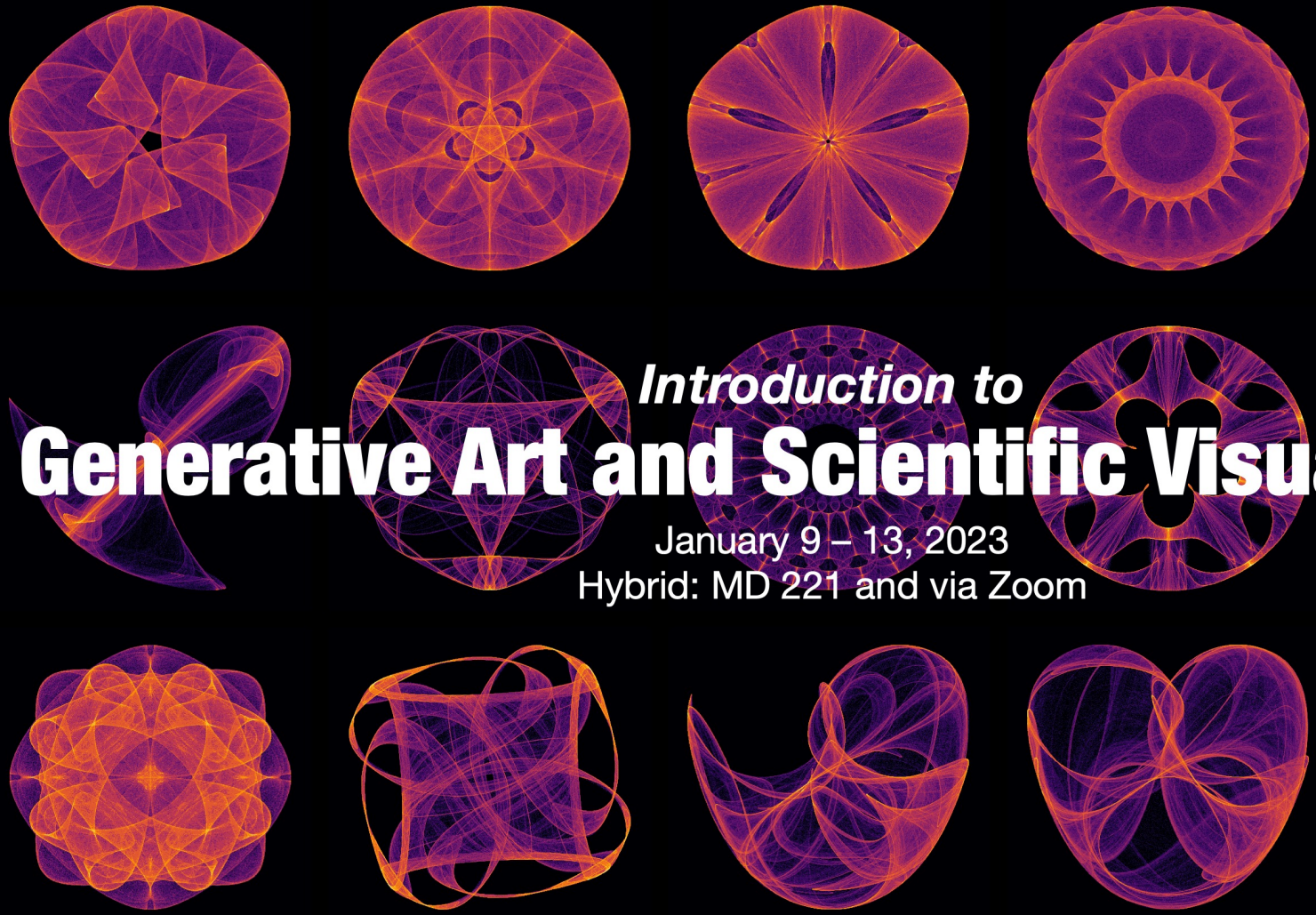


GSC

GSAS STUDENT COUNCIL

HARVARD UNIVERSITY GRADUATE SCHOOL OF ARTS AND SCIENCES

January@GSAS 2023 Mini-Course

Instructors: Yue Sun, Jiayin Lu
Jovana and Nina Andrejević

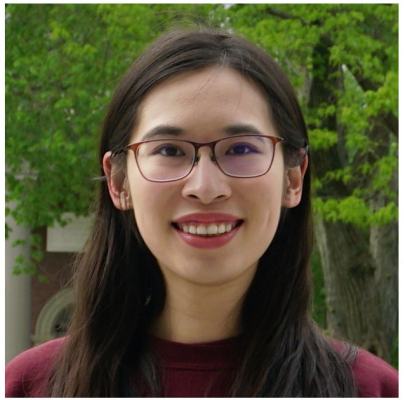
Introduction to

Generative Art and Scientific Visualization

January 9 – 13, 2023

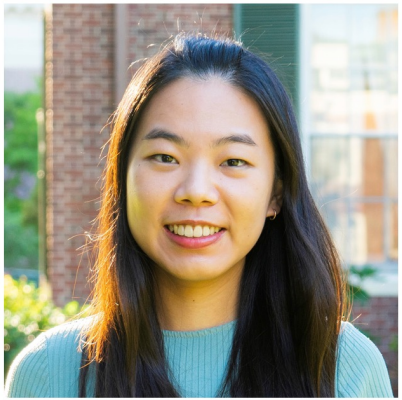
Hybrid: MD 221 and via Zoom

Mini-course instructors



Yue Sun

Applied Mathematics (G3)



Jiayin Lu

Applied Mathematics (G5)

