Robust Shape Reconstruction

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Abstract. We describe a recent framework for shape reconstruction based on optimal transportation between measures, where the input measurements are seen as distribution of masses. In addition to robustness to defect-laden point sets (hampered with noise and outliers), this approach can reconstruct smooth closed shapes as well as piecewise smooth shapes with boundaries.

1 Introduction

Shape reconstruction from measurements remains one of the most important concerns in geometry processing. While technological advances on sensors and scanners have greatly increased the availability of very detailed geometric measurements, current datasets are increasingly defect-ridden for several reasons: sensors are evolving from contact to contact-free and from short to long range, commodity scanners become cheaper but with higher levels of uncertainty and practitioners often resort to large series of low-cost acquisitions instead of one accurate but expensive acquisition. Consequently, the need for reconstruction methods that are robust to noise and outliers is growing steadily.

2 Smooth, Closed Shapes

In parallel to the reconstruction literature, the design of approximate unsigned distance functions which are robust to noise and outliers has recently made significant advances [CCSM09]. This approach leverages the notion of distances between *measures* to gain robustness while retaining the usual properties of distance functions including stability and semiconcavity. The distance function from a position x to a pointset is formulated as a minimization of the Wasserstein distance (a variant of the earth-mover's distance) between a delta function at x and a set of measures defined from the pointset. The resulting robust function, however, does not lend itself to reliable surface reconstruction: contouring of an unsigned distance is unreliable, creating numerous geometric and topological artifacts. We thus propose to sign the unsigned distance in order to obtain an implicit function suitable for contouring. We leverage the fact that signing a function, rather than the data, can be made more robust by exploiting the property that signing a distance function makes the function smoother [MdGD$^+$10].

3 Piecewise Smooth Shapes with Boundaries

For piecewise smooth shapes with boundaries we reconstruct a shape through an iterative, feature-preserving simplification of a simplicial complex constructed from the input point set. To achieve noise and outlier robustness, an error metric driving the simplification is derived in terms of optimal transport between the input point set and the reconstructed mesh, both seen as mass distributions [dGCSAD11].

References

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