Aggregation: Complexity out of Simplicity

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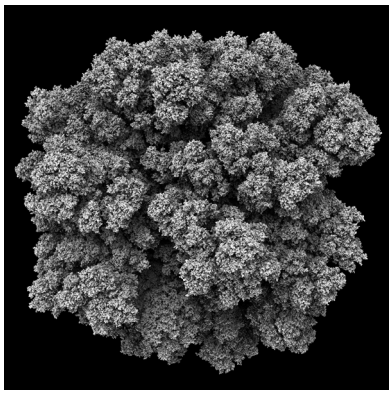

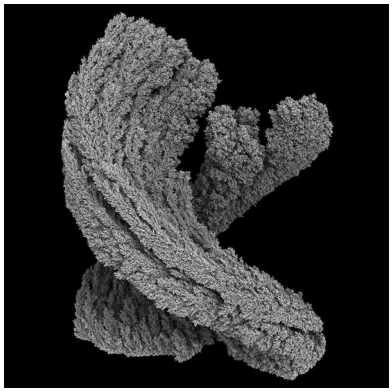

1 Introduction

This sketch presents a look at the creative processes and mathematical algorithms used to create the 'Aggregation' series of digital organic forms presented in the SIGGRAPH 2005 Art Gallery. The images explore how extremely complex structures reminiscent of plants and coral can emerge from simple rules for flow and deposition.

2 Background

These works come from an exploration of complex organic forms and their relationship to simple mathematical rules.

Major influences include:

D'Arcy Thompson's study of how mathematical constraints and the physics of growth govern the shapes of living forms [Thompson 1917].

Alan Turing's work on how complex animal coat patterns arise from simple reaction diffusion equations due to chemical processes [Turing 1952].

Ernst Haeckel's intricate lithographic plates documenting the complexities and symmetries of natural forms [Haeckel 1974].

3 The Aggregation Process

The sculptural shapes are created by a process of accretion over time. They are grown by simulating the paths of millions of particles randomly flowing in a field of forces. Over time they build on top of an initial simple seed surface to produce structures of immense complexity with radically different forms coming from simple changes to rules for flow fields and deposition.

During the simulation, particles are moved around randomly in the flow field until they hit either the initial seed surface or other particles that have already deposited. The process is similar to the Growth by Aggregation system described by Kaandorp and Kübler [Kaandorp and Kübler 2001] but uses particles rather than voxels, and generalizes the flow field to more complex models than the simple bi-directional one they use.

The images were rendered as implicit surfaces using a proprietary ray-tracer that can deal with very large numbers of particles.

4 Conclusion

The works explore aspects of both science and art. The process used to generate the images is in many ways similar to a scientific experiment while the prime motivation is to explore creation of aesthetic forms with extreme complexity coming from remarkable simplicity.

The relationship between complexity and simplicity works on a number of levels. As well as being an intrinsic element of the underlying processes used to create the forms, it is also designed to be part of the aesthetic effect created. One intention is to explore structures that appear deceptively simple when viewed from afar, but have an extraordinary level of intricacy when examined in detail.

Forms are created by a process of indirect design: the shape of forms is governed by controlling initial conditions and rules for deposition rather than by designing the final form directly. Through exploration, intuition is developed about how changes will affect forms but results are often surprising, which in turn leads to further exploration.

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THOMPSON, D. W. 1917. *On Growth and Form*. Cambridge University Press.

TURING, A. M. 1952. *The Chemical Basis of Morphogenesis.* Philosophical Transactions of the Royal Society of London, volume B 237, pages 37-72.

HAECKEL, E. 1974. *Art Forms in Nature.* Dover Pictorial Archive Series, Dover Publications, Inc.

KAANDORP, J. A. AND KÜBLER, J. E. 2001. *The Algortithmic Beauty of Seaweeds, Sponges and Corals*. Springer-Verlag.