Who?	Claude Heiland-Allen
When?	/dev/art #12 Paris

part one

- introduction
- how to trap the Borg
- visualizing hyperspaces
- symmetry and kaleidoscopes
- fractals and chaos

part one

- whoami
- rules
- underprepared
- survival
- practice
- symbiosis

whoami

who	Claude Heiland-Allen
what	art science maths
where	http://mathr.co.uk
why	because it's there

rules

speed slow me down

clarity question me

interact interrupt me

underprepared

illness	mental breakdown
hospital	late July to early September
isolated	no computers, no internet

survival in hospital

writing notebook and pen

drawing paper, coloured pencils, pens

relaxing poetry, meditation, smoking...

survival outside

written physical address/phone book

memorized important friend/family phone numbers

preplanned regular offline meetings

practice makes perfect

maths	symmetry, beauty, simplicity, elegance
art	smalltalk is too small, say big things
science	experiments show universal truths

symbiosis is love

yourself	look after yourself first
network	look out for your family and friends
ecosystem	care for your environment

mini recap one

survival	the most important thing you can do
technique	use all means available to express yourself
symbiosis	guard yourself first before you can care for others

part two

- hypercubes
- hyperspheres
- trapping the Borg

hypercubes

cubes exist in all dimensions

0D point

1D line segment

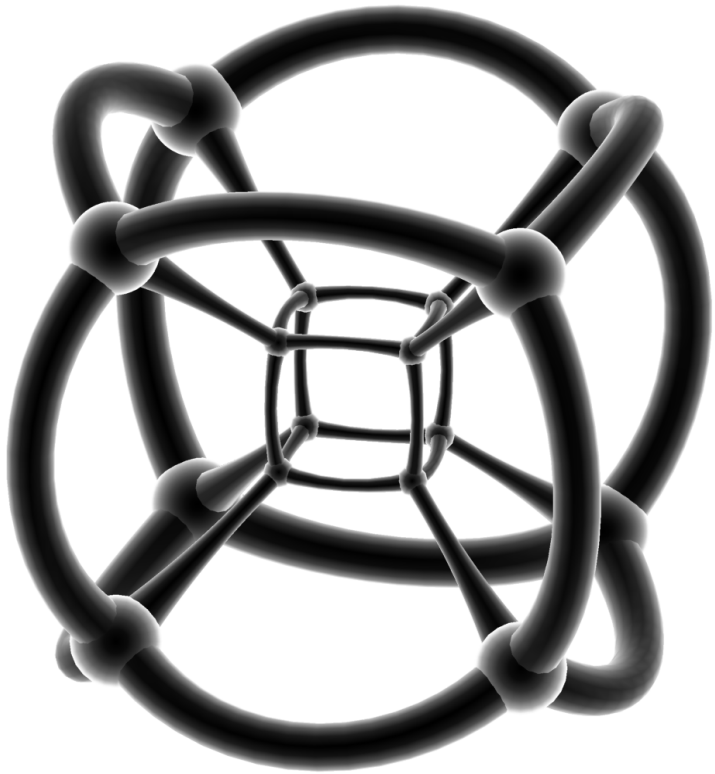
2D square

3D cube

4D tesseract (hypercube)

the "content" of a cube is 1.

hypercube in 4D



stereographic

hyperspheres

spheres exist in all dimensions

0D point

1D line segment

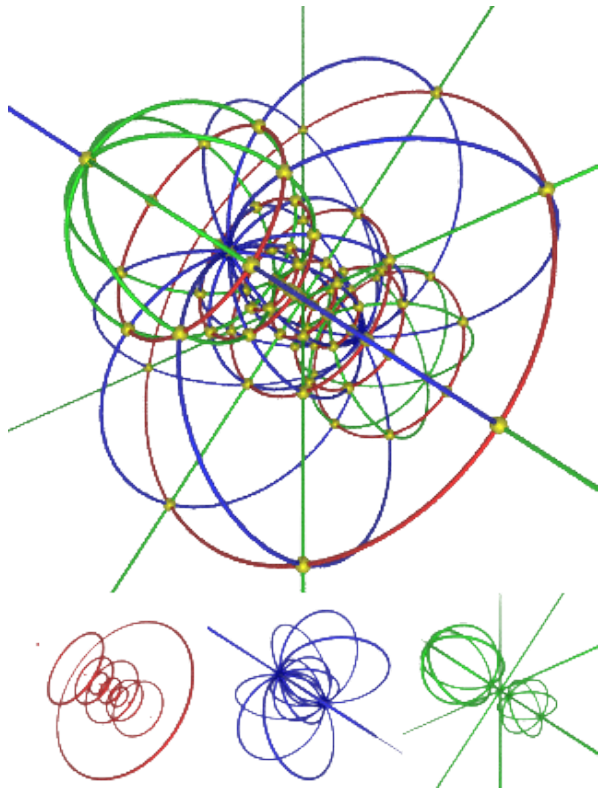
2D circle

3D sphere

4D hypersphere

the "content" of a sphere $\to 0$ as dimension $\to \infty$.

