P.D.E. based Complex Shapes Editing

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The modification of complex shapes is an important issue of computer-aided geometrical design. Classical tools as Bezier or BSpline pole editing are of course available for long and are well suited to the modification of surfaces made of patches (generally three or four sided) connected along their natural boundaries.

By complex shapes we mean here a complete industrial CAD model, generally made of many G^0, G^1 or G^2 connected faces. The formalisms of the underlying surfaces of the faces may be heterogeneous (NURBS, analytic or procedural surfaces) and each face may be trimmed along arbitrarily complex boundaries (as n-sided and internal boundaries).

The late modification of such CAD models, whether to fit local/global aesthetic requirements (in styling) or engineering constraints, or to anticipate mechanical behavior such as spring effects, is a key issue to improve the time to design of complex-shaped objects. The purpose of this contribution is to show how Dassault Systeme addresses this issue. A part of this work is related to a Brite-Euram project (FIORES BE96-3579).

The method presented here rely on a new point of view on actual models used in industrial CAD applications. The method would have been impossible to devise within the academic algebraic (or "exact") point of view of BSpline or NURBS surfaces. We have now to consider the polynomial or rational formalisms as approximations of a much wider class of functions. This way of thinking is usual in numerical analysis (as FEM algorithms, for example) and is well suited to modern industrial geometric kernels that often consider input of geometric operators as procedural (black boxes) curves and surfaces.

The idea of the method presented here is to consider the complex shape editing problem as a PDE (Partial Differential Equation) on the ambient space $\mathbb{R}^3$. The solution of the PDE is a displacement field on $\mathbb{R}^3$ inducing a deformation on the immersed shape. G^0, G^1 or G^2 constraints on points or along curves on the model are expressed as C^0, C^1 or C^2 constraints on the three dimensional displacement field, providing the boundary values for the PDE.

The practical difficulties encountered are:

- the expression of geometric constraints on surfaces (as G^1/G^2 contact conditions or reflection lines properties) as constraints on the displacement field or its derivatives,

- the choice of the PDE, that is a "good" or "aesthetic" ambient space displacement field behavior,

- the choice of a very fast and accurate numerical method for solving the PDE, allowing a "real time" interaction,

- the evaluation of the modified shape in the NURBS formalism.

Because this tool gives to Dassault Systeme a technological step ahead over the competitors we can not give a complete description of the actual solutions to each of these difficulties. However, we think that the general idea of the method illustrates a new point of view in industrial geometric software design.

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