MotionDraw: a Tool for Enhancing Art and Performance Using Kinect

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Figure 1: Abbie Wang dances with MotionDraw.

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Abstract
Contemporary staged performances frequently utilize advanced lighting and projection techniques. The design and creation of these stage effects are rarely accessible to the actual performers and must be designed by professional lighting designers or highly-paid programmers. With MotionDraw we want to create an affordable system that is easily controlled and manipulated by performers. With intuitive gestures, non-specialized users can control the MotionDraw visual library and interact with the captured visual record of their own movements. Possible uses for our system grew out of research with dancers and performers, and the current technical implementation sets a framework for including additional visual libraries and capabilities.

Author Keywords
Projection, drawing, real-time, Kinect, interactivity, design, experimentation, performance.

ACM Classification Keywords
H.5.m [Information Interfaces and Presentation]: Miscellaneous.; J.5 [Arts and Humanities]: Performing arts.

Introduction
Computer graphics, projection techniques, animations, and professional lighting enable effective stage effects in large-scale events that support the combination of live perfor-

mance, such as dance, and digital arts[1,2,3]. However, creating those exciting environments comes with the high cost of specialized hardware and often with dedicated software developed by professional programmers. MotionDraw, a Kinect-based tool that augments performance with projected visualizations created from tracked live movements of users, enables artists, performers, dancers and even the audience to easily design, create and control hybrid digital performances. In this paper we present the motivation and research that led to the development of MotionDraw, including a historical perspective on visual and digital arts. We describe the technical implementation of our system and the results of its deployment with dancers.

Figure 2: A concept drawing for MotionDraw by Emily Grenader.

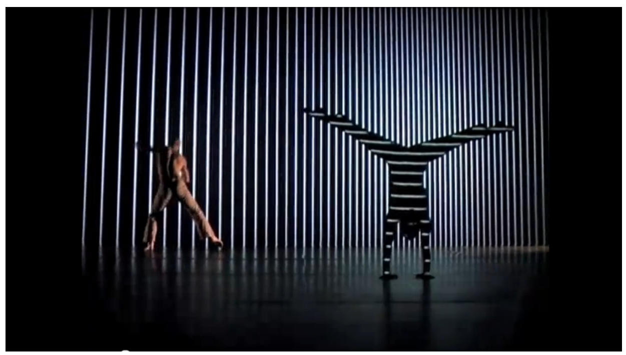


Figure 3: From the Performance "Apparition" by Klaus Obermaier and Ars Electronica Futurelab

Motivation, Inspiration, and Research

Inspired by the way photography began as a scientific tool, and later became an art form, we wanted to explore how the Kinect tool could be used to enable art and performance. In his photograph from 1884, shown in Fig. 4, Etienne-Jules Marey tracks a man's motion using multiple exposure photography. Even though the rationale of creating this photograph was a scientific study of motion, it is evident that the result is also an aesthetically interesting image.

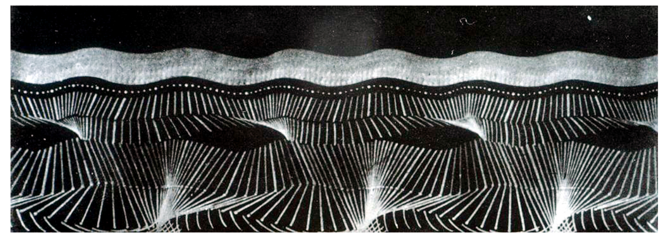


Figure 4: "Chronophotographic Image Formed by Man Walking in Black Suit with White Stripes", Etienne-Jules Marey, 1884

To aid us in the design of our application, develop and validate our idea, we conducted small research interviews with seven dancers from UCSD's dance department. We asked the dancers about their prior experience with the combination of dancing, projection and computing. All interviewees had seen large-scale performances that used technology and/or projection to enhance the performance, but none had been given the opportunity to work with computing or projection themselves, even though most of them expressed interest in doing so. Given that dancers usually have very little control over what is happening on the stage, we saw this as further opportunity to develop an application that would be easy to use for performers, therefore changing the established system. From the beginning our ultimate goal was to enable professional performers, students, and at-home users to create visual interactive effects that they can easily control with intuitive gestures.

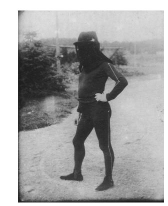


Figure 5: The man in suit photographed in Fig. 4

[1] "Apparition" by Klaus Obermaier and Ars Electronica Futurelab, http://www.exile.at/apparition, Fig. 3
[2] "Living room" by Recoil Performance, http://goo.gl/inDto.
[3] "Mortal Engine" by Chunky Move, http://www.youtube.com/watch?v=sbjOMualLVs.

