Abstract

Subspace Iteration Method for Complex Eigenvalue Problems with Nonsymmetric matrices in Aeroelastic System

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Modern airplane design is a multidisciplinary task which combines several disciplines such as structures, aerodynamics, flight controls, and sometimes heat transfer. Historically, analytical and experimental investigations concerning the interaction of the elastic airframe with aerodynamic and inertia loads have been conducted during the design phase to determine the existence of aeroelastic instabilities, so called "flutter". With the advent and increased usage of flight control systems, there is also a likelihood of instabilities caused by the interaction of the flight control system and the aeroelastic response of the airplane, known as aeroservoelastic instabilities.

An in-house code MPASES (Ref. 1), modified from PASES (Ref. 2), is a general purpose digital computer program for the analysis of the closed-loop stability problem. This program used subroutines given in the International Mathematical and Statistical Library (IMSL) (Ref. 3) to compute all of the real and/or complex conjugate pairs of eigenvalues of the Hessenberg matrix. For high fidelity configuration, these aeroelastic system matrices are large and compute all eigenvalues will be time consuming. A subspace iteration method (Ref. 4) for complex eigenvalues problems with nonsymmetric matrices has been formulated and incorporated into the modified program for aeroservoelastic stability (MPASES code). Subspace iteration method only solve for the lowest p eigenvalues and corresponding eigenvectors for aeroelastic and aeroservoelastic analysis. In general, the selection of p is ranging from 10 for wing flutter analysis to 50 for an entire aircraft flutter analysis.

The application of this newly incorporated code is an experiment known as the Aerostructures Test Wing (ATW) which was designed by the National Aeronautic and Space Administration (NASA) Dryden Flight Research Center, Edwards, California to research aeroelastic instabilities. Specifically, this experiment was used to study an instability known as flutter. ATW was a small-scale airplane wing comprised of an airfoil and wing tip boom. This wing was formulated based on a NACA-65A004 airfoil shape with a 3.28 aspect ratio. The wing had a span of 18 inch with root chord length of 13.2 inch and tip chord length of 8.7 inch. The total area of this wing was 197 square inch. The wing tip boom was a 1 inch diameter hollow tube of length 21.5 inch. The total weight of the wing was 2.66 lbs.

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Reference

1. W. P. Rodden, M. R. Zeifman and J. M. Powers, Jr., "Aero-Servo-Elastic Stability Analysis," Report WPR (NASA) TR-79-1, April 1979.
2. Anon., "Modal Flutter Analysis Study: Vol. IV, Aero-Servo-Elastic Stability Analysis Program: PASES," Rpt. No. SD 15204R, Hughes Aircraft Co., April 1971.
3. Anon., "Computer Subroutines Libraries in Mathematics and Statistics," International Mathematical & Statistical Libraries, Inc., Houston, TX, November 1977.
4. Dong, S. B., Wolf, J. A., and Peterson, F. E., 1972, "On a Direct-Iterative Eigensolution Technique", *International Journal of Numerical Methods in Engineering*, Vol.4, pp. 155-162.