Cochoreo: A Generative Feature in idanceForms for Creating Novel Keyframe Animation for Choreography

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Abstract

Choreography is an embodied and complex creative process that often relies on 'co-imagining' as a strategy in generating new movement ideas. Technology has historically been used as a tool to augment creative opportunities in choreographic process, with multiple choreographic support tools designed to function as a 'blank slate' for choreography. However, few of these tools support creative authoring with interactive or generative components. Cochoreo is a sub-module for generating body positions as keyframes that catalyze creative movement, as part of the movement sketching tool idanceForms (idF). Cochoreo catalyzes movement sketching by using parameters from Laban Movement Analysis, an existing movement framework, to generate unique keyframes that are used as seed material for choreographic process. idF is a creativity support tool that engages with choreographers' creative movement process by design. This paper presents the design of Cochoreo and evaluations from our pilot study with university dance students.

Introduction

Choreographers are artists who are always searching for new inspirations from which to design novel movement ideas. They derive inspiration by exploring movement physically on themselves, they view movement on others, they observe interactions between strangers, explore the physics of inanimate objects and manipulate existing technology to create new movement experiences. It is in these exploratory interactions that choreographers not only discover ideas but iterate them to develop larger pieces of creative movement material. The performance theorist Andre Lepecki developed the term 'co-imagining' for these specific kinds of interactions that require multiple participants to devise and develop ideas, but who are not necessarily co-authors in the composition process (Cunteanu 2016). This paper discusses the current state of choreographic support tools and how our system, titled Cochoreo, addresses existing gaps between the domains of creativity support tools and autonomously creative systems.

While there are a variety of digital systems designed to engage with choreographic process, few support inspiration of new movement ideas or the iterative process of developing movement material. Current tools fall on a spectrum of possible choreographer interaction, with limited options for co-imagining systems. Creativity support tools aid a choreographer in their existing creative practice, yet do not offer new movement ideas to the choreographer. Autonomously creative systems generate novel movement options but do not have a way to iteratively interact with a live choreographer. Few co-imagining systems exist yet none support the choreographers personal exploration of novel movement.

To combine the functionality of a creativity support tool with an autonomously creative system we have designed Cochoreo to co-imagine novel movement with the choreographer. Cochoreo is a sub-module within the existing platform idanceForms, a sketching tool for movement based on creating and animating keyframes. Keyframes are single frames, taken from film terminology and used in animation to describe important start and stop points (see Figure 1). Cochoreo generates keyframes (as single frames of body positions) and interpolates between keyframes to animate choreographer-designed movement.

Cochoreo generates novel keyframes for body positions by using a fitness function designed and tested by a choreographer. The iterative design process by the choreographer ensured that generated body positions would be

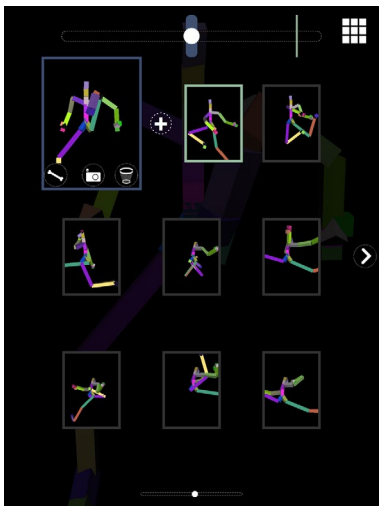

Figure 1: Keyframe Layout in idanceForms

unfamiliar, unstable and utilize complex movement understanding. There is also a parameterized fitness function option so that the choreographer can adjust generation options based on their personal preferences. The Cochoreo keyframes can then be edited and manipulated manually within the idanceForms framework.

Cochoreo was designed to leverage a co-imaginative approach to embodied choreographic process in technology. Cochoreo reflects the use of chance procedures made famous by world-renowned choreographer Merce Cunningham, who used the historical system DanceForms in his choreographic process. (Schiphorst et al. 1990). Our team has re-designed DanceForms (to idanceForms) to function on a mobile platform which utilizes affordances of a tablet for capturing and manipulating movement data.

