The Gestural Rhythm : An Alternative Cue For Motion Analysis

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Abstract

To embody the art of dance within intermedia means to accomodate the body within new technologies — to turn a perceptual reality into a set of virtual data — to expend the body and carry the flow of movement through other forms of perception. Considering the lack of a motion analysis that focuses on qualitative aspects, I looked at philosophi- cal theories of movement and experiments concerning the mechanisms of cognition and the perception of movement. In so doing I realized that a major aspect had been neglected : Gestural Rhythm. In this paper I try to explain what prompted me to conduct this study and why I believe a more precise definition and a deeper, automated analysis of gestural rhythm could open new spaces for the creation in contemporary dance by expanding the capabilities of motion analysis.

Introduction

As a sound engineer I had been wondering how to get more involved into dance performances for many years, until I realised that a better approach would be to get the dance material more involved in the way I worked with sound.

As a consequence, and considering the advent of dance within intermedia, I logically became interested into motion capture and motion analysis and noted that most dance performances exploring interactivity and motion analysis techniques still focused on quantitative specifications of dance, using for instance the Cartesian position of dancers in space, their speed, or their acceleration and mapping these elements onto sound synthesis parameters, video specifications or electro-mechanic systems.

Yet I still felt like something was missing. Something that could create a more intimate bond between the mechanisms of choreographic composition, the body language, the personality of the dancers and any media form in order to improve our cognitive response and our perception of a work by making it multi-modal.

Hence, by exploring theories of movement for which some kind of classification has been developed, the idea of a motion analysis that would focus on qualitative specifications of dance occurred to me.

Qualitative Specifications

This led me quite logically to experience Delsarte's, Laban's, Jacques-Dalcroze's and many others works about motion analysis as I thought that the best way to initiate my research was to get interested in the theories modern dance were built on.

This study began by considering Bergson's and Deleuze's philosophies in order to understand what it means to analyse motion.

Indeed, in Bergson's philosophy to analyse means to carry out the pure. Yet there are no pure elements for Bergson. Elements of a whole are as mixed up as the whole itself and the only pure things are the tendancies so that to performan an analyse means to carry out the pure tendencies of a whole.

Then Deleuze explains that :

> *Space covered is past, movement is present, the act of covering. The space covered is divisible, indeed infinitely divisible, whilst movement is indivisible, or cannot be divided without changing qualitatively each*

time it is divided[1].

i.e. to consider quantitative changes between sections means to consider only the poses, to consider the movement requires a consideration of the qualitative changes.

Thus, to proceed with a motion analysis would mean to carry out the changes of the qualitative tendencies of movement.

Therefore, the next step was Laban's theory of *effort* and the ensuing categories of movement expression. Indeed, Laban suggests two major opposite tendancies for *effort* subcategories referring to Space, Weight, Time and Flow which consist of a *struggle behavior* or an *abandonment behavior* against those subcategories. However, despite the fact that Flow is first supposed to be a subcategory equal to the others, Laban explains how an *abandonment behavior* against *action drive* leads to a free flow, whereas a *struggle behavior* against them leads to a bound flow, which suggests Flow would be an upper subcategory dependant on the three others.

Furthermore, Judith Kestenberg's development on the concept of Flow, in which she explains how Flow's quality depends on co-contraction of agonist and antagonist muscle pairs, led later to a motion analysis technique that focuses on Flow variations in *action drive* : Kestenberg Movement Profile (KMP).

Lastly, I would suggest a link between Rudolf Steiner theories on movement, and especially about what he calls *eurythmical space*, and Kestenberg's concept of Flow. Indeed, in *eurythmical space* we are surrounded by an infinity of invisible forces that shape the world and originate every move so that even immobility arises from the movement of contradictory forces that compensate each other.

However, I can't help thinking about a link between the previous concepts. Indeed, as with the flow, one may suppose an *abandonment behavior* against the invisible forces in *eurythmical space* should be ensuing from the absence of the co-contraction of agonist and antagonist muscle pairs. And on the contrary a *struggle behavior* against the invisible forces in *eurythmical space* should be ensuing from a massive co-contraction of agonist and antagonist muscle pairs.

Additionally, most dancers, and especially improvisational dancers, and many theorists of the movement like Hubert Godard, testify to how much our vision of the environment, the way we understand it, has an impact on the quality of movements.