Jovana Andrejevic

Applied Physics (PhD ’22)

Nina Andrejevic

Materials Science and Engineering (PhD ’22, MIT)

Class schedule

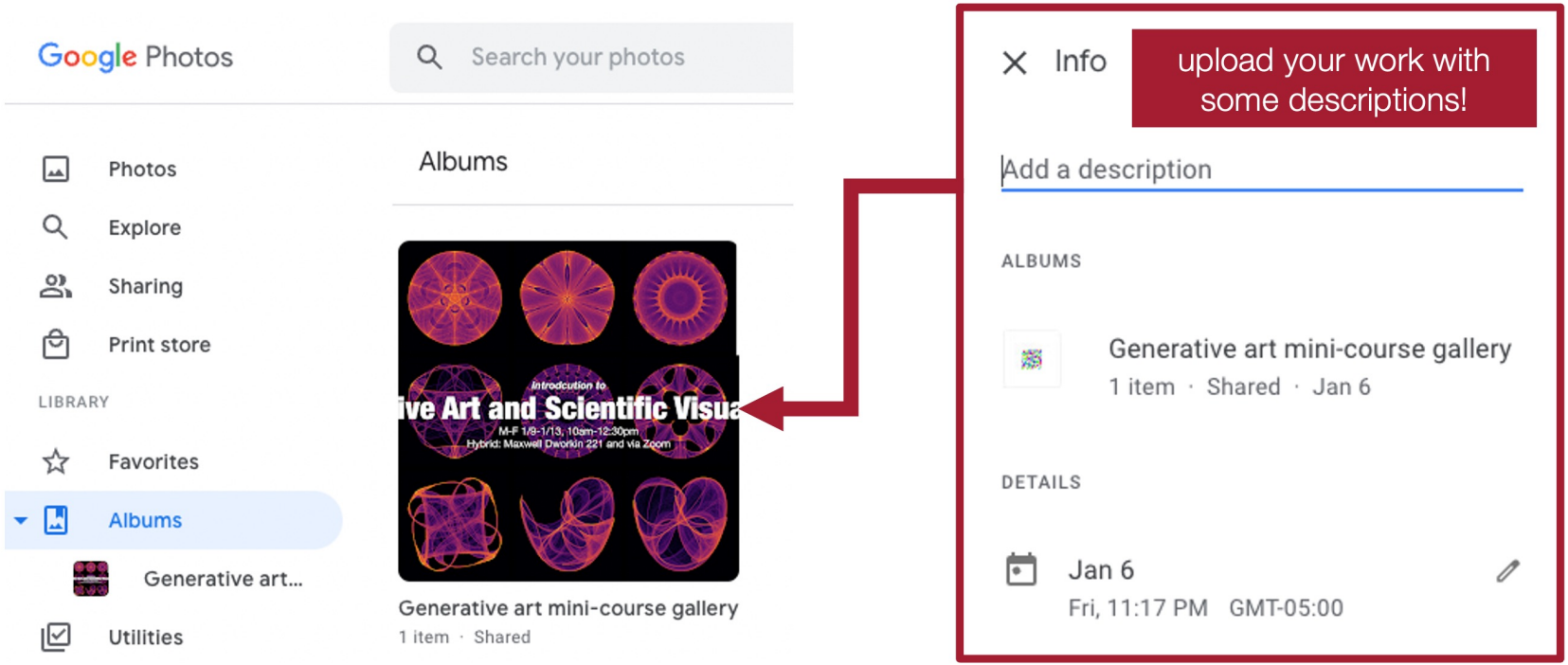
	Monday 1/9	Tuesday 1/10	Wednesday 1/11	Thursday 1/12	Friday 1/13
	Traditional methods	*Voronoi diagram and more*	*Physical systems*	*Tools for visualization*	*More tools and neural networks*
10:00 | 10:10	Introduction	Recap	Recap	Recap	Recap
10:10 | 10:40	Geometric fractals (Part 1)	Voronoi art (Part 1)	Elementary cellular automata	Interactive coding in Processing (Part 1)	3D printing (Part 1)
10:40 | 11:10	Geometric fractals (Part 2)	Voronoi art (Part 2)	Discrete physical systems	Interactive coding in Processing (Part 2)	3D printing (Part 2)
BREAK / IN-CLASS ACTIVITY					
11:20 | 11:50	Mathematical fractals	Voronoi art (Part 3)	Continuous physical systems	Python scripting in animation software	3D printing (Part 3)
11:50 | 12:20	Strange attractors	Space-filling curves	Reaction–diffusion systems	Data visualization in animation software	GAN art and DALL-E 2
12:20 | 12:30	Wrapup	Wrapup	Wrapup	Wrapup	Conclusion

More on logistics

- Course website (GitHub repo): https://github.com/yue-sun/generative-art/tree/main
- The class will be taught using Python (mostly):
  - we will use Google Colab to run Jupyter notebooks in Python; no need to install Python!
  - in-class code examples/exercises will be provided in the repo; solutions will be posted after each class.
- No assignment; but you're welcome to contribute to the course gallery/shared drive!
- What will you gain from the course?
  - be familiar with examples of generative art and their mathematical/physical formulation;
  - learn to code functions and recursive algorithms to procedurally generate/animate art;
  - use Python libraries and animation/modeling software to visualize 2D/3D scientific data;