This paper discusses the gap between creativity support tools and autonomously creative systems and illustrates an addressable gap in the design of choreographic support tools. We describe the system design of Cochoreo and present a pilot study with novice choreographers that explores their experience of choreography in relation to the integration of idanceForms, a platform for sketching movement and its generative feature Cochoreo.

Background

There are a variety of computational creativity projects that explore the generation or augmentation of movement material for choreography. Few of these systems are creative on their own and most involve some level of interaction with the human creator. However, these interactive systems often do not provoke creative compositional choices in the creator, and do not support the "sketching process". For example, programs such as Adobe Photoshop or Microsoft Word give artists a "blank slate to put their ideas on but do not assist them artistically in their practice (Coughlan and Johnson 2009). We are interested in how an autonomous creativity component can support the creative process of the choreographer, to enable co-imaginative interaction. In order to implement techniques that engage the agency of choreographers, we illustrate a selection of existing systems that support choreographic process (see Figure 2). A deeper analysis of prior work includes the survey paper by (Fdili Alaoui, Carlson, and Schiphorst 2014) that described existing systems which have been developed to digitally reflect on movement material, to generate choreographic material, to provide real-time interaction with movement material, and to annotate movement material.

Systems that interactively support generative techniques and choreographic process include The Dancing Genome

Project, Web3D Composer, Viewpoints AI and the standalone idanceForms. The *Dancing Genome Project* developed a genetic programming model to explore sequences of movement in performance (Lapointe and poque 2005) (Lapointe 2005). The system analyses movement data and reorganizes it to create a new sequence with the same movements. This system was used to generate variations of movement phrases which were performed by a combination of live and digital performers. *Web3D Composer* creates sequences of ballet movements based on a predefined library

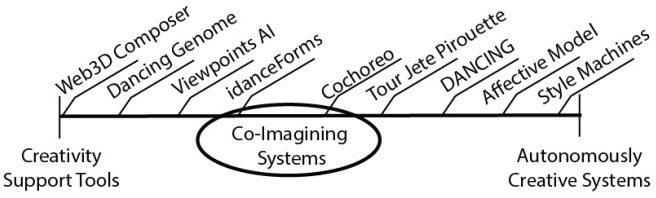

Figure 2: Co-Imagining Systems Scale

of movement material (Soga et al. 2006). The system allows the user to select movements from a pool of possibilities, which shift based on structural ballet syntax. This system is used mainly as a teaching tool to support the development of ballet structure knowledge. The Viewpoints AI project used the Viewpoints compositional framework to create a real-time interactive system exploring dance improvisation strategies (Jacob, M, Zook, A, and Magerko, B 2013). The system used kinect data and the SOAR reasoning framework to create a repository of short and long-term memory of the choreographers movements that select and apply different response modes and improvisational strategies. Both the system and the performer attend to each other's movement choices by interactively improvising movement material. idanceForms enables choreographers to design movement poses as keyframes and then animates them, creating an iterative and reflective space for choreography design (Carlson et al. 2015a).

Systems that border on autonomous creativity include the Cochoreo, Tour, Jete, Pirouette, DANCING and Style Machine systems. Cochoreo generates body positions as keyframes within the idanceForms sketching application, to be used as catalysts for innovative movement design. Keyframes are animated and can be edited and sequenced within the idanceForms platform. Making use of the *DanceForms* framework, Yu and Johnsons system generates autonomous movement sequences through the use of a Swarm technique in their project titled *Tour, Jete, Pirouette* (Yu and Johnson 2003). This project used the existing libraries of movement within the DanceForms software to autonomously generate sequences from a series of individual movements onto a group of dance avatars. This created group movement sequences explored by choreographers who deemed the movement too challenging to perform exactly as the system did. *DANCING* used a series of music-related parameters, spatial pathway rules and a predefined library of traditional movements to generate Waltz choreography using a Genetic Algorithm (Nakazawa and Paezold-Ruehl 2009). By connecting the correct, predefined 'steps' in a domain-specific sequence that provides stage directions and orientations, this system generates syntactically correct movements in a complete choreography that are represented as ASCII (American Standard Code for Information Interchange) symbols on a birds eye view of the stage. It was noted that the generated choreography was able to be performed by ballroom dancers. Brand and Hertzmann developed a system called Style Machine that generates stylistic motion by using unsupervised learning techniques based

on a Stylistic Hidden Markov Model (SHMM) (Brand and Hertzmann 2000). 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). Alemi, Li and Pasquier developed an interactive agent model that can capture and control the affective qualities of movement patterns (Alemi, Li, and Pasquier 2015). They trained a Factored, Conditional Restricted Boltzmann Machine (FCRBM) with a corpus of movement captured from two actors that was annotated based on their arousal and valence levels.