hypersphere in 4D



schematic

image (CC-BY) Claudio Rocchini

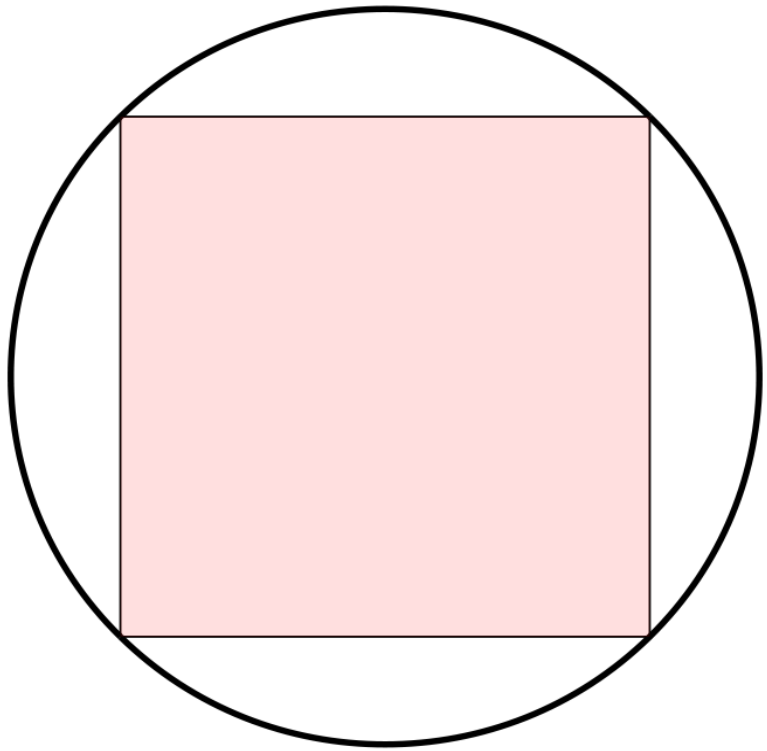
trapping the Borg

step 1 put your Borg's cube inside a spherical cage

step 2 increase the number of dimensions of space

result the Borg cube is crushed into a point in ∞-dimensional space

Borg cage in 2D



trapped

part three

- 4D space
- flat space
- spherical space
- hyperbolic space

visualising 4D space

386 implemented a renderer using `svgalib` - slow!

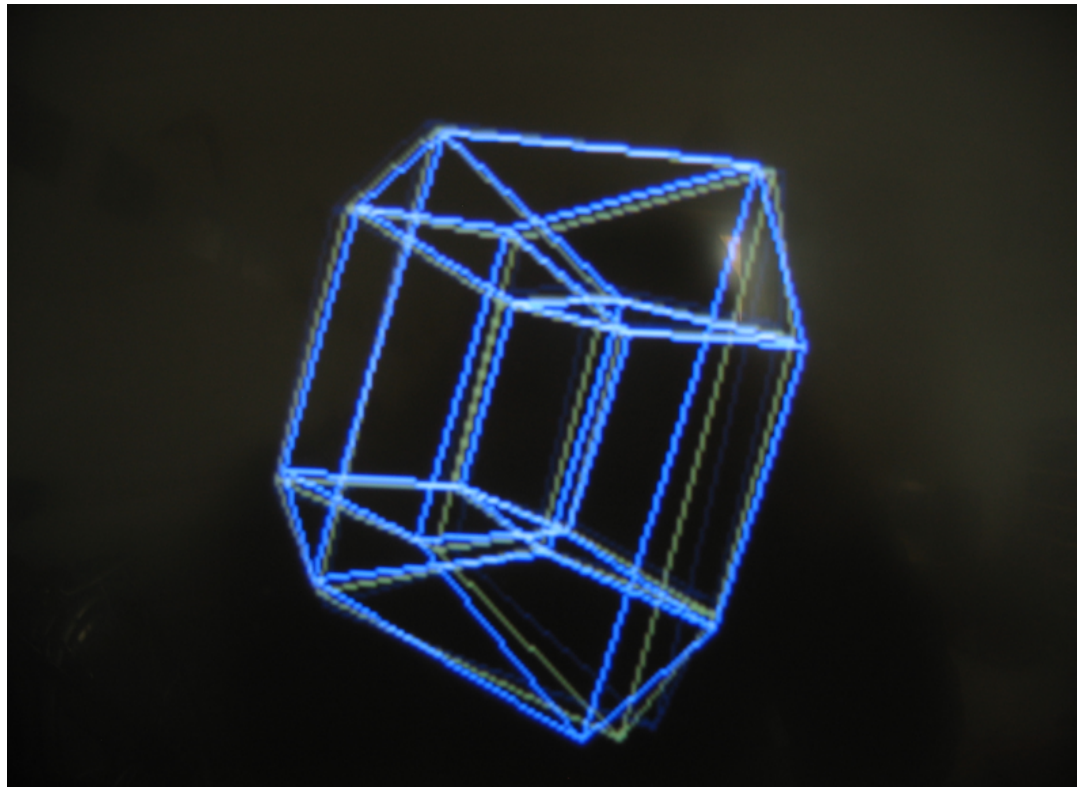
d01234 live hypercube performance with Pd, Gem, GridFlow, etc

h4tek exploring 24-cell (a rather special 4D shape)