As a consequence, I think Flow should be considered as a key qualitative specification to analyse, oscillating between two major tendancies : an *abandonment-free behavior* and a *struggle-bound behavior*, and I choose to restrict this study to that.

Movement Perception and Cognition: Towards Gestural Rhythm

At this point of the study the concept to be analysed has been defined, I did not, however, know how to capture it. Also, the mechanisms of perception and cognition of movements, the thought of another fundamental theorist, Emile Jacques-Dalcroze, and my experience as a dancer prompted me to consider the rhythmic aspect of movement.

Perception and Cognition Mechanisms

Indeed, measuring qualitative aspects of movement, sometimes hidden within muscular activity and postural anticipation, gets much more complex considering motion capture system are based on physical properties only giving access to kinematics.

Accordingly I considered learning from human beings' perception and cognition mechanisms, looking for a link between kinematics and the qualitative aspects of movement.

Shipley (2003) precisely suggested two types of mechanisms for the recognition of human movement:

> *Event-from-form* : suggesting a process only operating from kinematics information able to recreate the movement's form.
>
> *Event-from-dynamics* : suggesting a process oper- ating from dynamics information able to recreate dynamic patterns of movements to recognize.

[1] *Gilles Deleuze, The Movement Image, Chapter 1 Thesis on movement, First commentary on Bergson*

The following theories prompted me to consider the second proposal. Indeed, Runesson & Frykholm (1983) suggested a mechanism in which dynamic informations would be deducted from the apparent kinematics: *kinematics-specification-of-dynamic*s. This mechanism suggests the existence of a link between the perceptual system and the motor one. Then the Wilson & Knöblich theories (2005), built on the discovery of the mirror neurons, led to the idea of an embodiement process in which we would mentally mime the movement of recognition, thanks to kinematic informations, in order to get the dynamic informations, what Egil Haga names *event-from-imitation*. Those views are arguments in favor of a more general theory: the *motor theory of perception*.

This is the same mechanism that would be involved in Johansson's (1973) and further "point-light display" experiments in which it was found that we can recognize the type of movement (walking, running, dancing...), the gender of people and even some specific persons or ourselves only from the kinematic information contained in the movements of point-light.

Thus, those experiments seem to prove how we would be able to get qualitative specifications from kinematics.

Another, Bushnell & Boudreau's and Boone & Cunningham's experiment did show how much our somatic experience was essential in order to understand nonverbal and non-symbolic meaning of movement and body postures :

> *Certain motor skills may be necessary prior to the cue attunement to and the perception of specific cues[...] motor skills would limit the number of cues a child may perceive in their decoding of emotion.*

i.e. they observed that children could not decode some emotional aspects of movement, or more generally the nonverbal, non-symbolic meaning of body expression, unless they could physically reproduce it, they had experienced the ensuing body postures, or in some complex emotion unless their rhythmic abilities were good enough.

Also, one might suppose this phenomenon persists into adulthood, especially during dance performances where the body control of the performers leads to highly uncommon body postures, which would strengthen the interest of a qualitative motion analysis and of a multi-modal representation of it in order to improve the cognitive reception of the audience.

Lastly, I would mention some relevant observations that suggest a connection between rhythmic patterns of movements and the qualitative feelings that they provide, beginning with a concept developed by Daniel Stern under the name activation contour. Indeed, Daniel Stern found that the preverbal communication in infants would be operating from dynamic patterns recognized during amodal transfer, i.e. the nonverbal, non-symbolic communication inherent to body language would hide within the dynamic evolution of body postures, what Buck asserted to be a phenomenon still fundamental in adulthood yet coexisting with symbolic understanding. Furthermore, Daniel Stern thinks that the four basic emotions (joy, anger, sadness and fear) are way too simple and suggests the concept of vitality affect to name the kind of communion ensuing on a certain perceptual and cognitive reception. Also, a specific activation contour corresponds to a specific evolution of the vitality affects, i.e. a pattern of vitality affect, ensuing on the perceptual and cognitive reception of the dynamic evolution of body postures.

Finally Gabrielsson & Juslin (1996) and Juslin & Madison (1998) report, in the context of musical performance, that the expressive intention of any performer influences considerably on what they call the *timing patterns* of the performance and that the audience would use those same *timing patterns* to decode emotional aspects of the performance.

