

A new Fragile Points Method (FPM) in Computational Mechanics, Based on the Concepts of Point Stiffnesses and Numerical Flux Corrections

Tian Yang¹, Leiting Dong^{1,*} and Satya N. Atluri²

¹School of Aeronautic Science and Engineering, Beihang University, Beijing, 100191, China.

²Center for Advanced Research in the Engineering Sciences, Texas Tech University, Lubbock, TX 79409, USA.

*Corresponding Author: Leiting Dong. Email: ltdong@buaa.edu.cn.

Abstract: In this paper, a new method, named the Fragile Points Method (FPM), is developed for computer modeling in engineering and sciences. In the FPM, simple, local, polynomial, discontinuous and Point-based trial and test functions are proposed based on randomly scattered points in the problem domain. The local discontinuous polynomial trial and test functions are postulated by using the Generalized Finite Difference method. These functions are only piece-wise continuous over the global domain. By implementing the Point-based trial and test functions into the Galerkin weak form, we define the concept of Point Stiffnesses as the contribution of each Point in the problem domain to the global stiffness matrix. However, due to the discontinuity of trial and test functions in the domain, directly using the Galerkin weak form leads to inconsistency. To resolve this, Numerical Flux Corrections, which are frequently used in Discontinuous Galerkin methods are further employed in the FPM. The resulting global stiffness matrix is symmetric and sparse, which is advantageous for large-scale engineering computations. Several numerical examples of 1D and 2D Poisson equations are given in this paper to demonstrate the high accuracy, robustness and convergence of the FPM. Because of the locality and discontinuity of the Point-based trial and test functions, this method can be easily extended to model extreme problems in mechanics, such as fragility, rupture, fracture, damage, and fragmentation. These extreme problems will be discussed in our future studies.

Keywords: Fragile points method; point stiffnesses; numerical flux corrections