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VISUALIZATION TECHNIQUES AS METHODOLOGICAL TOOLS FOR DANCE RESEARCH

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Abstract

Dance Research is a term that refers to the methods and methodological approaches used in dance studies, a relatively new academic discipline. In this paper we describe how visualization techniques can be used to help the dance researcher visualize in a more intuitive manner the concepts underlying a choreographer's work. We describe tools developed for and used by researchers interested in improvisation and dance research, and we provide practical examples of how they were used to analyze choreographer João Fiadeiro's Real Time Composition (CTR) Method.

Keywords

Visualization Techniques
Dance Research
Real Time Composition
Point Clouds
Unity3D

1. MOTIVATION

Dance is a complex human endeavor. It is practiced as an artistic and creative activity, as well as a form of physical exercise (Cone 2015) and of therapy (Koch et al. 2014). As a social phenomenon, there are also ideological ramifications of how it is used, presented, thought about, and theorized. Current practices of conducting dance research mostly rely on principles of field work (Giurchescu et al. 1991), where "direct observation" of dance events in their natural setting was, and still is, the main method of dance studies. Within this practice, comprehensive technical recordings of dance, music, and texts, or of entire events, are realized through combining the following means: film / video (Twitchett et al. 2009), photo, sound recordings (Ungvary 1992), and interviews with graphic notation (Herbison-Evans 1988), and further written documents such as questionnaires. Other approaches are rooted in anthropological research methods, and in this case the researcher takes a more participative and self-experienced role (Kaeppler 1978; Kaeppler 2000). Dance can also be interpreted as a form of multimodal communication and as such allow itself to be studied using methods taken from the field of Linguistics (Camurri 2003).

Data captured during the research process is further subjected to analyses that usually result in monographs focused on one particular aspect of the subject matter, such as dance form, function, or content. Advances in computer vision and computer graphics, in particular human activity recognition (Aggarwal 2014) and visual analysis of human movement (Gavrila 1999), have presented new opportunities for dance researchers. An example is William Forsythe's *Synchronous Objects*.[1] In this project, Forsythe tries to answer the question "what else might physical thinking look like?" In an attempt to answer the question, he and his team developed a set of alternative visualizations of his choreography *One Flat Thing, reproduced* (2000). The result shows abstractions of how movement can be perceived visually and how certain physical characteristics of the movement can be used alternatively to a real human representation, thus bringing to light patterns and choreographic structures. Nevertheless, the work focuses on a single choreography, and the approaches used cannot be easily applied to other works. Tiss limits the possibility of developing comparative studies, in that it does not promote methods or practices that can be used or replicated by other dance researchers using other data.

1 Synchronous Objects Project: http://synchronousobjects.osu.edu/

In this article, we attempt to fill this gap by proposing research tools that provide novel ways to both document and analyze dance choreographic practices. Specifically, we introduce the Dynamic Annotation Visualizer, a software developed in Unity3D, that is fully parameterizable and allows to visually analyze data concerning any body movement, including facial movements in addition to eye gaze. We also propose a point cloud visualizer that supports the integration of 3D data captured with Kinect sensors from multiples viewpoints, and the application of visual effects in real time implemented using GLSL shaders. Finally, these tools are described using real-life examples from our collaboration with choreographer João Fiadeiro.[2]

2 João Fiadeiro biography: https://www.re-al.org/en/2277-2/

2. Case Study: Real Time Composition

Portuguese choreographer João Fiadeiro began developing his method of Real Time Composition (*Composição em Tempo Real*, or CTR) in 1995 resulting from the need to systematize his own choreographic compositional views and practices. As it evolved over time, the CTR method became not just a means to aid in the creation of new compositions, but also an educational tool for dancers to learn from and with it develop new decision-making processes when creating collaborative improvisations. The CTR method is exercised as a "game", with its own set of instructions that indicate when a player can perform an action and how the game progresses. The rules of each game, however, emerge during the performance and, in brief, practitioners of the method learn to position themselves in face of the improvisation rather than trying to understand the composition itself.[3] Because of its structured nature, the CTR has also attracted attention from other disciplines such as philosophy, anthropology, ethnology, economics, complex system theory, and neurosciences. A table version of the CTR exercise, or "the Game", was created specifically to have a scaled down version which was both more portable (rather than using a stage) and more accessible to people interested in Fiadeiro's method but unaccustomed to using their bodies like dancers do. The main goal of the Game can be described as follows:

3
A brief introduction to Real Time Composition method by João Fiadeiro: http://theobservatorium.net/docs/A_brief_intro_to_CTR_Social_Stigmergy_ISCTE.pdf

