

Self-Organization in Science and Society

SI-432, 5:30-7:00, NQ1265. Instructor: Ron Eglash. Monday-Wednesday 5:30-7:00

To contact instructor:

Office Hours: Mon 2:00-4:00 and by appointment, 4389 NQ. Email: eglash@umich.edu.

Description

Designers traditionally worked from the top-down, imposing grids of order. But new frameworks allow us to use Nature's techniques of bottom-up evolution and emergence. Adaptive interfaces, fractal architectures and swarms of autonomous agents are just a few of the examples in which designers can take advantage of new models for understanding and applying self-organization. This course will introduce students to self-organization theory and practice, exploring their application to creating designs that are more pleasing to use, more empowering for people and more sustainable for the planet. No prerequisites are required.

Academic Honesty

While ideas are available to everyone, credit for ideas, and the particular text used to express them, belongs to their originator. Plagiarism occurs when a student attempts to pass the ideas or words of someone else as their own. It is surprisingly easy to do. For example, students who are not writing in their first language will sometimes try to use a sentence from another written text, simply because they are worried about their grammar. Plagiarism also occurs when a quotation is reworded in an attempt to avoid citation—always make sure the sources of your quotations are specifically cited. The internet makes plagiarism particularly tempting, since you can copy and paste from the web to your paper. Recycling your own paper from another course would not be plagiarism, but it would be academic dishonesty and thus subject to the same penalties, which include failing the course (a grade of "F").

Special Needs

Please contact me if you have special needs such as disability or religious holidays.

Requirements:

Evaluation will be based on the 3 short "reading reflection" papers (10% each), the research project paper/presentation (40%), and [class participation](#) (30%). Note that the syllabus tells you the reading that will be discussed for that day. You need to have done the reading before you arrive, and you are required to bring the reading to class so that we can discuss the texts in detail. To get

participation credit for a class meeting you are required to be [physically present](#), AND post a discussion question or comment on our board [here](#). Class sessions will require your laptop as well, to play with simulations and other tools.

Short papers and research project:

Short “reading reflection” papers should be 4-5 pages (double-spaced, with proper citations); these allow you to demonstrate your understanding of the material and improve your writing ability on technical subjects. Please use your first and last name for the file name, then submit [here](#). The final research project paper should be 8-10 pages (double-spaced, with proper citations); the instructor will help you find a suitable topic for your research. Research projects can be done by groups, in which case the paper will be longer, and each individual is responsible for a different section of the paper. Working in a group is a great way to bring together more than one discipline (eg math and anthropology, or computing and environmentalism). Research project presentations may also be done by the group.

Texts:

Mitchell, Melanie. *Complexity: a Guided Tour*. Oxford University Press, 2009

Eglash, Ron. *African Fractals: Modern Computing and Indigenous Design*. Rutgers University Press 1999.

Attendance link [here](#) **Discussions link** [here](#) **Assignments drop folder** [here](#).

Course Schedule:

Part I: Foundations of Self-Organization

Jan 9: Intro

Lectures: [intro to self-org](#), [history of self-org](#)

[Discuss](#) Readings: Mitchell ch 1 (if you don't have the book yet you should be able to get it [here](#)); Larson et al, “[Self-organization And Emergence In Global Health](#)”.

In class videos:

Intro to emergence: <https://www.youtube.com/watch?v=AxEdGteSh0I>

- Floating magnets self-organize: <http://www.youtube.com/watch?v=KPP-4-LEHXQ>

- Slime mold maps tokoyo rail system: <http://www.youtube.com/watch?v=GwKuFREOgmo&feature=related> (image comparison [here](#)).
- Bees drive away hornet: <https://www.youtube.com/watch?v=GmsrWJU1si8>
Optional: Mitchell interviews complexity theorists: <http://www.youtube.com/watch?v=rVw5IRe1PMA>

Jan 14: fractals--technical background 1

[Discuss](#) Reading assignment 1: Mitchell ch 7, Reading assignment 2: Take a tour through Yale's "[Panorama of Fractals and Their Uses](#)"

Lecture: [Fractal Dimension](#)

In class: Video "Hunting the Hidden Dimension" <http://www.youtube.com/watch?v=ZbK92bRW2IQ>

Jan 16: fractals--technical background 2

[Discuss](#) Reading: Mitchell ch 17

Lecture: [Embedding dimension](#)

Homework: find a fractal and measure its dimension. It can be a leaf you found, a photo of something, grandma's quilt, or just an [abstract math fractal](#). Both mac and windows will work with jimage and its plugin fraclac, as explained [here](#). It has a file converter, or you can use something like photoshop to convert to bmp and then back to 8 bit greyscale.

