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Dealiasing harmonic balance method for obtaining periodic solutions of an aeroelastic system

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Abstract

The harmonic balance method with a dealiasing scheme, referred to as DHB method, is proposed to obtain the semi-analytical periodic solutions of a two dimensional subsonic airfoil. The equations of motion of this autonomous system are a set of integro-differential equations. To solve this problem, the original model is first transformed into a system of nonlinear ordinary differential equations by means of integral transformations, and consequently this system is transformed into nonlinear algebraic equations (NAEs) via the harmonic balance method. Previous study demonstrated that the harmonic balance method may yield mathematically aliased solutions. To remedy this drawback, a dealiasing scheme, based on shifting the high order harmonic coefficients to the correct low order positions and properly scaling the frequency, is proposed to effectively suppress mathematical aliasing. As for solving the resultant NAEs, a series of scalar homotopy methods (SHMs) are introduced. The SHM methods are robust to initial conditions, and do not require the calculation of the inverse of Jacobian matrix. Therefore, the computing cost can be reduced and the inaccuracy arising from inverting the ill-conditioned Jacobian can be eliminated. Finally, numerical examples are carried out to verify the efficiency and accuracy of the present method.

Keywords: mathematical aliasing, dealiasing scheme, scalar homotopy method, harmonic balance method, periodic solution, airfoil.