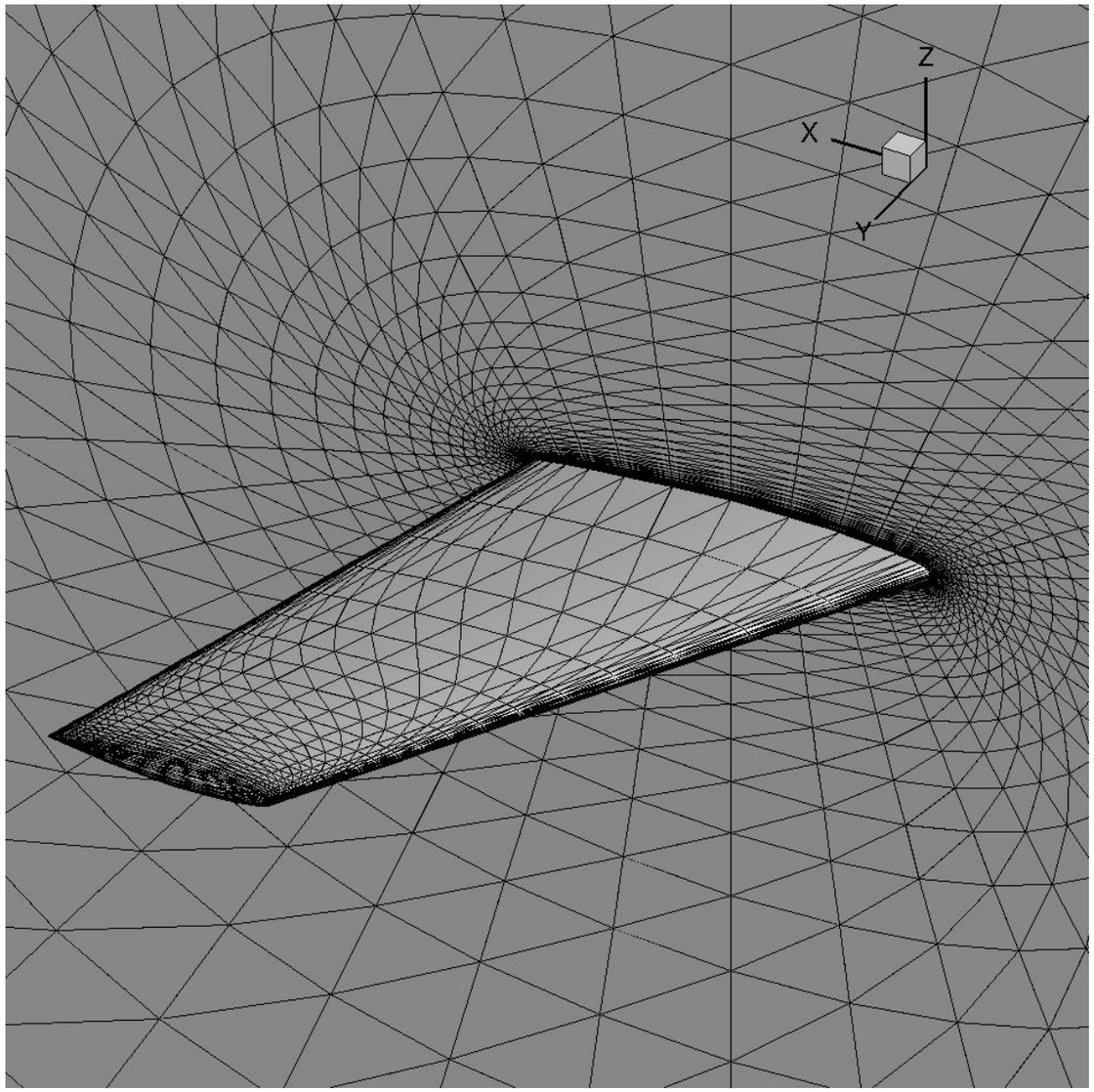


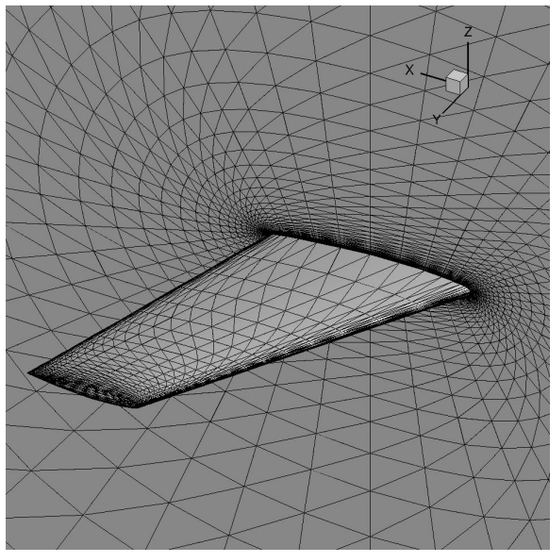


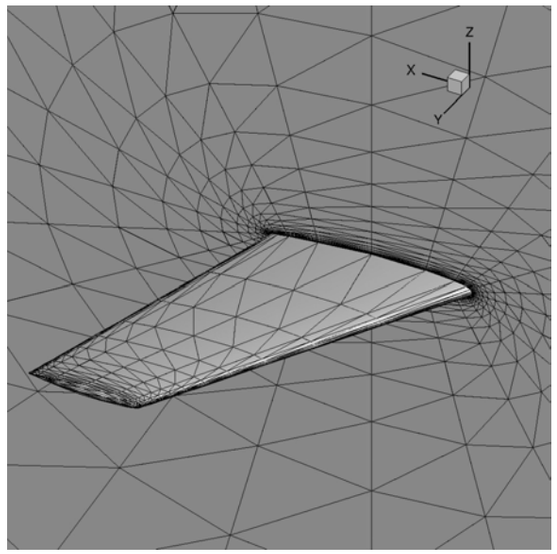
3D Wing (e.g., NACA00XX, ONERA M6)

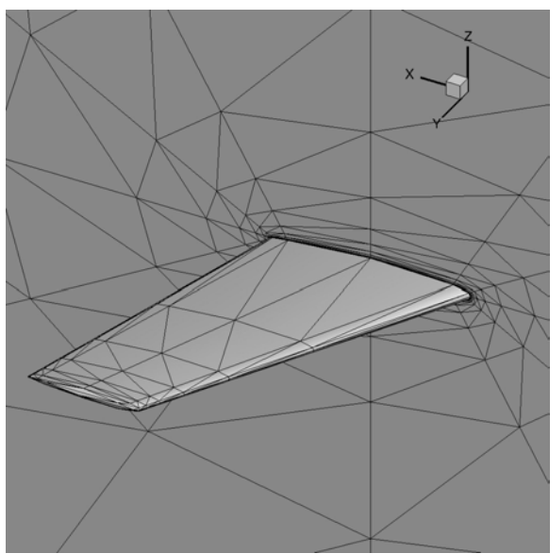
Grid generation code package:
`wing_release_072319.tar.gz` (Updated)

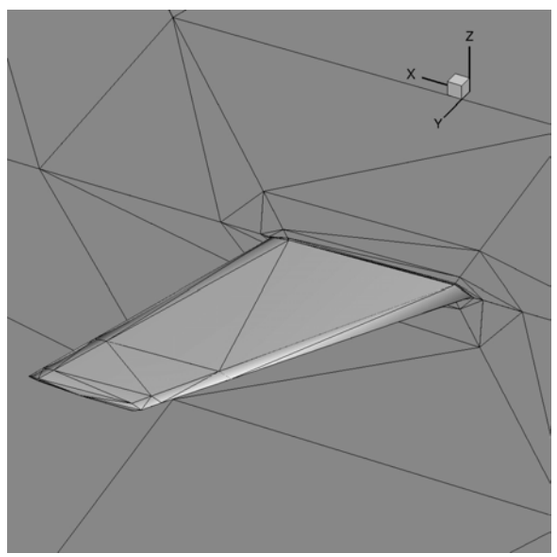
See "readme_release.txt" included in the package.









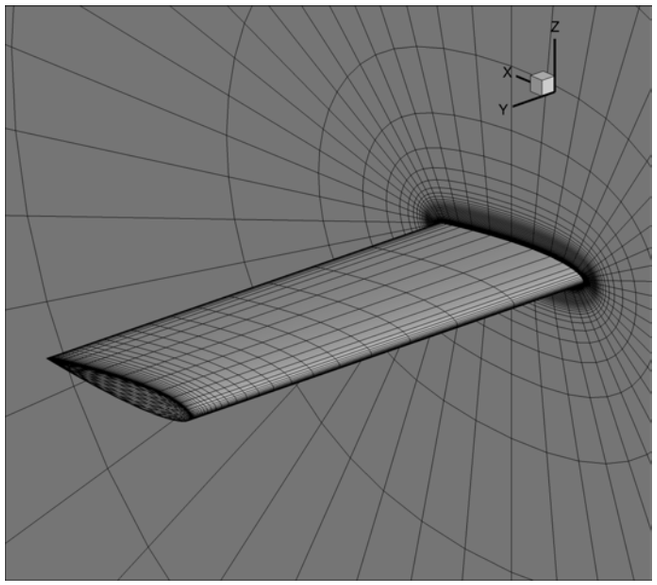


New Features: 3D Wing

- Blunt tip (NEW).

Sample input file: input.nml

Read the source file for details on the input parameters.



- Generate a 2D grid (symmetry plane) (NEW).

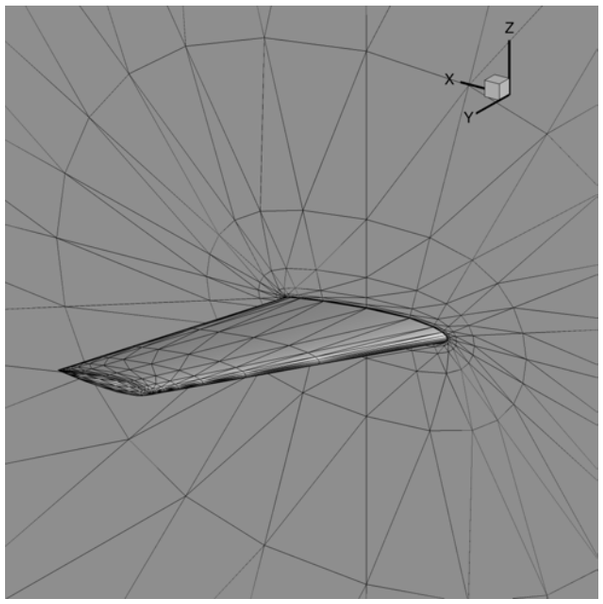
Add "generate_2d_grid = T" to input file.

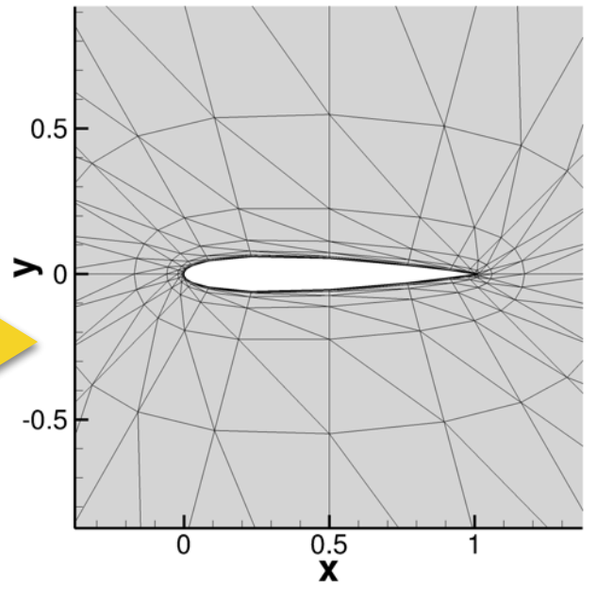
Sample input file: input.nml

This option is available only for the finest grid.

2D grid file is written in .su2 while generating a 3D grid.

NOTE: It can be very slow. A more efficient implementation will be considered in future.





