Abstract

This doctoral thesis presents a generic framework for providing end-to-end GPU-based solutions on isotropic remeshing of a two-dimensional manifold, which is given as input in the form of a triangle mesh. Based on the specified resolution, the mesh is first voxelized, and then the voxelized surface is processed for *centroidal Voronoi tessellation* (CVT) with some well-defined field on the surface for a particular distance metric. Although there exists a multitude of CVT techniques for 3D objects considered as discrete volumes, e.g., as sets of voxels, there is no significant work in the literature on CVT computation for voxelized surfaces. In this thesis we focus on this problem and propose a novel GPU-based algorithm for CVT computation on a voxelized surface. Its novelty rests on several fundamental ideas. Firstly, the digital surface, while being voxelized from a triangulated surface, comprises digital or voxelized triangles that are 2-minimal in topological sense. As a result, each voxel of the digital surface has the smallest possible neighborhood, which eventually limits the search space and aids in efficient computation. Secondly, as the optimization constraint, a novel formulation of *Voronoi energy* is used, which is easy to compute and leads to quick convergence of the algorithm. The GPU-based algorithm with related procedures and their complexity analysis have been discussed in detail, and related experimental results have also been furnished to adjudge the merit and usefulness of the proposed algorithm. For selection of seeds, needed for Voronoi tessellation, an efficient strategy of *functional partitioning* is used to partition the digital surface into a collection of functional components.

We explore the concept of *directional field* on voxelized surface for purpose of vertex regularity and feature preservation. We define rotationally symmetric vectors for each voxel in order to estimate *field energy*. When combined with *Voronoi energy*, the field energy provides an estimate of the uniformity of tessellation in each iteration. In the resultant tessellation, the Voronoi regions are mostly uniform in size and shape. As a result, the faces in the output mesh are predominantly isotropic in nature and the corresponding vertices are predominantly regular (i.e., of degree 6 for triangular mesh and of degree 4 for quadrangular mesh). In case of quadrangular remeshing, we show how Voronoi tessellation with chessboard metric on a voxelized surface results to square isocontours in a Voronoi region. Experimental results on different datasets have been presented to demonstrate its efficiency and robustness.

In order to tackle the problem of Hausdorff error of output mesh with respect to the input tri-mesh, we extend our technique to adaptive remeshing. For this, we use discrete curvature on voxelized surface. The size of each and every triangle

in an output mesh is made to vary depending on the curvature of that region on the voxelized surface. To the best of our knowledge, existing CVT-based methods on voxelized surface do not take curvature as input for remeshing. Further, in order to keep the length of the edges in output mesh close to the desired value, we formulate *localized lattice energy* that encapsulates edge-length along with directional field. We combine Voronoi energy and localized lattice energy in order to safeguard the overall mesh geometry while optimizing the necessary isotropic features. The lattice energy has certain advantages and disadvantages over field energy, as discussed in the thesis.