

How Things Break – Physics, CGI Techniques and Houdini Practical Examples

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ANNNOTATED LIST OF REFERENCES AND RESOURCES

- Marder M. and Fineberg J., 1996. How Things Break - Solids fail through the propagation of cracks, whose speed is controlled by instabilities at the smallest scales. *Physics Today*, Vol. 49 (9), 24-28. Available from: www.ebsco.com [Accessed 01 May 2010]

This source is a good article that tries to explain the basic physics behind the everyday experience in which we know that if a glass falls down on the ground it will break and why a piece of metal won't. It also tells briefly the story behind the fracture mechanics. It explains the concepts in a good way making understandable these concepts also to people that are not physicists.

I used this article to explain all the physics behind the breaking material.

- Norton, A., Turk, G., Bacon, B., Gerth, J., Sweeney, P., 1991. Animation of fracture by physical modeling. *The Visual Computer*, Vol. 7 (4), 210-219. Available from: www.ebsco.com [Accessed 03 May 2010]

This article is one of the first that tries to explain and solve the problem of the simulation of breaking objects in 3D in CG. It is quite basic but it has been the basement on which later papers and articles have developed their work. The basic concept is that each geometry is a set of nodes(point mass) and edges(springs), and their interaction with external forces produces the different simulations.

I used it to explain the very basic way of solving the problem. Understanding the base it is easier to understand the more complex things.

- O'Brien, J. and Hodgins, J., 1999. Graphical Modeling and Animation of Brittle Fracture. In: *Proceedings of the 26th annual conference on Computer graphics and interactive techniques*, Los Angeles, CA. New York: ACM Press/Addison-Wesley Publishing Co. pp. 137-146. Available from: www.portal.acm.org [Accessed 03 May 2010]

This paper tries to find a way for creating a physics driven simulation. The method shown is very accurate but also not very efficient (and not in real time). It is very realistic for breaking brittle objects.

I used it to explain a more sophisticated way of resolving the problem. It is based on physics laws. It uses tensors computed over a finite element model to find where the crack starts and where it propagates and it recalculates the remeshing as the crack advances.

- O'Brien, J., Bargteil, A., and Hodgins, J., 2002. Graphical Modeling and Animation of Ductile Fracture. In: *Proceedings of the 29th annual conference on Computer graphics and interactive techniques*, San Antonio, Texas. New York: ACM. pp. 291-294. Available from: www.portal.acm.org [Accessed 02 May 2010]

This paper is the extension of the previous one. It explains how, modifying few aspects of the previous method, this new method can simulate also breaking ductile materials in a very realistic way.

I used this paper because it is the natural continuation of the previous work and completes it.

- Martinet A., Galin E., Desbenoit B., Akkouche S., 2004. Procedural Modeling of Cracks and Fractures. In: *Proceedings of the Shape Modeling International*, Genova, Italy. Washington DC: IEEE Computer Society. pp.346 - 349. Available from: <http://liris.cnrs.fr/Documents/Liris-1915.pdf> [Accessed 03 May 2010]

This paper shows another way of approaching the problem. It creates an efficient algorithm to produce realistic breaking and fracturing object. It is not physics driven.

I used it to show a more artistic way of producing an efficient simulation. It uses a mask that can be drawn or similarly created and then produce the fracturing. It is quite automatic once the initial conditions are set.

- Spicer, P. , 2006-2007. *Creating Objects that Dynamically Break Apart*. Lecture Notes. Bournemouth University

I used some of the Phil Spicer Lecture Notes to start to understand the basic way in which fracturing and breaking work in Houdini.

- Zerouni, C., 2006. *Houdini: Rigid Body Dynamics*. The Gnomon Workshop. DVD.

This tutorial is a very rich source of information especially to understand how the rigid bodies simulations work in Houdini.

I used part of this tutorial to understand better some aspects of the RBD simulations and the dop networks.

- Houdini Software. Side Effects Software. Vers. 10.

I used Houdini like software for developing 3 simple simulations of things that break.