> Players use various objects to sequentially perform single actions, or "positions", so as to create connections between positions. These connections are called "relations". A player needs to perform a position which can have a relation (obvious to the other players) with the previous relation (connecting the previous two positions), and not with the previous position alone. Relations are built when a position has some sort of connection with how the Game has been played up to that point (in terms of size, color, placement, etc.). The Game is simple to play: anything goes, and there are no wrong positions per se, just more or less opportune ones. The player task is to allow the Game to continue. Moreover, the Game is a silent game. No talking is allowed between players. The Game begins with an empty table and a collection of objects available to be freely used throughout the game. (Evola & Fiadeiro 2015, 4)

To acquire a sufficient understanding of Fiadeiro's method, we participated in several workshops as non-expert performers, besides having also observed and recorded workshops targeted at expert dancers. Following these sessions, it was important to identify the core concepts of the CTR method and how they relate to the result of an improvisation performance. Our main aim was to visually and digitally represent the concepts using improvisation sequences from Fiadeiro's current works. In a series of unstructured interviews with Fiadeiro focused on identifying and defining these core concepts, together with the choreographer we analyzed video footage from previous workshops to detect different examples of each concept in order to better define and describe them. For example, we observed a series of videos where each improvisation started with the same "position" (following the terminology of the CTR; see Table 1), and from that we could understand what was both a position as well as a "relation". From these interviews resulted a selection of five focus concepts described in Table 1.

After having observed videos of Fiadeiro's past works, including rehearsals, performances and workshops, we were able to identify a set of video sequences matching each concept. This allowed us to have both a conceptual understanding as well as visual exemplifications of the concepts in order to develop a set of possible visualization effects for each concept.

Table 1
List of the selected CTR method concepts with respective descriptions.

CTR Concept	*Description*
Position	Any performed/performative action (e.g. a performer lifting a chair).
Relation	Performing a position which relates to another position (e.g. another performer also lifting a chair).
Cycle of Vitality	The time or duration of an improvisation exploring a specific idea.
Possible Futures and Pasts	A performer can choose in the improvisation from several possibilities of how to proceed (= futures), which will shape reinterpretations of previous understandings of positions and relations (= pasts).
Suspension	The time a performer takes to take a decision, suspending any action.

3. DATA GATHERING AND DATA VISUALIZATION

3.1 Dynamic Annotation Visualizer (DAV)

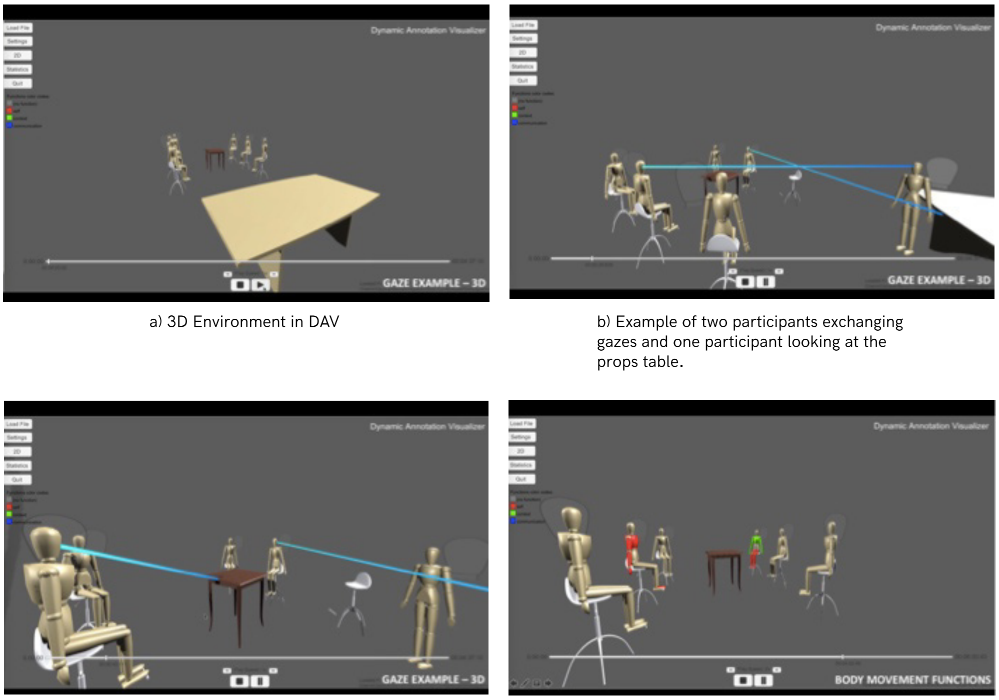
Three CTR table game sessions were video recorded using a four-camera setup. Each session occurred on separate days and involved three different sets of participants: non-performers naïve to the CTR; expert dancers with no previous knowledge of the CTR method; and expert CTR performers. Two cognitive linguistic researchers developed an annotation system (Evola et al. 2016) that was used to code videos from these sessions. Their data processing focused on body movements, including facial movements in addition to eye gaze. Annotating video is a common methodological approach in Gesture Studies, and involves coding video data frame by frame and the result is an XML or proprietary notation language file extracted from the annotation software used (e.g. ELAN)[4]. In order to facilitate and promote a more intuitive way to analyze this type of annotated data we developed a software program that can show this information visually—the Dynamic Annotation Visualizer (DAV).

