Frieze step pattern

CS-145
Spring 2014

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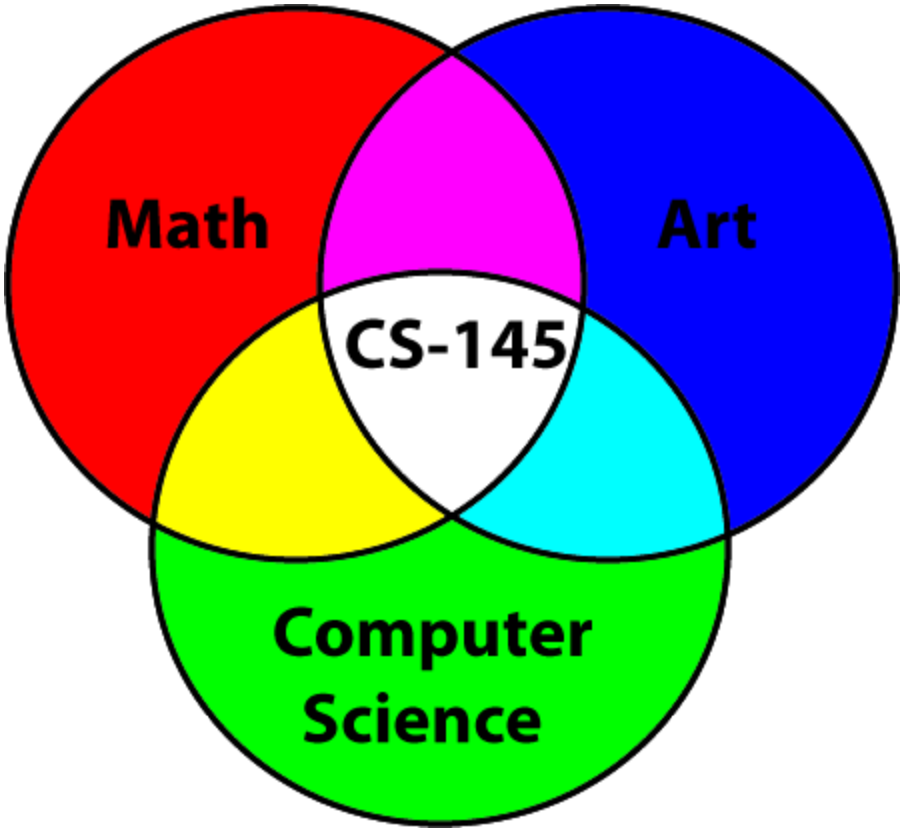
What is this Course About?



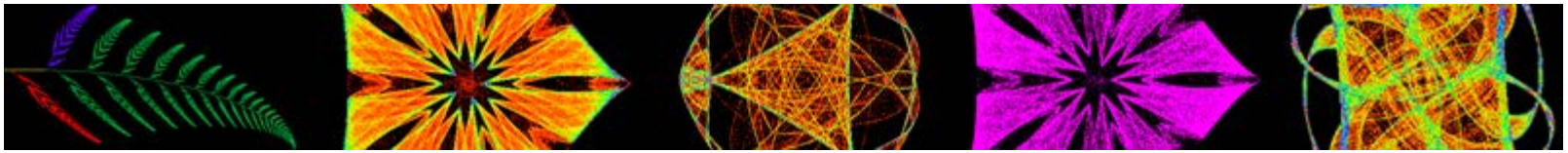
- Algorithmic Art
- Satisfies QA*
- The focus is programming and math in the context of visual art.

What is Processing?

Processing is an open source programming language and environment

for people who want to create images, animations, and interactions.

[processing.org]



Iterated function system

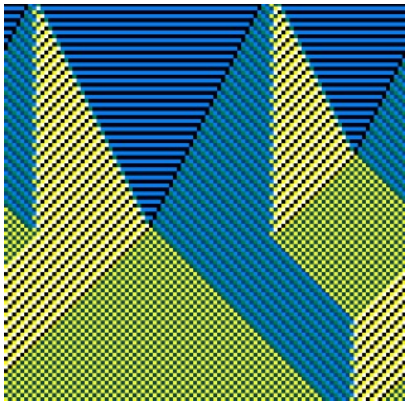
Processing is Good for:

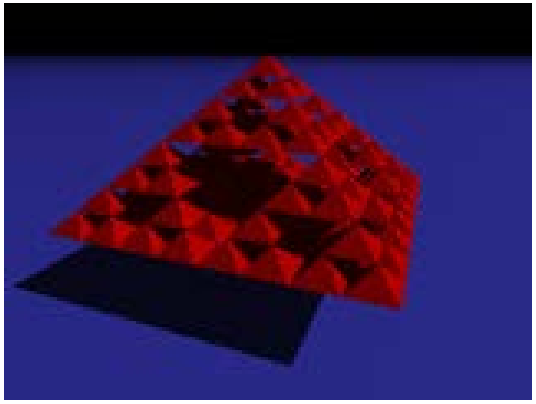
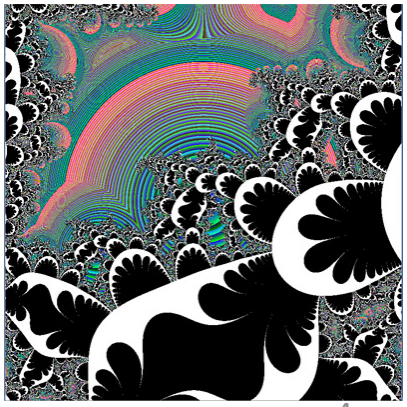
Art Creation

Exploration

Scientific & Mathematical Visualization

→ Understanding

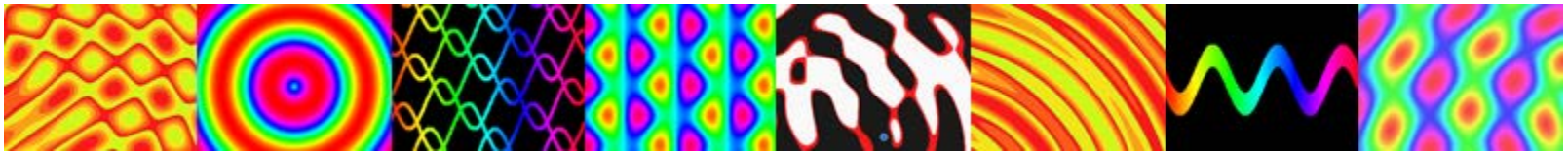


When to use Processing

- Processing is great for rapidly writing small programs that involve any sort of visualization, 2D or 3D.
- Easy to:
  - Create a drawing window.
  - Write code without a lot of overhead.
  - Read, manipulate, and save images.
  - Generate animations.
  - Apply transformations.
  - Interact with user via key and mouse
  - Convert programs to javascript for running on web.

