L-systems and Fractals Assignment

Name: Jordan Bailey

Abstract:

Problem 1: MxM Facilitated L-System Composition

(a) Title: **Jazz Song**

(b) **Description**

```
name=YAHOO
vocabularity = { A B C D }
productions...
A --> A C D A
B --> B A C A
C --> C D D A
D --> B D D B
start=A
```

(c**) Sequence of Generations**

```
G0: A (1S = 1A 0B 0C 0D)
G1: A C D A (4S = 2A 0B 1C 1D)
G2: A C D A C D D A B D D B A C D A (16S = 5A 2B 3C 6D)
```

(d) **Clay Code Composition**

```
Clay> SA >> X3 PLAY PLAY S3

Clay> SB >>PLAY PLAY 3RP PLAY 3RP PLAY 3LP PLAY 3LP PLAY

Clay> SC >> PLAY LP X2 PLAY LP X2 PLAY S2 S2 RP RP

Clay> SD >> PLAY PLAY 2RP X2 PLAY PLAY S2 2LP
Clay> LPATTERN >> SA SC SD SA SC SD SD SA AB SD SD SB SA SC SD SA
Clay> LPIECE >> ELECTRIC_JAZZ_GUITAR S3 4LPATTERN X3
```

(e) **jazzsong.mp3**

Problem 2: TGR Rendered L-System Image

(a)**Description of L-System**

```
name=SHAPEMAKER
vocabularity = { A B C D }
productions...
A --> A B C
B --> B B A
C --> C D A
D --> D D A C
start=A
```

(b) **Small Number of Generations**

```
G0: A (1S = 1A 0B 0C 0D)
G1: A B C (3S = 1A 1B 1C 0D)
G2: A B C B B A C D A (9S = 3A 3B 2C 1D)
G3: A B C B B A C D A B B A B B A A B C C D A D D A C A B C (28S = 9A 9B 6C
4D)
```

(c) **Mapping of L-Systems Symbols to Turtle Graphics Command Symbols**

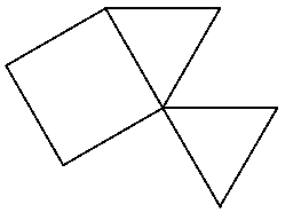
A ----> **F > F > F F**

B **----> L F L F L F R**

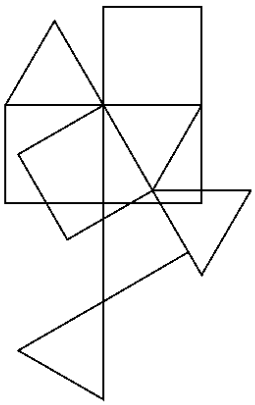
C ----> **< F < F**

D ----> **L F R F R F R F R F F**

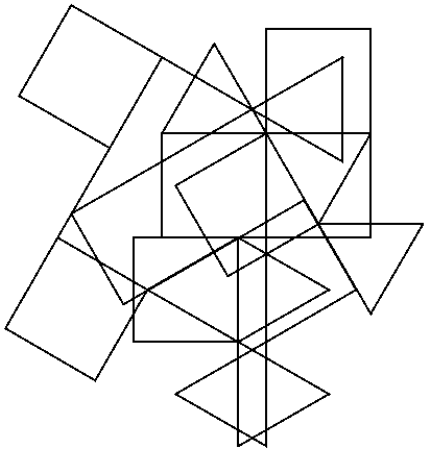
(d**) Generation 1**



Generation 2



Generation 3

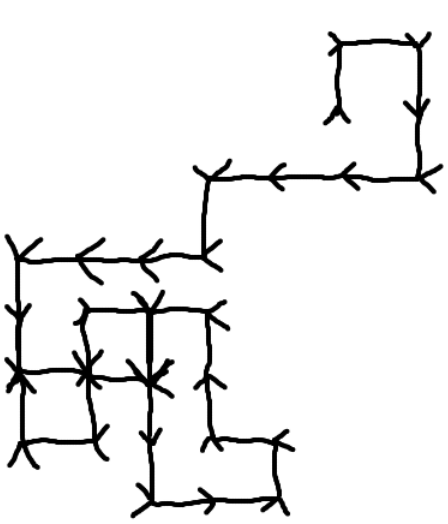


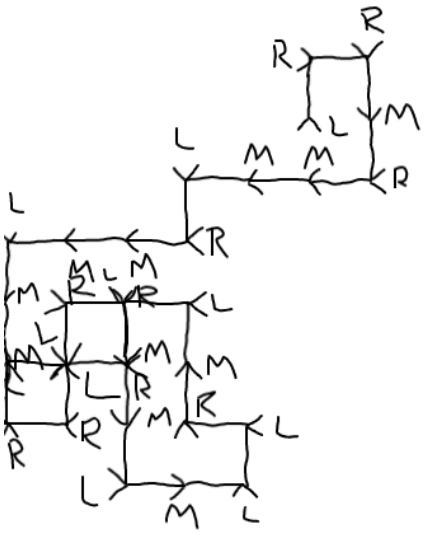
Problem 3: L-System Simulation of a Barnett Newman Line

(a) **Write down the fifth generation of this L-System.**

0: M
1: R M
2: L R R M
3: M L L R L R R M
4: R M M L M L L R M L L R L R R M
5: 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

(b) Draw the fifth generation L-System image corresponding to a screen creature with a pen (like the Logo Turtle has) that executes three instructions, R and M and L, according to the following semantics. These semantics are based on the creature moving forward along a vertical line that is (conceptually, at least) segmented with unit markers, and a square with side length equal to the unit. (For the line, think about the positive Y-axis beginning at the origin.)