This selection of systems illustrates the developments towards interactively co-imagining choreographic material between a system and a human, yet there continues to be a gap.

DanceForms History

Using digital tools to support the creative process of choreography has a historical precedent. DanceForms (formerly Life Forms) is a human figure animation system that is optimized for dance (Calvert et al. 1991) including the same capabilities that are available in general purpose animation systems (e.g. Maya, MotionBuilder, 3D Studio Max, or Unity)(see Figure 3). While the system has been used by many choreographers, the most well known is Merce Cunningham. Cunningham used DanceForms to design movement as inspiration for constructing dances, exploring the random and procedural components of the system into his existing creative process using Chance Operations (a version of controlled randomization for content selection). Cunningham is a seminal figure in the history of choreography worldwide, and a unique 'user' of technology in dance, in particular the DanceForms software.

The Life Forms / DanceForms software was designed for use with desktop or laptop computers and normally requires a large screen (Calvert et al. 1993). Typically the user interaction requires that up to 5 windows be open at any time. The computer and the screen can be used in a studio but the computer is typically seen to be cumbersome and does not merge easily into a mobile, in-situ movement practice. The great advantage of mobile devices is just that: they are mobile. They can be carried onto the dance floor and the animated movements compare directly to the movements of the live dancers. There are also new affordances in mobile devices that we can take advantage of; the use of accelerometers to determine the acceleration, velocity and position of a limb and the use of an integral camera to capture the stance of a live dancer.

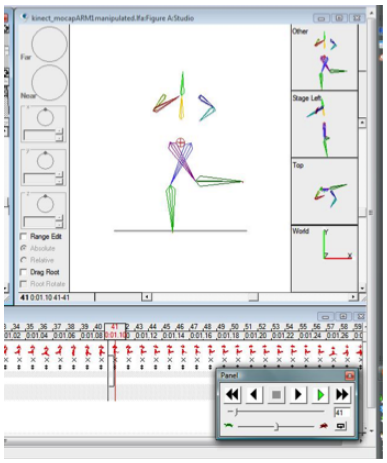

Figure 3: DanceForms Interface

DanceForms has three views: space, time, and body-position. The space view allows the user to design movement pathways as spatial patterns. The timeline allows the choreographer to design sequences and timings of movement. The body-position view allows the user to design body positions using joint manipulation or to choose codified positions from pre-designed libraries. Libraries were designed by using the corpus of standard positions that define a movement language in techniques such as ballet or modern. These Danceforms libraries have been used as source material in generative composition using a Swarm algorithm to automatically compose sequences of movement (Yu and Johnson 2003). While DanceForms is the most articulate system available for computer-supported choreography, its precision-based design does not support rapid, portable, mobile, embodied or experiential forms of interaction. However, the rich foundation DanceForms provides for supporting movement design in software is highly useful as a step for mobile development and exploration of movement-based sensors for sketching choreography.

Cochoreo and the idanceForms Platform

Cochoreo is a sub-module of the idanceForms (idF) platform, a tablet-based mobile animation tool. This section will describe the idanceForms platform first, and the Cochoreo details second to illustrate the platform in which Cochoreo operates.

idF is a creativity support tool that allows the choreographer to sketch movement by creating, editing and viewing human figure animation on a tablet (Carlson et al. 2015b). idF differs from DanceForms in many ways: idanceForms is designed to support the sketching process of choreographers and is not meant to support the highly detailed traditional process in DanceForms. The shift in interaction from mouse-based to touch has dramatically changed the design to be more minimal but directed towards a choreographer working in an embodied way. This inspired the development of the Camera Keyframing feature, where a snapshot of a live dancer can be taken and used as a keyframe. idanceForms has been designed based on the epistemology of choreography; leveraging whole-body interaction as well as the playful and low-risk properties of sketching to create a mobile support tool for exploring creative movement in-situ (Blom 1982) (Studd and Cox 2013). By using an animation platform we can continue to provide an element of precision that the original DanceForms software maintains while opening to new opportunities for interaction, design and representation of movement. Our contribution with iDF is its application to the live, in-situ creation and iteration of creative movement.

