Reconstruction of 3D "colored" Data†

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Abstract
An automatic method is proposed for reconstructing a 3D volumic representation of complex objects and scenes. Input data have associated colors, but may be sparse and heterogeneous, and do not need to be organized in any special way. The method is based on Voronoi diagrams and produces volumes. As to illustrate the power of the method, we present experimental results on geological data and medical tomographic images. This extends to three dimensions the reconstruction method we have proposed for the two-dimensional case (see [BN96]). The details about a real case study in geology modeling have been worked out in [NCG+].

1. Introduction

Automatic or semi-automatic reconstruction algorithms have proved to be efficient in a lot of domains, e.g, Medical imaging, Geology. Two main problems have been well studied in previous works: Volume reconstruction from (1) unorganized set of points (2) cross-sections. Methods in [EM94, HDD+92] are efficient approaches to reconstruct shapes from a set of points. Volume reconstructions starting from cross-sections in [OPC96, DSK91, BG92], are mainly based on a clever Delaunay triangulation or Voronoï diagram of the data, and improved by local operations. Current algorithms, require complete, close and more-or-less parallel sections. In the reconstruction method proposed here, the geometry of the input data is arbitrary but data are assumed to be colored. The color might represent for instance the X-ray absorption of a tissue or the nature of the underground. Attributing colors to data allows to reconstruct simultaneously objects that are known to be distinct. In the usual methods the objects are reconstructed independently and the reconstructed objects may intersect, or they are reconstructed simultaneously and the information about the nature of the objects is forgotten.

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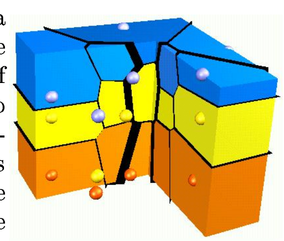
2. Reconstruction of colored objects

Our reconstruction method is based on “proximity” and therefore uses Voronoi diagrams. For simplicity, we describe the method for data points. First, the heterogeneous data set S (points, lines, surfaces, …) is discretized into a set of points S_d. A point inside an object receives a color. A point on the boundary B of two objects is duplicated and the two copies are slightly displaced (normally to B) and colored according to the two objects. We have to pay attention that the Delaunay triangulation of S_d conforms to the linear data of S in the sense given by [ET92, She96].



We successively compute a Voronoi diagram V of the colored points. Each cell of V is colored according to its Voronoi center. By merging the adjacent Voronoi cells that have the same color, we obtain a partition R of the space into colored connected regions (right Figure: clipped Voronoi regions of 3D colored points). A colored region A is represented as the adjacency graph of the Voronoi cells whose union is A. The color c_A of A is the color of its cells. The boundary of A consists of the Voronoi faces that are incident to a cell of A and to a cell of color $c \neq c_A$.

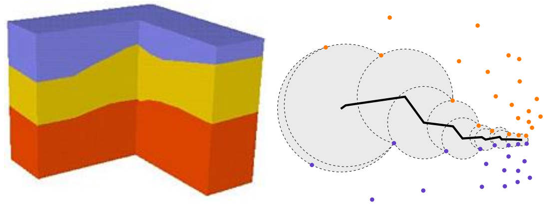
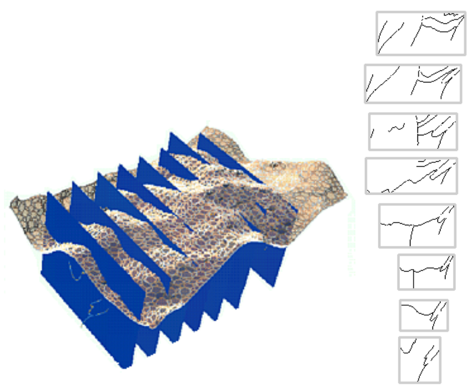


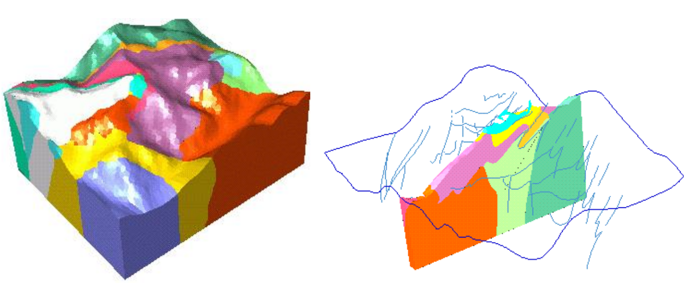
Figure 1: *Smoothed Voronoi region. Empty Voronoi balls for a 2D colored set of points.*

In addition, we smooth the boundaries of the regions of R, in such a way that the topology of the Voronoi regions is preserved, i.e. each new deformed region contains the same set of points as initially. This is guaranteed by constraining the deformed boundary to remain inside the union of the empty balls (see Figure 1) associated to the vertices of the Voronoi diagram.

3. Results

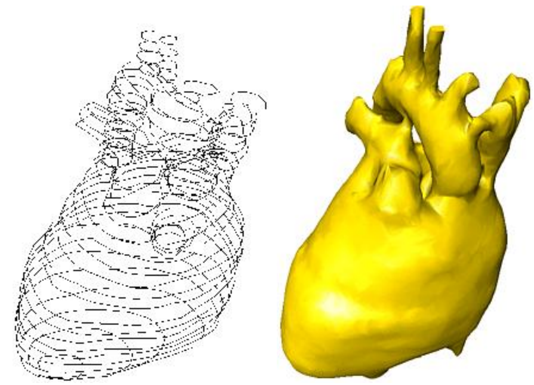
We have applied our method to reconstruct 3D geological model. The following example (next Figure) shows Aiguille de Morges in the French Alps. The initial data (left) are composed of eight incomplete cross-sections and the D.E.M. . On each section non closed contours are known (right). The DEM surface is discretized and colored according to a geology map and the atmosphere is treated as an object.





The previous Figure shows the reconstructed result (left) and a thin section of it (right).

Next example shows a heart defined by contours in parallel cross-sections. Contours are discretized using *IN* and *OUT* colors. The resulting object is simply the smoothed union of Voronoi cells that are colored *IN*.



Quality of the results is really difficult to measure, since it strongly depends on the data. In its current stage, our algorithm relies on the assumption that the environment is isotropic. However, taking local or global anisotropy into account would be possible by using Voronoi diagrams based on non-Euclidean metrics. This would be of particular interest in geological applications where directions of the layers may be known. We look forward considering such an extension. Work on discretization quality is also pursued.

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