Wicked Problems and Design Considerations in Composing for Laptop Orchestra

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ABSTRACT

Composing music for ensembles of computer-based instruments, such as laptop orchestra or mobile phone orchestra, is a multi-faceted and challenging endeavor whose parameters and criteria for success are ill-defined. In the design community, tasks with these qualities are known as *wicked problems*. This paper frames composing for computer-based ensemble as a design task, shows how Buchanan's four domains of design are present in the task, and discusses its wicked properties. The themes of *visibility*, *risk*, and *embodiment*, as formulated by Klemmer, are shown to be implicitly present in this design task. Composers are encouraged to address them explicitly and to take advantage of the practices of prototyping and iteration.

Keywords

Design, laptop orchestra, mobile phone orchestra, instrument design, interaction design, composition

1. INTRODUCTION

We typically think of the activities of composing music and creating musical instruments as occurring in different domains. In the Western art music tradition composition is an artistic endeavor in which a composer applies knowledge of musical instruments, forms, and idioms to create an artifact, a musical score which when performed addresses certain artistic aims. Instrument design is a separate craft carried out independently of any particular musical work.

This distinction is blurred when composers invent extended techniques that redefine traditional instruments, and in electronic and computer music, where the studio can be seen as an aggregate instrument assembled from available devices. As the tools for creating custom computer-based instruments become increasingly accessible, more composers and musicians become builders of the instruments for which they compose.

As the art of composition and the craft of instrument design collapse into a single task, the number of choices a composer must confront explodes. When composing for an ensemble of such instruments, such as a laptop orchestra, the complexity increases further. The composer must "compose" the instrument, the musical sound, the interactions between performers, and in some sense they even compose a definition of what it means to make music. This task is daunting to say the least.

The design community has a name for such situations where the task is complex, few guidelines are available, and the criteria for success are not known in advance. They call them *wicked problems*. This paper aims to show how composing for computer-based ensemble can be productively framed as a design task, and compares it to the wicked problem theory as described by Buchanan[1]. It also discusses themes from design thinking which composers should consider, namely *visibility*, *risk*, *embodiment*, and the benefits of the practices of *prototyping* and *iteration*.

1.1 Orchestras of performers with computers

The laptop orchestra is a new format for ensemble musical performance which is centered around the laptop computer as an instrument. The practices described here originated in 2005 with the Princeton Laptop Orchestra[10], and continued with the Stanford Laptop Orchestra founded in 2008. Musical performances with computers are not new, but a few characteristics distinguish laptop orchestra from other practices. Firstly, the laptop orchestra is organized similarly to a traditional orchestra in that there is an ensemble of performers, each with their own instrument, who perform pieces created by a composer, and who may be led by a conductor. Unlike traditional orchestras, these roles may be enacted by different people for each piece. For example, it is common for the composer of a piece to be a member of the orchestra who also conducts the piece.

Secondly, each performer in a laptop orchestra has their own sound source, typically a small hemispherical speaker array, located nearby. This creates a distributed sound field where each performer can hear their own activity and the audience can associate sounds with their performer. This makes performances suitable to small settings where the audience is close, and is distinguished from performance practices in which each performer's sound is mixed into a single, possibly distal, sound system.

The mobile phone orchestra[8] is a continuation of these practices, with the laptop computer being replaced by mobile computing devices. Laptop orchestra performers usually sit at their stationary computer, while mobile phone orchestra performers hold their "computers" and have speakers attached to their bodies, allowing them to move through the performance space. Both laptop and mobile phone orchestra performances are typically held in a concert-hall setting, and the audience follows social practices associated with traditional orchestras, such as listening quietly and clapping after pieces.

The author was a founding member of the Stanford laptop and mobile phone orchestras. For the purpose of this discussion, composing for laptop orchestra and mobile phone orchestra can be considered equivalent design tasks.

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2. COMPOSING AS DESIGN PROBLEM

Composing for laptop orchestra is multifaceted and complex. The composer must work simultaneously on a number of different levels while satisfying multiple stakeholders, including the audience, the performers, the composer him or herself, and possibly members of the hosting institution.

