MATH'N POP *VERSUS* MATH'N FOLK?
A COMPUTATIONAL (ETHNO)MUSICOLOGICAL APPROACH

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1. INTRODUCTION

According to a programmatic article by Philip Tagg on theoretical, methodological and practical aspects of popular music studies (Tagg (1982)), folk or traditional music is one of the three possible kinds of music, together with classical (or art music) and popular music. This typology constitutes what Tagg calls an *axiomatic triangle* of musical genres, each of which being characterized by criteria such as the usual or unusual mass distribution, the existence of a circle of professionals or a circle of amateurs who produces and transmits it, the principle modality of storage and distribution (ranging from oral transmission, in the case of folk music, to the recorded sound, in the case of popular music), the anonymous versus authorial character of the underlying compositional process, and so on.

This typology, as well as any other traditional taxonomy, has been recently criticized by several scholars (see, e.g., Fabbri (2007)) stressing the existence of other music genres which are not included in Tagg's axiomatics (e.g. jazz music or the so-called *musiques actuelles*) and suggesting the necessity of substituting this typology with a finer taxonomy based on computational models focusing on musical objects and making use of different theoretical approaches (or methods) in order to carry on computer-aided music analysis. The real musical objects would not be musical pieces belonging to pre-established and universal taxonomies, but, as suggested by Franco Fabbri, "musical facts" and "musical events", each being characterized by a set of properties turning out to be associated into high-order families called *types* (See Fabbri (2007, 2014)).

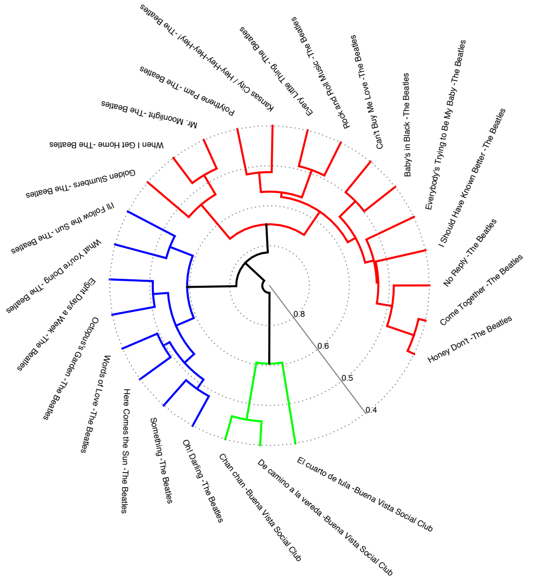
Starting from this change of perspective in the study of musical genres, we discuss in this paper some possibilities of overpassing the main linguistic-based approach which seems to motivate Fabbri's original formulation of types classification - largely inspired by George Lakoff's and Mark Johnson's theory of metaphors (see Tendahl & Gibbs (2008)) to more mathematically-based formalizations of musical structures and processes. After recalling the principle construction of a computational linguistic-based approach aiming at symbolically notating the audio files of large data based of popular and folk music (Bimbot et al. (2012)), we show how a mathematical formalization of the harmonic system provides some additional structural criteria in order to apply the System & Contrast Model to symbolic music information retrieval and automatic genre classification. A new approach to genre classification has been discussed in Andreatta (2014).

2. COMPUTATIONAL APPROACH IN FOLK MUSIC ANALYSIS

This computational approach clearly shows the interest of approaching the question of types or genres or categories with respect to automatic classification and the necessity of developing generic tools, in particular for the analysis of the harmonic space. We will discuss the use of the *Tonnetz* and some possible generalizations (Bigo (2013)) as it has been carried on until now principally within the "Math'n Pop Project" (Andreatta (2015)). Some new interesting approaches in dynamic *Tonnetz* construction, as described in the ongoing doctoral thesis within Ircam's Music Representation Team (Bergomi (2015a)) clearly suggests the possibility of using dynamic *Tonnetze* in folksong research and automatic classification. The use of the computer-aided models not only provides more efficient computational methods of handling large amounts of information, but they definitively "help the scholar in achieving what he has been unable to achieve so far with non-technological means [by] taking into consideration an unlimited number of parameters and [...] finding correlations between each and every one of them" (Keller (1984)). Computational models enable one to detect and recognize patterns that, according to Sorce Keller, "might then be used in bringing together variants in an objective way", which would offer scholars the possibility "studying how musical traditions interact and influence each other and, which is putting it in another fashion, to what extent they are similar and therefore compatible" (Keller (1984)). This suggests interesting applications of the tools developed within the "Math'n Pop project" to the special field of computer-aided folk music analysis, as we will show by automatically analyzing the folk component of popular music databases (such as Quaero. See Figure 1).

2.1 An anisotropic geometrical approach to music analysis

The whole set of geometric tools for music analysis endowed the isotropic structure of the primal representation of pitch classes as $\mathbb{Z}/12\mathbb{Z}$ (see Andreatta (2015)). Generally, folk music has clear tonal or modal centers, declared either harmonically (triads, seventh chords or altered with



