CornellEngineering
Electrical and Computer Engineering

Modular Synthesis of Chaotic Systems

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Exploration of a Chaotic System

A mathematical chaotic system is a system of equations that define the dynamics of the system. Core properties of this system are:

- Deterministic (Differs from being truly random).
- Non-linear hyper-sensitive trajectory based on initial state (Differs from being well-behaved).

Recontextualizing Chaotic Systems into Audio

- Application of human ear pattern-recognition to analyze the trajectory of the system.
- View chaotic systems in an applied setting, possibly more closely related to the real-life phenomena the system is modelling.
- The ability to hear mathematical chaos.
- What, if any, musical properties may be extracted from a chaotic system.

Modular Synthesizers

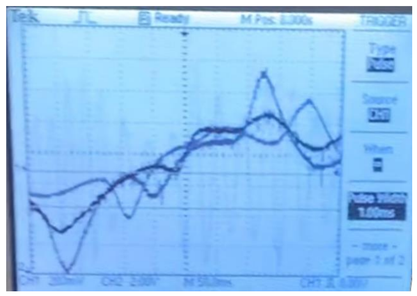
- Features elements of randomness in the production of music
- Creating guidelines for how to play instead of explicit writing of music
- Aim to introduce randomness into the system via mathematical chaos.

Standards for Synthesizer Module

This system is primarily supported by Control Voltages (CV) inputs to further guide the module during runtime. These control:

- Scaling of chaotic system state variables, affecting quantity of chaos in the audio.
- Default values of the system (Primarily baseline frequency for chaotic system to fluctuate)
- Due to hardware limitations, the system can only account for three of these inputs
- Discretized sampling of CV to allow for a more tempo-compliant system.

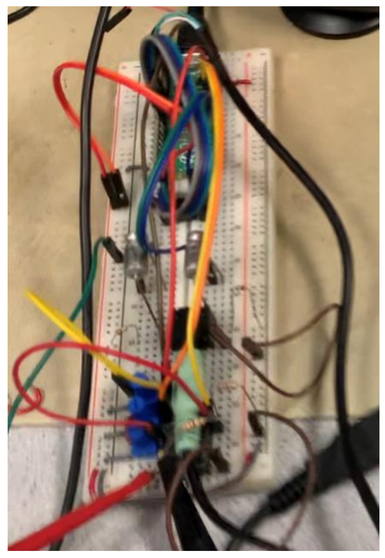
- Logarithmic scaling for pitch.
- A baseline frequency/pitch was implemented for the chaotic system to modify.



Output Waveform Rapidly Fluctuating from Chaos

Components Utilized

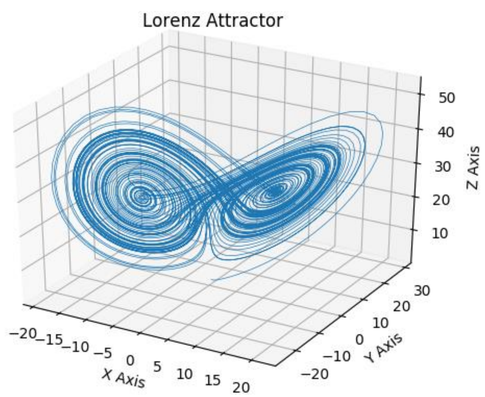
- Raspberry Pi Pico Microcontroller
- Control Voltage (CV) Inputs with default value dials
- Digital-to-Analog Converter (DAC) audio synthesized output



Circuitry construction

The Lorenz Attractor: A Chaotic System

- One of the first chaotic systems derived.
- Modelled thermodynamics and its effect on weather.
- Famously coined the term “Butterfly Effect”
- Offers three state variables that can be sampled and mapped to acoustic/waveform parameters for the system



Acoustic Parameters Controlled by Chaotic System

- Pitch
- Loudness
- Panning between two Speakers
- Tempo

Discoveries and Further Steps

- Any acoustical element mapped to Lorenz Attractor’s X state element goes between two distinct stages of sound
- While the tunable baseline frequency greatly increased synthesizer useability, it abstracted away from the exploration of chaotic systems.
- Due to the chaotic system modulating the baseline frequency, this chaotic characteristic can only be found via spectral elements of the sound
- There could be further discovery to be made if the system is instead recorded once more and more direct audio-analysis is taken on it (i.e. Fourier Transformation)
- Fully pushing the design to work with Eurorack Standards for industry-standard module compatibility

Acknowledgements

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References

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