Week 3 class 1 - Chaos and Fractals

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Today's goals

- Definition of Chaos
- Definition and exploration of randomness

Definition of Chaos

A dynamical system is **chaotic** if. . .

1. It's deterministic
2. Orbits are bounded (they don't run off to infinity)
3. Orbits are aperiodic (they never repeat)
4. Orbits have sensitive dependence on initial conditions (butterfly effect, small changes are magnified along the orbit)

a. Sensitive dependence on initial conditions is caused by a kneading motion: see Smale Horseshoes i. Due to stretching points apart ii. Due to folding points back onto themselves

Chaos is a property of a dynamical system. A dynamical system is a system which exhibits changes through time according to rules.

Example chaotic orbit:

Trajectory of the logistic map for R = 4 and X_0 = 0.1
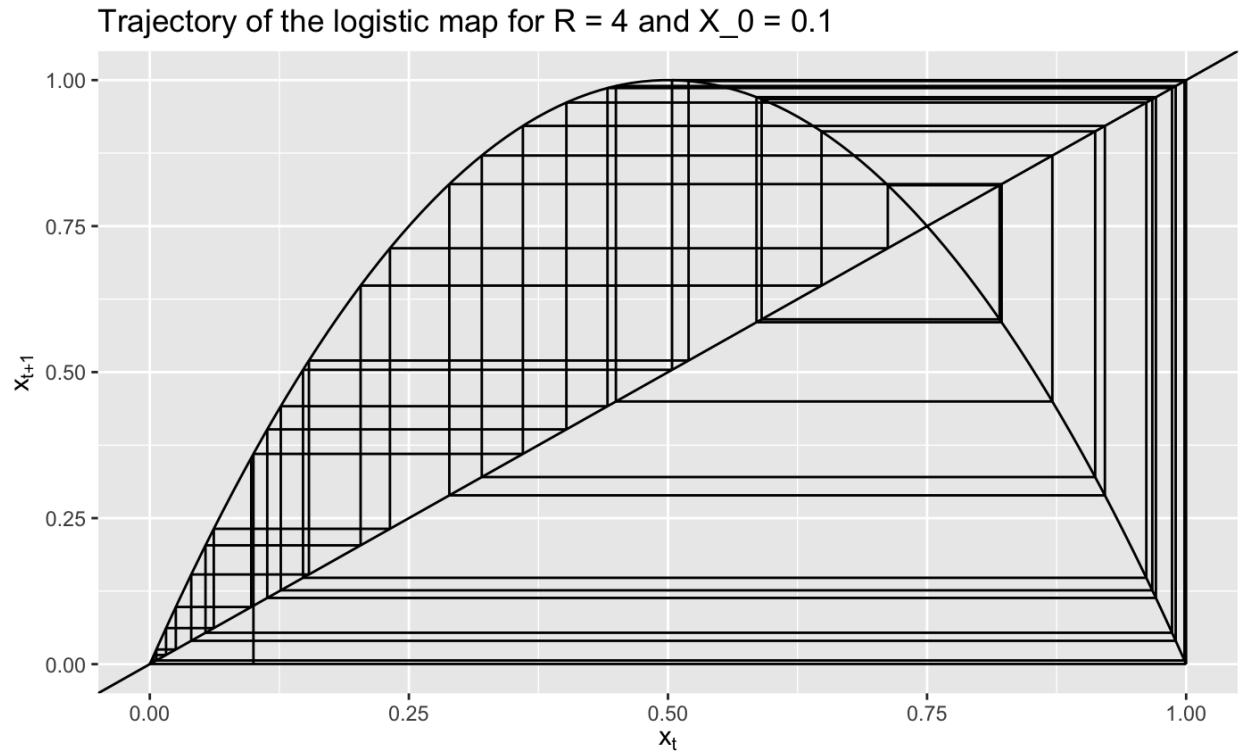
What is randomness?

