Proposal of Method of Visualization that using λ_2-cirterion in Computational Fluid Dyanmics

Sho Hanida (0810049)

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

February 9, 2010

Keywords: CFD, Visualization, Vortex Identification, Vortex Regions, λ_2 criterion.

Recently, a large-scale computed fluid dynamics(CFD) analysis is examined by improvement of performace of computer. Therefore, the data size of calculatino result becomes also very large and high resolution. As example of large-scale CFD,There are Ocean hydrodynamics and meteorological simulation,etc. In large-scale CFD it is important feature that vortex regions which is involved vortexs. Becouse of visualization object is too many, User can not understand the flow of phenomena in the large-scale size of the CFD result. Moreover, it is difficult to visualize CFD result as it is in the very large-scale data.

In generally visualization, the large-scale data is visulized by same data reduction techniques. There is a possibility of losing vortex which is important feature of flow phenomena. In CFD visualization, Vector and Method of LIC(Line Integral Convolution),etc. has been widely used. As for Vector, flow direction and strengh is expressible. As for Method of LIC, center of vortex is expressible. There visualization is very useful for imformation of detail of flow phenomena but it can not represent boundary of vortex. So we need a method of extraction of vortex. There is a method of using vorticity magnitude one of the methods of Extraction of vortex regions. However, this method is necessary to set a threshold of vorticity magnitude for Extraction of vortex regions.

I thought that the technique that does not set a artifact acceptance value, is nesseary to qualititively extraction of vortex regions. There are Δ-criterion by Chong et al.(1990) and Q-criterion by Hunt et al.(1988),etc.as other method of extraction of vortex. But Δ-criterion and Q-criterion have case that Extratino of votex cannot be done accurately according to Jeong et al. There is animation or arranging images in the thechnique for observing conversion of vortex regions in time-seri incompressible viscos flow. As for the method of animation, conversion of vortex regions is intuitively understood, but comperison of vortex boundary is not quantitatively appreciable. And, as for the method of arranging images, conversion of vortex regions is visually understood,but It is not a quantitative evaluation, and in a lot of time-series data it is necessary to do a lot of comparisons. In addition the visualization technique for large-scale CFD and CFD in complex structure is hoped for. Therefore, I was proposed and developed visualization techniques that can represent expressly conversion of vortex regions.

In this Research I selected λ_2 criterion by Jeong et al for extraction of vortex regions. The vortex regions is important feature in a flow phenomena. This Method can uniquely extract vortex regions without thresholds. Furthemore, I defined conversion of vortex regions in time-series like regions of generation, regions of extinction, regions of continuation and not vortex regions. So I can represent expressly conversion of vortex regions in time-series.

The visualization results using proposal technique was studied for cavity Flow and karman vortex street. And, the proposal technique is studied and considered in interval of defference of time-series data. Moreover, a method of superimposing proposal and general visualization is studied for Cavity flow and Karman vortex street.