Rotate Dots Example

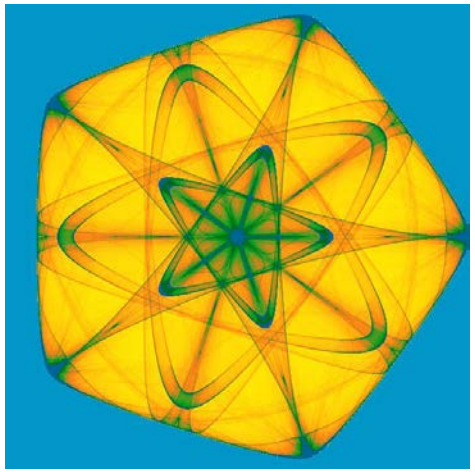


Trigonometric functions

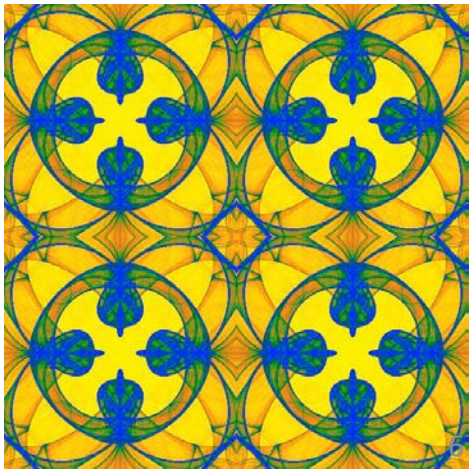
Pushing the limits of Processing

Processing may be slow or difficult to apply for programs that:

- Have a complex structure
- Involve large amounts of data
- Have complex user interaction.
- Are not visually oriented.



Iterated function system



Algorithmic Art

What is an Algorithm?

In the logician's voice:

An algorithm is

a finite procedure,

written in a fixed symbolic vocabulary,

governed by precise instructions,

moving in discrete steps, 1, 2, 3,...,

whose execution requires no insight, cleverness, intuition, intelligence, or perspicuity,

and that sooner or later comes to an end.

From *The Advent of the Algorithm*, by David Berlinski

Janet Parke, *Souls Bend, Hearts Break*

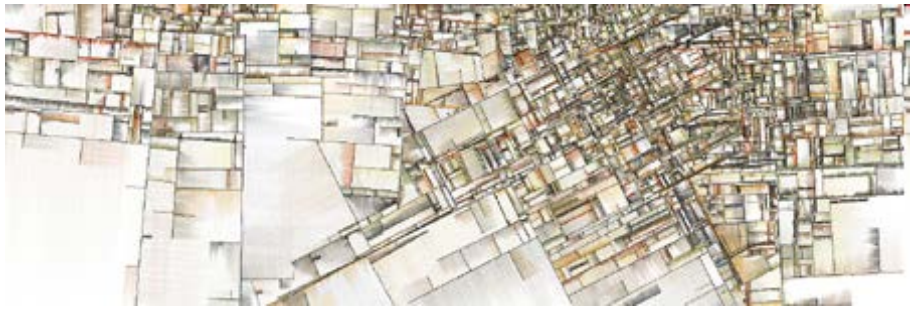
Harold Cohen,
Painting by AARON

Origami

- Origami Crane Instructions:
  http://www.origami-fun.com/support-files/origami-crane-print.pdf
- Origami and Math: Robert Lang TED talk:
  http://www.ted.com/talks/robert_lang_folds_way_new origami.html

Art Creation

Jared Tarbell, Substrate 2003, http://www.complexification.net/gallery/



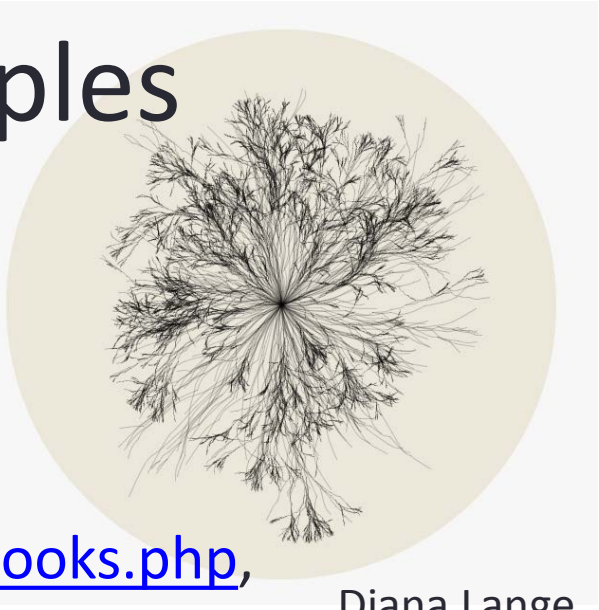
Mike Field,
Firestorm 2001
http://www.math.uh.edu/~mike/ag/recent/recent.html

Roman Verostko
Cyberflower Red 2002
http://www.verostko.com/gallery.html

Also,
see examples on
Hello Processing

Processing Art Examples

- Lots are online, e.g.
  - http://processing.org/exhibition/
  - http://www.openprocessing.org/
- Books:
  - Generative Art, http://zenbullets.com/books.php, Matt Pearson
  - Form + Code, http://formandcode.com/, Casey Reas, Chandler McWilliams, LUST



Diana Lange

Marius Watz

Robert Hodgin

Image Manipulation





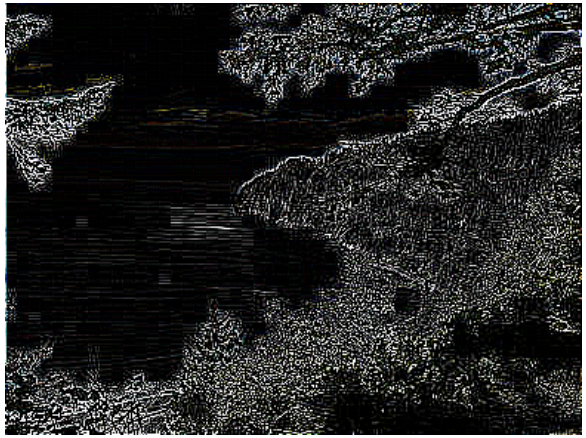
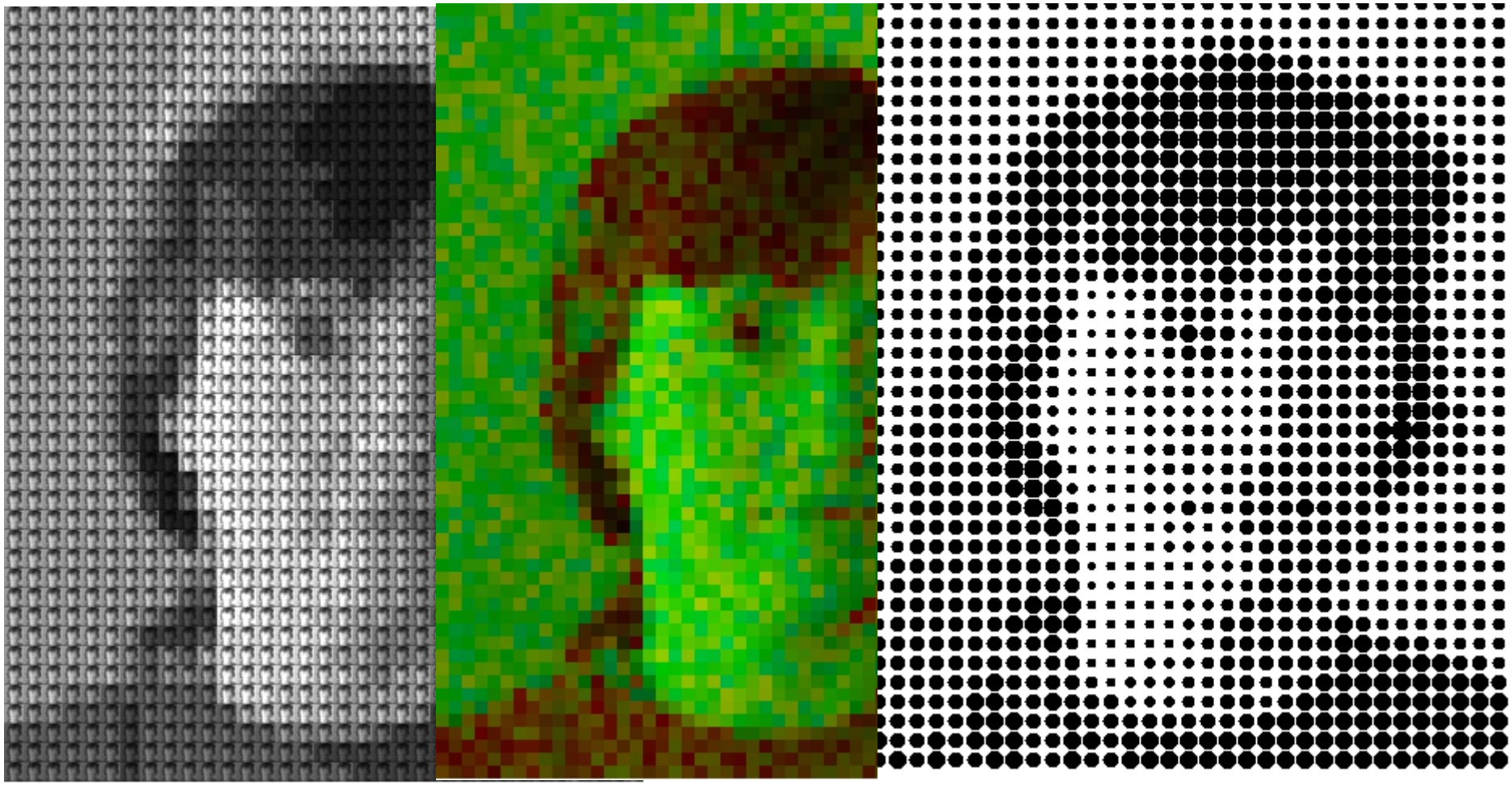



