Math'n Pop Workshop

Formal and Computational Models in Popular Music
An Introductory Tutorial with Pedagogical Demonstrations

Tuesday September 16
12:10-13:30 / 14:30-16:10

Description of the Workshop

This Workshop focuses on a new research axis we are currently coordinating at IRCAM, in collaboration, among others, with researchers from IREMUS (the Institute of Research in Musicology, Sorbonne University) and IRISA (University of Rennes). The project aims to bring together some major scholars and researchers in the field of Formal and Computational Models applied to Popular Music repertoire by focusing, in particular, on the links between the symbolic approaches commonly utilized in mathematical music theory and computational musicology and audio-centered tools which have been developed in the MIR and cognitive musicology communities. Computational and cognitive musicology, in fact, traditionally develops tools that are either based on symbolic structures or signal-oriented, rarely seeking to cross fertilizations and mutual interaction. We will show in the Workshop how to developing formal and computational models enabling to link these two approaches. These models are primarily applied to the analysis of the musical structures and processes found in popular music, with special emphasis on pop music, songs and music improvisation.

The different presentations will each focus on a different theoretical approach by showing the underlying formal aspects as well as their implementation in computer-aided music analysis environments. Since these implementations make use of different computer music techniques, ranging from spatial computing to constraints programming, machine learning, multiobjective optimization and time series matching algorithms, the presentations will provide a very large overview of a variety of approaches in contemporary computer music research. The presentations include a survey of the main mathematical and music-theoretical concepts used in each computational model, followed by practical demonstrations of how to use the different computer music environments.

Mostly of the topics of the presentations also raise interesting philosophical questions about the dialectics between the symbolic and the signal-oriented approach in computer-aided music analysis. Depending on the interests of the audience, we can open a general discussion on these philosophical and epistemological issues by eventually expanding some of the discussions that will take place during ICMC/SMC 2014 special sessions.

Schedule

Morning session

1. What Hyperspherical models bring to the analysis of symmetries in Pop Music - Gilles Baroin (mathemusician, ENAC / Univ Toulouse)

Hyperspheres of the Planet-4D family is a set of geometrical models dedicating to visualizing and analyzing musical objects. In this talk, we will briefly introduce the main tools and present the new visualisations system for the analysis of Pop Music based on Planet 4D spheres and combined with selected 2D representations. All movies are available on `MatheMusic.net`

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2. Analyzing Pop Music via spatial computing and generalized Tonnetz representations: a survey of the existing tools in HexaChord and OpenMusic - Louis Bigo (post-doctoral researcher, San Sebastián, Spain), Moreno Andreatta (CNRS researcher at IRCAM, Paris) and Carlos Agon (Computer Science Professor at IRCAM, Paris)

This presentation will focus on the notion of symbolic representations in musical structures and processes, by showing in particular the richness of the *Tonnetz* construction as a geometric tool for computer-aided music analysis. We will show how to automatically generate different types of *Tonnetze* according to the grammar of the analyzed musical sequence and how to represent these spaces by means of two visual programming languages: `Hexachord` and `OpenMusic`. The talk will therefore serve as a user-friendly introduction to these environments and their special features with respect to computer-aided music analysis.

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3. Real-time manipulation of geometric representations via `bach` environnement and their application to pop music analysis - Daniele Ghisi (mathematician and composer) & Andrea Agostini (composer)

The `bach` environment is a Max library bringing the computer-aided composition into the real-time world. Real-time properties of a CAC environment deeply affect the very nature of the compositional process. The underlying paradigm is that the creation and modification of a musical score is not an out-of-time activity, but it follows the composer's discovery process and develops accordingly. Starting from this point of view, we'll introduce bach notation editors, bach.roll and bach.score, and musical representation objects, namely bach.circle and bach.tonnetz. We will show some examples of how such objects can interact in real-time with the incoming flux of data.

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Afternoon session

4. The "system-contrast" model for the segmentation and structural annotation of popular music pieces starting from audio signal - Emmanuel Deruty (PhD candidate at the University of Louvain, Belgium) & Frédéric Bimbot (CNRS Director of Research at the IRISA, Rennes)

This talk will present an overview of the principles, methods and results obtained in the field of music information retrieval at the IRISA Laboratory in Rennes. A special emphasis is given to the segmentation process, which has been addressed by the so-called "system & contrast" model. This approach is based on a series of conceptual and practical tools for the description and "semiotic" annotation of musical structures enabling to specify a metaphoric representation of similarities and relationships one may find in a musical piece starting from some concepts belonging to information and communication theory. The practical result of this research has been the construction of an annotated database of 380 pop music pieces based on the described methodology. We will provide an overview of this database by suggesting how the segmentation process could be enriched by other symbolic and geometric approaches discussed during the Workshop.

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5. Visualization of complex and big data from the signal level to the symbolic level? (Philippe Esling, Computer Science Associate Professor at UPMC/IRCAM)

Visualization is a fundamental concept and a necessary step in the process of understanding of a musical problem. After showing how we have collected the information coming from millions of genetic sequences into an efficient visualization, we will discuss some interesting questions raised by such a big amount of data. These questions are even magnified in the field of music analysis because of the multi-dimensional and multi-scale character of the data to be analyzed. Moreover, music information is both symbolic and signal-based, as we will stress by discussing the multi-objective nature of sound data.

