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AUTOMATIC UNSTRUCTURED AND NON-CONFORMING REMESHING WITH BOUNDARY CONTROL FOR METAL CUTTING SIMULATION

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ABSTRACT

During the finite element simulation of high speed cutting processes, the mesh which represents the workpiece undergoes extreme large deformation, which could result in invalid mesh and numerical failure in the simulation. To overcome the problem and improve computation efficiency, an adaptive remeshing technique is required to update the distorted mesh frequently.

The existing meshing techniques can be classified into two categories: Unstructured meshing and structured meshing techniques. Generally, unstructured meshing techniques can generate a good quality mesh to replace highly distorted mesh, however, some of them (e.g. Paving [1]) are not able to generate local dense mesh in interior region and some of them (e.g. Advancing front approach introduced by Zhu and Zienkiewicz [2]) generate graded mesh with distorted element due to mesh transition.

In contrast to unstructured meshing technique, hanging-node-based hierarchical mesh generation [3,4] can easily achieve desired mesh density locally. It has been widely used for Eulerian finite element formulation, however, there are few papers which apply hanging-node-based mesh refinement technique to extreme large deformation problem in Lagrangian finite element formulation because it can not reduce mesh distortion. Therefore, we develop a combined unstructured and hanging-node-based remeshing strategy by exploiting the advantages of unstructured meshing technique and hanging-node-based refinement technique.

The combined remeshing strategy comprises four steps: 1) Extract boundary nodes from old mesh; 2) rearrange the boundary nodes according to desired mesh density on boundary and rebuild the geometry with updated boundary nodes; 3) perform unstructured mesh generation by projecting boundary segments towards the interior; 4) refine the unstructured mesh with hanging node according to desired mesh size field.

A hybrid error indicator which is based on plastic strain and the rate of plastic strain is developed to analyze the finite element solution and generate new mesh density field to achieve prescribed accuracy. After each remeshing step, the solution variables such as velocities, stresses, temperatures and hardening parameters are transferred from the old mesh to the new mesh.

The presented adaptive remeshing strategy is implemented in Python and C++, ABAQUS/Explicit is called by the Python scripts as the FE-solver in each remehsing step. In this work, the adaptive remeshing strategy is applied to the simulation of high speed cutting. Figure 1 shows the results corresponding to different displacements of the tool, which demonstrate the performance and efficiency of the proposed combined remeshing strategy for large deformation problem.

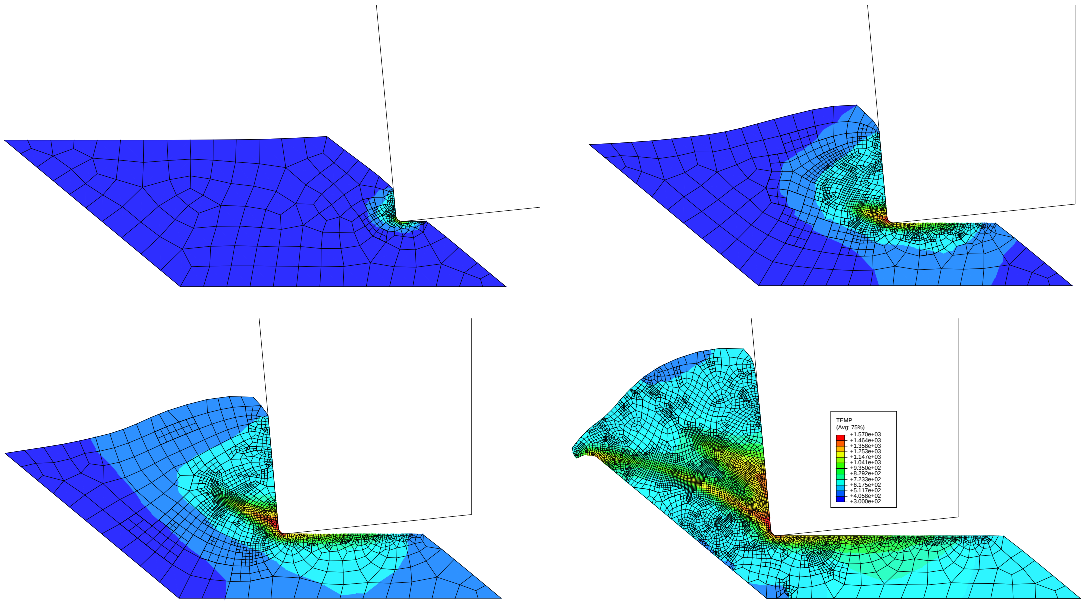

Figure 1: Adaptive meshes at displacements of 0.1,0.35,0.45 and 0.75mm

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