Cellular Forms: an Artistic Exploration of Morphogenesis

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1. Introduction

Cellular Forms: a series of computationally created artworks that uses digital simulation of morphogenetic processes. The aim is to create structures emergently: exploring generic similarities between many different forms in nature rather than recreating any particular organism, revealing universal archetypal forms that can come from growth-like processes rather than top-down externally engineered design.

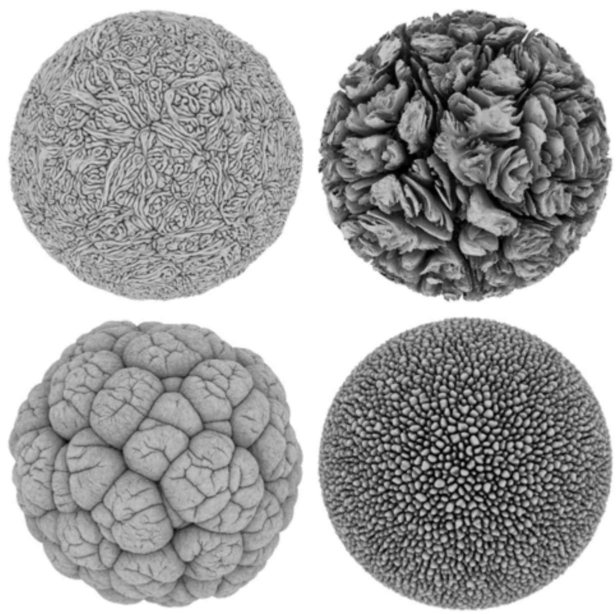

Figure 1. Examples of Cellular Forms.

2. Simulation and Rendering

Cellular Forms uses a simplified biological model of morphogenesis, with three dimensional structures created out of interconnected particles to represent cells. Each form starts with a small initial ball of cells which is incrementally developed over time by adding iterative layers of complexity to the structure.

A number of internal forces affect the structures. These include linear and torsion spring forces between connected cells. Additional forces repel cells that are in close proximity but are not directly connected. This imposes important physical constraints on the system which gives global structural coherence to the forms.

Cell division can be triggered by a variety of means, including accumulated nutrient levels. When the nutrient level in a cell exceeds a given threshold the cell divides. Various parameters for the system control effects such as how the plane of cleavage is chosen, and how both the parent and daughter cells re-connect to their immediate neighbors. Rules can also be adjusted for how nutrient is created, such as by being randomly uniformly produced by each cell, by use of reaction diffusion equations, or by incident light rays creating nutrient in cells hit by photons. Nutrient can also be allowed to flow to adjacent cells.

This process is repeated over thousands of iterations and tens of millions of cells to produce the final forms. The resulting artistic artifacts are high resolution images of final forms and animations showing the progress of the simulation over time.

3. Results

Many different complex organic structures are seen to arise from subtle variations on the rules governing the systems, with selection of forms based on aesthetic considerations. As such, this work is exploratory rather than trying to mimic any specific target behavior, though forms naturally emerge with strong reminiscences of plants, corals, internal organs and micro-organisms.

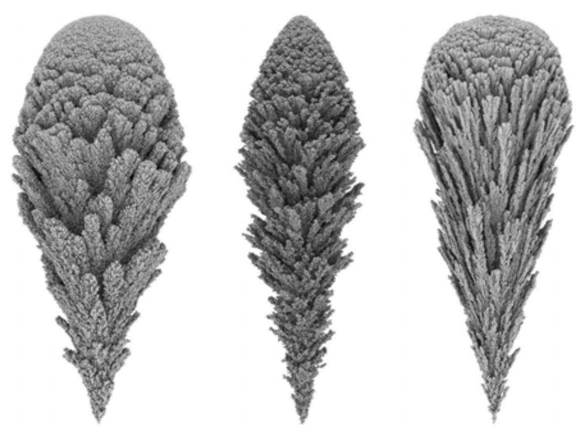

Figure 2. *Forms showing behavior such as folding and bifurcations.*

Since the principal aim is to emergently create intricate aesthetically interesting forms a number of simplifications are made when compared with a model designed to accurately simulate biological processes. In order to get the levels of geometric detail required the model that is used was designed to be computationally simple enough to be able to run with millions of primitives, and algorithmically capable of making use of the computational capabilities of graphics processing units. In particular the model does not feature cell motility or differentiation. Despite this a remarkable range of different biologically convincing forms are seen to be created. Examples of emergent behavior include complex folding, bifurcations, rhythmic pulses and waves of growth propagating across surfaces.

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