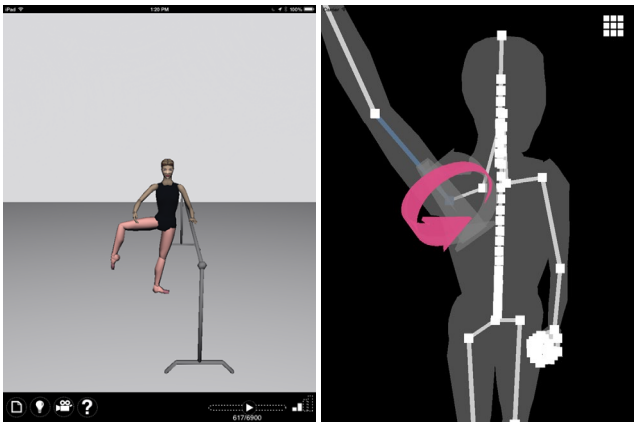

Figure 4: idanceForms Viewer and Skeleton Editing Tool

The 'home' screen is a playback screen that enables the choreographer to view the animation on a 'stage that they can move around using single finger touch to rotate around the space as well as pinch gestures to zoom (see Figure 4). The playback view is an important piece of the choreographic process, because it provides opportunities for viewing the animated movement, understanding the movement through the kinesthetically empathetic experience and reflection on the selection of and sequencing of still forms as keyframes. Playback is the portion of the creative process that provokes reflection and evaluation of choices made in the sketching process. Playback is the result of rapid prototyping: creating a space for choreographers to reflect in action and quickly continue working to create personal meaning.

Sequencing Keyframes

Once the choreographer has captured still poses to use as keyframes in their animation they have options for adjusting sequencing and timing of keyframes. Touching a keyframe once will select it and enable dragging and dropping to reorder keyframes for designing creative sequences. Because we are working with keyframes, there is built-in linear interpolation that takes the shortest path to move from one keyframe to the next. This creates a unique 'movement from the transition between a starting and ending still pose. The choreographer can control the timing of this 'movement by adjusting the timing into and out of a keyframe with the timing bar at the top of the editing screen.

Skeleton Editing Tool

Using the finger gesture the user can manipulate the skeleton in a joint and limbs level (see Figure 4). This fine control is facilitated by the gimbal ball visualization where the user can select the axis of the movement and then move the limbs accordingly.

Data Representation

The skeleton setup and skinning method we use is based on the COLLADA standard, using the CMU motion capture skeleton (cmu). We use a linked list of keyframes to

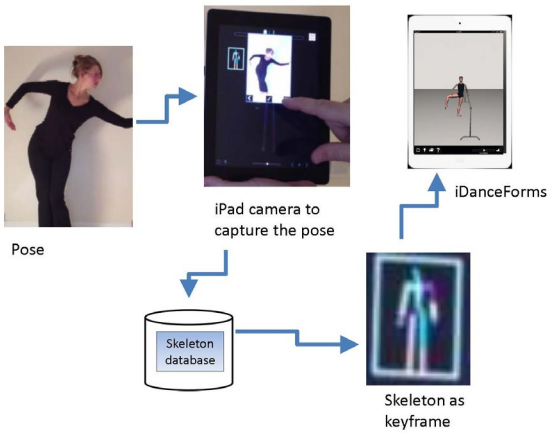

Figure 5: Camera Keyframing Feature

store our animations for two reasons a) this makes it easier to swap or move keyframes around during editing and b) it is also faster to play back the animation. Each keyframe stores a pose and an integer representing the number of inbetween frames until the next keyframe. We do not store the explicit frame number in a keyframe, this is determined by the sum of the previous keyframes in the linked list added to the sum of inbetween frames for each keyframe, and this allows keyframes to be easily swapped / moved without recalculating their frame.