The DAV software was developed in Unity3D[5] and is composed of a Graphical User Interface (GUI) that allows researchers to import their annotations in a 3D environment. The default settings show all the data types for every participant simultaneously, but the GUI also allows to select which data to visualize (e.g. gaze vs. upper body movements) and for which participant(s). A timeline allows to fast-forward, rewind, or play in slow motion. Personalizing the 3D environment is relatively simple, in that Unity3D supports the most common 3D data types, such as the free 3D models available on various websites (e.g. TurboSquid). Screenshots of DAV (Figure 1) show the 3D environment applied in the scenario replicating the setup used in the Fiadeiro case study (Fig. 1a). When researchers need to track multiple participants' gazes, it is cumbersome to use video data. DAV facilitates gaze analysis (Fig. 1b), even from a first-person participant's perspective (Fig. 1c). Finally, even minute body movements can be visualized (Fig. 1d), via highlighting according to a color code corresponding to a type of movement (e.g. formal vs. functional). By dynamically visualizing their otherwise static annotations, the researchers were able to better contextualize their data points, promoting a more critical analysis of their data.

4
ELAN: http://tla.mpi.nl/tools/tla-tools/elan/

5
UNITY3D: https://unity3d.com

Fig. 1
Screenshots of the Dynamic Annotation Visualizer (DAV).



a) 3D Environment in DAV

b) Example of two participants exchanging gazes and one participant looking at the props table.

c) Observing others' eye gazes from the perspective of one of the participants.

d) Isolating upper and lower body movements by type (context, function).

3.2 CTR Concepts Visualization

Another aim of ours was to go through the looking-glass to reveal and visually represent abstract concepts underlying the CTR as they came to life. Two three-hour improvisation sessions with João Fiadeiro and seven of his dancers were recorded in two separate days, with each improvisation starting from the same first position. Multiple Microsoft Kinects were used to capture 3D data, which presented challenges, such as establishing the number of Kinects necessary for a capture volume like a dance floor, the ideal setup to guarantee data quality, and data calibration and synchronization across devices. Three Kinect sensors were ultimately used for the triangulation of data, using a wide-baseline setup across the dance floor to minimize data loss due to occlusions. Although increasing the number of viewpoints would decrease the number of occlusions, it was considered unfeasible as it would linearly increase the amount of data to be handled during rendering.

The data processing procedure included the use of a point cloud visualizer developed for rendering the 3D data (see flowchart in Fig.2). Each Kinect stream was converted into point cloud data, which was then post-processed to extract contextual information (e.g. people and objects) and normal vector estimation. This processed data was then inserted into the point cloud visualizer developed in Unity3D. A set of GLSL shader programs was implemented to apply in real time a color code assigned to each CTR concept (described in Table 1).

We selected sections of the data from the improvisation sessions which clearly exemplify the base concepts from the CTR method. Since some concepts need longer periods of time to be comprehended, we also combined different subsections together in order to enable a shorter, but sequenced visualization for the user.

The most central concept of the CTR, *position*, was represented through assigning different colors to different positions, so users could track the concept during the development of the improvisation session.

