Detection of rhythmic patterns in real time with Pd

Cristiano Figueiró
figocris@gmail.com

ABSTRACT

This paper describe a research project that pretends develop a interactive composition system written in Pure data. The system has as data inlet the audio analysis of a real-time music performance and as outlet sonic structures derived from this analysis. Will be explained the actual stage of this research focusing in analysis, segmentation and rhythmic pattern recognition developed as a library of custom pd abstractions.

Keywords

interaction, pattern recognition, pure data

1.INTRODUCTION

The computer music traditionally uses developments in neural artificial networks (ann), artificial intelligent agents and other fields of artificial intelligence (AI); the musical production offers good test cases to this fields of research. This article expose a project that presents the challenge of build a system that use elements of AI research permitting a closer interaction with musicians and that be a basis of functional work for a artistic based approach. This is easier to talk than do; the human musical abilities in action fluidity, answer capability to new situations and cultural references, transform the capability of interaction in computer media in a hard task. In practice the system work in two instances: in a first moment the network need be trained. In this fase the musician realize a performance, the audio of the performance is captured, analyzed and allocated in a database which will work as training file by the network. The second moment will be the on stage performance, when the system will interact with the musician stimulus comparing the real-time performance analysis with the database previously captured. A global vision of the system is shown on figure 1 where we can see the top data flow through the system parts. The system answer to the musician stimulus depends on the output from the networks that search for patterns. The output from the networks distribute weights in the decision mechanism which apply transformation processes in the music material then allocated in the database.

The system have as paradigm the real-time music creation and this requires a multi-dimensionality of descriptions, fast learning and capability to answer and anticipate. The research field of interactive music systems [9] consists in software and hardware created to combine machines and musicians.

The actual works in this field include at the same time real-time audio analysis, music cognition and experiments in AI and robotics; an inspirer project in this area is MahaDeviBot[2] by Ajay Kapur, which is a percussionist robot set with thirteen drums, able to synchronize with a human sitarist through sensors.

2. SYSTEM CHARACTERISTICS

The system will be constructed in Pure data (Pd). Pd is a object oriented graphic language. The audio analysis will be done by the objects *fiddle~, sigmund~, fft~* and also by the library *Aubio* [8] which is a audio analysis tools library written in C and coded as a Pd external. The audio analysis outlet will be collected and parsed through a system of artificial neural networks build with the library FANN [1] ported to be used as a Pd external. The networks will be organized by order of size of temporal segments. In a simulation, the first network will look for patterns at each 20 seconds and send the results to the second network which will look for the presence of patterns at every 60 seconds and so on.

This process will be described in all parameters. The results of this networks will be sent to a database that will be compared with the database used in training the networks. The comparison between the databases of training and performance in real-time decisions will regulate the response of the system. A general diagram of the system can be seen in Figure 1.
Is possible therefore set a good approach for musical interactive systems research which encompasses a broad multidisciplinary field through a merger of equal weights between areas of cognitive psychology, computing, and theory of musical composition. This fusion occurs on a pragmatic, embodied in a system of software and hardware, able to respond musically to musical stimuli and also able to learn and analyze the behavior musical musician with knowledge of its past, present and so can design the future.

3. CURRENT STAGE OF RESEARCH

3.1 Fann

In the first experiment was used the external ann_mlp with the aim of detecting in real-time rhythmic patterns pre-established in the phase of network training.
Neural networks and other artificial intelligence techniques are ideal for experiments to detect patterns in real time by the fact

that return rates similar to pre-analyzed data and stored in a database, rather than objective responses as a result.