If you have windows or linux you can use: <http://www.fractalyse.org/>. Note that it needs .BMP or .tiff files (but some file converters will add some form of compression--using gimp or photoshop will help that issue). The "analyze" menu gives you several choices for dimension measures, I find that "Correlation" usually works best.

For the mac only -- you can try: <http://paulbourke.net/fractals/fracdima/>

If all the above fail, or you just feel like doing it by hand:

https://users.math.yale.edu/public_html/People/frame/Fractals/Labs/CoastlineLab/CoastlineLab.html

(here are some [more tips](#))

You can paste the results in your discussion entry. Make sure to bring your laptops as we will experiment in the classroom with software for creating fractals. I find that line thickness 2, iteration 7 is often the best match for the analyzers.

In class: [Fractal nature simulations](#) [Koch curve](#)

Jan 21: MLK day, no classes

Jan 23: fractals--social aspects

[Discuss](#) Readings: I have included both "beginner" and "advanced" readings -- read any 2 that you find suitable, in any combination you like (you can do two from one category or across categories):

Economics:

beginner: <http://aidwatchers.com/2010/09/beautiful-fractals-and-ugly-inequality/>

advanced: https://ecommons.cornell.edu/bitstream/handle/1813/58012/Cornell_Dyson_wp0342.pdf?sequence=1&isAllowed=y

Literature:

beginner: http://users.math.yale.edu/public_html/People/frame/Fractals/Panorama/Literature/PollardGott/PollardGott.html

advanced: <http://www.depauw.edu/sfs/backissues/113/wenaus.html>

Social science:

beginner: <https://pdfs.semanticscholar.org/d517/c093edafe9cf08a8e923984c1b0559c2b45b.pdf>

advanced: <http://salsa.ling.utexas.edu/proceedings/2003/andronis.pdf>

and just for fun two more reading options in literature:

[Diamonds within diamonds: Ethnic Literature and the Fractal Aesthetic](#)

[The Fractal Nature of Gary Snyder's Mountains and Rivers without End](#)

in-class video: http://www.ted.com/talks/geoffrey_west_the_surprising_math_of_cities_and_corporations.html

lectures: [fractal poverty traps](#) [fractal eye movements and art](#) [Types of self-similarity](#)

Jan 28 technical background 1

[Discuss](#) Reading: Mitchell ch 2, Nonlinear dynamics as low-dimensional self-organization.

Lecture: [Intro to chaos theory](#)

In class: Video, "[The Strange New Science of Chaos.](#)"

Jan 30 Polar Vortex Day

Feb 4 Chaos-- technical background

[Discuss](#) Reading: Gleick, Chaos: http://www.math.harvard.edu/~knill/teaching/mathe320_2014/blog/ChaosGleick.pdf

In-class: we will experiment with:

logistic map: <https://community.csd.t.rpi.edu/projects/773/run>

sonic version: <https://community.csd.t.rpi.edu/projects/355/run>

In class: [exercises](#) Lecture: [Applications of chaos theory](#)

Feb 6

Lectures: [Intro to STS](#)

[Discuss](#) Readings: [Chaos theory and international relations](#)

Chaos theory and social science: [The Problem of the Attractor A Singular Generality between Sciences and Social Theory.](#)

In class: [Rossler attractor exercise](#)

Feb 11 Cellular automata

[Discuss](#) Mitchell ch 8-10. In class: experiment with CA: [download Life32 windows here](#) (for mac use alternative <http://sourceforge.net/projects/golly/>)

Lecture: [Intro to Life32](#)

Lecture: [Measuring Complexity](#)

In-class video: http://www.ted.com/talks/stephen_wolfram_computing_a_theory_of_everything.html

Feb 13 Flocking

First paper due: drop in box [here](#).

[Discuss](#) Mitchell ch 12 (information in living systems); Young " [How the Science of Swarms can help us fight cancer and predict the future](#)";

Optional: Couzin, I.D. & Krause, J. (2003) [Self-organization and collective behavior in vertebrates](#). *Advances in the Study of Behavior* 32, 1-75.

In class:

Flocking simulations:

3D: http://www.heatonresearch.com/aifh/vol2/flock_3d.html;

2D with network vis: http://threejs.org/examples/#webgl_gpgpu_birds

Netlogo version: <http://ccl.northwestern.edu/netlogo/models/community/couzin> (requires netlogo: <http://ccl.northwestern.edu/netlogo/6.0/>)

Videos in class:

Wilbebeest migration: <http://www.youtube.com/watch?v=uiH-p1OSRZw> start at 1:20 and observe how split evolves over time.

