The MUSICtable: A Map-based Ubiquitous system for Social Interaction with a digital music Collection

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Abstract. Popular acceptance of the mp3 digital music standard has greatly increased the complexity of organizing and playing large music collections. Existing digital music systems do not adequately support exploration of a collection, nor do they cater to multi-user interaction in a social setting. In this paper, we present the design of a ubiquitous system that utilizes spatial visualization to support exploration and social interaction with a large music collection. Our interface is based on the interaction semantic of influence, which allows users to affect and control the mood of music being played without the need to select a set of specific songs. This design is inspired, to some extent, by Gaver's work on ludic design. We implemented a prototype as a proof of concept of our design. User testing demonstrates that our system encourages participation and strengthens social cohesion. Our work contributes to interactive interface research in that it extends the utility of map-based visualization of digital music.

Keywords. user interface, music map, social interaction, entertainment, tabletop display, music classification, mp3.

1 Introduction

Advancement in digital recording technology and the mp3 digital music standard have spawned a trend of large music collections. With this new technology has come a novel set of problems. One emergent issue is that interfaces used to play digital music do not support interaction with large collections in social situations.

Traditional forms of recorded music such as compact discs (CDs), tapes, and records present music at the granularity of the album, comprised of a set of 10-15 songs. Digital media poses a more challenging organization problem because mp3 files reduce the granularity of music to the size of the individual song. It is much more difficult to interact with a collection of 600 mp3 files than the collection of 50 CDs from which the songs were taken.

Digital solutions to the music organization problem have been attempted by means of metadata (ID3 tags) that explicitly denotes the artist, album name, year of production, and genre of an mp3 file. In practice, these fields are rarely utilized correctly.

Thus, classification of large digital collections remains an open problem for both single users interacting with a music player, as well as in the domain of multi-user social interaction with recorded music.

The standard PC-based digital music player is designed for single-user interaction. The user interacts with the system by adding individual mp3 files to a playlist. Selection of each file requires linear searching within the computer file system. The playlist metaphor does not support the idea of a continuous mood or feeling of music – often the goal of the music listener – because selection occurs at the granularity of a particular song. Additionally, this selection granularity may be problematic for users who are not familiar with the specific artist and song names. Furthermore, the system is constrained to the computer itself. These characteristics result in a system that requires a nontrivial investment of interaction time by a single user. A trend discovered through an initial user study was that many users abandon direct control by engaging a "random" play mode with all songs in the collection. This method requires continuous interaction with the system as users generally will continue to skip to a new random song until they find one that fits their current mood.

The user interface of the PC-based digital music player clearly does not support music selection by multiple people in a social situation. One manifestation of this deficiency is a phenomenon we will refer to as "separate party syndrome," wherein a small number of people tend to gather around the desktop computer, away from the other attendees of the party, dominating the selection of music. A small fraction of attendees participates in music selection with this type of interface and those who do are removed from the social atmosphere of the party while engaged in music selection.

Effective social interaction with a digital collection requires a means by which to explore and discover its contents and to play music in a manner that is inclusive of the preferences of each individual, yet results in a smooth progression of music through different moods, styles, and tempos of music. Such a solution should not require substantial investment of interaction time, nor should it require a departure from the social atmosphere. In an effort to address the shortcomings of current digital music solutions, we present a ubiquitous system that utilizes spatial visualization in order to support exploration and social interaction with a large music collection.

2 Related Work

2.1 Spatial Visualization of Music

As personal digital music collections grow larger, the science of visualizing such archives is becoming popular. A number of papers on this topic have been published. For example, Torrens et al. [7] have experimented with visualization techniques such as disk, rectangle, and tree-map visualization.

Other research has taken on the analogy of cartography. Pampalk et al. [5] have created a map-based visualization called Islands of Music. This system creates a self organizing map by sampling the songs and extracting raw audio data. The music is classified by comparing traits such as loudness, sensation, and rhythm patterns. The results are used to display the music collection spatially, such that similar pieces of music appear close to each other. This organization is visualized as a geographic map.

