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Fractal Assignment

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.

Problem 1: MxM Facilitated L-System Composition

Title of Composition: *Rising star*
Description (symbols and productions and start symbol):

Symbols: {A, B, C, D}
Start: D
Productions:

1. A → B D
2. B → D
3. C → A C
4. D → C

Sequence of generations:

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

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

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

G3: B D A C (4S = 1A 1B 1C 1D)

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

G5: C A C D C B D A C (9S = 2A 1B 4C 2D)

G6: A C B D A C C A C D C B D A C (15S = 4A 2B 6C 3D)

G7: B D A C D C B D A C A C B D A C C A C D C B D A C (25S = 6A 4B 9C 6D)

G8: D C B D A C C A C D C B D A C B D A C D C B D A C A C B D A C C A C D C B D A C (40S = 9A 6B 15C 10D)

Clay code:
PATTERN >> SD SC SB SD SA SC SC SA SC SD SC SB SD SA SC SB SD SA SC SD SC SB SD SA SC SA SC SB SD SA SC SC SA SC SD SC SB SD SA SC
SA >> LP PLAY RP

SB >> S2 PLAY X2
SC >> PLAY S2 RP PLAY X2 LP PLAY RP
SD >> LP PLAY X2 RP PLAY S2 LP

Problem 2: TGR Rendered L-System Image

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1. Definition of L-system

Alphabet: {A, B, C, D}
Start: D
Productions:

5. A → B D
6. B → D
7. C → A C
8. D → C

2. Small number of generations

Generations:

(0) D
(1) C
(2) A C
(3) B D A C
(4) D C B D A C
(5) C A C D C B D A C

3. Definition of mapping from L-system symbols to Turtle graphic command symbols

1. A → R F
2. B → L F
3. C → F
4. D → R F L F

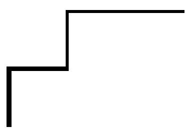
4. Images corresponding to the small number of generations

(0) D → R F L F

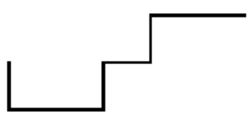
(1) C → F

(2) A C → R F F

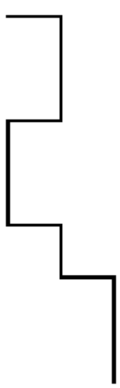
(3) B D A C → L F R F L F R F F



(4) D C B D A C → R F L F F L F R F L F R F F



(5) C A C D C B D A C → F R F F R F L F F L F R F L F R F F



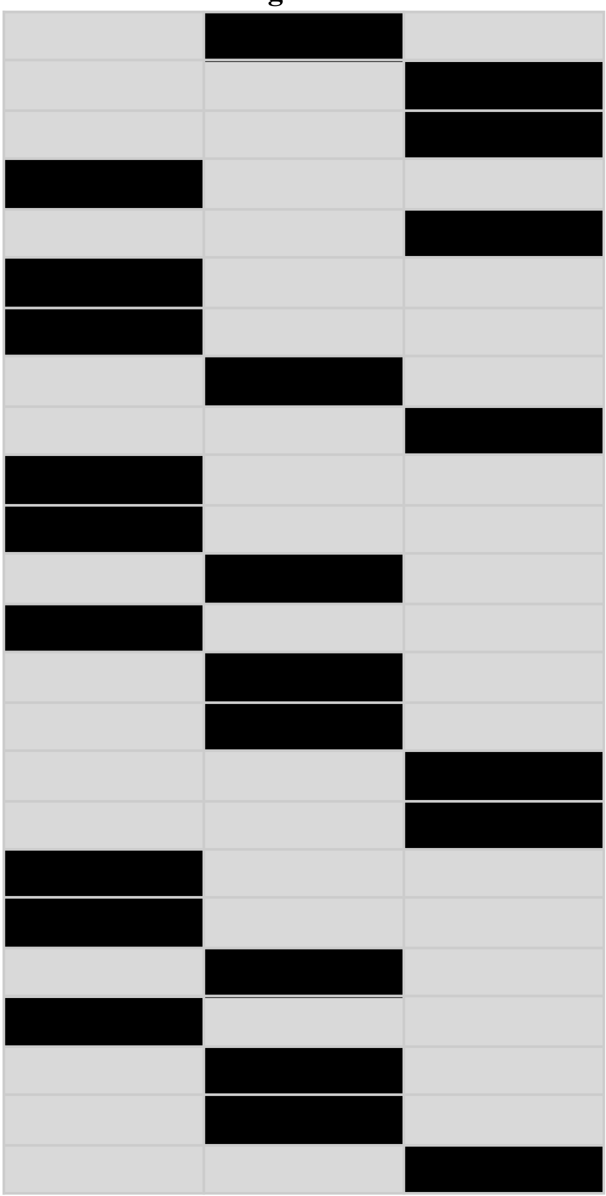
Problem 3: L-System Simulation of a Barnett Newman Line