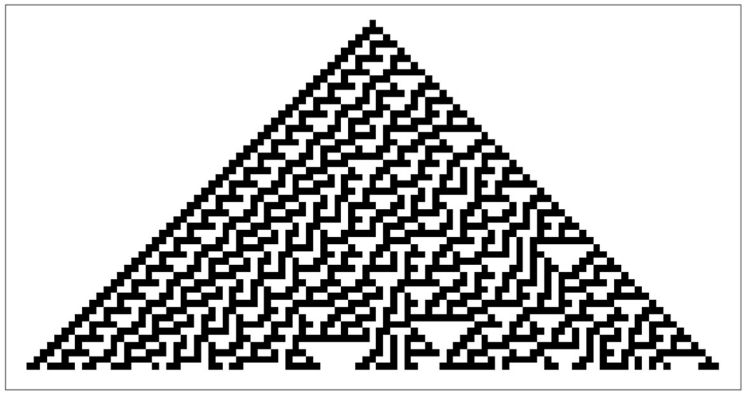
HAVE FUN GENERATING ART!

Mini-course gallery

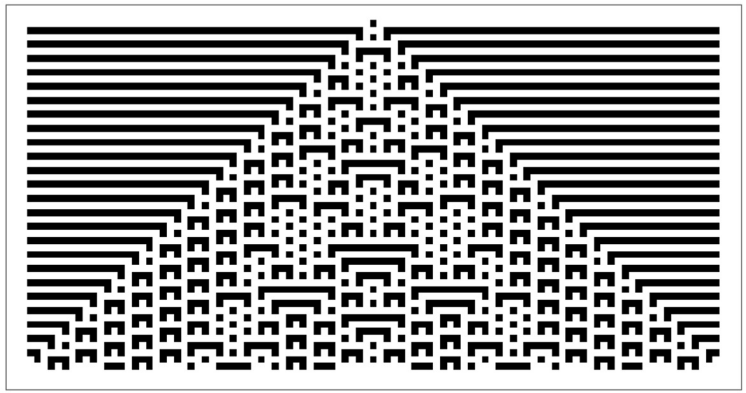


What is generative art?

- Generative art is art or design generated through an autonomous process.
- An autonomous process algorithmically generates new works based on preset rules:
  - it can create new shapes, colors, patterns, and even sounds;
  - by simply setting the creation process rules, we can enable computers to follow the rules to create art;
  - these rules can be based on mathematics, physics, biology, or machine learning!



cellular automata rule 30



cellular automata rule 73

Examples in nature…

fractals

Romanesco broccoli showing self-similar form[1]

more fractals

frost crystals on cold glass forming fractal patterns[2]

cellular automata

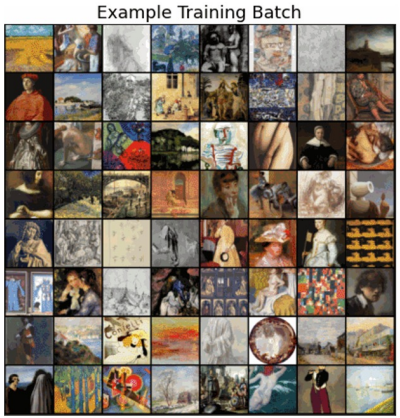
Conus textile exhibiting the rule 30 pattern on its shell[3]

reaction–diffusion systems

giant pufferfish skin resembling the Gray–Scott model[4]

[1] Wikipedia: “Fractal (Romanesco broccoli)”, https://en.wikipedia.org/wiki/Fractal#/media/File:Romanesco_broccoli_(Brassica_oleracea).jpg
[2] Wikipedia: “Fractal (frost patterns)”, https://en.wikipedia.org/wiki/Fractal#/media/File:Frost_patterns_2.jpg
[3] Wikipedia: “Cellular automata (applications in biology)”, https://en.wikipedia.org/wiki/Cellular_automaton#/media/File:Textile_cone.JPG
[4] Wikipedia: “Patterns in nature (pattern formation)”, https://en.wikipedia.org/wiki/Patterns_in_nature#/media/File:Giant_Pufferfish_skin_pattern_detail.jpg

…in machine learning…



generative adversarial networks[1] (GANs)

generate fake artwork that
emulates famous real paintings

neural style transfer[2]

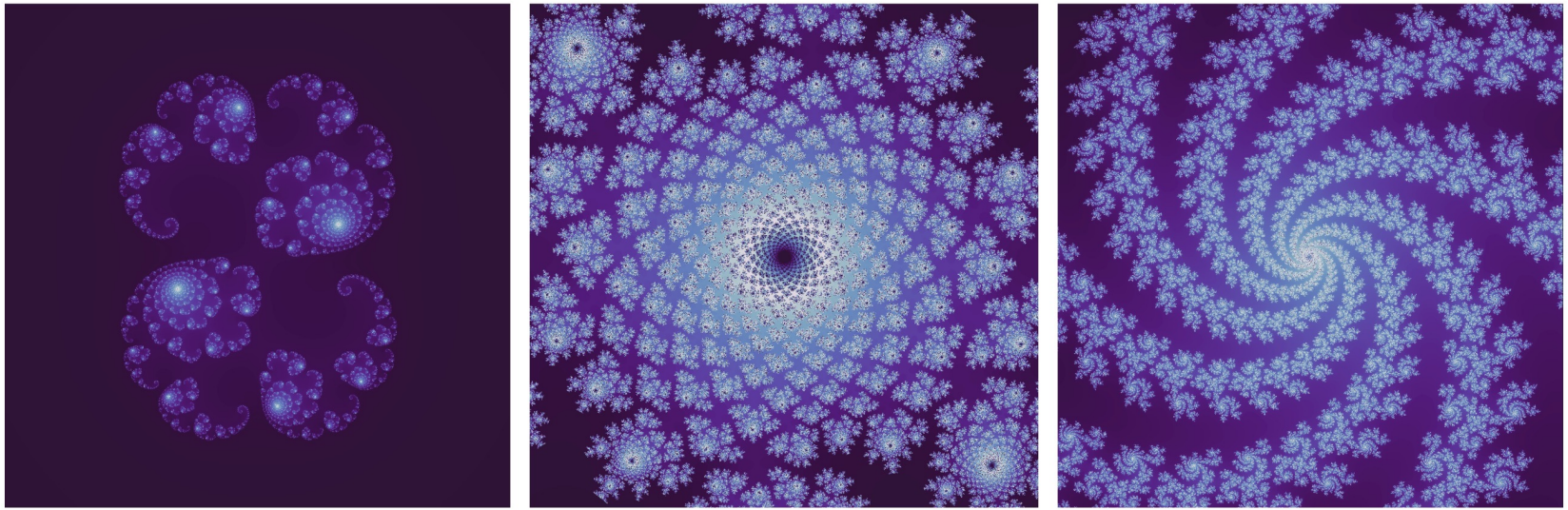
cat photo in the style of van
Gogh's self-portrait (1889)