Custom grid generation: 3D

For further details, see AIAA2018-1101:

Hiroaki Nishikawa and Boris Diskin, **"Customized Grid Generation Codes for Benchmark Three-Dimensional Flows"**, AIAA Paper 2018-1101, 56th AIAA Aerospace Sciences Meeting, 8 - 12 January 2018, Kissimmee, Florida.
[Paper | Presentation file]

There are no documentations for the rest of the codes,

Please read the source codes:

- Source codes contain detailed descriptions including references and explanations of all input parameters.
- Codes are written for my own research needs and also for an educational purpose: read the code, understand the algorithm, and then write your own.

Feel free also to modify them for your purposes.

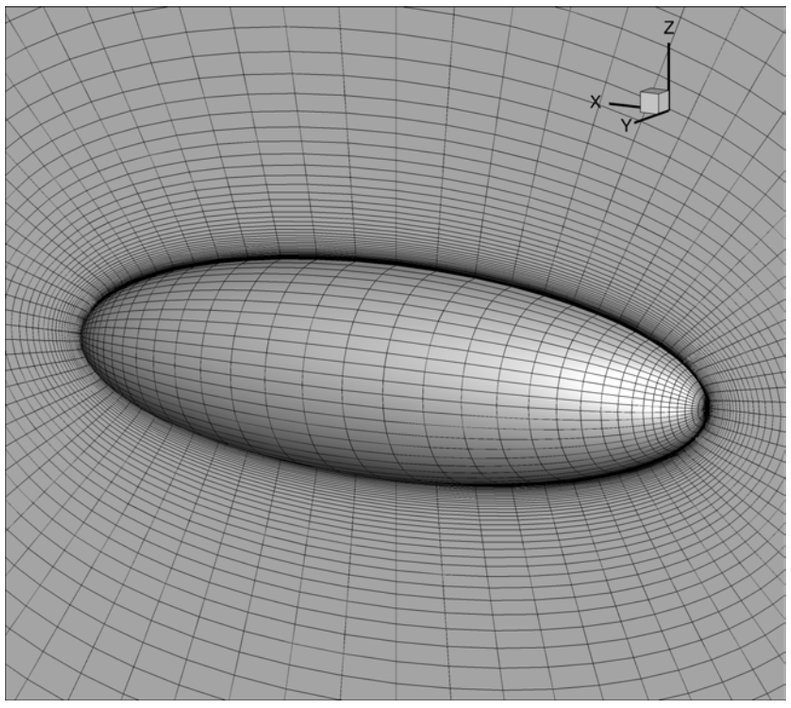
All codes are written in Fortran (.f90).
To run a code: e.g., at a Linux prompt,
%gfortran xxx.f90
%./a.out

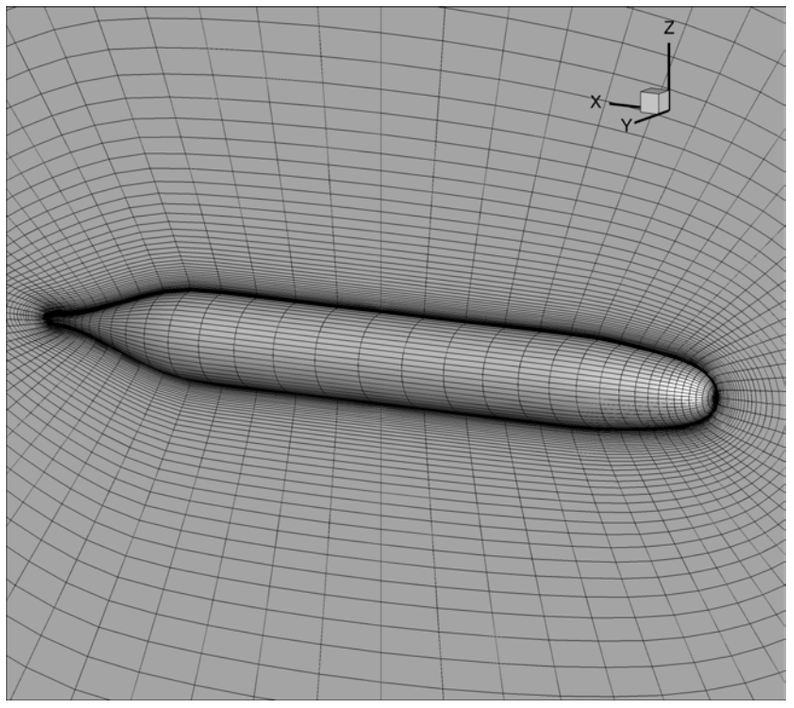
Feel free to ask me questions (hiro@nianet.org).

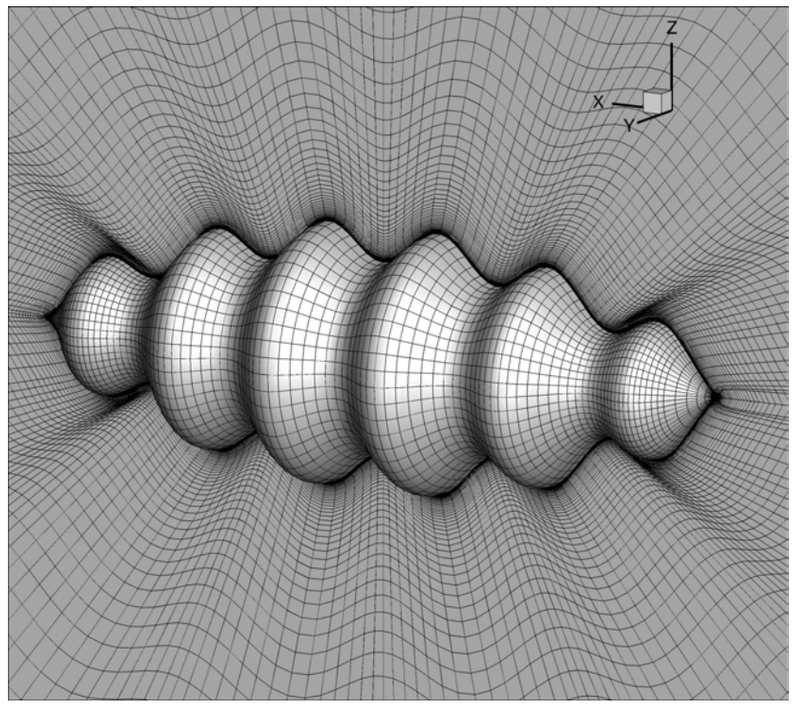
HCH: Hemisphere-Cylinder-Hemisphere

Package can be downloaded at cfdbooks.com
or directly at hch_v2p0_release.tar.gz

- Adjustable mesh parameters
- Structured/unstructured, regular coarsening, etc.
- Users can specify the shape.





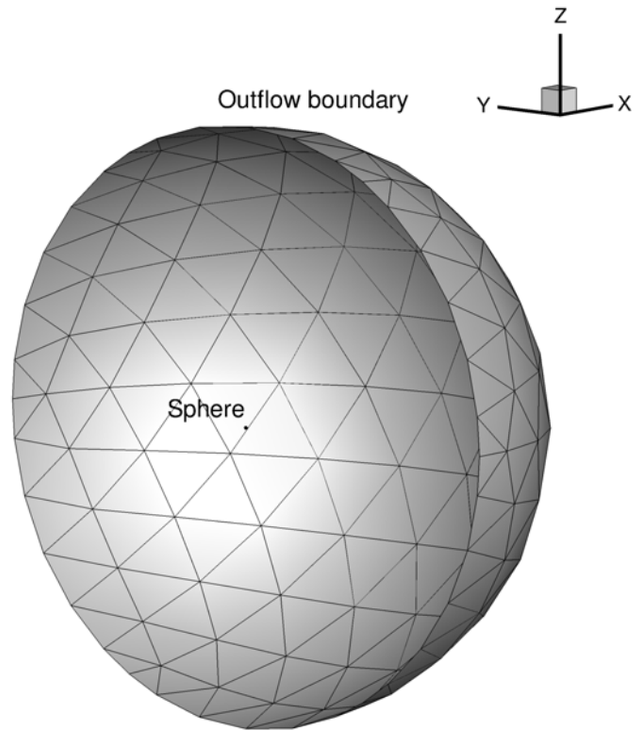


Sphere

Code: sphere_grid_v06.f90

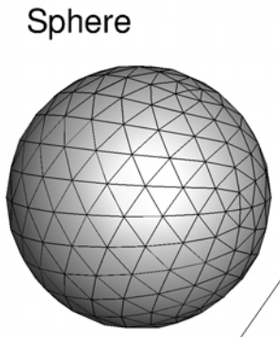
Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .ugrid, .mapbc.



Features:

- Adjustable mesh parameters
- No polar singularity
- Structured indices (optional)
- Grid line information (optional)
- Nodal perturbation (optional)

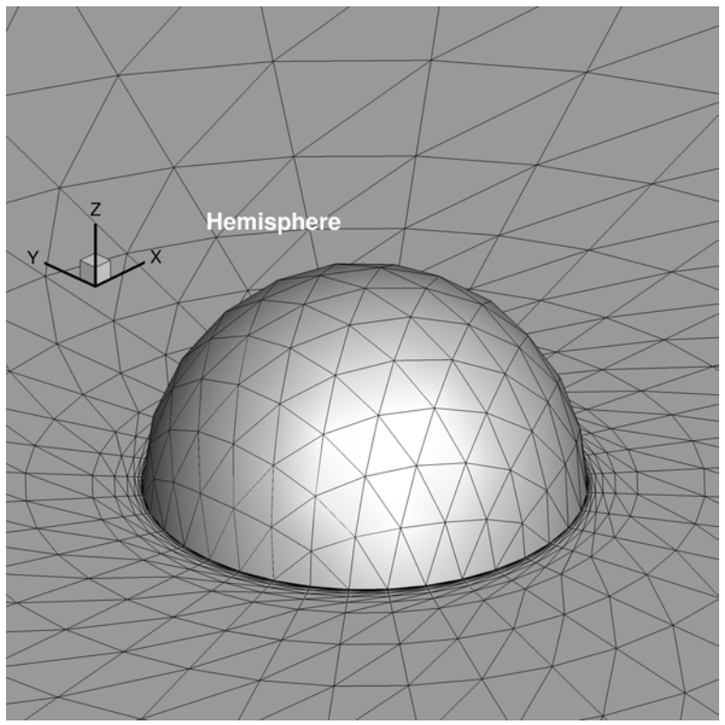


Hemisphere

Code: hemisphere_grid_v10.f90

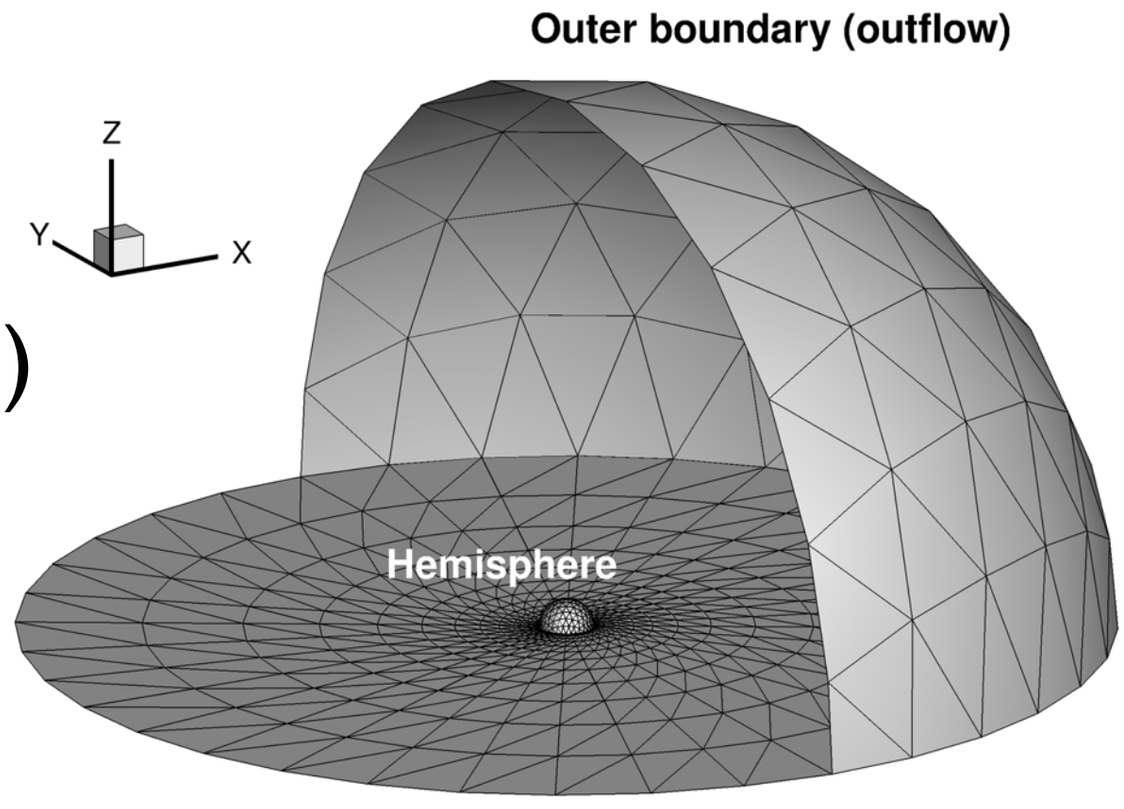
Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .ugrid, .mapbc.



