

Detection and treatment of inconsistent or locally over-constrained configurations during the manipulation of 3D geometric models made of free-form surfaces

The evolution of the manufacturing technologies and the advances in the domain of new materials have significantly increased the degree of freedom when defining the shape of a product that can now become very complex. Today, free form shapes are not only used to answer needs related to aesthetic criteria but also to be able to satisfy functional criteria. The dashboard, the wings or the optics of a car, a turbine blade, a lemon squeezer and so on, are so many products that can be made of very complex free form shapes whose design is not always easy with actual CAD/CAS software.

To enable the modelling of the free form shapes of a product, actual CAD modelers mainly use NURBS curves and surfaces. Subdivision surfaces also enable the representation of free form surfaces through a recursive subdivision at the infinity of a control polyhedron. But their use in mechanical engineering is still limited.

During the last decades, numerous methods have been proposed to ease the definition and manipulation of NURBS surfaces without going back to the underlying mathematical models. Most of these methods try to modify an initial model while satisfying a set of user-specified constraints. The constraints can be indirectly specified on the control points of the control networks/polygons, or directly onto the surface potentially made of multiple trimmed patches connected together with continuity conditions (Pernot04). Some of these approaches enable the specification of higher level constraints enabling the insertion of discontinuities inside the patches (Cheutet06). Some constraints may also be defined directly onto the trimming curves lying in the surface parametric space to enable simultaneous deformation of the patches and their trimming lines (Pernot08). But constraints may also be defined through the use of different supports such as the digital images that can be easily taken with a digital camera (Panchetti09). The common denominator to all these approaches lies in the fact that they all suppose that there are enough Degrees of Freedom (DOF) to enable the desired modifications without encountering locally over-constrained or inconsistent configurations. This hypothesis is very restrictive since it does not optimize at best the NURBS model description capabilities. Its satisfaction often requires the insertion of numerous DOF through the use of the Boehm's knot insertion algorithm. This uncontrolled increase of the DOFs impacts the quality of the final model which becomes heavier than the initial one. Some approaches try to improve this process while defining hierarchical NURBS surfaces (Qin01).

This thesis aims at defining models, methods and tools to detect and treat locally over-constrained and/or inconsistent configurations that may occur when defining and/or modifying NURBS surfaces. The detection module should produce an analysis of problematic configurations, i.e. a set of areas where either some new DOFs or some local changes in the constraints are mandatory. The treatment module should enable the definition of mechanisms to help the decision on modifications. On the basis of actual 2D sketchers, the idea is to be able to propose some appropriate tools to analyse the constraints and suggest some modifications in 3D. Thus, the number of DOFs will be optimized and there will be no systematic insertion of new DOFs.

Through the tools already developed and available within the INSM team of the LSIS laboratory, the candidate will have to analyse some critical configurations to identify the logical structures of some over-constrained configurations, thus enabling their analysis and post-treatment (identification of corrective solutions). The candidate will take advantage of the work of D. Lesage (Lesage02) that has been working on the definition of models and methods for the detection of such configurations on planar curves within a 2D sketcher.

(Cheutet06) Towards semantic modelling of free-form mechanical products, Cheutet V., Thèse de doctorat en cotutelle entre INP-Grenoble (France) et Università degli studi di Genova (Italy), 2006.

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(Panchetti09) Exploitation d'images numériques pour la simplification et la déformation de modèles polyédriques, Panchetti M., Thèse de doctorat ENSAM, 2009.

(Pernot04) Fully free-form deformation features for aesthetic and engineering designs, Pernot J-P., Thèse de doctorat en cotutelle entre INPGrenoble (France) et Università degli studi di Genova (Italy), 2004.

(Pernot08) A hybrid models deformation tool for free-form shapes manipulation », Pernot J-P., Falcidieno B., Giannini F., Léon J-C., 34th Design Automation Conference (ASME DETC08-DAC49524), New-York, USA, 2008.

(Qin01) Hierarchical D-NURBS surfaces and their physics-based sculpting. Meijing Zhang et Hong Qin, SMI 2001 International Conference, pp. 257 – 266.

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Keywords: geometric modelling, numerical optimisation, local over-constraints, inconsistent configurations, bipartite graphs.

Candidate profile: computer graphics, applied mathematics, C/C++ programming.

Candidature: send CV + motivation letter to the above mentioned contacts.

Application:

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