MUSIC ANALYSIS THROUGH VISUALIZATION

Jia Li

narkli@ccrma.stanford.edu
CCRMA, Stanford University
Shanghai Conservatory of Music

ABSTRACT

In this paper analytic visualizations are used to selectively highlight salient musical features in four modern compositions, focusing on micro or macro structures: from motivic pitch contour to large-scale form. At a glance these visualizations allow a quick grasp of the structure and assist listeners to make connections between local features and global trends. Textures obscured by musical notation become more apparent when displayed in a graphical format, such as broad registral shifts, polyphonic streaming, as well as interplay between instruments. Pitch, timbre and voicing are plotted against time to show large-scale patterns that would otherwise be difficult to recognize in a musical score or compare between different works. Music analysis through compositional data visualization not only makes sense to musicians but also to non-musicians, facilitating collaboration and exchange with artists and technicians in other media.

1. INTRODUCTION

At the turn of the nineteenth century, technological change occurred rapidly. Many inventions such as photography, cinematography, sound recording, telephones and aviation were heralding the dawn of a new age. Artists sought new ways to reflect the modernity of the era, such as subjective perspective in Expressionism and multiple perspectives in cubism. Modern compositional tendencies reflected those of the visual arts, with music becoming less tied to traditional tonality and musical notation. Music became more conceptual and experimental, with a unique form for every work. Some composers even abandon traditional music notation, instead experimenting with graphical ones, such as John Cage's Concerto for Piano. This kind of breakdown in genre gives rise to a need for a tangible form of the structure to assist in understanding.

Early in the twentieth century, graphic techniques were used to illustrate analytic aspects of musical scores. It can be dated back at least to Alfred O. Lorenz (1924), who used graphs to show the modulatory scheme for Wagner's Ring Cycle [3]. He developed a method of exploring Wagner's musical texture as large, closed totalities. With the increasing popularity of computers in the 1970s, music visualization becomes more accessible; either from pitch and rhythm extracted from traditional scores or sound-based visualizations such as waveforms and sonograms.

While sound-based visualizations are useful for displaying performance information, this paper examines compositional structures that are best visualized from data. While the musical notation is optimal for conveying instructions to a performer, it is not easy to quickly read larger structures from a score, which may otherwise be obscured by crossing many pages or extra-musical directions. Pitch, rhythm and timbre are the clearest features that can be extracted from scores, so these features are used in the following visualizations[1]. The axes for the visualizations display pitch against time in a manner similar to piano rolls or MIDI sequencing software, with time on the horizontal axis and pitch on the vertical axis. Color and shape are used in some of the visualizations to highlight timbral or voice information.

2. A MOTIF AND ITS DEVELOPMENT

The motif, a device widely used in compositions, always has been one of the basic musical elements. Impressive examples include the four-note motivic cell in Beethoven's Symphony No.5 Movement I, and the atonal thematic motif of Aaron Copland's Piano Variations. Development of a motif is a common method of composition. Therefore, visualizing a piece's motif and subsequent development is the best way to show the benefit of score visualization.

He Xuntian's *Scent Dance I* (2009) for solo clarinet is constructed using a short motivic pattern that is varied and developed throughout the piece. Although the

[1] A good example of this sort of visualization can be seen in those of the Music Animation Machine. (http://www.musanim.com).

composition is written for a single instrument, the monophonic line perceptually splits into polyphonic voices as the pitch range expands, bifurcating into two interlocking forms of the motif. The piece's construction is that of a fractal, with the motive pattern-forming event the large-scale double-arched structure of the entire piece. The following visualizations are used to highlight the motivic structures that He uses to construct *Scent Dance I*.

2.1 The Motivic Pattern

Scent Dance I starts with a ten-note motif that is used to generate structure throughout the piece. This section illustrates how graphical notation can be used to analyze and explain the construction of the piece more clearly than can be done by looking at the traditional score.

