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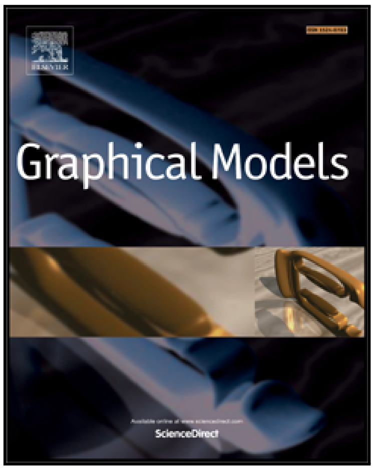

A Fast Propagation Scheme for Approximate Geodesic Paths

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A Fast Propagation Scheme for Approximate Geodesic Paths

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Abstract

Geodesic paths on surfaces are indispensable in many research and industrial areas, including architectural and aircraft design, human body animation, robotic path planning, terrain navigation, and reverse engineering. 3D models in these applications are typically large and complex. It is challenging for existing geodesic path algorithms to process large-scale models with millions of vertices. In this paper, we focus on the single-source geodesic path problem, and present a novel framework for efficient and approximate geodesic path computation over triangle meshes. The algorithm finds and propagates paths based on a continuous Dijkstra strategy with a two-stage approach to compute a path for each propagating step. Starting from an initial path for each step, its shape is firstly optimized by solving a sparse linear system and then the output floating path is projected to the surface to obtain the refined one for further propagation. We have extensively evaluated our algorithms on a number of 3D models and also compared their performance against existing algorithms. Such evaluation and comparisons indicate our algorithm is fast and produces acceptable accuracy.

Figure 1: Geodesic paths computed using our FPP (Fast Path Propagation) algorithm. Herein, the Lucy model contains 14M vertices. Refer to the supplementary material for more results.

1. Introduction

With the fast advancements in 3D reconstruction and scanning technology, 3D digital models of large and complex real objects are becoming more and more accessible. Such developments have made possible many applications in 3D geometry processing and shape analysis. Geodesics often play a fundamental role in these applications. For example, applications of geodesic distance include re-meshing [22], shape retrieval [27], and shape segmentation [5].

In contrast to geodesic distance, geodesic paths seem to have received less attention. Nevertheless, geodesic paths are indispensable in many research and industrial fields. For example, when Boeing was designing composite airplanes, one of the key steps is to identify geodesic paths across various surfaces of the airplane structure [19]. Geodesic paths can improve the performance of composite tapes as well as save weight and material. In general, geodesic designs have been widely utilized [3] in aircraft structures made of composite materials. Geodesic designs give rise to light-weight and cost-efficient composite structures. It is worth noting that such a geodesic design actually requires computing geodesic paths from all sources to all destinations. Geodesic paths are also critical to architectural design [23, 11], where geodesic curves can be used to decompose a mesh into adjoining strips. In human body animation, geodesic paths have been employed to reconstruct facial muscle fibers and the muscle fibers of a human heart, respectively [1, 15]. Geodesic paths from one source to all destinations are required in such work. In addition, geodesic paths have been widely applied to robotic path planning [12], terrain nav-