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Towards Structural (Popular) Music Information Research

ABSTRACT

Background

Within the field of computational music analysis, Music Information Research (MIR) has developed a panoply of approaches aiming at retrieving the musical content from large corpora ranging from classical to popular music. A first major distinction within the MIR community concerns signal-based versus symbolic approaches, the two having developed in the last decades in an almost orthogonal way.

Aims and repertoire studied

In contrast to currently employed signal-based approaches in Music Information Research, we stress the necessity of introducing a structural multidisciplinary approach into computational musicology making use of advanced mathematics such as algebraic invariants and simplicial complexes to represent musical spaces. These theoretical concepts are systematically accompanied by computational modelling making use of *spatial computing*, a non-conventional paradigm in computer science aiming to reformulate in spatial terms the data structures and their formal manipulations, applied to the popular music repertoire.

Methods

Our research is based on some concepts that have been developed within Neo-Riemannian music theory and analysis (Gollin & Rehding, 2011). The originality of the approach relies in the generalized framework which is proposed and in the computational aspects that are taken into account. The power of generalization comes from the interplay between algebra and topology, which enables to develop a new methodology in the study of all possible geometric spaces associated to a music-analytical situation. The computational counterpart is provided by the integration of these existing theoretical tools into an original computer-aided environment for music analysis and generation called HexaChord which can be used in an interactive way and in combination with other existing and more notation-oriented computer programming languages, such as OpenMusic <http://repmus.ircam.fr/openmusic/home>.

Implications

Spatial computing, a new paradigm in computer science, allows to formulate in a natural way *generalized Tonnetze* as topological and combinatorial structures called the *simplicial complexes*. Once integrated into a computer-aided model for music analysis and composition, these tools allow to approaching the problem of automatic classification of musical styles via a purely topological approach (Bigo and Andreatta, 2015).

The software HexaChord has been conceived for musicologists and composers to facilitate the use of topological pitch spaces in analysis and composition processes. The software represents, analyses and transforms any MIDI sequence imported from a MIDI file or recorded with a MIDI keyboard by the user. Any transformed sequence can be exported by the user as a standard MIDI file.

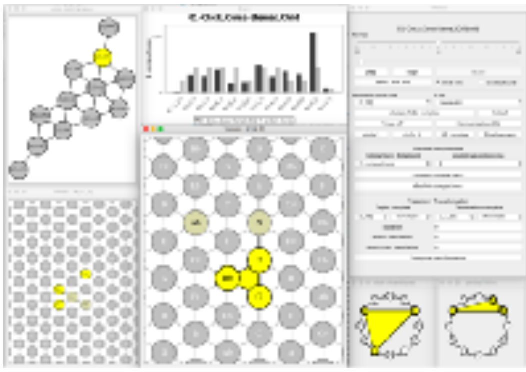

Fig. 1. Graphical User Interface of HexaChord.

The Figure 1 shows the graphical interface of the software. Sequences can be visualized in real time within the traditional (3,4,5)-Tonnetz (generated by minor thirds, major thirds and fourth intervals) as well as in its different instances corresponding to the eleven other 3-note chord intervallic structures (a,b,12-(a+b)). This corresponds to the choice of two alternative generating axes obtained by cyclically repeating the two generating intervals a and b. The software represents a musical sequence in a given space by a trajectory that has a particular shape. The compactness of the trajectory is systematically computed by the software and used as a measure to evaluate how a space fits with a musical piece. This measure is called the *compliance*. Representing a piece simultaneously in multiple spaces therefore allows to compare the pertinence of multiple representation spaces regarding the piece. Finally Hexachord allows to formulate in spatial terms the transformation of a trajectory and to generate the musical sequence resulting from this spatial transformation. The user can for example hear what a musical piece sounds like after its trajectory in a pitch space A has been rotated, translated, and embedded in a pitch space B. Additionally to the generalized Tonnetze, HexaChord includes different common musical representation spaces as fifth/chromatic circle and a 3-notes chord voice-leading space (Tymoczko, 2011). HexaChord can be downloaded at the following address <http://www.lacl.fr/~lbigo/hexachord>.