Figure 1 shows the opening motif in traditional notation, and a more graphical interpretation is shown in Figure 2, which plots pitch against time. The individual notes are shown as dots in the graphical form, with dashed lines enhancing the motivic shape of a double arch, or a capital "M". Although the contour of the motif can be seen in the original score, other notational features such as barlines, dynamic markings, and slurs obscure the essence of the pattern. Thus, the graphical display in Figure 2 better highlights the importance of pitch contour. Exact pitches are more difficult to read from the graphical version of the pattern, but this helps to emphasize the contour rather than the pitches. Besides this, it also helps to find out how many notes and how many times of these notes have been used in the motif, even in the whole piece. This motif contains four pitch classes, each repeated a different number of times: 1 A, 2 Fs, 3 C-sharps and 4 Ds.

At a glance, the motif seems to be symmetric, but in fact it is slightly asymmetric. The motif consists of two slightly offset symmetries between pitch and rhythm. The C-sharp at the start of measure 4 is a point of symmetry for the first nine notes of the motif, while the middle of measure 4 forms a mirror point for symmetry in the ten rhythms of the motif. The offset between pitch and rhythm shows up in the graphical version as a distorted symmetry.

Figure 1 The motivic pattern of *Scent Dance I* (Bars: 1-7)

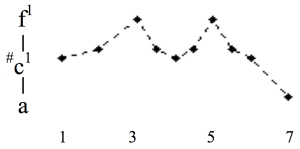

Figure 2 The visualization of the motivic pattern (Bars: 1-7)

2.2 The First Part with Motivic Development

Based on these elements of pitch, rhythm and contour, the motif is used to build the following phrase (Fig.3). Using the compositional data, we can plot a graph (Fig. 4) in which each pattern is clearly visible, showing 14 patterns including the opening motif. A quick examination of the graphical patterns shows that they are similar, but not exactly the same. Some contain wider intervals, while others have longer durations inside each motivic variation. The ending note of a motivic cell is not only the end of one cell, but also the beginning of the next. All of the patterns connect to each other, constructing the first part of the composition.

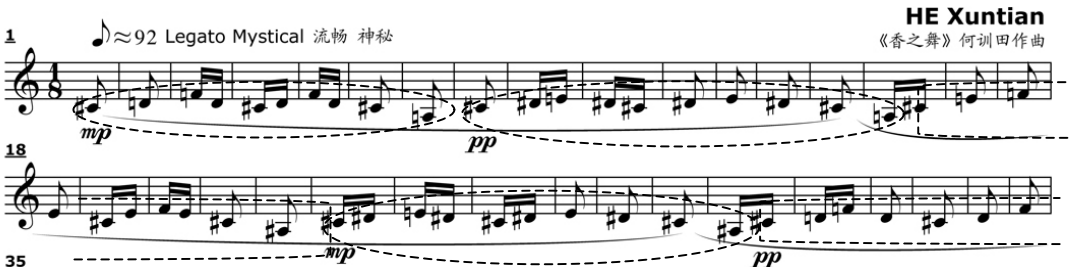

Figure 3 The first part with development on the motif (Bars: 1-34)

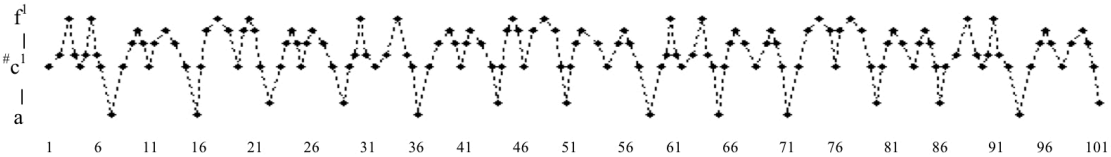

Figure 4 The visualization of the first part (Bars: 1-101)

2.3 The Second Part with Development

In second part of *Scent Dance I*, the development of the motif is more complex. Figure 5 gives the notation for the modified three-measure motif. On the graph in Figure 6, eight repetitions of this motif can be seen. The patterns in this part seem difference from the original motif. However, by carefully observing the shape of the new motif, we can identify patterns that use the "M" shape contour through the graph. The pattern changes into two interlocking forms of the original motif, each in a different register. It is no longer a monophonic melody, but rather a complex perceptual stream. One stream is outlined in Figure 6 with a blue line following the lowest notes of the pattern. This lower outline forms the same contour as the original motif (Figs. 1 & 2). Another stream is outlines by the red line following the contour of the upper pitches. This top stream can be viewed as an inversion of the lower one, a bit like a "W", or it can be viewed as an offset version of the "M" contour. These interlocking patterns and their trails are not otherwise easy to recognize in the score due to the rhythmic activity and linear presentation of the notation.

