# Duet for Solo Piano: MirrorFugue for Single User Playing with Recorded Performances

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## Abstract

MirrorFugue is an interface that supports symmetric, real-time collaboration on the piano using spatial metaphors to communicate the hand gesture of collaborators. In this paper, we present an extension of MirrorFugue to support single-user interactions with recorded material and outline usage scenarios focusing on practicing and self-reflection. Based on interviews with expert musicians, we discuss how single-user interactions on MirrorFugue relate to larger themes in music learning and suggest directions for future research.

## Keywords

Music Learning Interfaces, Augmented Reality, Visualization, Tangible User Interfaces

## ACM Classification Keywords

H.5.1 Multimedia Information Systems

## General Terms

Design, Human Factors

## Introduction

MirrorFugue [9] is an interface to support real-time collaboration between two users on the piano. Based on the idea that the visibility of gesture helps with learning and synchronization, MirrorFugue communicates the hand gesture of a collaborator using metaphors from the physical world to connect two disparate spaces.

We designed two modes of MirrorFugue, which we called "Reflection" and "Organ". Inspired by the reflective surface on a lacquered grand piano that mirrors the keyboard and player's hands, Reflection mode displays the mirrored keyboard and hands of the collaborator. Organ mode also employs the vertical surface in front of the keys but displays the unaltered, top-down image of the collaborator's keyboard like the aligned and offset keyboards on an organ. Organ mode implies a side by side relationship between the collaborators while Reflection mode gives the impression of collaborators across from each other.



**figure 1.** The Reflection and Organ modes of MirrorFugue

MirrorFugue was originally designed to supplement remote piano lessons. In an informal user study, we showed that seeing the to-scale hands of a teacher at the interaction locus of the keyboard helps students learn not only what to play but also how to play with the proper hand motions.

We have expanded MirrorFugue to include single-user interactions with recorded material to support daily practice and self-reflection at the instrument. In this paper, we first present the system design and outline a set of usage scenarios. We then summarize previous work in computer-aided musical practice tools. Finally, we discuss how MirrorFugue relates to larger concepts in music learning based on interviews with expert musicians. We conclude by suggesting directions for future research motivated by the interviews.



**figure 2.** Two users playing a duet on a collocated arrangement of MirrorFugue

## Design and Prototype

MirrorFugue is built on a MIDI keyboard with a projection display in front of the keys and an overhead camera to capture the keyboard and user's hands. We have implemented a feature to allow users to record and playback performances. Recordings are stored as video synchronized with MIDI sequences to enable playback at different speeds without audio distortion. Our prototype uses a keypad as controller.

The keyboard and hands in recorded performances are aligned and to-scale with the physical keyboard, creating a shared reference between the physical and virtual spaces. Since the virtual keyboard does not interfere with the space of the physical keyboard, users can layer their own playing with the recorded material, creating the impression that they are playing a duet with the recorded pianist.
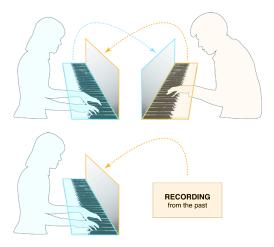


**figure 3.** Diagram of two-user mode (above) and single-user mode (below) of MirrorFugue

## Scenarios

Single-user interactions on MirrorFugue can be divided into two categories based on whether the user interacts with recordings of the self or of another, such as a teacher or other expert. For both types of interactions, the user can either study the recording by watching or choose to play along. We describe specific usage scenarios and discuss how they can supplement practicing and self-reflection.

*Recording of Self*
Users can record and examine their own performances using MirrorFugue. The to-scale video of the hands gives students an outside perspective to their own playing. The integration with the physical keyboard facilitates self-evaluation during practice sessions by enabling students to seamlessly transition between playing and reflecting.

Users can also play along with recorded passages of their own playing. Classical piano repertoire beyond the absolute basics involves complex coordination of the hands, and it often takes weeks for a student to be able to play a new piece in its entirety. With MirrorFugue, a student practicing a classical piece can record a portion of the piece and supplement the rest while playing along with the recording. For example, the student can record one hand's part and practice the other hand's part with the recording. This allows the student to experience the big picture of a piece at an earlier stage in the learning process. Playing along with recorded material can also make practice more engaging by supplying musical context for technical drills.

Jazz students can use MirrorFugue to supplement improvisation practice. Jazz piano often requires one hand to hold a steady pattern while the other improvises. Beginners may lack the physical coordination to keep the pattern steady. MirrorFugue can be used as improvisation training wheels, allowing a student to record a chord progression or bass line and improvise over the looped recording.

*Recording of Others*
Users can interact with the recording of another pianist, such as a teacher or other expert. Watching an expert

performance at the piano can support learning by imitation. When learning a classical piece, a student can review expert performances on MirrorFugue to learn the fingering and technique of difficult passages. The student can slow down the video to better understand the hand motions and mirror the movements of the expert on the physical keyboard.

