Concepts and applications of multi-directional finite difference method – in memory of Prof. Kunio Kuwahara

Hiroshi Suito[1,2]

[1]Department of Environmental and Mathematical Sciences, Okayama University, Japan
[2]PRESTO, Japan Science and Technology Agency
suito@ems.okayama-u.ac.jp

Professor Kuwahara developed multi-directional finite difference method around 1990. Previously, he had long been considering some possibilities of construction of a more natural finite difference method. Finally, he arrived at a new strategy, which was simple but which had nevertheless been difficult to strike upon:

i. If one has a finite difference mesh as presented in Fig. 1.
ii. Another mesh system can be considered by $\pi/4$ rotation, as shown in Fig. 2.
iii. The results from both mesh systems can be mixed in appropriate weights

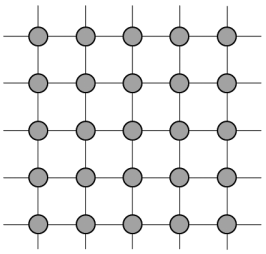

Fig. 1 Original mesh

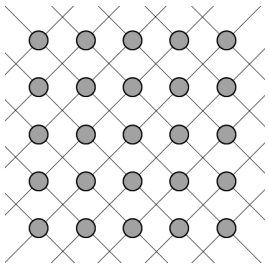

Fig. 2 Rotated mesh

The weights of both mesh systems were determined to render the leading term of the truncation error as invariant for rotation. If one had a CFD code for a generalized coordinate system, then necessary code modifications would be straightforward, the increase of computational time would be minimal and the flow computation stability increases greatly.

After establishing the multi-directional finite difference method, Prof. Kuwahara utilized it for various applications and various new techniques—such as the multi-grid approach—in quite an exciting manner, as we all know.

References

[1] K. Kuwahara and Y. Oshima: Thermal convection caused by ring-type heat source, *J. Phys. Soc. Jpn*. 51 (1982), 3711-3719.
[2] S. Shirayama and K. Kuwahara: A zonal approach for computation of unsteady incompressible viscous flow, *AIAA-87-1140-CP* (1987).
[3] S. Shirayama: Local network method for incompressible Navier–Stokes equations, *AIAA-91-1563-CP* (1991).
[4] H. Suito, K. Ishii, and K. Kuwahara: Simulation of dynamic stall by multi-directional finite difference method, *AIAA-95-2664* (1995).