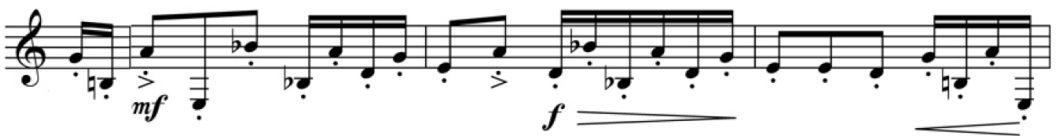

Figure 5 The second part with development on the motif (Bars: 123-25)

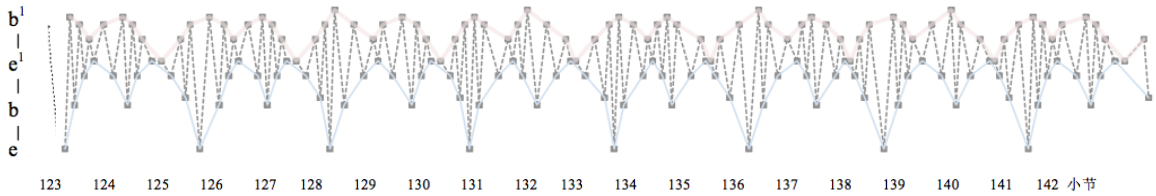

Figure 6 The visualization of the second part (Bars: 123-142)

2.4 The Fourth Part with Development

The technique of multi-layering in the second part continues within the fourth part, as the motif is further overlaid and streamed. It is more complex than ever before (Figs. 7 & 8). Besides the two layers, a mid-ranged pedal note and grace note has been added.

For the two layers of the pattern, we can see that the basic shape of the original motif has been kept in the lowest layer. The upper layer has more activity. At the end of the part, some notes change their register to the higher octave, giving the music more tension than before and leading to the climax of the piece.

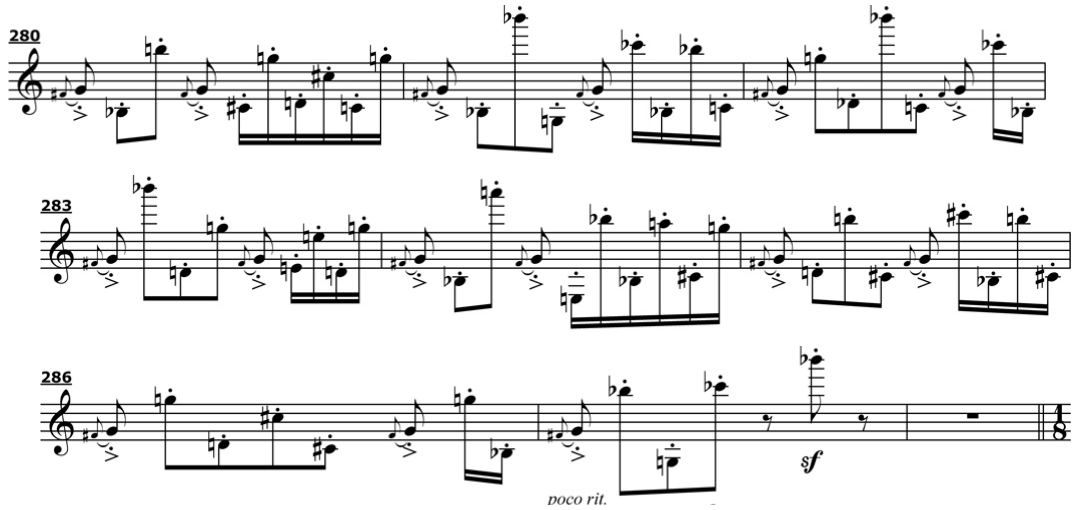

Figure 7 The fourth part with development on the motif (Bars: 280-287)