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6. Towards a unifying symbolic/audio environment for chord recognition and perceptual-based Tonnetze representations - Mattia Bergomi (PhD candidate at the Computer Science Lab of the University of Milan and at within the Music Representation Team at IRCAM)

It is possible to connect the audio processing and symbolic layer, by considering music as a dynamical system, with its own kinetic and potential energy. After briefly analyzing the geometrical structure providing some reasonable assumptions to establish a formula to compute the kinetic energy for a given harmonic structure, we will show how to compute the potential energy of the system and the dissonance value processing the audio signal. We will conclude by showing how this model could be used to clusterize music and by pointing out some interesting connections between this approach computational music analysis based on *Tonnetz* structures.

Equipment list

Video projection, audio playback system, digital piano

Upper limit in the number of people that can attend the Workshop:

30 people

Need to contact the workshop attendees in advance:

No

Bios of the participants (in alphabetical order)

Gilles Baroin is a mathemusician, specialized in geometric visualization of musical structures and musical processes. He is the designer of Planet-4D model used for visualizing musical systems and harmonic progressions in four dimensions. He regularly collaborates with artists, musicians and composers interested in visualization and geometric representation of musical objects in discrete spaces (pitches, chords, harmonic progressions, ...) but also continuous (timber). Among the animations he conceived and produced, we mention the first 4D visualization of the harmonic Path in Beethoven 9th Symphony (as originally discovered by Richard Cohn), the first animated movie of an atonal music piece from Anton Webern *Bagatelle* as well as many visualizations of pop music songs and progressive rock pieces (by Paolo Conte, Michel Legrand, Frank Zappa, …). He developed with Stephane de Gérando an original way to display any sound according to its spectra, within an original 4D environment.

Mattia Bergomi is a mathematician and a PhD student in Computer Science in co-tutorship (Università degli studi di Milano and Université Pierre et Marie Curie). He is currently a member of the Laboratory of Music and Computer Science (LIM) and of the Music Representation team at the IRCAM. His research interest lies in the intersection between music and mathematics. On one side the representation of musical objects with instruments borrowed from the Algebraic Topology; on the other side some new analysis methods given by the Computational Topology and their interaction with machine learning algorithms.

Louis Bigo is currently post-doctoral researcher in Darrell Conklin's Team at the Departamento de Ciencia de la Computación e Inteligencia Artificial Facultad de Informática, Universidad del País Vasco, San Sebastián, Spain. His doctoral thesis, entitled « Représentations symboliques musicales et calcul spatial » and written in collaboration between the LACL (University of Paris 12) and l'IRCAM (Université Paris 6), was rewarded with the young researcher prize in music & science of the AFIM (French Association of Music Informatics). **Moreno Andreatta** is CNRS researcher at IRCAM where he coordinates since 2004 the maths/music activities. **Carlos Agon** is a University Pierre and Marie Curie computer-science Professor at IRCAM. Together with Gerard Assayag he conceived the `OpenMusic` environments to which he contributes (together with Jean Bresson) and that is one of the most utilized programming languages in the field of computer-aided music theory, analysis and composition.

Emmanuel Deruty is currently a PhD student within the doctoral school "Arts and Arts Sciences" at the University of Louvain, Belgium, under the supervision, among others, of Frédéric Bimbot (CNRS-IRISA) and Moreno Andreatta (CNRS-IRCAM). His thesis is centered around the "System and Contrast" model as a special case of the Minimum Length Description principle in Muisc Analysis. **Frédéric Bimbot** is a CNRS Director of Research at the IRISA (UMR 6074) in Rennes, where he is the Team Leader of the PANAMA (Parsimony and New Algorithms for Audio & Signal Modeling) joint project-team between Inria and CNRS, as part of the D5 department (Digital Signals and Images, Robotics). His main interests are on speech recognition, audio signal processing, sound separation and music information retrieval.

Philippe Esling is Associate professor at the University Paris 6 – UPMC. He holds a PhD in the field of Acoustics, Signal Processing and Informatics which awarded with the young researcher prize in music & science of the AFIM (French Association of Music Informatics) and the first prize of the Université du conseil général in 2013. His main research area include Intelligent sound samples database, Multiobjective time series matching, Musical orchestration and Biological diversity analysis - DNA Metagenetics. He conceived and currently develops the ATO-MS (Abstract Temporal Orchestration - Modular Structure) software allowing complex interactions with time-evolving structure in order to produce rich orchestrations.

Daniele Ghisi has both a scientific and a musical background. He takes in 2006 his Master degree in Mathematics at the University of *Milano Bicocca*, and studies Composition (since 1997) at the *Istituto Musicale "Gaetano Donizetti"*, in Bergamo. After following the two years IRCAM Cursus in Composition and Computer Music (*Composition et Informatique Musicale*), he spent an entire year as a research composer at IRCAM working on automatic orchestration. He also conceived and developed, together with Andrea Agostini, the project "bach: automated composer's helper". His first chamber opera *La notte poco prima della foresta* has been premiered in September 2009. With the cycle of Lieder "abroad" he starts his collaboration with *Casa Ricordi*. **Andrea Agostini** holds diplomas in composition (2000), electronic music (2001), and piano performance (2004). After following Masterclasses by Ivan Fedele, Brian Ferneyhough, Michael Jarrell and François Paris, he entered IRCAM *Cursus in Composition and Computer Music en Composition et Informatique Musicale* (2008-2010). His compositions make use of different musical languages, from post-tonal contemporary idiom to rock and improvisation, with a special interest in non-Western music traditions. Together with Daniele Ghisi he conceived and developed the `bach` environments which he also teaches at the Conservatory of Cuneo and Torino in Italy.

Coordinator of the Workshop:

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