Computational Conformal Geometry and Optimal Mass Transport with Applications on Medical Images

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Abstract

In this talk, we would like to introduce the computational conformal geometry and optimal mass transport with its applications on medical images. The well-known uniformization theorem shows that a closed surface of genus-zero is equivalently conformal to a unit sphere. However, the numerical method and its convergence should be addressed. We will propose efficient algorithms on conformal energy minimization (CEM), stretch energy minimization (SEM) and volume stretch energy minimization (VSEM) for finding the conformal (angle-preserving) and equiareal (area-preserving) parametrizations, respectively, between a simply connected closed surface and a sphere, as well as, the volume-preserving parametrization between a 3-manifold with a single genus-zero boundary and a unit ball. Based on the SEM and VSEM algorithms we further develop the reliable and robust algorithms for solving the optimal mass transport (OMT) between an irregular 3D domain and a unit ball, while minimizing the deformation cost, and keeping the minimal distortion and the local mass ratios unchanged. Combining the proposed OMT with the U-net machine learning algorithm, we develop a novel two-phase OMT algorithm successfully applying for the detection and segmentation of 3D brain tumors with high training and validation Dice scores.