3D MUSICAL NOTATION - PROVIDING MULTIPLE VISUAL CUES FOR MUSICAL ANALYSIS

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Abstract

Visualization of musical information provides help and support for many musical analysis activities. This paper presents a system where standard music notation is augmented by multiple cue information display, using 3D visualization of spatially positioned auditory stimuli.

Virtual reality systems are visualization media for interpreting interactive dynamic simulations of physical systems. We propose a mapping that provides a visualization system whose goal is to improve the visual and auditory information available for music analysis.

The various parts of our system span different research domains: music cognition, visual perception and data visualization; in this paper, we focus mainly on visualization issues.

1 Introduction

This paper presents a Virtual Reality (VR) environment where standard music notation is augmented by multiple, 3D-positioned visual and auditory information.

The proposed VR system is based on the idea that standard music notation can be enhanced on the basis of perception-related results in the areas of music cognition, visual perception and data visualization.

Potential uses of this system include music analysis, computer music composition, and music education.

The final target platform for the system is the CAVE, a VR environment developed by the Electronic Visualization Laboratory (EVL) at the University of Illinois in Chicago [1].

Standard musical notation is the only indisputable standard way to visually represent the vast majority of music material.

It can be enhanced in two ways: augmenting the number of ways information is displayed (multiple cues) and augmenting the amount of displayed information (adding extra visualization paradigms). Our system approaches both problems.

Adding multiple visual cues

In a traditional computer-based musical notation system, music is played and simultaneously displayed using a scrolling notation; The user reads chords and melodic lines directly from the staves as they are played. To this standard feature, we add more visual cues:

Chord quality, key and function are presented on a separate table; played notes are highlighted on the staves. Melodic lines are color-coded, scale information is displayed on a different table.

Augmenting the amount of displayed information

These cues can be all presented on a single 2D image representation. While a 2D visualization could be overwhelmed by this amount of data, using the 3rd dimension allows some extra relevant information to be represented. Examples of 3D display possibilities include the following:

Melodic lines and chords can be extruded from the main staff and displayed on a parallel staff plane in 3D notation space; color coding establishes identity with the original source staves.

Staves can be grouped and moved in 3D space from plane to plane or within a staff plane, either manually or using predefined groupings (by instrument, pitch range, spatial positioning in the input data etc.).

Moving staves in different regions of available 3D space causes stereo left-right repositioning in the simultaneously played sound output.

Automatic 3D camera positioning can be set to follow the execution of the musical piece, or blocked to fixed points in the score while staff planes keep scrolling.

2 Potential uses of the system

2.1 Computer-aided music analysis

In the realm of music analysis, there is a multitude of theories that can be reinterpreted as algorithms or other rule-based systems, and thus at least partially implemented in software. One advantage of a software realization is the possibility of visualizing the outcome of any performed analysis.

In tonal music Form Analysis, it is beneficial to add and visualize extra structures that are only implied by standard musical notation.

As an example of cognition-oriented studies, Lerdahl and Jackendoff's Generative Theory of Tonal Music provides several different *reductions* to "represent hierarchical relationships among pitches in a piece" [3]. These reductions are notated by means of trees. This might be one of the most obvious cases where the outcome of an analysis, obtained by applying a music theory model, is naturally a graphical object - a graph tree structure superimposed on a music stave.

The reductions presented in Lerdahl and Jackendoff's model, have the goal of researching principles of music cognition. In this effort, a flexible and powerful visualization tool is very likely to provide new insight.

Both analysis examples need methods for displaying their outcomes as additional information to the standard musical notation. Drawing a parallel with scientific visualization tools used in fields such as quantum physics and algorithm parallelization, when a massive amount of information is analyzed, sophisticated visualization techniques are beneficial.

2.2 A tool for computer music composition

Another field, where there is promising use for a VR system capable of real-time musical notation visualization and manipulation, is the realm of computer music composition. Since the first distribution of the Music-V language for direct synthesis, a concept pioneered by Max Mathews at Bell Labs in the 1950s (leading to the Music-V in the 60s), powerful algorithmic paradigms have been available to computer music composers. Only recently have the descendents of such systems been equipped with adequate visual interfaces, in the attempt to remove inevitable human-computer interface barriers, and to allow a real-time control. One such example is the SuperCollider software environment, which provides a graphical interface to the underlying sound synthesis language [4].