diffusion model[3]

"an impressionist painting of
Harvard Yard" by DALL·E 2

[1] Generating Art using GANs: https://blog.jovian.ai/generating-art-with-gans-352ceef3d51f
[2] TensorFlow Core: Neural style transfer, https://www.tensorflow.org/tutorials/generative/style_transfer
[3] OpenAI: DALL·E 2, https://openai.com/dall-e-2/

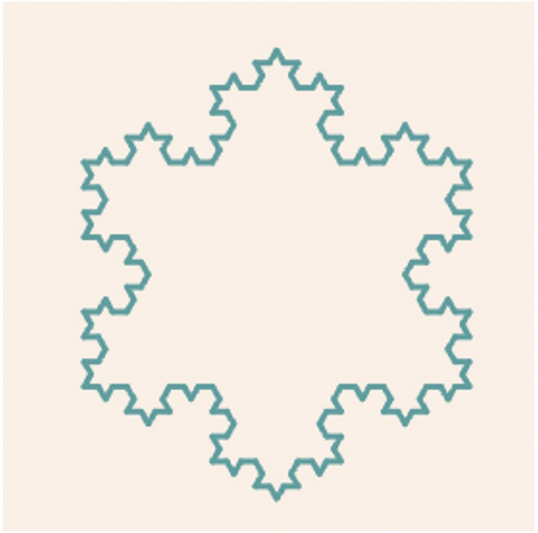
…and in this class!

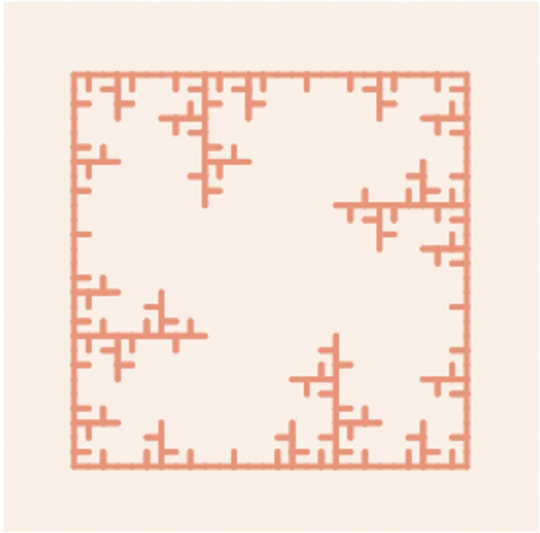


mathematical fractals

(Day 1)

…and in this class!

