Understanding Movement: the Design and Evaluation of Lighting and Wearable Technology in Dance Performances

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ABSTRACT
In this article, we describe the development and evaluation of a prototype electronic fashion garment to be used in modern dance performances. The objective of creating the garment was to study dynamic lighting in a dancer's movement and eventually to scale to the entire dynamic stage as a creativity environment. In the first prototypes, we designed a classroom project for undergraduate dance students to build their own garments and describe the theoretical mapping between movement and lighting through Laban Movement Analysis. From this, we investigate evaluation methodologies for each stage, the demonstration, the classroom, and the future performances.

Author Keywords
Dance; Modern Dance; Arduino; Lilypad; Fashion; Laban; Movement; Evaluation; Performance; Classroom.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

General Terms
Human Factors; Design

INTRODUCTION
Dance performances include many components: choreography, lighting, music, direction, and costuming to name a few. Increasingly, as wearable technologies become more prevalent, augmenting dances with various sensors to aid in visualization or sonification is becoming commonplace. In many cases, this augmentation is capriciously utilized in a performance, leaving the choreographer, director, and others to utilize the enhancement as add on effects and not a first order tool for conveying meaning during a performance. In this article, we describe the iterative creation and evaluation of such an electronic garment to investigate how choreographic movement can be enhanced with added technology as a first step towards creating a larger dynamic stage as a larger creativity environment.

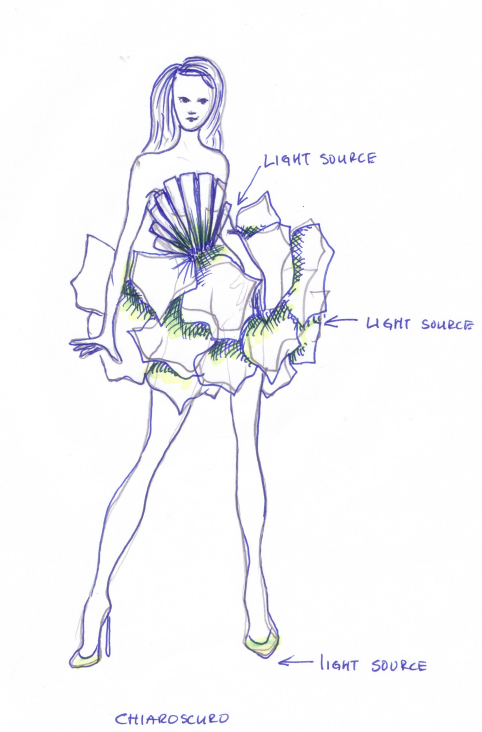

Figure 1. The sketched dress prototype included lighted shoes, dress, and torso.

Our work started with a choreographic question, not a technology one per se. In effect, how would motion effort and quality change if a dancer became illuminated in certain poses? This question drove the technology. However, it was important for the dancer to control the light with his or her body, rather than being controlled remotely by a stagehand or technician; the latter being a proxy for the interaction and hence differently conveyed in choreographic intent and design.

LABAN MOVEMENT ANALYSIS
We used Laban Movement Analysis (LMA) as the basis for codifying movement [3]. It was created through observations of human movement by Rudolph Laban, an early 20th century German choreographer and today has been combined with the work of Irmgard Bartenieffwho researches in movement in the field of physical therapy. LMA is a system of categorizing, notating, observing, and analyzing movement. LMA is a universal framework to describe movement and

provides a bridge between artistic expression and codified descriptions through well-defined concepts about how movement can be identified and categorized. The classification system describes movement with four main categories: Body, Effort, Shape, and Space (BESS). LMA is both a synthesizing and analytical tool that enables very specific awareness and description of movement. Labans practitioners and students often introduce interdisciplinary concepts, including Freudian and Jungian psychological theories, with movement theory. Much of this research introduces new evaluation methodologies, which may seem unconventional, but are increasing in number as researchers begin to surface more interdisciplinary and creative methodologies for evaluation of human-computer interaction, design, and systems research.

