Noise Robust Surface Reconstruction by Combining PU and Graph-cut

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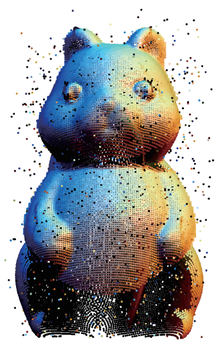
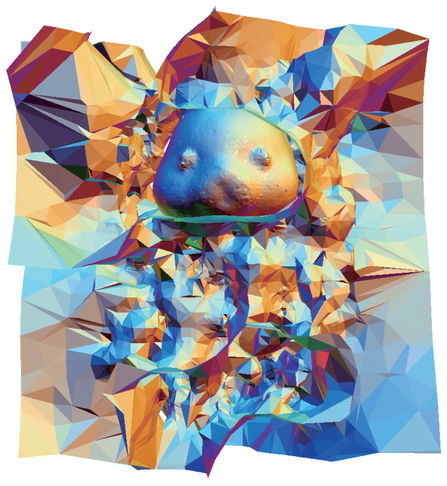
Overview

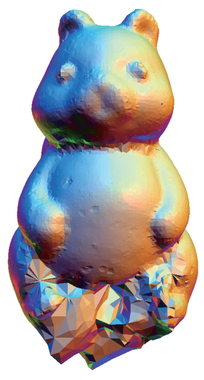
We present a novel method of reconstructing surfaces from 3D scattered points by combining Partition of Unity (PU) and a Graph-cut approach. PU is a local approximation technique, meaning that the surfaces obtained have high accuracy but are sensitive to noise. Graph-cut, on the other hand, is a global algorithm that is robust to noise but produces low-accuracy results because it is a discrete binary operation.



Sampling points



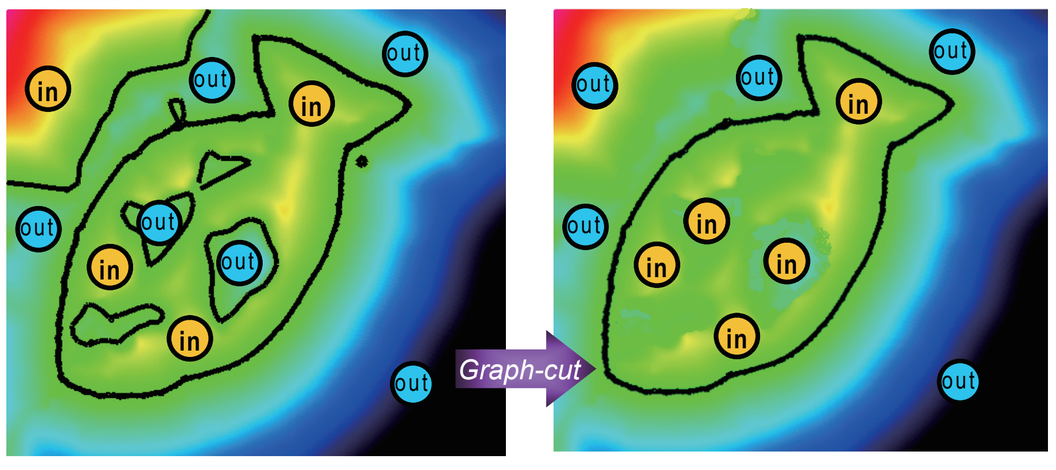
PU only



PU + Graph-cut

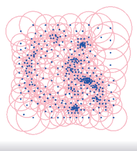
Our algorithm combines PU and Graph-cut to achieve robust, high accuracy surface reconstruction. **1.** A PU implicit function is constructed by covering a space containing a point cloud with spherical supports of linear polynomials. **2.** Graph-cut is performed to separate the covered domain into inside and outside areas of the object to be reconstructed. **3.** The surface mesh is extracted using the marching tetrahedra approach.