Camera Keyframing

idanceForms has developed a camera keyframing feature to enable embodied forms of interaction. Utilizing the 2D camera in mobile devices, the background is removed and the dancers still pose is compared to an existing database of images with existing skeletal data (see Figure 5). The built-in computer vision algorithm will then capture the pose and search through a database of pre-stored standard poses in order to try to find a corresponding skeleton pose. Once the skeleton pose has been found, it will be added to the list of keyframes. We have designed a database of movement using planar poses that can be easily detected from the front without occlusion. These poses include general and creative body positions as well as an imitation of alphabet letters that was used in a prior study with youth (Carlson et al., 2015). The existing skeletal data is used to create a keyframe that can be added to a sequence of keyframes to create an animation of movement and be further manipulated by the choreographer. This 'capture process is an exciting innovation for movement interaction which enables us to capture still forms as a wide range of potential planar figures.

Cochoreo System Design

Cochoreo is a sub-module of idanceForms, used to generate novel keyframes for creative movement (see Figure 7). Keyframes consist of a still body position, a human-shaped avatar with movement possibilities in all 3 axis. Cochoreo uses a Genetic Algorithm to evolve new keyframes from an

initial gene pool. Cochoreo is an extension of the Scuddle system (Carlson et al 2011), a generative system for movement catalysts. Scuddle generated movement catalysts as static positions with performative instructions to be interpreted by a choreographer and used as inspiration for designing new novel movement.

Cochoreo's implementation in the idanceForms animation platform enables a new parameterized fitness function, engaging the choreographer in the generative design process. idanceForms in return provides a sequencing and animation platform to iteratively view and design phrases of movement with the user, creating files that can be documented and used iteratively throughout the choreographic process. Currently Cochoreo operates using 2D data with the z-axis zeroed out. While we plan to move to 3D in the future, it will require another iterative design process to develop a constraint system for preferred creative catalysts.

Genetic Algorithm

We use a Genetic Algorithm to evolve movement catalysts. This approach enabled us to control fundamental components that problematize the choreographers process of creating movement, while generating novel inspirations for movement solutions. Genetic Algorithms are typically used to explore a wider range of potential solutions than other search algorithms can (Russell and Norvig 2010). We generate a population of 500 random individuals and give a score for their fitness against the prescribed goals for success. This initial population is then subjected to an iterative cycle of selection and breeding. Genes are bred using a two point cross over function with a 10 percent mutation percentage to create a new population that maintains diversity. Once a cycle is complete the new population is judged on its fitness once again and the process continues for a fixed number of five iterations or until a certain fitness threshold is reached (Floreano 2008) (Russell and Norvig 2010). More details on the generative process can be found in the Scuddle system paper (Carlson, Schiphorst, and Pasquier 2011).

Fitness Functions

Cochoreo has two fitness function options to evaluate novel body position criteria in keyframes. The options are: a predefined fitness function and a parametric fitness function based on Bartenieff Fundamentals movement constructs. The pre-defined fitness function uses a set of criteria specifically for provoking novel keyframes based on traditional dance movement. We have developed heuristic rules based on movement patterns discussed in Bartenieff Fundamentals and the authors expertise in contemporary dance practice to inhibit traditional habits when creating movement (Studd and Cox 2013). The fitness function evaluates each catalyst component separately (body symmetry, body position and levels) and then calculates the overall score. Preferred positions are those that highlight contralateral movement (body asymmetry), unstable levels with partially bent joints to create novel movement options. More on this function can be found in our prior paper (Carlson, Schiphorst, and Pasquier 2011). The parameterized fitness function allows the

