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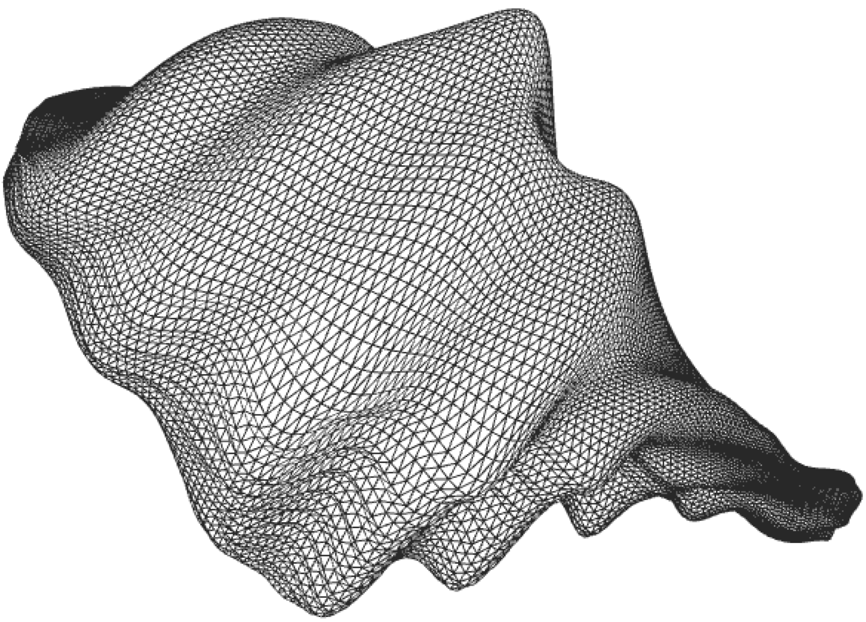
Five Studies in Computational Process and Form

INTRODUCTION

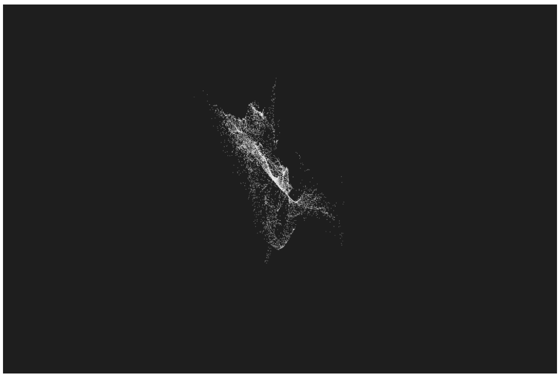
This document presents a series of five studies submitted as part of a module in Computational Process and Form led by Lior Ben Gai at Goldsmiths University of London in April 2018.

Each study takes either a natural phenomenon or a pre-existing dataset as a starting point or inspiration in the creation of a virtual artefact. Each of the first four explores a different computational strategy for generating form: random, functional, data driven and emergent. The fifth study combines emergent and functional strategies, and includes a physical artefact as its end product. An abstract visual approach has been employed throughout.

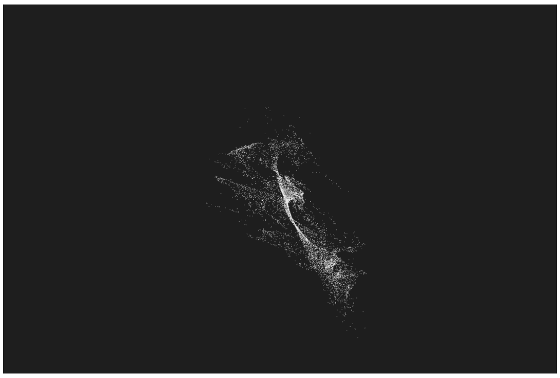
Each artefact was created in the Processing programming environment. Additional software used for presentation were Blender, Adobe Illustrator, Meshmixer and Preform. A Formlabs Form 2 3D printer was used in the creation of the physical artefact for the fifth study.



