A contribution to connect non-conform meshes with overlapping finite elements

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Abstract—In this paper, an approach is proposed to make easy the use of overlapping elements in non-conform mesh connection. Firstly in 2D, shape functions in overlapping elements are checked and an application is given.

***Index Terms*—Finite element method, overlapping elements, non destructive testing.**

I. Introduction

The overlapping finite elements [1] are well adapted for taking into account the movement in several applications; most particularly in eddy current non destructive testing (NDT). The main reasons lie in the fact that signals from the sensors are sensitive to the mesh and generally the scanning of a default need a plurality of calculations. In NDT the surface of a piece to inspect can not be plane (irregularity, hole, edge,…). A strategy was then proposed in [2]. This approach introduces new shape functions and gradient values are calculated using numerical derivations. Similarly to [3], we propose here to use the reference elements in order to make easy the gradient values in 2D. In the extended paper, 3D configurations will be studied.

II. Proposed approach for overlapping elements

The method consists to project the nodes of one surface on the other one and reversely. The projection creates virtual nodes represented by stars (Fig.1) and also virtual overlapping elements. The projected nodes are used to define the shape functions associated to nodal unknowns.

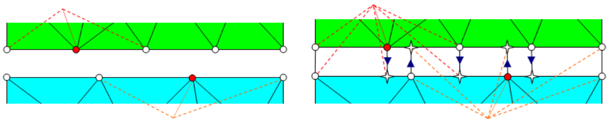

Figure 1: Before and after the projection of the nodes.

When the surfaces to connect are not planar, the projection leads to unconventional overlapping elements (Fig.2). For example, the overlapping element coming from the projection of nodes 3 and 4 is not a trapeze, and is composed of only 4 nodes.

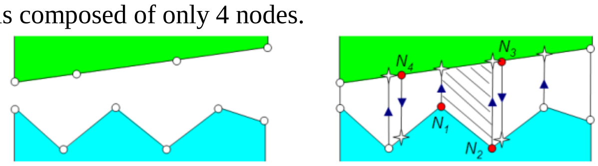

Figure 2: Node projection when the surfaces to connect are not planes.

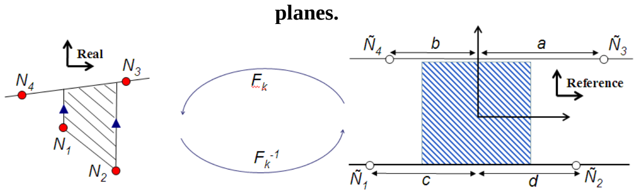

Figure 2: scheme for the calculation of the shape functions.

The areas where the nodal shape functions are commonly non-null represent the integration areas (one example is represented in hatched). The shape functions in each ones are then calculated using the reference elements, see Fig.2. The shape functions are then expressed in the reference element by:

$$\hat{\lambda}_1 = \frac{(d - x)(1 - y)}{2(c + d)} \quad \hat{\lambda}_3 = \frac{(b + x)(1 + y)}{2(a + b)} \quad \hat{\lambda}_2 = \frac{(c + x)(1 - y)}{2(c + d)} \quad \hat{\lambda}_4 = \frac{(a - x)(1 + y)}{2(a + b)} \tag{1}$$

To verify expressions (1), let suppose that nodes N_a and N_b (Fig.3.a) are projected and create an unconventional overlapping element. The shape function related to N_a, is shown on Fig.3.b, no discontinuity is observed.

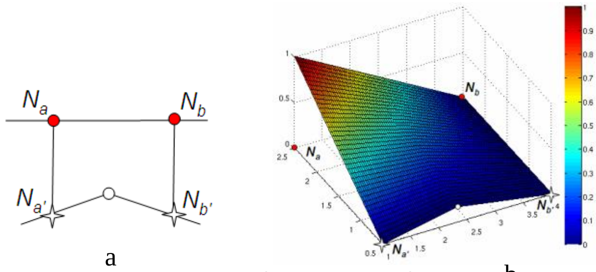

Figure 3: repartition of a nodal shape function in an unconventional overlapping element.

Using a 2D FE formulation with magnetic potential A, the following problem has been solved with the proposed approach. It is composed of an air-box with a non-meshed area, see Fig.4. A magnetic potential difference is imposed between top and bottom sides of the box. For the sake of clarity, the field is shown only in a part of the air box. As awaited, the field is uniform.

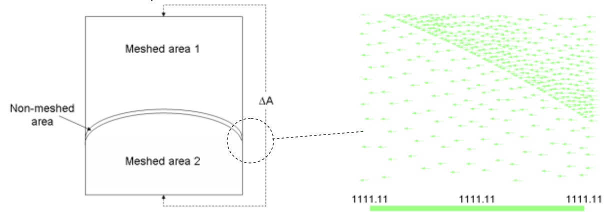

Figure 3: air box with a curved non-meshed area.

References

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