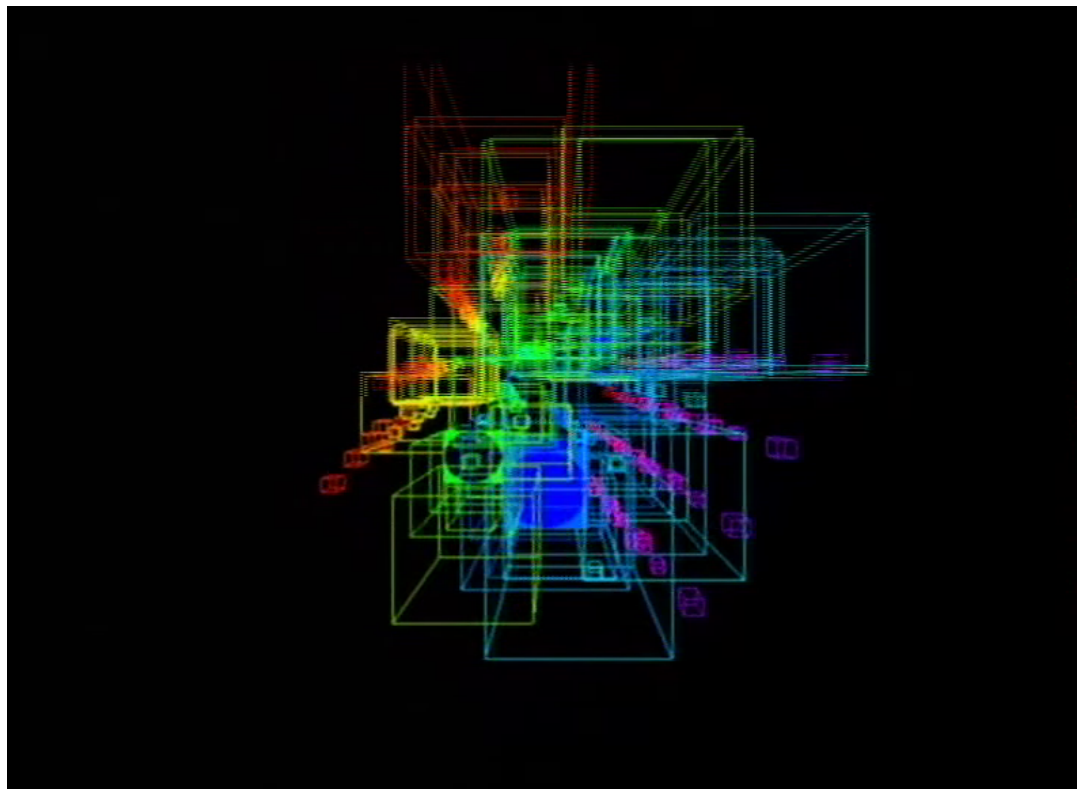
reflex spherical projections of 4D space to 3D space

