Choreography as Mediated through Compositional Tools for Movement: Constructing A Historical Perspective

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ABSTRACT

Choreography is the art of crafting movement, developed through a long history of techniques. Like other compositional processes, choreography is a complex creative process that explores a variety of formal procedures that can result in unique artistic creations. Current computational systems for assisting choreography tend to be idiosyncratic, with emphasis on different feature sets of the compositional process (including movement, structure or expression). In this paper we examine existing technological systems for supporting choreography and group them by their purpose: reflection, generation, real-time interaction, and annotation. We then analyze these system features using Laban Movement Analysis, a comprehensive language for movement description, representation, expression and performance. Our paper articulates the relative benefits of these systems based on experiential aspects of choreography, and posits future directions of intelligent systems for supporting and partnering with choreography.

Categories and Subject Descriptors

J.5 [**Arts And Humanities**]: Performing arts (e.g., dance, music)

General Terms

Theory

Keywords

Choreography, Computational Choreographic Systems, Movement, Expression, Laban Movement Analysis

1. INTRODUCTION

Dance is often described as an ephemeral art form, in constant shift, leaving no remaining tangible traces. The ephemeral character of dance provides its aesthetic value but also problematizes its codification, documentation, conservation, and transmission over time. This issue has occupied many researchers and the question of the appropriate strategies for formalizing dance movement, expression, and corresponding structures for computation remains an unsolved research problem. Though there are many codified movement techniques and compositional strategies available, each individual choreographer necessarily tailors a work through their embodied experience and situated actions.

Choreography can be defined syntactically as a sequential combination of human movements. However it is constantly shifting attitude towards exploration of body, mind, relationships and culture distracts from any codified syntax of movement. These higher level relationships between movement and meaning move beyond syntax to semantics, and as such not only recognize that choreography is a "language" but also require that we consider low-level syntactical abstractions of movement and integrate higher level compositional semantic strategies. The lens that recognizes choreography as a complex creative process may suggest that any formalization techniques border on the impossible, or could at least result in a reduction of creativity. However our goal of formalizing specific aspects of the choreographic process is targeted toward developing new knowledge regarding movement and meaning and contributing to the compositional richness that is derived from movement. Our perceived benefits include creating a shared understanding of choreographic strategies and bringing awareness to how choreographic strategies are used, enabling more options and control to choreographers in their creative process. DeLahunta questions current choreographic practice as "perhaps our practices are outdated or can be improved. How can we doubt our own processes and question our own methods?" as a way to question our current beliefs of choreography, and to pursue new investigations around our understanding of movement ([13], pg. 136).

We suggest that exploring opportunities for formalizing choreographic techniques is necessary if we are interested in questioning our existing creative and technological processes in a tangible way. Technology brings new opportunities for codification and clarification in complex processes. Candy states that the computer's capacity to facilitate a more precise specification of the constraints which artists work within make technology an attractive medium to explore [6], allowing the user to understand and articulate a larger palette of methods that support both movement perception and interpretation. The articulation of movement description and choreographic techniques brings awareness to current parameters, which support agency and creative choice in implementation strategies.

One of the primary challenges in developing intelligent computational support tools for choreography is in considering the complexity of choreography that results in unique artistic creations. Examples of digital tools that support choreography reveal to be highly idiosyncratic. In this paper we examine current systems that assist the choreographic process through emphasis on various features that we analyze using the language of Laban Movement Analysis (LMA) [18], a comprehensive language for movement description, representation, expression and performance extensively used in choreography. We describe existing systems for reflecting on movement material, generating choreographic material, providing real-time interaction with movement material, and annotating movement material. Overall, our paper articulates the focus of a variety of systems and what they bring to choreographic experience, how intelligent techniques contribute to the choreographic process and where intelligent systems can evolve in the future. This paper can contribute to the dance, movement and computational communities because it brings together the goals and needs of its unique members to explore and develop the process of articulating and codifying movement and compositional information in a choreographic context.

2. SOFTWARE FOR SUPPORTING CHOREOGRAPHY

De Keersmaeker states that "what is missing is an interface between mute videos and practical connaissance, or experiential knowledge, that would allow dance to be more than a 'wheel that turns on itself" [17]. Choreographers have been fascinated with the creative possibilities enabled by the use of technology in the compositional process. The use of digital technologies and software programs challenges choreographers to perceive their creative problem space anew through new limitations alongside new possibilities.

