Motor neuron based virtual drummer
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Abstract: A new implementation of mutually inhibited neuron network (MINN) based algorithmic (motion-) pattern generator is presented. The pattern generator is oriented towards non-pitched, yet discrete set, of instrument sounds, i.e. drums. The hypothesis is that even without complicated postprocessing, which was required when producing melodic elements with MINN, and without any preprogrammed stylistic patterns the model can simulate the movement oriented drumming and be able to produce plausible drumming patterns.

1. Introduction

During last few decades several different approaches have been adopted to automatize musical decision making. Typical for these approaches and algorithms have been that they have originated from mathematical or computer scientific fields. In this paper we present new method for making musical decisions, especially in the time/pitch domain. This new algorithm is based on physiological properties of biological neural networks, especially in time domain around 10 - 1000 ms, where the activity of individual neurons is the focus, rather than the connecting weights between neurons (by which one typically tries to simulate “learning” properties of biological systems, and which normally operate in time domain from 1 minute upwards).

The central pattern generators formed from oscillating motor neurons are common biological phenomena. Central pattern generators are able to generate large number of different patterns, ranging from small periodic patterns to chaotic ones [Matsuoka, 1987]. Earlier the oscillating neural systems have been used in rhythm perception research [Ohye, 1994], producing some evidence that oscillating systems may be more plausible models of human rhythm perception than for example rule-based rhythm perceptrons. Another area where simulated motor neurons have been used is the locomotion of robot insects [Cruse 1998].

The time, the duration and so called "inter onset intervals" of notes are most prominent aspects of musical rhythm. The musical rhythm have also other aspects, or it operates with other parameters like patterns and separating intervals.

The human drummer have access to multitude of different, but still rather discrete sounds. This means, that he does not operate using continuous parameters like pitch scale. This reduces the (assumed mental representational) problems arising from complicated pitch hierarchies, because now different sounds can be viewed as different entities not constrained by harmony or voice-leading for example. Combined with the fact that drumming is probably the most physical and tactile of all musical activities, it can be seen as most interesting field of exploration in semi-automatic motor-neuron based pattern generation.

The hypothesis of this paper can be stated as: Is it possible to make up a motor neuron based drummer, which does not require any stylistical information (except initial parameter adjustments) to operate?
2. Implementation

The idea behind the motor neuron based drumming is similar as in the musical pattern generator described in [Laine 1997]. Mutually inhibited connections of simulated dynamic neurons are used also here. Whereas in [Laine 1997] the connection or network was small and used discrete time steps, here a larger connection with continuous time representation is used. In addition there is now an adjustable inhibition delay implemented.

The current model consists of several identical model neuron objects. Each such object is simply an increase-and-fire type neuron of which speed of increase is controlled by the inhibiting connection. A number of these model neurons together (in current implementation eight) are connected with inhibitory links. There are some controllers affecting the whole connection, like a delay and the limitation of the inhibition strength. The inhibition is linked to other neurons without any delay. The actual architecture of the connection is not a decisive factor, because almost every connection is able to generate some patterns. Individual architectures affect the general style or behaviour of the connection.

The actual implementation has been done using MAX-music programming environment, but the program could be easily implemented in any real-time musical programming environment with even rudimentary graphical features. Using only very few parameters and absolutely no pre-programmed patterns the system is very effective and behaves quite like real (but sometimes not very good) drummer. Increase in "energy parameter" or "neural reaction speed parameter" does not simply accelerate tempo or increase dynamics, but it can result in a complicate non-linear, yet drumming-like, behaviour.

Figure 1: In this picture one can see the basic elements of the virtual drummer. The inhibitory connection (implemented using receive inhibit and inhibit2 commands and send uneval) and use of the neuronfd-subpatch. Large dial in top refers to uSpeed, universal neural reaction speed.

3. Results

Using the virtual drummer model several different drumming styles can be generated. Simple example of which is shown in (figure 2). In practice the non-quantized and non-symbolic rhythmic handling sounds quite natural. It is however more difficult to show the actual results in normal western notation. The problems are same as when notating real drumming.
I believe that it would have been very difficult to obtain similar behaviour with conventionally used generative grammars, stochastic methods or learning neural network programming. Patterns produced by the MINN-model resemble somehow the patterns generated by fractal methods, like bifurcating logistic function \( x_{n+1} = b \cdot x_n \cdot (x_n - 1) \). The difference between MINN-model and fractal methods being that MINN-model is inspired or even derived from physiological pattern generators and because of consisting of a set of adjustable neurons rather than single function is much more versatile and also easier to control.

The model behaves quite nicely when the parameters are adjusted. Decreasing the amount of energy injected to the network results in tempo slowing and pattern changes similar to real drumming when the playing intensity is decreased. On the other hand quite powerful dynamical pattern changes resembling the drum breaks and endings can be seen when the amount of energy is increased. The whole system can be controlled via very limited number of parameters.

4. Conclusion and further research

The principle of mutually inhibited neuron connections can be implemented in many different ways for different purposes. The basic behaviour of the MINN-model produces a large variety of different patterns. In this paper a virtual drummer has been presented, which is able to generate several distinctive drumming patterns and even some typical deficiencies of real drummer.

The current model requires development so as to be more easily controllable. Some rhythm presets are probably needed if the virtual drummer is used in real playing situations. These presets could be obtained by saving the adjusted parameters. An important direction on further research is to link the virtual drummer to other music players. Then it can be studied if the virtual drummer is able to synchronize itself to outer source. Then this model could be used as control system for mechanical drumming systems and also interactively connected via MIDI to human drummers and other instrumentalists to make jam sessions. Users can also control the system interactively either via mouse or drumpad.

References