Image Manipulation



Science

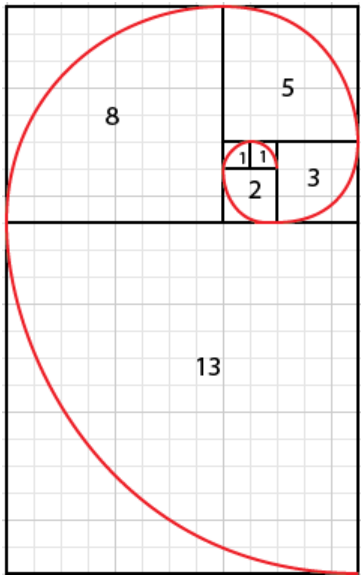
Phyllotaxis (Leaf Arrangement):

Pine Cones, Cacti, & Fibonacci Numbers

Red: 8

Yellow: 13

White: 21



Fibonacci Sequence:

0 1 1 2 3 5 8 13 21 34 55 89 …

Image taken from: http://faculty.smcm.edu/sgoldstine/pinecones.html

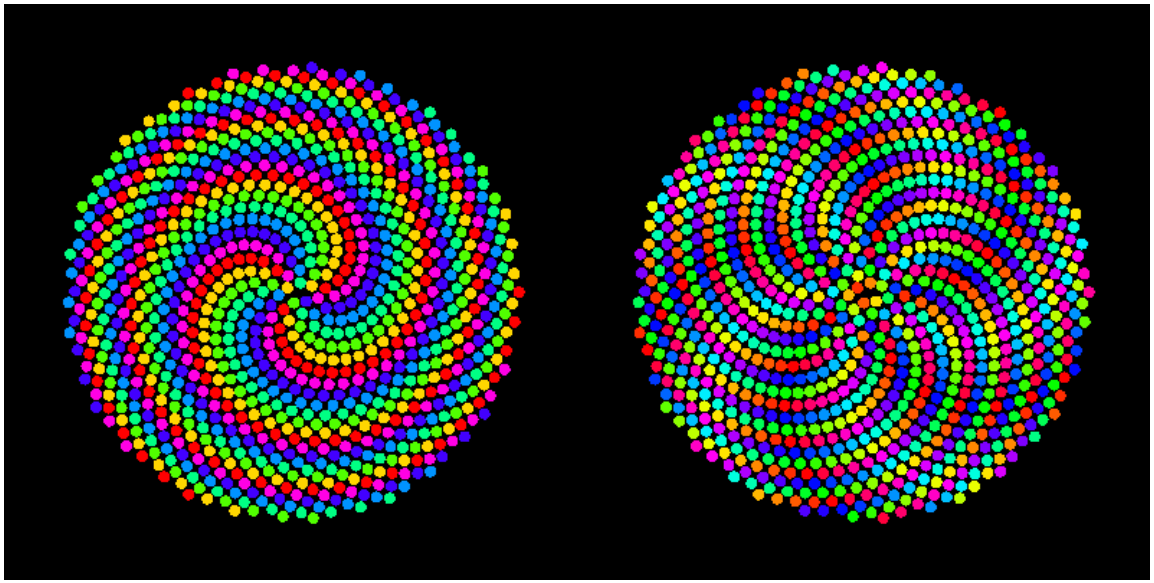
Also see:

http://www.maths.surrey.ac.uk/hosted-sites/R.Knott/Fibonacci/fibnat.html#plants

Phyllotaxis & Processing

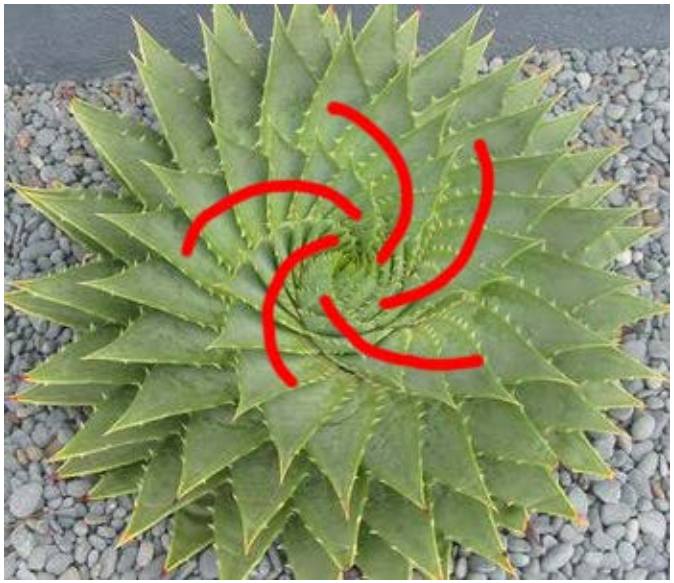
- Fibonacci Sequence:
  0 1 1 2 3 5 8 13 21 34 55 89 …