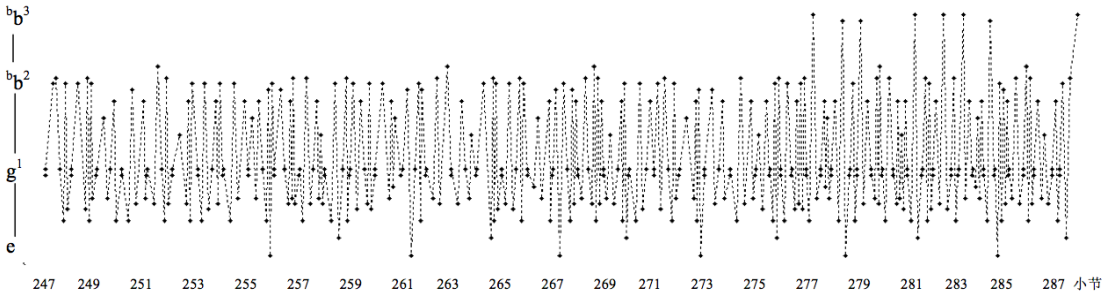

Figure 8 The visualization of the fourth part (Bars: 247-287)

2.5 The Whole Structure

In the visualization of the entire composition seen in Figure 9, we can clearly perceive the composers' thinking—the motif's transformation and recurrence in the original form, but in different registers, gives structure to the whole composition. The form of this piece is ABACA, plus a coda. In the whole graph of the piece, we can see the first, third and fifth parts are more active but also change register: the pitch ranges being a3–f4, a#4–f5, and b4–g5 / b3–g4. The interval in these three parts is about a sixth. In second part, the range is E3–Bb4; the fourth part has wider pitch range that is E3–Bb6; in the coda, the range is C4–C6. From these alternating narrow and wide pitch ranges, the whole structure of the piece has the same shape as a capital "M", mimicking the opening motif.

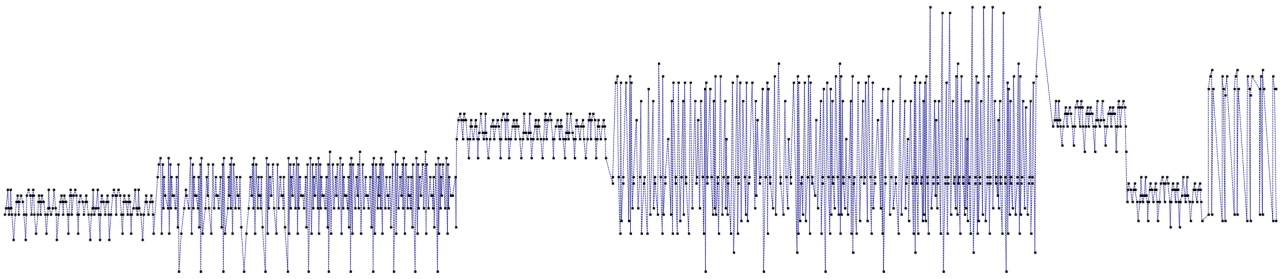

Figure 9 He Xuntian: *Scent Dance I*

3. VISUALIZING OTHER FEATURES

Data visualization not only shows the trail from the motif to the whole piece, but also shows many other aspects of a work.

"A good graphic representation enables us to perceive many aspects of the musical 'shape' of a composition" [4]. Even though the graphs only show pitch and time, other higher-level features such as pitch range and texture can be seen from micro to macro forms.

3.1 Pitch Range and Tendency

Viewing pitch usage in modern music on a graph can amaze an audience. The visual patterns are more obvious than in classical music. For example, Figure 10 shows a huge contrast of pitch range within a composition. This piece is for harpsichord by György Ligeti, written in 1968. The composer wanted to compose a piece "that would be a paradoxically continuous sound, something like *Atmosphères*, but that would have to consist of innumerable thin slices of salami". Ligeti's earlier works used a technique known as micropolyphony. Rather than a using large orchestra, this piece uses extremely rapid activity by a dense, rich stack of pitches with a solo instrument to create the impression of continuous sound and a monolithic image.

The graph also shows an attraction and repulsion of the two hands. In the outer parts of the composition the two hands are entangled in the same registers, but in the middle part they drift away from each other.

