Exploring the Design Space in Technology-Augmented Dance

Celine Latulipe
David Wilson
Sybil Huskey
Melissa Word
Arthur Carroll
Erin Carroll
Berto Gonzalez
Vikash Singh
University of North Carolina at Charlotte
Charlotte, NC 28223 USA
[clatulip, davils, sdhuskey, mword, aacarrol, e.carroll, agonza32, vsingh7]@uncc.edu

Mike Wirth
Queens University of Charlotte
Charlotte, NC 28274 USA
wirthm@queens.edu

Danielle Lottridge
University of Toronto
Toronto, ON 54321 Canada
danielle.lottridge@utoronto.ca

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Abstract
In this paper we describe the process and technology behind a dance performance, "Bodies/Antibodies," that will be presented at CHI 2010. This performance is part of an ongoing Dance.Draw project at the University of North Carolina at Charlotte, which investigates lightweight methods for integrating dance motion with interactive visualizations and enhancing audience interaction with dance.

Keywords
Embodied interaction, interactive dance, gyroscopic mouse, 3D accelerometers.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design

Introduction
There have been many attempts, some more successful than others, to blend dance performance with various modern technologies. The potential for interesting interactions between the triad of the dancer, the audience member, and some technological effect is intriguing to many choreographers. The intrigue goes the other direction as well, with many researchers and developers in the technical world wishing to see how

their marvels can influence and pervade the dance world. Of course, these two different groups bring different mandates and desires to the table, and finding common ground can be difficult. At the University of North Carolina at Charlotte, a modern dance choreographer and a computer scientist have found common ground and have brought to the dance stage a multidisciplinary team that seeks to push boundaries while maintaining balance between technological wizardry and the simple beauty of human movement.

Design Space and Goals

Our goals are to investigate better sensing systems for dance motion input, investigate IT support for creative dance design and investigate technology to increase audience interaction in dance. Through this project we are exploring a multi-dimensional design space for technology-augmented dance. The technology design dimension involves investigating a variety of inexpensive, portable techniques to capture dancers' motions. The choreographic axes we are exploring are twofold: developing new choreography versus adapting existing choreography, and augmenting pure movement choreography versus augmenting narrative choreography. The interaction axis spans acceleration, velocity, and (eventually) location-based control of visual and audio representation. The artistic axis spans very abstract, geometric visuals to more explicit representational forms. The participatory axis is one that we have not yet begun to explore, but it will involve the investigation of audience response tools to impact the direction of a live dance performance.

In this paper, we discuss related work, and briefly describe our previous productions and how they fit within this design space. Then we present our current technology system and a discussion of the CHI 2010 "Bodies/Antibodies" performance.

Related Work

The marriage of dance and technology is not new [1][5]. In the 1990s, choreographer Merce Cunningham experimented widely with technological integration. His work with Tom Calvert and Thecla Shiphorst making use of the Life Forms software, which later became the DanceForms software, allowed Cunningham to compose choreography on a computer, posing virtual dancers on a 3D stage [3]. Calvert has also written in general on the application of computing technology to dance [2]. Other computer scientists who have studied dance and technology include James et al., who have focused on modeling human dance movement [6], and Yang et al. who are investigating tele-immersive dance [10].

There is also an entire community of dancers and choreographers embracing technology with varying levels of assistance. This community has an online home at Dance-tech.net as well as their own YouTube channel [8]. These sites contain video and images from many interesting examples of technology-augmented dance, including the beautiful works of the Italian dance company Teatro di Piazza of d'Occasione [4].

The most relevant work to our project is that of Meador et al., who have looked at the issues involved in the collaborative design of live motion capture in dance [9]. Troika Ranch, the most well-known digital dance theatre company, have created their own "Isadora" software for managing interactive dance performances. The Dance.Draw project extends and builds upon these existing efforts with academic research goals.

Evolution of Dance.Draw

The Dance.Draw project began at UNC Charlotte in January of 2008 as an experimental investigation of the application of multiple mice as input during a dance performance. A three minute pilot dance named "Dance.Draw: Exquisite Interaction" was choreographed by Sybil Huskey, with visualizations created by Celine Latulipe [7]. The technological link in this dance was the use of gyroscopic mice (Logitech Air Mouse) that the three performers held in their hands as they danced. The term 'exquisite interaction' describes the nature of the visualizations in the performance, in which the three dancers (each carrying two mice which generate interaction points in the visualization) together control a 'flying origami' image, which is a six-cornered polygon (see Figure 1). Thus, it was not the case that each dancer had their own separate representation on screen, but that the dancers collaboratively controlled a mutual representation.

Figure 1: The "Dance.Draw Exquisite Interaction" pilot performance, 2008.

The pilot dance was performed three times and a number of lessons were learned. First, having dancers hold mice significantly impacted the dance vocabulary: dancers were not able to do floor work or falling-type movements that would quickly take the body to the floor since both required hand support. Further, risk-taking movements could not be safely choreographed for the pilot since being able to "catch" oneself in case of an inadvertent fall was not possible. Second, the visual cohesion between the audience, the dancers and the visuals is very important: the dance worked best and seemed most integrated as a whole when the viewing angle was such that the visuals were seen behind/through the dancers. In one of our performances, for example, the projection screen was above the dancers, leading to a serious divided attention issue. Finally, we learned that the gyroscopic USB mice generate fast enough input streams, have a wide signal range, are rugged, durable and reliable, and therefore in many ways, very suitable for this type of use. The main drawback is the lack of direct coupling. The 3D movement transmits 2D data streams and so 3D positional data is not available.