disco slices through a 4D honeycomb (grid) structure

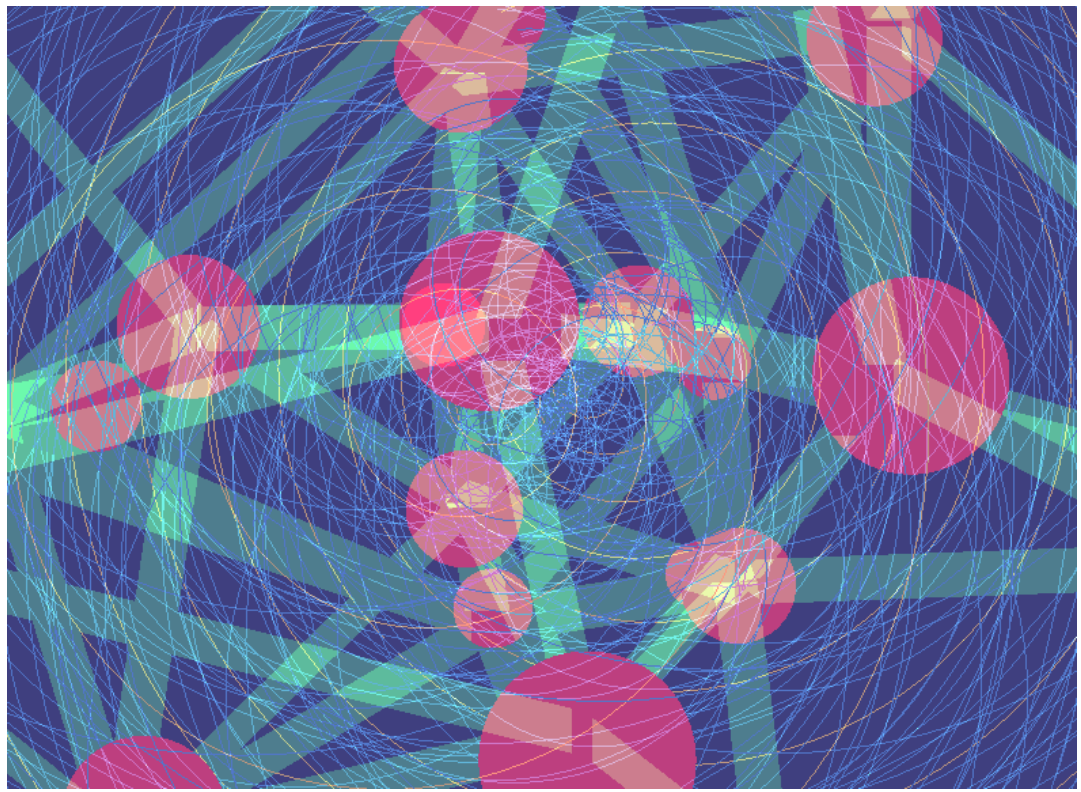
386: wireframe hypercube



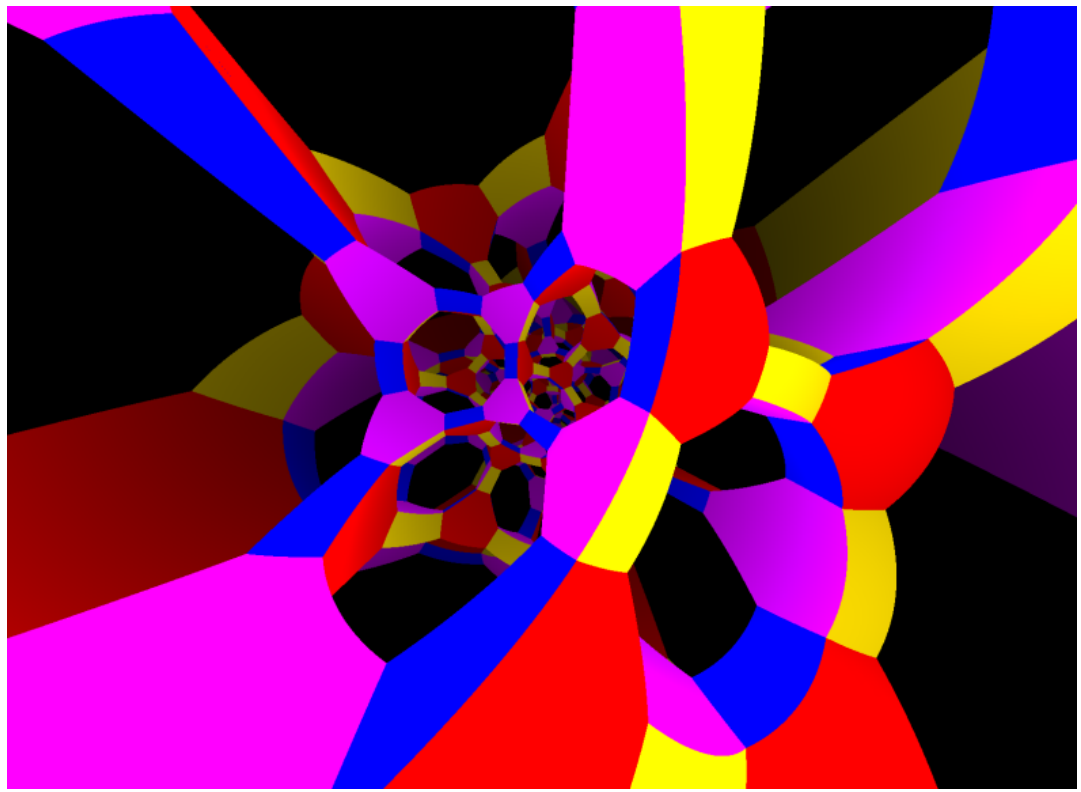
d01234: hypercube of cubes



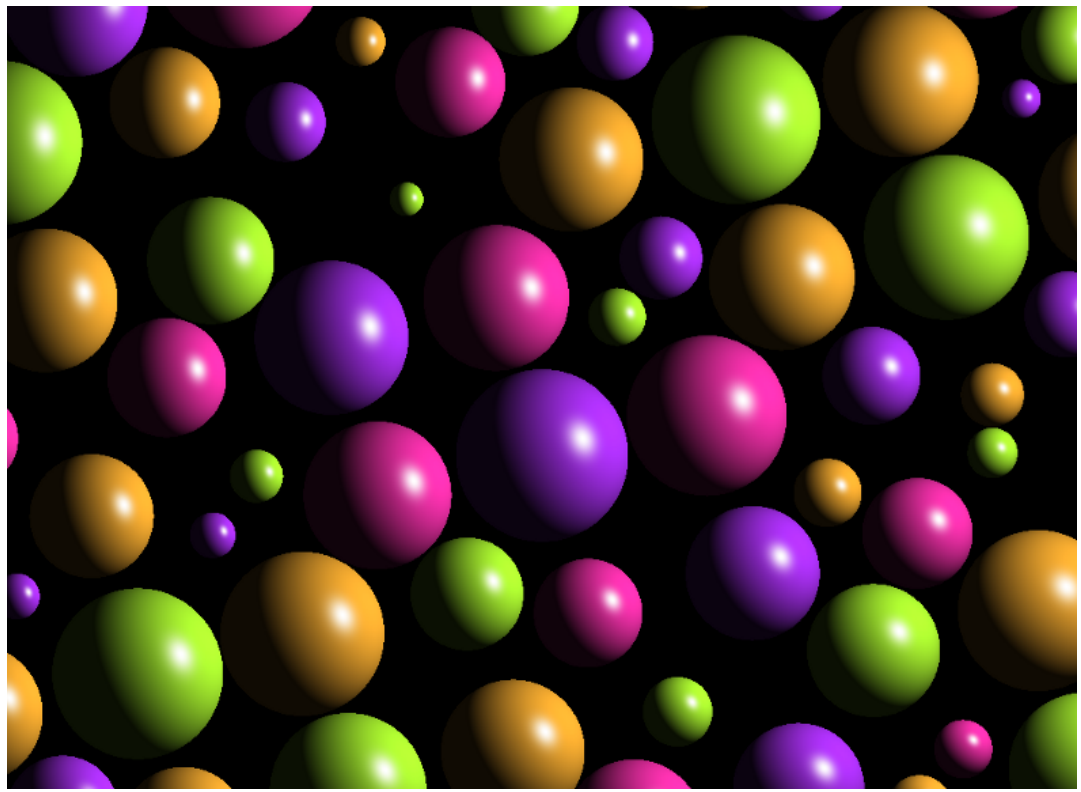
h4tek: fun with 24-cell



reflex: polytopes truncated



disco balls: honeycomb slices



flat space

aka Euclidean space, regular local geometry of this room

triangles interior angles always sum to π.

parallel parallel lines never meet

unique there is exactly 1 parallel to a line through a point

Euclid's axioms can be adjusted, however...

spherical space

like our Earth's surface

triangles interior angles always sum to more than π.

parallel lines that start parallel eventually meet as the world curves

impossible all geodesic lines will eventually meet when extended

Euclid's axioms can be adjusted in another way, too...

hyperbolic space

like nothing on Earth (but maybe the large-scale universe?)

triangles interior angles always sum to less than π.

parallel lines that start parallel get further apart as the world curves

multiple there are ∞-many parallel lines to a line through a given point

models of hyperbolic space can be embedded in flat space...