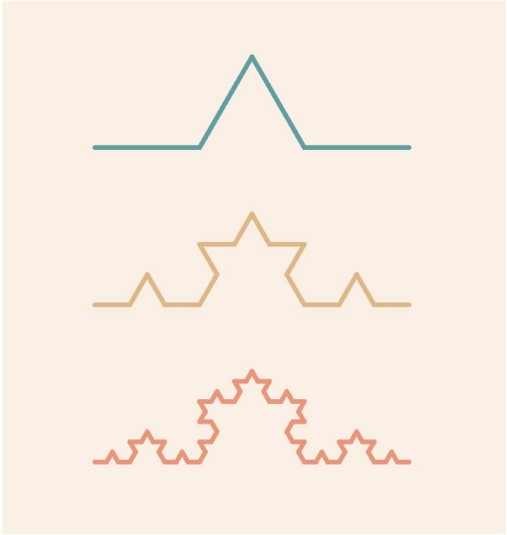


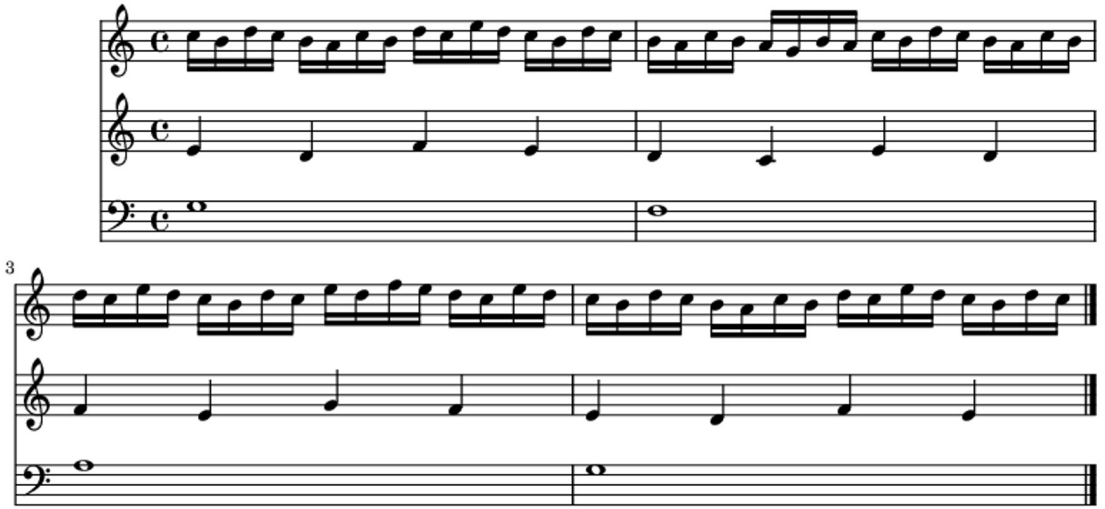


geometric fractals

(Day 1)

…and in this class!

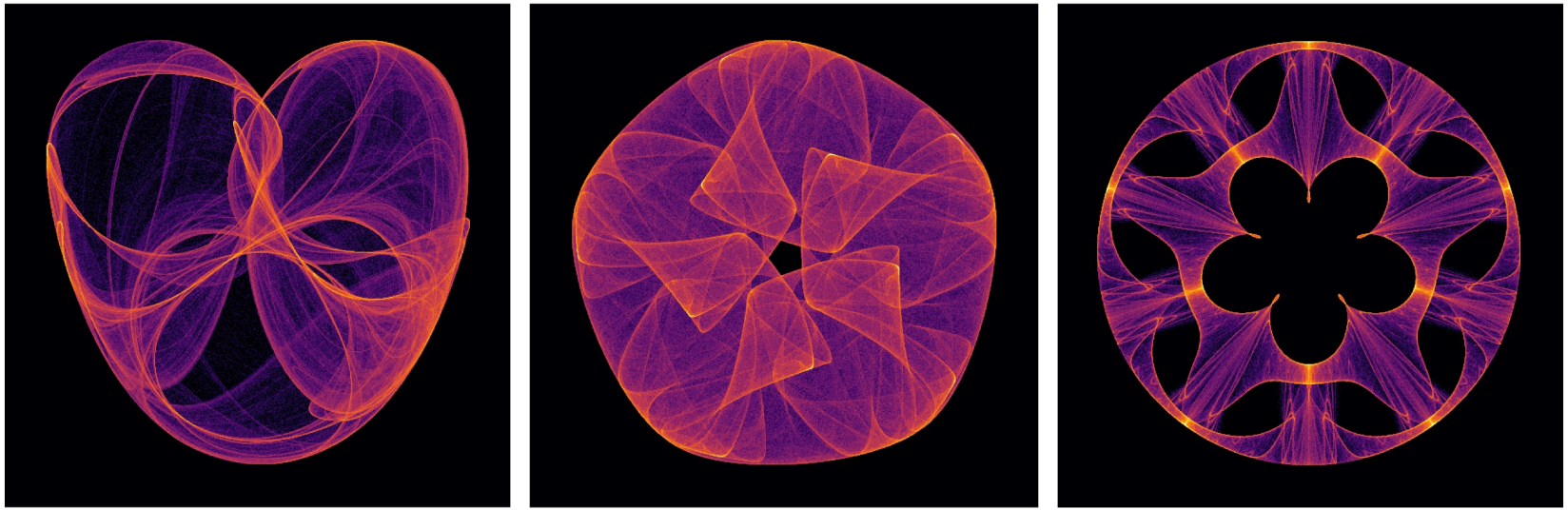




fractal symphony

(Day 1)

…and in this class!



strange attractors

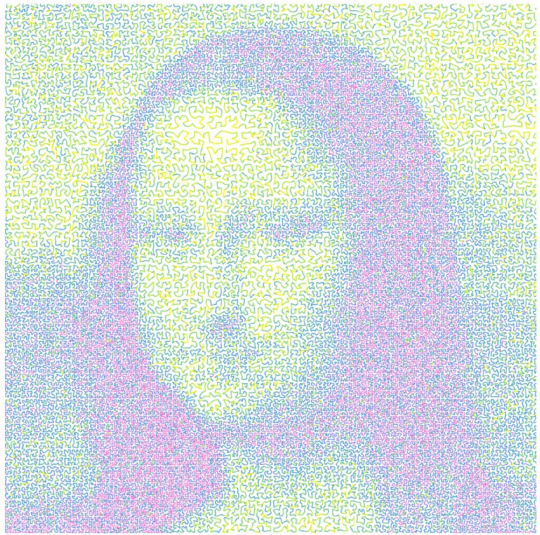
(Day 1)

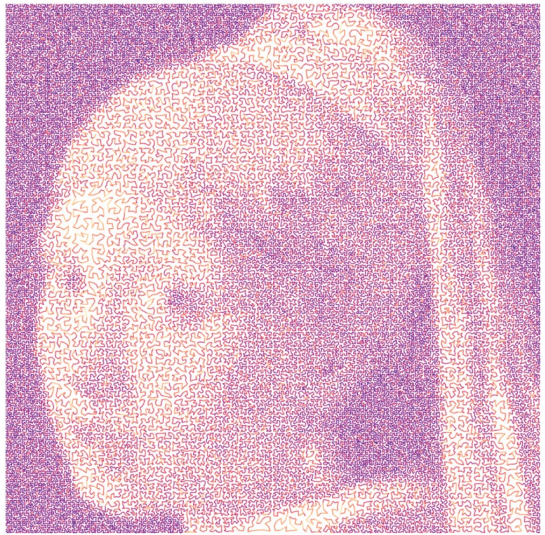
...and in this class!