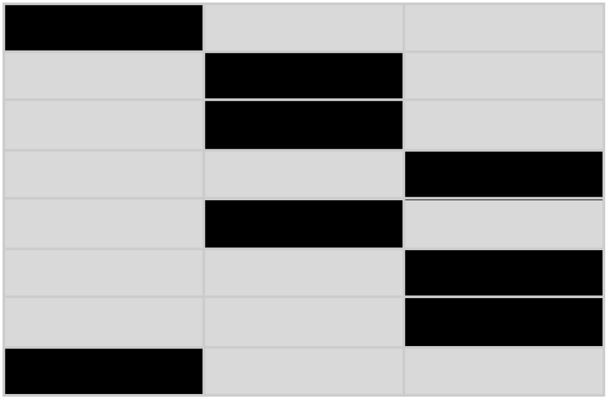
1. **Fifth generation:**

Start: M

M
R M
L R R M M L L R L R R M
R M M L M L L R M L L R L R R M
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

2. **Drawn fifth generation:**





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

Problem 4: Fractals as a Cognitive Infrastructure

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1. **Written down questions**

https://nautil.us/is-consciousness-fractal-6124/
Q1: What is a fractal dimension?
Q2: What are the geometrical blueprints discussed in the article?
Q3: What were they able to find by using this technique: medial-axis transformation?
https://www.npr.org/transcripts/6631149
Q4: What was the secret of Jackson Pollock?
Q5: What are the common examples of fractals?
Q6: What were the two patterns contained in a Pollock painting? How does it relate to fractals?

2. **Answers to the questions**

https://nautil.us/is-consciousness-fractal-6124/
A1: A fractal dimension is where the dimension of a straight line is one, and a rectangle is two, a fractal line drawn on a piece of paper will have a dimension between one and two.
A2: Geometrical blueprints are the fractal patterns that Jason Padgett saw after an accident outside of a karaoke bar.
A3: They found that the axes of symmetry between the rock clusters formed the fractal contour of a tree.
https://www.npr.org/transcripts/6631149
A4: His secret was that he was able to see the natural fractals within the canvas; Pollock believed that there were these complex patterns that he painted that were linked to nature.
A5: Common examples of fractals are things like trees, clouds in the sky, mountains, rivers.
A6: His motions (by walking around the canvas) and the splatters of paint. It relates back to fractals because they identified the two distinct patterns as fractal patterns.

3. **Compose essay (title, sources)**

Fractals as a Cognitive Infrastructure

A fractal dimension is a characterization of a collection of fractals. This collection may be described as where the dimension of a straight line is one, and a rectangle is two. Using this description, a fractal line drawn on a piece of paper will have a dimension lying somewhere between one and two. The increase of dimensions from one to two is positively correlated with the complexity of a given line. In nature, these dimensions tend to fall between 1.3 and 1.5. Naturally, humans will adjust and acclimate to their surroundings in such a way where our vision will look for fractals in this range. Our natural response is to trace the things we perceive with a dimension falling around 1.4 - directly in the middle of nature's range.