Similarly, van Gulik et al. [2] have developed the “Artist Map,” a technique that employs graph-drawing algorithms based on an energy model. Like Islands of Music, this system presents a visualization using data derived from the music itself, but also incorporates metadata that can be obtained from ID3 tags and web services.

In all the visualization systems discussed in the literature, the objective is to display a representation of the music collection. These systems focus on navigation and exploration of a music collection. We have yet to find evidence of any of these systems being utilized to listen to the music library, for example, via the creation of playlists. We endeavor to extend the idea of map-based music visualization systems by using such a visualization to support the selection and playing of music.

2.2 Social Interaction and Music

Current research on social interaction and music has focused on the creation of music through social interaction. A project at the MIT Media Lab examined changing ambient music at a social gathering based on the type of beverages people were drinking [3]. Ambient music was not recorded music, but a combination of various musical sounds.

In the domain of recorded music, O’Hara et al. have examined a song selection system used in a public space [4]. Patrons of a pub democratically chose which song to play next. Our interface is intended for a different social context: private social gatherings. Furthermore, our interface will gather input from each every user’s selection, incorporating this data to play music that will cater to the preferences of all participating users. This is quite different from a voting mechanism for song selection on a song-by-song basis.

2.3 Ubiquity and Interactive Displays

Rogers and Lindley [6] conducted a study to investigate how the physical orientation of a shared display affects group collaboration. They found that table displays encourage group members to switch roles often, explore ideas, and closely follow the activities of other members of the group. The social aspects surrounding the use of tables make them appealing for use as displays. Tables are common and are incorporated into the design of most rooms, allowing such displays to blend into everyday life. This “blending” is a defining characteristic of ubiquitous computing, as presented by Weiser [8]. Thus, we feel that a tabletop display is an ideal medium to utilize in the separation of the music collection from the computer. We were also encouraged by the social affordances associated with tables, and believe that they are well-suited to creation of a system in which groups of people are encouraged to interact.

2.4 Ludic Design

Gaver et al. explored the notion of ludic design in order to address computer use in the realm of people as “playful creatures” (“Homo Ludens”) [1]. The Drift Table is a tabletop display that displays aerial photography. The display slowly drifts across a landscape and is controlled by the distribution of weight on its surfaces. Goals derived from the ludic outlook include avoiding the appearance of a computer and supporting social engagement in ludic activities. Strongly contrasting with traditional goals for computer systems, the designers’ objective was to avoid meeting users’ immediate desires or demands. For instance, the system was designed to disallow a move to a particular location. Instead, users must work together to influence the direction of the drift. We were inspired by this idea of influence over selection in order to support open-ended, social use of an interface for exploration of a music collection.

3 Design

Our general design goals for a system that supports exploration and social interaction with a large digital music collection were as follows:

- Present the collection in a form that supports exploration;
- Preserve social cohesion;
- Encourage collaboration in the music selection process;
- Separate the music collection from the computer.

We propose a table-based system that utilizes music map visualization. A selection cursor is displayed on the map corresponding to the location of the next song to be played. Users interact with the system by entering directional input to affect the motion of the selection point.

The notion of exploration in a musical space is important to our design. Users who are unfamiliar with a particular music collection may be timid and may therefore shy away from participating in music selection. By providing an interface that suggests traversal and exploration, everyone is equipped with an equal level of understanding. This allows the unfamiliar user the freedom to participate and influence the navigation of the map without social pressures. We aim to provide an interface in which no one person chooses a specific song. Instead, we envision a group of people working together to influence the musical atmosphere of a room by exploring a map.