Problem 4: Fractals as a Cognitive Infrastructure

Q1: **What are fractals?**

Patterns that are self-similar across various sized scales

Q2: **What theory of consciousness was described by physicist Roger Penrose and anesthesiologist Stuart Hameroff?**

Consciousness results from quantum computation at the microtubule level

Q3: **What are philosopher Kerri Welch's beliefs on consciousness?**

She believes that consciousness is temporal, and layered (fractal)

Q4: **How are fractals potentially therapeutic according to Dr. Richard Taylor?**

By implementing certain patterns of fractals within architecture and artwork, it can yield positive effects

Q5: **How are fractals related to human's internal structure?**

The automatic processes within humans like breathing or balance are done with fractal characteristics involved.

Q6: **How is fractal analysis being used within art?**

Many studies have been dedicated to effectively distinguishing artist's paintings from one another by using fractal analysis.

In 1975, mathematician Benoit Mandelbrot gave name to the patterns that humans perceive every day which he called *fractals.* More specifically, fractals are patterns that are self-similar across various sized scales. To make sense of fractals, they are characterized by their "fractal dimension": a non-integer number, where a fractal line is drawn on paper, having a dimension between 1 (straight line) and 2 (rectangle).

Many modern scientists are dedicated to studying and even incorporate these phenomena into their theories of consciousness. Physicist Roger Penrose and anesthesiologist Stuart Hameroff suggest that consciousness results from quantum computation, and that quantum processing happens at the microtubule level rather than the neuron. This hypothesis also states that, "Proteins inside the microtubules contain clouds of delocalized electrons whose quantum behavior can cause vibrations in the microtubules to "interfere, collapse, and resonate across scale, control neuronal firings, [and] generate consciousness". Hameroff further argues that the vibrations created will have a similar fractal hierarchy to that of the brain itself. In other words, the patterns seen within the hierarchy in the brain are similar to the patterns seen in neural networks, the neurons themselves, and microtubules. According to this theory of consciousness, fractals are a core component of consciousness. Philosopher Kerri Welch has a different approach towards consciousness, yet still involves fractals. Welch looks at consciousness temporally, and in a layered fashion. This "layering" would be considered a fractal and would change how we as humans live depending on our brain states. Humans' brain states change over time as they get older, and Welch also suggests that as we get older, our personal internal fractal dimension increases. While these two theories aren't *necessarily* true, they do suggest that fractals can

be realized at multiple levels/scales within the process of consciousness, and in some sense, are pivotal to the overall cognitive infrastructure of a human.

Professor of Physics Dr. Richard Taylor spoke on the prevalence of fractals within nature, art, and the internal human structure on NPR's podcast, "Talk of the Nation". Many people have been able to analyze fractals through art, and more specifically through the artist "Jackson Pollock", and his captivating art that seemed to increase in its fractal dimension as he got older. Dr. Taylor mentions that there are multiple studies and investigations on Pollock's paintings, European modern masters (ex. Monet), and early Chinese drawings. All of these studies have published papers showing that fractal analysis can be used to distinguish between paintings from different artists. Later it is even suggested that a person's physiology and physical makeup affords the ability to paint in a certain way. This makes art a way of mirroring oneself onto the page, in the form of fractals. The similarities to artists and their respective paintings suggests that fractals play a powerful role on determining the current state of the person creating the art.

Dr. Taylor further elaborates on how fractals can be used therapeutically. He mentions that by working with artists and architects, you can have them implement certain patterns of fractals within their artwork that will potentially help stress-related illness. The Zen meditation garden referenced in the first article, *Is Consciousness Fractal*, is a great example of architecture/art being used in a meditative way through the use of fractals, even though they didn't have the knowledge on fractals at the time. If incorporating fractals into art and architecture yields positive therapeutic results, then it is safe to say that fractals and mood are at least *correlated* to each other.

Lastly, Dr. Taylor speaks on the wave of studies in the 90's focusing on fractals inside many of the structures that make up humans. These studies found that the automatic processes that we don't consciously control have fractal characteristics to them. Dr. Taylor uses the example of human balance as one of these unconscious processes which illustrates fractals at another scale within a person's spatial domain. Because fractals are seen at so many levels of one's spatial domain, it is important to further research their significance on human cognitive infrastructure.

NPR. (2006, December 15). *Jackson Pollock Fractals*. NPR. Retrieved March 23, 2022, from https://www.npr.org/transcripts/6631149

Cepelewicz, J. (2021, September 14). *Is consciousness fractal?* Nautilus | Science Connected. Retrieved March 23, 2022, from https://nautil.us/is-consciousness-fractal-6124/

Problem 5: L-Systems in Science and Technology

1. Modern Medicine
2. Fractal Antenna
3. Game Environments/visuals
4. Ecology

Within modern medicine, because the body is full of fractals, fractal math can be used to diagnose and potentially cure diseases in the near future. The fractal antenna is a more specific example, made by Fractal Antenna Systems Inc, and uses a fractal design in order to maximize the length of the material that can receive electromagnetic radiation. Within more modern videogames, environments and visuals use fractals for things like trees, mountains, etc.. Lastly, fractals can be used in ecology by quantifying how much CO2 forests can process.