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# MirrorFugue2: Embodied Representation of Recorded Piano Performances



**Figure 1:** Grand prototype (above); upright prototype with user (below)

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## **Abstract**

We present MirrorFugue2, and interface for viewing recorded piano playing where video of the hands and upper body of a performer are projected on the surface of the instrument at full scale. Rooted in the idea that a performer's body plays a key role in channeling musical expression, we introduce an upper body display, extending a previous prototype that demonstrated the benefits of a full-scale hands display for pedagogy.

We describe two prototypes of MirrorFugue2 and discuss how the interface can benefit pedagogy, watching performances and collaborative playing.

## **Author Keywords**

Piano; Music Learning; Embodiment; Augmented Reality; Video; Tangible Interfaces

## **ACM Classification Keywords**

H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems

## **Introduction**

Though musical instruments are played with specific parts of the body, masterful performances requires full-body involvement. Consider the piano: though the

fingers strike the keys to make sound, the entire body is essential beyond the basic task of playing notes for both technique and expression. To produce a wide range of tones, a pianist must precisely control the position, tension and movement of the shoulders, arms and wrists. Both subtle movements of the hands and wrist and large-scale movements of the body channel expressive qualities of the music performed [11].

The communication of expressive intent through musicians' body movements has been observed in several studies [4, 5, 12]. Audiences are able to identify specific emotional intentions such as sadness, anger and happiness through video clips of movement alone [4]. Musically naïve subjects perform even better at identifying expressive intent when only watching compared to listening and watching and listening conditions [5, 12]. Research with the help of movement tracking has significant difference in range of head movement between deadpan and projected performances [6].

Based on the idea that observing the body movements of a performance can contribute to deeper musical understanding, we introduce MirrorFugue2, which displays life-sized video of a pianist's upper body and hands at the piano. We present prior work influential to our design, describe the two prototypes and detail application scenarios.

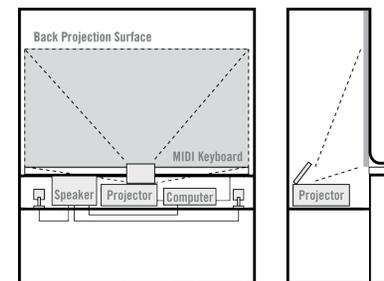
### Related Work

Our design incorporates lessons from research in video-based remote collaboration interfaces. We were especially inspired by ClearBoard, which featured overlay of the remote collaborators face an upper body with shared drawing surface, seamlessly combining

interpersonal space and shared workspace [9]. A series of experiments on interface variations regarding the body and space between collaborators revealed some guidelines on perception of presence. A life-sized video or slightly smaller is more effective than much smaller videos at simulating presence [8]. Including the upper body in the framing tends to increase participants empathy over head-only framing [10]. Addition of spatial cues to collaborator's video also contributes to copresence [7].

### Design and Prototypes

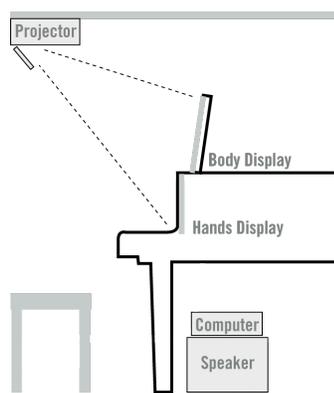
We extend previous work that displays video of a pianist's keyboard and hands in front of the keys by adding video of the face and upper body [13]. Based on the metaphor of a pianist's reflection on the surface of a lacquered piano, video of the body is displayed mirrored and at full-scale. The position and scale of the projected body implies an interpersonal distance of about three feet between the video and a seated user. We built two prototypes based on form factors of upright and grand pianos.



