Analysis of Flow in Elasticity Pipe using CIP method

Furuta Nobuyasu

School of Information Science,
Japan Advanced Institute of Science and Technology

February 13, 1998

Keywords: CIP, Moving boundary.

Background and Purpose

Euler's method and Lagrange's method are used as a means to solve the equation of motion of the fluid so far. Euler's method thinks about the volume element in the mesh where the space inside is fixed and it is a technique by which the velocity and the pressure of the fluid which crosses in the mesh momentarily there are calculated. As against this, lagrange's method is a technique by which the movement is pursued considering the fluid to be a meeting of the particle without fixing the flow area. In a word, the mesh is fixed to grid point in the space as for Euler's method, the other hand side, the mesh moves in Lagrange's method according to the movement of grid point.

From the difference of such a charactor, in the problem of the calculating interaction and fluid and solid area like the moving boundary, Lagrange's method is used. The compatibility of the Lagrange's method with the moving boundary problem is better, because it is dragged to moving fluid and solid and mesh is transformed.

However, when the problem of the moving boundary is solved by Lagrange's method, repapering the mesh of each time step is needed. In addition, there is a problem that the mesh collapses when a big transformation of the fluid and the solid is caused and arithmetic precision decreases.

It is easy to treat because the grid is fixed to the space for this in Euler's method. However, it is difficult to know coordinates of the boundary of the fluid and the solid accuracy good. When the pursuit of the boundary of fluid and solid is calculated, the decrease in accuracy because of numeric diffusion is caused.

About CIP Method

The CIP method proposed by Yabe Takashi is a technique that accuracy good can be very solved as for the advection. If we calculate the position of the moving boundary by using the CIP mehtod, we come to be able to take up the problem of the moving boundary by using Euler's mesh. The problem where the boundary of the fluid area and the solid area moves will be able to take up it easily.

There is a big characteristic in the interpolation method of each calculation grid in the CIP method. Basically, this interpolation uses the third spline interpolation. However, interpolation formula is not decided like the third spline interpolation of natural according to continuity of the first or second differentiation. In the CIP method, the profile of the value and the interstics has each grid point and interpolation formula is easily requested from the profile. As for the CIP method, it is concise and numeric diffusion is also a little. The characteristic of it is that the expansion into multi-dimensional is easy.

Experiment

An one-dimensional advection equation was solved as a preliminary experiment by using the CIP method in this research. It was confirmed to evaluate the accuracy of the CIP method, and to obtain enough accuracy. However, a over-shoot was seen in the grid with the discontinuities. Therefore, we do about the inclination of the discontinuities right and left dividing. As a result, we can confirm where the over-shoot was not caused in discontinuitinous.

Next, a two-dimensional advection equation was solved by the CIP method. Enough accuracy on practical use was obtained.

The CIP method was applied to the method of the Navier-Stokes equation. The Navier-Stokes equation was separated at the advective term and non-advective term, and advective term was solved by using the CIP method and non-advective term was solved by using the difference method. The cavity flow was ualitatively approximated well by this technique with the one which had been calculated by a past difference method.

Next, the calculation where the solid moved the piston up and down in the fluid was done. Here, the CIP method was used to calculate the position of the solid which moved in the fluid. For the moving boundary problem we examined how by the moving boundary to give the boundary condition. By calculating this model the voltexes occurred when a solid deceleraters. After of the stationary of a solid, that voltexes was observed.

Finally, flow of the vibrating pipe was analyzed. In this computation model, This pipe repeates vibration which is that center part in a straight tube slowly returns to stricture. The stricture part of a pipe was transformed by using the CIP method. The velocity of stricture was set in the grid of neighborhood in contraction area. The position of the moving boundary is calculated by solving the advection. When the CIP method was used, moving boundary problem is solved and we are confirmed to be able to solve the problem of the moving boundary to be accompanied by a complicated transformation.

Conclusion

The content shown by this research is shown above.

1. The CIP method was applied to the Navier-Stokes equation.
2. The CIP method was applied to the calculation of the boundary in moving boundary, and how by the moving boundary to give the boundary condition was shown.
3. It was shown to be able to treat the movement and the transformation of the solid area easily by using the CIP method.
4. As this application we can think a problem where solid is caused complicated transformation.