In his influential 1992 paper, 'Wicked Problems in Design Thinking'[1] Richard Buchanan describes four broad areas in which design is practiced: 1) the design of material objects, 2) the design of activities and organized services, 3) the design of symbolic and visual communications, and 4) the design of complex systems or environments for living, working, playing, and learning. These tasks are not independent and cannot be assigned to different individuals to be performed in isolation. Rather they are "places of invention" from which the unified design task is considered. By reinterpreting these categories we can map them to four aspects of composing for laptop orchestra: 1) the design of instruments, 2) the design of structured interactions, 3) the design of visual elements, and 4) musicking.

2.1 Design of material objects

In a traditional symphony orchestra the instruments are given or chosen from those available, but in laptop orchestra the instrument is initially undefined. A computer is a meta-instrument, a platform with general capabilities upon which a specific instrument can be built. It grants certain physical affordances – the built-in input and output devices such as keyboards, touchpads, displays, etc. as well as peripheral devices such as joysticks – and software affordances such as sound synthesis languages and application development frameworks. From these the composer crafts an instrument consisting of a piece of software, the physical means by which the performer interacts with it, and the methods by which these actions are mapped into sound. This activity corresponds to Buchanan's "design of material objects" in that it is the creation of an artifact which we interact with physically. Its primary user is the performer, and thus the design will be constrained by the skill level and enthusiasm of the performers, as well as the available rehearsal time.

2.2 Design of structured interactions

Traditionally an orchestral composer writes a score which the conductor and performers use to guide their performance. Written scores and musical notation may be part of a laptop orchestra piece, but more generally what the composer designs is the interactions between the conductor and performers, or amongst the performers themselves if no conductor is specified, and how these interactions are structured in time in order to achieve the desired musical effect. This corresponds to Buchanan's "design of activities and organized services". The primary user is the performer who must enact the interactions specified, but the *visibility* of interactions (see 4.1) also affects the audience's experience.

Different strategies can be used to structure interactions between performers. For example, in the laptop orchestra piece 'Crystalis'[5], the conductor uses symbolic arm gestures to communicate desired ranges of parameters within which performers may improvise. In the mobile phone orchestra piece 'InterV'[8], performers receive on-screen textual instructions sent from a central computer which follows a predetermined timeline. These two strategies lead to differing levels of *visibility* and *risk* (see 4.1, 4.2.)

2.3 Design of visual communications

In addition to the auditory component of a piece the composer must design any visual elements. From the perspective of the performers these include the visual information available to the performer from their instrument as well as any visual communication between performers. Some laptop orchestra pieces also include graphic or video displays that are visible to the audience. These correspond roughly to Buchanan's category of "design of symbolic and visual communications".

2.4 Design of Complex Systems

What is it we do when we produce or participate in a musical event? Buchanan's last area is the design of "complex systems or environments for living, working, playing, and learning." The human activity of music is one such complex system. However, the meaning or goal of our musical activities is never entirely clear or explicit. The participants, event organizers, composers, performers, and audience co-produce the musical event and its meanings through multiple hermeneutic acts of interpretation. The performers interpret the instructions of the composer and the actions of the conductor and other performers. The audience interprets the relationship between the performers' actions and their sonic results, mediated by *visibility*, and interprets these with respect to the possible intentions of the composer. And every participant interprets the meaning of their own role within the musical event.

Small[9] uses the term *musicking*, or the verb *to musick*, to describe the ways in which groups of people self-define through their musical activities. Fallman[4] describes how design "takes the form of a hermeneutic process of interpretation and creation of meaning, where designers iteratively interpret the effects of their designs on the situation at hand." In both cases the composer or designer, as the nominal locus of creativity, has the opportunity and responsibility to think explicitly about the interpretations which may occur around his or her work. It is this indefiniteness of meaning which makes composing music (or any artistic endeavor) difficult, yet in a sense it is also what makes it so fascinating for practitioners and audiences alike.

3. WICKED PROBLEMS

The *wicked problems* perspective on design was originally formulated by Rittel in the 1960's, and elaborated upon by Buchanan. Wicked problems are a "class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing[1]." The formulation was proposed as a counterargument to the linear model of design where a problem is broken into a *problem definition*, which is then followed by a *problem solution*.