The Segmentation of the Flow of Movement : Chunking and Peak-Structure

An interesting implication of the last process described, mainly based on pattern recognition, is the existence of a mental process performing a segmentation of the flow of movement. Yet, our perceptual processes appear to perform a chunking able to isolate *gesture units* in order to help movement recognition, i.e. we take advantage of our personal experience of

the birth, evolution and end o*f gesture units* in order to perform a pre-understanding of the flow of movement so that we can make a relevant chunking.

Such an organizational structure built around an emphasis was suggested by Kendon (2004) under the name *peak-structure*. Also, movement would consist of a preparation phase, an emphasis or *goal-point* (Godoy 2008) reflecting the intentional nature of movement, and a return phase. As welle as, the Wohlschlager experiments did showed we demonstrate a superior accuracy during emphasis when performing a mimicry process, so that he suggests the chunking process to be essentially *goal-directed*.

However, Emile Jacque-Dalcroze's experiments, realized as the eurythmic exercises, and Abramson's developments on his work, demonstrated we still are very sensitive to the shape of the preparation and return phases and show how much they matter in the context of nonverbal, non-symbolic communication decreasing the relevancy of considering a *goal-directed* process in such a context.

One should also point out that most motion analysis techniques draw on human processes and perform this kind of chunking. Yet, if they enable a chunking between *gesture units*, their usual *segmentation signals* are error-prone, being based on the idea of differentiating movement between *motion-phases* and *break-phases* in addition to not allowing any kind of differenciation between *gesture units* i.e. they make no differences between accents and, above all, they don't allow any chunking in relevant movement sequence.

Thus, two observations led me to focus on gestural rhythm. First, a set of works previously presented, among them those of Daniel Stern and Jacques-Dalcroze, seem to show that patterns of movement dynamic evolution are carrying the fundamental message that comes through nonverbal nonsymbolic communication. Secondly, the flaws inherent to the *segmentation signals* commonly used encourage the search for another signal to allow differentiation between the nuances of accents and above all to define the scope of gestural phrases.

The Gestural Rhythm : A Concept to Define

One could argue how obvious the importance of gestural rhythm is in dance performances.

Indeed, working on performing the right rhythmic accents and to develop one's own relation to rhythm is fundamental in learning to dance. Yet most definitions, based on musical rhythm ones, used to consider this as a temporal distribution of neutral goal-points, leaving aside the nuances of accents, the shape of the preparation and return phases, and their involvement in the creation of a gestural phrase.

Thus, I would suggest using this observation as a basis:

> *While this concept of rhythm as a neutral series of attack points and durations may be appropriate in certain contexts, it does not accord very well with our experience of rhythm in its fullest sense. When we respond to rhythm as listeners or feel a rhythm as performers, we experience something vital and dynamic – a flow of energy through time, one might say. This flow is not uniform and undifferentiated, but is rather characterized by a dynamic interplay of ebb and flow, of intensification and relaxation. Since this kind of rhythm is often associated with physical movement, I will call it gestural rhythm. . .*
>
> Graybill, 1990

Such a definition has the merit of pointing out the fundamental drive and emotional properties of rhythm, but it still doesn't really explain what gestural rhythm is made of.

There Rudolf Laban suggested a division of rhythm between *time-rhythm*, *space-rhythm* and *weight-rhythm*. He did not, however, clearly explain what cues to consider in order to analyse each division either.

So much so, that I was actually unable to find any definition of gestural rhythm that allowed operating this cue for motion analysis.

An Attempt for Quality Measuring Using Gestural Rhythm

Despite the lack of such a definition as previously argued I attempted to use the intellectual materials collected during my Master's thesis to carry out a motion analysis focused on qualitative specifications. The main idea was to sample a signal derived from the sum of acceleration signals of different parts of the body and to perform an IDS[2]analysis over it.

Protocol Development

First I chose to consider only *thrusting/punching* and *floating* movements that were the closest to *abandonment-free behavior* and *struggle-bound behavior* and, considering the advice of LMA specialist Angela Loureiro, i decided to work with the dancers on *motion factors* instead of working directly on *action drive*. Indeed, when i did work directly on *action drive* the movement were too stereotyped, caricatural, and didn't even always match with the right movement quality.