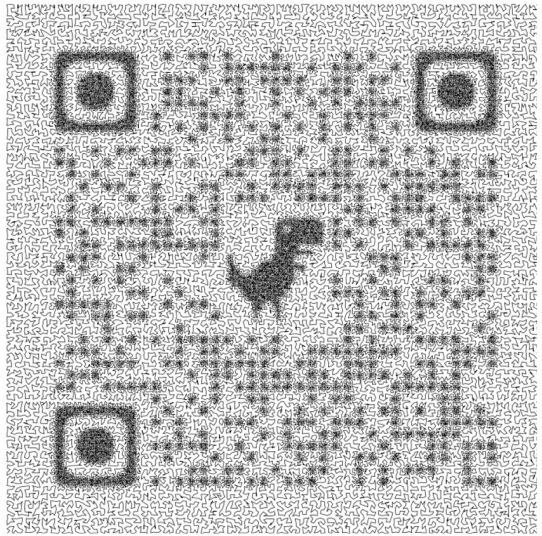
Voronoi art

(Day 2)

...and in this class!



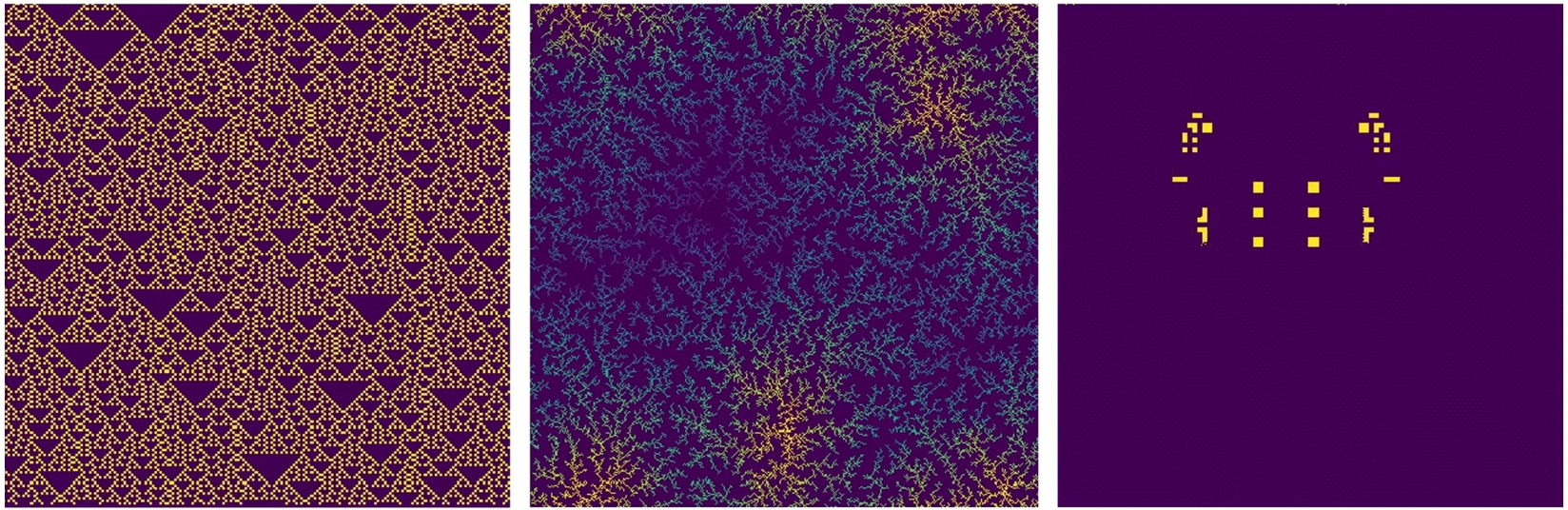




space-filling curves

(Day 2)

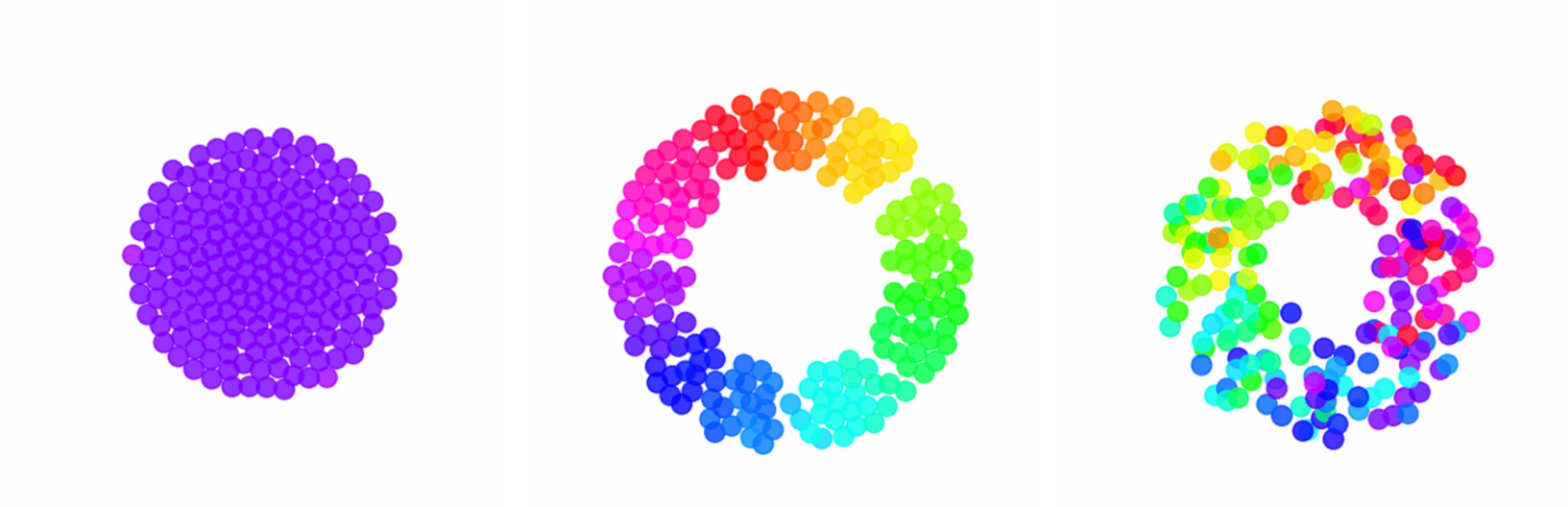
…and in this class!