Phyllotaxis Example



21

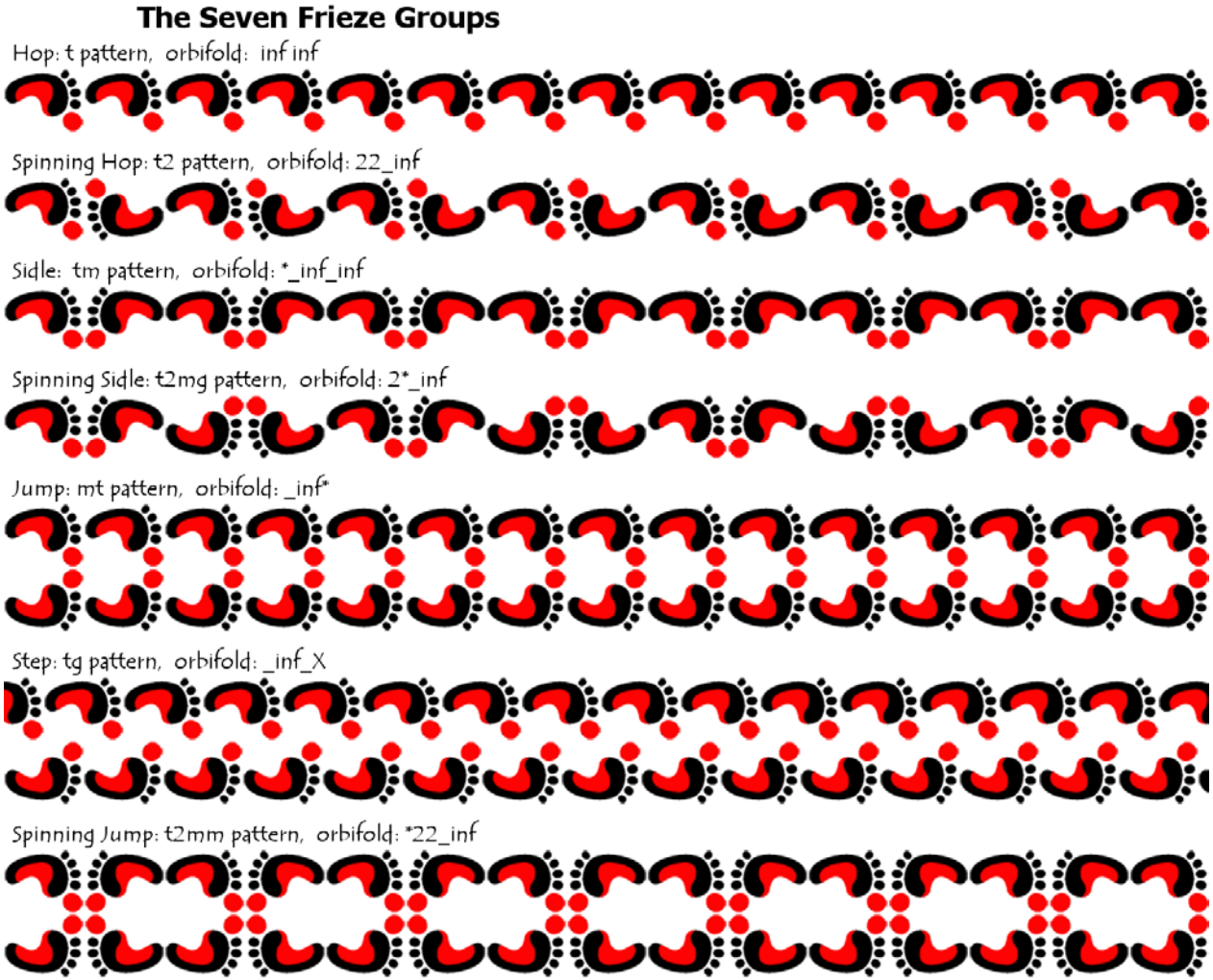
34



5

"Divergence angle" = angle between leaves = 360/tau = 222.5 (or 137.5°)
where tau=golden ratio

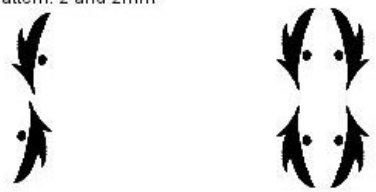
Understanding Transformations and Symmetry: Frieze Patterns



See FriezePatterns example (via Processing)