In this section, we will examine different systems through four main features that are central in assisting choreography. First, the capacity of a system to codify movement in order to craft movement as unitary choreographic material (often a focus on Body or Space in LMA). Second, the capacity to codify performative or expressive qualities of movement (often a focus on Effort and Shaping in LMA). Third, the capacity of a system to codify the rhythm of movement (often a focus on Phrasing in LMA). And, fourth, the capacity to codify the compositional structures in time in order to craft the overall creative process at the scale of the whole piece (often a focus on sequencing or cueing strategies). These features raise the question of adopting or designing appropriate models in order to formalize a compositional movement language appropriately. There are still many open questions in the domain of choreographic support tools and there is no methodological consensus regarding critical next steps. We refers to [11] that proposes an in depth reflexion with an emphasis on the use of choreographic technologies to address the application of dance creation, expression, preservation, documentation and notation. We describe and discuss existing applications for supporting choreographic process through the lens of system goals and values. Existing software goals include: Reflection (abstract movement material provides new options for perception of movements), Generation (creates new movement material), Interaction (transforms movement material based on user interaction), Annotation (annotates and views movement material).

2.1 Reflective Tools

We describe three systems that apply various approaches to visualizing movement or structures: two of these systems reflect on shapes and structures of movement to enhance an audience's viewing skill set in the moment and one system abstracts performance and structural aspects of choreography to illustrate change over time in a single perspective. While the content of these systems are similar, they depict movement information to provide different perspectives and uses.

2.1.1 Reflecting movement

Improvisation Technologies CD-ROM[1] is a system that aims at pedagogically presenting the compositional techniques used by the choreographer William Forsythe to craft movement. The CD-ROM provides video tutorials where the spatial component of movement is graphically augmented with geometric overlays that constitute the basics of Forsythe's approach to movement in relationship to space. Following the CD-ROM of Forsythe, the dance company Emio Greco|PC (EG|PC) published a book and DVD-ROM entitled *Capturing Intention* that reflects upon movement qualities crafted in the *Double Skin / Double Mind (DS/DM)* workshop that constitute the basis of the movement vocabulary of the company. The book and DVD was developed in the context a large research partnership initiated by the company EG|PC for the purpose of documenting their choreographic dance process and practice. They used the company's descriptions, Laban and Benesh notation, demonstrative video clips and sound as potential mean of transmission of their expressive material [12]. Thereafter, the company continued with a second project called *Inside Movement Knowledge*. In this project, disciplines such as linguistics, motion capture, and movement-based interaction were involved to reflect on the movement vocabulary of *DS/DM* workshop with their specific tools [1]. The project resulted in various studies, documentation, notation, glossary and a movement-based interactive sonic and visual installation.

2.1.2 Reflecting Structures

The choreography of William Forsythe in his piece *One Flat Thing Reproduced* has been studied by researchers from the Ohio State university [23]. They developed the website *Synchrounous Object*[2] to reflect upon the sequencing procedure of the piece by augmenting the videos through post-production techniques to visualize the initiations and cueing interactions between performers. Following the Synchronous Objects prototype, MotionBank project linked the Ohio State University researchers, William Forsythe and additional choreographers. This heightened audience attention to choreographic structures through graphical visualization by creating scores that reflect on the compositional data [3].

With the aim of reflecting on the choreographic structures in dance performance, researchers from Simon Fraser University developed an offline system called ActionPlot that codifies and plots expert viewer information from the viewer's

[1]http://www.movingimages.de/
[2]http://synchronousobjects.osu.edu/
[3]www.motionbank.org

first-person experience [8]. ActionPlot illustrates three levels of choreographic data; viewing dance for detailed movement information (Body), for structural or performative information (Space) or for interpretation or meaning (Effort). Choreographic data is plotted by the number of performers, the performer's attention and intention to move, the amount of energy exerted, the movement and effort phrasing, and the balance of the movement within the body. This data is mapped to glyphs including lines, circles and boxes broken into quadrants representing areas of the body in movement.

2.2 Generative Tools

We defined the term Generative Tools broadly, as tools that generate movement material either autonomously (through using an existing corpus of data) or manually (a tool that facilitates a human choreographer's creation of material). The following sections explore systems that focus on generative aspects of movement that support choreographic composition for humans, computation or video games.

