The Recovering of Flow Features from Large Numerical Data Bases

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Introductory Remarks

Several developments of post processing systems for computational fluid dynamics (CFD) and experimental results are in progress in almost every institution interested in treating fluid flow fields. There are three main reasons for this. One is the visualization of information to be obtained from the huge amounts of data because the eyes provide the broadest channel of information transfer to a human being. The second is the application of tools to reveal the physics of a flow field. New diagnostic tools have been suggested for the classification and description of the physics in order to reduce the huge amount of information, e.g. by capturing the topology of the flow field. The third reason is closely related to the second: The validation of CFD results is mainly achieved by comparison to other CFD results or to experimental results. While for other CFD results the same tools may be applied, the experimentalists are considerably restricted in their tools. Thus comparisons can only be made by simulating experimental tools, like light sheets, schlieren and shadow pictures, etc. Comparisons of oil-flow pictures and skin-friction lines as well as particle traces and streamlines have already been extensively performed, though there are shortcomings due to the finite mass and volume of particles in experiments.

The mapping into two dimensions, e.g. onto a sheet of paper, is the greatest disadvantage for the imagination and understanding of representations of three-dimensional, time-dependent and multivariate datasets. Though we have some assistance for the imagination by techniques like hidden surface removal and depth cueing, the three-dimensional impression can be achieved much better from stereo scenes, e.g. anaglyphs (stereo pictures) or holograms. Both possibilities are not widely applied because of their technical and financial expenditure. Thus for some time we shall have to work with two-dimensional pictures. We are mostly restricted to gray-tone pictures because the world of scientific papers is gray for reasons of cost in printing and copying.

The sheer size of the datasets being created by simulation of fluid dynamics phenomena, which is beyond the capability of human interpretation, is not the only reason for suggesting and introducing more methods of extracting and representing data, but also the growth of knowledge and cognition about the different functions describing a flow field. Thus knowledge and imagination go parallel.

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This argument is assisted by the fact that recognition is based on comparison of information. Therefore many representations are created for that purpose. The so called 'multi media show' is a special variety of such a presentation. In order to avoid overloading of the information channels to our brains we have to reduce information and to confine it to relevant effects. This demand is also in anticipation of an automatic recognition of correlation by the computer, as already done with pattern recognition.
New methods of representation will reduce the mental effort required to 'understand' the flow field. They adapt the information to human cognitive capabilities and assist intellectual work. They achieve a deeper insight into the mutual dependency of functions and interaction of effects.
Whether a new kind of representation will be accepted depends on the scientific community. Though tradition and convention are rather strong, the necessity of introducing new methods is recognized.

The objective of this paper is to give some ideas of recovering and representing flow features and to encourage the invention and introduction of new data reductions and representations. The results presented in the figures will be discussed only qualitatively.
After illustrating a first example we proceed to deduce some requirements by asking what is desirable and achievable for an analysis and graphics system. Then the use and necessity of several tools and kinds of representations will be explained.

As we draw attention to the reduction of data it seems to be necessary to discuss the overloading of workstations by large datasets and the circumvention of this situation.

For the representation of results mostly comparisons of information from different sources are necessary. The purpose is verification or validation of results. This shall be explained by

An Example.

The turbulent transonic flow around a delta wing with 65° sweep angle at 10° incidence was investigated experimentally and numerically within the IEPG-TA15 program [18]. A special experimental result were Video pictures of light sheets scanned over the surface [1]. For this technique particles are seeded into the flow in front of the body and are made visible by an expanded laser beam within a thin volume (cf. Figure 1, upper part). In the upper left corner of Figure 9 on page 16 we see a distribution of light being reflected from the particles. The gray tones have been mapped into colors to accentuate the variation of the corresponding density of particles.