Content Visualization in a Digital Music Library

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ABSTRACT
The Variations2 Digital Music Library project at Indiana University provides the opportunity to develop visualization methods aimed at students in schools of music. This paper describes several schemes involving the visualization of musical content.

Keywords
digital music library, music, visualization, timeline, music notation, Schenker

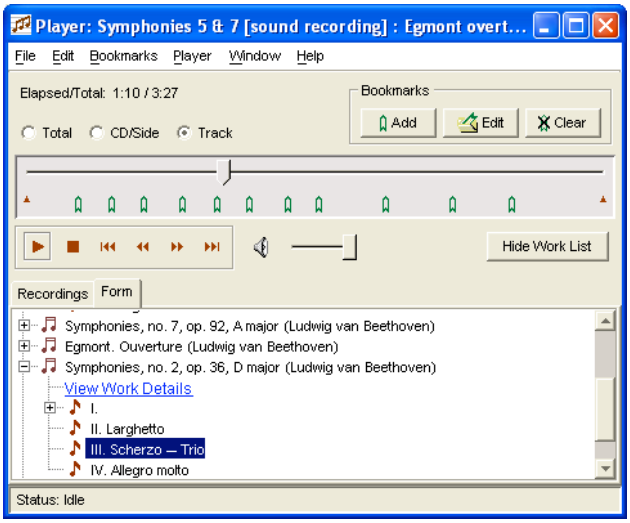
INTRODUCTION
Music is a temporal art. Experienced in its essential form—that is, by listening to it—we perceive it as a continuous stream of aural stimulus. Our native cognitive abilities enable us, however, to take that raw sensory information and perceive, recall, and interrelate intricate melodic, harmonic, and rhythmic structures in it. That same aural medium is ineffective, however, when we want to keep a record of those perceptions, describe them, and share them with others. Effectively communicating about music requires the use of verbal and visual labels, metaphors, and icons. There is a rich history for such systems dating back to the ancient Greeks, and they have been adapted through the centuries to reflect shifts of musical styles, changes of contemporary philosophies, and the development of new technologies.

This paper is concerned with the use of visualization in a digital music library (DML). Visualization techniques are needed for two distinct tasks in a DML: locating content, and exploring that content. At last year's Information Visualization workshop, Notess and Minibayeva [6] addressed the former problem. They described metadata-based visual interfaces to browse and search the holdings (works, recordings, and scores) of a DML. This paper is concerned with the second problem: the visualization of the content itself.

THE VARIATIONS2 DIGITAL MUSIC LIBRARY
Variations2 [9] is a second-generation digital music library project at Indiana University. The system on which it is based [8] provide music in audio format only. The original premise for Variations, however, was to include music in its fullest variety of representations. This vision is being carried out in Variations2, which will include music in three primary formats: digital audio, scanned score images, and symbolically encoded score files. Video recordings will also be supported.

A viewer/player is designed for each type of representation Figure 1 shows the player application for Variations2 audio content

Figure 1



At the heart of Variations2 are bibliographic records representing each *work* in the collection. The work record includes metadata about the composition, including the composer, date and place of composition and of publication, as well as structural information, such as the number of movements, and at least potentially the number of measures the work contains. Each *instantiation* of a work (recording, score) has its own bibliographic record, and it is bound to the work record. The work-centered design of Variations2 enables the synchronized playback/display of different instances of a work (say between a score and an audio recording).

VISUALIZATION IN THE DIGITAL MUSIC LIBRARY
One of the aims of formal music training is to develop in students the ability to describe and analyze music using appropriate technical vocabulary. Often this is taught and demonstrated through the use of various music-analytic visualizations. In designing visualization schemes for musical content in Variations2, we have been mindful of the fact that pedagogical applications would be by far the most common type, while at the same time allowing for eventual research applications involving large-scale data-mining processes. Therefore we focused on developing

music visualization schemes supporting the teaching and learning activities of the School of Music and the patrons of the Cook Music Library at Indiana University. This section of the paper describes these efforts. The following section will describe possible future developments.

Score Notation

The standard notation of Western music is certainly the most familiar way of visualizing musical content. Its principal purpose is to permit the realization of a composition in a performance. In that sense it serves roughly the same function as the printed word does for speech, say, as a script for a play. It communicates through a small number of simple *metaphors* (left-to-right orientation representing time, height on the musical staff representing audio frequency), *icons* with conventionally understood meanings (such as the use of variously shaped noteheads to represent different note durations, and symbols such as *sharps* and *flats* to raise or lower a note), and descriptive *text* (to indicate performance tempo, dynamics). Indeed, trained musicians can glean much information from a score, can hear in their mind's "ear" approximately how the music sounds, and can find patterns, contrasts, and other structural features of the music. Music schools probably spend more time helping students learn effective score reading than they do developing their critical listening abilities. For this reason, scanned score images are being included in the Variations2 digital music library alongside recorded performances.