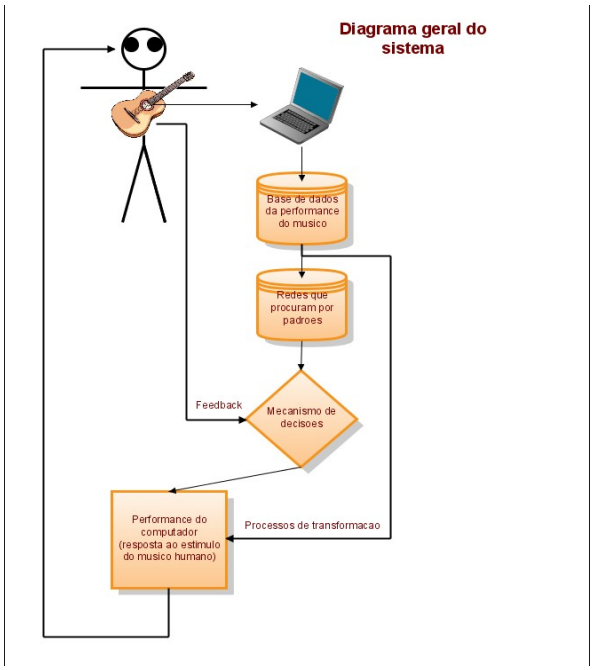

Figure 1. Diagram of the system

The main element used in this first experiment was the change in progress. One of the main characteristics of a musical dialogue is the fact that musicians readily recognize rhythmic patterns independent of the progress that they are presented. To do this it must be taken into account the temporal distance between attacks of events sound instead of the duration of these events or the time position within the total period of performance.

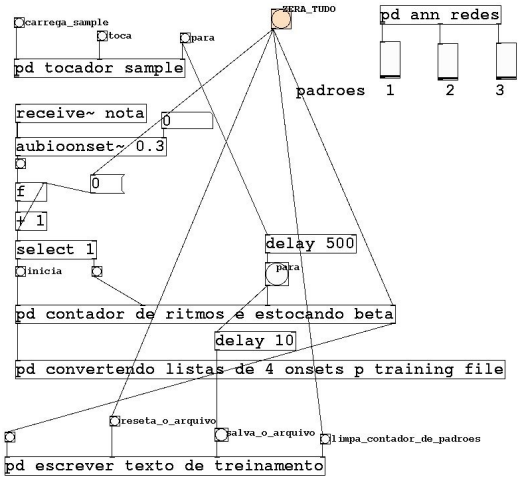

Figure 2. central patch

3.2 rhythmic segmentation

For the work of rhythmic segmentation was used the aubio library to identify attacks (onsets) of sound events. In the main patch can see how it makes the detection of attacks with the object, which returns a *aubioonset* bang for each event of attack. In Figure 2 we see the central patch with the object *aubioonset*, receiving a stream of audio data and responding to real-time bang for each attack recognized.

For the first experiment of this research was chosen one methodology for segmentation grouping sets of four attacks. In Figure 3 we can see the patch was implemented as a group of four attacks within the sub-pd patch counter rhythms and stocking beta.

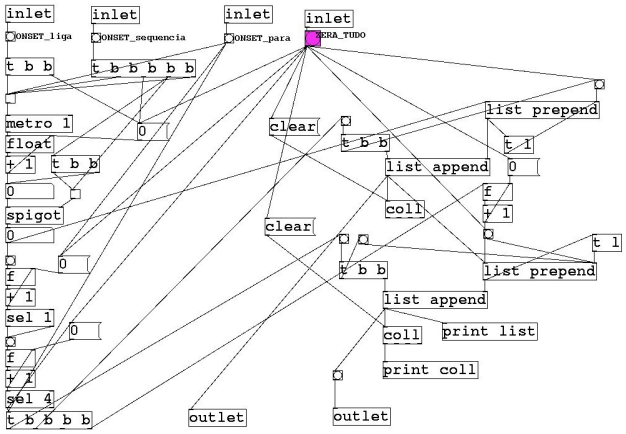

Figure 3. pd meter rhythms stocking

Within this structure of the system will be based on targeting the parameters of the audio input. This method serves both for the creation of files on the networks as training for real-time targeting.

3.3 Training and performance of networks

The artificial neural networks operate in two stages, training and performance. In the weight training the networks and patterns of how to create a file that serves as a training database. The file can manually edit the training and identify and label the patterns in order to refine the database. In this experiment was developed a abstraction which automatically creates a file of training, determining the quantity of neurons of the network, number of patterns to be stored and the quantity of elements of each pattern. In the experiment in question was using an audio tone with a percussive attack and clear. This file contains 3 rhythmic patterns presented 3 times with different tempo. In the result we observed that even when you change the tempo, the networks continue to detect patterns, because during the training patterns were presented several times in different tempos.