Deborah Gordon: http://www.ted.com/talks/deborah_gordon_digs_ants.html

Fish vortex: <http://www.discovery.com/tv-shows/other-shows/videos/superswarm-fish-vortex/>

Lecture: [self-organization in vertebrate collective behavior](#)

Feb 18 Flocking in Information Systems

Discuss readings: [Birds of a feather protest together: theorizing self-organizing political protests with flock theory](#)
(https://www.researchgate.net/publication/225641208_Birds_of_a_Feather_Protest_Together_Theorizing_Self-Organizing_Political_Protests_with_Flock_Theory)

Smarticles

In class:

Mosh pit video: <https://www.youtube.com/watch?v=70tWI7dw7yc&index=3&list=RDo7w7m4lb2ok>

Mosh pit sim: <http://mattbierbaum.github.com/moshpits.js/> (details [here](#))

Drone flocking video: <http://www.nature.com/news/autonomous-drones-flock-like-birds-1.14776> (start at 2:00)

Harvard's Kilobots: <https://www.youtube.com/watch?v=dDsmbwOrHJs>

Droplets: <https://youtu.be/qEtpwljR5mY>

Swarmanoids: <https://www.youtube.com/watch?v=0uDbwOtFKgU>

Feb 20 Autocatalytic sets:

Discuss Readings

- [Waldrop ch 3 https://drive.google.com/open?id=0B23VLXK2HL2rT0NJR3Jtb0NpUWc](https://drive.google.com/open?id=0B23VLXK2HL2rT0NJR3Jtb0NpUWc)
- [Kauffman http://www.santafe.edu/media/workingpapers/91-09-037.pdf](http://www.santafe.edu/media/workingpapers/91-09-037.pdf)
- <http://www.arn.org/docs2/news/kauffmaninterviewNS031701.htm>

Lecture: [autocatalytic sets](#)

Lecture: [boolean networks](#)

In class exercise: Make your own boolean network: <https://community.csdt.rpi.edu/projects/817/run>

Feb 25 Self-organized criticality and 1/f noise

Discuss Readings: Gardner, "[White, Brown and Fractal Music](#)"; Bak and Chen, "[Self-Organized Criticality](#)"; Eglash, "[Inferring representation type](#)"; Optional: <http://www.pnas.org/content/92/15/6689.full.pdf>

In-class exercise: show sub-critical, super-critical, and critical systems using simulations at <http://www.shodor.org/interactivate/activities/ABetterFire/>

Start video at 7:17 [California on fire](#)

Lecture: [1/F noise](#)

Pink noise generator: <https://soundcloud.com/onlinetonegenerator>

Feb 27 Self-organization in networks

Discuss readings

- Mitchell ch 15-16

In-class experiment: Use <http://oracleofbacon.org> to find the largest Bacon number in Kevin Bacon's adjacency matrix.

In-class experiment: Use network visualization at <http://visuwords.com/> to find the word with the most complex network.

In-class experiment: Use <http://tiddlymap.org/> to create your own network (start with "view" dropdown and check out samples).

Lecture [Network Theory](#)

Video: <https://flowingdata.com/2016/02/22/social-network-of-earths-plants-and-animals/>

March 4,6 break

Part II: Decolonizing Computing: self-organization and indigenous knowledge systems

March 11

Discuss African Fractals ch 1-3.

- In-class laptop experiment: African fractals design tool:
- https://community.csdt.rpi.edu/cms/application-contexts/african-fractals/african-architecture/mokoulek/?edit_off
- <https://community.csdt.rpi.edu/cms/application-contexts/african-fractals/african-architecture/nankani2/>
- <https://community.csdt.rpi.edu/cms/application-contexts/african-fractals/african-architecture/baila/>
- <https://community.csdt.rpi.edu/cms/application-contexts/african-fractals/african-architecture/logone-birni/>
- . Diffusion limited aggregation at <http://apricot.polyu.edu.hk/~lam/dla/dla.html>.

