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RETRIANGULATION TECHNIQUES FOR 3D MESH ADAPTATION

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ABSTRACT

The article concerns a comparison of 3D remeshing methods with respect to mesh adaptation for simulated phenomena.

The analysis is based on the mesh generator developed by the Authors [1]. For three-dimensional domains the unstructured surface (triangular or quadrilateral) and volume (tetrahedral) meshes can be created. The meshes are constructed via an iterative triangulation method using a concept of local non-Euclidean metric, which allows to generate meshes with varying density and anisotropic shape of elements. The generator is supplied with a mechanism of automatic retrieval of metric data from different sources and an evaluation of elements according to the prescribed metric.

The information about metric for the discretized domain is stored in an additional *control space* (CS) structure. In the developed generator the functionality of CS was extended with additional data on the size and shape of mesh elements. The structure of CS may vary, e.g. may be based on a quadtree/octree grid or a background mesh. In order to facilitate creation and utilization of different CS structures, a common interface of adaptive control space (ACS) has been proposed [2]. With this approach the automated procedure of establishing the proper mesh size does not depend on the selected type of CS, which also allows further extension of the set of implemented CS structures. The essential requirement of ACS is to provide the tensor of metric transformation in an arbitrary point within the discretization domain. Additionally, the ACS interface includes several base operations for enriching and adjusting of metric data.

These features of the developed mesh generator allow a comparatively simple introduction of the procedures of adaptation dedicated to numerical simulation of physical phenomena (e.g. using FEM). The error estimators used in such simulations (especially those based on the derivative approximation techniques [3,4]) can be easily transformed into proper metric tensor form and included into the procedure of mesh generation.

In general, the mesh adaptation with respect to retriangulation techniques can be categorized in three groups depending on the extent of space where the modification of mesh is required:

- local mesh transformation limited to several adjacent elements – performed by mesh refinement (insertion of additional nodes), topological modifications (swapping of edges and faces in neighboring tetrahedra), repositioning of nodes, etc.,

- retriangulation of subdomain formed by a cavity created by removing a number of elements (the size of the subdomain is considerably larger than in the previous case),
- construction of a new mesh for the whole domain.

During the adaptation process the information concerning the desired shape, size and directionality of elements are stored in a new adjusted ACS with respect to the previous computation step of the adaptation procedure. The selection regarding the extent of required mesh modifications can be performed using two methods – either by comparison of control space structures from two adaptation steps or through an assessment of the conformity of the previous mesh to the new updated control space. It should be stressed, that in both approaches the mesh can be locally refined or coarsened, also with anisotropic elements.

The Authors intend to present the results of comparison of both mesh adaptation approaches, as well as to review the technical aspects of the implementation of these procedures resulting in theirs satisfactory computational efficiency.

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