A Mischief of Mus musculus

Figure 2: The "Mischief of Mus musculus" dance performance, 2008.

In the fall of 2008, we staged the first full Dance.Draw production: "A Mischief of Mus musculus." In this production, we tested the limits of the interaction and choreography achievable using the hand-held 2D gyroscopic mice. This dance was an 11-minute production performed as part of the UNC Charlotte Fall Dance Ensemble Concert, and it included six dancers and nine different interactive visualizations. This dance was also choreographed by Huskey, but the visuals were mainly the work of digital artist Mike Wirth. The dance was a pure movement piece set to the musical composition "Portico" by Gauger.

In "*Mus musculus,*" we experimented with a number of different possibilities: in this piece, dancers passed the mice back and forth so that only a subset of the dancers at any given time were controlling the visualizations. We added a visualization that was triggered by the dancers pressing the buttons on the mice (see the fireworks visuals in Figure 2). Finally, we focused on establishing (for the audience) a strong connection between the dancers using the mice and the projected visuals by incorporating dramatic choreographic movements when dancers picked up or acquired the mice, triggering the start of new visualizations. Informal feedback from audience members suggested that this focus on establishing an explicit link between the dancers, mice and visuals was successful.

Whispering to Ophiuchus

In the fall of 2009, the Dance.Draw team staged the production "Whispering to Ophiuchus," which was seen by over 900 patrons at the UNC Charlotte Fall Dance Ensemble Concert. This production was a significantly larger endeavor, as we created and used a new 3D sensing system, choreographed a new and longer (22 minute) piece based on an original narrative structure, and created a custom soundtrack for the dance. "Whispering" depicts a "ceremony of secrets," within a tribal order under the guidance of the constellation Ophiuchus. The narrative of the dance follows the defiance of one member who won't share her secret in the ritual, which casts the community into chaos and labels her as outcast. The visuals were a mix of artist-created animations and interactively controlled 'secret representations' (see Figure 3).

Figure 3: A dancer's secret representation (the red graphic) rotates, pulses and expands in response to her movements.

There was less dancer-visual interaction in this production because of the concurrent development of the sensing system. The new sensing system used was based on wired 3D accelerometers worn by the dancers and transmitted via an ad hoc network of XBee processors. The form factor of wired accelerometers worn at the wrists and connected to a transmitter worn at the waist was not optimal, but was a necessary first step in testing the technology, before moving to a wireless version. While this production was being rehearsed and staged, new software for managing this

Figure 4: XBee accelerometer sensor box (with quarter shown for size comparison).

type of production was being developed and logging of the dancers' motions as well as video-logging of rehearsals was conducted. In the end, the motion logging proved to be useful, as the final performances did not use the live sensing system because of issues with the ad hoc network. Thus, the "Whispering to Ophiuchus" performances used interactive visuals that were based on logged dancer motion from rehearsals, rather than real-time motion capture.

The "Whispering to Ophiuchus" production allowed us to explore another part of the design space of interactive dance – the use of interactive and animated visuals in a narrative performance structure. In the following section we describe the current sensing system the dance production we present at CHI.

Mixed Sensing System

Our current sensing system is mixed; it consists of wireless sensing units enclosed in small plastic boxes, which are worn as part of the dancer's costume, or can potentially be placed inside of props or artifacts used in a performance. In addition, a receiver station connected to a laptop is setup in an off-stage area to receive the data sent from the accelerometer boxes. Each accelerometer box (shown in Figure 4) consists of a watch battery, a 3D accelerometer, an XBee transmitter, an on-off switch and an antenna. These transmit packet streams containing readings from each axis of the accelerometer. The receiver unit handles input from the sensor units, normalizes and maps the acceleration values (enabling different base values, e.g., velocity, distance). The sensor values are then sent to our Dance.Draw software, where the input streams are connected to visualizations created by an artist. The other part of our mixed sensing system is the ability to still use the wireless gyroscopic mice. Our aim is for the Dance.Draw software to be as flexible as possible, so that it can handle input from a variety of different sensors or devices.

Bodies/Antibodies

The "Bodies/Antibodies" performance being staged at CHI is an original choreographic work created by Melissa Word, a dance major at UNC Charlotte. The piece was first presented in the student "Choreographer's Showcase" in the fall of 2009, where it was presented without any technology. It is now restaged as part of the Dance.Draw project, with the four dancers wearing a combination of the XBee sensors and the gyroscopic mice, controlling interactive visuals (see Figure 5). This is designed to allow us to fully test the mixed sensing system.

Figure 5: "Bodies/Antibodies" performance.

The choreographer, Melissa Word, describes the dance: "In the beginning of the piece, the body is functioning in harmony, and all of the cells operate as a cooperative unit. Through various choreographic

choices, we see a fissure occur and a mutated cell is disposed of by the banning together of the remaining autophage cells." This production enables us to touch on another point within the design space – that of taking an existing choreographic piece and augmenting it with interactive visuals. This production also allows us to apply the lessons learned from earlier experiences. For example, though we are using the same 3D accelerometers, the form factor has vastly improved and requires no wiring of the dancers. And, while we are still using the gyroscopic mice, they are not 'held' by the dancers, but worn as part of the costume, removing the restrictions placed on the dance vocabulary in earlier productions.

Conclusion

The Dance.Draw project has explored areas within the design space of dance and technology through three productions: the possibilities of 'held' and worn technology, narrative and movement based choreography, and targeted and adapted staging. We described the contextual factors, lessons learned and technological inoovations over the course of the project, which led to "Bodies/Antibodies", the production being staged at CHI 2010.

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