Computer Mediated Visual Communication in Live Musical Performance: What's the Score?

B. Sudarshan, Lonce Wyse*

Arts and Creativity Lab, Interactive and Digital Media Institute,
Communications and New Media Department,
National University of Singapore
{sudarshan,lonce.wyse}@nus.edu.sg

Abstract. The document on the music stand in front of performing musicians has become reterritorialized by dynamic and interactive notation enabled by computational and communications technologies. The implications are far reaching for how we create, how we play, and how we listen to music. Considering the mediated musical score as a collaborative workspace, issues of awareness and structural relationship models that were latent in traditional scores now become foregrounded. A survey of current practices illustrates different score-based collaboration and communications strategies and provides motivation for a new "anticipatory" interactive scoring system.

Keywords: visual communication, real-time scores, improvisation, computer supported collaborative workspaces

1 Introduction

Some of the conventions defining the activities and the relationships between composers, performers, and audiences are so deeply embedded in our musical culture as to seem beyond question. Composers write music before a performance. Performers follow instructions encoded in notation to render a performance while communicating with each other through the sounds they make as well as through body movements and eye contact. Audiences experience music primarily through the sound the performers create with added understanding that comes from watching performers perform. Improvisational music shifts much or all of the musical decision making power to the musicians, but the paradigm outlined above remains essentially intact.

The most audible of the 20th century upheavals to music was the radical expansion of the sound palette from the pitched and percussive sounds of acoustic instruments to the theoretically unlimited palette of sounds made available via new recording, signal processing, sensor, and electronic and digital synthesis techniques. Although scores and performers were sometimes circumvented entirely in studio-based electroacoustic practices, the activities and roles between composers, performers (when present), and audiences remained essentially as it always had been for traditional ensemble music whether composed or improvisational.

Communications, particularly in conjunction with computer-based visualization strategies, are playing a role in the deconstruction of the tripartite structure of traditional musical relationships. By changing the way composers, performers, and audiences engage with each other (both within and across the group boundaries), sense-making and the experience of music are also altered.

In this paper, the focus is on visualizations that trace their lineage back to the traditional score in that they are comprised of graphical elements meant to communicate information to performers to help them understand what their fellow performers are (were or will be) doing, and/or are interpreted as encoded instructions that influence the performer's musical behavior.

2 Awareness

One of the key elements in skilled musical performance whether composed or improvisational is awareness. This includes awareness of what fellow performers are doing, and awareness of where the music is going. In traditional western orchestral music, the score, musical "parts", rehearsals, body movement and eye contact all contribute to the awareness a musician needs to play their role effectively. In electronically mediated music making, awareness is more of a challenge because of what Simon Emerson has called the "three electroacoustic dislocations"[1]. Sound can be dislocated from original musical gesture in space (by being electronically transmitted to remote speakers), dislocated in time (delayed through digital algorithmic processes or recording and retransmission), and dislocated in causality (since the mapping between gesture and sound is arbitrary and changeable in electronic music).

While awareness in electroacoustic musical practices is undermined by the dislocations that result from multiple stages of electronic mediation, computer-supported communications between performers through instruments, notational representations, and interfaces can help restore it. Networks digitally linking musicians began appearing in live musical performance in the 1980s. The League of Automatic Composers, for example, collaborated in their networked performances using audio and message passing between programs running on their different machines, but without visual support for insight into the digital exchanges. These programs relied on the control data flowing back and forth within the network to determine their behavior [2]. A limited view into the workings of the algorithms and communications could be gleaned from messages scrolling over text-based displays. In *Vague Notions of Lost Textures* (1987) [2], the Hub implemented computer-supported visual communication strategies in the form of text based communication to coordinate the creation of an improvised shape for the musical performance.

Dynamic visual graphic scores go considerably beyond screen dumps of text in creating awareness among performers, even when they are precomposed animations on fixed media. Luke Harris made use of a three-dimensional space to display the graphical notations in his piece titled *Animated Graphic Score for Quartet* . Four musicians played simultaneously by interpreting motion graphics (flying notes and rotating staffs) in a pre-recorded video projected on a large screen (Figure 1). The

musicians had no prior rehearsal or exposure to the graphics. The projected score contains four conjoint spaces, one part for each of the musicians. Animated notational elements enter the projection space, and move back and forth between the four component spaces. Such a visual technique provides separate areas as "parts" for each musician individually, while also connecting the individual performers informationally as well as visually. The audience also views the entire score which serves as an aid to understanding the performance.