Features:

- Adjustable mesh parameters
- No polar singularity
- Grid line information (optional)
- Structured indices (optional)
- Two configurations

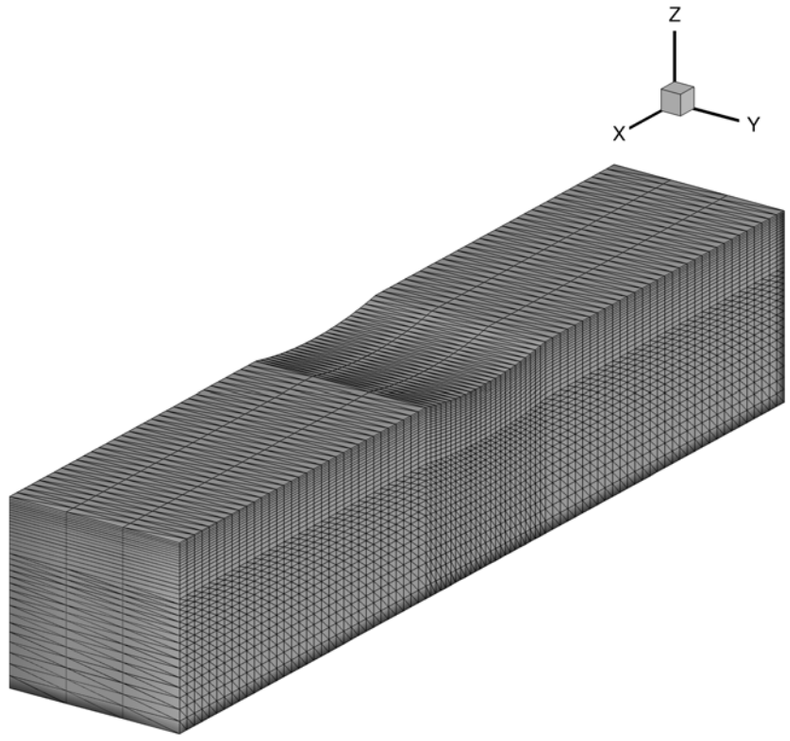


Bump (circular/sine bump)

Code: edu3d_bump_v3

Input: input.nml

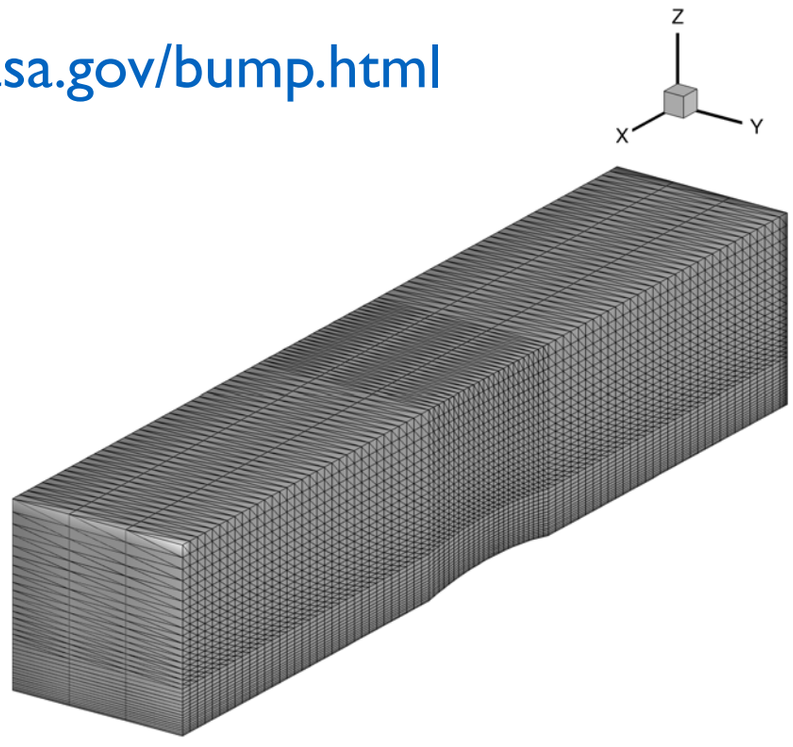
Output: .su2, .vtk, Tecplot files, .ugrid, .mapbc.



Features:

- Adjustable mesh parameters
- Circular or smooth sine^4 bump

  xle=0.3, xte=1.2, sine_bump_zmax=0.05 gives
  the sine^4 bump described at https://turbmodels.larc.nasa.gov/bump.html



- Bump on top or bottom.
- Tetra/prism/mixed grid.
- Stretching in z-direction.
- 6 or 8 boundary parts.

  separate_bump = T
  -> Split the boundary into 3 parts: sym, bump, sym
  which results in 8 boundary parts in total.

Cube: Hex

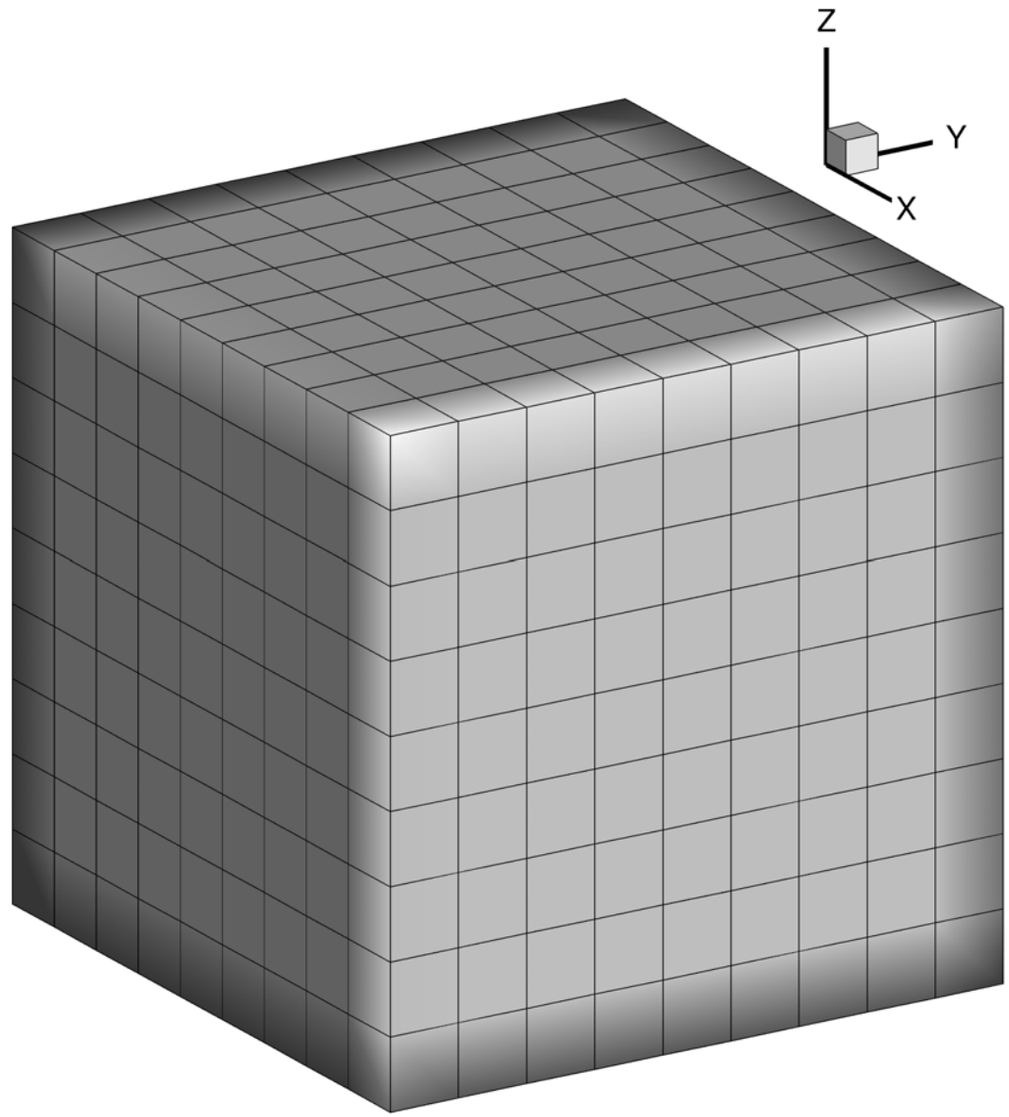
Code: hexgrid_cube_v4.f90

Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .ugrid, .mapbc.

Features:

- Adjustable mesh parameters
- 4 boundary parts



Cube: Prism

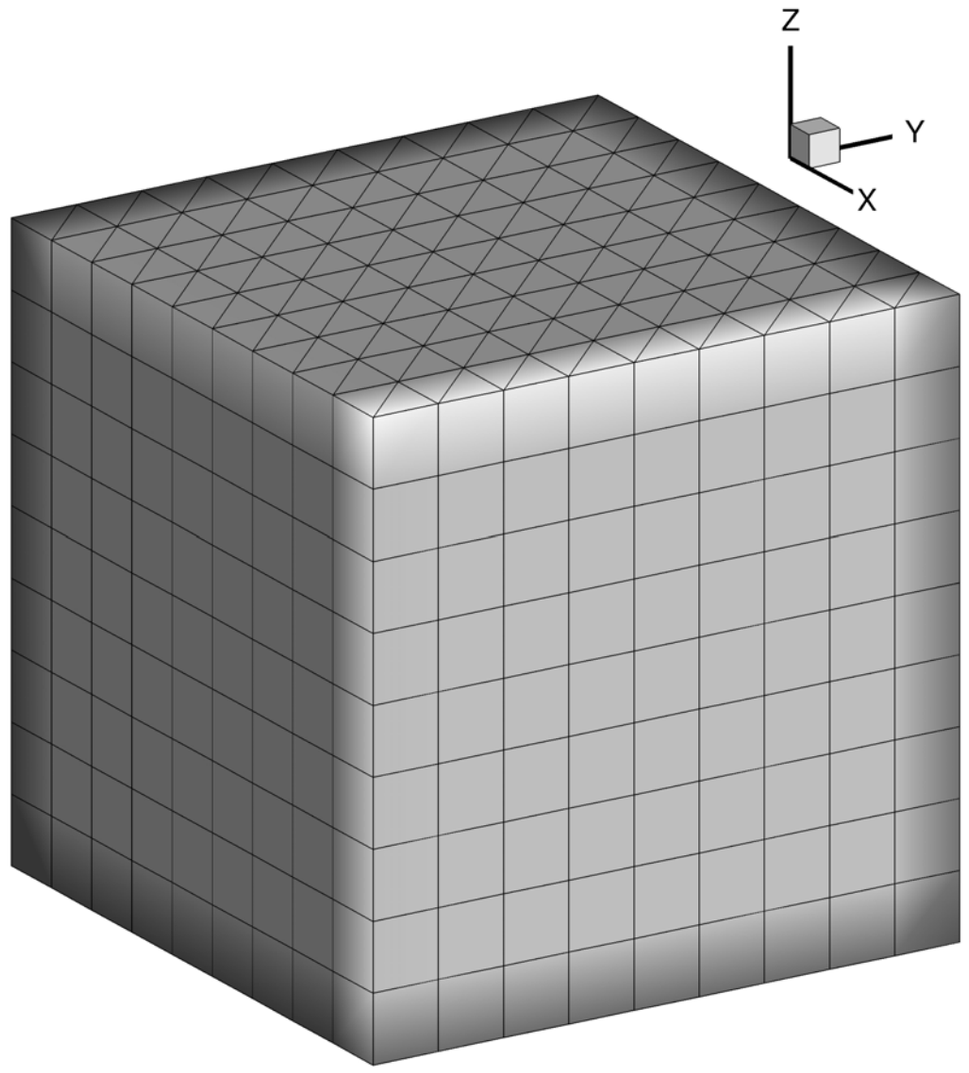
Code: przgrid_cube_v4.f90

Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .ugrid, .mapbc.