DESIGN ITERATIONS

The current stages of this work involve an initial prototype and a classroom experiment. As we are interested in how electronic sensing could map to LMA, we focused on one simple movement and the garment.

Single Dancer

The first prototype started as a simple sketch of the dress and its intended illumination. Figure 1 shows the first chiaroscuro garment prototype. No details were specified at this stage with regards to how the dress would illuminate based on the dancers position. We deferred listing any technical specifications; the initial focus was on the performing aspects of the garment. This includes the visual aesthetic of the dress as well as a choreographic mapping.

For a first step into this investigation, we only wished to explore a single repose. This simplified the electronic circuit design. LilyPad LEDs were used to make a simple circuit with conductive thread [1]; the lights were triggered on and off by a mechanical tilt sensor. This simplified the need for a microcontroller and accelerometer. More so, the tilt sensors position could be physically adjusted and tuned on the dress itself with hot glue. The dress itself was made from artist grade construction paper.

Classroom Experiment

The second prototypes were built from a basic classroom adaptation of the first prototype. The build, materials, and construction were handed to an undergraduate studio dance class with a similar set of build instructions. The students received a priori and in situ instruction on LMA, as well as, hands on construction help from both project members.

The classroom prototypes focused on movement and not on aesthetics. Students used sweatbands and other scraps of garments to make their designs. See Figure 3. The circuit was identical to the first prototype.

Dancer Coordination

The third iteration utilizes a more sophisticated set of electronics. In this embodiment, two garments coordinate an exchange of lighting between themselves. The basic illumination is the same, however, instead of a tilt sensor, an accelerometer is used with a LilyPad [1] Arduino [4] microcontroller. The LilyPad communicates to the other garment over

Figure 2. The first completed chiaroscuro dress prototype.

Figure 3. The two students testing their garments in the studio.

Figure 4. The wireless communicators in prototype 3.

a wireless 802.15.4 XBee serial connection. This prototype, borrowing from the classroom experiment, has an initial technical components and a deferred aesthetic component, see Figure 4.

EVALUATION

Dance and performances have their own evaluation methods both academic and practice, both distinct from Computer Science methodologies. It has been argued that the existing evaluation methodologies in artistic and creative systems should be accounted for in Computer Science when the work is interdisciplinary [6].

The first prototype, being a proof of concept, was submitted to the InLight Richmond festival in 2009[1]. The dress was exhibited with a dancer but no official performance took place. Here we received feedback from peers and curators. More so, lighting conditions at this venue made the garment difficult to see illuminated from afar.

The classroom assignment was intended to challenge the students' creativity in designing choreography and gave us the opportunity to engage with the system and its evaluation. With technology becoming so commonplace in the performing arts, dance programs are experimenting with interdisciplinary courses that require traditional, practice- based dance students to perform and choreograph with technology in order to prepare them for the work field and provide skill sets that match the market. Having had very little personal exposure to technology-based work, this assignment was very challenging for the freshmen studio dance students. See Figure 5.

The lectured framework for the movement assignment was based on the Laban Movement Analysis category of Body which focuses on the overall orchestration or organization of the body and looks at a movement in terms of the initiation, follow through, and resolution. This engages several questions:

- How does the body sequence through the movement?
- What part of the body initiates?
- And how does that part relate to the rest of the body?

The students were told to design a series of movements that simply moved across the floor and in the process triggered the lights to go on and off. Again, the trigger, as in the first prototype, was a simple ball bearing tilt sensor. Surprisingly, even with a very simple mechanic, this proved to be very challenging for the young and inexperienced age group, although a handful of students "got it" with ease. The successful students, who actually completed a prototype of their own, successfully attempted to illicit a reaction from the rest of the classroom, in the form of laughter, smiling, and verbal response, with their prototype. They found a relationship that reflected a cause and effect dynamic between their movement and the goal of turning the light on or off. Each student designed movement that was dependent on their light-costume prototype—collaboration between the movement and the technology. Without the prototype the movement did not elicit the same response and in many cases did not make choreographic sense.