A tabletop system, when strategically placed in a room, ensures that social cohesion is preserved. First, this type of system ensures that users are not required to remove themselves physically from a social area in order to attend to a computer, which may be located in the corner of the room or in another room entirely. Second, by separating our system from a traditional PC, we ensure that users will not become distracted by other software while in the process of selecting music. As discussed above, tabletop systems are also known to encourage collaboration.

Because of the low level granularity of digital music collections, displaying the collection at the level of a song can make the selection process tedious. Displaying a collection as a series of folders organized by traits such as artist or genre is not ideal. Instead, we aim to separate the names and titles of songs from the visualization, instead focusing on the mood or atmosphere inspired. We feel that the geographic map metaphor addresses this goal. This idea of a “music map” visualization of a music collection is useful and engaging because it compels users to traverse and explore the music. Just as an orienteer navigates a map to discover new locations, our users will be able to discover new music. We decided to implement our system as a static map with a moving selection point as opposed to the Drift Table design, which utilizes a static selection point and a moving map. This provides users with the context necessary to not only explore, but to learn and retain the discovered information.

Simultaneous multiple-user input is also important in encouraging collaboration. However, such input cannot be discrete: input from each user must be multiplexed together to achieve the music selection. We capitalized on the idea of influence over selection broached by Gaver et al. [1]. Discrete directional input entered by each user combines to influence the direction of movement of the selection point. The idea of influence is also important in effectively matching the interaction style to the map metaphor. In the case of a music system, ‘selection’ gives the user the expectation of specifying the exact song to be played. This does not work well in a group setting: each person will want to hear ‘his’ or ‘her’ specific song, and unfamiliar users have no opportunity for input. With an ‘influence’ semantic, on the other hand, there is no such expectation or limitation. Instead, users are given the sense that their actions will have an impact on the music played, but without the certainty of an exact song. Also of note is the fact that the map visualization, devoid of artist and song names, does not give the option of selecting a specific song; thus, we must approach the user interaction from the influence perspective.

4 Prototype

We designed, implemented and tested a series of prototypes. The goal of the first iteration was to avoid “separate party syndrome.” Evaluation demonstrated evidence that the system succeeded in this goal. Our second iteration focused on resolving issues reported during the initial user evaluation. These issues were restricted to the music map, the interaction metaphor, and the graphical user interface. All other aspects of the implementation were left untouched. Our discussion here is confined to the most recent iteration of the prototype.

4.1 Prototype Design

The Music Map. We created our own music map for the prototype; however, our system design can support any music map visualization, such as those referenced in the related work section. In the creation of our map, 348 songs of various styles were subjectively sorted by similarity of sound and genre into 50 categories. The categories were then arranged spatially such that similar genres appear near one another. Artistic license was employed to create the impression of a geographical map. Broad categories were indicated using a colour coding scheme and were communicated to users via a map legend. Lower level categorization is implied via blending of fills and spatial layout. Refer to Figure 1 for a screen capture of the music map visualization.

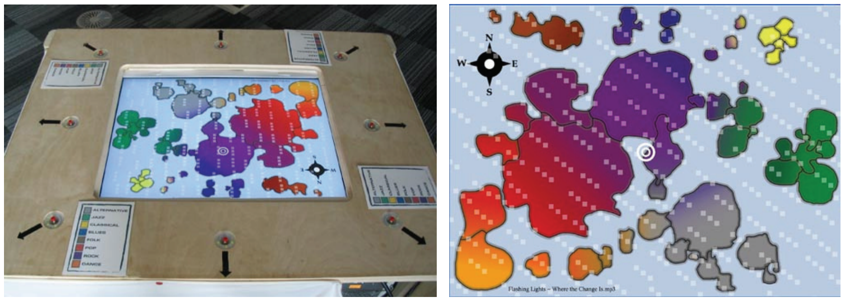

Fig. 1. The MUSICtable: table top (left); music map graphic (right)

