Issues and Challenges for the Visualisation of Computed Vector Fields

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Abstract

Computed vector fields are characterised by the fact that they are described discretely and their visualisation usually requires conversion to a continuum. Issues associated with the conversion can interfere with visualisation correctness. A very simple example, natural convection in enclosed spaces, is used to explore the effects of errors in commonly used algorithms for constructing vector tangent lines. In particular the algorithm most usually used in computational fluid dynamics visualisation packages is demonstrated to produce unrealistic visualisations.

The discussion then considers how scalar and vector potentials, generated via the Helmholtz theorem, can lead to discrete to continuum conversions which although having similar local errors have correct global representations of the vector fields. An impediment to using these potentials is that generally they are not part of the numerical description of the vector fields and must be generated by the post processor.

A more in depth study of the natural convection shows how several vector fields vector fields, such as the conduction and convection heat fluxes and the energy transport vector can treated by a unified approach that obviates the need to explicitly apply heat flux boundary conditions during a post processing stage, thereby having the ability to encourage more widespread use of potential based methods for visualisation. Examples show how vector fields with non-zero divergence can also be visualised using these methods and some, such as the conduction heat flux field, provide new interpretive visualisations of heat transfer processes.

Having described issues associated with the visualisation of computed vector fields, the final phase of the presentation is review of visualisation methods for computational flow vector fields and concludes that the visualisation of three dimensional steady and unsteady computed flow fields is still a major research challenge. Possible methodologies are discussed and it is suggested that a suitable approach and target for research is to understand how vector and scalar and vector potentials can contribute to visualisation strategies. Other derived fields such as dual stream functions and the Lamb vector, relate to the structure and physical characteristics of a flow. A particular focus is to use these fields to generate “structural” stream surfaces that segment the flow into self- contained regions, thereby significantly simplifying the visualisation of complicated flows.