Fig. 1. Animated Graphic Score for Quartet by Luke Harris showing a four-panel shared-view dynamic score for four musicians (http://vimeo.com/2625318).

Computer Supported Co-operative Working (CSCW) with real-time collaborative graphical spaces for work [3] and play [4] make awareness a central issue, and so it is when visual representations of musical activity are shared by musicians[5]. Typically different subsets of the visual representation are directly relevant to the different individual performers' activity, while the rest of the information is used for understanding the activity of others. In *Density Trajectory Studies* [6], Nick Didkovsky employed a shared visual space on which the notations are projected for all the musicians to see. The projection is divided into four equal quadrants, with each quadrant displaying instructions assigned to one of the musicians (or subgroups in a larger ensemble). Such a strategy of dividing up a shared visual space into individual segments that is meant for each of the performers is also observed in the real-time networked music environment called *Quintet.net* [7]. In this piece, the conductor controls the performance by constantly sending out text messages and performance parameters as settings to the shared space.

ChucK ChucK Rocket by Ge Wang and Scott Smallwood uses a checkered game board representation [8] where sound objects are placed and "mice" move creating sound when they encounter the objects. For this piece, each performer is assigned one spatial region to which his/her musical gestures are restricted though the whole space of other performer regions are visible to all. Knowledge of layouts on other performer regions can be used to make musical decisions such as "teleporting" a mouse between regions. A special role is played by a "conductor" who can change aspects of the entire system behavior. This shared space engages performers in a way that blurs the boundary between compositional and performative roles.

3 Relationship models

Scores as mediated collaborative workspaces embody models of interaction between and among composers, performers, and audiences. Notational strategies can be seen as existing on a scale from prescriptive leaving relatively little freedom for performance time flexibility, to interpretive where graphical elements may come with almost no preconceived rules or shared knowledge about their intended influence on performance behavior. In this sense, notational conventions establish a balance of decision making power between the notator and the performer.

Luke Harris's *Animated Graphic Score for Quartet* is an example of an interpretive score. It demands quick responses from the musicians that are dependent on the musicians' improvisational experience and creative thinking abilities. The flexibility in interpretation defines the musical indeterminacy of the piece by virtue of the balance it establishes between the structure provided by the composer and the freedom vested in the performer.

Textual notation animated in position, shape, and color, have been used as an interpretative performance score for unpracticed audience/performers. Shane McKenna makes use of this technique in one of his unnamed compositions in the *Graphic Score Experiment* series. Familiar iconic symbols such as letters are freely interpreted by audience/participants using their voices (Figure 2). Although, multiple interpretations are possible, there is a subtle and natural way in which performance rules are conveyed incrementally by the composer to the participants using motion graphics during the course of the performance. This score occupies a position somewhere between a fully interpretative and a fully prescriptive score.

Fig. 2. Textual graphic score in Graphic Score Experiment by Shane McKenna are freely interpreted by audience members to make vocal sounds (http://vimeo.com/10140889).

Another dimension in the establishment of relationships between musical participants is when notation is created during performance. While composers traditionally create scores in advance of performances, there is a proliferation of new works using dynamic and real-time scores in music performances by composers such as Jason Freeman [9] and Christopher McClelland and Michael Alcorn [10] and on open-form scores by David Kim-Boyle [11].

Justin Yang's *Webworks I* is representative of a score that is generated live during the performance through composer-performer interaction and is also rendered as

dynamic motion graphics. It is a network based performance that also demands the need for a shared visual space to ensure that there is mutual awareness amongst the geographically distributed musicians. A shared and consistent representation is important to the cooperative engagement of performers [12]. In this performance, the traditional role of the composer as sole notation generator is seen once again.

