ABSTRACT

Mesh generation is a basic and highly time-consuming task in the finite element method (FEM). Therefore, automatic mesh generation algorithms have been developed for last decades. An acceptable mesh is that which provides accuracy at reasonable cost. Mesh geometry is only one factor influencing accuracy. On the one hand, FEM error is a function of the element size. On the other hand, distorted elements reduce the precision of the solution in most problems. When the shape of an element is different from the shape of the regular element, the element is said to be distorted. For instance, the regular element in quadrilateral meshes is the square.

Therefore, the distortion of the elements needs to be considered during the mesh generation. In this sense, one of the mesh generators priorities is to obtain low distorted elements. Unfortunately, most of the mesh generators obtain very distorted elements in the initial stages of the discretization process. Thus, it is necessary to develop an algorithm in order to smooth the shape of the elements.

There are two main objectives in this dissertation. The first one is to analyze the behavior of the distortion measure developed by Oddy et al. [6] for quadrilateral and hexahedral meshes, and identify the problems that this measure may have if it is minimized using a standard mininimization procedure.

The second objective is to develop a smoothing method based in the continuum minimization of the distortion measure. To this end, and according to the results obtained in the first objective, the distortion measure has to be modified when elements (quadrilaterals or hexaedrals) have concavities. The developed modification of the distortion measure is different for quadrilaterals and hexaedrals. However, the proposed algorithm is analogous in both cases.

It is not possible to apply directly Oddy distortion in a smoothing algorithm, because the distortion of Oddy does not gauge correctly the distortion of degenerated elements. A modification of the distortion measure, based in a new geometric interpretation, is developed to overcome this problem and to compute properly the distortion of this kind of elements. Moreover, taking into account the new modification, it is possible to use an iterative Newton-Raphson algorithm to minimize the mesh distortion and obtain less distorted elements than applying other smoothing techniques.

Finally, some numerical examples are presented to assess the efficiency and robustness of this algorithm.