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# Extending Characteristic Ghost-Cell Boundary Condition to Unstructured Grid

**Yidao Dong[1*], Xiaogang Deng[2] and Guangxue Wang[2]**

[1*] National University of Defense Technology, No. 147 Yanwachi Street, Changsha, Hunan 410073, PR China, tianyatingxiao@163.com

[2] National University of Defense Technology, No. 147 Yanwachi Street, Changsha, Hunan 410073, PR China, xgdeng2000@vip.sina.com

[3] Sun Yat-sen University, Guangzhou 510275, PR China, wgx111@sina.com

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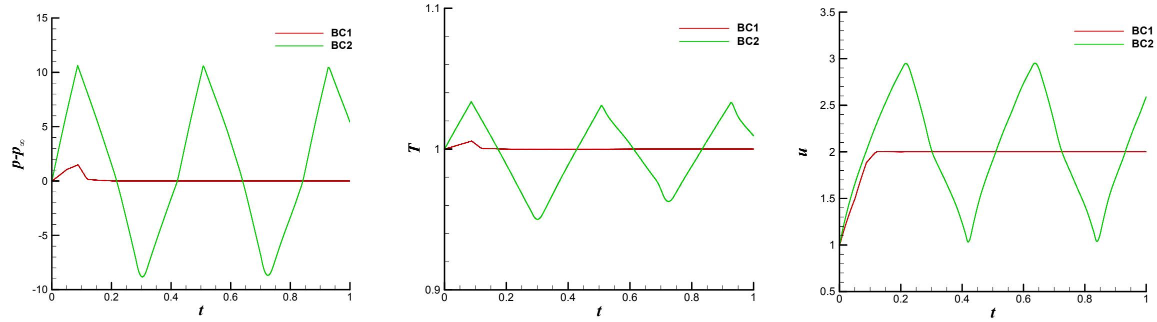
In the last two decades, great advances have been achieved for numerical algorithms based on the unstructured grid. To improve the accuracy and the robustness of the second-order finite volume methods on the unstructured grid, little attention has been paid to improve the methods for the boundary condition treatments. In this paper, the characteristic ghost-cell boundary condition developed by Gross and Fasel [1] for structured grid is extended to unstructured grid. This approach is generally based on the characteristic theory. Additional ghost cells are introduced to apply the characteristic boundary condition.

The characteristic ghost-cell boundary condition, which will be referred to as BC1, is compared with another two simpler boundary conditions, BC2 and BC3. For BC2, velocities and temperature are enforced at the inflow boundary, whereas the static pressure is extrapolated from within the computational domain, assuming zero first derivatives. At the outflow boundary, velocities and temperature are extrapolated assuming zero second derivatives and the static pressure is prescribed. For BC3, all flow quantities are extrapolated assuming zero second derivatives. These three boundary conditions are employed to simulate one-dimensional channel with varying inflow.

The computational domain is bounded in $x \times y = [0, 1.0] \times [0, 0.125]$. The left and right boundary conditions are set as inflow and outflow. The top and bottom boundary conditions are periodic. Unstructured triangular grid is generated. The flow is initialized with $p_\infty = 1/(\gamma M^2)$, $\rho_\infty = 1$ and $T_\infty = 1$. The Mach number is $M = 0.1$ and the specific heat ratio is $\gamma = 1.4$. The velocity at the inflow is $u_0 = 1.0$, but then subjected to a sudden increase. The target inflow velocity is set to $u_t = 2.0$. For the simulation, the second-order cell-centered unstructured finite volume method [2] is employed. The gradient is reconstructed by the least squares method [3].

When BC3 is employed, the simulation blows up. For another two boundary conditions, the root mean square of pressure perturbation, temperature and streamwise velocity for BC1 and BC2 are illustrated in Figure 1. Obviously, for BC1, the target velocity is achieved in a short time. Besides, initial state for the pressure and temperature is recovered after small oscillations in the beginning. Comparatively, all flow quantities calculated with BC2 oscillate in a large range.




(a) The root mean square of pressure perturbation

(b) The root mean square of temperature

(c) The root mean square of streamwise velocity

**Figure 1**: The root mean square of (a) pressure perturbation, (b) temperature and (c) streamwise velocity on the triangular grid

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