DANCE, SENSES, URBAN CONTEXTS

Dance and the Senses · Dancing and Dance Cultures in Urban Contexts

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DIGITAL MOVEMENT: AN OVERVIEW OF COMPUTER-AIDED ANALYSIS OF HUMAN MOTION

From the overall form of the music to the smallest rhythmical facet, each aspect defines how dancers realize the sound and movements. Especially in the field of dance the factors determining this connection can happen within fractions of a second. To understand these events and how musical parameters let dancers recognize music as "danceable", Motion Capture (MoCap) can help by capturing movement in 3D space together with the music. This allows the reconstruction of a performance, which then can be re-related to musical parameters. The paper will elaborate in what ways MoCap technology can support music and dance research, and what kind of problems arise with movement analysis in the special case of *tango argentino*.

Keywords: motion capture; *tango argentino*; choreomusicology; movement analysis

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In the "Tango-Danceability of Music in European Perspective" research project[1], we try to learn how dancers perceive music and implement their perception as dancing movement. For this, the analysis of human motion is a necessary part of understanding the moving body. In the case of *tango argentino*, the motional structures in question happen on such fine levels of granularity that new approaches for their analysis have to be developed and applied. This is where digital capturing technology and analytical methods come in as a research focus of this project.[2]

Choreomusicological approach

We all know well that music and dance often cannot easily be separated into two independent entities. When we analyze them we do this more often than not, for good reasons, as we may just want to concentrate on certain aspects of either the dance or the music. But working on the connection of these two parts can offer even more insight of how dance can be understood in terms of the music and vice versa. This idea can be found in the emerging field of choreomusicology. It was first mentioned by composer Paul Hodgins [1992], who tried to establish factors that determine the relation of music and dance which are applicable to both sides. It evolved from ideas concerning especially the Western bias of separable concepts of music and dance. We can use this principle to think about those relations in an abstract way of sound and movement produced by humans.

Paul Mason [2012], an Australian neuroanthropologist, adapts the idea, strengthening its theoretical foundation in a non-Western context, and elaborates on Hodgins' parameters of intrinsic and extrinsic relationships by explicitly separating the two categories. Intrinsic ones

[1] More information on the project can be found on Stepputat [2015].

[2] This paper differs from the presentation given at the symposium, as it also reflects the current progress of the ongoing research project. No information is being left out here, but up-to-date results are incorporated.

refer to the structural elements within the sound and movement, while extrinsic ones are valid only within a certain context and additionalknowledge about it. Instances of the first and their implementation would be rhythmic elements, such as pulse, accent and meter; qualitative features, such as timbre in sound, or sharpness and smoothness of a movement; or structural elements, as phrasing and form in music, and motives, figures and structure in movement. An example of extrinsic parameters is the emotional aspect, as communicated in music or dance, or the narrative.

These are just a few examples of what can define the relation of music and movement. If we now want to access these criteria in a choreomusicological framework of research, we must find a way to define them as analytical parameters, and that is where different disciplines have to work together.

Digital application

When we examine sound and movement by digital means, we need to collect the information in a machine readable format and simultaneously want it to be easily perceivable for humans. This is especially the case for intrinsic relationships, such as rhythmic aspects. A perfectly suited example is the beat. It is a temporally bound phenomenon, that is present both in music and dance and very often defines the actual connection between the two.

We can transfer humanly perceivable events into a digital format by inferring the domain they are set in. Here we have time as the constituting factor, producing the beat as just points in time. To find these points, we need to reconstruct both entities first: digital recording for music, and Motion Capture for the dance. In music, the field of Music Information Retrieval (MIR) already offers a great variety of methods to automatically detect a beat in a sound file. In the dance, the researcher must define how a dancer realizes the beat in order to write routines for automatic detection. Having defined these two variables, we want to find a connection between them. One fitting approach is to define a metric on the two, that is, an abstraction of the notion of distance. In defining this "distance", we can derive idiosyncrasies of certain motional structures.

Concering *tango argentino* movement repertoire, the style we concentrate on is characterized by a close embrace of the dance partners and their physical connection from the waist up. The embrace is opened up only during the execution of a few, more embellishing movements. The focus in close embrace tango dancing lies on elaborate footwork and the detached working of both dancers' hips and waists. *Tango argentino* is a highly improvised dance whose movement repertoire comprises mainly walking and turning techniques, instead of a great variety of predefined sequences of steps. We can find the constituting elements of this dance in aspects like posture, walk, or turns and their distinctive quality of execution. This is the entry point for Motion Capture (MoCap).