The dancers we interviewed were interested in real-time creation of visual effects—projections on a stage that respond to their movements—but they also showed interest in post-processing possibilities that would augment a recorded performance with digital artifacts—such as fine tuning the data captured from their dance by adding effects in external 3D applications. The idea of drawing with movement, as proposed by us (body movements being drown as "brush strokes" on screen) was well accepted by the interviewees.

We were surprised that most of the dancers would not mind having another person *conducting* their performance. Many of them thought that improvising in collaboration with an external *conductor* would be a great experience, and actually preferred this set-up, wanting to also experiment with acting as the conductor themselves. As expected, our interviews showed that practicing dancers are very interested in enhancing their performance with interactive projection and computing, but that the technology to do this is not easily accessible to them at the moment. Each of the dancers we interviewed thought that drawing with motion using Kinect technology and having a conductor that would direct part of the performance would be an attractive solution to this problem. We will describe how we achieved this goal in the remainder of this paper, after situating our work within previous research in this setting.

Related Work

Previous projects use visual displays in order to augment performance. For example, dancer and choreographer Merce Cunningham frequently worked with digital artists and musicians to place dancers into dynamic visual environments. In *Hand-drawn Spaces*[4] from 1998, Cunningham worked with the *OpenEndedGroup* to create displays of multiple abstract figures across many screens using motion capture. In 2002 during a performance at Purdue University, W.S. Meader and colleagues explored interactive dance with the use of a motion-capture suit worn by a dancer that created a projected, mirror-image visualized character. This character, mimicking the moves of the real dancer, interacted by becoming abstracted, changing size, and using different camera angles [1]. In this kind of performance, although the choreographer can be in close conversation with the computer operators and graphic artists, the dancers and choreographers do not have any way to easily make changes to the graphic display on their own.

Projects like Sandde[5] allow for three-dimensional digital drawing using gesture, but rely on hardware (a magnetic pen) to track movement. A project by Raptis et al. [2] focuses on the recognition and classification of a set of predetermined dance gestures. While this work is more related to computer vision research, the ability to recognize specific dance moves provides an interesting feature.

Since the release of the Microsoft Kinect device, there have been several efforts towards integrating art and motion-tracking technology. Super Mirror [3] brings the low-cost possibility of using the Kinect into dance instruction, functioning as an "augmented mirror". Alexiadis et al. [4] used Kinect technology for a similar project that provides real-time evaluation of dancers with visual feedback, and also supports evaluation of one dancer's performance against another. Both of these projects have instructional or evaluational purposes, and are not aimed at performances. Crossole by Sentürk et al. integrates gesture tracking and sound manipulation, which allows the user to modify characteristics of the music [5]. Kinect has also been integrated

[4] "Hand-drawn Spaces" by Merce Cunningham and OpenEndedGroup, `http://openendedgroup.com/artworks/hds.html`.

[5] "Sandde - Stereoscopic animation drawing device", `http://www.sandde.com`.

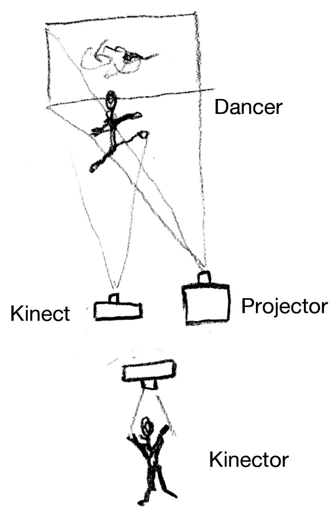


Figure 6: Two-Kinect set-up

into professional performances as in *.cyclic.*, a collaboration between University of Waikato and Stellaris dance in New Zealand, where choreographers and computer scientists created an interactive performance [6]. This project depends highly on each individual collaborator's ability to complete a task, and remains inaccessible to everyday users.

The MotionDraw System

MotionDraw consists of a set-up with one or two Kinects, that record the position of joints of a person's body over time and draws the resulting trail on a 3D canvas. One Kinect points at the dancers and tracks their movements. A GUI-based control panel, enables a separate user to change the parameters of the projected drawing in real-time, such as (a) change the color and width of the trails, (b) move the position of the camera-view, and (c) enable or disable the visualization of specific joints tracked. The program also saves the Kinect stream to a file for further post-production.

With a two-Kinect set-up (Fig. 6) the second Kinect captures a "conductor" (from here on, referred to as the *KinecTor*) who can interact directly with the MotionDraw system and change the visualization parameters through gestures. This integration is covered in more details below.