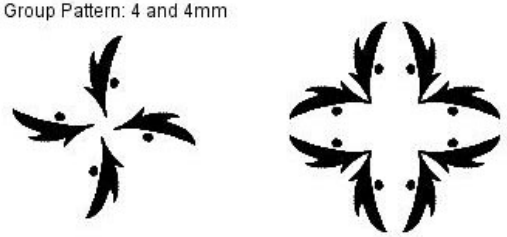
Symmetry: Point Group

Point Group Pattern: 2 and 2mm

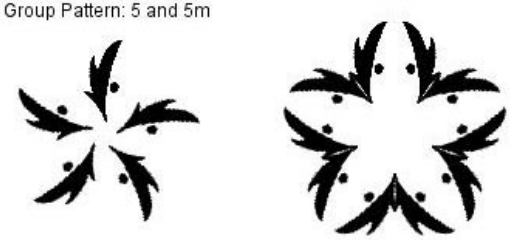


Point Group Pattern: 3 and 3m

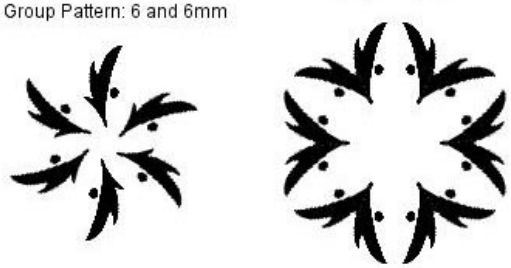
Point Group Pattern: 4 and 4mm



Point Group Pattern: 5 and 5m



Point Group Pattern: 6 and 6mm



Point Group Pattern: 2 and 2mm

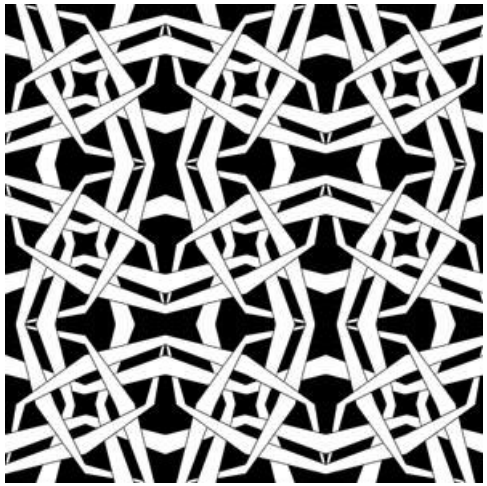
Point Group Pattern: 3 and 3m

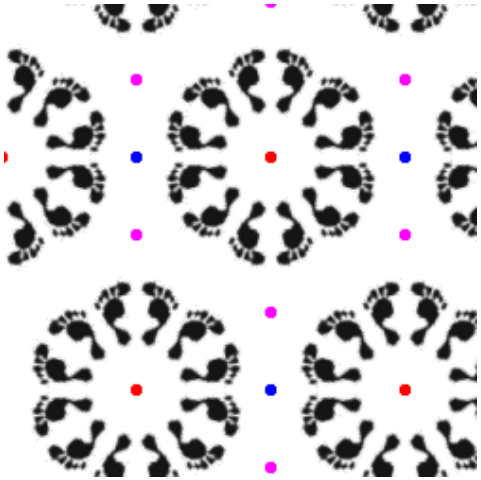
Point Group Pattern: 4 and 4mm

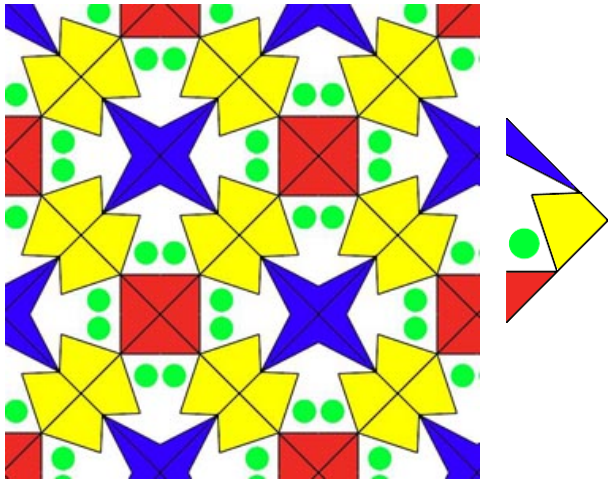
Point Group Pattern: 5 and 5m

Point Group Pattern: 6 and 6mm

Symmetry : Wallpaper Group







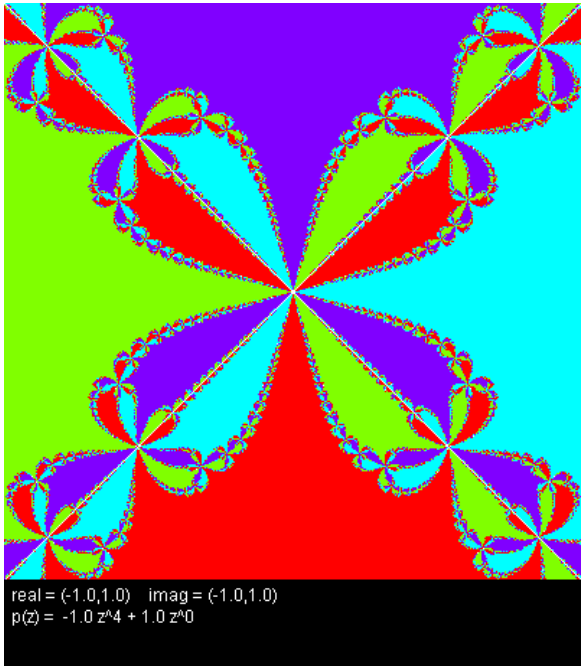
Math: Complex Numbers

- Physics: AC circuits, quantum mechanics
- Mathematics: Solutions to cubic and quartics
- Art & Science: Fractals
- Computer Graphics Transformations:
  - Complex numbers → 2D Rotations
  - Quaternions → 3D Rotations

"*So, progresses arithmetic sublety the end of which, as is said, is as refined as it is useless.*" Cardano (1501-1576)

Math: Polynomiography

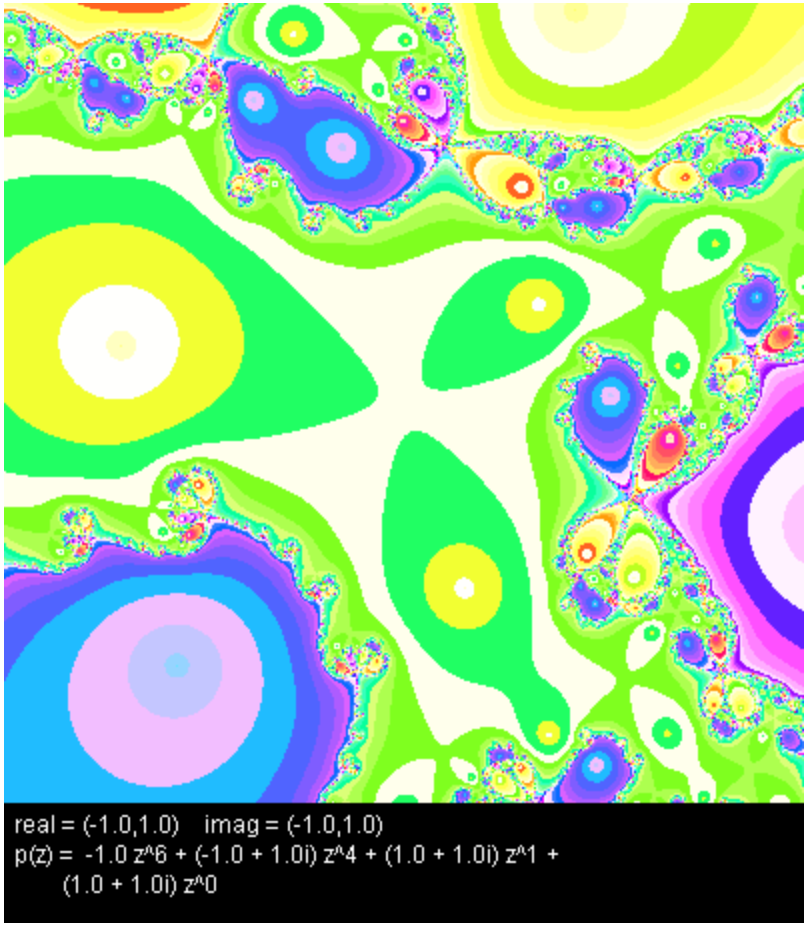
Formally, polynomiography is the art and science of visualization in approximation of zeros of polynomials. This visualization is via fractal and non-fractal images created based on the mathematical convergence properties of iteration functions. [*http://www.polynomiography.com/about.php*]