**Figure 2:** Diagram of upright prototype

#### *Upright Prototype*

We constructed one prototype as a custom wooden case around a full-sized MIDI keyboard made to resemble an upright piano with the entire frontal plane above the keyboard as a rear projection surface. A short throw projector, computer and



**Figure 3:** Diagram of grand prototype

speakers sit within the body of the piano. We mounted a sheet of darkly tinted acrylic in front of the projection surface to mimic the reflective surface of an actual piano. The acrylic also reflects the body of a user as appearing in the same space as the virtual pianist.

### Grand Prototype

While the upright prototype satisfactorily demonstrates visual form, its MIDI keyboard is insufficient for serious playing. We constructed a second prototype built on an acoustic grand piano by installing projection surfaces in place of the keyboard cover and music stand for video of the hands and body, respectively. To ensure that a seated user does not obscure the displays, we installed a short throw projector 5.5 feet overhead the piano bench.

### Content

We recorded video at 1280x720p on a grand piano with two cameras, one overhead to capture the entire keyboard and the other mounted at the end of the piano to capture the upper body. We also recorded high quality audio with a separate device.

Video and audio streams were combined with Adobe After Effects [1]. Playback and control was programmed using Max 5 [2].

### Applications

MirrorFugue2 can be used for three types of applications which benefit from seeing the body language of a performer.

- *Learning:* A student can watch a teacher's demonstration on our interface for reference on fingering, technique and expression.

- *Watching:* Anyone can watch a piano performance on our interface for an intimate view of a performer's hands, facial expressions, and upper body gesture.
- *Duet Playing:* A real-life pianist can play a duet along with the virtual pianist, using the video for visual cues for timing and anticipation.

Content on the interface can be live-streamed remotely or pre-recorded. A pianist can even interact with the recordings or the self, watching or playing along.

### Future Work and Conclusion

We presented the design and implementation of an interface for playback of piano performances that features life-sized video of the pianist's hands and body projected onto the instrument.

We are continuing development of a prototype on a Yamaha Disklavier [3], where the keys move as if played by the projected pianist. We are exploring how the implied cause and effect between the digital and the physical can intensify the sense of presence of the virtual pianist.



**Figure 4:** Prototype on Disklavier with actuated keys

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## References

- [1] Adobe after effects. <http://www.adobe.com/products/aftereffects.html>.
- [2] Max MSP. <http://cycling74.com/products/max/>.
- [3] Yamaha Disklavier. <http://www.yamaha.com/disklavieroffer/>.
- [4] S. Dalh and A. Friberg. Visual perception of expressiveness in musicians' body movements. *Music Perception*, 24:433–454.
- [5] J. Davidson. Visual perception and performance manner in the movement of solo musicians. *Psychology of Music*, 21:103–113.
- [6] J. Davidson. What type of information is conveyed in the body movements of solo musician performers? *Journal of Human Movement Studies*, 6:297–301.
- [7] J. Hauber, H. Regenbrecht, M. Billinghamurst, and A. Cockburn. Spatiality in videoconferencing: trade-offs between efficiency and social presence. In *Proc. CSCW '06*. ACM.
- [8] Y. Ichikawa, K.-i. Okada, G. Jeong, S. Tanaka, and Y. Matsushita. Majic videoconferencing system: experiments, evaluation and improvement. In *Proc. ECSCW '95*, Kluwer Academic Publishers.
- [9] H. Ishii, M. Kobayashi, and J. Grudin. Integration of inter-personal space and shared workspace: Clearboard design and experiments. In *Proc. CSCW '92*. ACM.
- [10] D. T. Nguyen and J. Canny. More than face-to-face: empathy effects of video framing. In *Proc. CHI '09*. ACM.
- [11] Ortmann, O. *The Physiological Mechanics of Piano Technique*. E. P. Dutton, New York, NY, USA, 1929.
- [12] H. Shinosako and K. Ohgushi. Interaction between auditory and visual processing in impressional evaluation of piano performance. In *Proc. of the Third Joint Acoustical Society of America and the Acoustical Society of Japan*, pages 357–361, 1996.
- [13] Xiao, X., and Ishii, H. Mirrorfugue: communicating hand gesture in remote piano collaboration. In *Proc. TEI '11*. ACM.