About the Challenges of Surface Reconstruction

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Abstract:

We consider the problem of constructing a Bézier or B-spline surface from an unorganized points cloud. The method introduced by M. Eck and H. Hoppe in ACM SIGGRAPH 96 consists in four consecutive steps: the first one is a mesh generation. Several methods can be considered: α-shapes, Delaunay triangulations or Marching cubes if the points cloud is a digital surface. The second step is the partition of the mesh of arbitrary topology in "patches" homeomorphic to discs. This problematic is directly related with the domain of shape analysis. The third step is the parametrization of each patch. This topic has a rich history since it is related with cartography, riemannian geometry... Mesh parametrization has been recently the center of many recent works as key-point of texture mapping. The last step is a Least-Squares Fitting routine computing the surface having a minimal error vector. The norm of the error vector considered in Least-Squares Fitting is euclidian while other norms can also be considered. In the case of L_1 or L_∞ norms, the computation of the surface providing the minimal error is expressed by a linear program which can be solved by any LP algorithms.

The assembling of these four steps is not straightforward.

The first challenge is about the partitioning step. What should be the properties of the partition in order to simplify the following steps?

Second question is about the mesh generation. One of the best parametrization scheme is related to harmonic maps but its use requires specific meshes: the sum of the opposite angles of an edge should be less than π. Such a property characterizes the Delaunay triangulation of a 2D-set but such a triangulation does not always exist for a 3D-set since all 3-simplexes do not verify this property. It leads to the questions of the conditions of existence of such triangulations, their relation with other meshes and the way they could be computed.

Third question is about the computation of the parametric surface corresponding to each patch. Is it hard to guarantee the regularity of their junction? Should they be computed sequentially or is it possible to obtain them in parallel ?

As far as we know, these questions are open and their presentation would be a great occasion to meet people interested in this area.

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