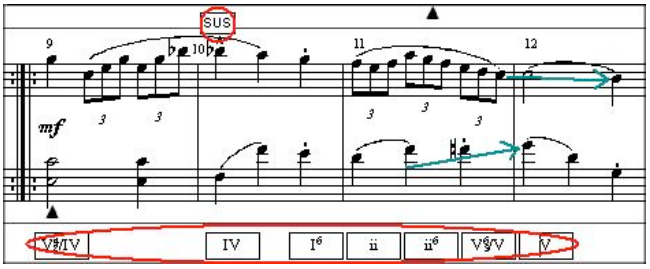
Score Editor

Variations2 will also include symbolically encoded scores, together with the ability to display and edit them. Scanned score images have the benefit of being professionally typeset and edited, plus they are relatively easy to implement—requiring only scanning. Using encoded scores in conjunction with an appropriately designed music notation editor provides its own benefits, however. Among them are that the music can be re-edited, modified, and excerpted, which supports pedagogical activities such as model composition exercises in which a student is given part of an existing composition and then asked to complete it in the same style. The notation itself can be enhanced, for instance through the use of selective color display. Furthermore, a collection of encoded scores can be searched and subjected to batch-processing, which will have benefits for researchers.

Score Annotation

By itself, a musical score is largely uninterpreted, and hence does not represent an analysis of the work. We are therefore adding the ability to annotate a score in the library in a variety of ways (Figure 2). Drawing tools will enable a user to add lines, arrows, boxes, and other shapes. One kind of pre-defined object (such as the one circled at the top of the figure) enables users to attach pre-defined analytic labels of various kinds to notes. Another type (circled at the bottom of the figure) enables the user to type in the symbols used to analyze chord functions in the key. The boxes automatically apply the appropriate sub- and superscripting, which simplifies input. Users will also be able to attach arbitrary text to the musical score.

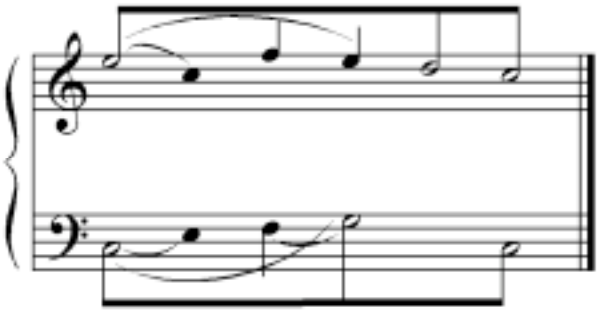
Figure 2



Analytic Notation

The integrated notation editor planned for the display of encoded music in Variations2 will also support the display of special analytic notation, such as that devised by Heinrich Schenker [7] and illustrated in Figure 3. Schenker's notation is designed to show the hierarchical organization of pitches in a musical passage. The notation does not show all the notes of the passage, but rather just the structurally most significant ones—those that serve roles similar to the foundation and framing of a building. In this notation, beamed open noteheads are structurally more foundational, closed notehead with stems are less important, while closed noteheads without stems are still less significant. Other notes from the hypothetical passage, structurally equivalent to, say, wall coverings, may be omitted from the diagram altogether. This style of notation is difficult to implement in commercial music notation editors, but it is sufficiently important in music instruction that we plan to support it.

Figure 3



Timeliner

Timelines are often used as a visual metaphor for a succession of historical events. Most musical works can also be effectively represented in this way. Musical timelines are used to show the sections of a piece and the relationships between them.

The Variations2 timeliner tool, shown in Figure 4, can be used to create such diagrams. A timeline is constructed based on a Variations2 audio file. While listening to the file <1>, the user can add timepoints <2>. When a new timepoint is created, lowest-level bubble straddling that

point is divided into two parts <3>. The timepoints can have used-defined labels or the corresponding time index displayed beneath them (not shown here). Once the timepoints are marked, the user can select and group bubbles, forming higher-level bubbles, and can add labels to each bubble <4>. These labels typically use the same letters to represent passages that are the same (a a), primes for passages are similar (a a'), and different letters if the music is different (a b). The colors of the bubbles can be changed as well, to provide a visual analog relationships depicted by the alphabetic labels. Finally, a more extensive text annotation can be added to each label <5>. Clicking on a bubble will then play that the music under that bubble, and display any associated annotations. A well-constructed timeline can provide a clear picture of the thematic structure of a movement. By tying the diagram to an audio file, it is then possible to quickly compare non-adjacent passages, which can enhance one's understanding of a musical work.

FUTURE PLANS AND OPPORTUNITIES

The various content visualization components within Variations2 will eventually be integrated into a single application, as part of the Multimedia Music Theory Teaching component of the project [4]. A lesson authoring environment will enable instructors to provide guided activities for their students. Students are able to save their files, share them with each other, and submit them to their instructors.

