Linking CAD design sensitivities with adjoint CFD data

Peter M Thompson*, Trevor T Robinson* and Cecil G Armstrong*

**School of Mechanical and Aerospace Engineering, Queen's University of Belfast, UK.*

Tel: +44 (0) 28 9097 4277

Email: pthompson15@qub.ac.uk

The aim of this research is to compute geometric CAD sensitivities called design velocities and link these with adjoint CFD simulation data to allow efficient aerodynamic optimisation of parametric CAD models within an aerospace design context.

Design velocity is a measure of geometric shape change in response to parameter change. It links parametric perturbation to boundary movement. More specifically, the normal component of design velocity (V_n) is the outward normal movement of a point on the model boundary due to a parametric perturbation. A design velocity field can be efficiently computed for each parameter of interest in the model, and the resulting design velocity fields allow the effects of continuous dimensional CAD parameters on the shape of the model to be quantified, thus allowing use of the native CAD model parameters as design variables.

The method used in this work to compute design velocities is based on a novel finite-difference approach using faceted approximations of the parametric CAD geometry. Each appropriate CAD model parameter is automatically perturbed, and a faceted version of each perturbed geometry is exported. Each of these perturbed faceted geometries is then compared in turn to the original unperturbed geometry and a design velocity field computed for each parameter. This approach has a number of advantages over existing design velocity computation methods, including its computational efficiency and its robustness to topological changes caused by parametric perturbations. The computational efficiency of this approach allows design velocity fields, and thus sensitivity data, to be computed for up to several hundred parameters in the time required for a single adjoint analysis.

This computation of design velocity data forms the first step in an adjoint design optimisation process chain, in which the design velocity data is combined with adjoint surface sensitivity data from the discrete adjoint solver in Tau. This allows a sensitivity with respect to objective function to be computed for each CAD model parameter. The resulting parametric sensitivity information can be passed to a gradient-based optimisation algorithm and the original CAD model parameters can be automatically updated.