CEIG – Spanish Computer Graphics Conference (2019), pp. 1–1
A. Jarabo and D. Casas (Editors)

Quasi-Isometric Mesh Parameterization using Heat-based Geodesics and Poisson Surface Fills

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Abstract

In the context of CAD CAM CAE and reverse engineering, the problem of mesh parameterization is a central process. Mesh parameterization implies to compute a bijective map ϕ from the original mesh $M \in \mathbb{R}^3$ to the planar domain $\phi(M) \in \mathbb{R}^2$. The mapping may preserve angles, areas or distances. Distance-preserving parameterizations (i.e. isometries) are obviously attractive. However, geodesic-based isometries present limitations when the mesh has concave or disconnected boundary (i.e. holes). Recent advances in computing geodesic maps using the heat equation in 2-manifolds motivate us to re-visit mesh parameterization with geodesic maps. We devise a Poisson surface underlying, extending and filling the holes of the mesh M. We compute a near-isometric mapping for quasi-developable meshes by using geodesic maps based on heat propagation. Our method: (1) pre-computes a set of temperature maps (heat kernels) on the mesh, (2) estimates the geodesic distances along the piecewise linear surface by using the temperature maps, and (3) uses multi-dimensional scaling (MDS) to acquire the 2D coordinates that minimize the difference between geodesic distances on M and euclidean distances on $\mathbb{R}^2$. This novel heat-geodesic parameterization is succesfully tested with several concave and/or punctured surfaces, obtaining bijective low distortion parameterizations. Failures are registered in non-segmented, highly non-developable meshes (such as seam meshes). These cases are the goal of future endeavors.

CCS Concepts

•Mathematics of computing → Partial differential equations; •Theory of computation → Computational geometry; •Computing methodologies → Texturing; Parametric curve and surface models; •Applied computing → Computer-aided design;

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