2.2.1 Generation by movement simulation

Among the more renowned contemporary compositional tools for choreography is DanceForms (historically also referred to as LifeForms and Compose). Danceforms is a compositional tool and software system that uses graphical animation for generating simulated dance movement based on user input or library selection. Libraries have been developed from motion capture data, key-frame animation, and movement vocabularies such as Cecchetti ballet and Cunningham Choreographic Technique [24]. The system focuses on three components of movement as formalized in LMA: space, sequencing and body-posture. The space perspective allows the choreographer to design movement pathways and spatial patterns. The sequencing perspective allows the choreographer to design sequences and movement phrasing in a timeline. The body-posture perspective allows the choreographer to design body positions using detailed joint manipulation or choose codified positions from movement libraries. DanceForms, aside from the provided libraries, relies on the user's selection of movement postures in order to aid the production of dance sequences, similar to the choreographic process that is necessary for a dancer in the studio [25]. Merce Cunningham used DanceForms to generate movement on avatars, transposing the movement decisions onto live dancers. Cunningham exploited the use of error and "glitch" interaction to produce highly improbable and unlikely movement scenarios, supporting his strategy of uncovering unexpected movement choices that he could explore in the studio. This experimental process allowed Cunningham to explore movement options that he may not have otherwise considered, further facilitating his strategy of using of chance operations to open up new ways of viewing movement possibilities.

2.2.2 Generation of movement sequences

Yu and Johnson's system generates autonomous movement sequences through the use of a Swarm technique [29] within DanceForms on the project titled *Tour, Jete, Pirouette*. This project used the existing libraries of movement within DanceForms to autonomously generate sequences from a series of individual movements onto a group of dance avatars. Sequences were developed by comparing and selecting qualities of individual movements yet did not account for transitions from one movement to the next. Due to DanceForm's interpolation algorithms, the sequences would look as though they flowed smoothly.

A similar approach with a more sophisticated system generating plausible transitions between movement is that of Web3D Composer. It creates sequences of ballet movements based on a predefined library of movement material as a tutoring tool for ballet students [27]. The system allows the choreographer to select movements from a pool of possibilities, which shift based on structural ballet syntax using markovian probability systems. The beginning and ending positions of each movement are catalogued so that the system can chose a sequence based on transition possibilities for the human dancer as well as for syntactic structures.

2.2.3 Generation of procedural rules

CorX facilitates dance improvisation by generating rules through textual instructions about pathway, speed, spatial direction and body action (jump, skip, bend) [2]. The instructions are used to change the immediate action of the performer and bring their awareness to a spatial change in the moment. The system uses an If/Then syntax as a conditional statement with a shifting action to change performer's movements. For example, If speed is fast then make speed slow. All possible rules are pre-designed and the user selects conditional statements. Action statements are assigned probabilities based on their frequency of use and are system-selected to pair with conditional statements.

Similarly, the DaNcing system generates sets of rules resulting with sequences of dance steps, represented as ASCII symbols superimposed upon a bird's eye view of the stage. The system uses a series of music related parameters, stage use rules, and a predefined library of traditional movements to generate syntactically correct Waltz choreography using a Genetic Algorithm [22]. The dance form itself is initially quite restricted and relies heavily upon the rule system.

2.2.4 Generation by mutation

Another approach to generative systems is to use genetic algorithms to generate new material by mutating existing material. This challenges the choreographer by causing their usual creative process to become 'unusual' in order to allow them to reframe their approach to designing movement. This can also be referred to as "Making Strange", a choreographic strategy described by Lian Loke [20]. For example, The Dancing Genome Project developed a genetic programming model to explore adaptations of movement sequences for performance [19]. The movement material was gathered through motion capture data extracted from a dancer performing a movement sequence in a studio. The motion capture data was used as input to the genetic programming model to shift the sequence of dance movements, creating a mutated sequence. The final mutated sequence is performed by virtual avatars alongside the original sequence performed by live dancers to create a mixed-reality duet.

Another example of the use of a Genetic Algorithm is The Scuddle system. It generates movement catalysts for creative decision-making in contemporary choreography [7]. The use of movement catalysts allows choreographers to distance themselves from habits, making their usual creative process strange and unfamiliar to reframe the approach to designing creative movement. The Scuddle system uses low resolution of movement data to allow for the choreographer's creative freedom while utilizing a heuristic-based fitness function to generate catalysts focused on body posture, height of execution and qualities of movement when performed. Body posture was evaluated based on asymmetry, instability and complexity while Effort Factors were evaluated for complex combinations of Fighting and Indulging Effort Factors in LMA.

