L-Systems/Fractal Assignment

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Abstract: This assignment affords you an opportunity to generate a musical composition via an L-system of your own design, to generate an image via an L-system of your own design, to simulate a Barnett Newman line via a given L-system, to consider fractals as cognitive infrastructure, and to consider fractals in science and technology.

MxM Facilitated L-System Composition

name=LSYSTEM

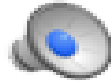vocabulary = {A B C D}

productions...

A --> B

B --> C A

C --> D

D --> A C B

start=B

G0: B (1S = 0A 1B 0C 0D)

G1: C A (2S = 1A 0B 1C 0D)

G2: D B (2S = 0A 1B 0C 1D)

G3: A C B C A (5S = 2A 1B 2C 0D)

G4: B D C A D B (6S = 1A 2B 1C 2D)

G5: C A A C B D B A C B C A (12S = 4A 3B 4C 1D)

G6: SD SB SB SD SC SA SA SC SB SC SA SB SD SC SA SD SB (17S = 4A 5B 4C 4D)

TGR Rendered L-System Image

name=TURTLE

vocabulary = {A B C D}

productions...

A --> B D C

B --> A C

C --> C A

D --> D B
start=A

G0: A (1S = 1A 0B 0C 0D)
G1: B D C (3S = 0A 1B 1C 1D)
G2: A C D B C A (6S = 2A 1B 2C 1D)
G3: B D C C A D B A C C A B D C (14S = 3A 3B 5C 3D)
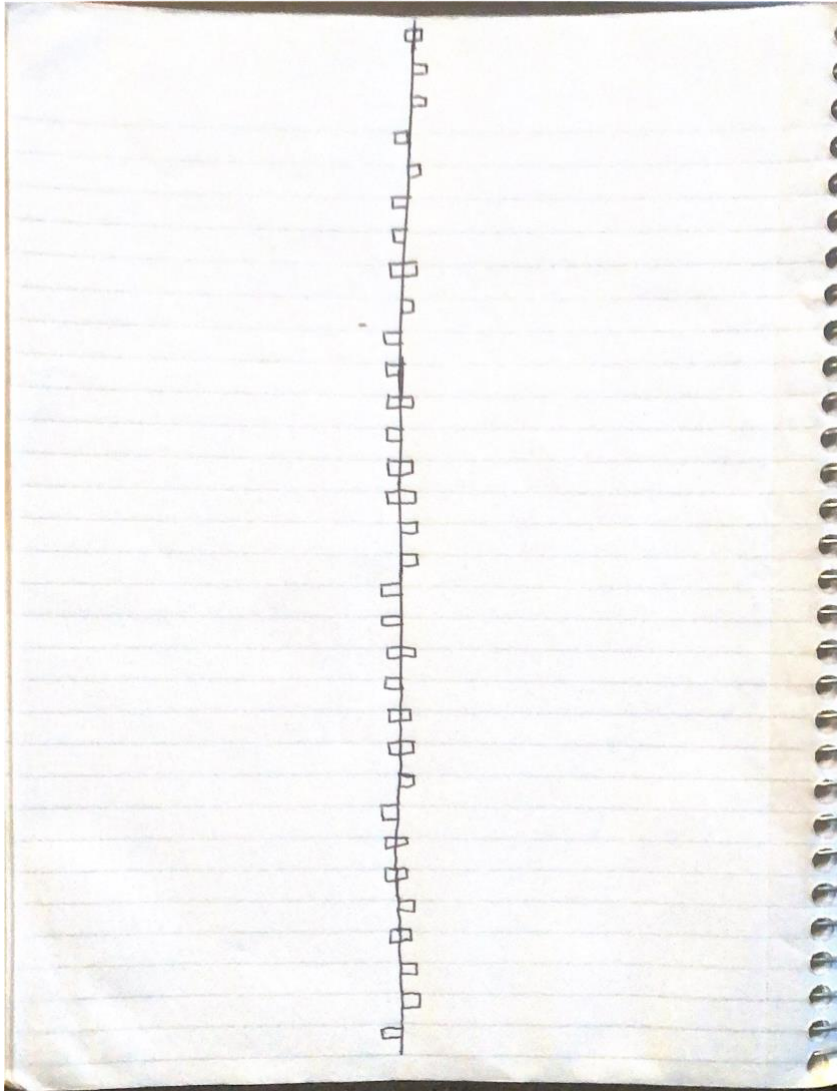
A → F
B → F
C → <
D → >
G2: F < > F < F
G3: F > < F > F F < < F > F F < < F F > <

L-System Simulation of a Barret Newman Line

G0 : M
G1 : R M
G2 : L R R M
G3 : M L L R L R R M
G4 : R M M L M L L R M L L R L R R M
G5 : L R R M R M M L R M M L M L L R R
M M L M L L R M L L R L R R M

Q1: Where do we see fractals in nature?

