Music Generated by Fractal Curves

MAS.641J (Barry Vercoe) Fall 2005 Final Project

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For my final project, I explore a few ways of generating music from fractal curves. In this paper, I explain what are fractal curves and how they are created from simple geometric shapes. I then show a few ways to interpret these fractal curves so as to generate music.

Fractal Curves

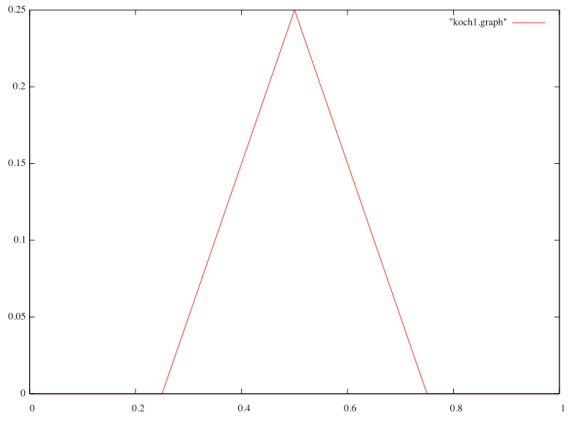
A fractal curve is a curve in which every line segment is expanded into a geometric shape, whose line segments are further expanded by the same geometric shape, and so on. In the limit where this expansion is repeated infinitely many times, the curve has infinite length, because each expansion increases the length of the curve.

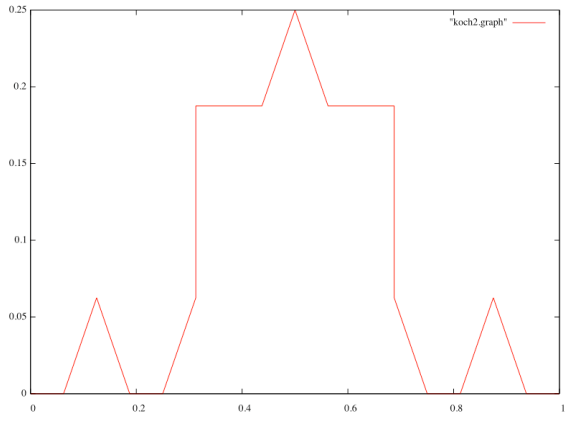
Here is how to generate a fractal curve:

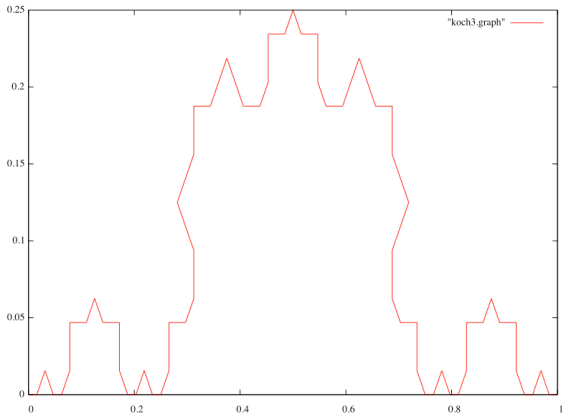
1. Design a geometric shape, composed of many line segments.
2. Start with a curve of one segment, a straight horizontal line.
3. For each line segment in the curve, replace the line segment with the geometric shape.
4. Repeat step 3, potentially an infinite number of times.

