Towards a Genetic L-System Counterpoint Tool

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Abstract. *In this article we discuss some aspects of algorithmic composition with L-Systems and how it can be enhanced with genetic operators. We attempt to create counterpoint with Genetic L-Systems and we present a few results and scores extracted from them.*

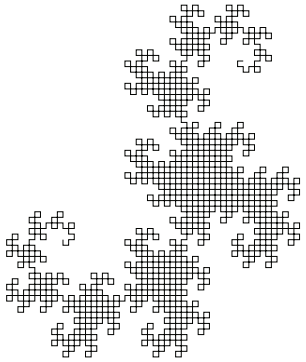
1. Introduction

L-Systems are rewritting systems first described by Aristid Lindenmayer [1]. They consist of an axiom and production rules that can be used to derive strings. Figure 1 shows an L-System for the famous dragon curve.

```
#level 11
#delta 90
#axiom FX
--------------------
Production rules

X -> X+YF+;
Y -> -FX-Y;
--------------------
Resulting strings
0 FX
1 FX+YF+
2 FX+YF++-FX-YF+
```

(a) L-system Grammar



(b) The Dragon Curve after 11 iterations

Figure 1: Dragon curve.

The work of Prusinkiewicz [1, 2] and others established L-Systems as tools for graphical modelling of objects that exhibit auto-similarity such as flowers, trees and fractals. The usual technique to render an L-System is to interpret each symbol in a LOGO-like manner. For such approaches, “F” means draw a segment with length d, “+” means turn the turtle +δ degrees, “-” means turn the turtle -δ degrees. “X” and “Y” are just auxiliary symbols and do not have a graphical interpretation.

In order to extract a score or a melody from the strings produced by an L-System we must use a certain musical rendering. Prunsiecwicz [3], for example, described a *spatial rendering* where a score is derived from the graphical interpretation of an L-System by projecting it on a musical scale. Each horizontal segment of the picture is interpreted as a note with a length proportional to the length of the segment. The pitch of a note is the y-th note of the chosen musical scale, where y is y-coordinate of the segment.

Other authors have sought to separate the graphical interpretation from the musical one. In [4], the authors described two techniques: the *sequential* and the *schenkerian* rendering. Both techniques do not need to go through the graphical interpretation to extract melodies. There is also the work of McCormack [5, 6], where he described L-Systems that use notes (*A,B,C..,G*) instead of LOGO style commands (*F,+,-*), and devised some mechanisms to express polyphony.

But why bother to use L-Systems at all? Mason and Saffle [7], for example, showed that both traditional western music and music generated by L-Systems share the same degree of self-similarity, so it's possible and plausible to produce interesting melodies that sound "familiar" to western ears. In the same article they suggested that we could even create a feeling of counterpoint by reading different rotations of an L-System at the same time.

Following the steps laid by Mason, we explore counterpunctual possibilites of L-Systems, but instead of relying on different rotations of the same L-Systems, we explore other possibilities using Genetic L-Systems [8] as a way of adding variability.

2. Genetic L-Systems

Genetic L-Systems are described in details in [8], and the reader should refer to that article for further explanation. Basically, a Genetic L-Systems is an augmented L-System with mutation and crossover capabilities. For example, a Genetic L-System for the Dragon curve is shown in Figure 2 . Each time the symbol Y is replaced, the crossover operator is triggered and modifies rules 0 and 1 and the same goes for X, but the mutation operator modifies rule 1 instead. An important aspect of this technique is that there are no fitness functions as in most Genetic Algorithm approaches, and the reader should also refer to [8] for a discussion of this matter.

```
#axiom FX

X -> X+YF+,
Y -> -FX-Y,crossover(0,1)
------------------------------------
        Resulting string
0 FX
1 FX+YF+
2 FX+YF++-FX-YF+
```

Figure 2: Genetic dragon curve

3. Counterpoint and L-Systems

Mason and Saffle [7] explored what happened when two rotations of the same L-System are played together and noticed that it created a feeling of counterpoint. With Genetic L-Systems we can make a few more combinations. We made three experiments joining: two mirror versions of the same Genetic L-System; two different realizations of the same Genetic L-System and finally different genetic versions of the same L-System. In all experiments we used the spatial rendering [3].