MotionDraw is designed to be simple and extensible. In our system, users can easily control the interface in different ways, communicate with external software, and export the recorded data for further processing. In the remainder of this section we explain the different components behind the system, while Fig. 7 illustrates MotionDraw's main software architecture.

Graphical User Interface

The user interface is built using *OpenFrameworks*, specifically, using a plugin named *ofxUI*[6]. It is composed of one window, on which it is possible to switch from a *Viewer* perspective to a *Control Box* perspective, and vice-versa. A 3D drawing is presented in the Viewer window and users have options to select different Kinect devices in the Control Box window (Fig. 9). Here, users are able to change options such as color, width, tail and visibility, for all skeleton joints. The 3D drawing on the viewer window is achieved by processing data received from a Kinect device using OpenGL.

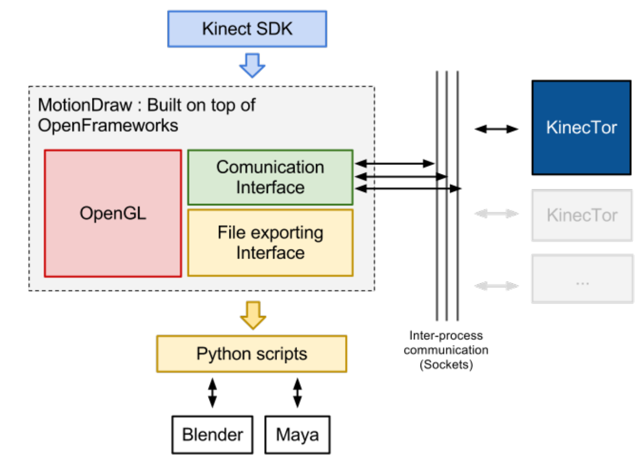
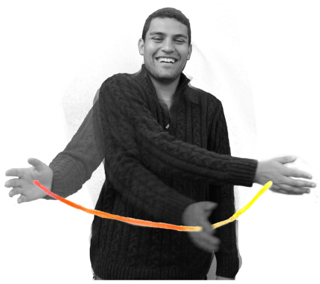
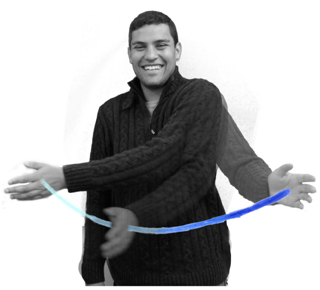


Figure 7: MotionDraw architecture. The Kinects communicate directly with MotionDraw (the Kinect tracking the dancer) or over an IPC interface (one or more KinecTors, on the right). The OpenGL interface (on the left) is responsible for the graphical representation that is projected on the stage. MotionDraw also supports directly exporting the tracking of the joints to external tools such as Blender and Maya for post-processing, through dedicated Python scripts (bottom).

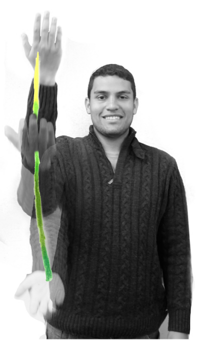
[6]Filip - "ofxUI" a new GUI addon for openFrameworks projects, `http://goo.gl/NLxUt`



Rotate point-of-view



Zoom in and out



Change paint color

Figure 8: KinecTor gestures.

KinecTor
The modular architecture enables external plugins to communicate with the MotionDraw application and control the main visualization. One of these plugins is the KinecTor. As in an orchestra, the KinecTor works as a conductor, enabling users (i.e., dancers) to participate in the performance by changing the way the dancers inputs are processed. By using a dedicated Kinect to implement the KinecTor, we enable users to interact with the system directly with gestures (as a conductor) without having to use a standard computer interface based on mouse and keyboard. This approach further supports the hands-free paradigm expanding it to the conductor as well. Figure 8 illustrates the use of the KinecTor and the gestures employed by the conductor.

While the KinecTor represents one way to tune visualization parameters, the flexible architecture of MotionDraw makes it possible to use other input devices or other interaction metaphors as an interface to the projected visualization. We envision a range of possibilities in this setting and discuss this further in the *Future Work* section.

Inter-Process Communication
In order to support two or more Kinect devices interacting with MotionDraw through the KinecTors, we developed a general Inter-Process Communication (IPC) interface that enables any outside applications (Kinect or non-Kinect based) to control the way MotionDraw processes the user's inputs. We based the IPC implementation on sockets and dedicated messages passed across machines interconnected through a network.

Post-Processing
MotionDraw also allows users to create self-contained recordings of performances and work on it offline, using a log of tracked movements as recorded by the Kinect. In this way, MotionDraw makes it possible to use different software packages for post-processing purposes, such as importing the recorded data into tools, like Blender or Maya.