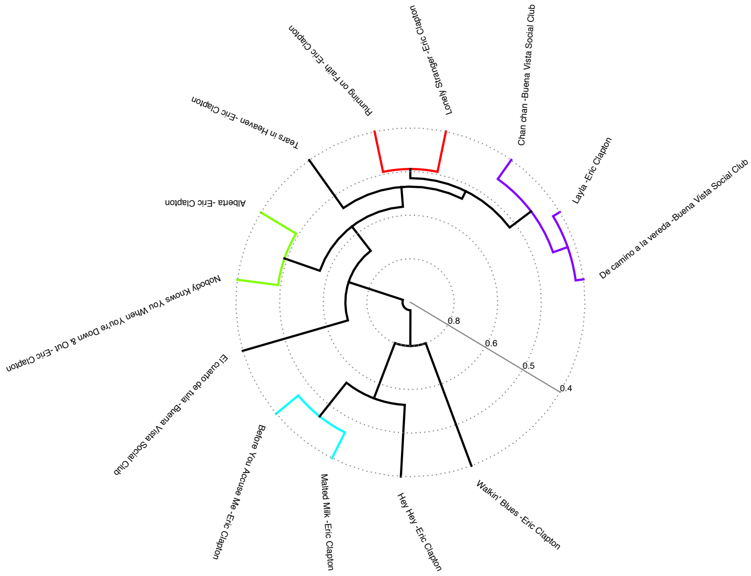


Figure 1: Two clusterings of Quaero database showing the place of the music by Buena Vista Social Club with respect to the Beatles and Eric Clapton's music respectively.

chord tones) and melodically (the voice generally stresses consonant notes of the arpeggio of the harmony, although it can be enriched and embellished with passage notes). This kind of feature suggest the idea to represent this kind of music introducing preferred directions. The model presented in Bergomi & Popoff (2015) allows to deform the standard geometric spaces used in music analysis, such as $\{(\mathbb{Z}/12\mathbb{Z})^n, \mathbb{T}^n/\mathcal{S}_n, \dots\}$ through a certain feature.

In particular, using the *Tonnetz* and the dissonance induced by the chord played in a certain time span Δt, it is possible to describe a song as a sequence of configurations of the *Tonnetz* representing either on an harmonic and melodic level the tension/resolution pattern in time. Each state is created via a deformation of the vertices of the *Tonnetz* (as shown in Figure 2).

2.2 Shapes classification

Each folk song can be represented as a sequence of chords and thus as a series of dynamical states, representing either a deformed configuration of the *Tonnetz* or a subcomplex. The method we suggest to characterize each shape obtained from the segmentation is Persistent Homology and it is borrowed from the the field of Computational Algebraic Topology [1]. Given a simplicial complex K, this particular strategy consists in rebuilding it through a filtration of the complex $\emptyset = K_0 \subseteq K_1 \subseteq \dots \subseteq K_n = K$ and computing the homology for every subcomplex K_i for $i \in \{1, \dots, m\}$. The results of this kind of analysis can be represented as a *persistent diagram* which is a signature of each frame of the song.

The Wasserstein distance allows to compare persistence diagrams belonging to different shapes and hence to find related states belonging to a certain song, or to a set of songs. This method ha been discussed in Bergomi (2015b).

3. RESULTS, CONCLUSIONS AND FUTURE WORKS

If persistent homology is widely used in shape recognition and image analysis (see, e.g., Di Fabio & Landi (2011)), the application of these powerful algorithms to the symbolic/signal articulation is still very rare in the field of Music Information Retrieval. Applied to the domaine of popular music, and — more specifically — folk music, this approach gives a different point of view on the tonal and modal structure of existing songs. The aim of this analysis is twofold. On one side, comparing two surfaces in a 3-dimensional space is a task everyone can perform directly having an immediate intuition on the features stressed by the deformation of the surface; on the other side, the analysis of the geometrical properties of the shapes we computed enables one to classify and create explicit links concerning both the study of the inner structure of a song and its relation with other works. In particular, folk music, thanks to its structure, fulfills the hypothesis on the tonal (modal) nature of the music to be analysed.

We will end by suggesting some future research directions, in particular concerning the use of some other topological and algebraic approaches to folk music representation and classification. We are particularly interested in Formal Concept Analysis (Ganter & Wille (1998)), a paradigm which has been recently applied in music analysis by combining topological structures with ordered-structures (Freund et al. 2015). We will show how this approach enables one to open a wider discussion about the possibility of a general theory of classification (Parrochia & Neuville (2013)). If the question of the existence of universals in

[1] See Edelsbrunner & Harer (2008); Zomorodian & Carlsson (2005); De Silva & Ghrist (2007); Carlsson et al. (2005); Cerri et al. (2006) and many others.

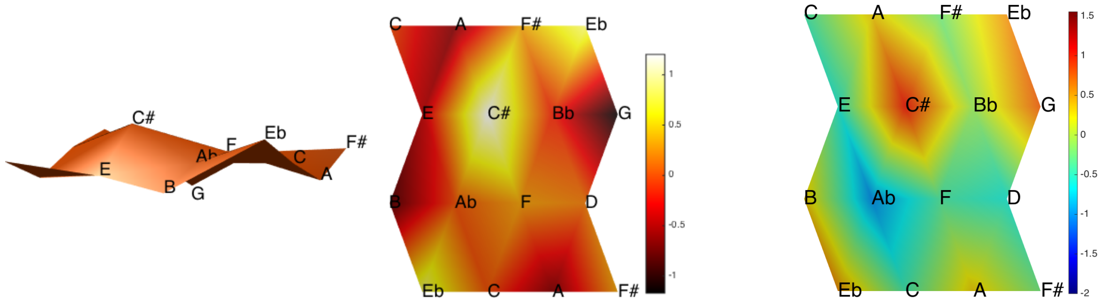


Figure 2: The *Tonnetz* whose vertices are deformed by the dissonance induced by a C_M chord, and its discrete Gaussian curvature.

music is still open in contemporary (ethno)musicology, the use of universal constructions in computational musicology has been definitively made possible thanks to the role played by algebraic, topological and ordered-structures representations and formalizations of musical events, independently of any existing underlying taxonomy. This would finally minimize the impact of ideology in disciplinary divisions, as recently suggested by Franco Fabbri in his critical overview of Music Taxonomies (Fabbri (2014)), and contribute to the emergence of new theoretical paradigms in the field of contemporary computational musicology.

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