Polyphonic Music from a Two-Dimensional Cellular Automaton (Conway's Game of Life)

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August 2025

Abstract

We explore a simple rule-based method for generative music using Conway's Game of Life, a two-dimensional cellular automaton. Starting from a random binary grid, the system evolves according to Life's standard neighbor rules. At each step, we interpret one row of the grid as a snapshot in time and map active cells to MIDI notes in a fixed C major scale. Multiple cells in a row yield simultaneous notes (polyphony). The method produces a sequence of chordal and rhythmic patterns without any learned model – relying only on deterministic CA dynamics. Our results show that emergent Game of Life structures translate into repeated musical motifs and polyphonic textures. This proof-of-concept demonstrates that even basic cellular automaton rules can generate non-trivial musical output in a transparent, training-free manner.

1 Introduction

Algorithmic composition refers to creating music via formal rules or algorithms rather than by hand. Such methods have long been studied in computer music, with examples ranging from the stochastic processes of Iannis Xenakis to the rule-based Baroque counterpoint systems developed for educational purposes. A cellular automaton (CA) is a mathematical model in which a grid of cells evolves over discrete time steps according to simple local rules. Conway's Game of Life (GoL), introduced by John Conway in 1970, is one of the most studied examples [1].

While GoL was originally developed to illustrate properties of complex systems and emergence, researchers have explored its potential for music generation. Burraston and Edmonds provide a historical and technical overview of the use of CA in electronic music, emphasizing that CA can function as generative engines for both melodic and textural content [3]. Dorin [4] and Miranda [5] demonstrated that CA can be used to derive pitch sequences, rhythmic patterns, and polyphonic structures, often relying on mappings between cell positions and musical parameters. In contrast to data-driven machine learning approaches, CA-based methods remain interpretable and deterministic, offering insights into how simple systems can yield structured musical results.

More recently, Hedblom and Schaap explored the creativity of AUTOMATONE, a music generator based on GoL that produces both audio and visual patterns [6]. Their findings suggest that human observers perceive CA-based music as both coherent and novel, especially when note mappings are restricted to musically consonant subsets such as pentatonic or diatonic scales.

In this study, we present a straightforward method for producing polyphonic music from the Game of Life. Our approach relies on a fixed pitch mapping (C major scale) and uses each generation of the CA to drive note sequences in a MIDI file. We aim to evaluate the musicality and structural properties of the resulting compositions and to explore how GoL dynamics translate into musical forms.

2 Proposed Methodology

2.1 Cellular Automaton Setup

We construct a 2D grid of binary cells with dimensions 32×16. Each cell is initialized randomly to either 0 (dead) or 1 (alive), with a bias toward sparsity to avoid overpopulation. The CA evolves according to the standard GoL rules: a cell survives if it has 2 or 3 neighbors; it is born if it has exactly 3 neighbors; otherwise, it becomes or remains dead. These rules are applied synchronously across the grid at each time step [2].

2.2 Temporal Iteration and Note Mapping

We interpret each row of the grid as a time slice. At time step t, the t-th row is mapped to MIDI note events. Each column corresponds to a fixed pitch, calculated from a C major scale: C4, D4, E4, F4, G4, A4, B4, C5, extended across octaves to fill the full column range. If a cell is active (value 1), a MIDI note-on event is triggered followed by a short note-off event. This results in chords and harmonies when multiple notes are triggered simultaneously.

The grid is updated after each timestep, simulating the evolving state of the CA. The music generated reflects the internal dynamics of the CA: static regions produce repeated motifs, oscillators generate rhythmic patterns, and gliders yield shifting melodic lines.

3 Results Analysis

The resulting MIDI files exhibit a range of musical behaviors. Initial sparse populations tend to generate sparse, ambient textures, while denser configurations result in clustered harmonic structures. Oscillatory patterns in the Game of Life produce rhythmic loops, while mobile structures like gliders create melodic arcs.

Because the system evolves deterministically, the same initial state will always produce the same music. However, slight variations in initial conditions can lead to dramatically different musical outcomes due to the sensitivity of the CA to initial configurations [2].

In informal listening tests, compositions were perceived as musically coherent, especially when the scale and rhythm constraints were applied. While the system lacks traditional musical phrasing, it offers textural richness and repetition patterns that mimic musical forms.

4 Conclusion

We presented a method for generating polyphonic music using a two-dimensional cellular automaton. By mapping cell activations to MIDI notes in a diatonic scale, we translated the structural complexity of Conway's Game of Life into algorithmic compositions. Despite its simplicity, the system exhibits rich musical textures and variations that reflect the emergent behavior of the underlying CA.

Future work could incorporate dynamic pitch sets, rhythmic variations, or multi-track harmonization. This approach demonstrates the feasibility of deterministic, interpretable music generation without training or probabilistic models.

References

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