User Interface. The music map is presented on the tabletop display along with the legend that relates map colours to music styles. The selection cursor is denoted by a small target icon that pulses in brightness to capture the users' attention. The notion of influence is attained through the analogy of wind flow. Users cannot directly move the position of the selection point; they can only affect the direction and speed of wind flow that causes the cursor to drift slowly across the map. Wind flow is visualized as semi-transparent flow lines moving over the map. Eight buttons arranged at compass points around the tabletop display allow users to control direction and speed of the wind flow. Wind flows in the direction of the last button press and multiple button hits in the same direction cause the flow to increase speed. LED indicators around the buttons, in addition to the change in direction and speed of flow line motion, provide feedback to users regarding the way in which their input has affected the system. The selection cursor slowly drifts in the direction of the wind flow and each time a song ends, the next song to be played is selected from the musical area nearest to the current location of the selection cursor. The incremental change in the selection cursors position fits well with the semantic of influence. The cumulative effect of all users' input shapes the path of the selection cursor as it moves through the music space.

4.2 Implementation

Software System. The control and visualization software was developed in Windows and can be broken down into the following tasks:

- Display the music map and wind flow visualization;
- Receive button input and change wind flow direction / speed;
- Select a song based on the location of the selection cursor;
- Ensure music plays continuously without repeating songs.

Graphic visualization was implemented with the openGL graphics library and Utility Toolkit (GLUT). The control system integrated button input using Windows drivers for the Phidgets USB interface board. The actual playing of mp3 music files utilized the open source FMOD audio engine.

Fig. 2. The MUSICtable prototype (left); Users interacting with the MUSICtable (right)

In order to select a song based on location, all songs were spatially subdivided using a quad-tree data structure. This creates a grid representing the music map where each grid square contains, at most, five songs. When the system selects the next song to play, it finds the grid square at which the selection point is located and then randomly chooses a song from that grid square. To ensure that songs are not repeated and that music plays continuously, an additional coarse-grained subdivision is created and used if the fine-grained grid contains only songs that have already been played.

Hardware System. Key features of the hardware system were the tabletop display and the button hardware. We used an LCD monitor embedded into the middle of a table in order to provide a bright display with high resolution. A glass cover over top of the display was flush with the table surface to maintain the system's utility as a table. The table stands three feet tall at a comfortable height to use while standing.

The button hardware was created with simple contact push buttons and LEDs. We used a Phidgets Interface Kit 8/8/8 board, housed inside of the table, to capture button input and to control the LED indicators. The software system ran on a Windows PC located inside the MUSICtable. An external audio jack provided a connection to the stereo system. The prototype is shown in Figure 2.

5 User Evaluation

5.1 Iteration One

We evaluated our initial MUSICtable prototype in comparison with a laptop computer system running Nullsoft's Winamp mp3 player. This popular software is used to build and play playlists of songs from a digital music collection.

The broad goal of our system was to avoid the "separate party syndrome" often involved in digital music selection in a social setting. Thus, it was necessary to compare our system with a Winamp interface also located in the centre of the party room in order to show that more is required to solve the problems associated with social interaction with a digital music collection than merely moving the traditional computer-based system into the centre of the social circle.

Hypotheses

H1: A larger percentage of participants will involve themselves in music selection with the MUSICtable tabletop system than with the PC-based Winamp system.

H2: The MUSICtable system will preserve social cohesion: Participants will experience lowered feelings of separation from the social atmosphere while involved in music selection with MUSICtable than with Winamp. The MUSICtable system will encourage a higher level of collaboration than Winamp.

Participants. 13 participants, all between the ages of 18 and 30, were recruited from a pool of graduate students. This age group is representative of the generation that has embraced digital music collections and related technologies.

Procedure. The experiment consisted of a party to which the participants were invited. The experiment was divided into two 45-minute sessions. Subjects were told to feel free to change the music that was playing. That is, music selection was in the hands of the party attendees.

