

Determining Worst Case Errors in Computing Solutions to Partial Differential Equations

An accurate prediction of the behavior of systems is affected by the capability of the computational model to correctly assess all possible sources of uncertainties altering the solutions. Not taking into consideration all aspects of modeling uncertainties leads to numerical results whose true measure of reliability cannot be verified. Moreover, one needs to distinguish between uncertainties in the solutions caused by limited or incomplete information about the system and those generated by numerical analysis. Furthermore, due to the expense of experimental techniques many numerical models are not validated, thus increasing the need for reliable numerical methods. This work presents a boundary element based method which accounts for verification errors due to discretization of the weak form of the partial differential equation as well as numerical errors due to numerical integration and floating point truncation. The method is based on closed convex set or interval analysis. Validation error due to uncertain boundary conditions, modeled by fuzzy sets, is also considered. The resulting interval boundary element method and fuzzy boundary element method provide a guaranteed enclosure or the worst case scenario bounds on the point-wise solutions to partial differential equations. These methods can be easily implemented into any computer language, which supports interval operations, and are computationally inexpensive. Examples of the use of these methods will also be presented.

Mr. Bart Zalewski is a Ph.D. candidate at Case Western Reserve University. He has received a B.S. and M.S. degrees in May 2005 from Case Western Reserve University. His M.S. thesis dealt with dynamic load effects on bridge-mounted structures. Currently, Mr. Zalewski's research interests are in the area of reliable engineering computing and focus on interval methods for treating errors and uncertainties in numerical methods. Mr. Zalewski is a recipient of Case Prime Fellowship and Miller Memorial Outstanding Academic Achievement Award. He has presented six conference publications and has two journal papers under review.