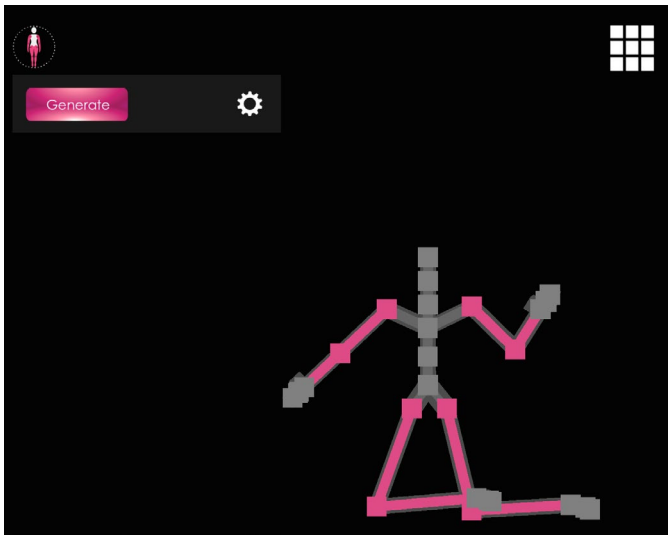

Figure 6: Pre-Defined Fitness Function Interface

choreographer to change the weighting of each parameter, creating more personalized generated options.

Cochoreo Interaction

To use the Cochoreo feature in idanceForms, the choreographer goes into the keyframe editing screen and selects a new keyframe. The Cochoreo screen is simple, providing a button for 'Generate and a gear icon for access to the settings (see Figure 7). Every time the Generate button is pressed a new keyframe is created. This keyframe can then be re-edited in the skeleton editing view. Limbs can be isolated by selecting them, changing the color from pink to white. Isolated limbs will stay in place during the next generation cycle and can be un-selected by touching them again. If generation including a spinal configuration or spatial orientation is desired the user can manipulate these features first and then generate new keyframes in which the edits will be retained.

The default fitness function generates keyframes based on the pre-defined rules, developed through an iterative design process to specifically restrict habits from dance technique and provoke novel movement options. This default fitness function weights body asymmetry, uneven reach space and unstable levels more strongly to encourage novel movement exploration.

The parameterized fitness function enables the choreographer to select options based in the Bartenieff Fundamental parameters to weight the probability of that feature more or less strongly (see Figure 8) (Studd and Cox 2013). Parameters include: Body Half (symmetry on one side of the body), Upper Lower (symmetry on top or bottom half of the body), Cross Lateral (symmetry across the body with one arm and one leg), Near Reach Space (arms contracted), Far Reach Space (arms extended), Knee Extension/ Flexion (creating more or less stable levels).

Body positions can also be interacted with in the gener-

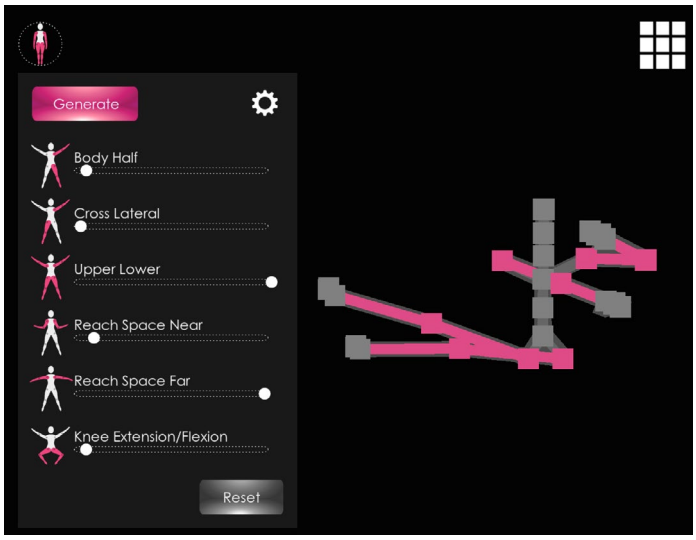

Figure 7: Parameterized Fitness Function Interface

ation by isolating limbs (see Figure 9). By isolating limbs they are removed from the algorithm while remaining limbs continue to be generated. The shape of the spine can also be manipulated by manually editing the vertebral joints using the skeleton editing features (selecting individual joints and moving them using the 3 axis) and then generating new limb positions.