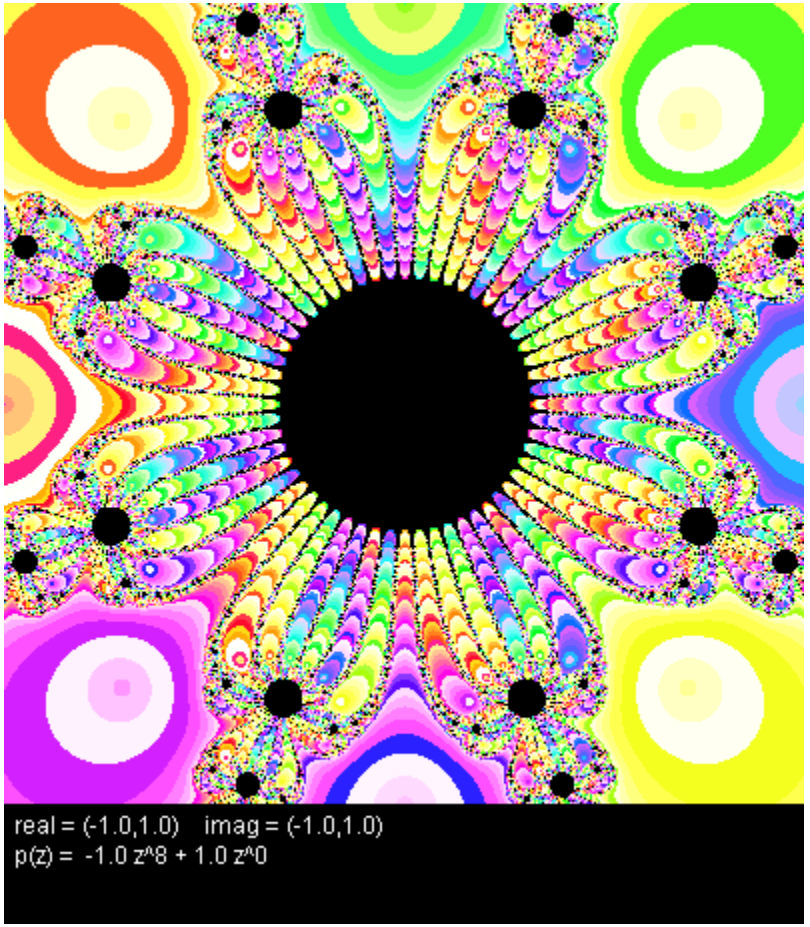
$P(z) = - z^4 + 1$

Roots: 1, -1, i, -i

Polynomiography



$P(z) = - z^6 + (-1 + i)\, z^4 + (1 + i)\, z + (1 + i)$



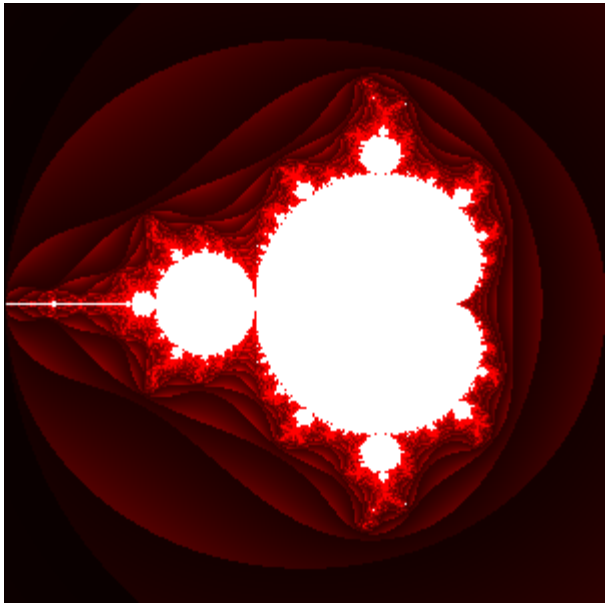
$P(z) = - z^8 + 1$

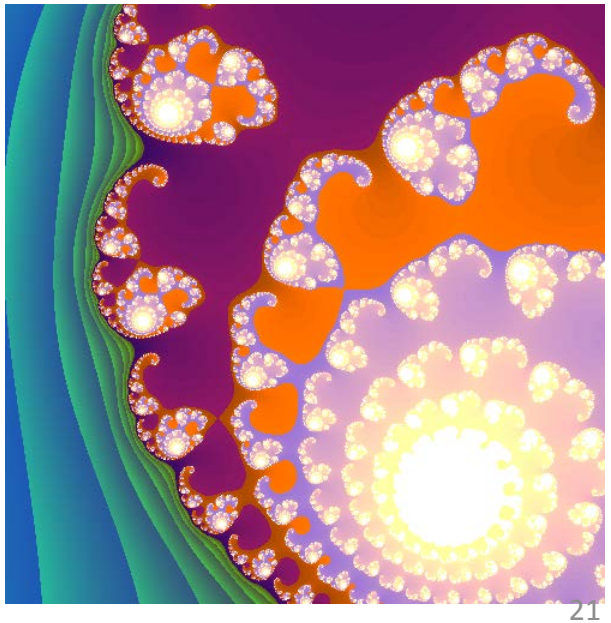
Fractals

Mandelbrot and Julia Sets:

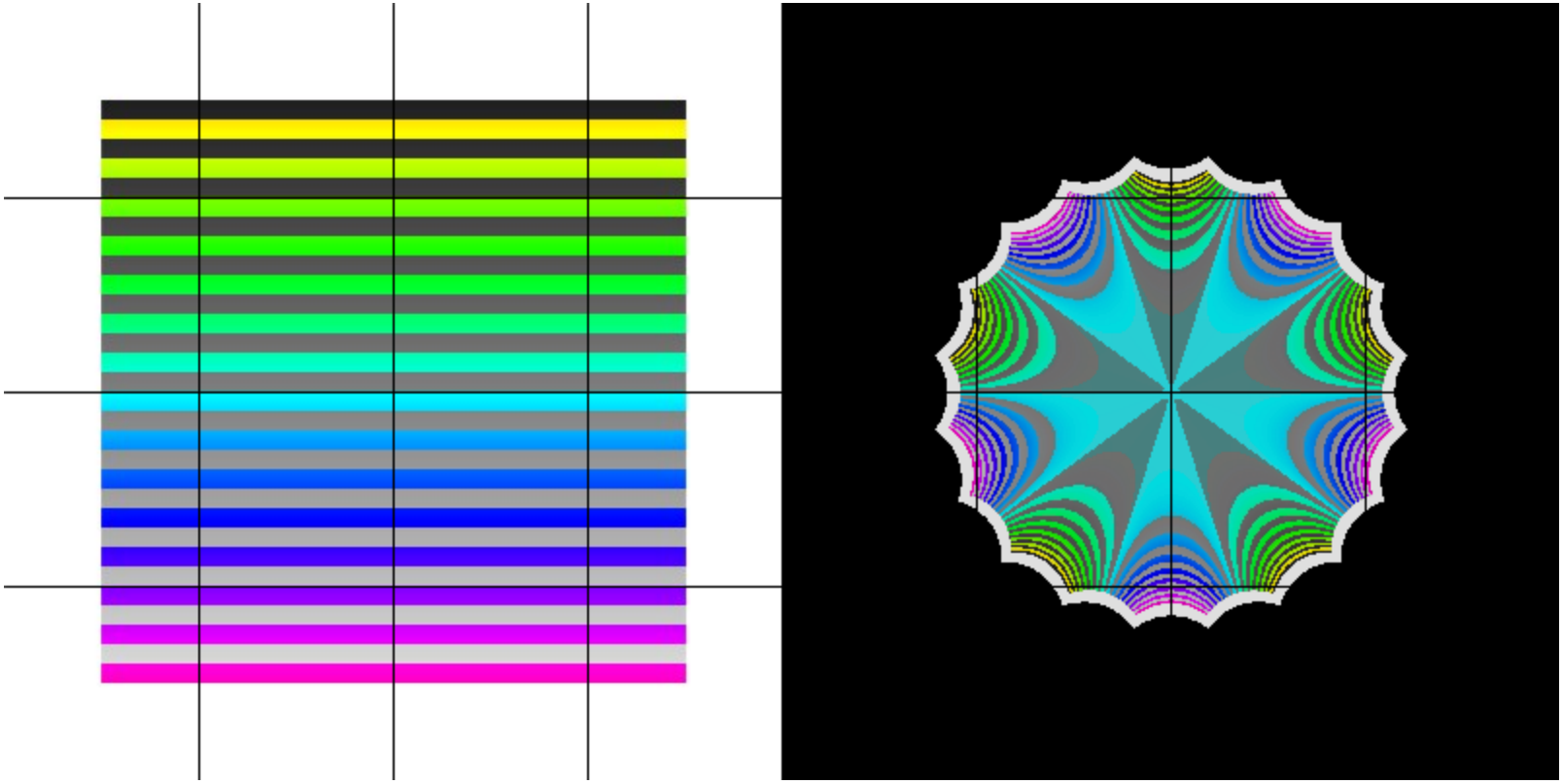
Iterate: $z_n = z^2_{n-1} + c$

What is happening?



