Title	An Internet of Sounds sonification prototype
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Publication date	2025
Original Citation	Roddy, S 2025, 'An Internet of Sounds sonification prototype', Paper presented at IEEE International Symposium on the Internet of Sounds , L'Aquila, Italy, 29/10/25 - 31/10/25 pp. 1-2.
Type of publication	Conference item
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Download date	2026-09-18 17:19:56
Item downloaded from	https://hdl.handle.net/10468/18627

An Internet of Sounds Sonification Prototype

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***Abstract*—This demo paper presents an overview of the design of a research prototype for the sonification of sensor-level data in the context of an Internet of Sounds network. After a short introduction and justification, the prototype design is presented in terms of its constituent subcomponents.**

Keywords—sonification, internet of sounds, sound synthesis, auditory display, sound and music computing

I. Introduction

Sonification is the mapping of data to sound in order to communicate information about the original data source [1]. There have been calls for a closer examination of what value sonification might contribute to Internet of Sounds (IoS) research [2]. The research prototype presented here is one method for the sonification of sensor-level IoS data. It employs FM Synthesis techniques to map changes in a dataset to perceived sonic changes. The sonification technique in question is parameter mapping sonification (PMSon) which involves the mapping of data control synthesis parameters of the FM Synthesis routines used. Although sonification is already a critical tool for monitoring and understanding the flow of information across the Internet of Things (IoT) networks, exploration of its potential for IoS applications is only just beginning [2,3,4]. FM synthesis was developed by John Chowning in the late 1960s as a means of synthesizing rich frequency spectra for musical applications and has since become a useful technique for sonification [5]. The research prototype here described was developed in Max/MSP as a standalone application. The signal chain is illustrated in Fig.1.

II. The Prototype

A. Data Acquisition and Handling

First, three streams of data are read and processed in real-time and an overall rate for the sonification is set by the user. Rate in this capacity means how many data points are mapped to sound per second. Once read and processed these data are normalized and fed forward along the signal chain.

B. Data Smoothing

The prototype allows the user to apply a smoothing filter directly to the three incoming data streams as opposed to the output audio. This helps to address the rapidly varying components of complex, high-frequency time-series data that might otherwise dominate the acoustic result obscuring the components of a given data set that only emerge over longer spans of time. This simple one-pole low pass filter divides the difference between the current data value and the previous filter output by a smoothing factor, adding this to the previously filtered value.

C. Mapping Data to Sound

FM synthesis involves the modulation of a carrier signal, which is usually a simple sinusoidal wave, with another sinusoidal signal termed a modulator thus generating new sinusoidal partials called sidebands on either side of the carrier frequency.

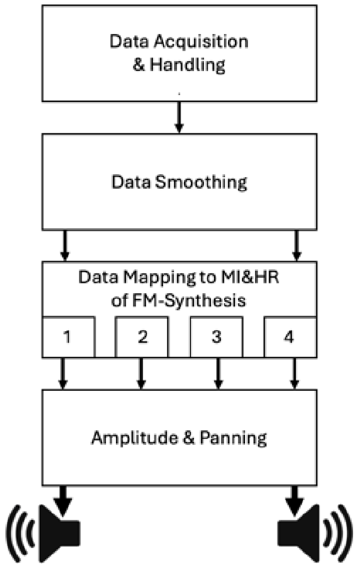

Fig. 1. Signal chain for a single sonified data stream

These are produced at frequencies equal to the carrier plus and minus integer multiples of the modulator frequency. This results in rich spectral results for modulator in the audible 20hz-20khz range. Below 20hz vibrato effects are produced. There are two novel parameters for controlling FM synthesis routines. The first is the modulation index which describes the ratio between the amplitude and frequency of the modulator (Am/Fm) and determines the number of audible sideband partials and their relative strengths. The harmonic ratio describes the relationship between the frequencies of the modulator and the carrier respectively (Fm/Fc). It determines the frequencies of the sidebands with reference to the frequency of the carrier wherein integers produce harmonic, and decimals produce inharmonic frequency profiles. Mapping data to these parameters allows us to represent changes in the original dataset as timbral transformations. This is a more advanced and perceptually rich approach to data sonification than simply mapping onto basic features of the waveform such as frequency or amplitude. It engages and exploits the capacity of the human ear to discern between small changes across evolving spectral shapes. It engages and exploits the capacity of the human ear to discern between small changes across evolving spectral shapes. Each of the three FM synthesis routines consists of 4 voices that are pitched to chords Am(add9), Dm(add9), and C(add9) respectively. 9th chords were chosen in order to keep each of the sonified data streams perceptually distinct from one another. The chords do not change over the course of a sonification, but rather, the timbre of the chords change in accordance with changes in the data which are mapped to the MI and HR of each voice in a given chord. For each voice, the HR is modulated on a scale from 1 to 4, and MI on a scale of 0-3, both with positive polarities, as demonstrated in Fig.2. These chords provide a kind of acoustic baseline, in that they will only be clearly audible when the data is close to its minimum, but as the data values increase the number of sidebands, their relative amplitudes, and their harmonic relation to their fundamental frequencies, begin to shift obscuring the original chordal structures somewhat.