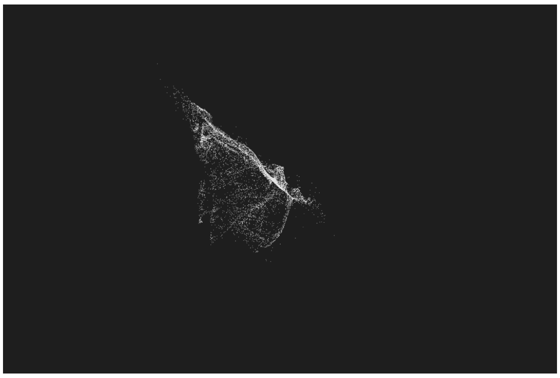
STUDY I : RANDOM



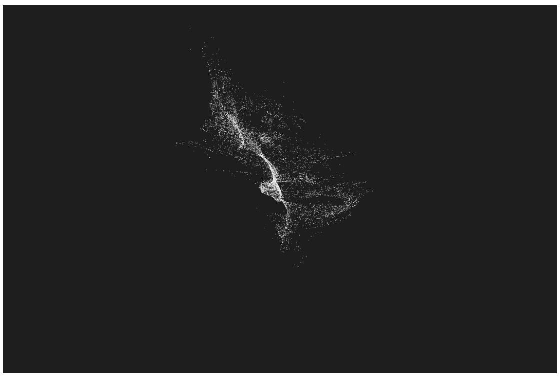
For the first study I took inspiration from turbulent flow patterns in fluids. I had understood this to be a chaotic but deterministic process, and was surprised to discover that randomness was inherent to the phenomenon. A paper I found by Gregory L. Eyink[1] described a property of turbulent flow called spontaneous stochasticity, in which two particles deposited in the flow at the same place and time would end up in different, entirely random locations.



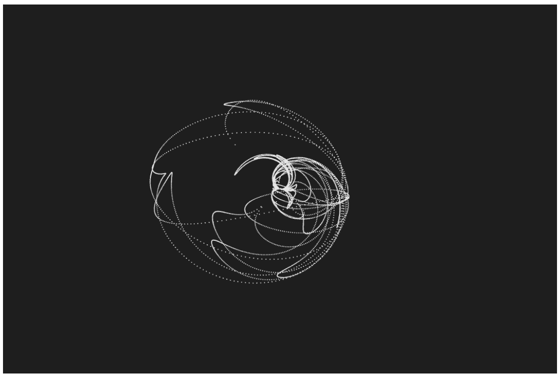
Intrigued by this breakdown in classical determinism, I took it as the point of departure for the study. Instead of attempting to model fluid flows directly using the Navier–Stokes equations[2], I decided to take a more abstract approach and simulate the motion of particles through a vector field determined by noise values. These values evolved over time, causing particle trajectories to change continuously, ensuring that particles with the same initial direction of motion would eventually diverge.



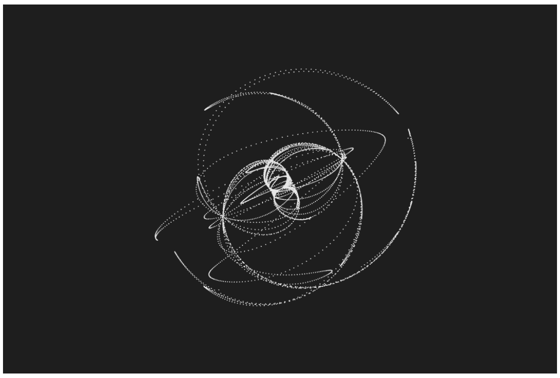
Particles were emitted from the central point with initial velocities determined by a normal distribution, leading certain paths of motion to be travelled by more particles, others less so. The effect was reminiscent of organic tendrils, structures in the vector field being highlighted briefly by a cluster of particles before shifting and dissolving.



