Design considerations for technology to support music improvisation

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Abstract
Our musical culture is intertwined with our music technology. The tools available to musicians channel and influence the music created. The conceptual framework underlying the process of music creation has significant implications for the tools built to facilitate the creative process. Tools designed to facilitate music creation and interaction must reflect the needs of musicians in light of the cultural and conceptual context. In this paper I discuss the process of creative musical improvisation in an interactive environment and the resulting needs of the creator which may be addressed through new software tools.

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Music, Improvisation, Design

ACM Classification Keywords
H.5.5 Sound and Music Computing: *Methodologies and techniques*

Introduction
Our musical culture has been intertwined with our technological culture since before recorded history. Musical instruments are a prime example of this. Flutes carved from mammoth ivory are known to have been in use over 30,000 years ago in the Swabian mountains in Germany [3]. Instruments like the flute may be

thought of as musical prosthetics. They let those with a good ear but less-than-golden voice participate in musical creation.

Of course, instruments are much more than musical crutches for people without good voices. The introduction of each new instrument changes the set of musical possibilities and these possibilities help define a musical genre. Imagine jazz without the tenor saxophone, or techno without the drum machine. Rock music has been defined by the capabilities of the electric guitar even it has driven the development of guitar technology.

Music notation is another example of how our technology is intertwined with our music culture. Among other things, notation serves as a memory aid and helps coordinate musicians to play complex, differing parts simultaneously. As a compositional tool, music notation lets a composer manipulate compositional forms larger than can be held in the head, with more parts than a single person can play. Without written notation, a piece like Stravinsky's *The Rite of Spring* would be impractical (or perhaps impossible) to compose or perform.

Recording and reproduction technologies have also transformed music creation. Opera singing developed in the absence of microphones and amplifiers. Once these were created, the softer singing style of Bing Crosby became practical and popular.

Advances in recording technology have had a freeing effect on the level at which music may be constructed. Audio sampling (recording and storage of short recordings) of individual instruments, media recordings and even sections of other songs have made audio collage possible. Artists such as Beck, Public Enemy and Negativeland, along with many lesser-known DJs, now commonly create mashups and house-mixes by recombining portions of existing recordings.

In recent decades, software developers have created numerous tools to facilitate music creation. Most have focused on improving the functionality of existing technology without altering the role the technology plays in the creative process. Programs such as Finale and Sibelius are to music notation what Microsoft Word is to the creation of text documents. Software such as Garage Band, Fruity Loops and Acid make the creation of mixes and mashups easier than was possible using audio tape. Software instruments (such as the Ivory piano sampler) duplicate the functionality of individual instruments.

The limits of technology

While new technologies enable new kinds of music, they may also create new limits. A piano cannot bend pitches. Thus, someone composing on a piano will tend not to use pitch bends. The length of the typical pop song was, for decades, determined by the time period that could be recorded on a standard 78 RPM record. Standard Western music notation is designed to represent the timing and pitch of notes based on the chromatic scale and a fixed metric structure. Music compositions based on timbre, or that use different tuning systems may be difficult or impossible to notate in this system, leading composers to design compositions around parameters that are easy to notate.

Since a technology may limit creativity along one dimension even while freeing it along another, technologists must carefully consider the inherent implications of their designs. In this work, we are concerned with issues involved with facilitating musical improvisation in an interactive environment.

Improvisation is Not Composition

I follow Sarath [8] in defining music *composition* as the discontinuous process of creation and iteration of musical ideas. "The composer generates materials in one time frame and encodes the work in another" [8]. A prime characteristic of composition is a multi-layered temporality. A composer may rework sections of a piece that are broadly separated by time in the actual performance. Thus, the content of any portion of the piece may be directly influenced by and related to any other portion of the music.

Improvisation is the spontaneous creation and performance of music in real-time. In improvisation, reworking is not possible. Improvisation and composition are not the same process undertaken at different speeds. While both processes structure sounds in a temporal sequence, improvisation may described as having the Markov property, composition cannot. Thus, in improvisation, the next event is influenced by some finite set of recent events. Future events simply cannot influence current choices. This is in direct contrast with composition, where the choice of an ending may influence the beginning of a work.

In addition to this, improvisation is often undertaken in a collaborative environment, with multiple people influencing the work at any one point. In some traditions, such as straight-ahead jazz, the roles of collaborators are relatively fixed. In addition, the choices that are considered grammatically and stylistically correct are limited by the constraints of the style [4,5]. In others (free jazz) there are relatively few constraints on what any one of the collaborators may do in response to the current musical context.