The visualization techniques described here for music are by no means the only possible visualizations. For example, Cogan [2] uses audio spectrograms to display musical structures of recorded music. Brinkman & Mesiti [1] convert encoded musical scores into x-y plots, with x representing time, and y representing various musical parameters (often pitch) to show interesting musical relationships that are not readily apparent in the score. More generally, ongoing research in visualization and retrieval tasks are carried out by members of the Music Information Retrieval Community [5]. Which kinds of data visualization will prove to be of sufficiently general use to justify developing robust user interfaces for them in the context of a digital music library is a question for which answers are still being sought.

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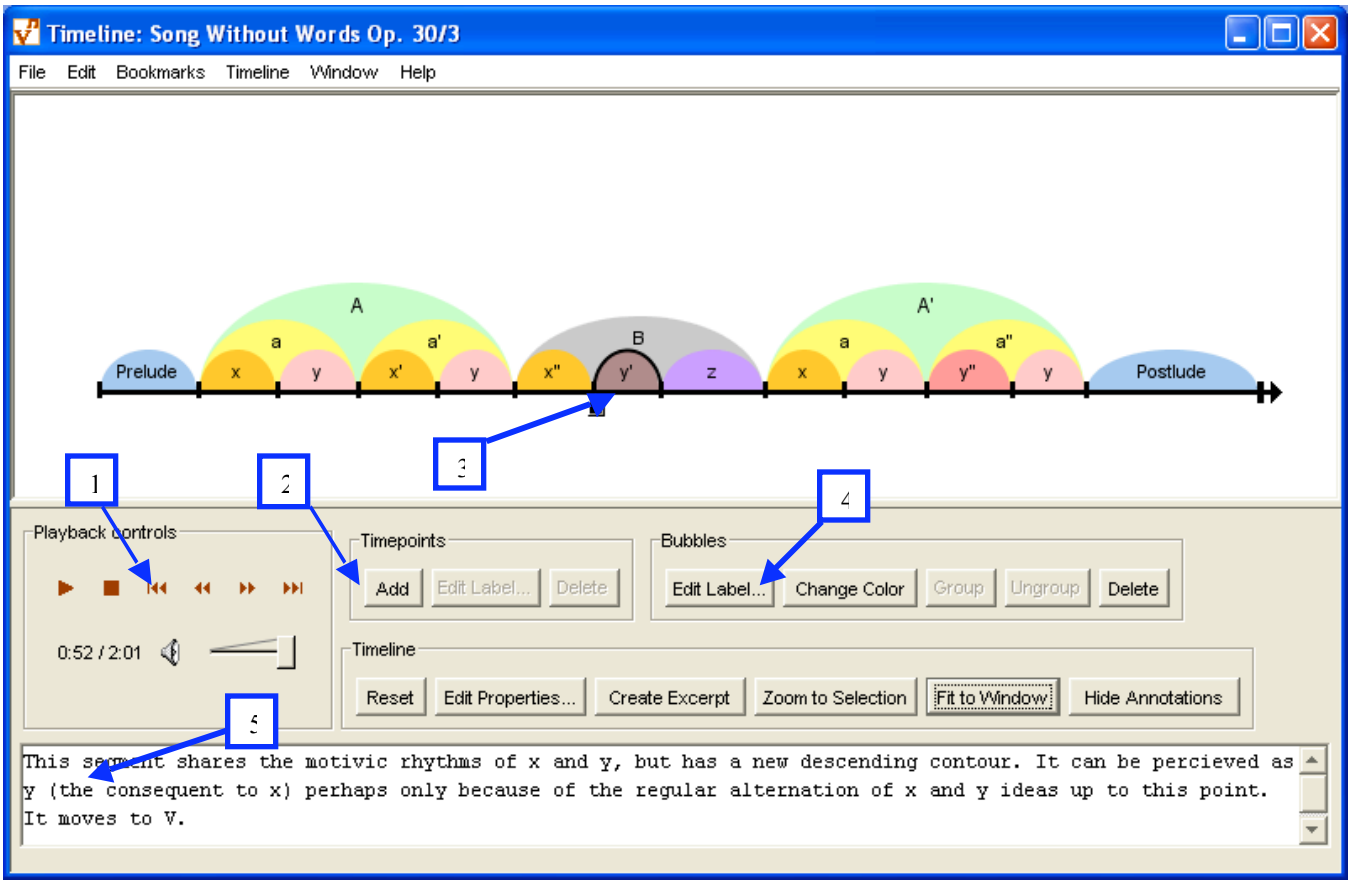
Figure 4


Timeline: Song Without Words Op. 30/3
File Edit Bookmarks Timeline Window Help
A
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Playback controls
0:52 / 2:01
Timepoints
Add
Edit Label...
Delete
Bubbles
Edit Label...
Change Color
Group
Ungroup
Delete
Timeline
Reset
Edit Properties...
Create Excerpt
Zoom to Selection
Fit to Window
Hide Annotations
This segment shares the motivic rhythms of x and y, but has a new descending contour. It can be percieved as
y (the consequent to x) perhaps only because of the regular alternation of x and y ideas up to this point.
It moves to V.