Features:

- Adjustable mesh parameters
- 4 boundary parts

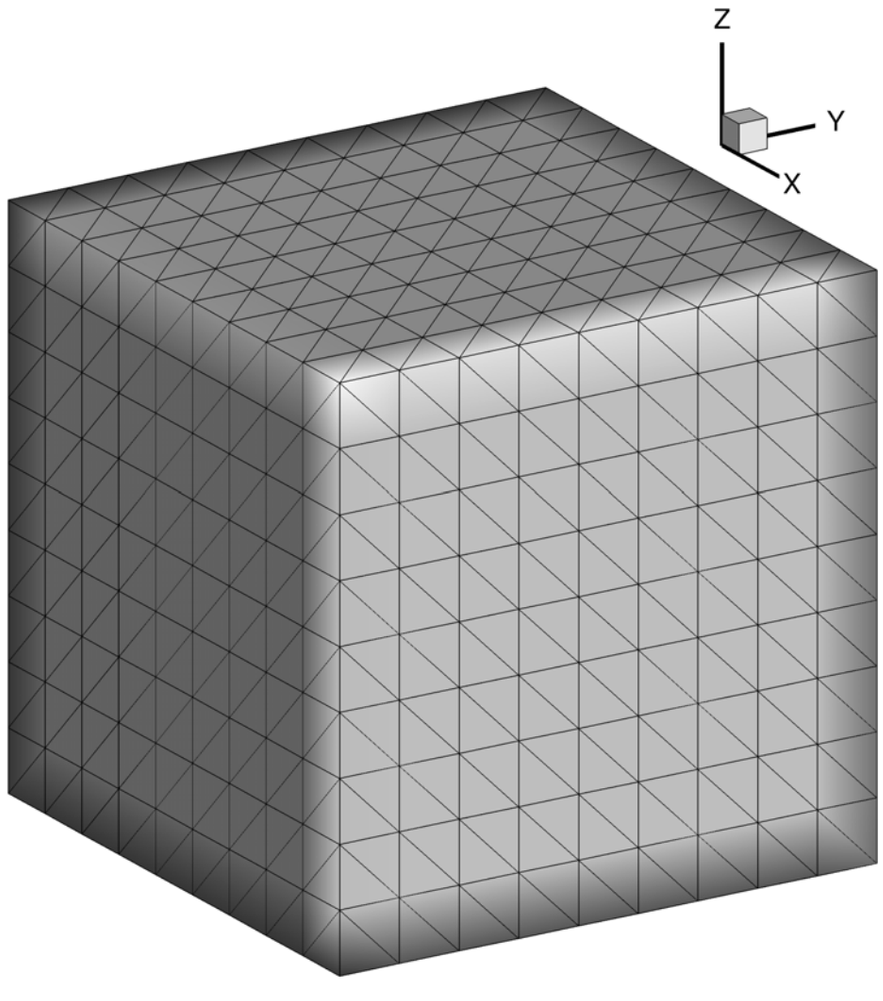


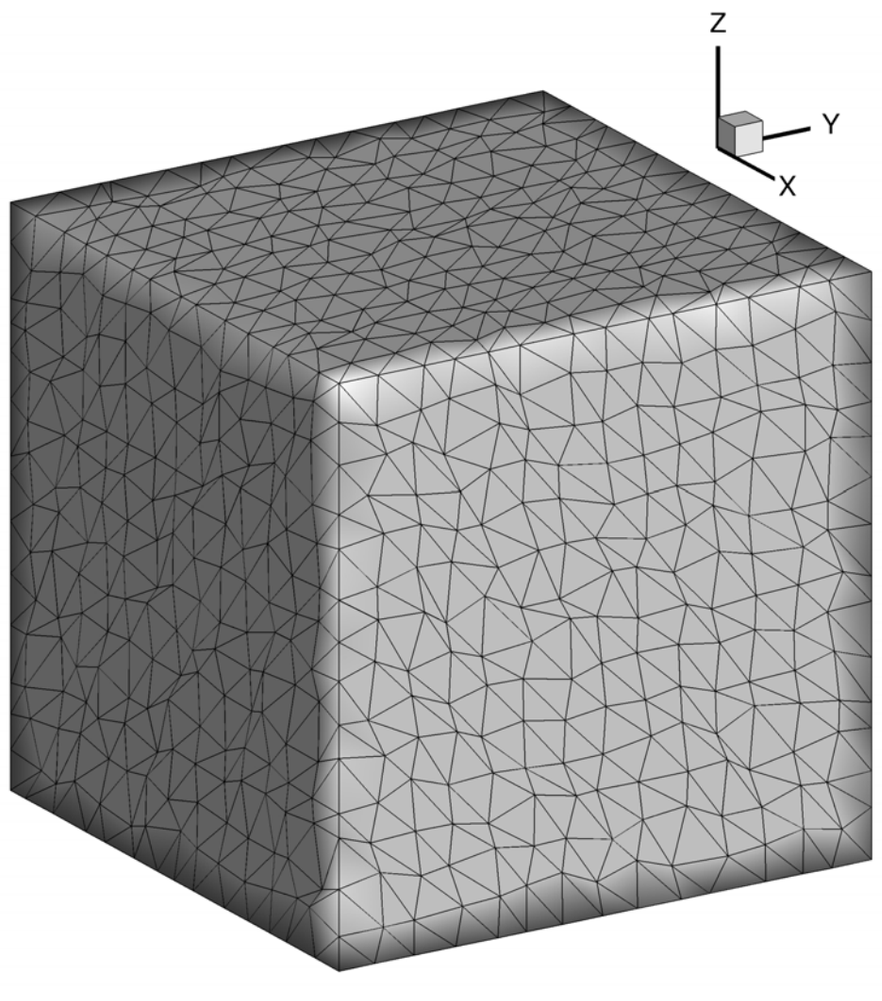
Cube: Tetra

Code: edu3d_tetgrid_cube_v4.f90 edu3d_tetgrid_cube_ptb_v7.f90

Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .ugrid, .mapbc.





Cube: Mixed (Prism-Tetra)

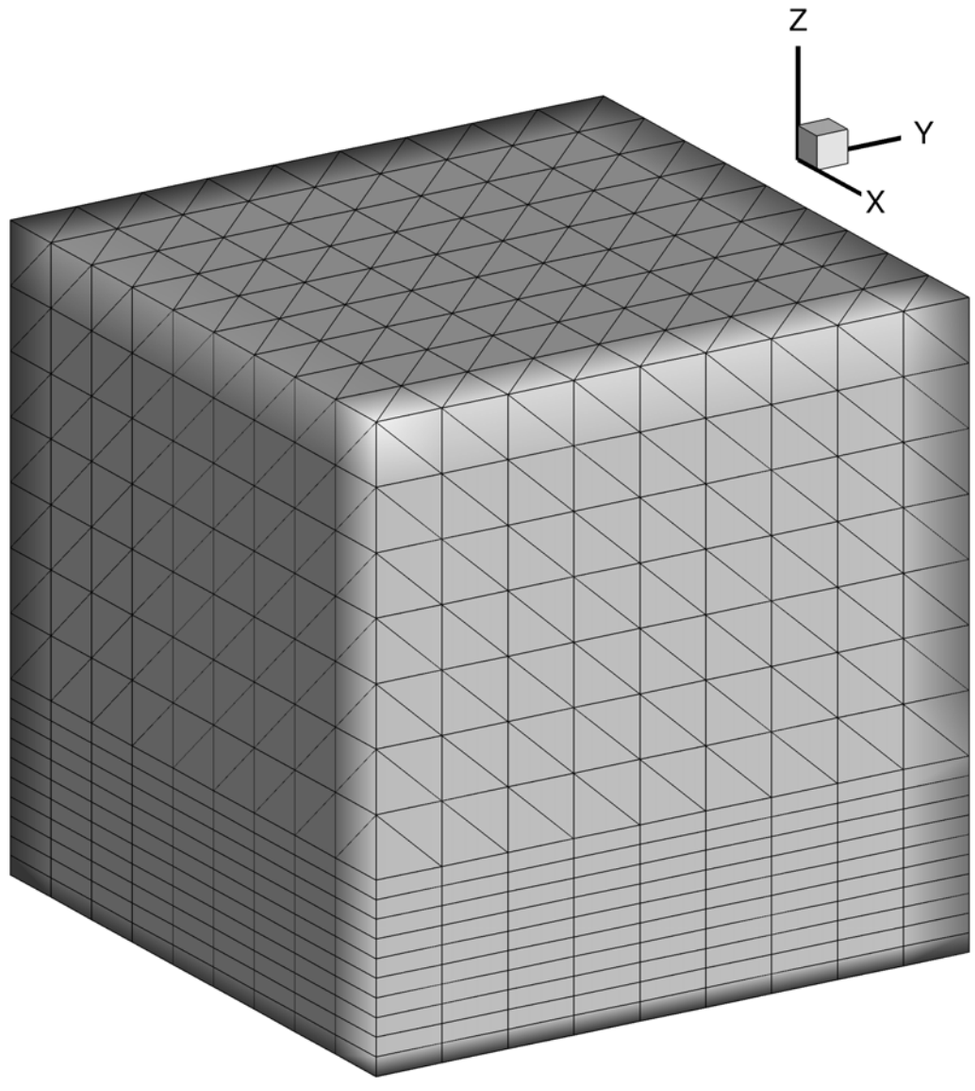
Code: mixgrid_cube_v5.f90

Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .ugrid, .mapbc.

Features:

- Adjustable mesh parameters
- 4 boundary parts



2D grid -> 3D grid

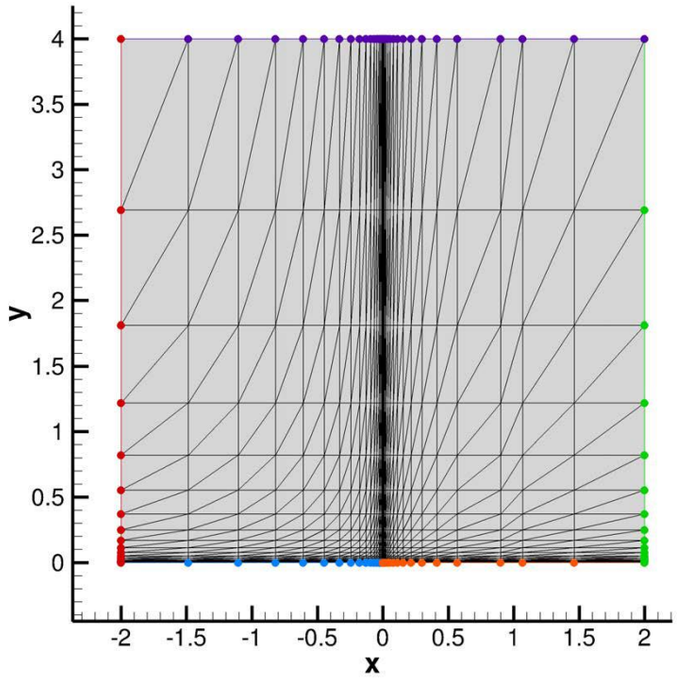
Code: edu2d_twod2threed.zip (package) **Updated on 08/03/19**

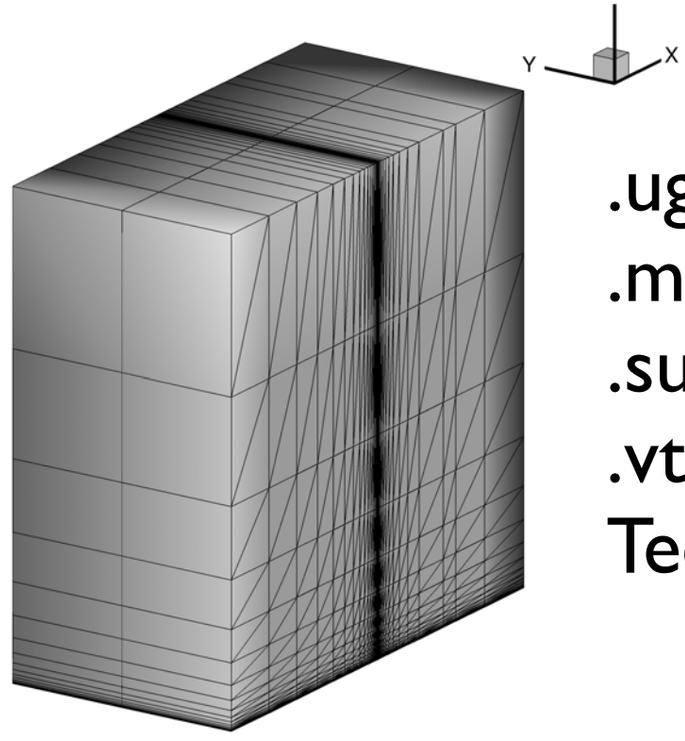
Input: input_twod2threed.nml and a 2D grid (.grid and .bcmap)

Output: .su2, .vtk, Tecplot files, .ugrid, .mapbc.