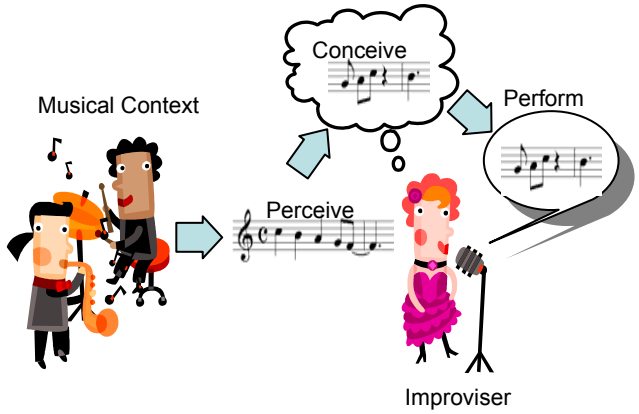

figure 1. Three phases of the improvisation process.

The task of the improviser is to collaboratively create a compelling musical experience in real-time. Each improviser is performing a three phase task. In phase one, the improviser *perceives* the constantly changing musical context. In the second phase, the improviser *conceives* of an appropriate response to the context. Ideally, this response meaningfully references the existing music and adds some element that supports new creation on the part of the participants. The improviser must then *perform* the response, in real-time. This is illustrated in Figure 1.

Designing Improvisational Tools

In the context of improvised music, the ideal assistive tool is one that facilitates the central tasks of the improvising musician. Facilitation can take several forms. A *perceptual aid* highlights elements of the musical scene so the improviser can better understand the musical context. A *cognitive aid* facilitates the selection of musical ideas to perform in reference to the current musical context. A *performance aid* may make it easier for the improviser to execute a response to the existing musical context.

Monitor speakers are an example perceptual aid, letting performers hear the full musical context more clearly. Of course, different elements of the context may be more or less important to the musical context. An improved perceptual aid might be one that highlights recurring musical motifs in the performance, making it easier for the performer to build on structures inherent in the performance. Current technology in query-by-humming [2] lets a search engine find match hummed musical themes to those in a database. This technology could be repurposed to highlight recurring themes in an ongoing music context. This would then let the performer make a more informed choice about what elements of the musical context to consider.

The most speculative area for computer aided improvisation (and perhaps most interesting) is in the creation of cognitive aids that help the performer create a contextually meaningful response to the musical scene. Such tools necessarily depend on perceptual tools that can parse the musical scene into musically meaningful elements, so that good actions may be suggested or prepared for the improviser to execute. An example creative tool might be one that perceives the tonal context is that of a G major chord and prepares four possible arpeggio patterns over G major for the improviser to select.

Music instruments and effects devices are performance aids that help the performer create responses to the musical context. Over the last few decades, computer languages for sound design (e.g. Nyquist [1] and Cmusic [6], Max, PD [7]),) let composers create music in new ways, with an emphasis on timbre development. These music programming environments have enabled the genre of computer music, but have significant learning curves and slow response cycles (often requiring a compilation step). This makes them unsuited to on-the-fly creation or live interaction.

Recently, commercial products such as Abelton Live have speeded the execution cycle, enabling live performance. Unfortunately, the interfaces of existing systems still tend to be difficult for performers to learn and the affordances are not always clear. Thus, even if the desired musical interaction is possible, the performer may not have a good idea of how to execute it. It is important to continue efforts to map tool parameters to perceptual effects in this area.

Given a particular stylistic context, performance aids may help improvisatory performers by constraining performed responses to those that fit a stylistic constraint. Tools such as pitch-correcting and one-touch organs that produce arpeggios are already in common use. Imagine a "quantize time" button for a microphone that listens to the rhythmic context of an ongoing performance and keeps the output of the clarinetist's microphone on the nearest subdivision of the beat.

Conclusions

The tools available to musicians channel and influence the music created. The conceptual framework underlying the process of music creation has significant implications for the tools built to facilitate the creative process. Tools designed to facilitate music creation and interaction must reflect the needs of musicians in light of the cultural and conceptual context. In an improvisatory environment, tools may be designed to aid the improvising musician in perceptual, creative and performance tasks. Such tools must be transparent, have clear affordances, be under control of the performer and be able to respond in the demanding real-time context of live improvisation.

Citations

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