The unsuccessful students created designs and movements with the same impact and significance, even without the costume. This was considered a failure in terms of designing movement, and showed the student's difficulty in relating movement and effort to costume light augmentation.

We then reused several of the students' successful garments in the creation of two wearable costume hats for an informal public showing. See Figure 6. With an understanding of the concept, and having built one themselves, the classroom dancers and they were able to experiment with movement with a more finished product. More so, they continued to find ways to create successful reactions with an audience. The meaning of the costume, the movement, and the dynamic lighting worked symbiotically to create the performance experience.

The process of evaluating a dance typically intersects with the creative process of making the dance. Generally speaking, the evaluation process goes through different levels with three main components: choreographer, performer/performers, and an audience. This happens throughout the creative process from preliminary showings of unfinished work to trusted sources for feedback, much like presenting a prototype to a test user group, to a formal stage production involving lights, costume, theatre and a paying audience, much like launching a beta test product.

In the performing arts, the development process is closely intertwined with the evaluation process. It is important, but not considered necessary, to get feedback from outside sources—peers but not anyone involved in creation, production or performance—continually as part of the process of iteration. Some choreographers may choose not to have external feedback during the creative process for artistic or personal reasons or because they are not seeking a formal or semi-formal evaluation of the process or work. Without focusing on philosophical notions of art making and meaning, it can be generally asserted that the evaluation process in dance relies on a combination of subjective/objective observation of the combined performing elements which include music, sound, costumes, performers, choreography itself, and any additional props that together make up the final composition. The successful performance is the merging construction of these features.

Within conventional academic research, existing evaluation methodologies broadly fall into the qualitative and the quantitative. Towards the latter, there exist opportunities for systems research and evaluation, where advancements in latency, power draw, and lumen performance can traditionally explored (in our case, this would be found in ubiquitous computing research). Towards the former, there exists opportunities to conduct semi-structured interviews with dancers, technologies, and others to explore how the hardware improved the individuals roles and tasks as well as the overall perfor-

[1] Video available at `https://vimeo.com/7315657`

Figure 5. A student prototype illustrating the first ever attempted sewing as well as circuit building for the student.

mance. But it should be noted; the performances success is also evaluated by other metrics like critics reviews and ticket sales.

There still exists the question of evaluating the theoretical mappings between LMA and augmentation technology. We suspect this work, still in its infancy by us, might follow verification and might follow the methodologies of Ekmans work on emotions and facial coding [2] in particular Perlins applications of that work [5].

FUTURE WORK

In this work, we began an exploration in how movement, lighting, and technology could make a dancer want to move? This focused on how a the dancer would "play" with the on/off function as she or he walked around and moved. We aim to scale this interaction slowly, taking time to explore the choreographic possibilities and ultimately gain a larger understanding of the dancers and a stage as a cohesive interactive creative environment. Through the construction of several prototypes, we examined the construction and evaluation of each prototype as either a proof of concept or classroom experimentation—both relied heavily on theoretical grounding and designed to create a choreographic mapping. From the informal public showing, we found that dancers wanted an aesthetic component to the technology as it helps add purpose, intention, and clarity in terms of the movement design. In particular, through iterations, we have found how wearable lighting technology can repeatedly elicit audience reactions. We hope to test the third prototype in a lightweight performance or studio workshop, where we may gleam feedback from the dancers as well. From there, we aim to expand the environment to the entire stage and a set of dancers in a mesh network, connected through choreographic action during a comprehensive performance. Through the creation of these garments, we hope to develop not only a theoretical understanding of movement and technology, but also to codify the mixed methodologies under which these systems can be academically evaluated.

Figure 6. A dance student testing the formalized expansion of his garment. The hat contains the students prototype.

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