The Method of Generated Solutions for Numerical Verification of ICE Code

Amjidanutpan Ramanujam, Christopher Sikorski, Todd Harman*

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School of Computing
University of Utah
Salt Lake City, UT 84112 USA

*Department of Mechanical Engineering
University of Utah
Salt Lake City, UT 84112 USA

Abstract

Method of Manufactured Solutions (MMS) is a widely used technique to verify convergence and possible coding errors in numerical algorithms. This method involves designing analytical solutions satisfying the governing equations that are solved by the numerical algorithm. The solutions investigated by MMS may not resemble the physical solutions. In order to overcome this limitation, we propose a new verification technique called Method of Generated Solutions (MGS). The MGS method designs its analytical solutions by approximating or interpolating discrete data from the solver or data measurements from physical experiments. This can be achieved using appropriate mathematical techniques such as spline interpolation or least-squares approximation. The analytical solutions obtained in that way will closely resemble the physical solutions. Hence, the verification results based on these analytical solutions will provide us with an accurate benchmark of the solver's capabilities. The proposed MGS method is implemented and utilized to verify ICE (Implicit, Continuous fluid, Eulerian), a semi-implicit finite volume solver, that simulates fluid phenomena.

Floating point analysis of the time-stepping summations in the ICE algorithm was also performed. The condition numbers of such summations are evaluated and possible use of a corrective summation algorithm was explored.