

# Graph Theory: Linking Online Musical Creativity to Concert Hall Performance

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## ABSTRACT

Graph Theory links the creative music-making activities of web site visitors to the dynamic generation of an instrumental score for solo violin. Participants use a web-based interface to navigate among short, looping musical fragments to create their own unique path through the open-form composition. Before each concert performance, the violinist prints out a new copy of the score that orders the fragments based on the decisions made by web visitors.

## Keywords

Music, Composition, Violin, Graph, Traveling Salesman.

## INTRODUCTION

In recent years, technological and aesthetic developments have challenged us to become more engaged and active cultural consumers, helping to create the content we enjoy rather than serving as mere spectators; we curate the playlists we listen to, we compete in the massively multiplayer online games we play, and we collaboratively filter the media we watch. Within this context, traditional concert performance, particularly of classical and contemporary art music, seems increasingly anachronistic: audiences sit in a dark concert hall, often looking at a conductor whose back is turned toward them, afraid to cough or sneeze lest they disturb their neighbors.

Graph Theory aims to bridge this experiential gap. Through its availability on the Internet, it seeks to creatively engage audiences outside of the concert hall; the project then transposes their activities into the context of a live concert performance. Web site visitors, who need not have specialized musical or technical training, use a visual interface to navigate among short, looping musical fragments for solo violin to create their own unique path through the open-form composition. Before each concert performance, the violinist prints out a new copy of the score from the web site, which linearly orders the

fragments based on the decisions made by site visitors.

## BACKGROUND

### Networked Music

Networked music research and practice in recent decades have focused primarily on real-time, collaborative, networked performance systems. Graph Theory, though, is inspired more by recent projects in which participants interact with each other out of real time, contributing to the ongoing evolution of creative content. For example, Splice Music [6] creates a multi-track audio interface for collaborative remixes and collages built from shared sound libraries. And in the visual realm, Peter Edmunds' *SwarmSketch* [3] creates a structured environment for collaborative drawing.

### Dynamic Score Generation

Graph Theory also draws from a tradition of dynamically generated musical scores that change their visual appearance from one performance to the next. In Earle Brown's *Calder Piece* [1], the music, which is part of a sculpture, literally moves. And recent projects by Art Clay [2] and David Kim-Boyle [4] render digital scores in real time based on the activities of musicians and/or audience members.

## IMPLEMENTATION

### Interface

Graph Theory draws on Stockhausen's moment form [5], the graph structures common in computer science and discrete mathematics, and the hypertextual structure of the web itself. Participants navigate through a set of musical fragments for solo violin, which they see in a visual piano-roll notation and hear as audio recordings. Their navigation is constrained by the work's graph structure; each fragment is directly linked to only three or four other fragments on the graph. The web interface (Figure 1), which was designed in Flash by artist Patricia Reed, also shows users their current location within the entire graph structure, tracks which fragments they have visited, and enables them to review the path they have followed thus far.

## Score Generation

As users navigate through the musical fragments, each decision they make is logged on a server-side MySQL database. The server also records the number of times a fragment loops before a new decision is made. Each day, then, the server regenerates the PDF score file for the piece, which can be downloaded from the web site for use in concert performances. The performance itself is entirely acoustic, with no technology involved.

The algorithm, implemented in PHP, generates a linear path through the composition. It first assigns weights to the directed edges linking each pair of fragments on the graph; the more “votes” a particular edge has received from participants, the lower its weight. The software then finds the path that visits all fragments at least once but has the lowest total weight, solving this optimization as a variation of the traveling salesman problem. In this manner, more popular path segments are more likely to appear in performance scores. For each fragment, a suggested number of repetitions are notated, based on the average number of loop iterations by web site users.

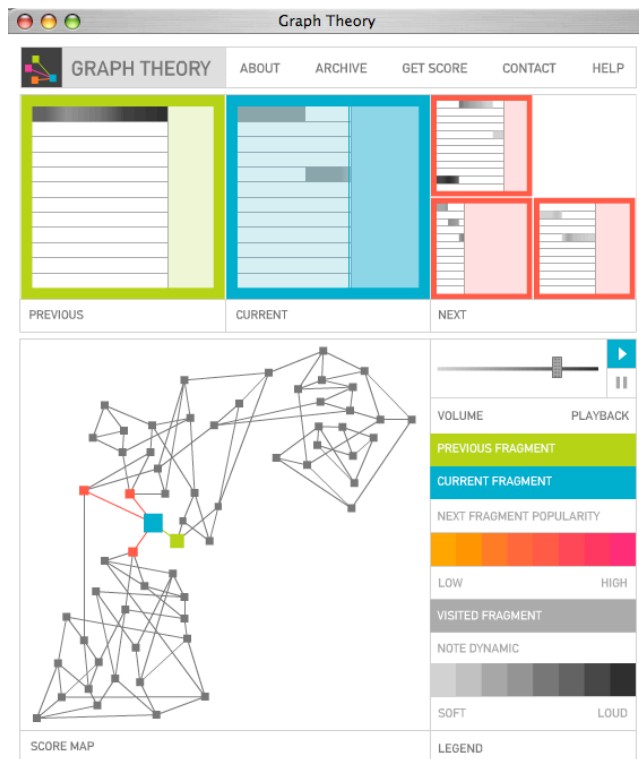


Figure 1. Graph Theory web interface.

## The Music

The sixty-one fragments that comprise the work range in length from 0.6 to 4 seconds, and each fragment contains between 1 and 5 pitches drawn from a shared twelve-pitch set. Each fragment is linked to 3 or 4 other fragments on the graph, and connected fragments always differ by only a single added, removed, or changed pitch. The rhythmic and metrical content of each fragment were composed intuitively, without systematic restrictions. The music is

mostly slow, meditative, and minimal, inspired by composers such as Feldman, Cage, and Pärt.

On the web site, sound is continuous; a fragment loops until the next one is chosen or playback is paused. The fragment recordings, which were created by violinist Maja Cerar and recorded with a click track, are identical each time they play back.

In each 7-10 minute concert performance, the violinist exercises considerable interpretive freedom to modify dynamics, timbre, and tempo, insert pauses, and vary fragment repetitions in order to musically shape series of fragments into cohesive, large-scale musical phrases.

## DISCUSSION AND CONCLUSION

Informal feedback was solicited and received from twenty web site participants. While almost all of them found the site easy and intuitive to use and visually and aurally pleasing to explore, many of them expressed a desire to preserve the individual paths they created. Beyond the collectively-generated scores and the individual path review features, they wanted to generate downloadable audio files and musical scores based on personal, not only group, creations. Future works in this series will further explore this duality of individual and collective creation, and they will also more clearly show participants the role their individual contributions play in the development of the collective musical products, through visualization and auralization of the work's evolution over time.

Future works in the series will also enable participants to modify the connective structure between fragments and the content of fragments themselves; they will incorporate larger ensembles of musicians into concert performances; and they will link participants via a social network.

## ACKNOWLEDGMENTS

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