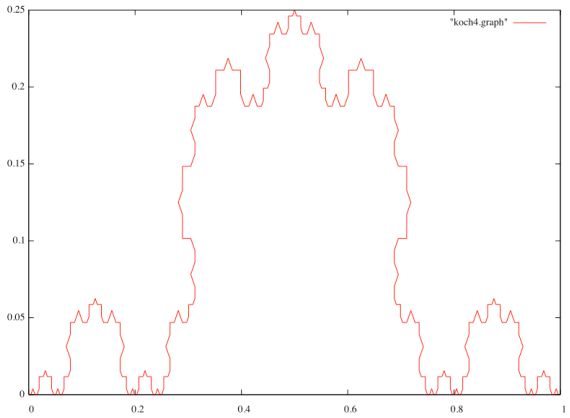
Koch Curve

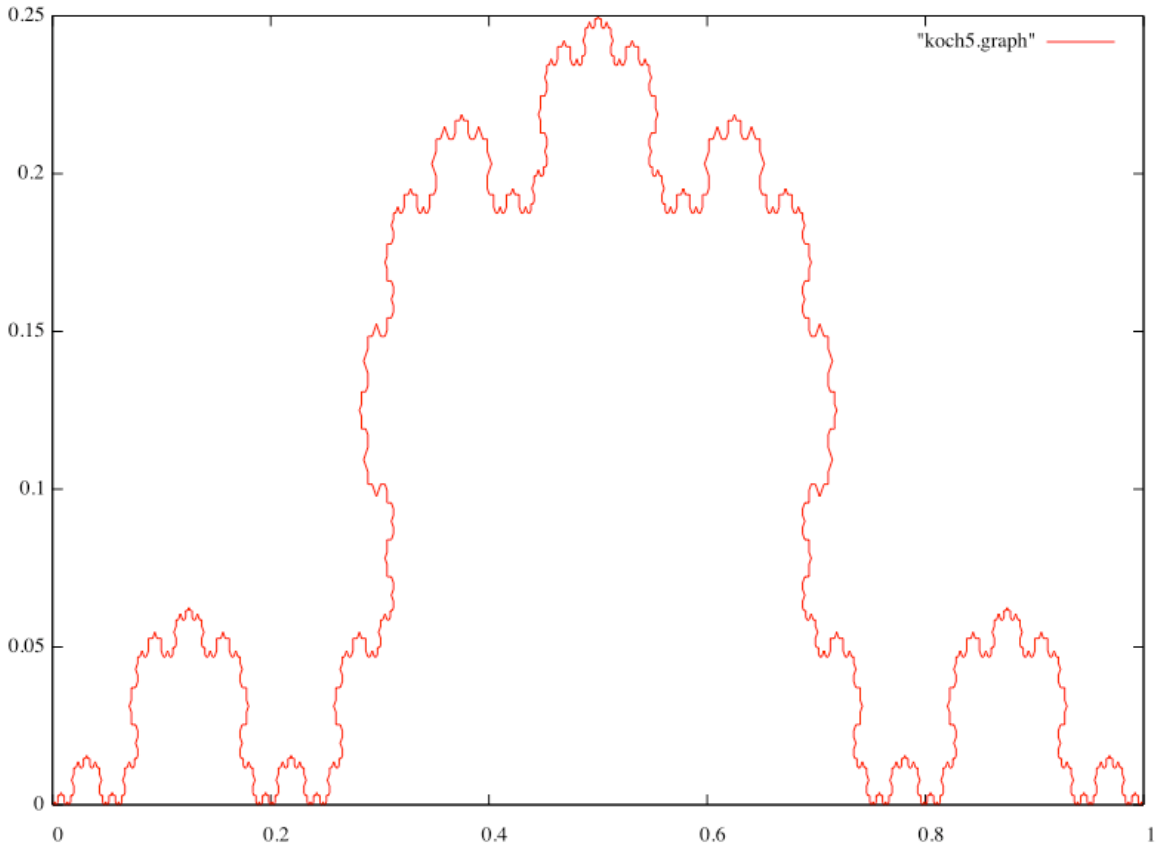
The Koch Curve expands using the following geometric shape: a line segment divided into three equal parts, in which the middle part is an equilateral triangle without the base. The figures below show an approximation of a Koch Curve, after 1, 2, 3, 4 and 5 expansion iterations.





