

# COLLOQUIUM

Group: Engineering Fluid Dynamics

As part of her MSc thesis assignment

**Anouk Aimée Hol**

will give a presentation, entitled:

## **Adjoint-based Automatic Shape Optimization Evaluation and Automotive Applications**

**Date: Thursday February 19, 2015**

**Time: 13:00**

**Room: Horst Building Room N109**

### **Summary:**

This study concerns the testing and evaluation of the solver adjointFoam which is implemented in the open source CFD software package OpenFoam. AdjointFoam is an in-house code developed at Volkswagen AG in collaboration with Engys. It is based on a continuous adjoint formulation which can be used for optimizing the topology and calculating the shape sensitivities. The adjoint method is preferred for gradient-based optimization in computational fluid dynamics (CFD) as its computational cost is independent of the number of design variables. It finds its applications in problems with large design spaces which are common in the automotive industry.

In the first part of this study, a test of the adjoint solver comprising the newly implemented adjoint turbulence model and wall functions has been carried out. For turbulent flows, the state equation involves the equations for the mean-flow and the equations for the turbulence model. For flows at high Reynolds number, all the variations of the mean flow parameters and of the parameters of the turbulence model should be considered in deriving the adjoint formulation. The approximation of the adjoint to the 'one-equation Spalart-Allmaras' turbulence model has been evaluated. A validation of the computed sensitivities for a 2D flow problem has been performed using a finite difference check. The setup of the finite difference check has been verified with literature. For a number of 2D and 3D flows the sensitivities computed using the adjoint turbulence model have been compared to sensitivities based on the frozen turbulence assumption. It is demonstrated that the sensitivity map based on the adjoint turbulence formulation is valid and the subsequent solution obtained is correct.

In the second part of the study, a mesh morphing algorithm coupled to the adjoint solver for updating the mesh has been tested. The mesh morphing algorithm translates a surface sensitivity map into a shape update. A surface sensitivity map represents the changes in the objective function with respect to the normal displacement of the mesh. Modifying the surface in just the normal direction will lead to a highly distorted mesh. Therefore, in order to obtain a good mesh quality, a vertex morphing method has been used as it includes the regularization of the mesh in addition to the modification in the normal direction. In the present study the influence of the primal and adjoint solutions on the performance of the mesh morphing algorithm has been investigated. For the purpose of improving the robustness of the adjoint-based shape optimization, the best possible way of coupling the mesh morphing routine to the primal and the adjoint solvers has also been evaluated.

### **Assessment committee:**

Prof.dr.ir. C.H. Venner (chairman)  
Prof.dr.ir. H.W.M. Hoeijmakers (mentor)  
Dr.ir. E.T.A. van der Weide (mentor)  
Dr. M.M. Gregersen (mentor)  
Dr.-Ing. H.P. Bensler  
Dr.ir. H.J.M. Geijselaers

**Chairman,**

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