SYNAESTHETIC ANALYSIS, EXPLORING MUSIC STRUCTURES BY MULTIMEDIA REPRESENTATION. PROMETHEUSZ12, A NOVEL 3D VISUALIZATION TOOL.

Paolo Tagliolato
Università degli Studi di Milano
Dipartimento di Informatica e Comunicazione - Laboratorio di Informatica Musicale, Milan, Italy
paolo.tagliolato@gmail.com

ABSTRACT

Visual representations have always been fundamental tools to communicate about music. While common music notation was for centuries the standard way to encode western music information, different visual representations were developed and exploited by music analysis. The importance of such representations lies in their great explanatory power. The real-time exhibition of visual models of music features joins together aesthetic and analytical perspectives, favoring the comprehension of analytic systems. In this article I present PrometheusZ12, a novel 3D visual representation tool for music, based on the concept of product GIS introduced by D. Lewin. As suggested by its name, a tribute to the synesthetic explorations of A. Scriabin, the software involves $\mathbb{Z}_{12}$, the well known mathematical model of the pitch class space, providing the real-time geometrical rendering of the product extensions of $\mathbb{Z}_{12}$ with some rhythmic models.

1. INTRODUCTION. MULTIMEDIA REAL-TIME SYNAESTHETIC SYSTEMS: ART AND ANALYSIS

Multimedia real-time association of visual aspects and sounds can be exploited from an aesthetic and artistic point of view. An early attempt in this direction is Scriabin’s Prometheus (Symphony No.5, Op.60), in which colors and sounds are associated. More than a simple sort of choreography, the research of Prometheus originated from Scriabin’s hypothesis about the existence of a synaesthetic correspondence among sounds, colors and emotions. Figure 1 b. presents this association on the circle of fifths. It is interesting to observe how this map makes use of enharmonic equivalence. [15] presents a picture (fig. 1 a.) of a light instrument used by Scriabin, which is precisely a 12 tone wheel whose pitch classes are colored light bulbs.

On the other hand, the real-time exhibition of visual models of music features can be linked not only to aesthetic but it can also be regarded in an analytical perspective. E. Isaacson, in [6], outlined the importance of visual representations of music founded on analytical models, for their great explanatory power. It could be said that it is a case in which analysis and aesthetic are joined together. Tools which let this type of visualization can favor the comprehension of analytic systems. Moreover, they could help their learning.

To learn the association between sound aggregates and forms is one of the basic aspects in instrumental apprenticeship, forms being in that case mental images which musicians must develop, like the positions (or configurations) of hands on their instrument. The automation of the movements to translate those mental images into instrumental gestures are the basis for learning an instrumental technique. Also music notation, in alternative to the CMN abstraction, historically made use of the configuration of hands on musical instruments: “intavolature per liuto” of Renaissance, guitar tablatures, organ tablatures used by the German Baroque organ school (see e.g.[17]) are some examples. The resorting to the description of physical configuration of the control interface of an instrument was also the practice adopted for notation by many electroacoustic composers.

Coming back to analysis, music analysts like Allen Forte or David Lewin start from their listening experience, educated by theory and trained on geometric analogies. It is my opinion that real-time models could favor this analogical and synaesthetic training.
2. RELATED WORKS

Musical set-theory, developed for the analysis of atonal music, focuses on classes of pitches under octave and enharmonic equivalence. The quotient set, isomorphic to \( \mathbb{Z}_{12} \), is that of the twelve pitch classes, whose well-known pictorial two dimensional representation is also called the \textit{twelve tone circle} or wheel. Chords can be regarded as elements of the power set of \( \mathbb{Z}_{12} \), called pitch class sets (pcs). Set-theory founds its analyses on pcs, their classifications (cf. Forte [4] and Solomon [14]), their intervallic structures and properties. In the mentioned geometric representation, which well exposes the cyclic nature of \( \mathbb{Z}_{12} \), a pcs becomes a polygon inscribed in the circle.

In the framework of transformational analysis, the set-theoretical model can be regarded as an example of a more complex mathematical structure, namely a Generalized Interval System (GIS) [9], which interprets musical intervals as elements of a group acting simply transitively on \( \mathbb{Z}_{12} \). In this context the pitch class space (PC) is then a pitch related GIS. The same theoretical framework can model also rhythmical features of music. For example it can be shown that the space of onsets (\( \mathcal{O}_{ns} \)), whose "intervals" are time-spans between events, shares the same mathematical structure and can be regarded as a rhythmic GIS. Moreover, different features can be combined, considering that the product of two GIS is also a GIS.

The visualization of PC, as said, has been widely used in music theory. Moreover we can find it in several software tools. IRCAM’s OpenMusic [2] and Laurson’s PWGL [8], two Computer Assisted Composition systems, offer their users modules for that kind of visualization, which can be exploited both for analysis and composition (figure 2 a., from [1]). Malinowski’s Music Animation Machine [10] -

![a. Open Music, b. Malinowski's MAM.](image)

This kind of visualization exposes very clearly what we can call the interval structure of a pcs. Moreover, this simple geometrical representation is very useful, when one compares different pcs.

In the context of PC, Thomas Noll explored affine transformations in \( \mathbb{Z}_{12} \) and widely made use of 2D computer animations of the twelve tone circle [12]. Three-dimensional representations of music structure have been developed in theories of tonal space (see [7] for an introduction, [5] for recent works in the field). Noteworthy is E. Chew’s Spiral Array 3D model [3], exploited for key-finding, which led to a software tool for real-time representation of midi performances.

