Preparing for the unpredictable: 
Identifying successful performance strategies in human-machine improvisation

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We examine the human creative process involved in performing with Mimi (Multimodal Interaction in Musical Improvisation), a system designed for human-machine music improvisation on a keyboard or other MIDI instrument. Mimi makes use of a factor oracle data structure to generate new musical material based on seed material from a human performer. Used in conjunction with a MIDI interface that gives the performer operational control over Mimi and a visualization scheme that gives the performer advance notice of Mimi’s actions, this system presents opportunities and challenges for the improvising musician that differ from other improvisational contexts in significant ways. This study identifies and examines some strategies for successful performance with the system, including managing interpolations, transitions, and formal design, with implications for pedagogy and for future development of human-machine improvisation systems.

Keywords: improvisation; multimodal interaction; musical structure; improvisation strategies; human-machine interaction

In this paper, we explore some strategies employed in performances with Mimi (Multimodal Interaction in Musical Improvisation), a human-machine improvisation system that uses a visualization scheme to give performers advance notice of Mimi’s actions (Francois et al. 2007, François 2009, François et al. in press-a).

The Mimi system is designed by François and collaborators for human-machine improvisation on a keyboard or other MIDI instrument. Mimi can
take musical material provided by a musician, encode it as a factor oracle (Allauzen et al. 1999)—an efficient data structure first used by Assayag and Dubnov (2004) in music improvisation—and recombine the material as improvisations on the learned input. In the OMax systems by Assayag and collaborators, in addition to the improvising musician, a second performer at the computer manipulates the audio generated by the factor oracle. With Mimi, the improvising musician has full operational control of the system and can affect Mimi’s learning state, improvisation state, memory, recombination rate, and playback volume through a MIDI controller. A piano roll-style visual display gives the user information on the current state of the improvisation engine, a ten-second heads-up for the music the machine will soon play, and ten seconds’ review of music the user recently played together with Mimi. Figures 1-3 show screenshots from Mimi. The lower panel shows the music in Mimi’s memory, with a cursor indicating the portions of music used in the recombined material; the upper panel shows a scrolling timeline of the notes to be played and recently played (notes sound when they cross the centerline). Mimi has been deployed in performances, and employed in an installation for high-level structural improvisation using four instances of Mimi (François et al. in press-b).

We have discovered in our research that Mimi’s interactive visualizations play an important role in assisting the improvising musician in the act of planning and orchestrating a performance. WoMax (Lévy 2009), an offshoot of OMax, offers an alternative visualization scheme that displays the links created by the factor oracle. Relatively few studies have examined the human experience of performing with human-machine improvisation engines. A study by Addesi and Pachet (2005) examines the ways children interact with the Continuator (Pachet 2003), another human-machine improvisation system. Related to improvisation planning, Dubnov and Assayag (2005) proposed a method of quantifying novelty and varying the sequence and flow in OMax. Studies of performers’ experiences with human-machine improvisation systems may be useful to researchers interested in better modeling of human improvisation, to music pedagogues interested in formalizing improvisation strategies, and to performers interested in pursuing new modalities for improvisation. This study examines the human creative process and some of the improvisation strategies involved in performing with Mimi.

**MAIN CONTRIBUTION**

Improvisations performed with human-machine systems like Mimi present their own distinct set of challenges and benefits for the human performer
apart from the issues that typically arise in improvisation between human performers. In the following sections, we outline some strategies that can be used to help guide a performer in both preparing for, and playing with, a system like Mimi. These strategies were discovered over the course of several months by the first author practicing and performing with the system. Examples are taken from live performances at the People Inside Electronics concert at Boston Court Performing Arts Center in Pasadena, California, USA, on 5 June 2010, and the Ussachevsky Memorial Festival concert at Pomona College on 4 February 2011 (videos of these performances and others are viewable online at www.youtube.com/mucoaco).

Interpolations

Mimi’s visualization scheme, which gives advance notice of Mimi’s actions, affords the performer unique musical opportunities not ordinarily available in the course of improvisation. Improvising musicians are not normally privy to the exact details of the immediate plans of other improvisers, but with Mimi, the improviser is also able to plan a precise reaction to musical material before it sounds, adding a compositional element to the interactions. Thus, the performer’s actions can become intertwined with Mimi’s in an intimate and almost seamless way.

The performer may choose to interpolate material that leads up to a musical event, departs from an event, or links two events. Figure 1 shows one example of a musical phrase, generated by Mimi, which is then elaborated on with interpolations improvised by a human performer both before and during the phrase. The final result is a synthesis of two or more musical ideas that nonetheless can be perceived as a single phrase.

As a side effect of its data structure, Mimi may occasionally recombine two segments of material that seem disjunct in terms of range or dynamics. In cases like these the performer can “smooth out” this boundary through the interpolation of connecting material. Figure 2 shows one instance of such a boundary, where the performer plays a series of ascending chords to lead up to what would have otherwise been an abrupt chord onset.

Transitions

Transitions between different musical sections or ideas present particular challenges for the performer improvising with Mimi, since the performer has no direct control over what Mimi chooses to play, and Mimi does not respond directly to the performer as a human improviser would. For example, a human improviser would be likely to respond immediately to a change in har-
Figure 1. A musical phrase generated by Mimi before it is played (left, circled) and after it is played (right), with interpolated material by a human performer (circled).

Figure 2. An abrupt chord entrance by Mimi before it is played (left, circled), and after it is played (right), with connecting chords by a human performer (circled).

Figure 3. A new pitch introduced by the human performer (left, circled) and then reintroduced by Mimi (right), with a new harmonization by the human performer (circled). (See full color versions at www.performancescience.org.)
mony or texture, while Mimi cannot do so (though Mimi may learn from that material and perform that change at some point in the future). Therefore, the performer who wishes to incorporate musical transitions into an improvisation must use more indirect methods.

It is possible to create gradual harmonic transitions through the use of common tones or common chords. For example, the performer can at any time introduce new tones that complement the existing texture. As Mimi incorporates these new tones into its data structure, over time it may move to introduce these new tones into its musical tapestry, and the performer may move to a different sonority that incorporates those tones. By stringing several transitions of this sort together, long-term harmonic progressions can be created, if the performer so wishes. Figure 3 demonstrates one example of a common-tone transition.

Mimi’s controls also give the performer the option of clearing Mimi’s memory of all musical material. This is a more drastic transition strategy, but it is effective in creating large structural boundaries in an ongoing improvisation. Other issues relating to formal design of improvisations with Mimi are discussed in greater depth elsewhere (Schankler et al. 2011).

**IMPLICATIONS**

Mimi’s visualization scheme can serve as a support for planning, exploring, and studying improvisation strategies. The strategies developed for successful performance with Mimi may be applicable to other systems, or to performance with other human improvisers. The visuals may also help listeners intuit the kinds of online problem solving that improvisers engage in: contrast, interpolation, and transitions. Thus, systems like Mimi may be able to play a powerful role in improvisational pedagogy, not only for the performing musician, but also for the active listener. There is a strong indication that Mimi shapes the habits of performers, but further study is needed to determine what those effects are, and if they are consistent across a large group of performers.

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