CREATING SIGNAL TO NOISE LOOPS V4

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ABSTRACT

Signal to Noise Loops v4 is a data-driven audiovisual piece. It is informed by principles from the fields of IoT, Sonification, Generative Music, and Cybernetics. The piece maps data from noise sensors placed around Dublin City to control a generative algorithm that creates the music. Data is mapped to control the sound synthesis algorithms that define the timbre of individual musical voices and data is also mapped to control post-processing effects applied in the piece. The first movement consists of data recorded from noise level sensors around Dublin in March 2019. This is before the COVID-19 pandemic and the bustling nature of the city is well represented. The second movement consists of data recorded in March 2020 when restrictive and social distancing measures were introduced culminating in a full lockdown on March 27th. This section is notably more sedate. The piece was created with Python, Ableton Live, Max MSP, Reaktor, and Processing.

1. INTRODUCTION

Signal to Noise Loops v.4 is a fixed-media data-driven audiovisual work that incorporates IoT Network Data, AI/ML Techniques and data sonification within a Cybernetic framework. It is created with data drawn from networks of IoT devices placed around Dublin City. Network traffic data is mapped to control parameters of the live performance. How this takes place is mediated by a system that integrates decision loop structures with machine learning techniques. The state of the system is determined by the state of the city, represented by the IoT sensor data. The system's state in turn determines the musical choices it makes while co-composing alongside a human composer. Each composition produced with this system is unique as it represents a complex array of data relations that describe the state of Dublin City and any given time. The larger project from which this work stems involved the iterative development of the system with live performances and the production of compositions acting as an evaluation after which the system would be expanded and further refined. Recent compositions produced with the system are notably quieter, thanks to COVID-19, with interspersed moments of frenetic activity. The current piece presents a snapshot of a city in which human activity was been effectively frozen due to the lockdowns used to combat the COVID-19 pandemic.

2. CYBERNETIC MUSIC

In 1948 Wiener established Cybernetics as the scientific study of control and communication in the animal and the machine [1] before Von Foerster's second-order cybernetics [2] integrated the observer into the system introducing a form of reflexivity which was built upon by Beer who saw Cybernetics as the science of effective organization [3]. 20th-century experimental music was shaped by developments in Cybernetics [4].Louis and Bebe Barron, Herbert Brn, Alvin Lucier, and Roland Kayn created first-order cybernetic music with approaches that privileged homeostasis through corrective feedback while Steve Reich, Brian Eno, Agostino Di Scipio and Alvin Lucier produced second-order cybernetic music [5] [6][7].Third-order cybernetics privileges the concept of Emergence, the appearance of new properties not present in the constituent parts of a system and it is argued elsewhere that works by William Basinksi fall into this category [8]. The current piece represents an effort to reconcile data-driven musical practices (w/ IoT data).

3. INTERNET OF THINGS DATA

A smart city is an urban space in which Internet of Things (IoT)-sensing technologies are used to collect data that is used to aid the management and governance of life in that space [9]. This piece uses GDPR-compliant data obtained from Smart Dublins open data store, Dublinked, which is accessible through a series of APIs and/or data stores [10][11]. This piece made use of dB noise level data gathered at a network of monitoring stations across the city which are operated by Sonitus Systems.

4. ORGANISATION: EVENTS, PATTERNS, SOUND SYNTHESIS AND POST-PROCESSING

The sonic content of the piece is organised across a variety of levels. Data is mapped to control changes at the level of the individual event or note, the larger rhythmic/harmonic pattern, the sound synthesis level and finally the post-processing level. There are two "decision loops" driving the piece. These are a set of looping processes that continually make decisions about what musical content should be generated. These loops feedback into themselves with outputs defining inputs over each iteration. Each loop consists of a series of data-driven stochastic processes that generate

semi-randomised musical patterns. These processes are mapped to the original data. The probability distributions determining the likelihood that new notes will be created as well as the pitch and duration of those notes is directly determined by the noise level data at three different noise monitoring stations around the City. Thee noise data also determines the degree to which distortion and reverb effects are applied to the audio signal. This work uses the Google Magenta project's "Continue and "Interpolate" models [12]. Continue creates novel musical passages based on previously input musical patterns and has a recurrent neural network (RNN) architecture. Interpolate is a Variational Autoencoder (VAE) that has been trained on the MAESTRO data set and produces a series of interpolations between two input musical patterns [35]. The outputs of the decision loops are sent to the AI/Ml component of the system for further elaboration. The data is mapped to determine which variation of a musical pattern produced by Continue should be used and to control the degree of interpolation between the 2 input patterns for Interpolate. This process is described in detail elsewhere[8].

The composition exists in two movements. The first uses data from before the pandemic in March 2019 while the second movement used data from March 2020. At that point in time, the pandemic was worsening, and Dublin was preparing for its first lockdown. The visual element involves a data-driven dot distribution map in the shape of Dublin. In this visualization, random processes applied to the radii and colors of the individual dots are constrained in their extent and directionality by the data values recorded at noise level sensors across the city. this was created with Processing 3 and Python for data processing/handling, specifically the NumPy and Pandas libraries for data processing and the pyOSC library to send the data back to Processing via OSC.

The sounds in the piece are created using Wavetable Synthesis techniques for harmonic materials and a mixture of additive and subtractive techniques to produces the rhythmic patterns. The mapping function involved in this piece is complex and data is mapped at the level of the events, the pattern level, the sound synthesis level, and the post-processing stage.

5. DISCUSSION

This piece is number four in a series of pieces in the Signal to Noise Loops project which is detailed elsewhere [8]. The initial point of the project was not to produce an accurate representation of the original data involved but rather to create a series of data-driven music performances and pieces that operated as a collaboration between a musician or composer and the city in question as represented in the data. In this regard, concepts from cybernetics, specifically the use of iterative feedback and feed-forward loops to evolve a system towards some desired state and the the integration of human-in-the-loop reflexivity were key to the design of the system. The looping structures are evident in the decision loops driving the generative component of the system, but integrating a human into a fixed piece like this that does not have a live performer associated with it required a different approach. The 'humans-in-the-loop' here are those people whose activities are being measured by the noise monitoring stations as they go about their lives in the city. Their role is somewhat different to that of an observer of the system in a traditional cybernetic sense but they have a level of involvement nonetheless. the other humans involved are those who provided data for the Maestro data set on which the machine learning components were trained. It is comprised of more than 200 hours of midi and audio recording from 10 years of international Piano-e-CompetitionLINK]. These recorded performances determine how musical patterns will be extended and interpolated and so it represents another group of humans who have impacted and determined some of the rules governing the system. While the original intent was not to sonify or directly represent the data in a traditional sense, the impact of the COVID-19 pandemic on the city was so great that it is revealed in the piece. I further enhanced this by presenting data from before and during the pandemic side by side across two distinct movements.

6. REFERENCES

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