Choreographic Study Exploring Creative Experience

We evaluated the system in a pilot study with 14 novice choreographers who were second year university dance major students. Choreographers met for two workshops over a week and had a composition assignment in-between

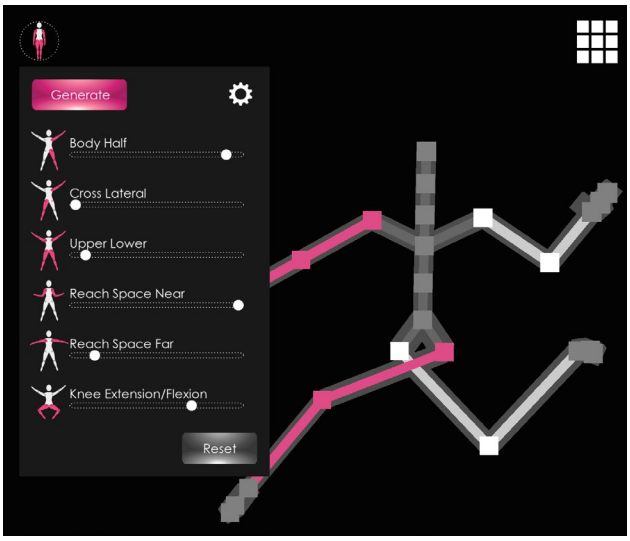

Figure 8: Isolating Limbs in Generation

workshops. The technology was introduced as a tool to support their existing choreographic process, and they were guided through short exercises to use it while constructing a movement phrase. Observational data was collected by the researcher through notes, photo and video documentation. Semi-structured focus groups were used to gather information about the creative experience. Data was analyzed using thematic analysis to highlight salient topics identified about choreographer's creative experience.

The goal of this research was to explore how choreographers can interactively develop creative movement with a system, where both user and system generate creative ideas and iteratively develop a movement phrase. Understanding how choreographers would work with the system required observing and understanding the embodied process of exploring and 'trying on' the movement on their particular bodies. When provided with the idanceForms app, choreographers explored the shape of the movement on their body. They then made mapping decisions about how to translate the data from the avatar to themselves, exploring it on the body and finding new connections where they could interactively augment the movement design themselves. In iteration with the system choreographers would insert new movements, and augment existing movements by either recapturing the movement into the device (and manipulating it there) or by viewing the movement 'cues from a different perspective.

Novelty of Generated Keyframes

Cochoreo's generated movement catalysts were viewed to be interesting, suggesting movement options that the choreographer would not have developed themselves. Paired with the manipulation tools of idanceForms, choreographers had a variety of options for controlling the generation of movement material. The camera keyframing feature enabled choreographers to capture positions with the iPad's camera, which was matching images to an existing database (and not always precise to the movement performed by the choreographer). However, when the data was less precise and more embodied it supported the choreographer's exploration of movement.

> D: I liked working with the program because it pushed me to do movement I would never think of ... that was really interesting to me to try to put myself in this uncomfortable place and now a week later be comfortable in moving in that sort of way.

Resolution of Data/ Mapping Strategy

In the original design of Scuddle, generated positions were static and minimalistic stick figures. This design prompted choreographers to focus more on the interpretation of figures (and invention of new positions) than attempting to map the exact 2D position onto their moving 3D bodies. The low resolution of data catalyzed novel exploration, yet it could not guide positions into movement. Cochoreo generates keyframes, yet they are animated to create movements and use a 3D stick figure. This design uses a higher resolution of data, which prompts more attention to the physical mapping