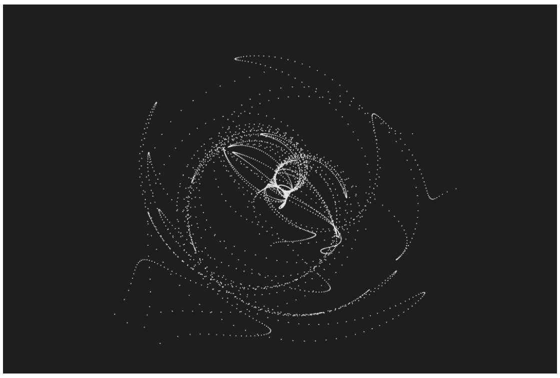
STUDY II : FUNCTIONAL

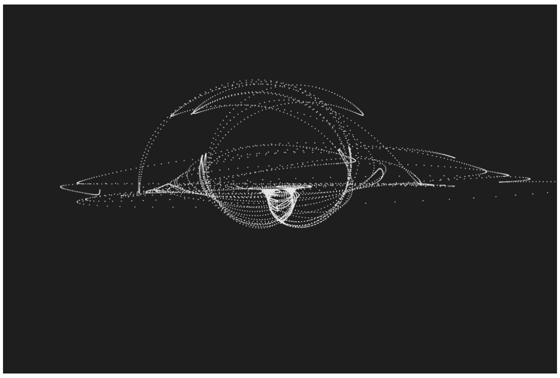


For the second study I researched elliptic functions, mathematical functions originating in the field of complex analysis which when plotted look like simplified, organic versions of the Mandelbrot set[3]. The mathematics behind these turned out to be too complicated to do anything substantial with. Instead I took inspiration from their periodic, repetitive quality and created my own functions based on similarly periodic trigonometric functions.

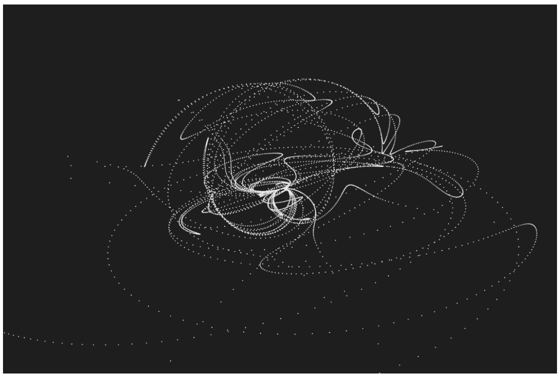


I found that interesting forms began to arise when I used combinations of scaled sine and cosine waves to distribute points in space using spherical coordinates. The inclusion of exponentiation began to introduce breaks in the symmetry, yielding jellyfish-like objects whose coherent central structures broke down into loose tentacles as distance from the centre increased.



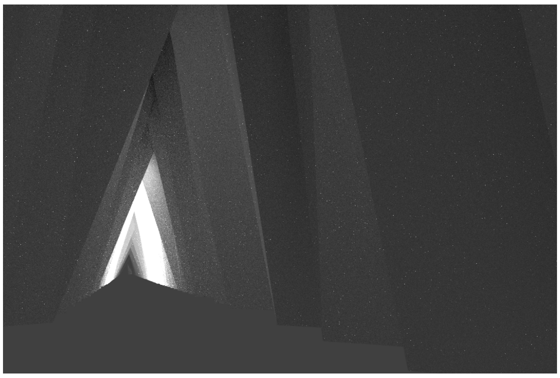


Building on ideas from the first study, I animated the scale factors over time. The motion this gave rise to exaggerated the sense of an underwater creature wriggling under its own volition and being tossed around by deep sea currents.