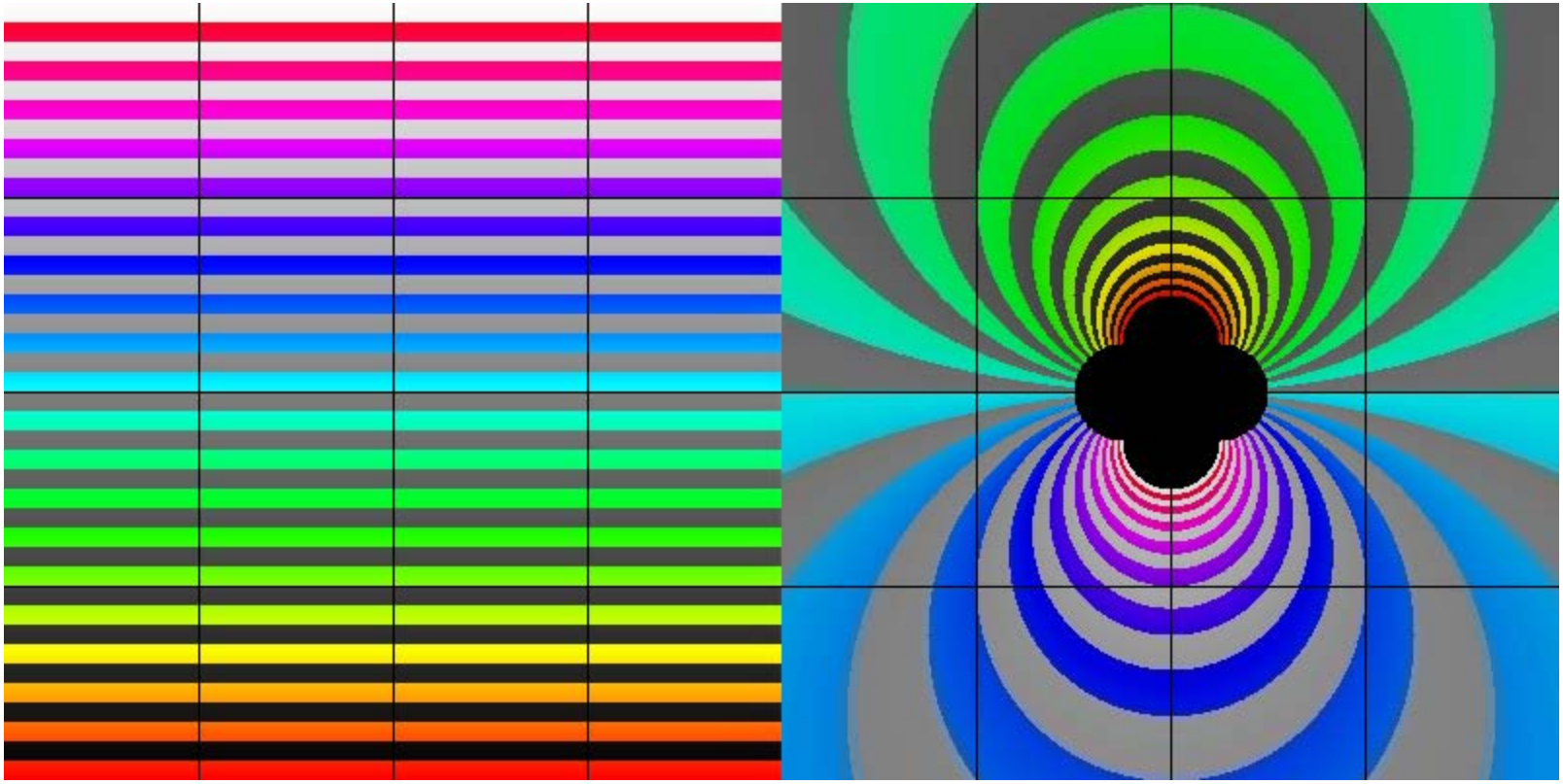


Example: $z \rightarrow z^5$



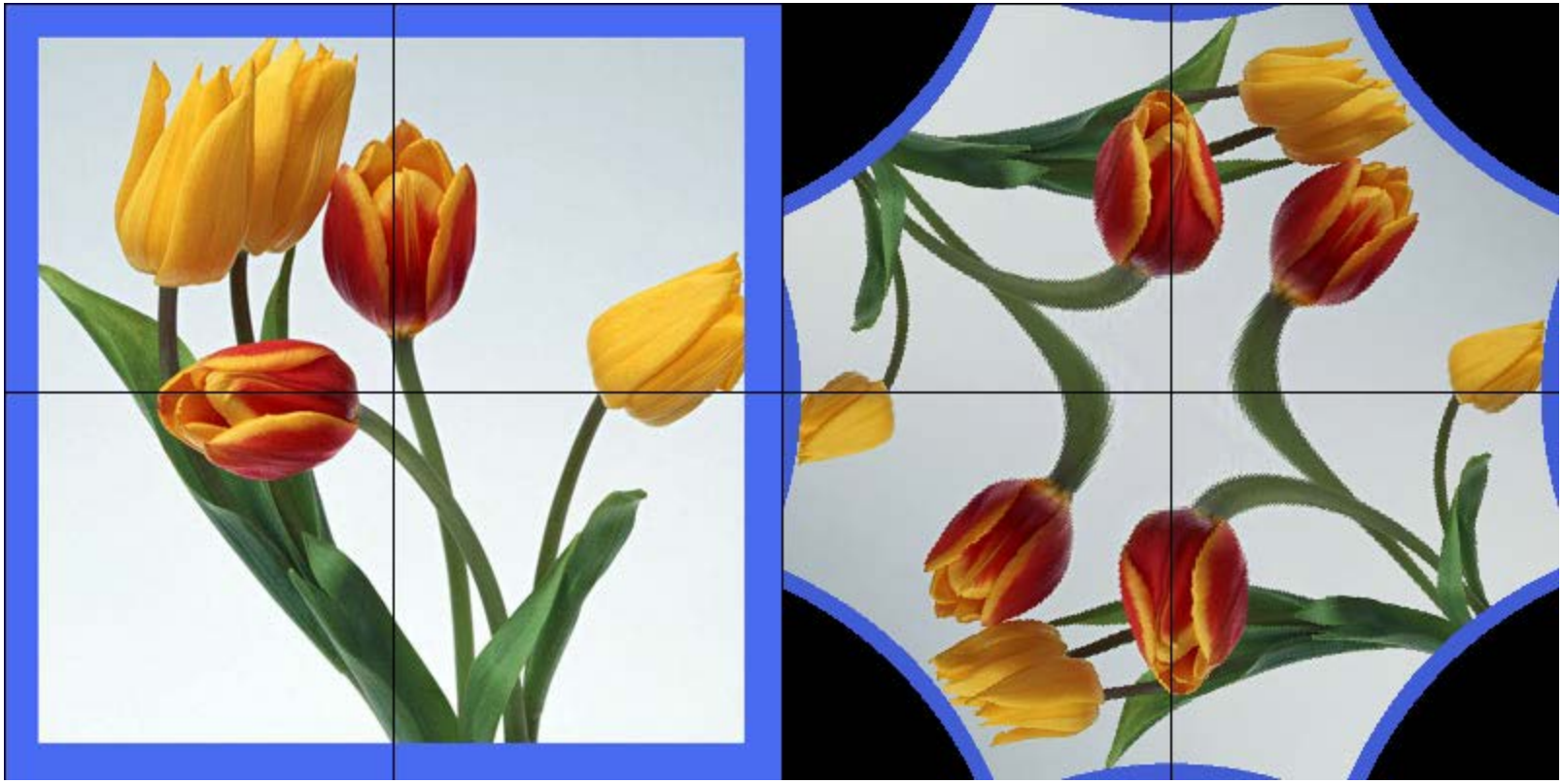
$-2 < x < 2, \quad -2 < y < 2$

Example: $z \rightarrow 1/z$



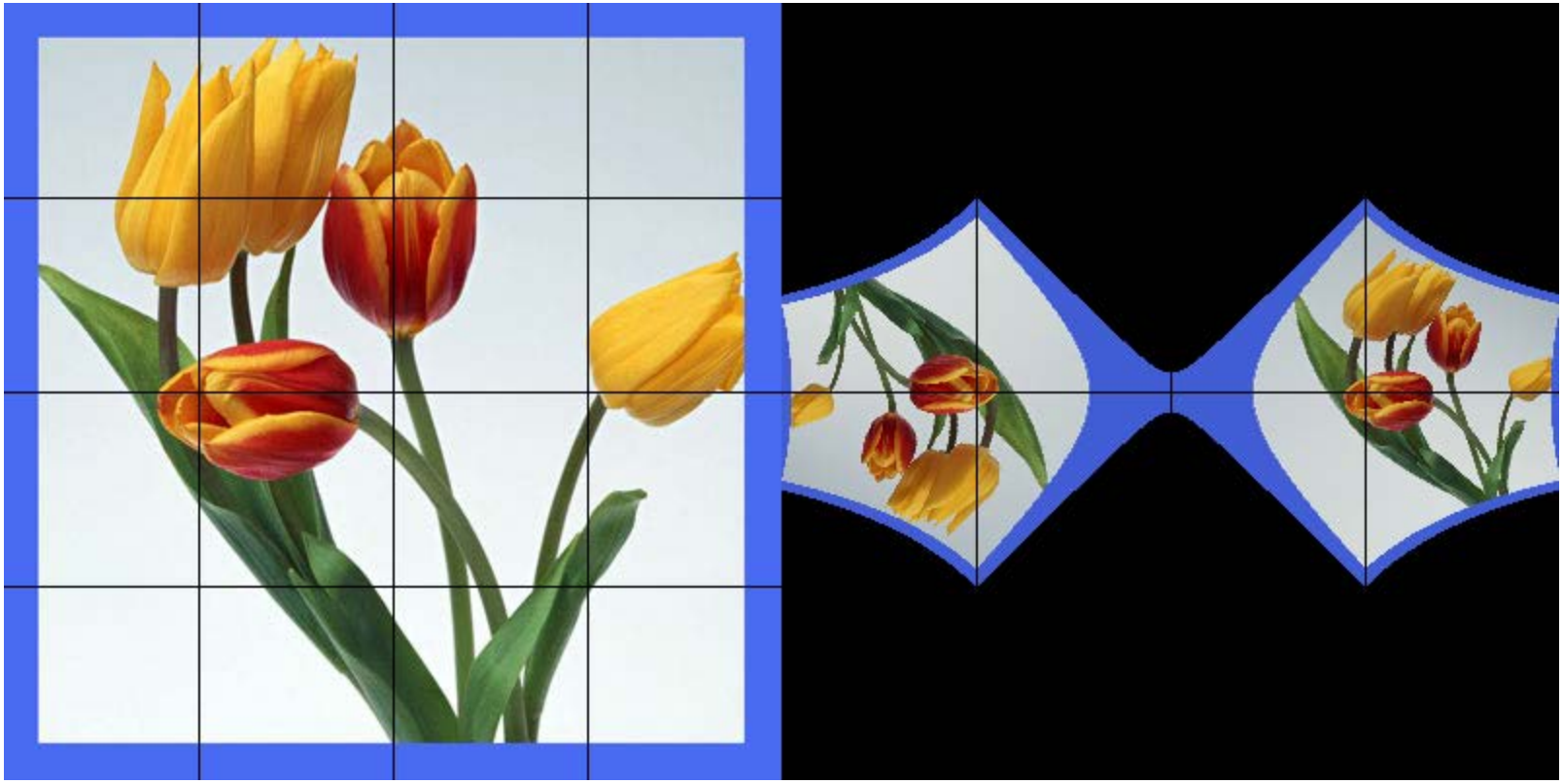
$-2 < x < 2, \quad -2 < y < 2$

Example: $z \rightarrow z^2$