On our first experiment we did something similar to what Mason previously did, but instead of using rotations of the same L-System we created "mirrored" versions by

changing + for − and vice-versa. So instead of rules X→X+YF+ and Y→-FX-Y, we have rules X→X**-**YF**-** and Y→**+**FX**+**Y.

Since we are using a mirrored version of the same L-System, we produce something close to what is usually called *first-species* counterpoint, because of its note against note structure. While the example of such counterpoint in Figure 3 does not sound bad at all, in this particular example it feels dull since we produce the same rhythm for both voices.

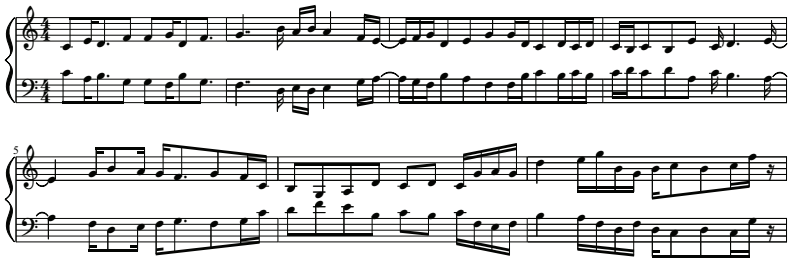


Figure 3: First experiment: Genetic Dragon Curve and its "mirrored" version

If we use different realizations of the same Genetic L-System, because of their stochastic nature we might produce more interesting scores, but obviously the intervals between notes will be unpredictable. Figure 4 shows an example of our second experiment based on this technique of joining different realizations of the same Genetic L-System. We used the dragon L-System described on Figure 2. Since both voices are independent the feeling of counterpoint is more evident. In this case, we didn't find dissonant intervals between both voices.

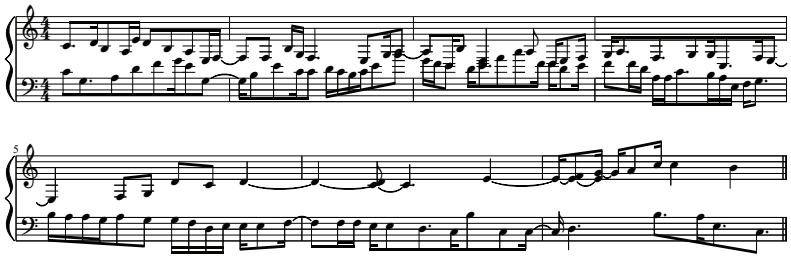


Figure 4: Second experiment - Two different realizations of the Genetic L-System shown in Figure 2 played together

On our third experiment, we explored the possibility of using different genetic operators for the same L-System. Figure 5 shows two realizations of the Dragon curve using two different genetic operators. The first L-System is shown in Figure 2, the second is almost the same but the crossover is "linked" to the first rule instead of the second one. So, in the first L-System the crossover operation is done each time the Y is replaced, while in the second the crossover operation is done each time the X is replaced.

4. Conclusion

In this work we investigate the possibilities of using Genetic L-Systems to generate counterpoint. By mirroring the L-Systems, we were able to create melodies that were reminiscent of first-species counterpoint because of its note against note structure. More independence between voices can be achieved by means of generating two different realizations of the same Genetic L-System. The feeling of counterpoint is obtained by playing both melodies together. Another possibility we explored was the use of the same L-System but with different genetic operators.

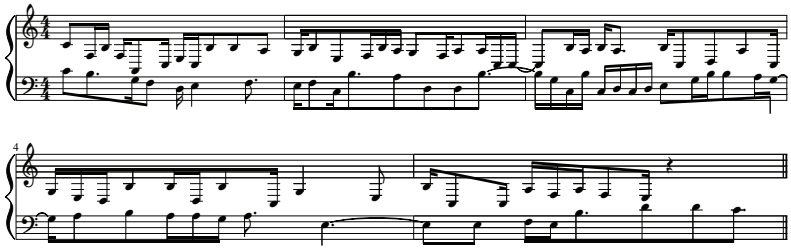


Figure 5: Third Experiment - Dragon Curve

The quality of a musical output is always highly subjective, but we think that the results were interesting. We intend to incorporate more counterpoint knowledge into the rules themselves, but we need to explore further this matter since the modelling of interaction between voices is essential to a good counterpoint. But even *without* this modelling we could achieve interesting results with fairly simple production rules.

References

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