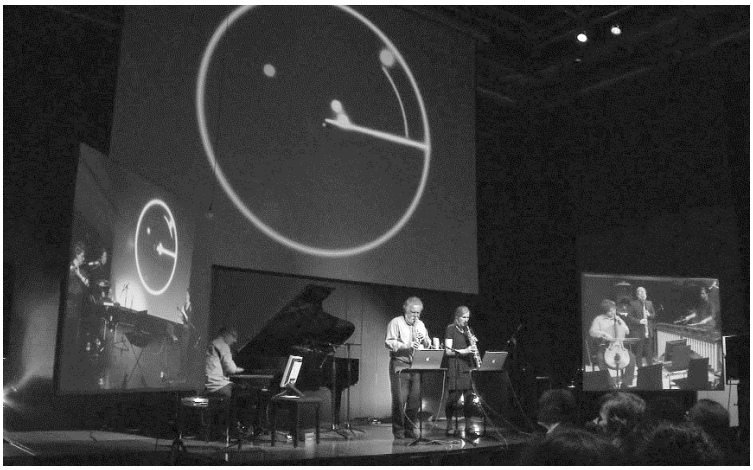

Fig. 3. *Webworks I* by Justin Yang is a networked piece that uses a shared clock-like scrolling score element to which the composer adds dynamic elements in real-time (Image: Justin Yang).

4 Temporal representation

The representation of time in a score has important implications for the kind of awareness that performers can develop. Although there may be examples of alternative time representations in 20th century graphical works (c.f. [13],[14]), dynamic and interactive scores where time moves or is moved through create fundamentally new paradigms. In this section, we outline three broad categories of temporal representations based on a study of a wide variety of current practices. McClelland and Alcorn previously identified *pages, scattering,* and *scrolling* as three basic modes of display [10]. Our categorization maintains McClelland and Alcorn's scrolling type, but specifies two other categories that seem more generally applicable to current practices such as those surveyed herein.

In a *scrolling* score, the notations move across the screen (usually horizontally) and the performers act when the notation comes in contact with a fixed vertical cursor indicating the 'present' moment. The scrolling score representation typically provides a view of both the past and the future in a way similar to traditional printed score notation. Smule's commercial iPad applications such as *Magic Piano* and *Magic Fiddle* [15] make use of a scrolling visible future so performers can anticipate actions.

MIMI by Alexandre François et al.[16] is an interactive music-improvisation software system that engages a human improviser in an interactive loop with machine as a partner (Figure 4). The scrolling score is projected and enables anticipatory activity by the performer by providing visual access to the future activity of the computer partner, as well as visual access to past events. Despite tradition, it is not immediately obvious why it might be important to have visual access to recent history. However, previous research [17] found that electroacoustic improvising musicians in particular may find information about who made which sound helpful.

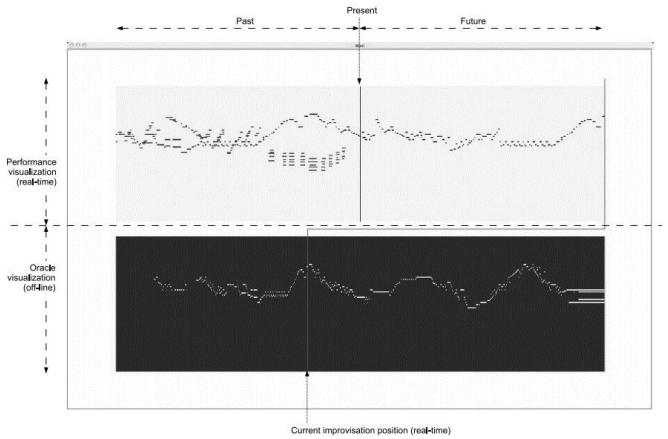

Fig. 4. MIMI score in which the bottom window contains musical material used by the machine improviser, and the top window is a scrolling view of the machine-generate music to the right of the cursor (the future), and both human and machine-generated to the left (the past). (Image from [16], with permission).

Another variant of the scrolling score can be observed in *Webwork I* by Justin Yang where the "present" time indicator is not fixed, but rotates like hands on a clock within a circle. Like its horizontally scrolling cousin, a window of time extending in both directions around the present is visible. The notational elements generated in real-time by the composer also have independent animated behavior. This makes this representation a kind of hybrid of both the scrolling and filmic view categories (discussed below).