2.2.5 *Generation by style incorporation*

Generative systems for movement investigated the incorporation of Style element into existing pre-recorded movements to create, modify, and transform the movement material. For example, Brand and Hertzmann developed a system called Style Machine that generates stylistic motion by using unsupervised learning techniques based on Stylistic Hidden Markov Model (SHMM) [3]. This model learns patterns from a highly varied set of movement sequences recorded from motion capture data. The model then manipulates movement by identifying structure, style and accidental properties and applying style qualities to movement (such as modern dance style in ballet movements).

Similarly, the SmartBody project models style components from movement qualities layered upon functional movement vocabularies to imbue movement with meaning, personality or affect for gaming environments. For instance: Bound extension in the sagittal plane layered upon a walk will generate a sneaky walk [26]. The authors use Independent Component Analysis, an unsupervised learning technique to separate motion capture data into style variables and functional movement variables. Thus style components can be reapplied, enabling the user to explicitly re-adapt existing movement by selecting the style's quality.

2.3 Interactive Tools

Interactive tools allow dancers to interact with a digital media that responds in real-time to their performance. The digital media can be designed for assisting choreography by facilitating improvisation or exploration of the creative process through behaving as the dancer's virtual partner. The crucial point here is how the link between the dancer's movement and the digital response is designed. In other words, within interactive tools the mappings between input and output modalities are crucial for generating expressive cause-effect relationships that allow for a rich exploration of movement.

Camurri et al developped expressive movement-based interactive applications for dance. For this purpose, they designed the Eyesweb platform providing modules for the analysis, classification, and multimodal synthesis of expressive movement[5]. Eyesweb is a generic development platform that provides high-level descriptors of movement related to LMA (including the Effort component). A less generic, more idiosyncratic interactive system was developed by Fdili Alaoui et al for real-time visualization of the dance movements qualities of EG|PC in *DS/DM* [14]. This system can recognize predefined qualities through movement analysis and control of abstract visuals based on physical models, displaying in real-time graphical animations with "qualities" responding to the participants' expression. The physicality of these models evokes movement quality capabilities and supports the user's engagement and movement exploration through embodied interaction. This system provide an immersive and interactive space where the participants are invited to learn, experience, improvise and generate dance material using some EG|PC's movement vocabulary. Work by Subyen et al explores the visualization of movement aesthetically, generating color, lines, and graphics to suggest the participant's Effort qualities [28]. Similarly to Fdili Alaoui et al's system, the mappings are meant to create strong visual responses that resonate the afforded kinaesthetic quality. These mappings are selected based on a combination of theoretical frameworks and first-person experience of how aesthetic information is perceived.

The Viewpoints AI project looked to the Viewpoints compositional framework to create a real-time interactive system exploring dance improvisation strategies. The system used kinect data and the SOAR reasoning framework to create a repository of short and long-term memory of the choreographer's movements that select and apply different response modes and improvisational strategies. The reasoning framework can respond by: doing nothing, mimicking the user's movement, transforming the user's movement and then performing it, repeating a movement it has learned during its lifetime of experience, or executing various kinds of interaction patterns [16]. Using this same Viewpoints framework, Corness et al designed the Ariel system that provides musical responses for movement improvisation. This system explores performer's embodied knowledge in traditional sense-respond models of interaction to find new opportunities for engaging performer in interactive systems. The resulting flute music also contained a breath that indicated the flutist's performance qualities, enabling the performer to anticipate the flutist's musical gestures and resulting in more coordinated and sympathetic performance improvisations [10].

Finally, McKinney et al. designed and implemented a 3.5m tall robot spider as a dance improvisation partner by exploring themes of composition, embodiment and play [21]. The robot is suspended from the air and is controlled using information gathered from multiple sensory inputs.The robot follows three interaction scenarios: mimic/ follow, oppose, and innovate/random. There are currently no learning algorithms. This research addresses habit through exploring the dancer's own habitual patterns, where the robot reflects these movement preferences back to the dancers in its own movement. The robot's movement focuses on the Effort qualities as formalized in LMA.

2.4 Annotative Tools

Annotating dance movement or structure during the rehearsal has a strong potential for assisting choreographic reflection. It allows choreographers to analyze, edit, play, and re-frame material in order to prototype it and craft it incrementally during the choreographic process. For example, the Choreographer's Notebook is a web-based annotation tool for choreographic process [9] that operates as a creativity support tool for documenting, annotating, reviewing and editing choreography. Dancers can rehearse their parts in real-time and film themselves, then compare their performance to the video in the annotation tool. The choreographers also used the tool to provide detailed feedback on the performance for coaching purposes.