cellular automata

(Day 3)

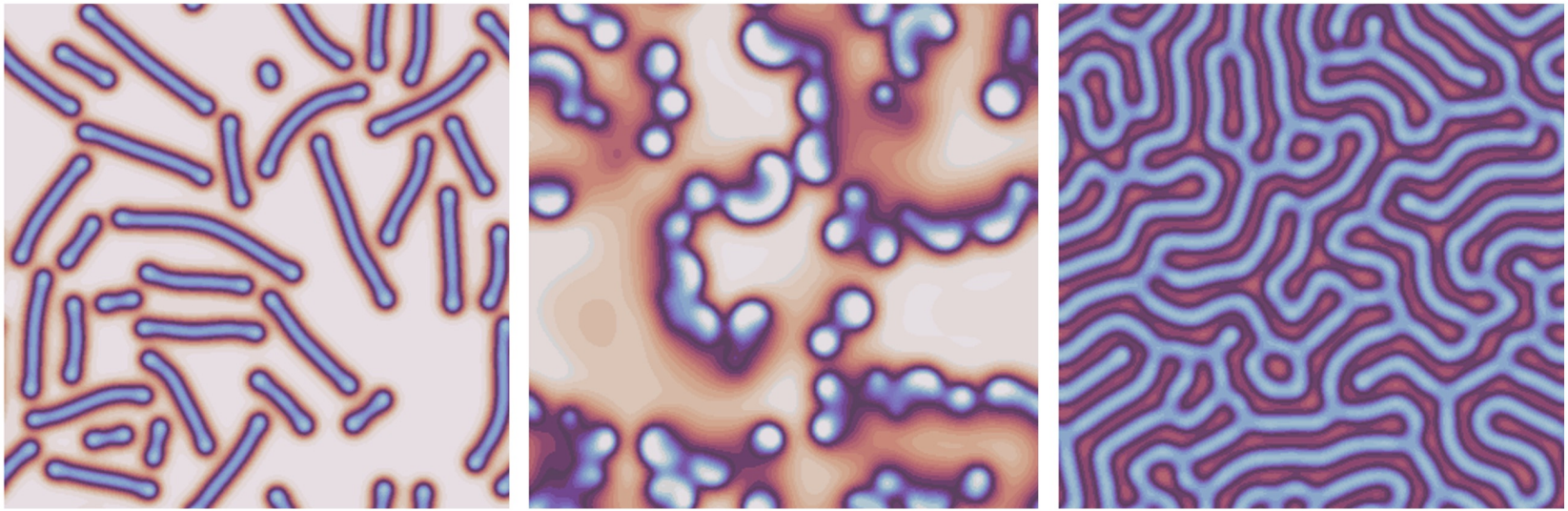
...and in this class!



continous physical systems

(Day 3)

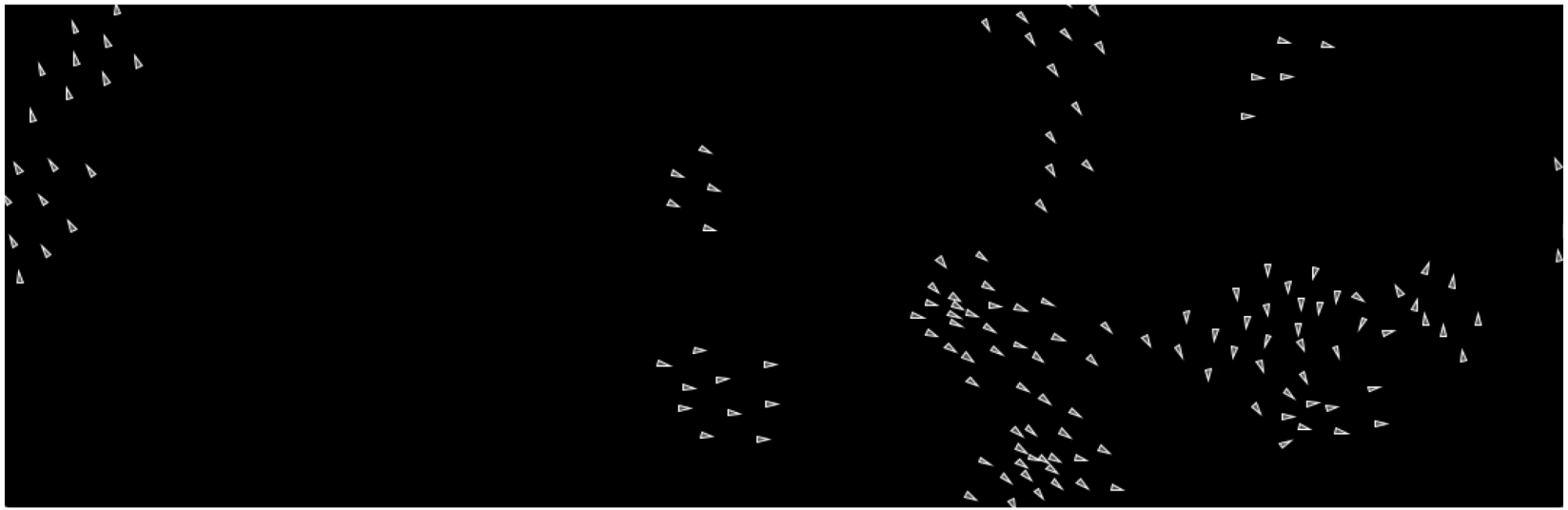
…and in this class!