3. PROMETHEUSZ12

Pitch class sets have their balance and symmetries on which some analyses are founded. The geometrical representation of \( \mathbb{PC} \) as points of a circumference is useful to visualize these properties.

I developed PrometheusZ12, a novel 3D visual representation tool for music, with the intent of seeing through the analysts’ eyes the geometrical content of \( \mathbb{PC} \)-related music analyses evolving in time. Differently from what can be done with the existing systems, I wanted a system which could maintain the geometrical peculiarity of the \( \mathbb{PC} \) representation but which could let also the “navigation” of the resulting representation of music, in order to better analyze it. It should appear clear how the concept of product GIS were well suited to these aims.

PrometheusZ12 shows a three dimensional model of a product GIS \( \mathbb{PC} \times \mathbb{Rhythmic} \), which extends the 2D representation of PC with rhythmic information. The resulting geometry is that of a cylinder made up of pc circles disposed along a time axis centered in the center of circles and perpendicular to circles’ planes.

Each harmonic change triggers the addition of a new pcs to the tube, whose distance from the preceding depends upon the choice of the rhythmic model \(^1\). Pcs are depicted as polygons inscribed in the circumferences, and optionally their semi-transparent areas are visualized, whose colors are combination of those of their vertices. Starting as said with Scriabin’s association, I tried also different combination of colors\(^2\). Pcs can be presented, like in MAM’s dyad view, along with their intervallic structure. While the areas of pcs with the same transpositional prime-form have different colors, depending on their transposition, intervals’ color are invariant: one interval, one color.

\(^1\) Two models are available: \( \mathcal{O}_{ns} \) or \( \mathcal{O}_{cc} \) - this second being a trivial model in which subsequent events are equally spaced along the time axis. For the characterization of this second simple rhythmic space as a GIS, see [13]

\(^2\) Following some ideas from Malinowski, see “Harmonic Coloring based on the Perfect Fifth”, in [10]
4. GEOMETRIES OF MUSIC THROUGH PROMETHEUSZ12

Let me show some examples of what we can see through PrometheusZ12.

Figure 3 compares two segments of “Lasciate i monti” for Mixed Choir and Continuo from Monteverdi’s Orfeo. Here, following Malinowski, adjacent pitch classes in the circle of fifths are mapped to adjacent colors in a color wheel. Moreover, coloring of pcs’ area is enabled: this way, in this almost triadic piece, tonality changes are somehow evidenced: the change of accidentals for B, E, F acts so that the overall colorings of the two segments are well distinguishable. Left screenshot shows note names, in the right picture this feature is off, making the view less confusing.

Figure 4 shows the PrometheusZ12 3D rendering of the Adagio from J.S.Bach’s “Toccata, Adagio e Fuga in C major” BWV 564. It is easy to distinguish two sections of the piece, the first (in 1. and 2.) with a simple choral accompaniment, the second (4.-6.), which is marked grave, characterized by chromatic progressions and dissonances. The double descending scale (3.) functions as a separator of the two sections. Here each interval is associated to a specific color. This way the interval structure of pcs is more evident. 1. Succession of consonant triads which are characterized by green, blue, red intervals (resp. major third, minor third, perfect fifth). 2. A major consonant triad following two non-consonant triads. 3. The melodic line is well outlined (a nice spiral): PrometheusZ12 was set up in this case to show PC × Rhythmic intervals only in presence of melodies. 4. The interval structure of a more complex harmony, towards the end of the piece. 5. Concluding harmonies of the piece, in Scriabin’s colors. 6. Same as 5 but in Malinowski’s colors, this time showing all the PC × Rhythmic intervals, that is all the intervals between successive pcs.

Figure 5 shows Alexander Scriabin’s Poem of Fire, op.72. Like the other late compositions of Scriabin, the Poem of Fire is an atonal work. Several authors indicated the Prometheus chord (figure 5 a.) as central in Scriabin’s compositional technique ([11] pg.313, serving as the basis for harmonies. It is not difficult to observe how, effectively, many of the chords used in the Poem of Fire are related to the Prometheus chord. In 1, we find a half-diminished seventh (prime form 0258, classified by Forte with its inverted form 0368, a more familiar dominant-seventh, as 4-27). This chord is also known as Tristan chord since its use - moving towards atonality - by Wagner in “Tristan und Isolde”. Tristan is a subset of Prometheus, as we can easily see comparing the two figures. It is interesting also to observe in this screenshot, that Tristan is here the resolution of a french-sixth chord (prime form 0268, Forte’s 4-25) similarly to its first appearances in the Wagnerian Prelude. Moreover, the voice leading which maps the french-sixth to Tristan chord (F into E) is a movement within the same rotation of Prometheus. 2. The superposition of some pcs is shown. Being extremely near in time, we could associate them to a single harmony properly containing Prometheus. In 3, a chord is shown, obtained by the same voice leading described in 1. but in which all the notes are maintained, so it is the union of the two chords Tristan and the french-sixth chord, and it is a subset of Prometheus. The
second-last chord in 4. and the chord in 5. are other two Prometheus subsets. In 4. the last chord, a Minor-Major ninth chord (prime form 01348), is obtained by symmetrizing the second-last one.

5. CONCLUSIONS

In this article I introduced PrometheusZ12, a novel visualization tool intended for music analysis popularization and presentation. I proposed a 3D geometrical interpretation of a Generalized Interval System $PC \times Rhythmic$. In this way the classic geometrical model of pitch class space is extended with rhythmic informations, letting the navigation of this peculiar analytic view. I showed, with PrometheusZ12, how does music appear through centuries, following the evolution of pcs complexity, which exploded in 19th century, when this kind of geometrical schematizations were firstly conceived.

6. REFERENCES