Brainstorming part:

- Aperiodicity with no determinism, or no known deterministic describing function.
- Maybe it's just aperiodicity? Does it matter if there is or isn't a predicting function?

What might randomness mean...

What might randomness mean?
Feel like?
Look like?

Be metaphorical or poetic if you wish.

We'll now do a structured
listening/sharing exercise.

What might it mean to say that something is *random*?

there's no plan	unplanned	uncontrollable
not common	nondeterministic	It does not follow an identifiable rule
Up to chance	never repeats	
No possibility of prediction	I think something is random when there is no apparent reason for its cause, no conditions to look at to see how it came to be	there is no deterministic outcome, or rule that explains the outcome, unless the rule is randomness?
Elements of chance, non-		Highly dependent

What might it mean to say that something is *random*?

deterministic

silly

unrepeatable

things that happen independent of someones or somethings control

uncontrollable

Unexpected and with the same answer being an unlikely occurrence.

unknown

wild, wicked, wacky

chance and unplanned

an eclectic combination or scattering of any witch thing that doesn't seem to follow any particular guidance

unpredictable and/or irregular

something that doesn't seem to fit with our expectations of the world

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Listening/Sharing: Break into groups of 2 or (at most) 3

1. Person A speaks speaks for 1.5 minutes on what randomness might mean.
2. Person B listens, makes some notes, and asks short friendly questions if needed.
3. Person A and B switch roles
4. Each person spends a minute looking over their notes .
5. Share with the other person a few phrases from what they said, some images or words that stood out, seemed salient or interesting.
6. Each person writes a sentence, starting with "Randomness is".

Randomness is:

beyond the human perspective.

not dictated by a system!!!!!!!!!!!!!

practically independent of its cause and coincidental

Randomness is distinctly different from chaos

A surprise that needs to be familiar

sometimes good, sometimes bad; it depends on the circumstances.

Hot and sexy

randomness is a natural phenomenon (lightning!?) that is hard to replicate purely and entirely unpredictable

everything

human

A fake concept

something that can be beautiful and something we try to prepare for but never really can

the magic that we dont want to believe as such

Randomness is:

Randomness is distinctly different from chaos

A surprise that needs to be familiar enough so that its not frightening but foreign enough so it sparks confusion.

Impossible

randomness is a thread of certainty that a part of our universe will always be unplanned

everything

A change in a pattern that is not what we expected, while also conveying a sense of surprise. A difference in how you expect something to act or react to something.

Randomness is outside of cause and effect and happens for no known or unknown reason

the magic that we dont want to believe as such

the word we slap onto things around us that don't seem to follow our expectations, don't seem to have a plan or purpose, or exist in patterns beyond our comprehension.

caused by influences without control

Randomness is:

randomness is a thread of certainty that a part of our universe will always be unplanned and equally random to everything within it.

Unexpected out of the blue happenings that don't have any rules for why they are the way they are

randomness has no implications for free will

The unseen Synchronicity that we can't predict

a matter of perspective, meaning that anything may seem random from our perspective but might have an order or pattern completely beyond our understanding, or may have a purpose without needing a pattern. It is the unknown and may exist or not exist

caused by influences without control

Unexpected, out of the blue happenings that happen in every part of life that don't have any rules for why they are the way they are

randomness is aperiodicity (with no known deterministic function?) – never exactly repeating at infinite detail

Mathematical definition:

- A system is random if it has no patterns. It is random if it cannot be compressed.
- **Randomness = no patterns and cannot be compressed.**

Note: If you know a deterministic function to predict randomness, and you know the initial condition with infinite detail, then you know a way of compressing the orbit of the function.

The statistics of randomness generated by the deterministic random orbits on the logistic map are as random as truly 'nondeterministic' random numbers.

Deterministic randomness is when you have a deterministic function to produce the random output. Stochastic randomness is when the randomness is produced in a process that involves chance.