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EFFICIENT EXACT INTEGRATION OF NURBS AND T-SPLINES WITHIN A 3D-CARTESIAN GRID FRAMEWORK

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The Finite Element Method has become one of the most powerful and widely used techniques to find approximate solutions of differential equations governing many types of engineering problems.

The utilization of Cartesian grids independent of the geometry implies a great computational saving since mesh generation procedures are not necessary and numerical integration is trivial and highly efficient at interior elements, which are regular hexahedra in Cartesian meshes. Only the elements intersected by the contour require special treatment for numerical integration[1].

On the other hand NURBS (Non-Uniform Rational B-Splines) are a geometric technology that has gained popularity in recent years and has become a standard in CAD programs. Most recently, a new technology called T-spline was developed to overcome NURBS technical drawbacks.

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The aim of this paper is to propose an efficient integration strategy, using Cartesian meshes, of 3D geometries defined by NURBS and T-spline entities. The first step will consist in finding the intersections between the geometries and the Cartesian grid. With the intersections we can define integration subdomains needed to integrate properly the intersected elements. In order to do that, a strategy to identify intersection patterns has been implemented based on the Marching Cubes algorithm[2]. This strategy will allow us to precalculate sets of tetrahedra for the most common intersection patterns, i.e., when the element is cut by one single surface.

Regarding the integration step, for internal elements the standard FEM efficiency will be preserved while for intersected elements we will consider proper quadratures whose aim will be to capture the exact definition of CAD models created with NURBS or T-splines[3]. T-spline models will be handled by using their extracted Bézier elements[4][5].

As a result of the consideration of the exact geometry of NURBS and T-splines, the only errors in the integration process are due to the numerical quadrature scheme and the round-off errors. Hence the numerical results show how the proposed strategy involves significant decrease of geometrical error during FE calculation, showing the Cartesian grid independent of the geometry as an efficient and accurate design-through-analysis methodology.

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