A definition for MoCap can be found in the entertainment industry: "Motion capture involves measuring an object's position and orientation in physical space, then recording that information in a computer-usable form" [Dyer, Martin, Zulauf 1995]. In general, we can expand the definition given here in regard to the objects' mode of capture: what we want, is to get information about the relation of an object to the physical space it is involved in and interacts with. Furthermore, the information collected has to be made accessible to both

human and machine, in order to store and analyze it. This generalization is important when it comes to the technology actually used, since the mode of how the data is gathered can be based on contrasting approaches. The main difference here is between absolute versus relative representation of the information. Current systems are based on the principles of kinematics treating the motion of points, bodies or systems. Thereby the reason for the motion (the force) is not taken into account. Absolute values in this context then would be the above mentioned position and orientation in a defined physical space, while relative values comprise velocity and acceleration. This gives us six degrees of freedom: three dimensions of position, and three dimensions of orientation, which is an immense difference to common recording methods such as 2D videos.

We will use a passive marker based optical system. This system captures markers attached to a body, which can be fitted to reconstruct a model of the captured body in a 3D environment. The data produced by a MoCap system can give insight into very small details of the moving body in all dimensions. This goes down to sub-millimeter position and milliseconds in timing.[3] Thus we can say, that these techniques allow highly detailed analyses best suited for music -movement relations.

Tango application

The application of the theoretical approaches described above led us to the experimental setup described below. We will conduct detailed studies on three couples who are professional *tango* dancers. They each have to complete movement tasks to four different auditive stimuli. The selection of these are partially based on the findings of the first part of the study, where parameters relating to the danceability of *tango argentino* were defined via an online survey. The music chosen is as follows:

1) the musical piece that was rated most danceable according to the survey
2) a piece especially composed for this project, fulfilling all parameters that were previously established
3) the piece each couple feels most comfortable dancing to, chosen by them individually
4) a computer-generated click track for reference

The dancers will perform three different movement tasks to each of the stimuli: dancing (only basic walking and turning) in a couple, walking alone, and tapping along to the music alone. With this setup we achieve a high number of comparable datasets available for cross-referencing.

By including a click track we allow for a well suited method to control an actual synchronization task. In this, attention has to be paid to the aspect of negative asynchrony, which has been shown by many studies already[4]. It describes the phenomen of humans anticipating the beat on a motor level, that is, tapping a few miliseconds[5] in advance of the actual sonic event, but still perceiving as being in time. From this point of view, searching for rhythmical structures in the dance is an expansion of such experiments. We try to understand

[3] For example, a typical system setup works with a recording rate of 250 images per second, which is equivalent to 4 milliseconds. Higher frame rates are possible, depending on the system used.

[4] See Aschersleben [2001] for an overview.

[5] The average anticipation is about ten to fourteen miliseconds.

the perception of the musical factors by the dancer, for example, the embodiment of a beat. Since we work with entire musical pieces and not only one simple click track, we also have to take the localization of the beat in the music into account. On the level of just a few miliseconds, we have to decide which event actually defines a musical beat. By comparing kinematic landmarks (such as acceleration peaks or pivot points) in the movement of professional *tango* dancers on different beat locations (onset, energy peak), we might be able to understand their individual perception of musical structures within their bodies.

Outlook

In the work on sound-movement interrelationship, we are using the theoretical approach proposed by choreomusicology. It suggests that the said relation should be described not from only one of either of the two perspectives, but rather to understand one side in terms of the other. By relating the salient features of each domain, we can deduct new parameters that are fundamental for the proposed study of sound-movement relationships. Understanding this can "illuminate kinaesthetic and perceptual processes of the embodied brain as subjectively experienced and manifested by individuals who are immersed in, subject to and the producers of cultural activity" according to Paul Mason [2014:225]. This further means, that we can start to analyze culturally bound activity, such as motional structures, in a new light, to better understand the impact of such processes.

By incorporating new state-of-the-art technologies in the analysis of the two entities, we are introducing new methodological modalities to make their way into the field of ethnochoreology. Valuable insights for the further examination are thereby offered on a theoretical level, letting us understand cultural implications caused by the analyzed motion and sound structures.

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