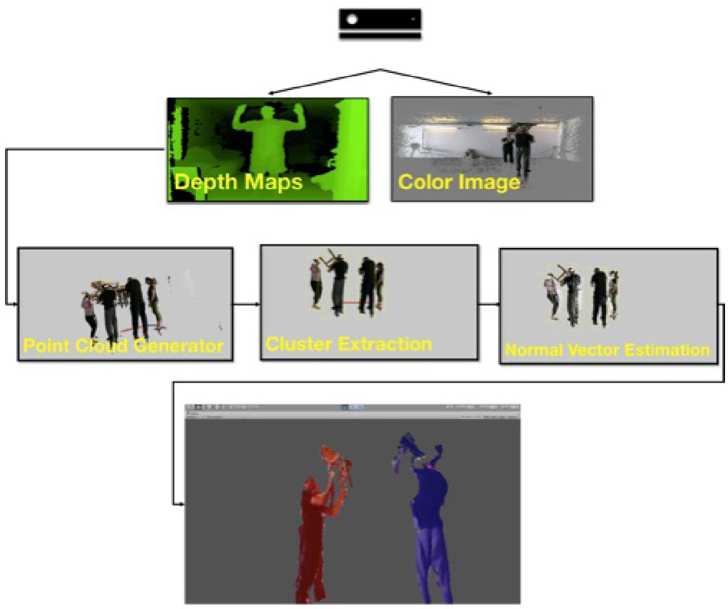


Fig. 2
Flowchart representing the procedure of data capture, post-processing, and visualization.

In one sample segment, each dancer entering the stage created a new position. We identified each different body through a color-based clustering algorithm, combined with video annotation that would connect each player to a different position and an assigned color. An example can be seen in Figure 3, where the third position was being introduced: The participant in red entered the space holding a table in the air (first position) followed by the one in blue that had a table in the air (second position), and by the one in green (third position) with a cup that was held above the table. RGB values for the colors were tested against a color blindness simulation [6] and adapted to assure wider user accessibility.

Elements introduced in a new position may create a *relation* with some or all elements from previous positions in the scene. This CTR concept of relation was visually represented by giving the elements of the two positions the same color. The establishment of newer relations was represented as a gradual assimilation of colors, as seen in Figure 4. This example only contains a single relation between two elements: the participant holding a chair, and the one holding the table, which create a clearly identifiable relation (i.e. holding things) coming from the real world. In a more complex scenario, several separate relations might co-exist at any given time. Changes in relations and positions can go unnoticed by novices to the method, especially in longer scenarios, with more performers, or in faster paced sequences of actions. Although a simple solution, color coding can intuitively help identify these concepts without adding visual pollution to the actual recorded content.

The concept of *cycle of vitality*, the time frame during which the sequence in a composition is progressing, was represented through the loss and gain of color. According to the CTR, the end of a session must be postponed by creating new relations through new positions. We selected a longer passage from a session performed by two dancers, where the prolongation of the cycle of vitality was evident through several positions being performed, as well as the cycle of vitality's approach to an ending when no new positions were being introduced (see Figure 5). In this example, one participant left the scene as he hurt himself during the performance. The cycle was coming to an end, but another performer introduced a new position by inviting the performer who had left back on stage and, using the accident as an element of their improvisation, starting a new cy-

6 Etre's Colour Blindness Simulator: http://www.etre.com/tools/colourblindsimulator/

cle of vitality. In our visualization, we spatially organize the possible futures in a three-dimensional space (Fig. 6). The performer is placed inside a cube, in which he has a possible future in each one of the sides of the cube, and the camera can navigate through each one of the possible futures exploring new relations. In reality, there are countless possible futures for each position. We display different outcomes starting from the same first position to exemplify this concept.

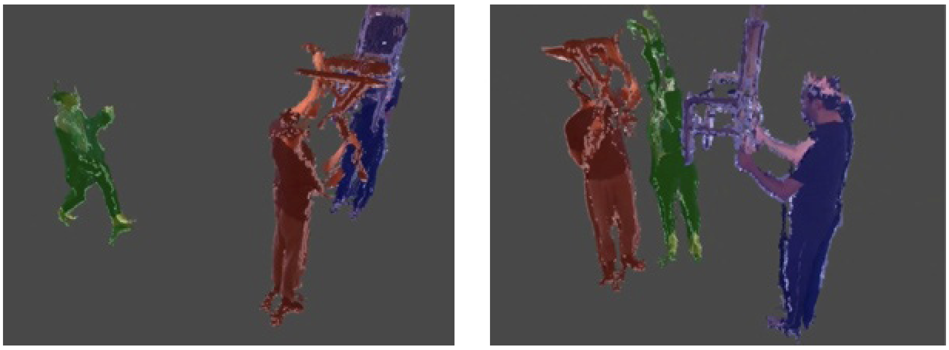


Fig. 3
Visualizing "position": Different color-coded participants represent different positions.

