

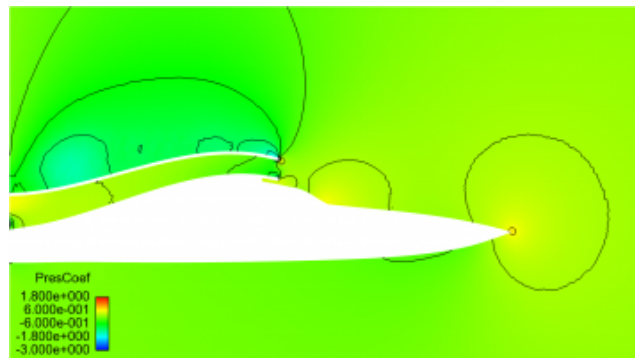
# A NOVEL IMPLEMENTATION OF COMPUTATIONAL AERODYNAMIC SHAPE OPTIMISATION USING MODIFIED CUCKOO SEARCH AND REDUCED ORDER MODELLING

David Stefan Naumann, Ben Evans, Oubay Hassan

Swansea University  
College of Engineering, Swansea University Swansea SA1 8QQ, UK  
717761, b.j.evans, o.hassang@swansea.ac.uk

## ABSTRACT

An automated aerodynamic optimisation algorithm has been developed using a novel method of parameterising a computational mesh making use of the concept of control nodes. The shape boundary movement is coupled to the movement of user-defined control nodes on the boundary via a quasi-1D-linear deformation. Additionally, a second order smoothing step has been implemented to act on the boundary during the mesh movement based on the change in its second derivative. The domain mesh movement is then coupled to the shape boundary movement via a Delaunay graph mapping. A Modified Cuckoo Search (MCS) [1] algorithm is employed for optimisation within the prescribed design space defined by the allowed range of control node displacement. A finite volume compressible Navier-Stokes solver [2] is used for aerodynamic modelling to predict aerodynamic design fitness. In order to accelerate the fitness evaluation, a reduced order model utilising Proper Orthogonal Decomposition (POD) [3] has been incorporated. This has been modified incorporating an adaptive sampling to act as a self-improving surrogate model. The resulting coupled algorithm is applied to a range of test cases in two dimensions including the design of a race car diffuser and subsonic, transonic and supersonic intake duct optimisation.



## References

- [1] Walton et al., S., Modified cuckoo search: A new gradient free optimisation algorithm. *Chaos, Solitons and Fractals*, 2011
- [2] B. Evans, T. Morton, L. Sheridan, O. Hassan, K. Morgan, J. W. Jones, M. Chapman, R. Ayers, I. Niven, Design optimisation using computational fluid dynamics applied to a landbased supersonic vehicle, the BLOODHOUND SSC. *Structural Multidisciplinary Optimization*, 47, 301–316, 2013,
- [3] S. Walton, O. Hassan, K. Morgan, Reduced order mesh optimisation using proper orthogonal decomposition and a modified cuckoo search. *International Journal for Numerical Methods in Engineering*, 93, 527–550, 2013