Poincaré disc

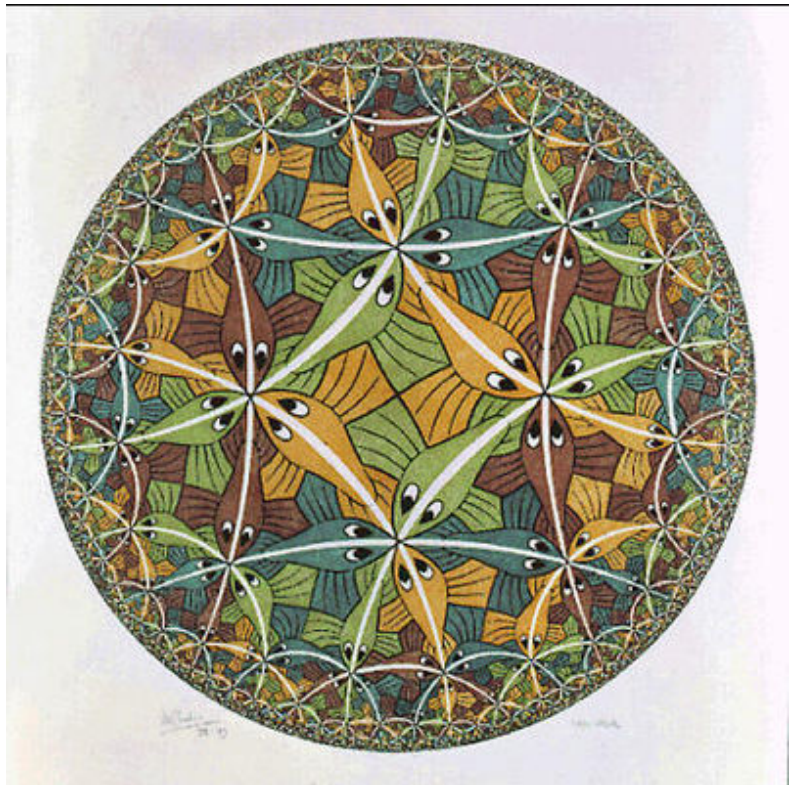
wrap the whole universe in a ball with a circular "horizon"

Escher circle limit series

me DVD2473 random walk video DVD

things get smaller to the horizon, but angles are preserved

Escher's Poincaré disc



circular

Circle Limit III by M. C. Escher (1959)

Poincaré half-plane

unwrap the disc into a half-infinite plane with a linear "horizon"