MirrorFugue can also supplement learning by ear. Jazz students often learn to play improvised solos from recordings of musicians they admire. Because improvisations are rarely written down, students must figure out all the notes by ear, a difficult task especially for a beginner whose listening is not yet so developed. Using MirrorFugue, students can supplement what they hear with what they see and play along with the expert recording to learn the passage.

Users can also play duets with the expert recording. A jazz pianist can practice improvisation over a recorded performance, using the display to better anticipate upcoming passages in the piece. A classical pianist can practice parts of a piece "karaoke style", with the expert performance playing in the background.

## Related Work
MirrorFugue as a tool to support piano practice takes a different approach from most computer-aided music practice systems, which use the computer to analyze and display abstract, graphical feedback to student playing [2, 7, 8].

Some practice support interfaces, such as iMaestro [5] and IDVT [7] for violin and Lin et al.'s virtual piano tutor [4] include a gesture display to show students how to play difficult passages. The piano tutorial videos included with Apple's GarageBand [3] feature a close-up view of the teacher's hands at the keyboard. MirrorFugue builds on the insight of these examples by integrating the gesture display at the interaction locus of the piano keyboard.

System like as Oshima et al.'s Family Ensemble [6] are based on the idea that playing with others can enhance the practice experience. MirrorFugue's single-user mode gives a sense of presence to the recorded performer, lending the impression that the user is playing with another person.

## Discussion and Future Work
The design of single-user interactions on MirrorFugue was influenced by interviews that we conducted with expert pianists on their learning process and practice methods. We interviewed three musicians: a classical pianist, a jazz pianist, and one known for combining both genres. While our interviews results are not statistically significant, they did suggest interesting directions for our research. Three themes from the interviews were especially relevant to our designs: physicality, social playing, and staying fully engaged during practice. MirrorFugue is our first step in designing interfaces to support music learning that explore these ideas. We discuss each theme in detail and outline directions for future research.

*Physicality*
In both classical and jazz, watching the physical movements of a performer helps with understanding both technique and expression. The cross-genre pianist described how he understood the way a student produced a certain quality of sound by watching the "wave motion" of her hand. The jazz pianist noted how

watching Thelonious Monk perform piano with erratic dance movements helped him figure out how music "resonated" in his own body.

MirrorFugue makes visible the hand gesture of a piano performance, but playing piano also involves movements of the wrists, arms, shoulders, and feet. Even the head movements and facial expression of the pianist contribute to the feeling of the music. In the future, we plan to extend the display in MirrorFugue to show the entire upper body of a pianist.



**figure 4.** Mock-up of MirrorFugue displaying the full upper body of a collaborator and the score

*Social Playing*
All three pianists emphasized the importance of playing with and for others. The classical pianist suggested that "there's a kind of thinking which only happens with other people present" that is useful in understanding a complex piece of music. The jazz pianist described how many of his most profound learning experiences have occurred on stage.

Playing with others can be a source of new musical ideas. The jazz pianist explained how he developed his skills by playing with better musicians. Playing with others can also make practicing more fun. The cross-genre pianist cited his most enjoyable early memories of music learning as those from social experiences.

Musicians often use audio recording to simulate social playing. The classical pianist frequently records himself to critique his playing, replicating a third person perspective. The jazz pianist commented that playing with a recording can mimic the feeling of playing with others though a recording can never completely replace the intricacies of interaction with real people.

MirrorFugue simulates the presence of a remote or recorded collaborator. We plan on conducting user evaluations to determine how much the simulated presence of a collaborator can replicate the feeling of playing with co-present people.

*Staying Engaged*
All three stressed the necessity of staying fully engaged whether during practice or performance. Csikszentmihály terms the state of full engagement as "flow" [1]. People commonly experience flow in goal-directed systems where one's skills match the challenges at hand.

To maintain awareness of the goal when learning a piece, all three experts prefer to start with the big picture. The classical pianist likes to "make a sketch" with the "right gestalt" and then come back to fill in details. The cross-genre pianist begins a piece by analyzing its harmonic structure and finding where technical difficulties may occur.

Balancing one's skills and challenges during practice involves making sure tasks are neither too difficult to be discouraging nor too easy to be dull. When learning improvisatory passages by ear, the jazz pianist initially used pre-written transcriptions to verify his playing. When practicing difficult passages, the cross-genre pianist varies the material to avoid rote repetition.

MirrorFugue helps amateurs stay aware of the big picture and maintains musical interest while the user practices technical details. In the future, we plan to explore other information to show on the MirrorFugue display that are useful to a musician's practice without being a distraction.

## Conclusion

We presented an extension of MirrorFugue to support single-user interactions with recorded material and outlined usage scenarios. We discussed how MirrorFugue relates to concepts in music learning from interviews with expert pianists. Based on the interviews, we identified directions for future research.

## Acknowledgements

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