Abstract

The Project FAUN aims to study how networks of non-linear and recurrent systems can be employed for the generation and processing of audio signals. Such networks exhibit highly complex behaviours but are barely analytically tractable and difficult to control intuitively. At the same time, the behaviours of these networks provide the possibility to create and render musical structures on a wide range of temporal scales. Accordingly, these networks show great promise as generative mechanisms for sound synthesis, algorithmic composition and sound installations.

Background

Feedback and delay mechanisms play an important role in computer music as ubiquitous techniques for digital audio signal processing and sound synthesis. These mechanisms also play an important role in artificial neural networks that process temporal data. Despite the shared interest, there exists very little research concerning the adoption of recurrent neural networks as mechanisms for signal processing and sound synthesis [1][2]. The FAUN project is motivated by the desire to continue and expand this promising but seemingly neglected research.

Prototypes

As part of preliminary studies that were conducted prior to an application for a SNF funded research project, the authors have realised two prototypes that incorporate different time-delay feedback mechanisms [3]. These prototypes employ different recurrent network topologies which are depicted in figure 1. In these networks, audio signals are delayed and attenuated as they travel along the network connections. The networks are initially excited with a short audio signal.

Prototype 1 consists of nodes that act as gates (see figure 2). These nodes and their gating behaviour are loosely inspired by neurons and their action potential threshold. The gate opens and closes over a period of time depending on whether the average of the summed input signal falls in between our outside a lower and upper threshold. The implementation of this prototype has been realised in the programming environments Max, Pure Data and SuperCollider.

Prototype 2 realises an audio signal propagation mechanism that resembles neuronal spiking. The summed audio signals that arrive at a neuron are passed through a sigmoid activation function in order to calculate the neuron’s activity level. If this activity level is in between a lower and upper boundary, the neuron triggers a spike in the form of a sound grain (see figure 3). The implementation of this prototype has been realised in C++.

Results

Based on our explorations into the sonic capabilities of time-delayed feedback networks, it became clear that these systems possess musical potential but are very challenging to work with. For a given network architecture, the anticipation of the sonic effects of parameter changes is difficult due to a number factors. (1.) The effects are often highly non-linear and mutually independent, (2.) they can differ considerably depending on the network's topology and its current state, (3.) they often not only affect the immediate audible results but also influence the long term sonic evolution of the network. Accordingly, these networks are particularly difficult to employ for purposes of musical improvisation and live experimentation.

Discussion and Outlook

To improve the musical usefulness of these networks, it is important to establish design heuristics that are based on an understanding of the relationships between network properties and sonic output. We are convinced that such an understanding can only be acquired via a systematic approach that interleaves a mathematical assessment with a musical evaluation of the networks’ sonic output. Furthermore, we believe that the applicability of these networks for musical practice benefits from the provision of techniques and physical interfaces that help explore and manipulate these networks. Such an integrated approach which combines mathematical, engineering and musical expertise is essential for developing a novel generative system for artistic practice. Accordingly, we hope that this project can serve as inspiration for other research projects within generative art.

References