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A LOCAL MESHFREE UPDATED LAGRANGIAN (UL) APPROACH FOR GEOMETRICALLY NONLINEAR ANALYSIS

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ABSTRACT

A geometrically nonlinear analysis of solids is a challenge for researchers in computational mechanics. Although the finite element method (FEM) [1] is a well-established mesh-based method for modelling nonlinear problems, it often encounters difficulties for nonlinear analyses due to the mesh distortion issues. Especially for some geometrically nonlinear problems with very large deformation, FEM will fail to give reasonable solutions due to the severe mesh distortions. Because no mesh is used, meshfree methods show very good potential for the geometrically nonlinear analysis. The meshfree methods based on the global weak-forms have been successfully used in this area. Chen et al. [2] and Jun [3] concluded that the meshfree methods, EFG and RKPM, are very effective for the large deformation analyses. However, the studies for the nonlinear analyses by the meshfree methods based on the local weak-forms [4] are very few, especially using the updated Lagrangian (UL) approach [1], which refers all variables to the current configuration. Easily to perform the adaptive analysis is one of distinguished advantages of meshfree methods. To achieve the adaptive analysis in geometrically nonlinear simulation, the UL approach is necessary for many cases, so it is important to develop a local meshfree UL approach.

In this paper, a local meshfree formulation based on the radial basis function (RBF) interpolation [4] is developed for the large deformation problems. The discrete equations for 2-D solids are obtained using the local weak-forms, and based on the updated Lagrangian approach. In the UL approach for the geometrically nonlinear analyses of solids, after several deformation steps, the nodal distribution may become improper and lead to a large computational error. In these cases, the deformed problem domain should be re-noded (a type of adaptive analysis) to improve the computational accuracy. Because no-mesh is used in the meshfree method, the procedure to re-node the deformed problem domain is much easier than the re-meshing in the FEM. Considering the properties of the UL, the re-noding is much efficient in the UL approach than in the total Lagrangian (TL) approach [1].

A simple technique to re-node the deformed problem domain for 2-D solids, as shown in Figure 1, is firstly developed. The detailed procedure is : a) to form a large rectangle including the deformed domain; b) to draw several parallel lines regularly distributed on

x direction (or *y* direction); c) to compute intersection points with the global boundary for the deformed domain; d) to get the new field nodes by regularly dividing the line segments between intersection points. It has been found that this method is very easy to be used in the practical simulation.

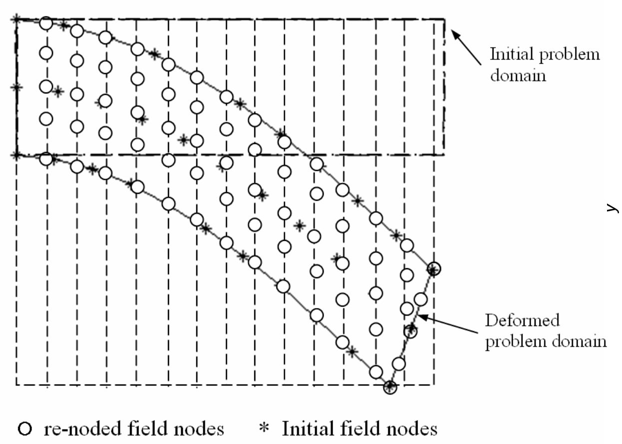

Figure 1 Re-noding (adaptive) in UL

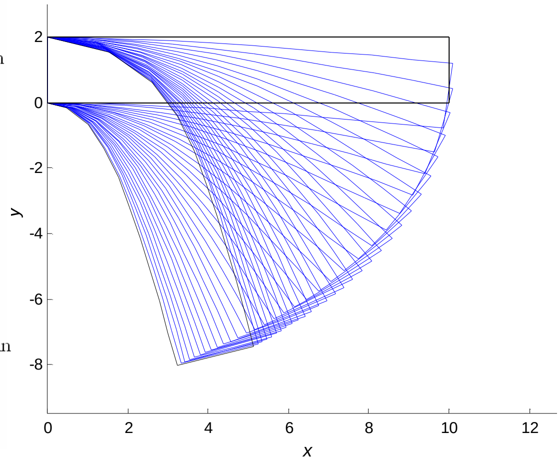

Figure 2 Large deformation for a cantilever beam

Several numerical examples of the 2-D geometrically nonlinear analysis have been studied to illustrate the performance of the present local meshfree formulation. As shown in Figure 2, the large deformation analysis is performed for a cantilever beam, which is subjected to a distributed vertical loading. Sixty-six irregularly distributed field nodes are initially used to discretize the problem domain, and re-noding is performed every 5 steps. Figure 2 plots the meshfree deformation results of 30 loading steps. It is found that very stable results have been obtained by the present local meshfree UL approach. It should be mentioned here that, in Figure 2, the vertical deflection at the free end of the beam is already more than 5 times of the initial depth of the beam. It proves that the meshfree method is still stable even in the case of very large deformation.

It can conclude from above studies that that the local meshfree technique using updated Lagrangian (UL) approach is very effective for the geometrically nonlinear analysis in computational mechanics, because it avoids all mesh distortion issues. In addition, since no mesh is used, the meshfree UL approach is very suitable for adaptive analysis.

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