Fracture generation on polygonal meshes using Voronoi polygons

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Abstract

This sketch describes a way of generating realistic cracks and fragments to visually simulate brittle fracture on polygonal surfaces.

Keywords: Natural Phenomena, Visual Simulation

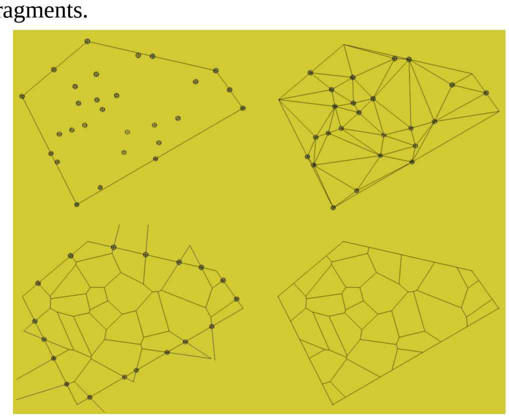
1 Introduction

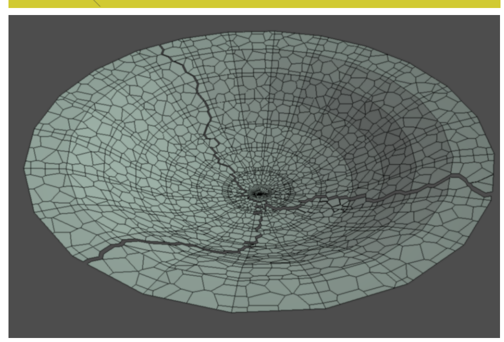
Prior computer graphical approaches to modeling inelastic deformation and brittle fracture have employed continuum approaches[1], cubical lattice spring networks[2] and more recently, tetrahedral finite elements[3] and Delaunay tetrahedra coupled with distance-preserving constraints[4]. The approach outlined in this sketch focuses on the generation of realistic cracks and fragments through synthesis of Voronoi polygons on each face of a given polymesh and subsequent propagation of cracks through the mesh by the separation of adjacent Voronoi polygons along their shared edges[5].

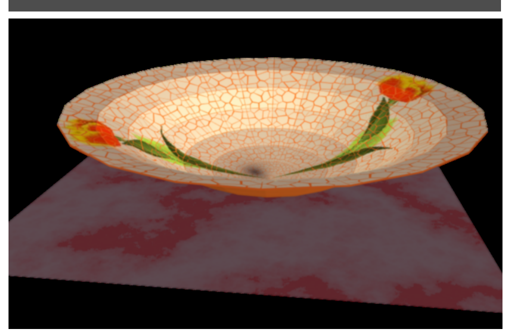
2 Cracks, fracture, fragment generation

The first step is to synthesize a Voronoi network on the polygons of the input mesh. This involves seeding the interior and edges of each polygon with additional seed points, triangulating the resulting point set (expanded to include the polygon vertices as well), constructing the Voronoi tessellation from the triangulation (its geometric 'dual'), and most importantly, clipping the Voronoi network against the edges of the parent polygon. The result is a collection of smaller polygons which tile the original polygon. The first figure on the right illustrates this step. When such a synthesis is carried out independently on each polygon of the original mesh, we obtain a 'piecewise' Voronoi network over the mesh. Note that a Voronoi network contains convex polygons where exactly three edges radiate from each vertex. This property is what is behind the visually realistic cracks and fragments we are about to generate.

The next step involves using the Voronoi polygons to cause the parent surface to crack/fracture. The idea is to advance cracks along the edges of the Voronoi polygon networks. This can be done in a variety of ways. For instance, Voronoi vertices could nucleate cracks which would traverse the parent surface until they terminate at a free edge or at an existing crack (see the second figure below). Alternately, a small number of spatially separated Voronoi polygons could serve as seeds for region-growing which would proceed outwards from these seeds, generating fragments. Holes could be created in the surface by removing some of these regions. Alternately the surface could be shattered into very small fragments by essentially turning each Voronoi polygon into a shard. Also, a network resembling ceramic 'glaze' cracks can be obtained by slightly shrinking each Voronoi polygon about its centroid (third figure below). These approaches could be either procedurally driven or be under animator control. As a final note, each of the generated fragments could be used to create Voronoi networks on a finer scale which in turn would be the source of smaller crack networks and fragments.







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