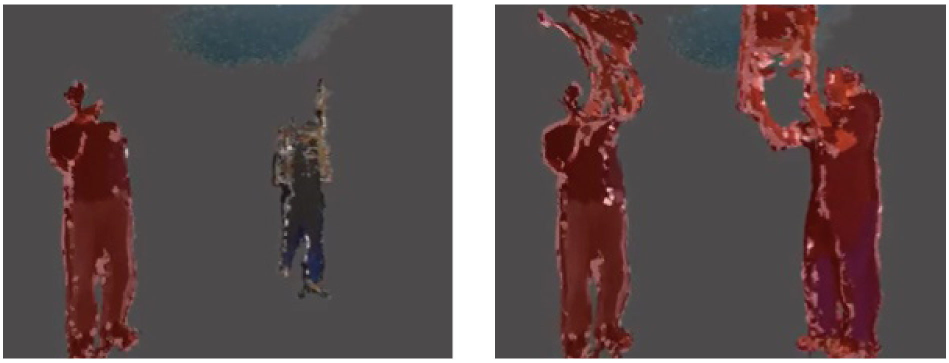


Fig. 4
Visualizing "relation": The color of the second participant slowly assimilates the color of the first as they establish a relation.

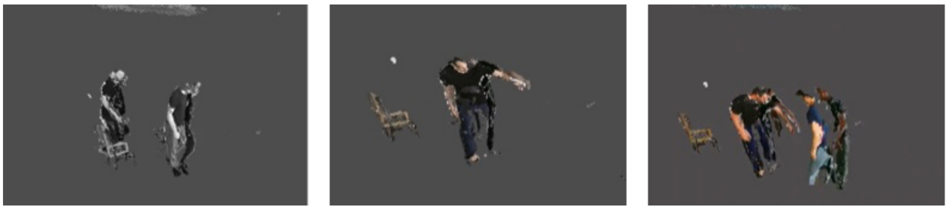


Fig. 5
Visualizing "cycle of vitality": When one performer leaves the stage, the vitality of the scene seems to end (gray); saturation gradually increases when another performer starts a new position.

The last concept related to Fiadeiro's "real time" that we chose to represent is that of *suspension*, which happens during the performer's decision- making process. By spatially separating the present and the future, and manipulating the reproduction speed of a segment, we exemplify the suspension of time in which one participant is examining the current situation, with her personal, inner time being disconnected from the real time. In one instance (Fig. 7), various performers created positions and relations with the performer, who was holding the table in the first position, by piling various objects onto it.

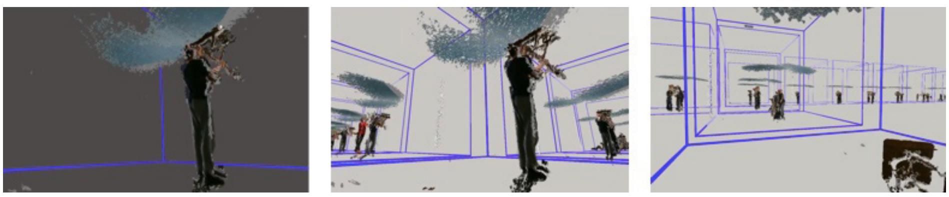


Fig. 6
Visualizing "possible futures and pasts": Possibilities are unveiled through the sides of the cube, where possibilities are organized in a three-dimensional space.

A critical point was reached when it was considered terminating the current sequence of positions, due to the fact that the first participant was not able to physically carry more objects. Here a suspension is exemplified, with the reproduction speed of the "present" (participant holding objects) slowed down, to represent the disconnect between "real time" and the time as perceived by the outermost participant, representing the desired decision-making process in CTR. An alternative, future possibility can be viewed in a scene in the background, and when or if that future is "accepted" (participant decides this is the course of action to be taken), the camera navigates into the new "present" scene.

Fig. 7
Suspension: Sequence of instances in the visualization where a possible future appears in the background, towards which the camera navigates until the suspension ends.

5. CONCLUSION

In this paper, we described the motivation for and practical usage of two methodological tools based on computer visualization techniques for dance research based on case studies of contemporary dancers.

The first, the Dynamic Annotation Visualizer, is a highly customizable tool, already used in research on human interaction, and allows to visually represent annotated data concerning any body movement, including facial movements in addition to eye gaze. The graphical user interface integrated in this tool also gives users the ability to focus on particular phenomena in the data, bringing into light subtleties that otherwise could be missed just observing video data (i.e. tracking simultaneous movements in multiple people). The second tool we described is a point cloud visualizer that supports visualizing in an interactive system a 3D representation of a choreography and applying visual effect in real time. Capturing dance in 3D supporting a viewpoint-free visualization opens up a vast range of possibilities.

Primarily, dance is about movement, specifically expression through movement. Having an interactive, digital representation of movement facilitates closer observations of specificities that characterize a particular aesthetic language and, as such, analyze choreographic works within the creative context it was created. 3D data is essentially a composition of graphical primitives that can be manipulated and changed to serve a certain purpose. By manipulating this kind of data, meaning the digital representation of movement, it can potentially provide different perspectives that can open up new future research directions in Dance Studies.

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