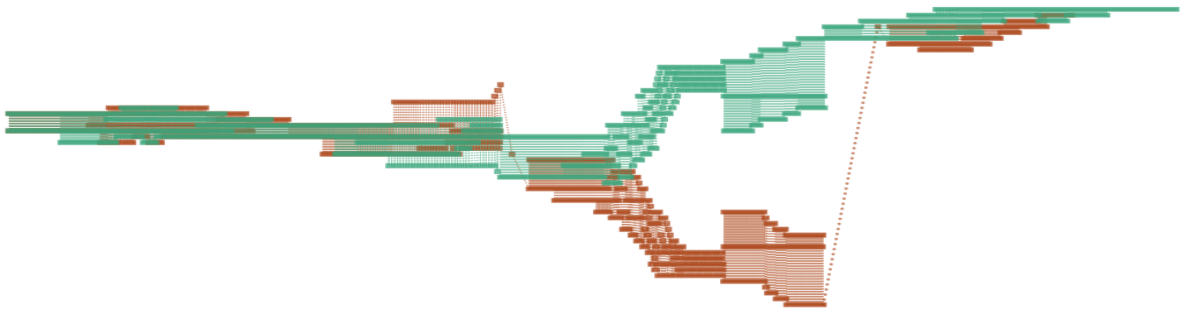

Figure 10 Ligeti: Continuum for Harpsichord

3.2 Texture and Voice

The texture generated by the two dimension of pitch and time represent the inter-stream correlations of a piece. Through an overview of this texture, broad categories of monophony, homophony, polyphony, and heterophony can be read from the graphs.

The following graph displays Webern's Symphony, movement 1, part 1 (Fig. 11). Schematic organization of pitch, rhythm, register, timbre, and melodic contour is Webern's innovation. His eagerness to redefine imitative contrapuntal techniques, such as canon and fugue, can be seen clearly using this graph.

Different colors represent each voice in the score. Some imitative patterns can be seen counterpoint relationships, such as the pink and green points, or the yellow and purple diamonds. These pairing have inversional symmetry.

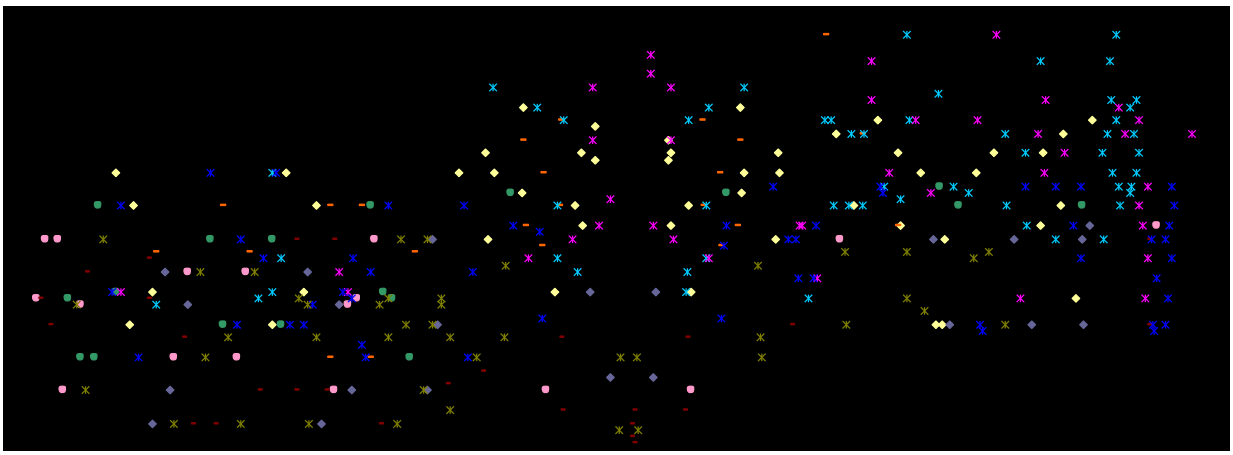

Figure 11 Anton Webern: Symphony (Op. 21) Mv.1 Part1.

