Unsteady adjoint optimization

with grid adaptation

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Background and Current Position

Background

- Born in Khulna, Bangladesh
- B.Sc. in Mechanical Engineering from Bangladesh University of Engineering &Technology
- M.Sc. in Computational Mechanics from University of Duisburg-Essen,Germany

Current Position

- Joined WUT as ESR 14 on October, 2013
- Supervised by Prof. Jacek Szumbarski

Objectives

Primary Goal

- Adjoint solver for unsteady Navier-Stokes (including check pointing)
- Shape optimization using unsteady adjoint solver with option for optimal control
- Optimize the performance with grid adaptation and optionally multi-gird

Work Plan

Preliminaries

- Unsteady adjoint for a simple ODE with check pointing
- optimal control for simple ODE

Prerequisites

- Unsteady Euler/NS solver (Residual Distribution Scheme)

Primary Task

- Implementation of unsteady adjoint in the NS solver
- Implementation of moving geometry
- Gradient-based shape optimization

Work Plan - continued

Testing and evaluation

- Testing of the Euler/NS code on non-stationary cases
- Testing of the obtained gradients against finite difference
- Testing of a complete optimization

Performance improvements

- Hessian-of-solution based mesh refinement
- Goal-oriented based mesh refinement

Progress

Training

- Literature review
- In house training on adjoint-based mesh adaptation and optimization
- Training workshop attended on AD tools organized by AboutFlow project
- Training workshop attended on MPI organized by HLRS, Germany

Current Status

- Development of Adjoint implementation on Euler solver is underway.

Secondments

RWTH

- Envisaged Feb-March 2015
- Familiarization in parallelization of adjoint solvers
- Review of AD tools for parallel application
- Implementation of operator overloading based AD to develop Adjoint solver
- Participation in courses on AD and scientific computing

Secondment

Rolls Royce

- Planned October 2016
- Familiarization with the industrial flow cases
- Training on industrial approach to optimization
- Investigation of turbo-machinery problem using the developed adjoint solver
- Application of grid adaptation tool chain available in WUT for turbo-machinery test cases
- Benchmarking of developed approaches with current practices

Expected Outcome of the Project

- Robust adjoint solver with shape optimization and grid adaptation capability
- Experience gain in cfd solver development and application to industrial flow problems
- Collaboration with academia and industry

Advantage of Finite Difference to Develop Jacobian

$$
\begin{bmatrix}
a_{11} & a_{12} & 0 & \cdots & \cdots & \cdots & 0 \\
a_{21} & a_{22} & a_{23} & \ddots & & & \vdots \\
0 & a_{32} & a_{33} & a_{34} & \ddots & & \vdots \\
\vdots & & \ddots & \ddots & \ddots & \ddots & \vdots \\
\vdots & & & a_{76} & a_{77} & a_{78} & 0 \\
\vdots & & & \ddots & a_{87} & a_{88} & a_{89} \\
0 & \cdots & \cdots & \cdots & 0 & a_{98} & a_{99}
\end{bmatrix}
\tag{1}
$$

- Developed Jacobian is a complete sparse matrix which can be calculated locally
- It is conveniently scalable
- Options to implement higher order FDM, if more accurate jacobian is required
- Tested for stationary problems with sufficient accuracy

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This work has been conducted within the **About Flow** project on "Adjoint-based optimization of industrial and unsteady flows".

http://aboutflow.sems.qmul.ac.uk

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