



An error indicator for two-dimensional elasticity problems in the discrete least squares meshless method

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Abstract

An error indicator of the discrete least squares method (DLSM) for 2D elastostatic problems is presented. In the DLSM, the problem domain is discretized by distributed field nodes. The field nodes are used to construct the trial functions. The moving least-squares interpolant is employed to construct the trial functions. The least-squares technique is used to obtain the solution of the problem by minimizing the summation of the residuals for the field nodes. The error indicator is readily computed from the residual of the governing differential equation. It is demonstrated, through some elastostatic problems, that the error indicator reflects the exact error.

Keywords: Discrete least squares method, Meshless, Error estimate, Elasticity.

1. INTRODUCTION

Finite element method (FEM) has been successfully used for the simulation of a broad range of applications in the last decades. The method, however, encounters some difficulties when dealing with problems involving moving boundaries, crack propagation or extremely large deformation due to their need for remeshing of the domain. Different methodologies have been suggested by FE practitioners to overcome this problem with varying degrees of success. These methods, however, either partially solve the problem or are computationally very demanding. This has motivated the numerical activists to seek for a method that totally circumvents the mesh generation requirement of the FE and other mesh based methods.

In the last decade a wide range of methods referred to as meshless methods have been devised in an attempt to overcome this problem. These methods are common in that they do not require a mesh with predefined connectivity among the nodes. Some important examples of these methods are the smoothed particle hydrodynamic (SPH) method [1], reproducing kernel particle method (RKPM) [2], element free Galerkin (EFG) method [3], meshless local Petrov–Galerkin (MLPG) method [4] local boundary integral equation (LBIE) method [5], and hp-cloud method [6].

Recently collocation methods are being used more and more to devise meshless methods due to their simplicity and efficiency. These methods, however, lack enough accuracy and more importantly suffer from stability problems when used for non-self adjoint problems. A remedy to this problem has been sought by hybridization of the collocation method with other discretisation schemes mostly least squares method. Arzani and Afshar [7] developed Discrete Least Squares Meshless (DLSM) method for the solution of Poisson equation. While most of the existing meshless methods need background cells for numerical integration, DLSM did not require numerical integration procedure due to the use of least squares method to discretise the governing differential equation. Zhang et al. [8] proposed the Least-squares collocation meshless method to solve elliptic problems. Liu et al. [9] used a Meshless Weighted Least Squares (MWLS) method for the solution of some steady and unsteady heat conduction problems. A sensitivity analysis on the meshless weighted least-square parameters to solve the problems of a cantilever beam and an infinite plate with a central circular hole was performed by Xiaofei et al. [10]. An error estimates for moving least square approximations used for the solution of 1-D convection-diffusion problems was developed by Armentano and Durán [11]. Wang et al. [12] proposed a Point Weighted Least-Squares Meshless (PWLSM) method for the solution of 1-D and 2-D Poisson equations. Firoozjaee and Afshar [13] proposed Collocated Discrete Least Squares Meshless (CDLSM) method to solve elliptic partial differential equations and studied the effect of the collocation points on the convergence and accuracy of the method. The method can be considered as an extension the earlier method of DLSM by introducing a set of collocation points for the calculation of least squares functional. CDLSM was later used by Naisipour et al. [14] to solve elasticity