During the first session, a laptop computer running Winamp was used as the music selection system. During the second session, our MUSICtable system was used. During session one, the laptop was placed on top of the table that housed the MUSICtable system, with the prototype turned off. This was done so that both systems were centrally located in the room. The switch between the two systems was made as inconspicuously as possible while the users' attention was directed to the other side of the room.

Results were collected via a post-party questionnaire. Here, participants indicated which of the two systems they interacted with (Winamp, MUSICtable, or both). Participants answered questions pertaining to the level of collaboration that was encouraged and feelings of separation induced by use of each system. Additionally, the survey gauged understanding of the system itself, as well as a preference between music player systems.

Results and Discussion

Verification of Hypotheses. 8 users participated in the selection of music using Winamp, whereas 12 users participated in selection of music using the MUSICtable. Only 1 user who used Winamp did not use MUSICtable. This supports our hypothesis that a larger number of participants will involve themselves in music selection with the MUSICtable tabletop system.

Qualitative results from the questionnaire indicated that users felt more encouraged to collaborate in music selection while using the MUSICtable than while using Winamp, and felt less separated from the social circle while involved in MUSICtable interaction. Responses were rated on a five-point Likert scale.

The mean response to the survey question “The Winamp system encouraged me to collaborate with others while selecting music” was 2.5 (corresponding to an answer of “Disagree-Neutral”). The mean response to the survey question “The MUSICtable system encouraged me to collaborate with others while selection music” was 3.67 (corresponding to an answer of “Neutral-Agree”).

The mean response to the survey question “I felt separated from the social atmosphere of the party while participating in music selection using the Winamp system” was 3.125 (corresponding to an answer of “Neutral-Agree”). The mean response to the survey question “I felt separated from the social atmosphere of the party while participating in music selection using the MUSICtable system” was 1.92 (corresponding to an answer of “Strongly Disagree-Disagree”).

All users indicated feeling more included in the social circle while using MUSICtable. These results support our hypothesis that the MUSICtable system will preserve social cohesion.

General Feedback. Users generally enjoyed the interface, feeling that it encouraged participation and led to conversation. Some users commented that they felt that the interface was game-like and compelled them to participate in order to figure out how it worked. People were generally happy with the music played by the MUSICtable and liked that the mood of the music progressed in a continuous manner.

Issues. Our user study indicated that the system made a significant improvement in social interaction but failed to provide users with the level of control they desired. This factor clearly influenced overall system preference, as eight participants indicated a preference for Winamp, three preferred the MUSICtable, and two participants were undecided.

There were problems with the mental model of the system. Many users had trouble understanding how their input affected the selection of music. This stemmed from a lack of understanding of the relationship between the visual map and the music played. Users indicated that the visualization did not provide enough information about which areas of the map corresponded to which type of music. This lack of understanding was further complicated by confusion over the interaction metaphor. Thus, these two areas were reworked in the second design iteration.

5.2 Iteration Two

Our initial evaluation demonstrated that the system succeeded in reducing separate party syndrome. The ensuing redesign focused on resolving the problems associated with appearance and control of the interface. Thus, evaluation of our second prototype was concerned with user perception of the system itself rather than with comparison to the Winamp system.

Participants. The 41 participants were all faculty and graduate students within the departments of Electrical and Computer Engineering and Computer Science at the University of British Columbia.

Procedure. The study took place during a party to celebrate the opening of a new building on the university campus. The MUSICtable was utilized as the music control system at the party. The gathering was videotaped so that detailed observations could be made. A post-party questionnaire was utilized to gauge user understanding of the system. Note that this was not a controlled study but a legitimate party, and so participants were free to come and go as they pleased. Some participants were present and interacted with the MUSICtable for as much as an hour and a half, while others were present for only a very short period.

Results and Discussion

Survey Results. 35 of the 41 attendees filled out the questionnaire. Of these, 24 indicated participation in selection of music using MUSICtable. The following survey results pertain to these 24 survey responses. Our focus was on aspects of the design that were poorly received during the previous user evaluation. Responses were rated on a five-point Likert scale.