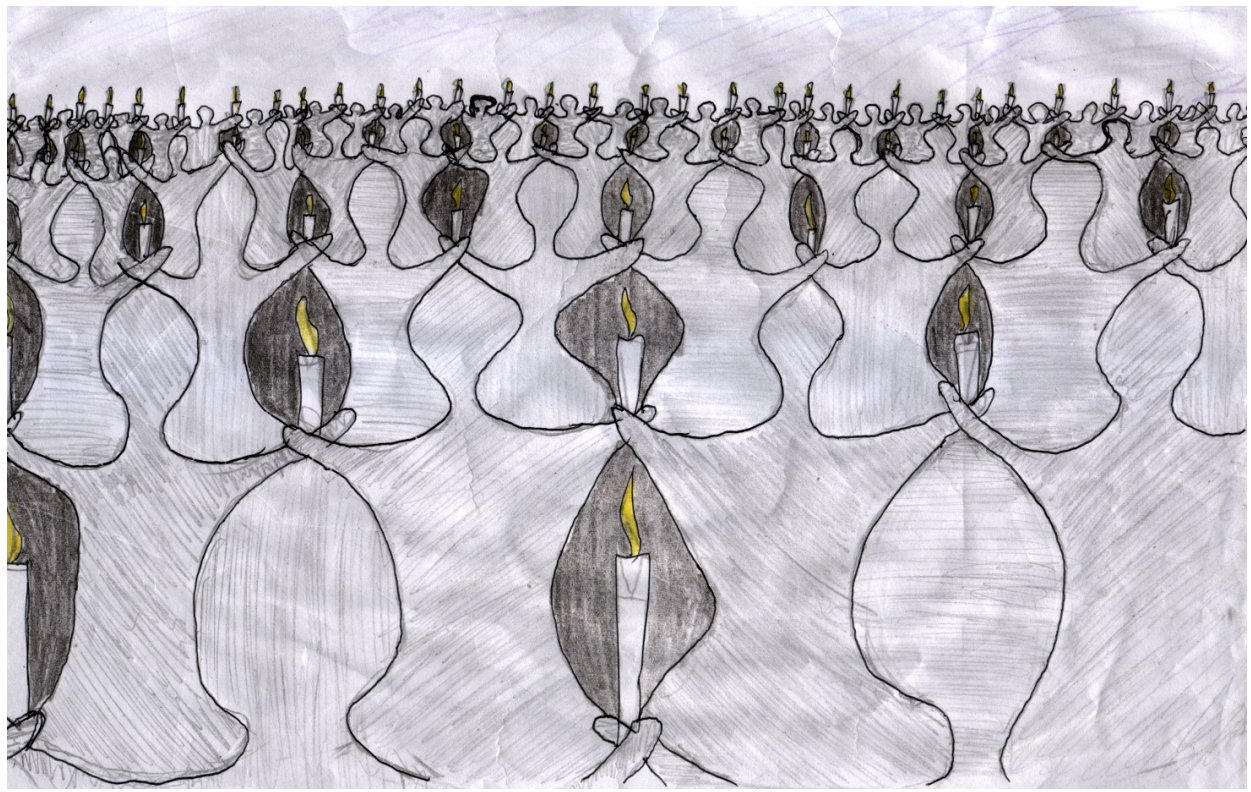
kjhf King James Hyperfuck software

blessings Angels and Candles drawing

things get smaller to the horizon, but angles are preserved

King James Hyperfuck

Angels and Candles



mini recap three

flat	our familiar local geometry
spherical	all roads lead to Rome
hyperbolic	more and more space the further you go

part four: symmetry

- 2D Polygons and Tilings
- 3D Platonic solids
- 4D Regular Polytopes

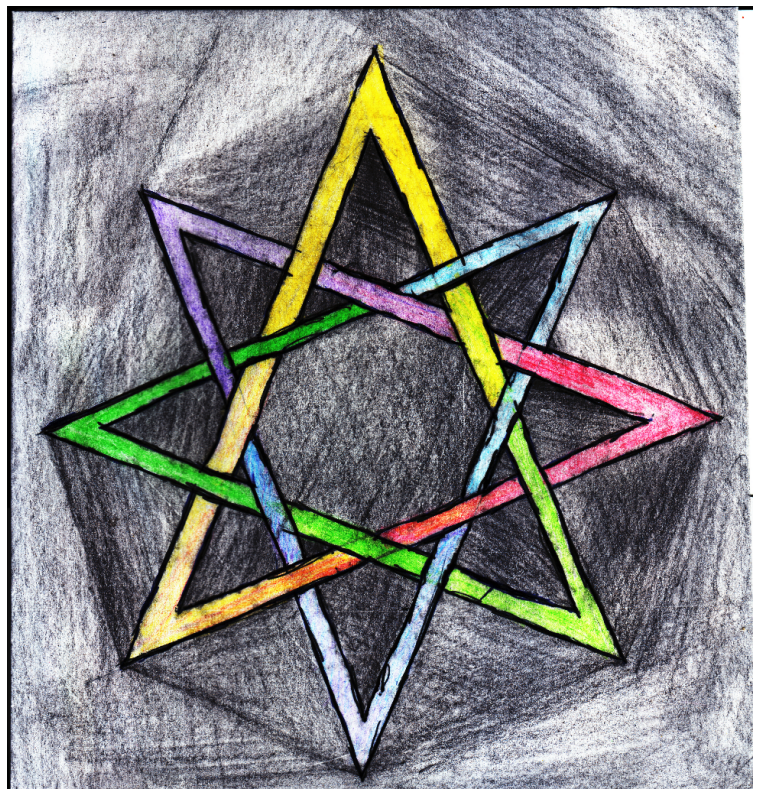
flat space in 2D

groups of reflections

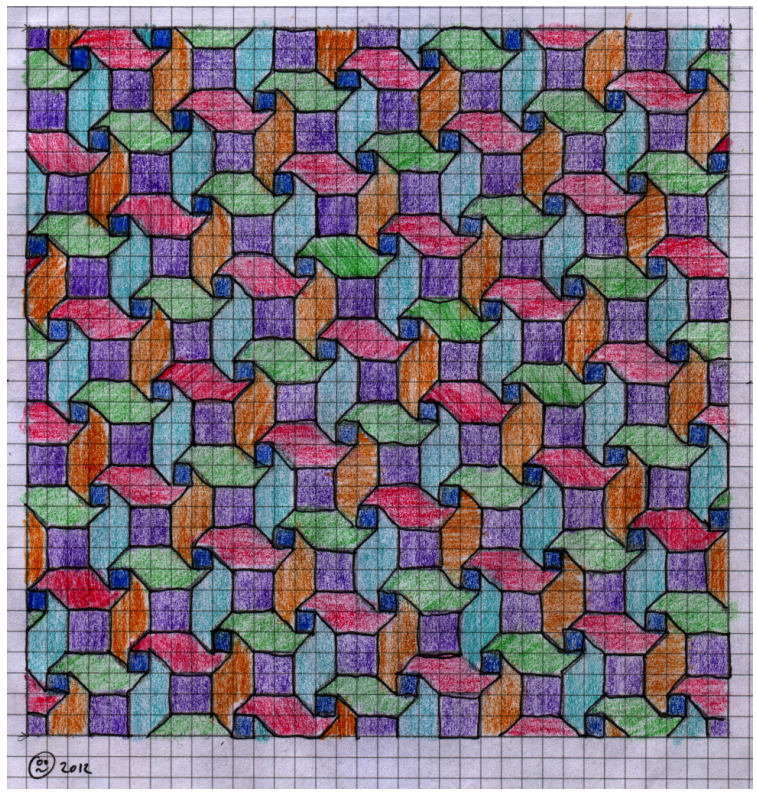
finite ∞-many polygons and star polygons

infinite 17 wallpaper groups

Star Polygon 8/3

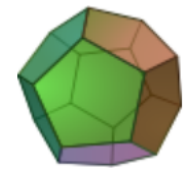
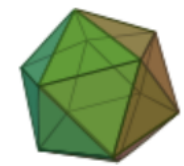


