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Minimizing edge length to connect sparsely sampled unstructured point sets

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Highlights

- A perception-inspired minimization objective for connecting sparse samples with an orientable closed triangulation.
- Introduction of the boundary complex, an extension of the Minimum Spanning Tree into 3D.
- Topological operations to transform the boundary complex into a Closed Manifold Triangulation for extremely sparse point sets.

Abstract

Most methods for interpolating unstructured point clouds handle densely sampled point sets quite well but get into trouble when the point set contains regions with much sparser sampling, a situation often encountered in practice. In this paper, we present a new method that provides a better interpolation of *sparsely* sampled features.

We pose the surface construction problem as finding the triangle mesh which minimizes the sum of all triangles' longest edge. Since searching for matching umbrellas among sparsely sampled points to yield a closed manifold shape is a difficult problem, we introduce suitable heuristics. Our algorithm first connects the points by triangles chosen in order of their longest edge and with the requirement that all edges must have at least two incident triangles. This yields a closed non-manifold shape which we call the *Boundary Complex*. Then we transform it into a manifold triangulation using topological operations. We show that in practice, runtime is linear to that of the Delaunay triangulation of the points. Source code is available online.

Graphical abstract

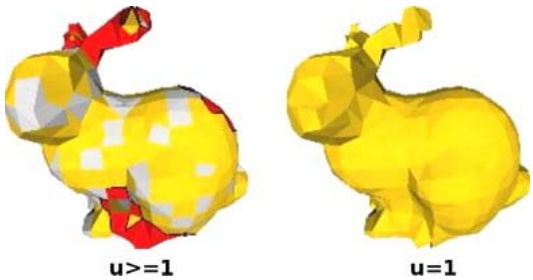

Figure options

Keywords

Surface reconstruction; Point cloud; Boundary complex; Sharp features; Sparse sampling; Energy minimization

1. Introduction

Defining the piece-wise linear boundary shape for a solid object in R^3, for which only the surface point coordinates but nothing of its connectivity is known, is a difficult problem. It has been the subject of a lot of research over the last 3 decades. Unorganized point sets are increasingly encountered resulting from simulations of objects with connectivity changing over time, or editing, e.g. with particles or sketches. Scanning techniques may supply the connectivity partly though not reliably, say in the form of estimated