See edu2d_twod2threed_v3_readme.txt included in the zip.

.grid
.bcmap





.ugrid
.mapbc
.su2
.vtk
Tecplot

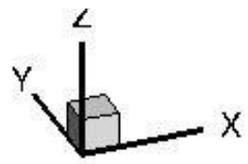
This code reads a 2D grid (in .grid format) and extends it to 3D.

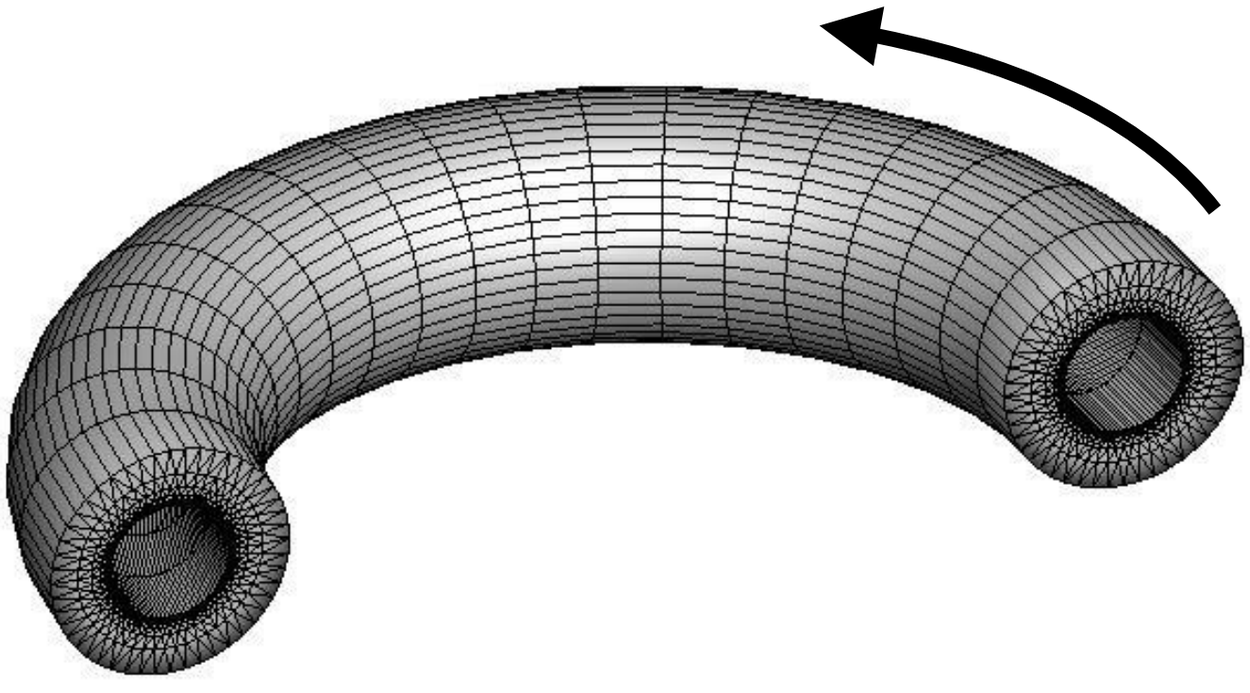
Custom grid generation: 2D to 3D

2D grid -> 3D grid

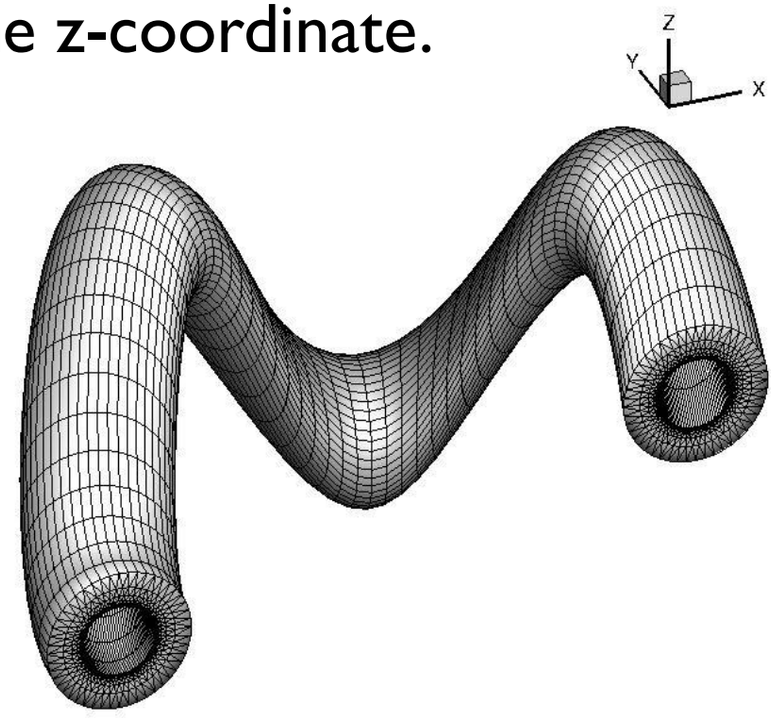
Updated on 08/03/19

This code can generate a 3D grid also by rotating a 2D grid:

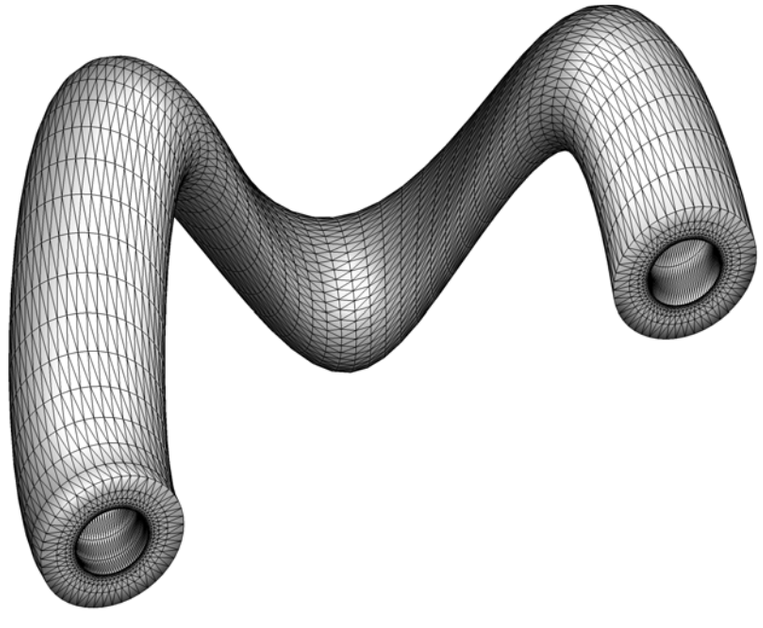




Can also add variation in the z-coordinate.



It can also generate a pure tetrahedral grid by subdivision.



2D Grid Generation Codes

Following 2D grid generation codes will generate 2D grids (in .grid, .su2, .vtk), which can then be extended to 3D by the “edu2d_twod2threed” code.

Custom grid generation: 2D

Rectangular E.g., for a flow over a flat plate

Code: edu2d_fp_grid_v1.f90

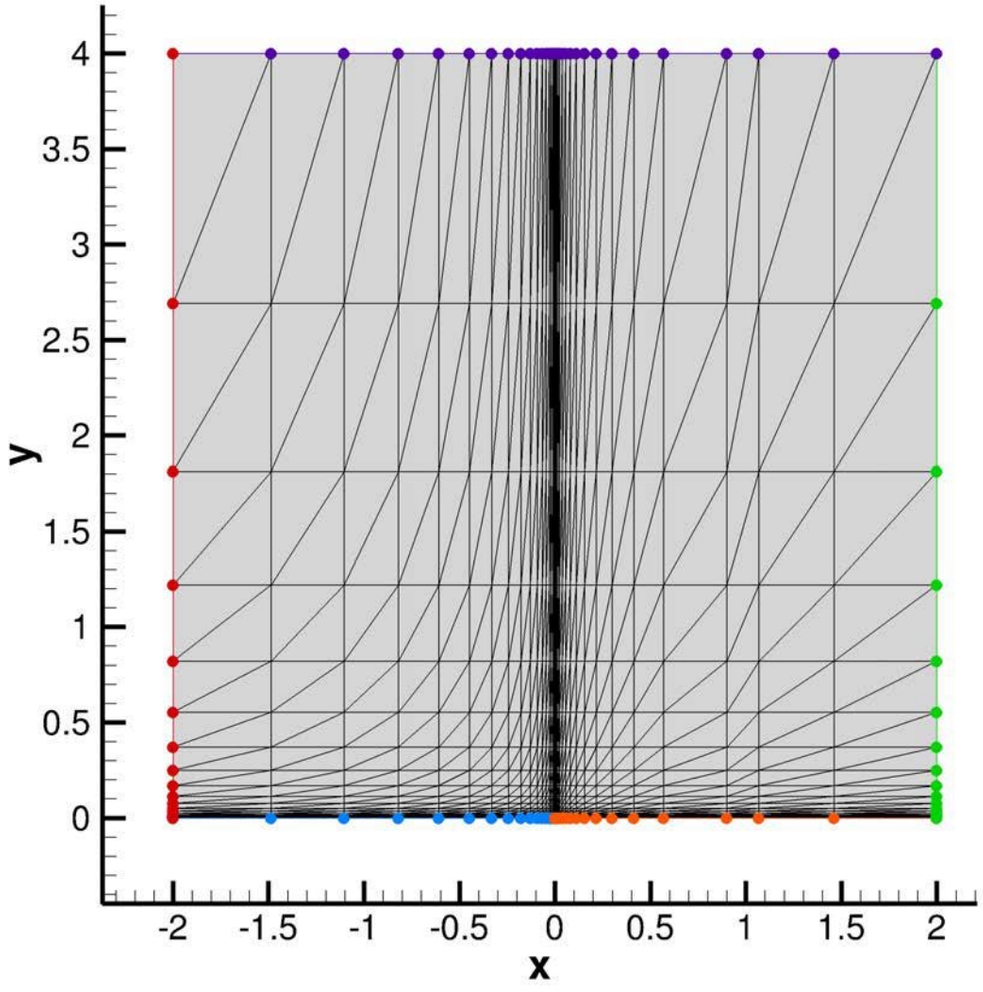
Input: input.nml

Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Features:

- Adjustable mesh parameters
- Exponential stretching
- 5 boundary parts
- Quad/tria/mixed grids
- Mixed grid = quad in BL, tria outside

  Reynolds # is used to determine the BL thickness.