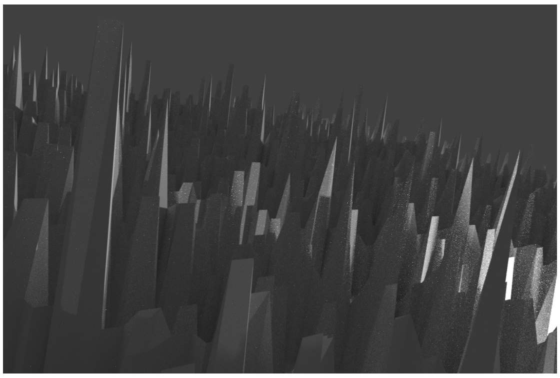


STUDY III : DATA DRIVEN

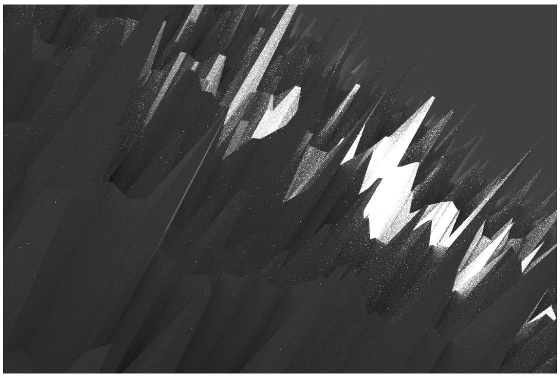
For the third study I wanted to work with music. Rather than attempting to extract useable data from audio files I found an online resource containing midi files of modern classical compositions[4], providing me with access to their full musical structure.



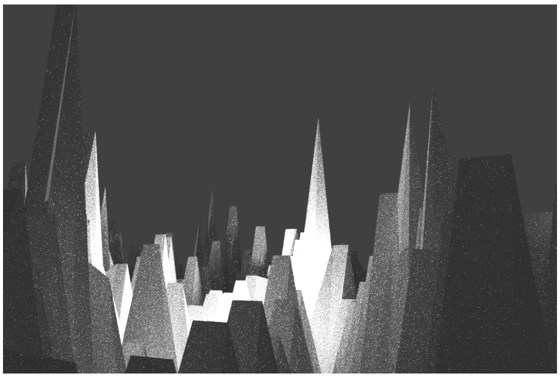
I was particularly interested in using compositions by Iannis Xenakis, a composer I admire not only for his music, but also his graphical scores and work as an architect[5]. The aim was to spatialise the midi data in a way that paid lip service to his monochrome visual aesthetic, turning the music into a 3-dimensional city that could be explored at ground level.



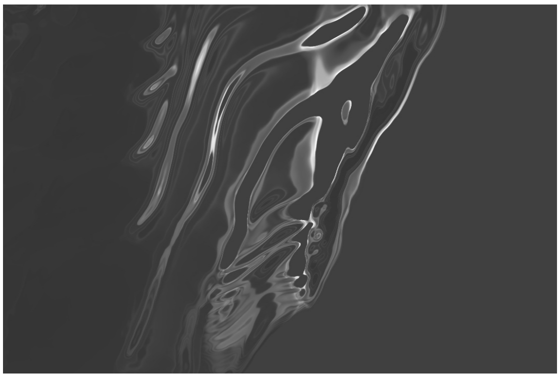
My approach was to use the midi data from Xenakis' piano composition A.R[6], using it to deform the vertices on a plane to create jagged spikes corresponding to moments of musical change. The end result was a surface punctuated by various clusters of spikes and pockets of flatness, evocative of paths, tunnels, monuments and skyscrapers.



I used 3D modelling software to light the structure from different angles, moving the camera around to take snapshots of its surface and skyline.