- Lecture: [Comparison of Native American and African ethnomathematics](#)

March 13

[Discuss](#) African Fractals ch 4-7

- In-class laptop experiment: [Cornrows](#), [Adinkra spirals](#), and [Mangbetu](#) design tools using simulations from various designs.
- **Optional:** For a technical analysis see “Quantifying Self-Organization in Cyclic Cellular Automata” at <http://www.cscs.umich.edu/~crshalizi/research/FN03.pdf>. For more on Owari as CA see <http://ehess.modelisationsavoirs.fr/marc/publi/awele/> and <http://isgem.rpi.edu/files/1546..>

March 18

[Discuss](#) African Fractals ch 8-10;

- In-class laptop experiments:
- 1) Starting with positive feedback using the "C" shaped fractal at <https://community.csd.t.rpi.edu/projects/1346/present> create a version with negative feedback (which retains a recognizable "C" shape upon iterating to higher levels), and one that is in-between negative and positive. Just to show who is boss, create your initials in fractals. Compare to how chromosomes fashion DNA to look like letters: <https://pmgbiology.files.wordpress.com/2015/10/chromatin.jpg>
- 2) Using [Life32](#), create negative and positive feedback by changing the rules, and one that is in-between.
- 3) Using [Bamana divination](#) interpret your fortune for the first 3 signs (see <http://www.princeton.edu/~ezb/geomancy/geostep.html#figures> for interpretation).

March 20

[Discuss](#) African Fractals ch 11-14.

- Lecture: [Cultural Politics](#).
- Lecture: [Europe comes late to the fractal party](#)
- Watch in class: http://www.ted.com/talks/xavier_vilalta_architecture_at_home_in_its_community

Part III: Self-organization in Design Studies

March 25 **Second paper due (drop here)**

[Discuss](#) readings on self-organization in interface design

[Self-Organizing User Interfaces: Envisioning the Future of Ubicomp UIs](#)

[An enactive based realtime 3D self-organization system for the exploration of a cultural heritage data base](#)

- Lecture: [evolution and technology](#)
- Video of Grey Walter : <https://www.youtube.com/watch?v=ILULRImXkKo>
- <https://community.csdt.rpi.edu/projects/1081/run>

March 27

[Discuss](#) readings on cooperation in agent-based simulations and real life commons:

Hofstadter, Douglas R. 1983, "[Computer Tournaments of the Prisoner's Dilemma Suggest How Cooperation Evolves](#)";

Ostrom, Elinor et al, "Revisiting the Commons." *Science* 9 April 1999:Vol. 284. no. 5412, pp. 278 - 282

(<http://www.sciencemag.org.libproxy.rpi.edu/cgi/content/full/284/5412/278>);

Optional: readings: Nowak, "[Why we help](#)"

In class: Simulation of iterated prisoner's dilemma

<http://www.christopherxjensen.com/research/projects/online-cooperative-resource/easy-iterated-prisoners-dilemma>

Lecture: [Common Pool Resources](#)

Lecture: [Ostrom's Social-Ecological Model](#)

Lecture: [Animal Altruism](#) Video: [Friends Furever](#)

April 1

[Discuss](#) readings on self-organization for city-level information systems

[Smart Cities, Big Data, and Communities: Reasoning From the Viewpoint of Attractors](#)

[Governing the Complexity of Smart Data Cities: Setting a Research Agenda](#)

April 3

Project proposal due (drop [here](#)).

[Discuss](#) readings on self-organization of economic production

Diez, Tomas (2016) ['Locally Productive, Globally Connected, Self-Sufficient Cities'- Fab City Whitepaper](#)

[Leveraging OHS growth through a city's innovation ecosystem: the case of Barcelona](#)

Lecture: [digital fabrication for generative networks](#)

April 8

[Discuss](#) readings

- Clay Shirky, "[Cognitive Surplus](#)" chapter 1
- Evgeny Morozov, "[Sharing Liberally](#)" Boston Review July 2010.
- "[Up for Debate: Can Social Media Solve Real-World Problems?](#)" Evgeny Morozov vs Steven Johnson (New Republic).

In class: http://www.ted.com/talks/chris_anderson_how_web_video_powers_global_innovation.html

Video: [Yochai Benkler on open source economics](#)

Lecture: [Smart Mobs](#)

April 10

[Discuss](#) readings

Select two papers for your reading from <https://generativejustice.wikispaces.com/Papers+and+presentations>.

In class

- Students's informal progress report on proposed final project (just verbal "check-in")
- Lecture: [Ethics from the bottom-up](#)

Part V The Politics of Self-Organization

April 15

Third paper due (drop [here](#))

[Discuss](#) readings:

[A "Social Bitcoin" could sustain a democratic digital world](#)

[Lievens, "Penguin and the Levithan: a summary"](#);

In-class lecture: [Basins of attraction from flocks to networks](#)

In-class video: [Gabriella Coleman on hackers](#)

April 17

- Student presentations

April 22

- Student presentations

April 29 **Final research paper due no later than 5pm ([drop here](#)).**

A few helpful readings for those who want more:

[Chaos Theory Tamed](#): this book by a geologist nicely strikes a compromise between too technical and too popular accounts.

[Complexity](#): a nice math/programming overview from Downey