PU scalar field

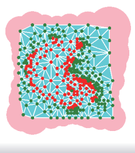


Outline

Points with normals



Partition of Unity (PU)
Covering by local approximations

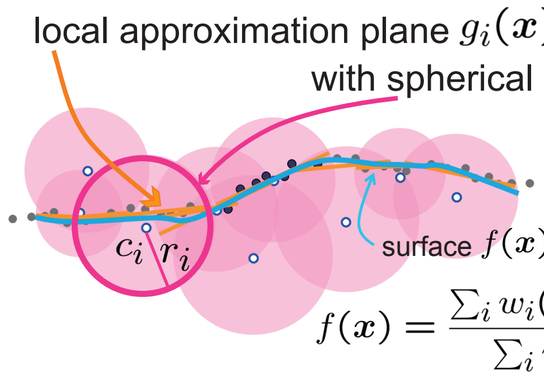


Graph-cut
Tetrahedral meshing, In/out classification

Surface mesh generation

1. Partition of Unity (PU) Implicit

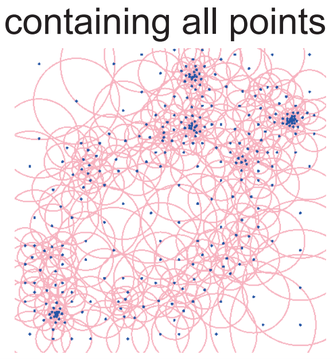
local approximation plane $g_i(\boldsymbol{x})$ with spherical support



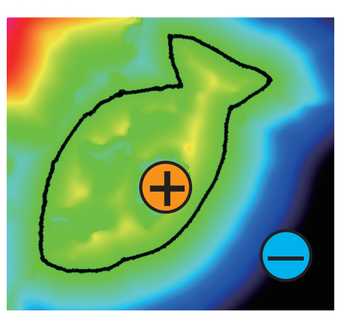
$$f(\boldsymbol{x}) = \frac{\sum_i w_i(\boldsymbol{x}) g_i(\boldsymbol{x})}{\sum_i w_i(\boldsymbol{x})}$$

$w_i(\boldsymbol{x})$: 2nd degree B-spline

Spherical cover of the domain containing all points

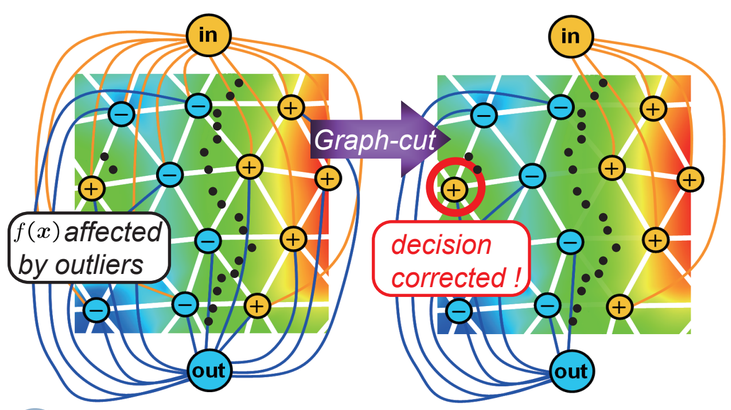


$f(\boldsymbol{x})$: inside positive

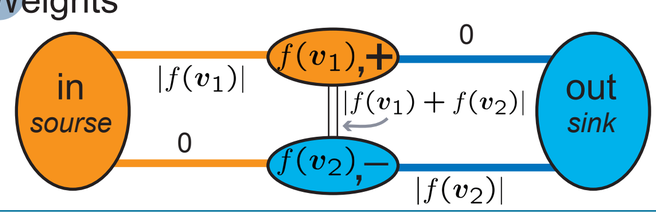


2. Graph-cut

Graph: weighted Delaunay tetrahedrization for sphere centers $\{(c_i, r_i^2)\}$
+ terminals (source and sink)
+ edges { (terminal, mesh vertex) }