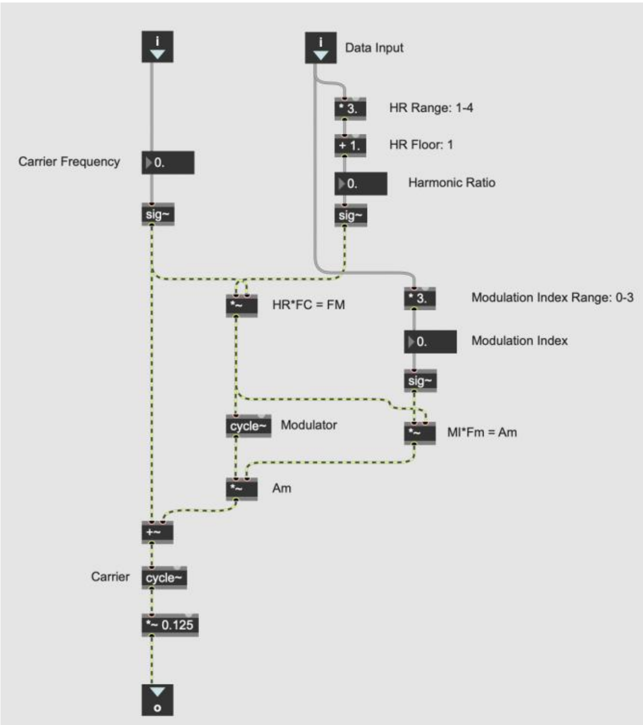

Fig. 2. Subpatch mapping data to a single FM Synthesis voice.

D. *Panning and Amplitude*

As mentioned, the prototype is designed for the sonification of a maximum of three concurrent data streams. These three streams are panned across the stereo stage with one presented in the center and the other two panned hard left and hard right. The user can control the amplitude of each sonified data stream.

E. *A Note on Data and GUI*

The prototype was developed with three specific datasets: Noise level data collected between February 28th, 2020, and February 28th, 2024, at three separate locations around Dublin City. Temperature, humidity, and computed heat index collected in Mexico City between April 4, 2022, and the 19th of January 19, 2023. The third dataset consists of random walk data generated from a classic one-dimensional random walk implemented in real-time in the prototype itself. The GUI for the prototype created in Max/MSP is shown in Fig.3 with each of the controls for the system visible. The prototype can be downloaded from [6].

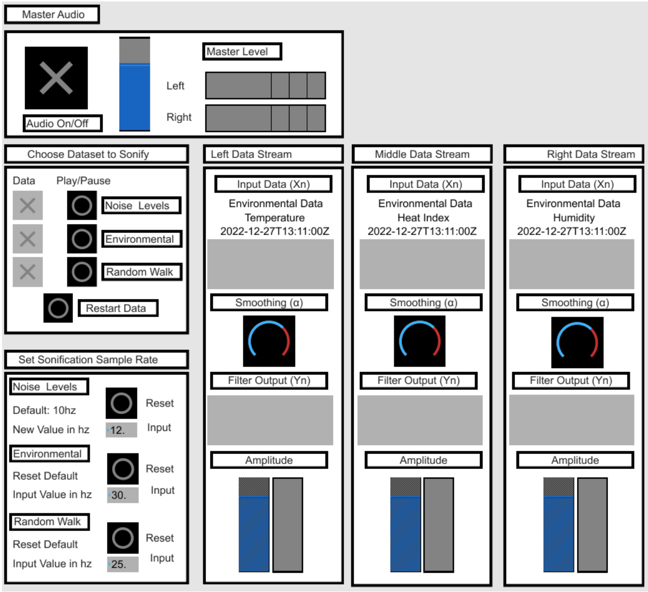

Fig. 3. GUI for the sonification prototype.

III. Discussion & Future Work

A more complete description of the psychoacoustic parameters at play in a system of this nature is beyond the scope of this paper but critical nonetheless to the development of future iterations. It is envisioned that a system of this type would sit at the applications and services layer of the generalized IoS architecture presented by [2] and prove useful for monitoring the data captured by sensors in both IoS and similarly configured IoT networks. However, I argue that there is a need to develop a dedicated IoS network schema to fully describe how a sonification-enabled IoS network might be typified, designed, and implemented. Equally important to this work is the need for a standardized definition of sonification as it relates to the IoS which can capture both how IoS data might be mapped to sound, and how a listener might experience those sounds during sonification listening. Beyond simply iterating over the prototype, future work will explore these avenues.

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