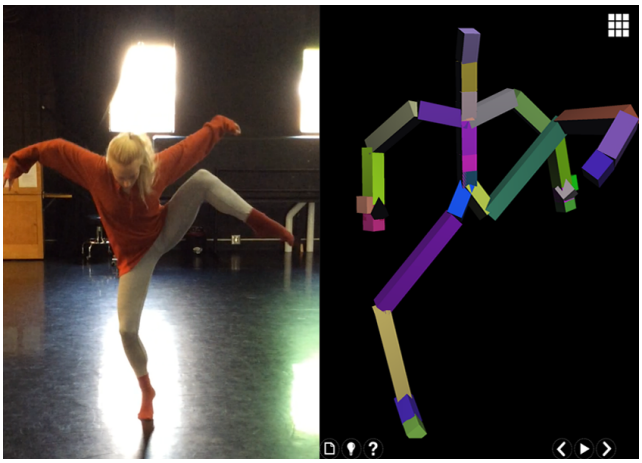

Figure 9: Pilot Study Session 2

from screen to body. When choreographers were learning material from the static keyframes, the higher resolution of data prompted them to focus less on their creative interpretation of the positions themselves, but brought attention to the transitions between positions as they had to maneuver dynamic changes in the data. Though when choreographers attended to the animated phrases instead of the static positions, they attended to the translation of dynamic parameters such as time and momentum more than the body position.

> B: I felt that it felt better on my body if I used the app for inspiration for my movement and didnt necessarily try to replicate it exactly. So that really helped. And then when we sped up our movement or added repetition that helped it flow more easily through my body.
>
> B: I felt that after going back and forth, like when I was first working with it it was very planal, but once we took it from there and took the movement home I could explore the other aspects of it. So then today in the space, even though we went back and added that bit in, I tried to keep the idea of my home movement but from a generated source.

Co-Imagining/ Interaction with System

Choreographers were asked to generate multiple keyframes in Cochoreo, then learn them on their own body to create a movement phrase. The goal was to eventually move smoothly back and forth between designing movement in the system and exploring the movement on the body. While the translation of data from device to body and back was a new challenge for many choreographers, they discovered unique perceptions to movement design through their interaction with the system. These included an attention to momentum as related to time in the system, the focus on angular limb positions and how they moved through time and attention to spatial orientation and engagement in relation to a focus on a mobile device. Choreographers also became aware of their movement habits (many which developed through movement training) and preferences when exploring movement with specific sensory feedback (if a movement 'feels right' or 'looks right' in the mirror).

> A2: It was interesting working with this movement away from an image (the software) because I feel like when you have this image in front of you, the mirror neurons you want to mimic this movement, and thats the way we learn movement, rather than learning from feelings, so not having that 'mirror' (of an image) and taking what this movement was in our memories and playing with the feeling of what it was, it was interesting and illicited new... it helped me evolve the movement. Having the exposure to it and then taking it away.
>
> J: I usually focus more on momentum so its interesting to approach with more emphasis on the angles, because its like whoa I have limbs! I just realized I have limbs and its in my face! Also realizing peripheral vision because there is a lot of stuff with angles happening back here which I dont usually think about.'

Conclusion

The evolution of Cochoreo as a sub-module within the idanceForms framework enabled us to explore how a creativity support tool could also provoke creative choreographic choices. We observed how choreographers devise movement using embodied methods, and augmented that process by inserting Cochoreo phrases within the embodied methods.

We view *Cochoreo* as a preliminary exploration of generative authoring tools for movement to evaluate how the affordances of such a system can support the creative values of a choreographer. While the goal of this project is to create an interactive toolkit for choreography design where a workflow can move smoothly between the choreographer and the technology, this is a complicated process that does not have obvious solutions in the near future. We are interested in how to take small steps to work towards this goal. In this study we observed the playful discovery process that each choreographer experienced and began weaving into crafted movement sequences. We see potential for systems that utilize generative movement augmentation to create embodied and personalized qualities of work, as opposed to designing for known creative processes using traditional interaction methods.

Future work includes connecting the Camera Keyframing feature Cochoreo to use embodied methods in the genetic algorithm. The choreographer would then be able to contribute to the initial gene population with their own movement data and could create target fitness functions. We are also investigating options for implementing novelty search to generate new positions that are maximally different from what the choreographer designs in Cochoreo.

Additional Media

Links to view videos of movement phrases:

Demonstration Videos of Cochoreo Generative Feature in idanceForms:

Predefined Fitness Function: https://goo.gl/JjqqUc

Parameterized Fitness Function: https://goo.gl/AIkwNG

Demonstration Videos of Select Choreographers in Final Cochoreo Study:

Participant m: https://goo.gl/gfLcBV

Participant b: https://goo.gl/G3lsHb

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