QUASI-ISOMETRIC FLATTENING OF LARGE-SCALE CORTICAL SURFACES*

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Abstract

For quantitative analysis in high-resolution imaging studies of neocortex from either MRI or tissue section data, surface-based representations, including *flattened* representations, have come into wide use. Cortical flattening is especially important for receptotopically organized cortex, since sensory maps are 2D in nature but are embedded in 3D as a convoluted surface. Both visualization and analysis are difficult without accurate flattened cortical representations. Early flattening algorithms [Schwartz & Merker, *IEEE CGA*, 6:36–44, 1986] were based on computing a geodesic distance matrix, followed by an optimal metric-preserving mapping into 2D. Variants of this method are commonly used, but algorithms based directly on geodesic distance matrix computation have been considered too expensive for large-scale MRI data sets. Here we show that recent improvements in efficiency and computer power have made this approach feasible for large data sets, producing mesh-independent, optimally quasi-isometric solutions.

First we present a method for computing minimal geodesics on a triangular mesh, which rapidly computes exact distances on meshes with thousands of triangles, as opposed to the approximate geodesics derived from Dijkstra's algorithm. Then, two flattening algorithms are presented. The first optimally preserves the lengths of minimal geodesics and is practical for meshes with up to 30,000 triangles. To flatten larger-scale meshes, a multi-scale algorithm is presented that respects the original geodesic distances by using the first algorithm at the coarsest scale and iteratively refining the flattening at finer scales. Together these algorithms significantly improve the speed and accuracy of quasi-isometric flattening methods. Demonstrations of our flattening algorithm applied to surface reconstructions of human occipital cortex, with a per-vertex error analysis, are given. (See Polimeni *et al.* and Hinds *et al.*, this meeting, for further demonstration of this approach.)

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