2.3 A tool for music education

A third field that can gain benefit from an interactive VR musical notation system is *music education*, starting from the introductory level, in theory and analysis classes.

Musical Education exploiting Musical Intelligence

Gardner's Theory of Multiple Intelligences [2] provides a theoretical foundation for recognizing abilities in such different areas as music, spatial relations and bodily control. It is mainly a psychological theory - not a direct educational strategy - but understanding its principles should allow a wider range of students to successfully profit from classroom learning.

An implication of this theory is that different approaches are needed to efficiently teach students whose intelligences are (in Gardner's classification) not musical, but rather visual, logical, verbal or kinesthetic.

An enriched musical notation stimulates mental models about harmony, exploiting visual abilities instead of kinesthetic ones, thus stimulating the visual/spatial intelligence, according to Gardner's model. Methods for displaying multiple visual cues are needed again.

3 Rendering Musical Notation

Mapping musical data to a geometric representation can assume different specific meanings in the presented system. For example, the structure of a Bach's Canon can be mapped in space using the structure obtained from a form analysis. This method does not use standard music notation, but it's been extensively used in interactive explanations of form analysis bases [5].

Another approach starts by adding color to standard musical notation. Coloring musical phrases can help in recognizing similar horizontal structures in the standard musical notation.

When fine-grain analysis tools are used, such as the GTTM method [3], spatial representation can be shifted from the traditional flat 2D view to the 3D space.

The outcome of an analysis such as the GTTM method, being a tree, consists of several levels of detailed information about the same music material. These levels can be layered in 3D to denote the fact that they represent the same input data.

Additional experiments are needed to define the best possible visualization of naturally linear and directed data, when each layer of information hides the previous ones and simple transparency can not be used easily - legibility has to be preserved.

3.1 Multi-Modal Perception and Color-Sound Associations

A system using VR and 3D visualization techniques for Music Analysis should aim at the most intuitive representation of musical data. That includes not only an appropriate use of symbology and geometry, but the use of colors and color mapping as well. Directions about mapping decisions can be searched in multi-modal perception studies, which explore the interactions between auditory and other sensory processing in the human brain.

3.2 System Prototypes

To display standard musical notation, the building blocks consist of canonically defined symbols for notes, staves, embellishment, expressivity notations etc. Few musical notation software packages exist in publicly available source code form; examples are the Vivace and Rosengarden systems - neither one is easily transportable to a 3D library such as OpenGL. Therefore, the first prototypes for the presented system are built using CosmoWorld - an authoring tool for VRML scenes. VRML allows to combine animation, and audio/video information for fast prototyping.

Labels are in the form of 3D-positioned table objects, small rectangles containing a visual presentation of classes in a categorization of music data.

Colors can be used used in pitch-class representations. The choice of a color scale is not unequivocal. For example, when analyzing functional harmony in tonal music, different chord functions denote their *distance* from the tonal center of a piece. A dominant chord is in this case often considered the closest to the root, being the one which most strongly tends to resolve to the tonal center. It could be therefore visualized with a *warm* color, to denote its proximity to the center. However, it can also be considered the most *distant* chord, because of its tensions.

Similar considerations can be made when choosing colors for chord quality classifications. Major and minor chords are often simplistically described as *happy* and *sad*-sounding chords, and in some cultures these two emotions could be depicted using red and purple colors - such a choice is very delicate.

When the two classifications are combined - quality and function of chords displayed simultaneously - two color scales have to be used and even more care is needed to avoid potential perceptual clashes.

4 Conclusion

Previously presented similar systems for 3D music visualization represent musical information using an ad-hoc, nonstandard notation, using 3D objects such as spheres and ellipsoids to represent notes, their resizing to identify played notes in real time, and a fixed space positioning to represent category grouping.

Our system relies on standard music notation as the main visualization of music material. We add multiple visualization cues to enhance this notation instead of sacrificing the user's familiarity. Played notes are displayed in real time using color-coding and highlighting; separate 3D objects are used as information sources to emphasize temporally related material - an undistorted view of music notation is always available. Finally, the spatial positioning system is interactively controlled by the user.

References

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