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High-order generalized-α methods for dynamic problems

The generalized-α method was introduced by Chung and Hulbert in [2] for solving structural dynamics problems. The method provides second-order accuracy in time and has a feature of user-control on the numerical dissipation in the higher frequencies of the discrete spectrum. This method includes a wide range of time integrators such as the Newmark method, the HHT-α method by Hilber, Hughes, and Taylor, and the WBZ-α method by Wood, Bossak, and Zienkiewicz; see [2]. The generalized-α method was then extended to computational fluid dynamics governed by the parabolic differential equations such as the Navier-Stokes equations [3].

We propose a new class of high-order generalized-α methods that maintain all the attractive features [1]. In particular, we extend the method to the higher order of accuracy in time that is unconditionally stable and can be applied on both parabolic problems as well as hyperbolic equations to address a wide range of cases such as wave propagation, structural dynamics, heat transfer, and fluid dynamics. The dissipation-control is also provided for any arbitrary order of accuracy.

References

[1] P. Behnoudfar, Q. Deng, and V. M. Calo. Higher-order generalized-a methods for hyperbolic problems. *arXiv preprint arXiv:1906.06081*, 2019.

[2] J. Chung and G. Hulbert. A time integration algorithm for structural dynamics with improved numerical dissipation: the generalized-a method. *Journal of Applied Mechanics*, 60(2):371–375, 1993.

[3] K. E. Jansen, C. H. Whiting, and G. M. Hulbert. A generalized-α method for integrating the filtered Navier–Stokes equations with a stabilized finite element method. *Computer Methods in Applied Mechanics and Engineering*, 190(3-4):305–319, 2000.

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