Square Tiling



convex regular 3D polyhedra

aka the Platonic solids

Tetrahedron (four faces)	Cube or hexahedron (six faces)	Octahedron (eight faces)	Dodecahedron (twelve faces)	Icosahedron (twenty faces)
				

known since ancient Greek times

convex regular 4D polytopes

hardcore maths (see Coxeter's works)

simplex like a tetrahedron

cube like a cube

cross like an octahedron

above in all dimensions, below 4D only

120cell like a dodecahedron

600cell like an icosahedron

24cell like nothing else in any dimension

mini recap four

space pick a spatial curvature

symmetry pick a symmetry group

design elaborate on it to make art

part five

- chaos emerges from feedback
- graphgrow fractal designer
- the Mandelbrot Set

video feedback demo

at this point I try to point my webcam at the projection for video feedback fractal fun...

the aim of this exercise is to show that chaos just **emerges** from a system with enough feedback...

graphgrow

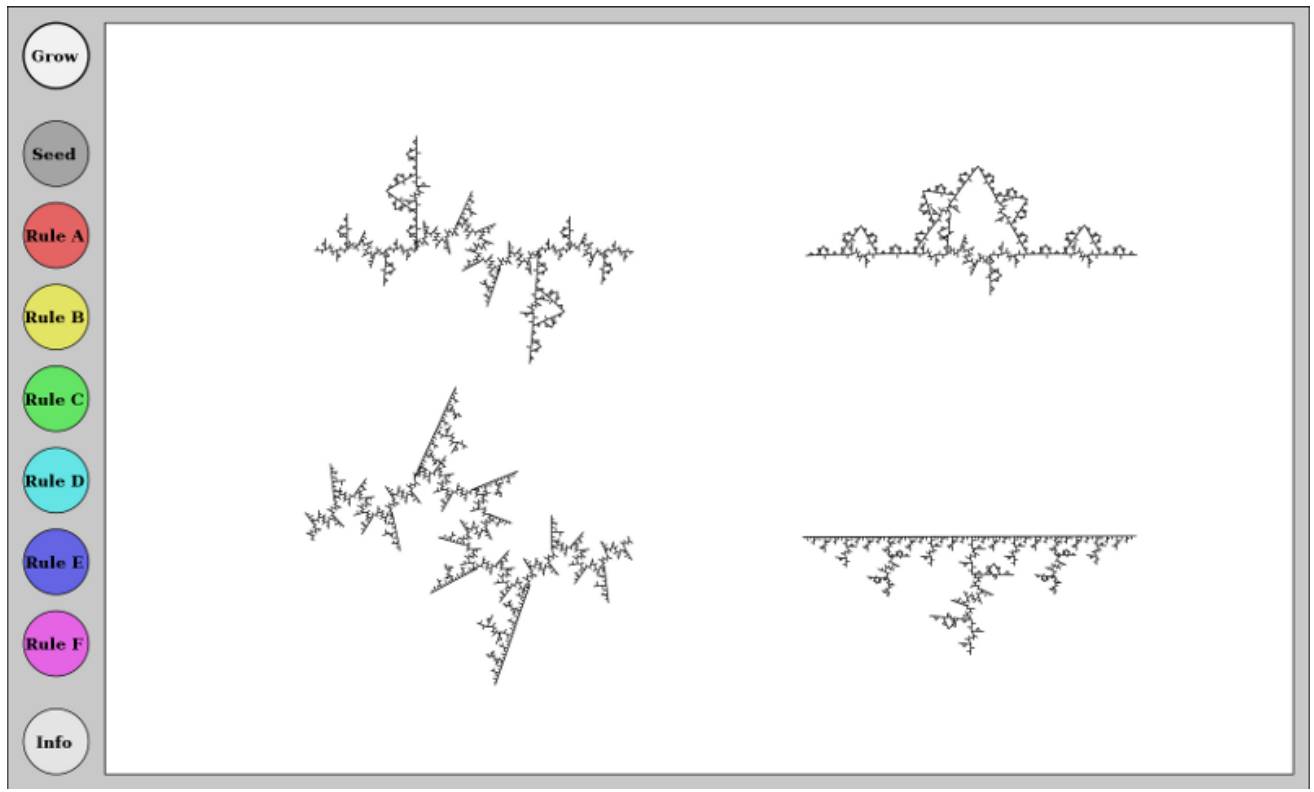
what interactive designer for graph-directed fractal generation.