Results, Initial Evaluation and Future Work
We employed MotionDraw in a live performance with two dancers, Tony Ho and Abbie Wang, who volunteered to perform for a few people accompanied by a solid set-up containing music and a projector for visual effects. Our system was used to track the movements of both dancers. An opera singer also accompanied the performance, while acting at the same time as the conductor, using our KinecTor interface.

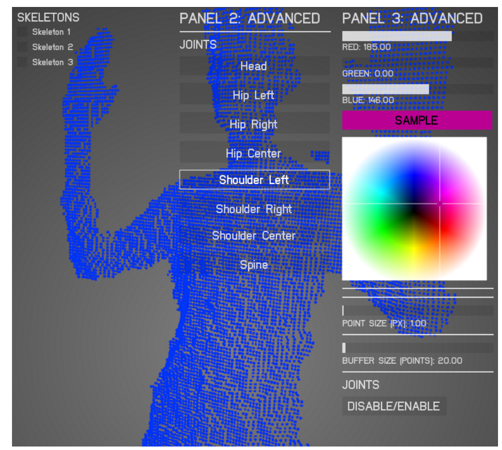


Figure 9: MotionDraw Control interface

Although the event was informal, it was possible to gather initial feedback from both the audience and the dancers. We found that MotionDraw did indeed provide the performance with an additional level of interaction and visual effects, which both the audience and the dancers found to be pleasing. However, since the system is in an early stage of development, the range of possible effects and interactions

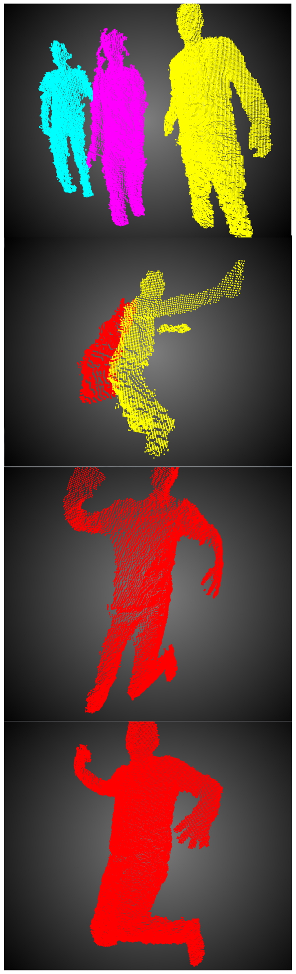


Figure 10: Point cloud representation generated with MotionDraw.

that we could implement was limited. Nevertheless, the flexibility and extensibility of MotionDraw enable the creation and easy integration of new effects both for real-time and post-processing.These can be added to the existing library of visualizations and used by novice KinecTors.

We are further developing the graphical and interactive functionality in MotionDraw. In particular we would like to support following functionality:

- Interactivity among dancers (e.g. touch of hands) as a trigger for changes in the display.
- Interacting with the actual projection - touching the projected drawing and influencing the projection.
- Relate the position of the projection to the body's position in order to create a shadow or completely cover the performer with the drawing.
- Improve real-time graphics with filters or point cloud effects (see Fig. 10 shows an example).

We are also considering alternative scenarios where the audience could be directly involved as the KinecTor or two dancers as each other's KinecTors. Figure 11 illustrates those scenarios. Additionally, MotionDraw would also be suitable for use via the Web to bring people from different places together in an online dance collaboration.

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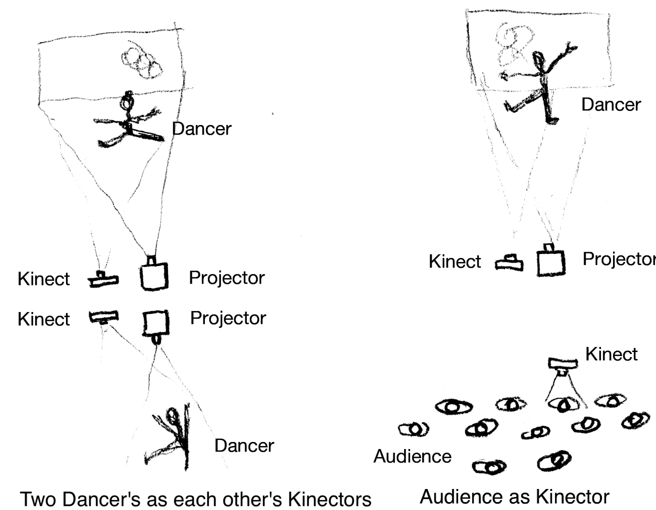

Figure 11: Future set-up

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