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A new framework for curving structured boundary-layer meshes

A. Johnen[1,2], X. Roca[2], T. Toulorge[3] and J.-F. Remacle[1]

[1] Université catholique de Louvain, Louvain-la-Neuve, Belgium
[2] Barcelona Supercomputing Center, Barcelona, Spain
[3] CEMEF, MINES ParisTech, PSL Research University, Sophia-Antipolis, France

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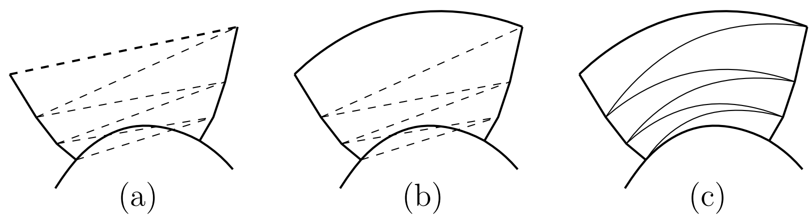

Figure 1: (a) One stack of a 2D BL mesh. Thick black lines are fixed edges and dashed lines are edges to be curved. (b) The exterior edge is curved before the interior edges (c).

CFD simulations require high-quality boundary-layer (BL) meshes. The general consensus to create a curvilinear BL mesh is to first generate a straight-sided BL mesh that is subsequently curved. To operate the curving process, many techniques have been proposed in recent years. Some methods relies on an elastic analogy [1, 2, 3]. These methods are generally fast but do not feature explicit untangling capabilities. On the contrary, optimization techniques feature untangling capabilities [4, 5, 6] but at the cost of a large computation time. Other methods have been proposed such as a PDE-based method [7] and a method based on a *spring-fields* [8]. An interesting approach has been recently proposed using isoparametric mappings [9]. This fast method is robust when some constraints are respected. Those constraints include a constant number of layers, a constant thickness of each successive layers along the BL and extrusion normals that keep a constant direction. Moreover, this method is not devised to curve quadratic simplicial elements.

We propose a new framework for curving any structured BL mesh (that we define as a BL mesh constructed by extruding the boundary and splitting the created elements if simplicial elements are requested). Similarly to the method of [9], we curve each stack of elements separately. However, we allow the surface between the BL and the external mesh to be curved which is useful to control the thickness of the first layers. We make the choice to fix the corner of BL elements and we impose the mapping of the elements to be linear in the direction of extrusion. We first compute a curving of the exterior surface such that the distance to the boundary is constant in the least-square sense (Fig. 1(b)). This curving induce a deformation that can break the validity or significantly decrease the quality of the external mesh [10, 11]. When it is the case, the deformation is reduced such that to recover the validity and quality of the external mesh. The interior of the BL is then curved by using a linear transfinite interpolation or by solving an elliptic problem (Fig. 1(c)). In 3D, interfaces between stacks are curved before curving the stacks which ensures a straightforward parallelization of the whole process. In order to better control the thickness of the first layers, we compute the curving of the first layer surface in the same way we compute the curvature of the exterior surface and use this information for doing a Hermite transfinite interpolation. In pathologic cases, this can produce invalid elements in the stack in which case we compute a combination of the linear and Hermite transfinite interpolation. This method is extremely fast, produce high-quality curved BL mesh and is able to handle complex BL mesh. While not fully robust, an *a posteriori* optimization process allows to recover invalid stacks.

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