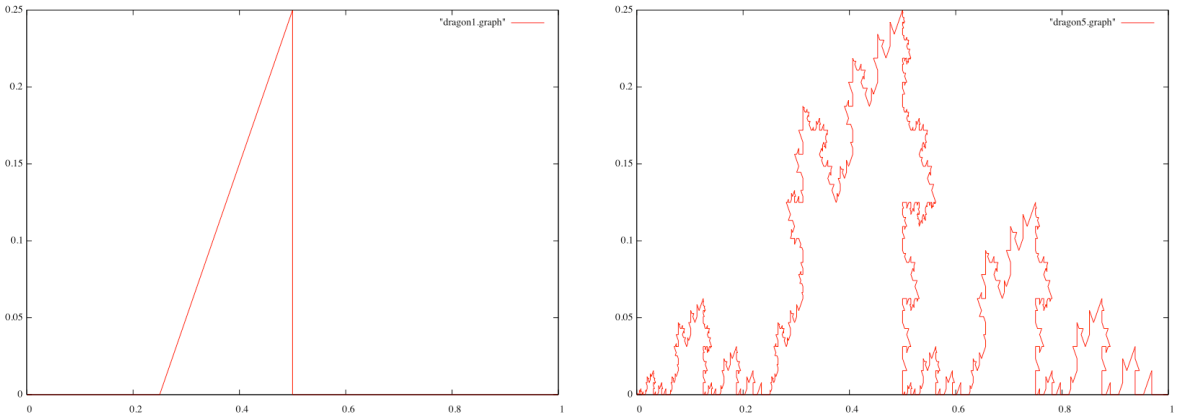




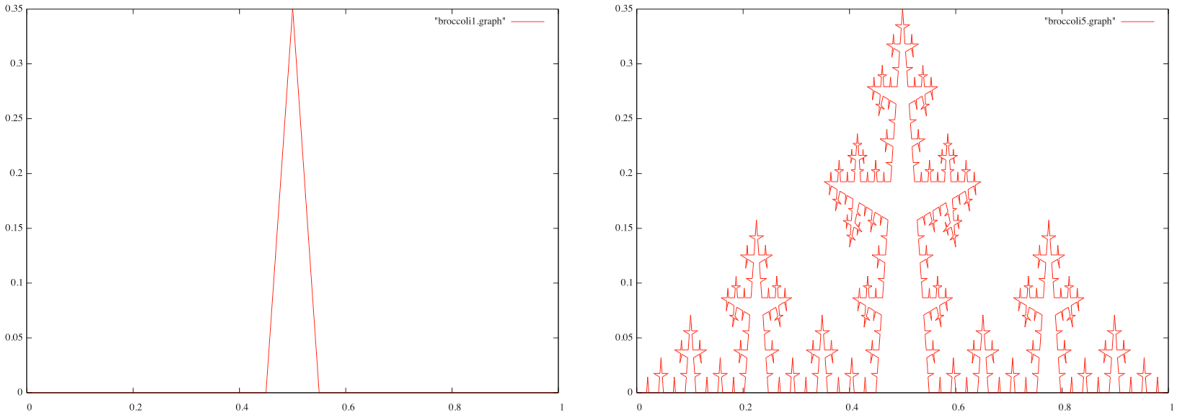


Other Curves

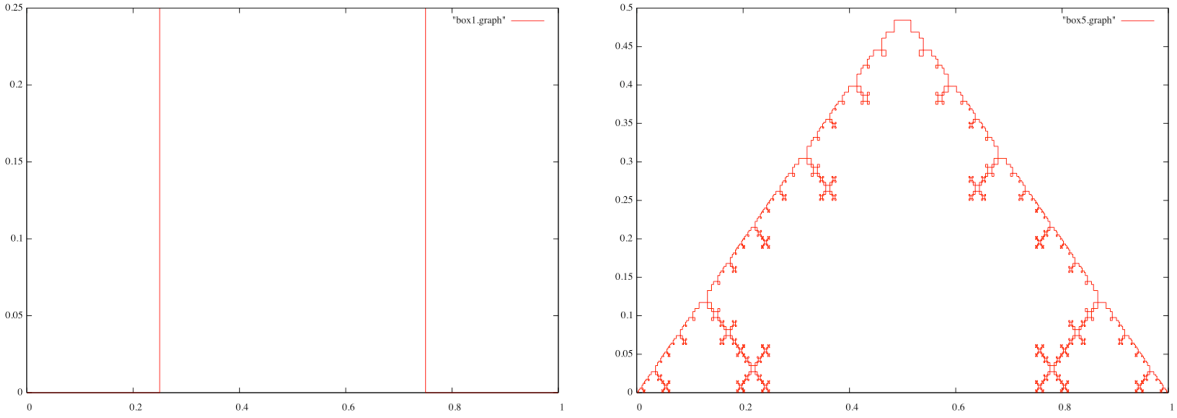
By varying the geometric shape, we can generate different fractal curves. Below are a few examples of geometric shapes and the curves they expand to after five iterations. We will use some of these curves later to generate music.



“Dragon” Curve
after 1 and 5 iterations



“Broccoli” Curve
after 1 and 5 iterations



“Box” Curve
after 1 and 5 iterations

Generated Music

In order to generate music from a fractal curve, we have to somehow map the fractal curve into the music domain.

Idea 1

The points that trace the fractal curve are sorted by their x-coordinate. Each point maps to a note whose pitch is proportional to its y-coordinate and whose duration is proportional to the distance between its x-coordinate and the x-coordinate of the next point. The amplitude remains constant. The notes are played sequentially, one after the other.

Music generated by the Koch curve after 5 iterations, using this idea, can be found at:
http://web.mit.edu/namin/www/vercoe/final/koch5-sorted.aif

Idea 2

We assemble the fractal curves generated from a sequence of iterations. Each point maps to a note whose start time is proportional to its x-coordinate, whose duration is proportional to the distance between its x-coordinate and the x-coordinate of the next point and whose pitch is exponentially related to its y-coordinate. The amplitude remains constant.

Music generated by the sequence of "Dragon" curves from 3 to 5 iterations, using this idea, can be found at:
http://web.mit.edu/namin/www/vercoe/final/dragon-together.aif

Other Ideas

Both the ideas above use the height of the fractal to vary the pitch parameter. I tried to vary other parameters, but they didn't work as well. For example, I tried extending idea 2 by using a second set of fractal curves with the same number of points overall as the first set. Once, I used the second set to vary the volume of each note, which didn't work well, because it generated too many sudden changes in volume. Once, I used the second set to change the timbre by having it vary the modulation frequency of a frequency modulation instrument, but the result was awkward. I also tried various other modifications.

Conclusion

In conclusion, fractal curves can be used to generate interesting music, especially when they are used to vary the pitch.

Appendix

The code to generate the graph and score files and can be found at
http://web.mit.edu/namin/www/vercoe/final/kochlib.py