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Technical Comments

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Comment on "A z-Transform Discrete-Time State-Space Formulation for Aeroelastic Stability Analysis"

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Marques and Azevedo [1] claim to present a more effective and accurate alternative formulation for linear state-space unsteady aerodynamics using a z-transform than a continuous time, rational function approximation (RFA), such as Eversman and Tewari [2]. Such a claim is misleading due to the following reasons.

The accuracy of any state-space approximation of a continuous system depends upon the number of states (called the order of system). Whereas a rational function approximation in Laplace domain [2] introduces only a few additional (augmented) states for a given fit accuracy with frequency domain data, Marques and Azevedo admit [on p. 1571 of [1], immediately following Eq. (117)] that the number of augmented states required by them is the same as the number of time steps required to accurately represent the unsteady aerodynamic response. In other words, the approximation of [1] is tens of thousands times larger in order compared to the rational function approximation of [2] for a given accuracy. How can such an absurdly large order approximation be termed more effective?

The second rationale offered by Marques and Azevedo [1] for their formulation is that it is free from the ill-conditioned eigenvalue problem issue that is frequently encountered by the traditional RFA methods when the poles are close to one another. Eversman and Tewari [2] precisely address the issue of ill conditioning and show that the repeated pole case can be handled efficiently using the consistent multiple-pole approximation (which also results in a large reduction in the number of augmented states). Thus, there is no need for a method based on z-transform only for this purpose. Furthermore, when examining the formulation of [1], one finds that the state-dynamics matrix [Eq. (116)] is in the classic companion form, which is well known for its poor conditioning [3].

Therefore, the method presented in [1] is neither more efficient, nor better conditioned that the consistent RFA formulation of [2]. Furthermore, Marques and Azevedo [1] attempt to base their linearized aerodynamics model on inherently nonlinear, unsteady aerodynamic data (2-D, transonic, Euler equations): a very questionable approach at best.

References

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