Buchanan enumerates the qualities of wicked problems. While composing for a musical performance is not a true wicked problem due to the limited scope of its consequences (people's lives or health are usually not at stake), it does share some of these qualities. In addition to making the task difficult and the linear model useless, these qualities also make it impossible to eliminate *risk* (see 4.2.)

- *"Wicked problems have no definitive formulation, but every formulation of a wicked problem corresponds to the formulation of a solution."*

This relates to the hermeneutic nature of music as described above. The composer must decide what it is that constitutes this new piece for laptop orchestra, and by doing so they simultaneously describe their task and its solution.

- *"In solving wicked problems there is no exhaustive list of admissible operations."*

- *"Wicked problems have no stopping rules."*

Only the composer can decide what sounds, techniques, instrumental affordances, and interactions, are part of a piece, and only the composer can decide when a piece is complete.

- *"Solving a wicked problem is a 'one shot' operation, with no room for trial and error."*
- *"No formulation and solution of a wicked problem has a definitive test."*

Whatever a composer's intention for a piece may be, he or she cannot predict how it will be received or interpreted. They may revise a piece after its performance, but they cannot take back or undo a performance once it is done, and there is no way to definitively say how successful it was. This risk can be mitigated somewhat through multiple iterations of prototyping and rehearsal (see 5).

- *"The wicked problem solver has no right to be wrong – they are fully responsible for their actions."*
- *"Every wicked problem is unique."*

The composer takes an artistic risk, but the performers and event producers also experience forms of risk (see 4.2). Thus the composer is responsible to these parties. Once these design issues have been addressed for one composition, they must be addressed anew for the next.

- *Every wicked problem is a symptom of another higher level problem.*

Again this relates to the hermeneutic nature of musicking. One reason computer-based music (or any music for that matter) is difficult to compose is that we don't know for sure what music is or why we engage in it. Thus, a composition can be seen as a statement regarding the definition of music.

4. INTERACTION DESIGN THEMES

The wickedness of the design task is unavoidable. Furthermore the themes of *visibility*, *risk*, and *embodiment* are implicitly present in all computer-based music performance and cannot be avoided. These can be seen as further constraints to design, or they can be explicitly acknowledged and used as opportunities for structuring the design process. This discussion draws heavily on Klemmer's themes for interaction design[7].

4.1 Visibility

When considering the perspective of the audience it is useful to take into account *visibility*. Computers allow complex sonic effects to be controlled by small movements such as keystrokes or mouse movements, but unless the instrument's GUI is projected onto a large screen, the audience remains oblivious as to what actions were performed and how they relate to the sounds produced. In the case of traditional performance the audience's familiarity allows them to feel comfortable not seeing the instrumentalist's every finger movement. While the audience may be familiar with using a laptop, they likely have no experience with the software being used.

The composer must decide what visual information will be made available to the audience and anticipate how this might affect their conception of what is taking place. Different strategies for increasing visibility were used in two pieces for mobile phone orchestra. 'Touch Patterns' featured a projected graphic display on which appeared colored squares corresponding to every note performed, creating a visual field highly correlated to both the music and performance gestures. In 'SoundBounce'[2] performers controlled sound by making bouncing gestures with their iPhones. Sounds could be passed from one player to another by making throwing gestures in the recipient's direction. This design allowed the performers to focus visually on eachother instead of their screens, and made performers' interactions easily visible to and interpretable by audience.

4.2 Risk

Putting an artistic work into the world comes with artistic risk. However there is a more corporeal form of risk which we experience every day, and which is amplified for performers. Klemmer et al.[7] give a phenomenological account of this risk: "One's unmediated experience of acting in the physical world is characterized by uncertainty and an awareness of corporeal vulnerability... In social interaction [we can substitute 'performance'], risk may not necessarily entail physical harm,but can also come from the imperative to act in the presence of others." Performers experience this vulnerability when they place their bodies on stage in front of an audience and subject themselves to scrutiny and the risk of mistakes. To perform they must act, and they cannot step out of the performance to reflect on these actions or their possible consequences. These are characteristics of what Heidegger calls the experience of *thrownness*[11].

It seems that this risk is an essential element of performance, since if there were no chance of mistake or mishap the audience would likely feel that they were not witnessing a true performance. Technology is often used to minimize risk, e.g. the 'undo' function in software applications. In recordings it is acceptable to use the technology of the recording studio to achieve a "perfect" rendition of a piece. However, in the case of live performance the composer must allow the possibility of imperfection or failure in order to ensure a valid performance situation.