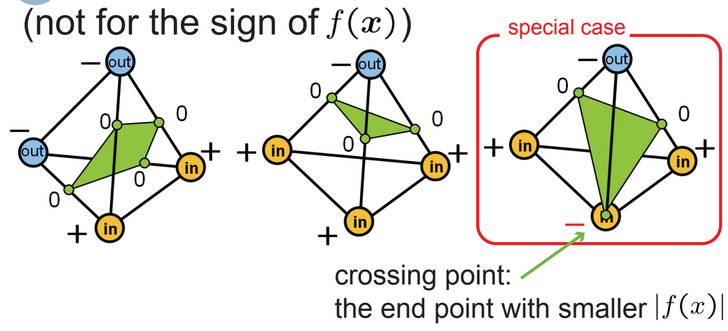


Weights

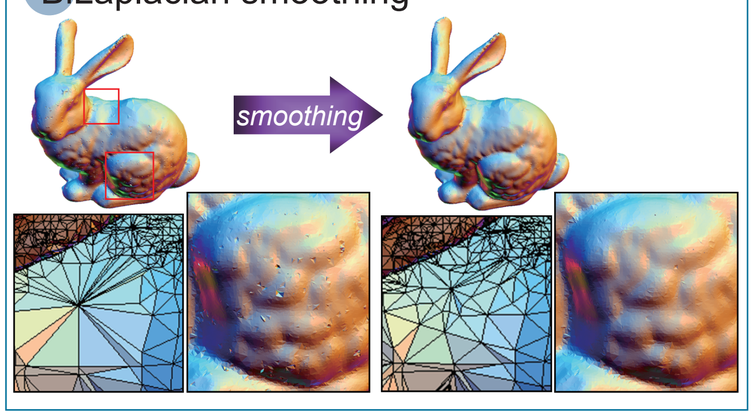


3. Surface Mesh Generation

Marching tetrahedra for in/out decision (not for the sign of $f(\boldsymbol{x})$)

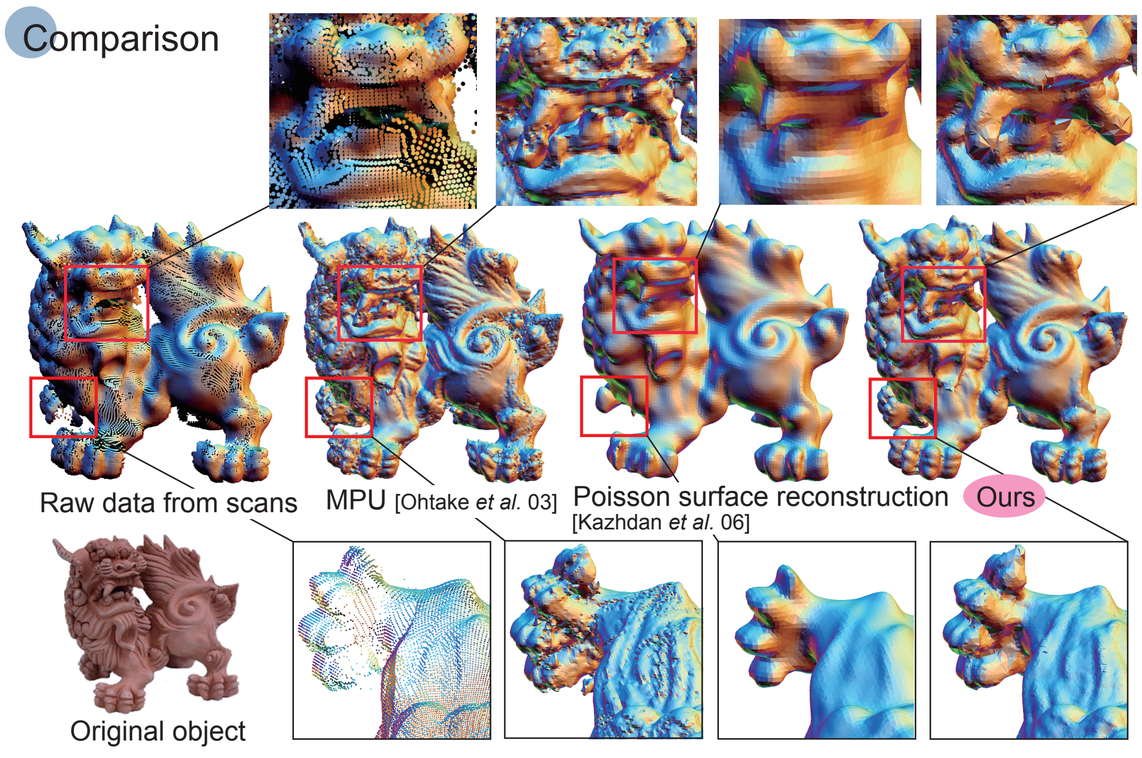


BiLaplacian smoothing



Results

Comparison



Hole filling