Foreword to Special Issue on Music Visualization

This special issue on music visualization focuses on the visual conveyance of music structural information through the automated analysis of digital music and the graphical rendering of its analytical forms. Music can be described as highly organized sounds that exhibit time-varying structures in the pitch (frequency) and time domains. When we listen to music, our minds group pitch structures into horizontal streams (such as melodies) and vertical bunches (such as chords and keys). These pitch collections create musical contexts that situate and orient our hearing of the music. It is the visualization of these time-varying pitch contexts that forms the common theme among the contributions in this special issue.

In music-theoretic terms, all four articles are concerned with the tonal structure of music. Tonal structure emerges in music that is tonal, music for which the pattern of notes generates the perception of varying levels of stability amongst the pitches. The term "tonal" applies to almost all of the music that we hear. Computer systems for music visualization that automatically capture and display such structures will enable people to see, and better understand, the tonal patterns that they hear.

The large-scale availability of music in digital format, coupled with the rapid increase in computational prowess, has made the automatic visual rendering of musical structure more accessible than ever. According to Jeremy Strick, one of the organizers of the Visual Music exhibit (2005) at the Los Angeles Museum of Contemporary Art and Hirshhorn Museum of the Smithsonian Institute, “In digital media, … music and visual art truly are united, … They are created out of the same stuff, bits of electronic information, infinitely interchangeable. … the aspiration to novel experience created by the compounding of sensation and association has never been more possible” [Strick 2005, p.20]. Even though scientific visualizations of musical structure do not pretend to be fine art, the interlocking of visual and musical sensations featured in this collection similarly seeks to evoke what might be illusive mental associations between music and its analytical structures through visual mediation.

THE STORY BEHIND THE SPECIAL ISSUE

This special issue must first be attributed to Carol Krumhansl, who, at the 8th International Conference of Music Perception and Cognition, suggested with acumen that there was now a critical mass of research efforts in visualization of tonal structure in music, and that perhaps a special cluster of papers on the topic was due. In March 2005, I approached Newton Lee, editor-in-chief of *ACM Computers in Entertainment*, about hosting a collection of papers on tonal visualization. Newton responded with great enthusiasm, and generously agreed to handle the review and editorial process for the collection. Thus, the ACMCIE special issue on music visualization was born.

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The gathering of the papers was a particularly congenial and collaborative affair. The participating authors circulated earlier drafts of their papers and helped review eachothers' work to ensure consistency and variety in the collection, before the papers were revised and submitted to ACMCIE for regular review. For coherence, the authors agreed to analyze a common set of pieces; additional examples were left to the authors' discretion. A quick search for the top classical downloads on Apple's iTunes (*www.apple.com/itunes*) on April 17, 2005, produced a shortlist of 10 contenders. Elimination of pieces with voice or percussion narrowed the selection down to the three pieces featured in this collection, namely, Bach's Unaccompanied Cello Suite in G, Barber's Adagio for Strings, and Pachelbel's Canon in D. Craig Sapp scanned and generated Musical Instrument Digital Interface (MIDI) files for the three pieces.

IN THIS ISSUE

The collection begins with an introductory piece, "The Geometry of Musical Structure: A Brief Introduction and History," by **Carol Krumhansl**. This article offers an introduction to the concept of tonality and to geometric representations of tonal structures, followed by reflections on the relation of the present contributions to the canon.

Krumhansl is best known for her work with Roger Shepard on the probe tone method (see Huron [1992]), and for the empirical determination of probe tone profiles as key templates for computational determination of key (work with Kessler and Schmuckler, respectively, described in Krumhansl [1990]). The next two articles use the probe tone profile method as a starting point for algorithmic key-finding.

In "Visualization of Tonal Content with Self-Organizing Maps and Self-Similarity Matrices," **Petri Toiviainen** presents two visualizations of tonal patterns: one using self-organizing maps (first trained using the Krumhansl-Kessler profiles) and another using similarity matrices. The paper concludes with the introduction of a real-time implementation of the model called keySOM.

In "Visual Hierarchical Key Analysis," **Craig Sapp** proposes a two-dimensional map, called a keyscape, that shows key regions at multiple hierarchical time scales. Two versions of the keyscape are introduced, showing arithmetic and logarithmic scaling of the analysis windows. Keyscapes are shown for the results of the Krumhansl-Schmuckler key-finding method, using two different sets of key profiles.

Finally, in "Interactive Multi-Scale Visualizations of Tonal Evolution in MuSA.RT Opus 2," **Elaine Chew** and **Alexandre François** present an interactive system for real-time recognition and visualization of pitches, chords, and keys in a geometric model for tonality called the Spiral Array. In MuSA.RT, Chew's Spiral Array model and its associated algorithms are encapsulated in François' Software Architecture for Immersipresence, a framework for asynchronous parallel processing of generic data streams.

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