how connect nodes and move them around, then fractalize the curves

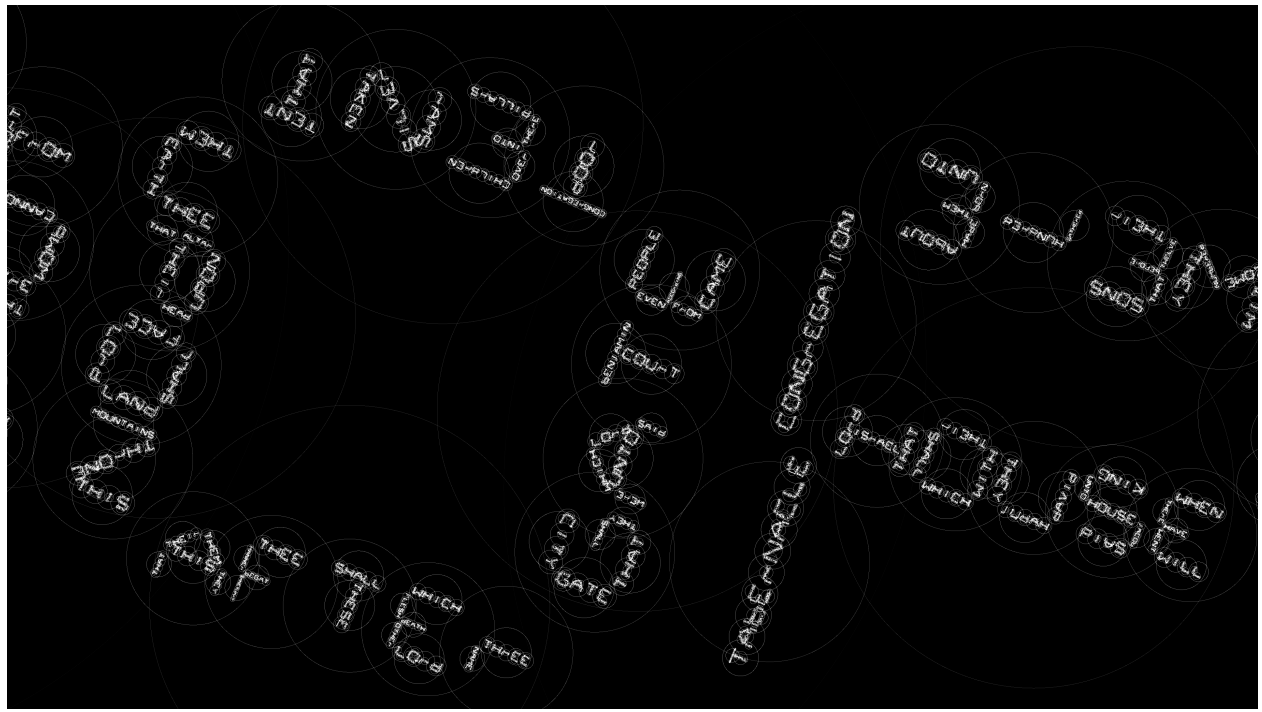
future next generation is outside the browser

bigger Netbehaviour mailing list fractal uses a very large graph...

GraphGrow web example



GraphGrow offline example



the Mandelbrot set

equation $$z \to z^2 + c$$

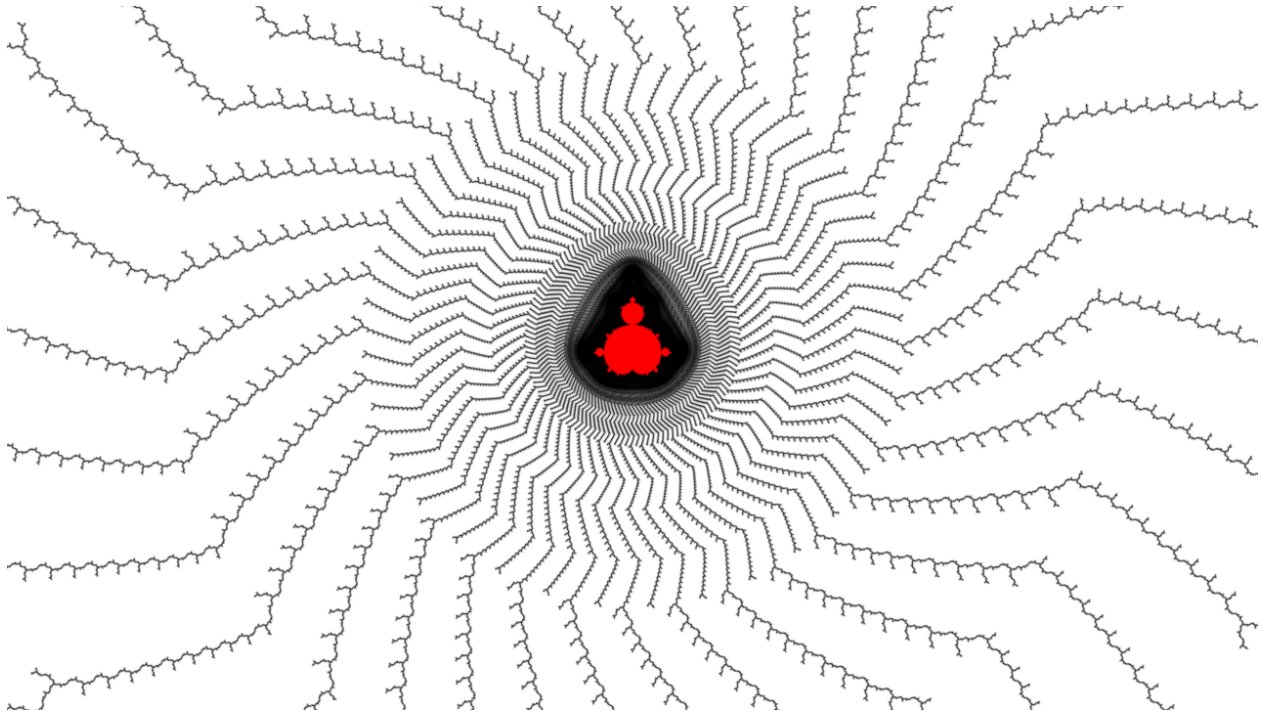
repeated over and over and over

pixel c is the coordinates of the pixel (complex numbers)

iterate z starts at zero

count how long z takes to explode into ∞.

a bit of the M-Set



mini recap five

order boring, too predictable

chaos "between darkness and wonder"

noise boring, too unpredictable

thanks

? questions?

@ claude@mathr.co.uk

stay tuned for performance...