Through appropriate use of visibility the audience can better appreciate the risk being taken. Interestingly, visibility of risk may also reduce the consequences of failure. During a performance of 'SoundBounce'[2], there was an instance where a performer clearly intended to throw a sound to another performer, but the sound ended up going to a different performer. The audience responded with laughs and sympathetic vocalizations that conveyed their participation in the event and their appreciation of the risk the performers were taking.

It seems that audiences may be willing to accept some types of mistake. However none of the participants in a concert wish to experience the type of failure that occurs during a technical breakdown, such as when a computer crashes or communication between devices fail. Perhaps this is because such failures destroy the sense of a special space that surrounds a performance. It is a risk that all performing music technologists dread, and which it seems will never disappear.

4.3 Embodiment

The body is the means by which performers interact with any instrument. Before the use of electronic remote sensing interfaces such as cameras or capacitive sensing, all instruments required physical contact with the body, and the majority of those involved the use of the hands.

The hand is exquisitely sensitive and dexterous. Like all actions, the actions of the hand can be used simultaneously to effect a result (pragmatic actions), or to explore and learn about objects and their possibilities (epistemic actions).[7] Epistemic actions are an important aspect of learning to

play a newly encountered instrument. By creating instruments that afford and sense a rich range of physical actions, we benefit from the body's ability for skilled performance and allow performers to develop kinesthetic motor memory which is fast and reliable.

The goal should be that the instrument becomes integrated into our physical experience such that we no longer notice its presence. When this occurs the instrument has become what Heidegger calls *equipment*, and he would say that it is *ready-to-hand*[3]. This state enables a feeling of transparent translation from musical intention to expression in sound. Most traditional instruments require years of dedicated practice to achieve this state. With computer-based instruments the designer confronts a tradeoff between approachability and the fine level of expression available when expertise is allowed to develop. When an instrument exists for the sake of a single piece, performers are not well-motivated to invest the time necessary to achieve true expressivity.

Part of instrument design is creating the mapping from sensor input to sound output, or from the physical world of movement to the abstract realm of musical sound. Visibility may be facilitated by using metaphor-based mappings which draw on common associations between movement and music[6]. When performers' actions are visible to the audience, and those actions are mapped to sound through motion/music metaphors that are part of the biological or cultural background shared by the audience, it will be easier for the audience to attribute causal relationships between what they see and what they hear.

5. PROTOTYPING AND ITERATION

Composition, like design, is a process of moving from the abstract – the composer's general artistic aims and the resources available to her or him – to the concrete, i.e. a specific piece and the artifacts and practices that make up its performance. Many design practitioners emphasize the importance of prototyping in this process. Making working instruments early in the compositional process allows composers and performers to try out interfaces and controls, their mapping to sound, and the interactions they enable. The prototype allows the composer and musicians to have a "conversation" with the instrument, and to explore epistemically its potentials as well as possible problems. The prototype also enables the composer and performers to have a conversation with each other *through* the instrument and serendipitously discover unexpected interactional possibilities.

For example, while creating the piece 'Colors' for mobile phone orchestra[8], the composer and performers rehearsed with early versions of the instrument, allowing them to discover and refine various interactions that became part of the final piece, such as musical "conversations" between performers and a sequential round-robin interaction similar to the game 'Simon.'

The benefits of prototyping are only available if it is part of an iterative cycle of design, prototype, test, and reflect. Enough time must be allowed for playful exploration with working prototypes, and revision based on the outcomes. More generally, given the situated and hermeneutic quality of artistic endeavors, reflection on one's own design process allows one to extend the benefits of an iterative cycle from within a single work to the larger scale of one's creative career.

6. CONCLUSIONS

Composers of music for laptop and mobile phone orchestras create not only music, but instruments and interactions. This task shares many of the features of wicked design problems, and can benefit from incorporating design practices such as prototyping and iteration. By taking into account the visibility of the technologies applied, the embodied nature of using instruments, and the risk inherent in performance, composers can better create new musical practices and therefore new opportunities for musical self-definition for composers, performers, and audiences.

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