Custom grid generation: 2D

Rectangular

E.g., for shock diffraction, forward-facing step

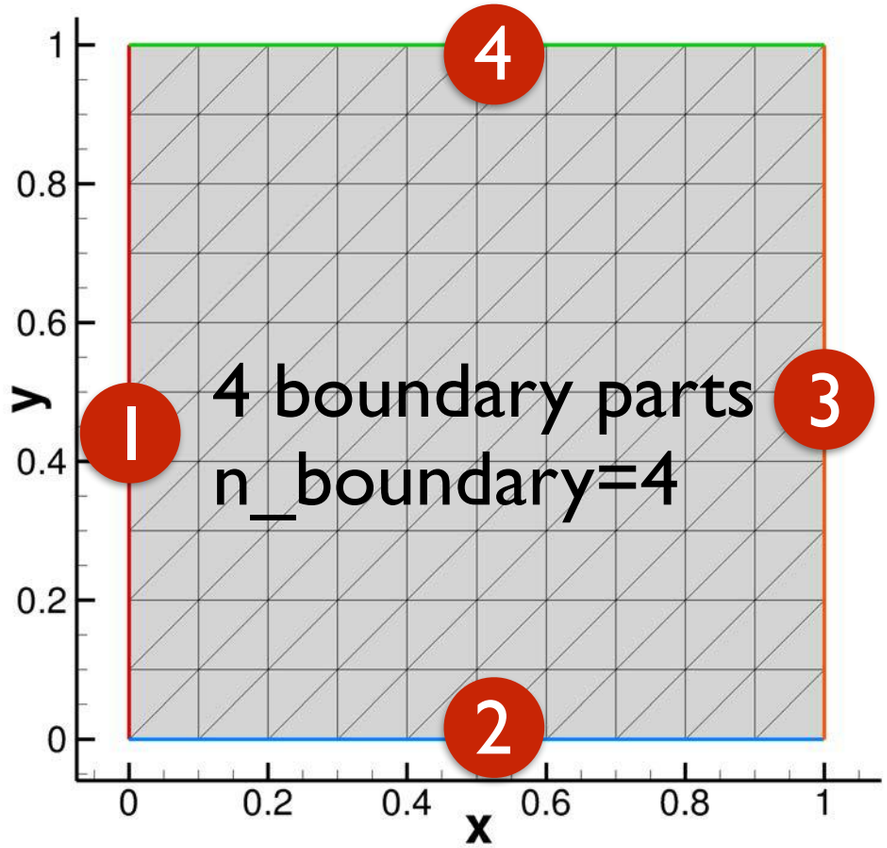
Code: edu2d_rectangular_grid_v1.f90

Input: parameters are specified inside the code.

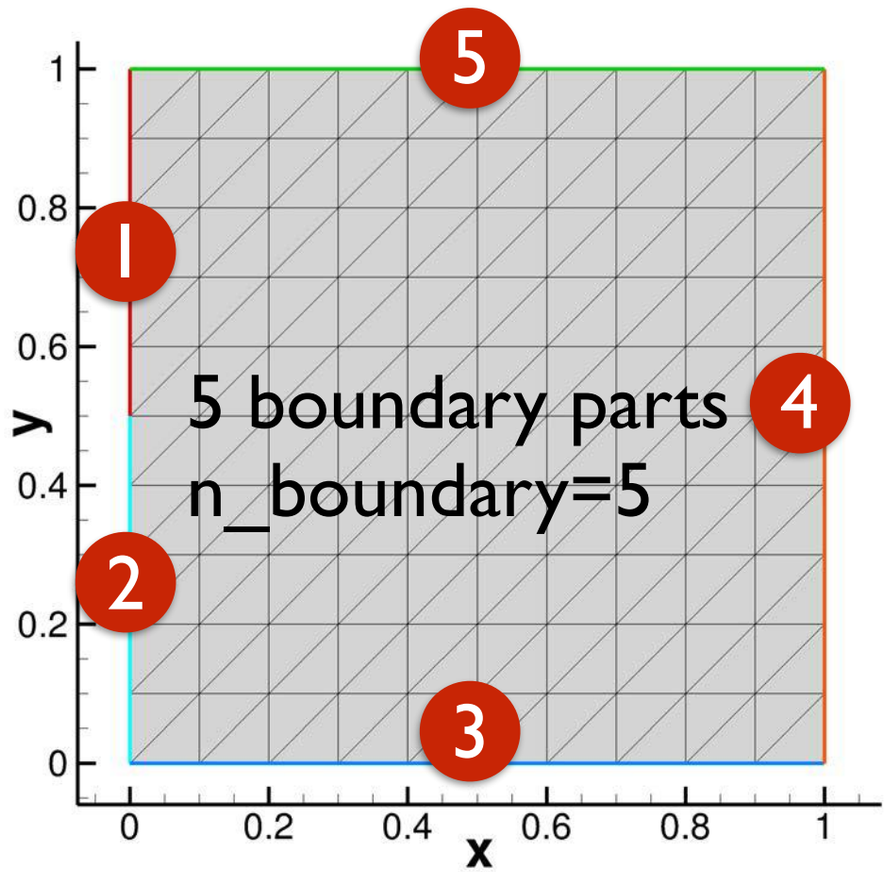
Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Features:

- Adjustable mesh parameters



- Quad/tria grids



Custom grid generation: 2D

Rectangular

E.g., for buoyancy-flow, natural convection

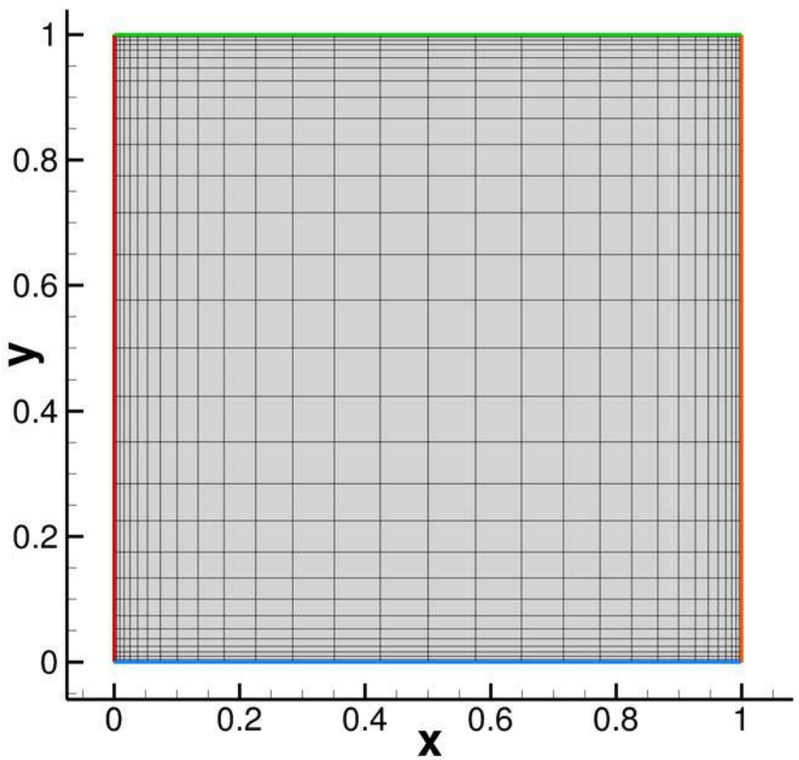
Code: edu2d_viscous_box_grid_v0.f90

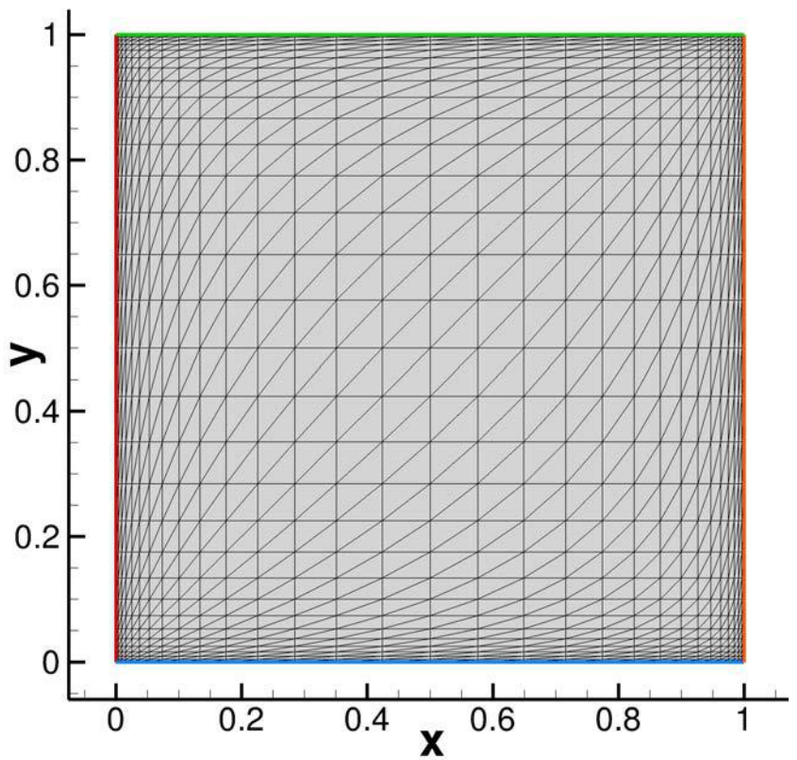
Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Features:

- Adjustable mesh parameters
- Adjustable stretching parameter (tanh function).
- Quad/tria grids with 4 viscous walls





Rectangular E.g., for a flow over a bump

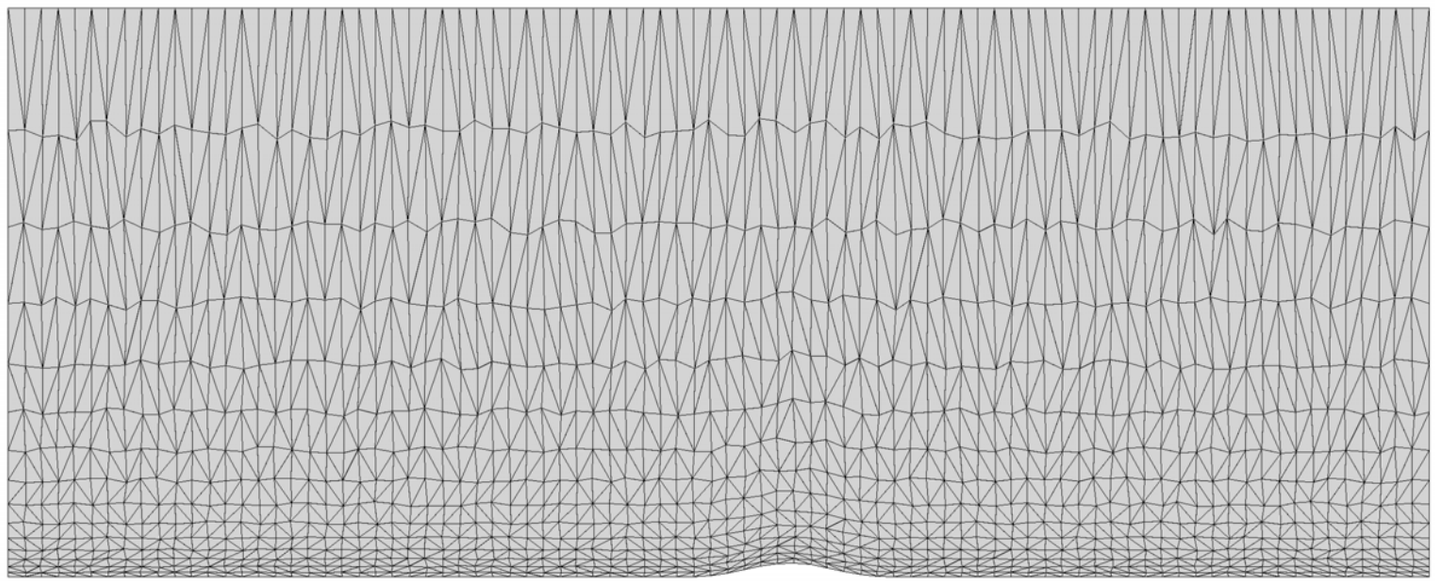
Code: edu2d_bump_irregular_grid_v1.f90

Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Features:

- Adjustable mesh parameters - 4 boundary parts
- Irregular triangular grid (can be made regular)
- Bump is described in https://turbmodels.larc.nasa.gov/bump.html



Half Cylinder

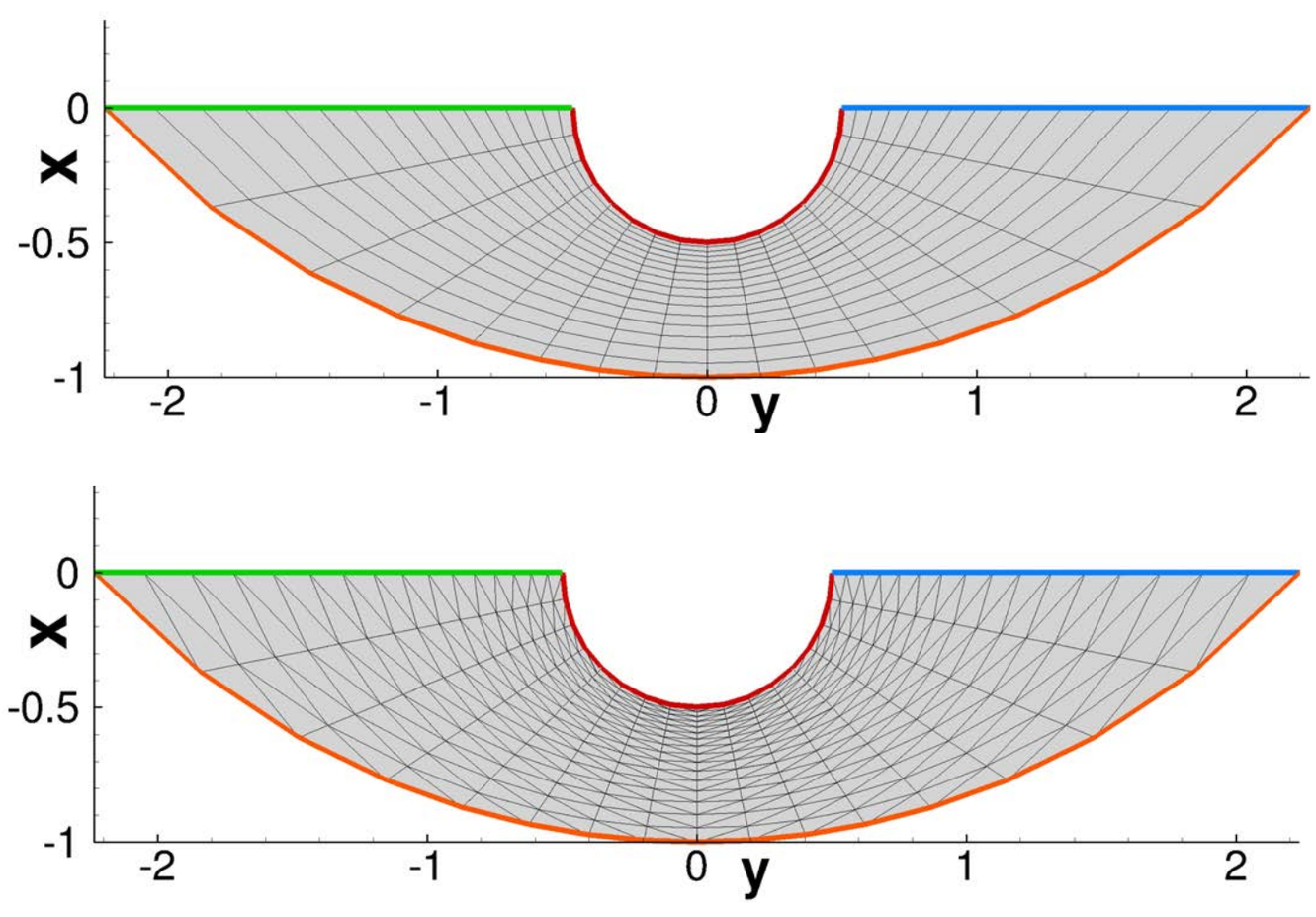
Code: edu2d_half_cylinder_grid_v0.f90

Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Features:

- Adjustable mesh parameters
- Adjustable angle of outflow
- Quad/tria grids.



Sector, Disk, Annulus (Cylinder)

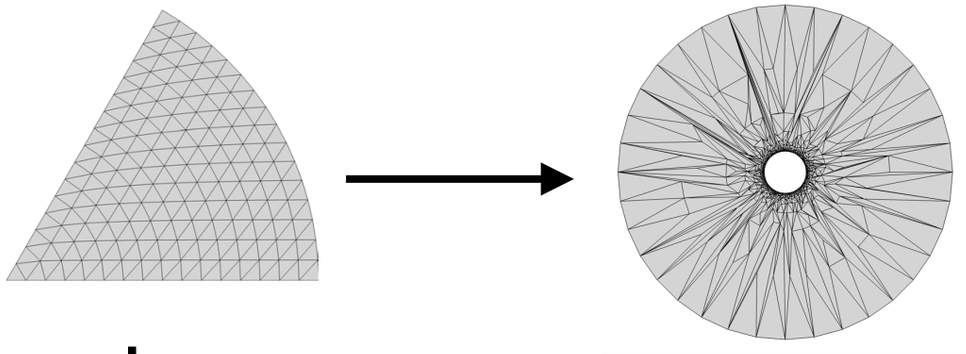
Code: edu2d_50yen_tria_grids_v2.f90

Input: parameters are input on screen

Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Features:

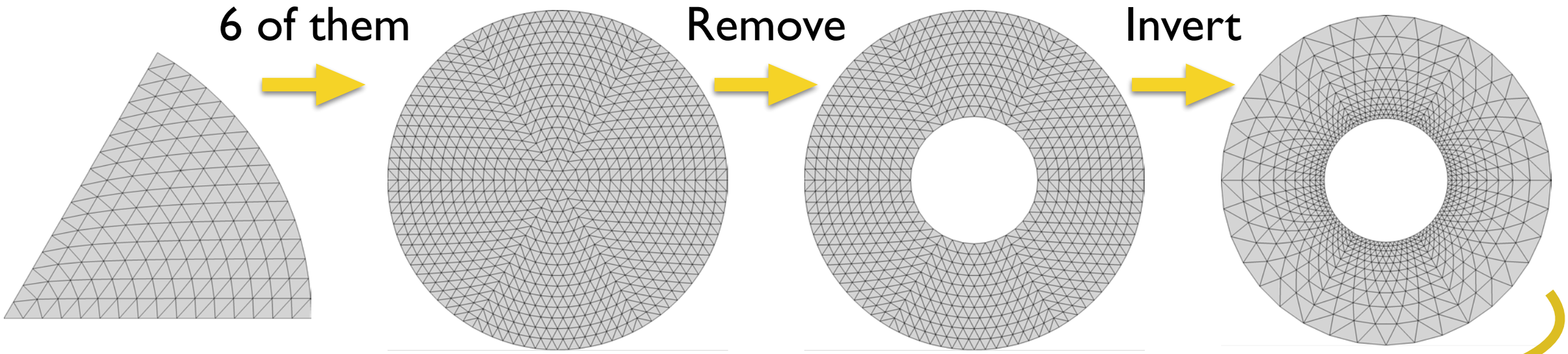
- Various grids are constructed in turn from a triangular sector, as illustrated in the next slide.



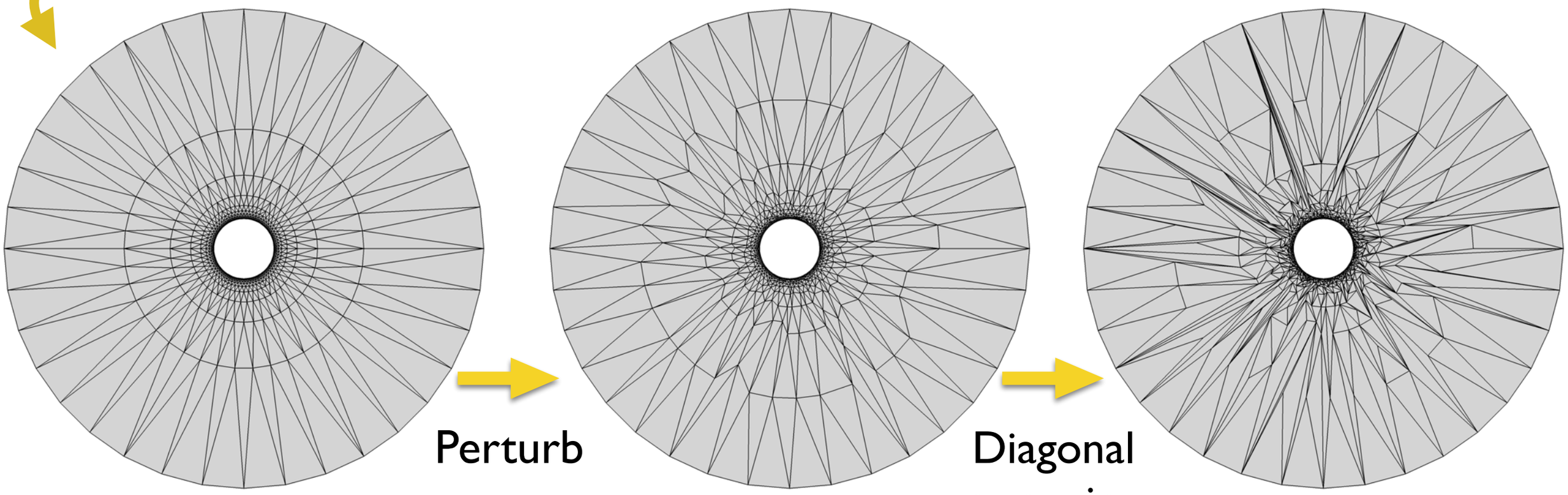
- Adjustable mesh parameters
- Only triangular grids will be generated.
- More points on the inner circle than the outer circle.
- Highly irregular triangular grid can be generated.

Custom grid generation: 2D

Sector, Disk, Annulus (Cylinder)



Rescale/stretching

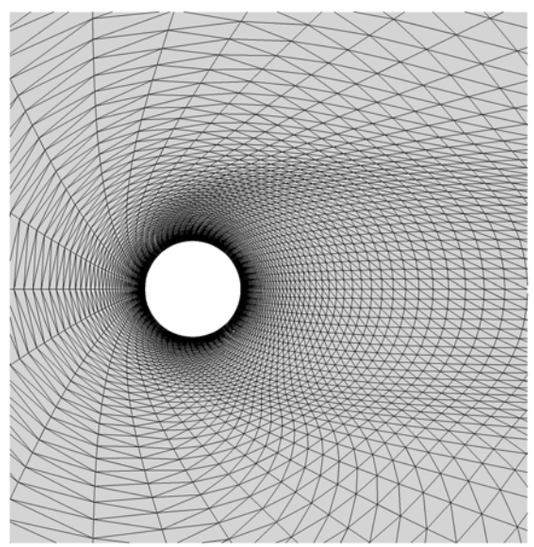


Cylinder flow with a wake

Code: edu2d_cylinder_wake_v4.f90

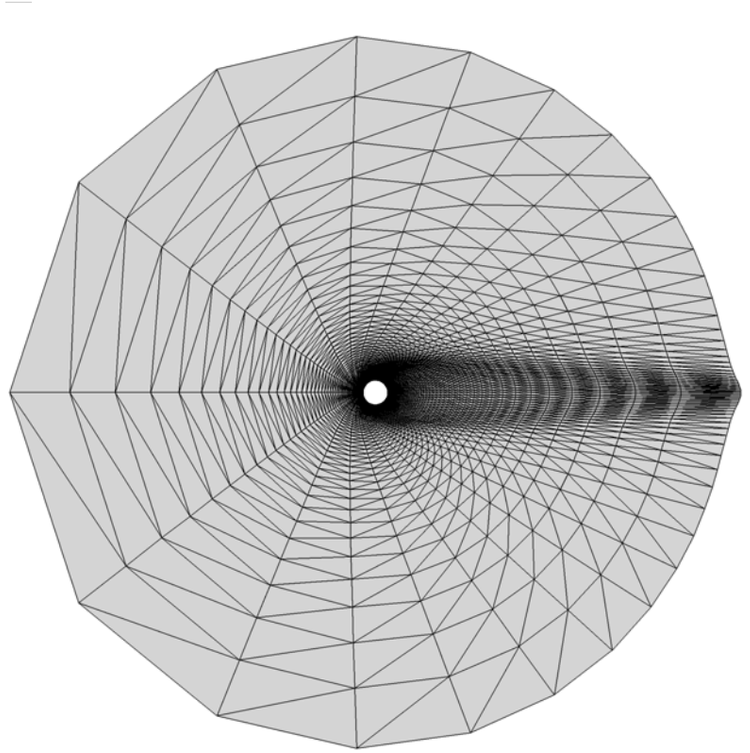
Input: input.nml

Output: .su2, .vtk, Tecplot files, .grid, .bcmap.