4. MACRO STRUCTURE

In musical compositions, texture also delineates structural aspects. Data visualization is an ideal format for recognizing such structures. Let us examine the complete musical formal structure of a piece, which can be recognized in a glance from a visualization, showing both the dissimilarity and similarity in the macro structure.

The following example is Steve Reich's minimalist work "Octet" composed in 1979, later rescored as "Eight Lines" in 1983. The ensemble consists of string quartet, two pianos and two clarinets doubling both bass clarinet and flute as well as piccolo.

Figure 12 shows that the piece is organized into five sections. We can see that the two pianos (shown in orange and light green) build a dense background, using syncopated ostinatos. In first, third and fifth parts they cover a wide register, while in second and fourth parts they move to narrower higher section of the register. This gives space to the cello (purple), viola (blue) and bass clarinet (red) for their sustained lower tones. It also shows that the division between sections is very smooth with some overlapping between the sections. These characteristics show the compositional technology, such as repetitive figures, slow harmonic rhythm and canons.

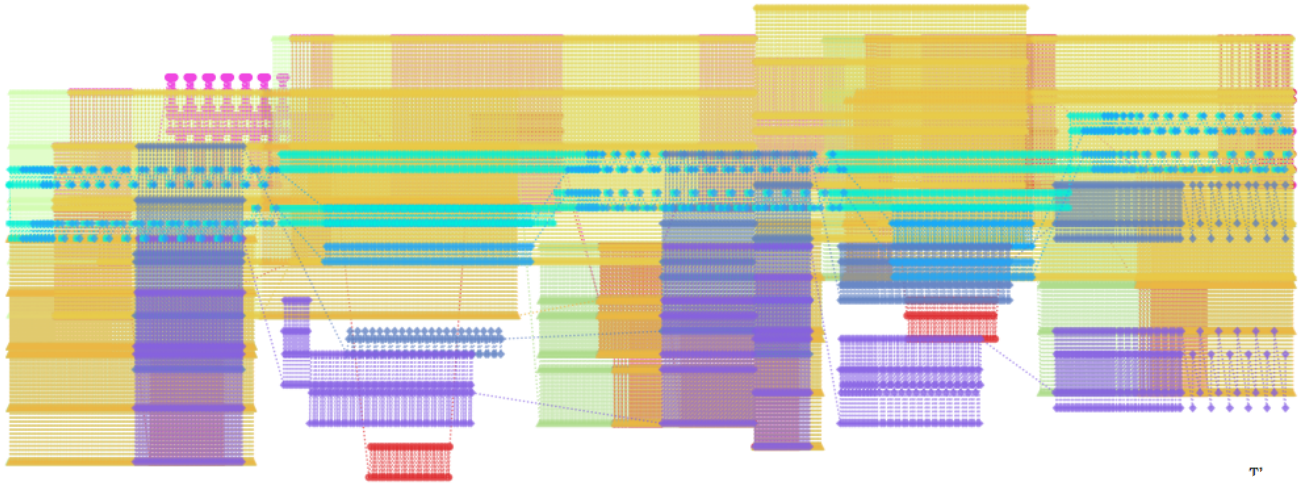

Figure 12 Steve Reich: *Eight Lines*

5. CONCLUSIONS

Above all, visualization graphs help in the recognition of motifs and their development through pitch contours, register, texture and the structure in both the pitch and time domains. Graphs can make the audience more aware of the overall structure in a composition rather than focusing on individual notes or phrases. They can find the details on graph to enhance their listening experience. Performers can also discover new relationships between the surface features of notes and the deeper structures of form by using such graphs; otherwise, the link between notes and a composers' overall intentions are difficult for individual band or orchestra members to intuit from the parts.

We have seen that visualization can produce a beautiful picture for a piece. Listening to the music while viewing the graphs, a listener will become a bit like the conductor who sees the whole score. People can foresee what will happen in the next passage and remember the music already passed through on the graph. Mapping time into space also allows non-musician to understand better the temporal aspects of the music. The artists and technicians can also use it as a sketch to interrelate with other media, such as dance, drama and animation.

For more example graphs, view the GraphMusic channel on YouTube at www.youtube.com/channel/UCnF-gtWPS520-C4-bu6WvQg .

6. REFERENCES

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