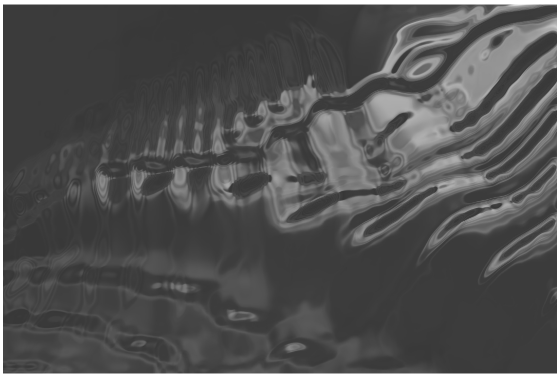


STUDY IV : EMERGENT

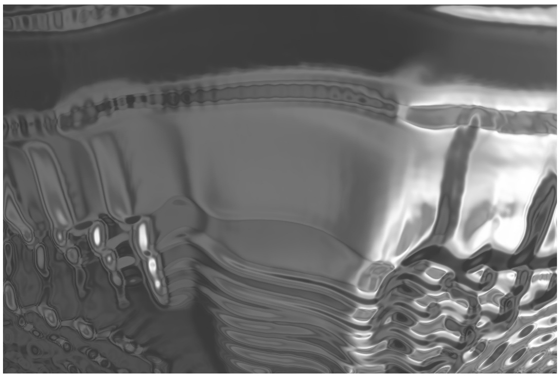


The primary inspiration for the fourth study was Berenice Abbott's 1958–61 series of photographs Water Patterns[7], which show the process of wave propagation and interference in flat bowls of water. The aim was to use emergent techniques to create simulations of similar patterns.

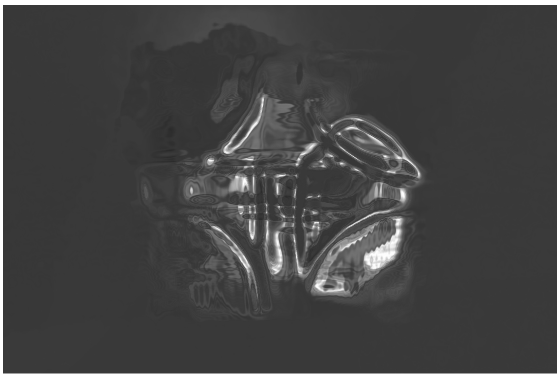
My approach was to use a standard technique for ripple simulation known as height field maps[8] in which each local column of fluid continually adjusts its height based on a weighted average of its immediate neighbours. I implement this on a plane treated as a toroidal space, so that ripples disappearing off one side of the surface reappeared at the opposite edge.



The effect created depended heavily on the initial state of the wave, which would then degrade over time as the ripple patterns became more disordered. Through a process of trial and error I found some initial states that produced pleasing results.



Snapshots were taken at different times after the simulation was started. Various lighting and smoothing techniques were used to capture images of the results.



STUDY V : COMPOSITE

For the final study I continued to build on the fourth, this time incorporating a functional approach to deform the surface across which the ripples would move. By doing this I wanted to create fluid 3D objects that could not exist according to real world physics.

The approach was to first wrap the plane from the fourth study into a cylinder. In order to keep the ripple moving along this cylindrical surface the ‘height’ of a point on the surface had to be reinterpreted as distance from the surface in the direction of the normal vector perpendicular to it.

The next step was to deform the cylinder using trigonometric functions, creating a shape evocative of a shell or gourd. In addition to the function used to set the initial state of the wave, this comprised the functional component of the study.

I was attracted to the idea of contrasting the fluid, always-in-motion nature of the resulting 3-dimensional forms with the solidity of a static real world object. To do this I 3D printed the objects using white SLA resin. This material provided an extremely smooth finish to the surface, doing justice to the detail of the rippling patterns.

REFERENCES

1. Gregory L. Eyink, “Stochastic flux freezing and magnetic dynamo” https://link.aps.org/accepted/10.1103/PhysRevE.83.056405
2. Jos Stam, “Real-Time Fluid Dynamics for Games” http://www.dgp.toronto.edu/people/stam/reality/Research/pdf/GDC03.pdf
3. Hans Lundmark, “Elliptic Functions” http://users.mai.liu.se/hanlu09/complex/elliptic/
4. “Contemporary Midi Files” http://www.geocities.jp/leo_ornstein/others.htm
5. “Graphic Notation: Iannis Xenakis” https://graphicnotation.wordpress.com/tag/graphic-notation/
6. Iannis Xenakis - A.R. performed by Keiko Shichijo https://www.youtube.com/watch?v=ZM4wJdL5ONM&t=84s
7. Berenice Abbott, Water Patterns 1958-61.
8. Mathias Müller-Fischer, “Fast Water Simulation for Games Using Height Fields” http://matthias-mueller-fischer.ch/talks/GDC2008.pdf