Features:

- Adjustable mesh parameters
- Quad/tria/mixed grids
- Extra resolution in the wake region.



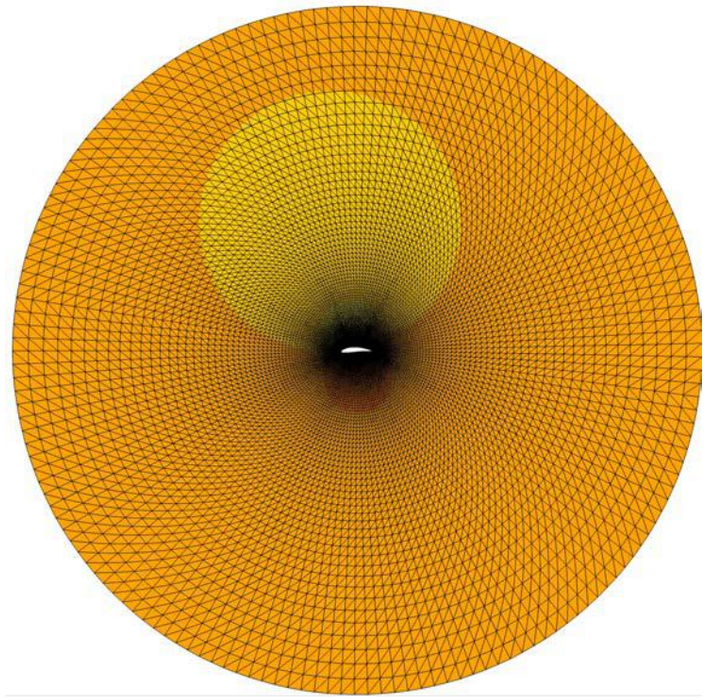
Karmann-Trefftz Airfoil

Code: edu2d_vkt_airfoil_v4.f90

Input: parameters are specified inside the code.

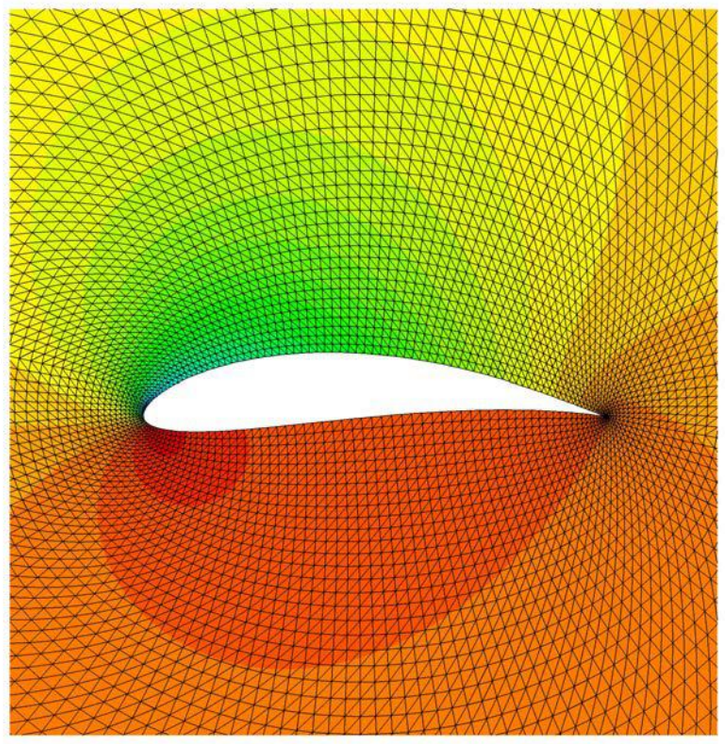
Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Exact solution data included in Tecplot files.



Features:

- Adjustable mesh parameters.
- Quadrilateral/triangular grids.
- Exact potential-flow solution is computed.
- Joukowsky airfoil is a special case.
- Circular cylinder is a special case.



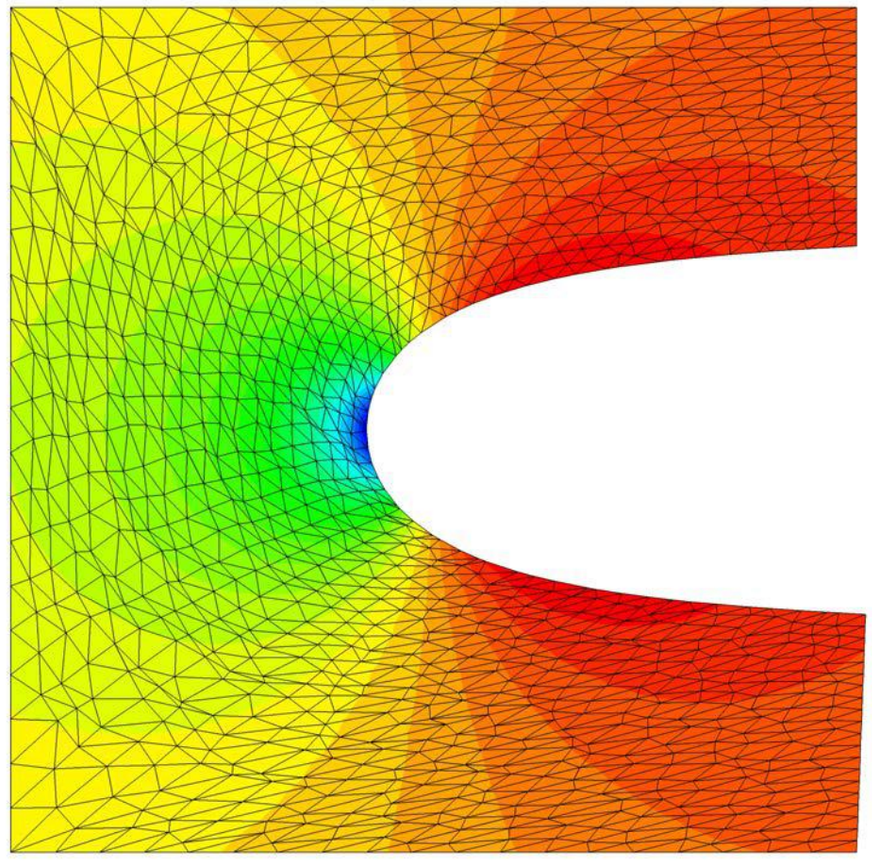
Rankine's Half Body

Code: edu2d_rankine_half_body_grid_v1.f90

Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Exact solution data included in Tecplot files.



Features:

- Adjustable mesh parameters

- Quadrilateral/triangular grids

- Nodal perturbation (irregular)

- Exact potential-flow solution is computed.

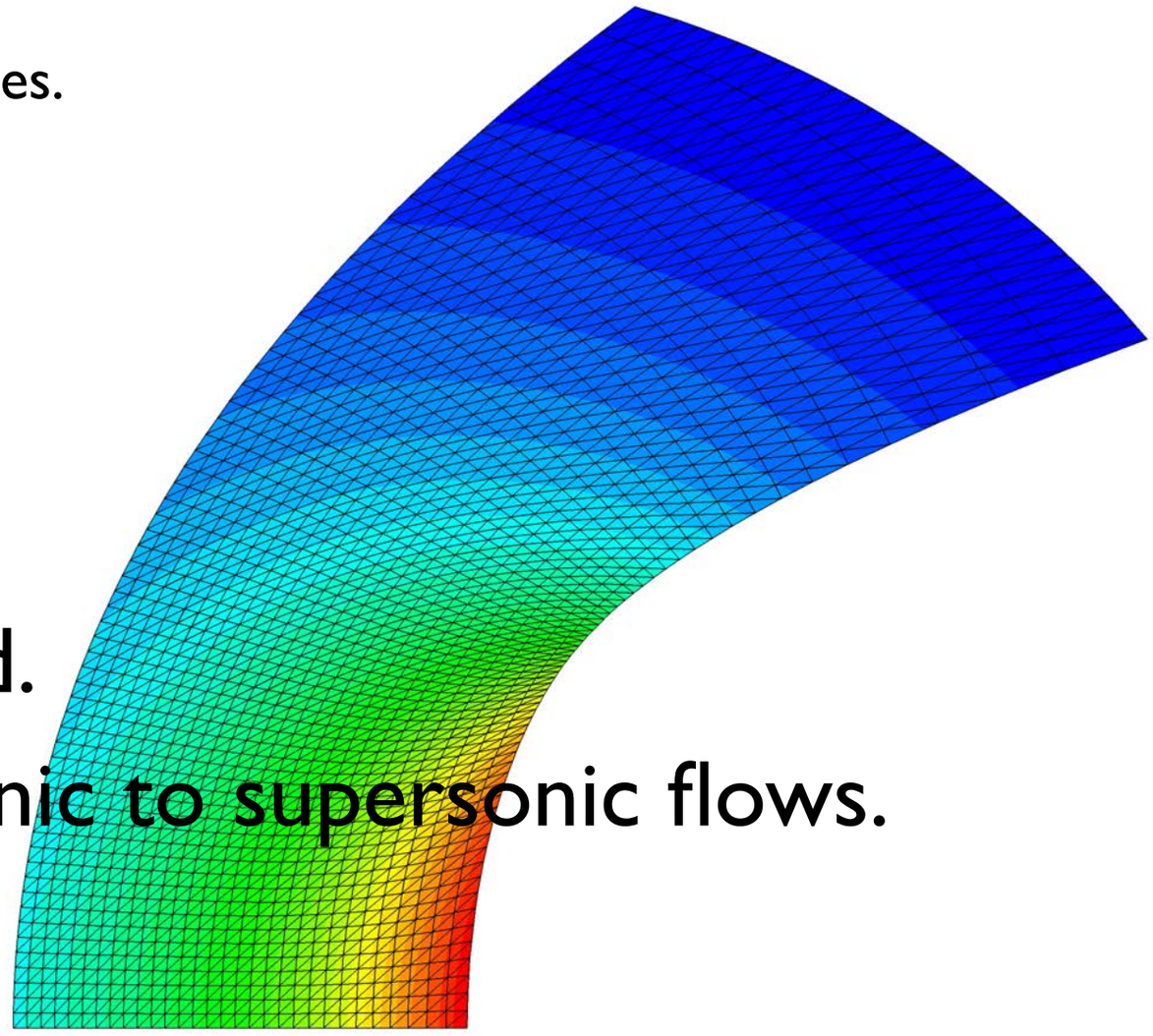
Ringleb's Flow

Code: edu2d_ringleb_v2.f90

Input: parameters are specified inside the code.

Output: .su2, .vtk, Tecplot files, .grid, .bcmap.

Exact solution data included in Tecplot files.



Features:

- Adjustable mesh parameters
- Quadrilateral/triangular grids
- Exact Euler-solution computed.
- Smooth transition from subsonic to supersonic flows.

More codes

(Not yet released or .su2 not yet implemented, as of August 9, 2019)

3D grid generation codes for

- Supersonic viscous flow through a duct

  to appear at NASA TMR https://turbmodels.larc.nasa.gov/3dsqduct_mod_numerics_val.html

2D grid generation codes for

- Subsonic/supersonic flow through a nozzle
- Supersonic flow over a triangular bump/wedge
- Delaunay triangulation of arbitrary domains

Let me know if you want to use any of these codes for SU2.
I may be able to find time to implement .su2.