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Interval method for solving the dynamics problems of multibody system with uncertain parameters

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The theoretical and computational aspects of interval methodology based on Chebyshev polynomials for modeling complex nonlinear multi-body dynamic systems in the presence of parametric and external excitation uncertainties is formulated, implemented, and validated. Both the parameters uncertainties and external excitation uncertainties are modeled by uncertain-but-bounded interval variables, where the bounds on the magnitude of uncertain parameters or external force are only required, not necessarily knowing the probabilistic distribution densities. The Chebyshev inclusion function which employs the truncated Chevbyshev series expansion to approximate the original nonlinear calculates sharper range than the traditional Taylor inclusion function. For multi-dimension problem, the multi-dimensional Chebyshev polynomials are constructed as tensor products of one-dimensional Chebyshev basis functions. The coefficients of the Chebyshev polynomials are calculated through the Mehler numerical integral method. The multi-body systems dynamics are governed by differential algebraic equations (DAEs) which are transformed to nonlinear equations with interval parameters at each integral step by HHT-I3 methods, and then the proposed method for nonlinear systems with interval parameters can be employed to find the interval region of the system responses. The numerical example results show that the novel methodology can reduce the overestimation largely and is computationally faster than the scanning method.

Keywords: interval method; Chebyshev polynomials; uncertain analysis; DAEs