Fracture and Cutting

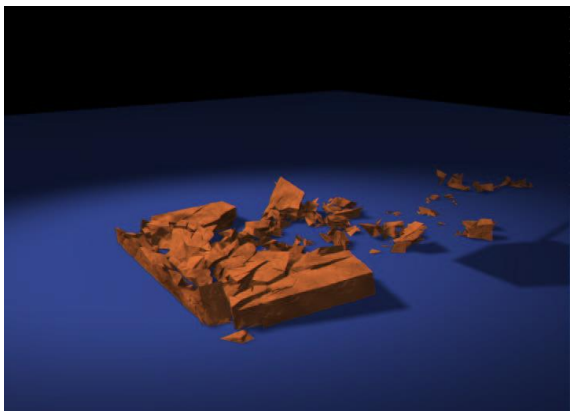
(CSCI 599 : Akshay Hegiste Scribe Notes)

Reference : J. O'Brien and J. Hodgins: Graphical Modeling and Animation of Brittle Fracture, SIGGRAPH 99.

The above mentioned paper is one of the most cited paper in Computer Graphics and Animation.

Introduction :

The approach used in this paper is to animate breaking objects based on linear elastic fracture mechanics. It models three-dimensional volumes using a finite element method (FEM) that is based on techniques presented in the computer graphics and mechanical engineeringliterature. By analyzing the stresses created as a volumetric object deforms, the simulation determines where crack should begin and in what directions they should propagate. The system accommodates arbitrary propagation directions by dynamically retesselating the mesh. Because cracks are not limited to element boundaries, the models can form irregularly shaped shards and edges as they shatter.



Algorithm :

The fracture algorithm is as follows:

After every time step,

The system resolves the internal forces acting on all nodes into their tensile and compressive components, discarding any unbalanced portions.

At each node, the resulting forces are then used to form a tensor that describes how the internal forces are acting to separate that node.

If the action is sufficiently large, the node is split into two distinct nodes and a fracture plane is computed.

All elements attached to the node are divided along the plane with the resulting tetrahedra assigned to one or the other incarnations of the split node, thus creating a discontinuity in the material.

Any cached values, such as the node mass or the element shape functions, are recomputed forthe affected elements and nodes.

With this technique, the locationof a fracture or crack tip need not be explicitly recorded unless this information is useful for some other purpose, such as rendering.

Explaination :

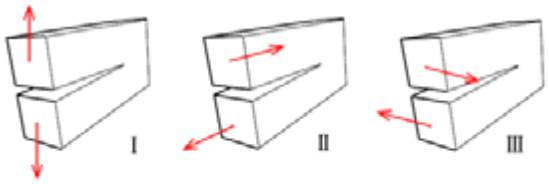
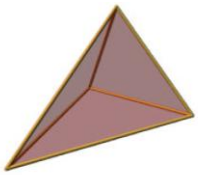
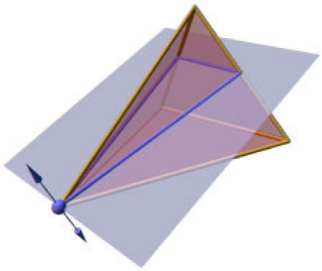


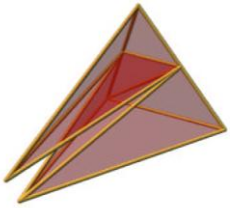
Figure 6: Three loading modes that can be experienced by a crack. Mode I: Opening, Mode II: In-Plane Shear, and Mode III: Out-of-Plane Shear. Adapted from Anderson [1].



(a)



(b)



(c)

(b) The initial tetrahedral element.

(b) The splitting node and fracture plane are shown in blue.

(c) The element is split along the fracture plane into two polyhedra that are then decomposed into tetrahedra. Note that the two nodes created from the splitting node are co-located, the geometric displacement shown in (c) only illustrates the location of the fracture discontinuity

1) Do FEM deformable dynamics.
2) For every vertex check

   IF VERTEX IS **OVERLOADED**(Threshold which can be set)

   IF YES THEN REMESH

3) Goto 1)

Important links and references :

J. O'Brien and J. Hodgins: Graphical Modeling and Animation of Brittle Fracture, SIGGRAPH 99.

http://graphics.eecs.berkeley.edu/site_root/papers/Obrien-GMA-1999-08/BreakingObjects.avi

E. Parker and J. O'Brien: Real-Time Deformation and Fracture in a Game Environment, ACM SIGGRAPH/Eurographics Symposium on Computer Animation, 2009.

http://graphics.cs.berkeley.edu/papers/Parker-RTD-2009-08/parker-2009-RTD-video.mov

Changxi Zheng and Doug L. James, Rigid-Body Fracture Sound with Precomputed Soundbanks, *ACM Transactions on Graphics (SIGGRAPH 2010)*

http://www.youtube.com/watch?v=nHH8N_lNZzI