Some examples of the way that fractals can be seen in nature include the way that galaxies spiral, the branching of a tree's roots and branches, clouds in the sky, to even the way a waterfall tumbles at its base. These patterns can also be applied in relation to human creations, such as music as composed by famous composers such as Bach or Beethoven or landscaping.

A team of researchers studying the public appeal of the Zen garden found in Kyoto's Ryoanji Temple found that the axes of symmetry between the rock clusters formed the fractal contour of a tree. In this garden, there was a collection of fifteen rocks over gravel placed in this natural fractal shape. When this shape was shifted through the use of computer programs, the appeal of its effect was lost. This further shows that nature and humans have a tendency to see and apply fractal contours to the perception of a plethora of situations, even without prior knowledge of fractals.

Fractals can also be seen in the work of Jackson Pollock. His secret was that he was unconsciously able to see the natural fractals within the canvas. Pollock believed that the complex patterns that he painted that were linked to nature - later coined as fractals. There are two patterns contained in a Pollock painting, including those made by his motions while walking around the canvas and his splatters of paint. These patterns flow in a mathematical sequence and are then able to be related to fractals.

Geometrical blueprints as discussed in the Nautilus article are the aforementioned fractal patterns. These patterns can be seen in a variety of cases. This includes those seen in the Jason Padgett case, as he saw these shapes after an accident outside of a karaoke bar. Padgett saw a sort of overlay upon the world, where he saw complex spirals and geometrical shapes mapping along the world as he perceived it.

References

https://nautil.us/is-consciousness-fractal-6124/
https://www.npr.org/transcripts/6631149

Problem 5: L-Systems in Science and Technology

Four representative applications of fractals that are scientific or technological are: (1) fractal antennas, (2) image compression, (3) fractal devices using high precision fluid mixing, and (4) fractal medicine. A fractal is a never-ending, recursively produced pattern that is typically self-similar in nature. Fractal geometry deals with more non-uniform shapes found in nature, such as mountains, clouds, and trees. Fractals provide a systematic method to capture the "roughness" of objects. This method is used to capture the roughness in a wide variety of fields ranging from programming to medicine.

A fractal-shaped antenna is a new application that drastically decreases the size and weight of antennas. Fractal Antenna Systems Inc (FAS) develops fractal antennas, fractal metamaterials, and fractal batters, as well as fractal circuit architecture. Their fractal technical breakthroughs are limitless. FAS's fractal antennas are being integrated into phones and other gadgets. The advantages of these antennas vary depending on the fractal used, the frequency of interest, and other factors. The sierpinski triangle, which we learned about in class, is an example of an antenna.

Because the real world is well characterized by fractal geometry, image compression is a representative application of fractals. Images are compressed far more in this manner than in other methods (eg: JPEG or GIF file formats). Another benefit of fractal compression is that it eliminates pixelation when the image is magnified. When the image size is raised, it often appears to be better.

Amalgamated Research Inc (ARI) develops fractal space-filling devices for high-precision fluid mixing. Chromatography, ion exchange, absorption, distillation, and other applications where plug flow characteristics are required to optimum performance are among the uses of their fractal fluid distribution technology. High fructose syrups, biomass hydrolysate, organic acids, inorganic separations, and cannabinoid separations are among the uses for their fractal-based chromatography. This technology has also been employed in other industries to allow for the careful mixing of fluids such as epoxy resin without the use of turbulent stirring.

Fractal medicine is a representative application of fractals. Modern medicine often involves examining systems in the body to determine if something is malfunctioning. Since the body is full of fractals, we can use fractal math to quantify, describe, diagnose and perhaps soon to help cure diseases. Cancer is a disease where fractal analysis may not only help diagnose but also perhaps help treat the condition. It is well known that cancerous tumors often have a characteristic growth of new blood vessels that form a tangled mess instead of the neat, orderly fractal network of healthy blood vessels. Not only can these malfunctioning vessels directly harm the tissue, but they can also make it harder to treat the disease by preventing drugs from reaching into the inner parts of tumors where the drugs are most needed.