Hands-On Training with OpenFOAM

External Aerodynamics: Ahmed Body

Hrvoje Jasak

hrvoje.jasak@fsb.hr

Faculty of Mechanical Engineering and Naval Architecture

University of Zagreb, Croatia

Outline

Summary of Objectives: Steady turbulent flow around a 3-D car-like geometry

- Mesh manipulation
- Basic solver setup
- Adjusting discretisation and linear solver parameters
- On-the-fly data extraction: function objects
- Field visualisation
- Parallel processing: case preparation, parallel run, data reconstruction

Outline

Tutorial Steps

1. Convert the mesh generated in Pointwise
2. Check mesh: problem with size
3. Transform mesh size: `transformPoints`
4. Boundary conditions: air tunnel simulation
5. Turbulence model; transport properties; initial field
6. Run simulation; plot residual
7. Change discretisation: Laplacian and turbulence
8. Change linear solver: AMG
9. Add pressure sampling point
10. Add `minMaxField` function object on the fly
11. Field post-processing: FieldView
12. Parallel decomposition, file layout and decomposition visualisation tool
13. Basics of parallel operation of the solver
14. Data reconstruction and visualisation after a parallel run

Geometry and Flow Conditions

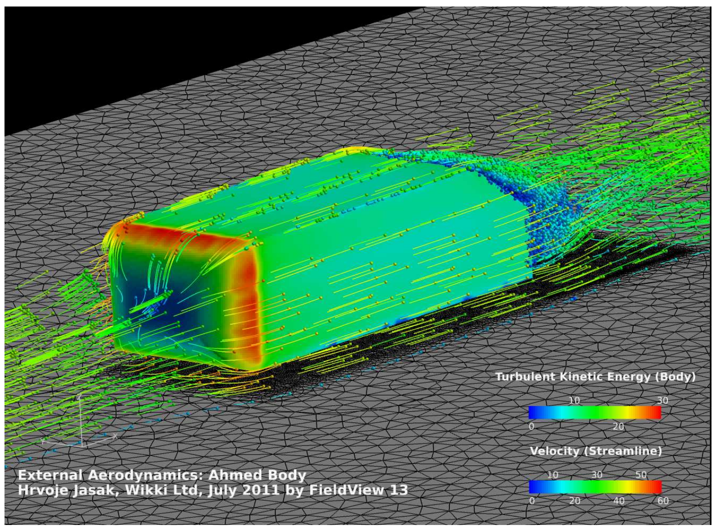
Case Setup: Ahmed Body

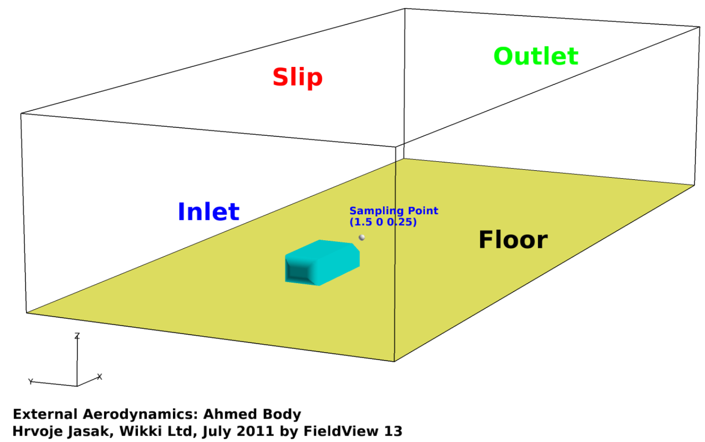
- Steady incompressible turbulent flow: `simpleFoam`
- Material properties: $\nu = 1.5 \times 10^{-5}\,\mathrm{m}^2/\mathrm{s}$
- Inlet conditions:

$$\mathbf{u} = (40 \quad 0 \quad 0)\,\mathrm{m/s}$$

$$k = 6\,\mathrm{m}^2/\mathrm{s}^2$$

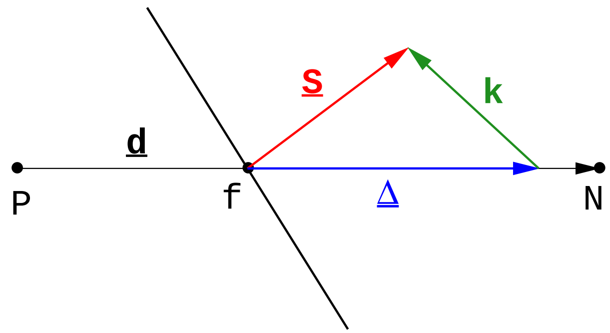
$$\omega = 21.41\,1/\mathrm{s}$$





Mesh Quality Metrics

- Quality of the mesh is closely connected with the underlying discretisation method: a cell away from "ideal" isotropic shape is not necessarily bad
- **Cell aspect ratio**. Defined as ratio of longest to shortest edge length. In many cases, this is desirable: align the cell with solution gradient
- **Cell size grading**. Usually with no consequences
- **Face non-orthogonality**. Defined as the angle between the face normal and $\overline{PN}$ vector



Non-orthogonality of $70 - 90^o$ increases solution cost and reduces accuracy; Non-orthogonality over 90^o is fatal. This is due to diffusion discretisation in FVM (but we still use special practices to keep the solver running)

Mesh Quality Metrics

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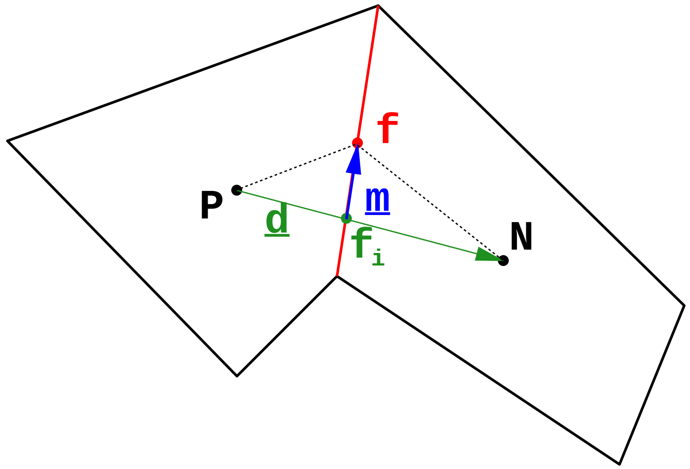
- **Face skewness**. Defined as the distance between face centroid and face integration point.



- Skewness reduces the order of face integration but without stability implications
- Meshes with highly skewed cells work better with special gradient calculation schemes: use least square gradient (with limiters)