$-1 < x < 1, \quad -1 < y < 1$

Example: $z \rightarrow z^2 - 2$

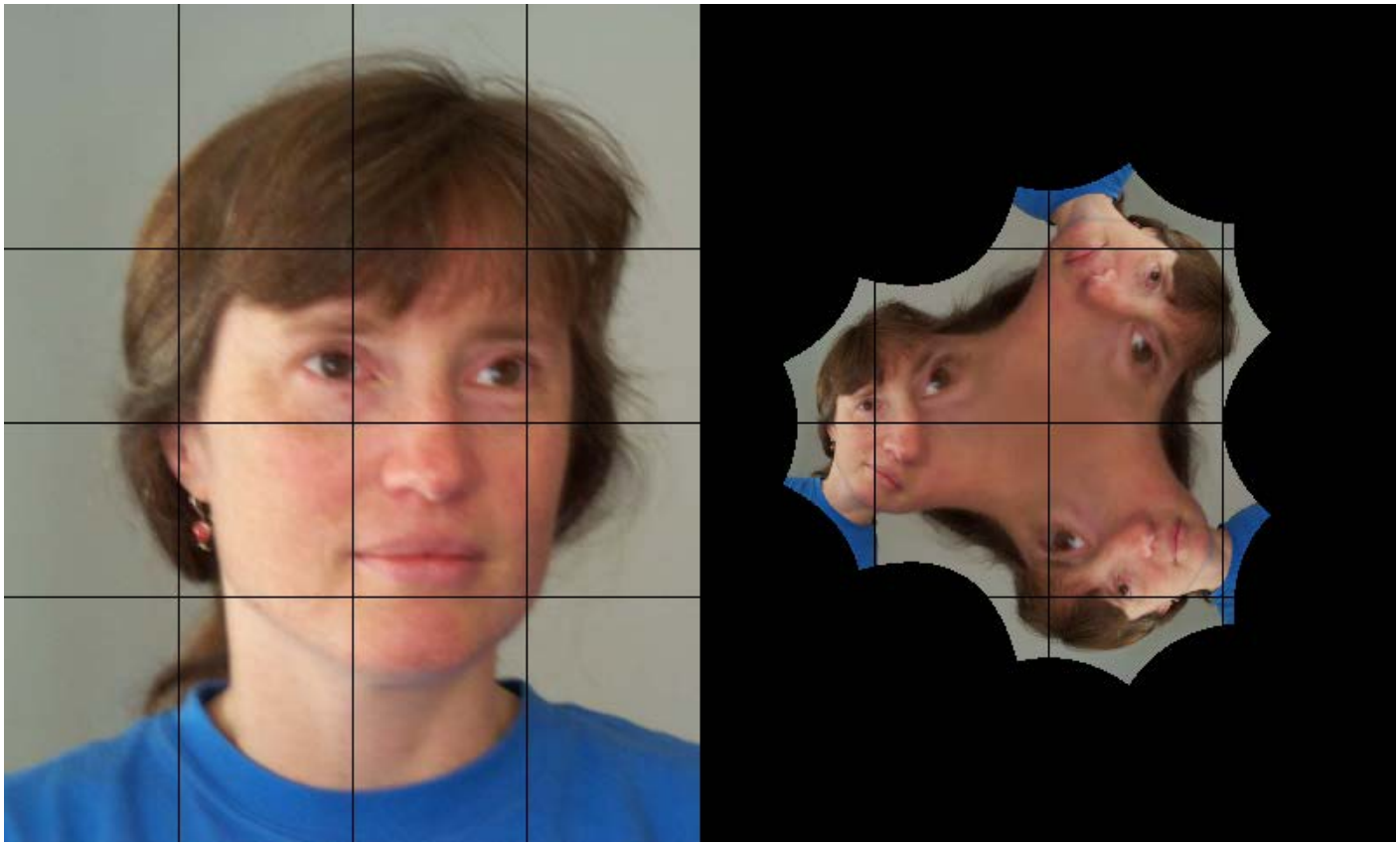


$-2 < x < 2, \quad -2 < y < 2$

Example: $z \rightarrow z^3 - 1$

$-2 < x < 2, \quad -2 < y < 2$

Example: $z \rightarrow z^3 + 1$



$-2 < x < 2, \quad -2 < y < 2$