Self-Organized Criticality as a Method of Procedural Modeling

Alex Pytel*
David R. Cheriton School of Computer Science
University of Waterloo

Figure 1: SOC coastline evolution.

CR Categories: I.3.5 [Computer Graphics]: Computational Geometry and Object Modeling—Physically based modeling;

Keywords: procedural modeling, self-organization, erosion

1 Introduction

Self-organized criticality (SOC) is a theory of fractal dynamics in which a physical system approaches an attractor state that is scale-free. In the simple example of a sandpile, the grains of sand can slip down steep slopes and the resulting changes to the system propagate via avalanches. By the time the sandpile reaches the attractor state, the avalanches have propagated throughout the entire system and the features of the resulting landscape are not tied to a specific length scale.

As long as a process of erosion causes transport of material to occur within a physical system, it will exhibit SOC properties to some extent. The physical systems that have been previously studied from this point of view include sandpiles [Duran 2000], coasts [Sapoval et al. 2004], and river basins [Rodríguez-Iturbe and Rinaldo 1997]. Noting how broadly the theory of SOC applies, I suggest that the elements of SOC system evolution can be used as a method for procedural creation of geometry. Specifically, SOC avalanches are geometric in nature and can be applied more freely than SOC, as a physical theory.

My poster demonstrates that in order to use avalanches effectively as a modeling paradigm a certain notion of scale has to be re-introduced into them. As an illustration, I show that the extended SOC-based procedural modeling method can simulate the melting of the Earth’s polar ice cap in a plausible way.

Figure 2: Coastline length within a search radius.

2 Local and Global Shape

The avalanches that dominate SOC coastline evolution (Figure 1) can be modified to respond to local parameters, distinguishing local and global shape. I re-introduce a notion of scale into the behaviour of the avalanches using a local formulation of coastline length, illustrated in Figure 2.

3 Polar Ice Cap

To simulate the melting of the polar ice cap, I also rely on local parameters to control avalanching. These parameters are: land distribution [Rekacewicz 2005], ice distribution [Ahlenius 2007], approximate ice thickness [Maslanik and Fowler 2009], and latitude. Figure 3 shows a result of the simulation following some erosion.

Figure 3: Simulation of ice cap melting.

References