The mean response to the survey query "I understood the relationship between the visual map and the music that was played." was 4.1 (corresponding to an answer of "Agree"). This was a marked improvement over the previous iteration, which had yielded a mean response of 2.6 (corresponding to an answer of "Disagree-Neutral").

The mean response to the survey query "I did not understand how to use the MUSICtable or how my input affected the music that was played" was 2.3 (corresponding to an answer of "Disagree-Neutral"). Again, this was an improvement over the previous mean response of 3.2 (corresponding to an answer of "Neutral-Agree").

Results from queries relating to encouragement of collaboration and separation from social atmosphere were very similar to those obtained in the previous study. Thus, we assert that the changes made to the prototype resolved the weaknesses present in the initial system without detracting from that system's success in terms of preservation of social cohesion.

Positive Feedback. The system was well received by a large number of subjects. Many users indicated that the aesthetics of the visual map interface were appealing, with descriptions such as "colourful" and "attractive." Participants also responded well to the social and collaborative aspects of the map, commenting, "all people [can] participate," "it made the selection of music a social process," and that the "interactive nature [was] fun." Our goals for the system design were vindicated most notably by survey feedback from one user who "like[d] the concept of [being] able to set a trend with the music instead of selecting a song or a playlist."

Continuing Issues. A general complaint in both studies was the sense that the system progressed too slowly with too little immediate feedback. Participants expressed a desire to have their input affect music playback with more immediacy. However, the selection point was designed to drift slowly across the map and the major feedback loop was designed to be the slow progression from song to song. This was a point of frustration for numerous users. However, we believe that this concern over lack of control can be overcome under the right social circumstances. In a party that takes place over the course of an entire night, we believe that users will begin to accept that input is reflected in the progression of music and is not meant to effect a direct change in the playback.

6 Future Work

The core concept of our system holds promising application in various domains. Portable digital music, for instance, is becoming a very commonplace commodity with the popularization of personal hardware mp3 players such as the Apple iPod. Our system could be extended to utilize algorithms that automatically classify and organize music collections dynamically. This would allow a guest at a party to download her own collection into the MUSICtable, observing her own specific musical tastes reflected in the map.

In designing our prototype, we focused on supporting social collaboration in music selection at a party. The chosen domain assumes that the users are unfamiliar with the music collection and music map displayed on the MUSICtable. The core concept of MUSICtable applied to the domain of single user interaction opens up some interesting possibilities where the user is completely familiar with the music collection and map. In a single user design the user could be given finer control over the progression of music but still maintain the benefit of selecting music above the granularity of the specific song. We envision that such an interface could involve tangible interaction by manipulating widgets directly on top of the music table. This type of interaction is not well suited for multi-user collaboration; however, for the single user it has the potential to be a very rich experience. Since the user is completely familiar with all areas of the music map visualization, we also envision an interface in which the user specifies paths through the map to generate a specific time-varying progression of music. In this domain, the MUSICtable interface would move from the metaphor of exploration to that of orienteering.

Another future direction of the MUSICtable concept would be to explore the creation of music. Although the MUSICtable may not be effective as a music controller in the traditional sense, we envision that it could be utilized to create music through sampling of pre-recorded music. This type of interface would require a specific organization of music for the performer to be effective in navigating the space and creating a composition out of short music samples.

7 Conclusion

We have presented the design of a system in which a spatial visualization of a digital music collection is utilized to support multi-user interaction in the process of music selection. We implemented a tabletop display prototype to realize this novel interface concept. Informal user testing showed that the design was successful in encouraging collaboration and reducing isolation in music selection tasks within a social environment. Iterative redesign improved the intuitiveness and aesthetic appeal of the interface. Results indicated that the design was successful in creating an effective and engaging multi-user interface for the exploration of a digital music collection.

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