    Example: Trees

Q2: What the purpose of the structure of fractals in nature?

    In some cases, its fractal shape is the reason that life is found in nature.

Q3: Are fractals in nature seen on all scales?

    Yes

Q4: Where are fractals in the human body?

    Our Lungs

Q5: Can the human body produce fractals without conscious aid?

    Yes, our heart produces beats that resembles a fractal structure

Q6: What is the most complex fractal structure in the human body?

    The brain

Fractals as a Cognitive Infrastructure

Fractals, while initially being noticed from art is cognitively seen throughout nature. Fractals are seen as the geometry of objects nature. This entails the structure and shape of an object that can be split up into synchronous similar parts. A prime example of a structure with repeating fractals in nature is a Tree. As stated from https://www.diygenius.com/fractals-in-nature/ , "Each tree branch, from the trunk to the tips, is a copy of the one that came before it. This is a basic principle that we see repeatedly in the fractal structure of organic life forms throughout the natural world". What's more, fractal structures can be seen down to the roots.

Fractals aid us digitally to create structures with similar geometric patterns to the real world. We see fractals in the geometric shape of plants that grow in a way where they try to maximize the amount of sunlight the entire plant body is exposed to. "Fractals are hyper-efficient in their construction, and this allows plants to maximize their exposure to sunlight and efficiently transport nutritious throughout their cellular structure. These fractal patterns of growth have a mathematical, as well as physical, beauty" (https://www.diygenius.com/fractals-in-nature/). In this case, the fractal structure of the plant is the reason sunlight can support its life.

Fractal patterns in nature are seen in the smallest and biggest structures. A large piece of broccoli can have its pieces chopped and still have similar geometric fractals from what was cut

off. On a larger scale, "Aerial footage from NASA of the Ayeyarwady River Delta (also referred to as Irrawaddy) in Myanmar is a great example of the fractal branching patterns of river delta ecosystems" (https://www.diygenius.com/fractals-in-nature/). The image on this page showed river delts from a bird's eye view and the fractals geometric shapes where difficult to miss. It had some resemblance to that of tree roots. This is how fractals are seen in nature, What about the human body?

Fractals as mentioned in the podcast can be seen in our lungs. Just like in nature they resemble tree link structures with long and short "branches" across our body that share similar fractal structures. Fractals are also heard rather than just seen. When listening for fractals the duration of a beat and the timing is what is distinguishable amongst them. According to http://www.fractal.org/Life-Science-Technology/Publications/Fractals-and-Human-Biology.pdf, "Our heartbeats seem regular and rhythmical, but when the structure of the timing is examined in fine detail, it is revealed to be very slightly fractal. And this is very important". Human and animal hearts are producing fractals while it beats. The timing of each fractal or heartbeat can be very fast and it is an indication of the body needing the heart to transport blood quicker. Likewise on the other hand, "heart disease can be detected by extreme and arrhythmic fractal behavior" (http://www.fractal.org/Life-Science-Technology/Publications/Fractals-and-Human-Biology.pdf).

The most complex fractal structure in the human body is the brain. The brain is made of many complex fractals and can be seen in the wrinkles of the brain that seem to fold onto itself and repeat in other parts. To add on, fractals are being used to try to study and understand the brain. "Understanding how our brains function is probably the greatest challenge facing the scientific community currently. Fractal geometry is at the leading edge of research in this area" (http://www.fractal.org/Life-Science-Technology/Publications/Fractals-and-Human-Biology.pdf).

Works Cited

https://www.diygenius.com/fractals-in-nature/

http://www.fractal.org/Life-Science-Technology/Publications/Fractals-and-Human-Biology.pdf

L-Systems in Science and Technology

Fractals are applied in many domains. For starters, in statistics you can often find many patterns in data. One way to do so is by doing a Fractal analysis which involves assessing fractal characteristics around a pattern of data. Fractals also have a huge role in physics. Fractal antennas are designed in fractal form and have various benefits to it making it an efficient antenna design today. In virtual reality and the creation of simulations, fractals are used digitally to model real world fractals we see in things like mountains and buildings. Lastly as mentioned previously, fractal structures are used to replicate the fractals in the human brain to detect early diagnoses.