The *filmic* view is one that uses two spatial dimensions, neither of which is time. The visualization changes with time, and the view always represents a notational "now". Animated scores are almost always filmic, but interactive scores may be as well. Shane McKenna's composition, *Three for Four* is an example using the filmic temporal view[18]. The performer generally has no access to either the past or the future (though there are examples that do represent a temporal window with, for example, graphical fades).

Navigational strategies were developed for printed scores long before computers were used. Stockhausen's *Klavierstuck XI* (1956) and John Cage's *Fontana Mix* (1958) are two such examples. Navigational scores embody a very particular balance between precomposed structure and performance-time flexibility. At any given time, the "present" is represented by the specific location of the performer. Notational

objects that are spatially more distant represent musical states or events that would take more time to reach than those close by. The performer is aware of many *potential* actualizations of music which are determined by the particular path the performer chooses to navigate. Two representative examples are Tarik Barri's *Versum*[19] and Jason Freeman's *Flou*.

5 Anticipatory Improvisation

This survey of contemporary live scoring reveals patterns of practices dealing with awareness support, temporal visualization, and models of interaction. The central composer model for example, where a privileged non-sounding performer generates notation in real-time for sounding performers, is relatively common. Filmic scores with interpretative notation supporting improvisation are also frequently employed.

Score strategies that permit performing musicians themselves to be engaged in generating notation for others to use is a relatively neglected strategy. The neglect may well be due to the fact that many instruments keep hands busy. However, for platforms that support both notation and a performance interface for sound synthesis (for example a tablet computer), this strategy enables novel performer relationships and musical possibilities.

One incarnation of such a strategy currently in development can be seen in Figure 5. The workspace is divided into two areas; one that contains a scrolling score that includes a "now" indicator dividing the time window into a visible past and a visible future. The future area supports notation of a performer's own performance intentions or compositional elements designed for other performers. The other section of the workspace is the performer's own instrumental interface. The multi touch screen permits simultaneous activity in both the future (on the score) and the present (on the instrument).

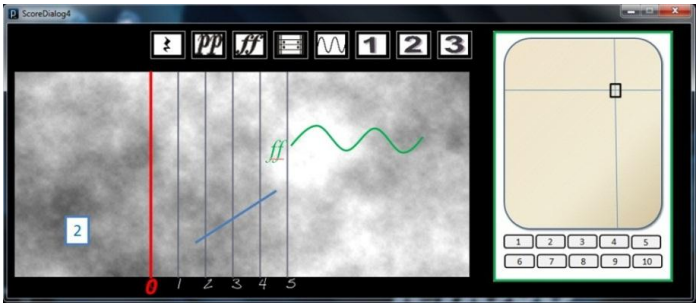

Fig. 5. Anticipatory improvisation. On the right is a private instrument interface. On the left, a shared graphical space includes a scrolling score (cloud background) with a stationary temporal "now" indicator (marked '0'). The area to the right of the "now" indicator is used by performers to communicate performance intention or prescriptive notation by drawing or positioning icons.

One relatively unexplored musical dimension this design supports is what we term "anticipatory improvisation". Improvisation is typically either structured around a musical "chart", in which case awareness of the structure permits synchronization of

musical activity (e.g. simultaneous key changes), or unstructured in which case coordinated activity grows out of the awareness that musicians build through listening, memory, and visual communication. "Anticipatory improvisation" represents a hybrid of these two paradigms where coordinated activity is facilitated by structured notational material planted in the future "just in time" during performance.

6 Summary

Computer-supported musical performance has developed in tandem with notational techniques that take advantage of newly available graphical, dynamic, and interactive capabilities. Notational, spatial, and temporal representations affect the musicians' ability to anticipate upcoming events, they affect the various performer/performer interactions such as mutual engagement, awareness, cooperation, consensus building, and they determine the balance of decision making between composers and performers. The model of a central conductor or composer still remains prominent in contemporary practices of dynamic scores. A novel system for "anticipatory improvisation" was presented that puts tools for scoring into the hands of the performers themselves. Relationships between musical participants embedded in visual communication and notational strategies are still rapidly evolving. The notational and communications approaches we have discussed are certainly not exhaustive of current practices, and even less so of future possibilities.

Acknowledgments. This work was supported by project grant NRF2007IDM-IDM002-069 from the Interactive and Digital Media Project Office, Media Development Authority, Singapore.

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