Multi-scale Non-Rigid Point Cloud Registration Using Robust Sliced-Wasserstein Distance via Laplace-Beltrami Eigenmap

Hongkai Zhao
University of California, Irvine
Email: zhao@math.uci.edu

In this work, we propose computational models and algorithms for point cloud registration with non-rigid transformation. First, point clouds sampled from manifolds originally embedded in Euclidean space are transformed to new point clouds by Laplace-Beltrami(LB) eigenmap using the n leading eigenvalues and corresponding eigenfunctions of LB operator defined intrinsically on the manifolds. The LB eigenmap are invariant under isometric transformation of the original manifolds. Then we design computational models and algorithms for registration of the transformed point clouds in distribution/probability form based on the optimal transport theory which provides both generality and flexibility. Our methods use robust sliced-Wasserstein distance, which is the average of projected Wasserstein distance along different directions, and incorporate a rigid transformation to handle ambiguities introduced by the Laplace-Beltrami eigenmap. By going from smaller n, which provides a quick and robust registration (based on coarse scale features) as well as a good initial guess for finer scale registration, to a larger n, our method provides an efficient, robust and accurate approach for multi-scale non-rigid point cloud registration.