3.4 Future development

The next steps will be implemented at the same time the detection of patterns for the other parameters such as harmony, melodic contour, density and timbre variation.

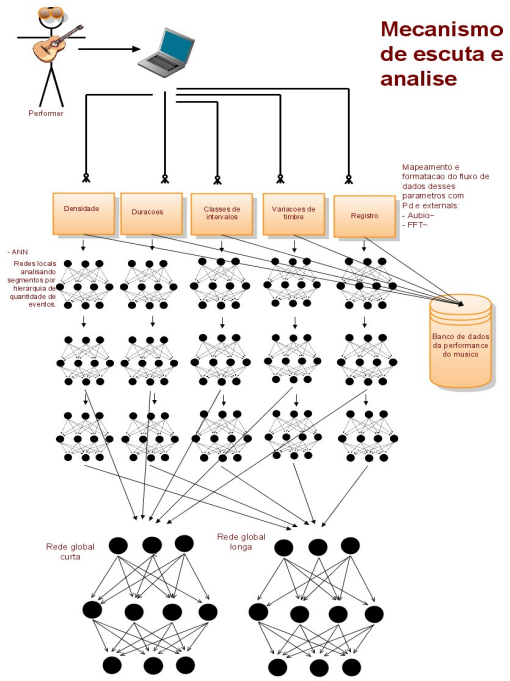

Figure 4. Mechanism of hearing and review - system of networks.

Networks will be established more time segments, the network of level 1 will deal with 4 events, the 2nd level with 16 events (4 outputs of the networks of 1st level) and the 3rd level with 64 events (4 outputs of the networks of 2nd level). At the same time networks will be implemented that will act on a global, looking for patterns that concatenate multiple parameters as we can see in Figure 4.

The outputs of these networks will compete, and will make the detection of pattern stronger with each cycle. The default winner will interact with the performer taking a decision to copy, change or propose contrast, the decision can be strengthened or weakened by the feedback of the performer as can be seen in Figure 1.

4. CONCLUSION

This article presents a research project that aims to build an interactive system where the performer feeds and interacts with the computer only from the performance of audio and control the flow of musical patterns. The objective is to establish an area of structured improvisation from the musical performance, with the hope that can be used by any musician in any genre, which is open to semi-structured improvisation. In this sense the result presented here indicates a good contribution to research in detecting patterns to show the ability to detect rhythmic patterns independent of changes in progress.

Besides the option of exclusive development in open source, updates to open the main repository in www.github.com/cristianofigo provides the collaborative development of the system in addition to other research that could boost use segmentation and detection of patterns in Pure data.

5. ACKNOWLEDGMENTS

To all the international community of Pd an open source software and PPGMUS/UFBA, Cnpq to finance such research.

6. REFERENCES

[1] FANN - Creation/Execution: Fast Artificial Neural Network.

[2] M. S. Benning G. Tzanetakis A. Kapur, E. Singer. Integrating hyperinstruments, musical robots and machine musicianship for north indian classical music. In Proceedings of NIME 2007.

[3] A. Eigenfeld. Drum circle: Intelligent agents in max/msp. In Proceedings of the ICMC 2007.

[4] M. Chemillier A. Cont S. Dubnov G. Assayag, G. Bloch. Omax brothers: A dynamic topology of agents for improvisation learning. In ACM Multimedia Workshop on Audio and Music Computing for Multimedia.

[5] G. Holzmann. Echo state networks in audio processing.

[6] G. Holzmann. Efficient c++ library for analog reservoir computing neural networks (echo state networks). Technical report.

[7] G. Ligeti. Transformações da forma musical. In: Die Reihe (revista) nov/dez 1958. Tradução para português: Conrado Silva (1971).

[8] J. P. Bello P. Brossier and M. D. Plumbley. Real-time temporal segmentation of note objects in music signals. In Proceedings of ICMC 2004.

[9] Robert Rowe. Interactive Music Systems. Cambridge, MA: The MIT Press, 1993.

[10] I. Xenakis. Determinacy and indeterminacy. Organised Sound, 1996.