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Numerical methods-VIII
Fri. Jul 19, 2024 10:45 AM - 12:45 PM Room A

[13-A-01] Importance of considering repeated use of a combination of explicit filters

*Yuki Wakamatsu[1] (1. Japan Coast Guard Academy)

Keywords: Numerical methods, Filter, Transfer function

Twelfth International Conference on Computational Fluid Dynamics (ICCFD12), Kobe, Japan, July 14-19, 2024

Importance of considering repeated use of a combination of explicit filters

Y. Wakamatsu*
Corresponding author: wakamatsu@jcga.ac.jp
* Japan Coast Guard Academy, JAPAN

Abstract: Explicit filters are widely used in computational fluid dynamics. Under non-periodic boundary conditions, boundary filters are often used with interior-centered filters. The characteristics of these filters are often analyzed using transfer functions. In general, the characteristics of boundary filters are worse than those of interior-centered filters. Thus, repeated use of the combination of explicit filters may contaminate not only the area near the boundary but also the interior area. This study discusses the importance of considering the repeated use of a combination of explicit filters. Examining not only the characteristics when a combination of explicit filters is applied once but also when a combination of explicit filters is applied repeatedly is crucial.

Keywords: Explicit filter, Filter, Numerical methods, Repeated use

1 Introduction

The aerodynamic sound generated by fluid flow near a wall is important. Numerical methods that do not adversely affect the amplitude and phase of aerodynamic sound waves near the boundary are crucial. Explicit filters [1-7] are often used to compute aerodynamic sounds and eliminate numerical oscillations. Generally, high-order central filters are used at the interior nodes, and low-order boundary filters are used at the nodes near the boundary. In computations for the generation of aerodynamic sound, minimizing the negative effects of filters near the boundaries on the amplitude and phases of aerodynamic sound is desirable. Therefore, emphasis must be placed on the selection of explicit filters near boundaries.

Various methods have been used to analyze the characteristics of explicit filters. First, transfer functions have been extensively used to characterize a single filter. The procedures for calculating the transfer function (Lele [8], Gaitonde and Visbal [7], Gaitonde and Visbal [9], Visbal and Gaitonde [10], Falissard [2], Falissard [3], Falissard [4], Sengupta [11], Sengupta and Bhumkar [12], Berland et al. [6], Bogey and Bailly [5], Sagaut et al. [13]) are widely known. Second, the order of accuracy is often used to analyze the characteristics of explicit filters when a filter is applied once. Third, an eigenvalue analysis (Vreman [14], Wu and Meyers [15], and Ghadimi et al. [16]) was used to characterize the stability of the combination of filters. Fourth, to the best of my knowledge, the effect of the repeated use of a combination of explicit filters remains controversial. The effect of the repeated use of a combination of explicit filters has been rarely investigated. Shapiro [17] discussed the effect of repeated use of filters under the condition that boundary values maintain zeros at boundaries. A similar discussion is found in Sengupta [11]. Sengupta [11] discussed the spectral properties when the compact schemes are used twice.

In general, a combination of explicit filters is used at each time step. In the actual numerical calculations, the influence of the boundary filter used at the nodes near the boundary is spread each time a filter is applied.

2 Numerical results and discussion

This study provided concrete examples to explain the effect of the repeated use of a combination of

explicit filters. Numerical results suggested that the repeated use of a combination of explicit filters may contaminate not only the area near the boundary but also the interior. Therefore, examining not only the characteristics when a combination of explicit filters is applied once but also when a combination of explicit filters is applied repeatedly is crucial.

3 Conclusion and Future Work

This study discussed the importance of considering the repeated use of a combination of explicit filters. Further studies are required to quantitatively determine the quality of a combination of explicit filters.

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