reaction–diffusion systems

(Day 3)

…and in this class!

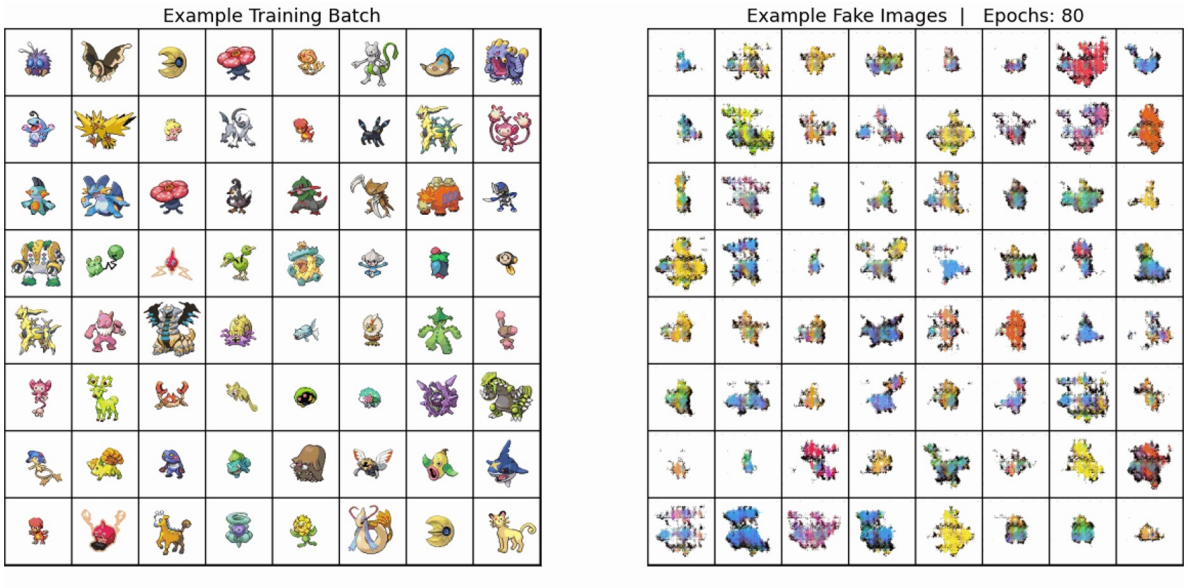


Boids flocking simulation[1][2]

(Day 4)

[1] Boids (background and update) by Craig Reynolds: https://www.red3d.com/cwr/boids/
[2] Example code of flocking in Processing: https://processing.org/examples/flocking.html

...and in this class!



new Pokémon with GANs[1]

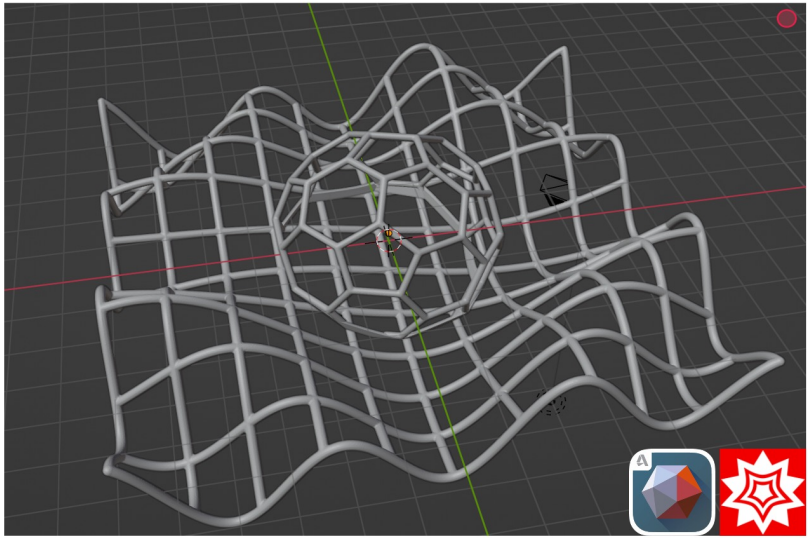
(Day 5)

[1] Monster GANs: create monsters for your game: https://medium.com/@yvanscher/using-gans-to-create-monsters-for-your-game-c1a3ece2f0a0

Tools for visualization

rendering with animation software

(Day 4)



3D printing

(Day 5)

Access course materials

- Course website (GitHub repo): https://github.com/yue-sun/generative-art/tree/main