Ongoing Research Into Numerical Simulation of Fluid Flows Utilizing Software Developement Practices

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How is software complexity managed when the required infrastructure is increasing?

Entire Computational Fluid Dynamics (CFD) packages have been written by individuals or small teams of researchers. They were developed in an ad hoc manner that was successful for the size of problem that was attempted. CFD packages are continuing to evolve into more and more complex systems to handle more classes of problems. They require larger teams to assemble and maintain. One way to address this complexity is with modern programming practices.

- Research capabilities in a "production" code
- Software versioning system
- Software development practices (Agile)
- Extreme Programming principles **communication simplicity feedback courage**
- Extreme Programming *interconnected* practices

    Sustainable pace
    Metaphor
    Coding standard
    Collective ownership
    Continuous integration
    Small releases
    Test-driven development
    Refactoring
    Simple design
    Pair programming
    On-site customer
    Planning game

- Software testing

    Programmer's (unit testing)
    Integration
    Regression
    Verification
    Validation

- Unit testing
- Test-first programming
- Communication – Scrum status meetings

    What they **did** since last meeting
    What they will **do** by next meeting
    What got **in the way** (impediments)

How is discretization error impacting the solution?

Local error estimates for the discretization error have been used to describe where increased grid resolution is required to improve a solution. These methods have missed the connection between the impact of local errors on global output quantities and how these local errors are transported. The *adjoint* solution provides the critical connection between local errors and global outputs as well as how errors are transported.

- Discretiztion error is a major problem
- Adjoint solution
- Error estimation
- Work of Venditti and Darmofal
- Sonic boom propagation
- Turbulent transport configuration

How is a grid modified to match a desired resolution?

Mechanics are required to modify the grid to match a specified grid resolution. These mechanics must be able to generate grids with anisotropic resolutions for high Reynolds number flows both near bodies and in structures like wakes and shocks. These mechanics should work seamlessly with the flow solver and error control infrastructure.

- Limiting factor in applying the output-based adaptation scheme
- The goal is to never need to look at the grid
- Work seamlessly with flow solver and error control: must be robust, sufficient quality, parallel, etc.
- High fidelity surface representation
- ONERA M-6 example

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Entire FUN3D Development Team

Resources

FUN3D

`http://fun3d.larc.nasa.gov/`
`http://hefss.larc.nasa.gov/`

Version Control

`https://www.cvshome.org/`
`http://subversion.tigris.org/`

Portland Pattern Repository's Wiki

`http://c2.com/cgi/wiki?WelcomeVisitors`
`http://c2.com/cgi/wiki?TestingFramework`

Edward Tufte

`http://www.edwardtufte.com/`
The Visual Display of Quantitative Information
and
The Cognitive Style of Powerpoint

Andrew Hunt and David Thomas

`http://www.pragmaticprogrammer.com/`
The Pragmatic Programmer: From Journeyman to Master

Tom Demarco and Timothy Lister

Peopleware : Productive Projects and Teams, 2nd Ed.