A Modal Analysis Platform in SU2 for Computational Aeroelasticity and Applications in Linear and Nonlinear Reduced Order Modelling

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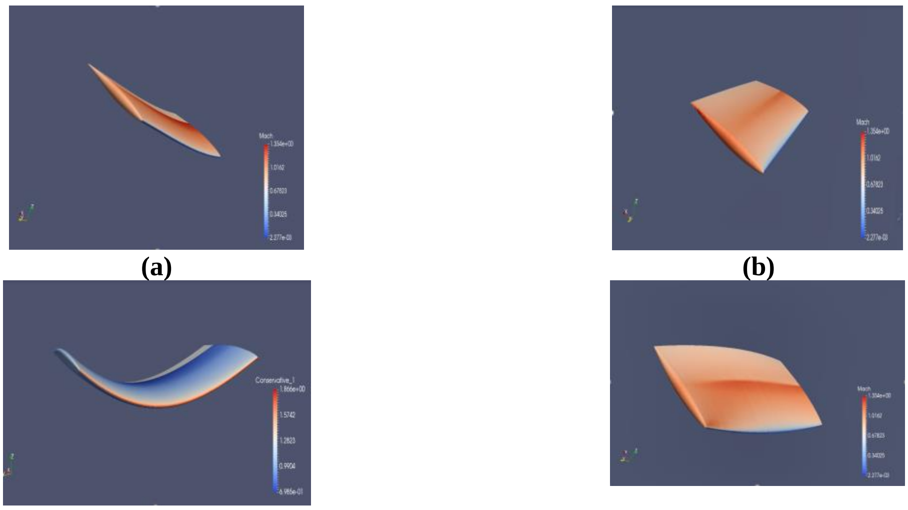
ABSTRACT

The current SU2 solver can handle six degrees of freedom rigid movement of a solid surface as outlined by Economon et al.[1] but not the modal deflection or random excitation of a three-dimensional body immersed in a compressible or incompressible flow. This contribution aims to implement the modal analysis platform for aeroelastic computation in SU2 and for the application of linear and nonlinear Reduced Order Modelling. For the current analysis, the governing structural equation is considered to be linear. To develop a Subspace Identification based linear reduced-order model outlined in Halder et al. [2], the structural modes must first be computed from a Finite Element Analysis (FEA) based solver such as NASTRAN [3]. The SU2 solver must be excited randomly using the white noise functions in all the modal directions in order to compute the corresponding generalized aerodynamic forces. For the development of the deep learning-based nonlinear reduced-order model in Halder et al. [4], the excitation functions are generated by superimposing the sinusoidal function of different amplitudes and frequencies and then Long Short Term Memory (LSTM) based ROM is used to develop a functional relationship between the structural input and generalized aerodynamic force as output. Figure 1 shows the four modes i.e., first bending, first torsion, second bending, and second torsion modes of deflection of the BACT wing [5] without any control surface at a Mach number of 0.85. Figure 2 shows the linear and nonlinear reduced-order computation of the first generalized aerodynamic force under the excitation of the first bending mode. The modification of the codes in Opensource CFD solver SU2-5.0.0, linear and non-linear ROM codes are demonstrated in the GitHub link https://github.com/rahulhalderAERO/nusSU2_Aeroelasticity-Code-Base. In the final version of the paper, the modified SU2 codes will be upgraded to the most recent version. In the complete paper, the current algorithms and corresponding codes will be coupled with the Discrete Empirical Interpolation Method (DEIM) as outlined by Chaturantabut et al.[6] to reconstruct the unsteady Coefficient of Pressure (C_p) and Coefficient of Skin Friction (C_f) distribution over the wing surface.



(a) **(b)** **(c)** **(d)**

Figure 1: Implementation of the first four modes in SU2 solver (a) First Bending (b) First Torsion (c) Second Bending (d) Second Torsion

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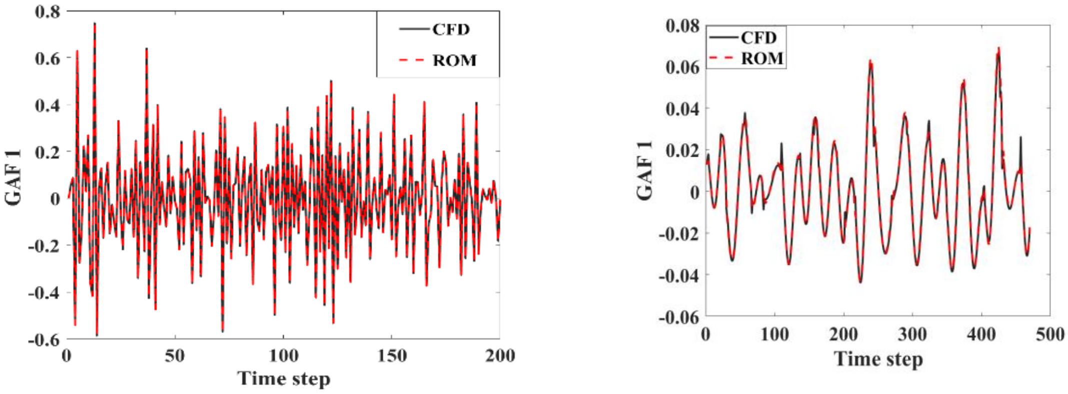

(a) **(b)**

Figure 2: Application of Modal Analysis platform of SU2 in (a) Linear and (b) Nonlinear Reduced-Order Computation of the First Generalized Aerodynamic Force under First Modal Excitation.

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