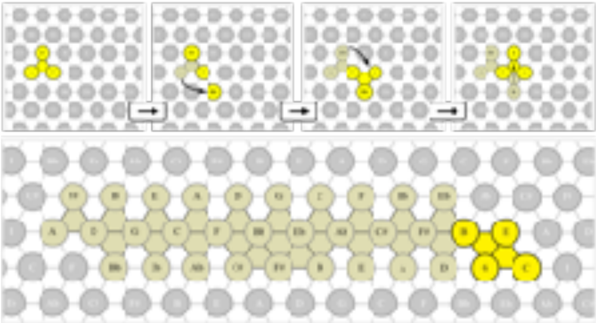

Fig. 2. Tonnetz trajectory representing the chord sequence of the song *Take A Bow* (Muse).

The top of the Figure 2 shows the representation in the traditional Tonnetz of the four first chords of the song *Take A Bow* of the Britannic pop rock band *Muse*. The chords of the song are arpeggiated by a synthesizer and consist quasi-exclusively in major, minor and augmented chords. At each step, one unique pitch of the current chord is augmented from a semi-tone producing then the next chord. At the end of the song, 25 of the 28 {minor, major, augmented} chords have been played. The low part of Figure 2 displays the trajectory generated by the full chord progression. This chord progression might also be represented in voice-leading spaces that, contrarily to the Tonnetz, will emphasize the upward chromatic progression of the moving tone.

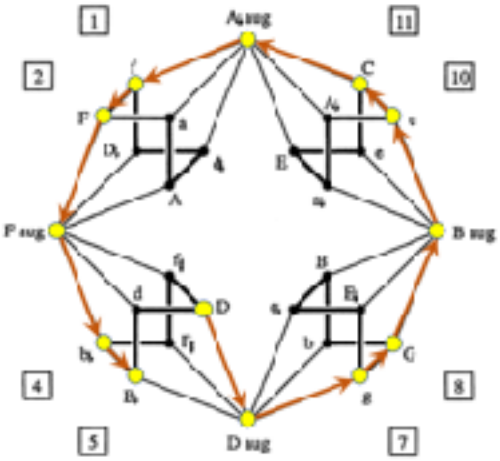

Fig. 3. Trajectory followed by the 13 first chords of the song *Take A Bow* (Muse) in the "Cube Dance" chord space.

The Figure 3 represents the progression of the 13 first chords of the song within the space named "*Cube Dance"* (Douthett and Steinbach, 1998). This voice-leading chord space consists of an organization of major, minor and augmented triads in which two chords are neighbor if it is possible to switch from one to another by adding or subtracting one semitone to one of its three notes. This space is also the central section of the three-note chord voice-leading orbifold T^3/S_3 (Callender et al., 2008). The chord progression followed by the song corresponds to the exterior path in the Cube Dance, which shows how parsimonious voice-leading was taken into consideration in a quasi algorithmic way in the composition process.

Generalized Tonnetze offer similar possibilities for algorithmic composition, as we will see by taking Earl Hines' piece *Rosetta* as a case study. Figure 4 shows two possible geometric transformations of the piece, whose first measure is represented in the traditional (3,4,5)-Tonnetz and notated via the OpenMusic "poly" object (See Fig. 4, (a)). The piece is successively transformed via a rotation by π around the note C of the trajectory in the Tonnetz (Fig. 4, (b)) and finally "pentatonized" via and embedding of the initial trajectory of the piece into the (2,3,7)-Tonnetz (Fig. 4, (c)). These transformations, that correspond to two different types of isomorphisms that can be applied to the shape of the piece, clearly show the interest for algorithmic composition of using a generalized approach to the Tonnetz representations and combining it with notational systems such as those provided by the OpenMusic visual programming language.

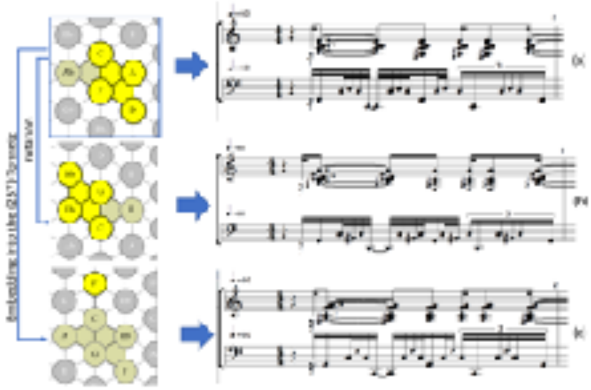

Fig. 4. Two spatial transformations applied to the *Tonnetz* trajectory representing the first measure of the song *Rosetta*.

Keywords

Popular music, musical modelling, mathematics and formalisation, harmony, structure.

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