

Alberto CARRETERO

Composer and professor of Composition

Conservatorio Superior de Música « Manuel Castillo » Seville, Spain

« Membrane Computing and artistic research in music composition »

SUMMARY

This contribution focuses on membrane computation, i.e., P-systems introduced by Gheorghe Păun, applied to music composition. These bio-inspired systems are part of Artificial Intelligence and simulate the behaviour of cellular membranes. They make possible the modelling of certain facets of the compositional work, in particular those of a mechanical or systematic nature, which need a big volume of calculation. In this case, the technological tools currently available become excellent assistants for the composer, the teacher and the researcher.

The research process is carried out from the point of view of musical creation. In this way, the composer makes his artistic and scientific work transparent and step by step detailed to the scientific community, offering tools that can be useful for students and other composers for the development of a personal artistic language. The results obtained allow widening the range of possibilities of algorithmic composition by using some of the relatively most recent branches of Artificial Intelligence.

A main topic of study is the generation of form and musical material based on algorithms and computational techniques that imitate natural processes at cellular level, specially at membrane level inside a single cell, applying concepts from auxiliary disciplines such as Biology, Genetics or Neurology.

Membrane calculation techniques are applied to musical composition by using seven different models of P-systems. A step-by-step methodology of analysis is presented. It describes the auto-ethnographic process of creation and the taken decisions, accompanied by its technical and aesthetical justifications.

The creative research does not only take into account the purely technical aspects, but also considers the aesthetical and stylistic dimensions, exploring ways to obtain interesting musical results and to serve the expression at the same time, framed in the panorama of the current musical composition and its pedagogical transmission.

The methodology of this research project is based on a solid deductive theoretical framework that leads to prospects of applicability. Then, an inductive research process leads to a generalization of techniques from specific strategies. Finally, an auto-ethnographic approach is adopted, through the composition of a new work and a step-by-step explanation of the musical decisions and applications.

Some transversal axes of the research are intelligent agents and automatic learning, genetic algorithms (evolutionary computation: natural selection, mutation, crossover, mitosis, meiosis), neural networks, structure of DNA and proteins (biomolecular computing), Márkov chains, generative grammars, transition networks, chaotic

algorithms, fractals, cellular automata and P-systems. In our P-system model we assign musical parameters to “vibrant” membranes, chemical compounds and applicable rules of evolution. To feed a musical P-system it is necessary an independent initial material and a categorization of compositional techniques, for instance variation, expansion, compression, repetition and contrast. Each type of P-system is suitable for different compositional strategies and parameters.

In conclusion, we have studied the state of the art of Artificial Intelligence applications to musical composition, specifically natural bio-inspired techniques, and the stylistic and aesthetic principles of these tools. This leads us to investigate on possible relations between natural and musical processes to get results and conclusions from musical applications of membrane P-systems. Finally, by composing new works based on these models, it is possible to prove that we can find analogies between compositional processes and natural processes at the cellular environment, that is, membrane computing can be used as tool to compose bio-inspired music. Some examples of application in own scores are *Ars vivendi* (2013) for string orchestra and *Parallel lives* (2017) for ensemble.

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BIOGRAPHY

Alberto CARRETERO is a composer and professor of Composition at the Higher Music Conservatory of Seville. He has a multifaceted training in Composition, Musicology, Piano, Computer Science Engineering and Journalism. He has obtained an extraordinary award for his doctoral thesis on bio-inspired composition with artificial intelligence techniques. His music has received international awards and has been performed in renowned halls like Centre Pompidou or Carnegie Hall by the Ensemble Intercontemporain, Recherche, Klangforum Wien, Musikfabrik, Flashback, Plural, Divertimento, Real Orquesta Sinfónica de Sevilla, Helsinki Chamber Choir, SWR Orchester, IRCAM, ExperimentalStudio among others.