Finally, the project *Transmedia Knowledge Base for contemporary dance project* is designed to facilitate multi-modal forms of annotation of the movement and the compositional process on video of contemporary dance [4]. The tool includes three components: verbal annotations synched with videos, the creation Tool as a digital notebook for real-time video annotation, and a web-based collaborative archive for contemporary dance. Their systems plays a role in note taking, sketching and visualizing compositional elements without actively engaging in the creative process. While the tool can be used within the process to re-frame a creative problem or see a work from a different perspective, it also has strategies for learning and analyzing movement. This creation tool has been designed with and for the choreographer Rui Horta, to assist during the compositional process. The methodology for dance annotation using linguistic approaches has been used for a microscopical documentation of the repertoire of Rui Horta and EG | PC [15] as well as the glossary of *DS/DM*.

Table 1: Classification of softwares for assisting choreography according to their purpose and to the feature that they focus on (described using LMA)

System	Purpose	Feature	LMA Component
Improvisational Technologies	Reflective	Movement	Body/Space
Capturing Intention	Reflective	Expression	Effort/Shape
Synchronous Objects	Reflective	Structures	Sequencing
ActionPlot	Reflective	Movement	Phrasing
DanceForms	Generative	Movement	Body/Space
Tour Jete Pirrouette	Generative	Structures	Sequencing
CorX	Generative	Structures	Sequencing
DaNcing	Generative	Structures	Sequencing
Web3D	Generative	Structures	Sequencing
Scuddle	Generative	Expression	Effort/Shape
Dancing Genome	Generative	Movement Expression	Body/Space Effort/Shape
Style Machines	Generative	Expression	Effort/Shape
SmartBody	Generative	Expression	Effort/Shape
Viewpoints AI	Interactive	Structures	Sequencing
SpiderRobot	Interactive	Expression	Effort/Shape
Eyesweb	Interactive	Expressive	Effort/Shape
DS/DM	Interactive	Expressive	Effort/Shape
Emviz	Interactive	Expression	Effort/Shape
Ariel	Interactive	Expression	Effort/Shape
Choreographer's Notebook	Annotative	Movement Structures	Body/Space Sequencing
TKB Project	Annotative	Movement Structures	Body/Space Sequencing

3. DISCUSSION AND CONCLUSION

Choreography is a complex creative process that explores numerous formal procedures that supports the art of crafting movement. We have examine existing technological systems for supporting choreography. We present our analysis in Table 1 which illustrates a cartography of theses systems and how they reflect, generate, interact and annotate choreographic material and focus on different features of movement, structures and expression. We describe these features using the language of LMA, a comprehensive language for movement description, representation, expression and performance. This table illustrates the great variability of materials and methods of authoring movement, almost as many as there are contemporary choreographers applying movement to computational systems. Our analysis also indicates how uniquely each existing system is coping with singular aspects of movement composition, each encompassing particular elements of the creative process required to craft movement in time. We can see that it is as if each system has been created for a single choreographic area, focusing on a unique user interest and methodology. Therefore, these systems appear to be highly idiosyncratic, which explains in part their proliferation and eventually their inability to be generalized within a larger choreographic domain.

Our analysis articulates the relative benefits of these systems based on experiential aspects of choreography, and allows to posits future directions of intelligent systems for supporting and partnering with choreography. Based on our premise, we ask the following questions: What features would we imagine that a future intelligent compositional tool for choreography should include? Should it be individual or collaborative? What movement language(s) could be included to describe movement and compositional structures? Would LMA provide a useful underlying framework to represent various choreographic approaches? Should it provide multi-modal feedback for movement to unpack its multiple components in choreography such as body, effort, shape, space? What strategies can be used to map movement data over time to see structural changes live? Could we generate new movement material from a choreographer's past choices?

While our historical review of the choreographic literature does not answer these questions directly, it aims at opening a discussion around their critical importance within the compositional, choreographic, dance, movement and computational communities. We seek to bring together members of the movement and computational fields to reflect upon and contribute to central concepts that can direct research agendas toward developing the process of exploring choreography as mediated through compositional tools for movement, particularly in support of developing compositional strategies for modelling and codifying movement that can generate new creative models for creating, designing, understanding and experiencing movement patterns in their multiple expressive forms in the world today.

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