Then, looking for a relevant signal to represent gestural rhythm I considered using the acceleration signal as analogous to an accent evolution signal quite representative of the tension between *struggle* and *abandonment* phases. I also chose to add up many acceleration signals to consider the polyrhythmic aspect of gestural rhythm. The most relevant experiments did considered three accelerometers positioned at wrist, elbow and shoulder level of a performer's arm.

Finally the IDS analysis was selected as it was quite easy to imagine an implementation of such a system for live performances considering FFT are provided by usual software and IDS analysis is juste ome kind of loop to read through an FFT spectrum.

Experiment Results

The measurement were made with three different dancers. A first time with Lilou (April 2010), the second time with Irénée and Marie-Charlotte (February 2012) using the exact same protocol.

There we could observe high similitude between Lilou's and Marie-Charlotte's IDS portait for the same movement quality. However Irénée's IDS portrait, if they still evolve the same way as the others, have noticeably different shape.

I would assume those different are inherent in the fact Irénée's personality, as a dancer, is very different of Lilou's and Marie-Charlotte's personality ensuing different IDS portait shapes.

Conclusion

During my Master's thesis I looked for a way to have the qualitative aspects of dance performances involved in other media in order to enhance the perception of dance by making it multi-modal.

Thus, my research led me to consider gestural rhythm. Yet, I realized the apparent lack of any definition of gestural rhythm that allowed it to be used in motion analysis, avoiding considering gestural phrases. Furthermore, perception and cognition mechanisms previously described attest to how much rhythmic patterns are fundamental in nonverbal nonsymbolic meaning of movements which suggests gestural rhythm should be a premium cue to analyse qualitative aspects of movement. Finally a simple experiment did show differences could be observed between rhythmic implications of the different possible quality of movement.

Still a measurement campaign would be needed to determine IDS portrait shape relative to determined movement quality and maybe even relative to determined dancer's personnality[3]. Plus I must point-out the fact that the current system only considers one arm instead of the whole body.

This has prompted me to develop the ideas of this Master's thesis with the fundamental goal of providing a definition of gestural rhythm that would determine the cues that make us sensitive to gestural phrases changes and more general gestural rhythm

[2]IDS : Intensity of Spectral Density, this form of analysis is much easier to read than FFT spectrum as it gives information through the distribution of spectral energy between predetermined frequency-band.

[3]This is essentially relative to the idea of having different type of dancers having different relationship with their gravity-fed system

changes[4].

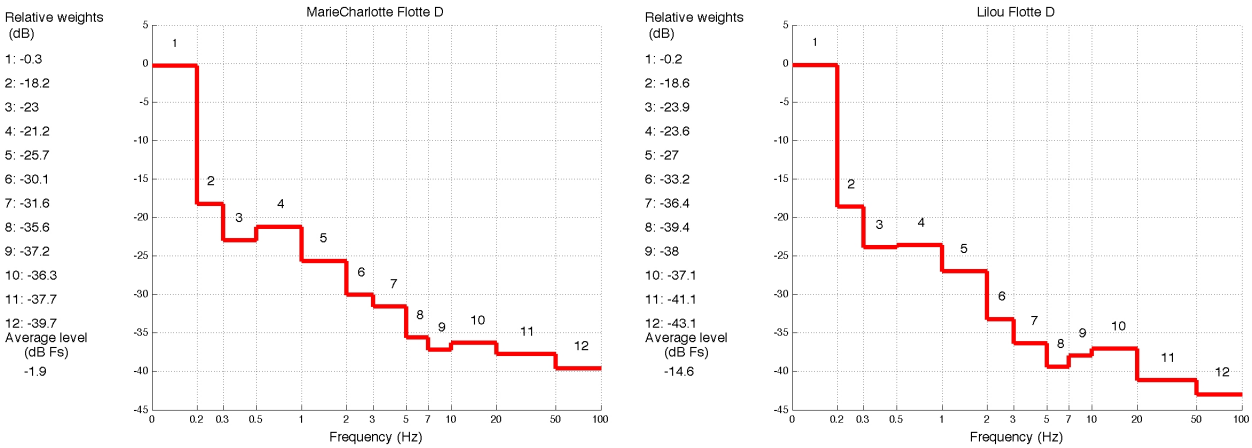

Figure 1: Marie-Charlotte and Lilou floating quality

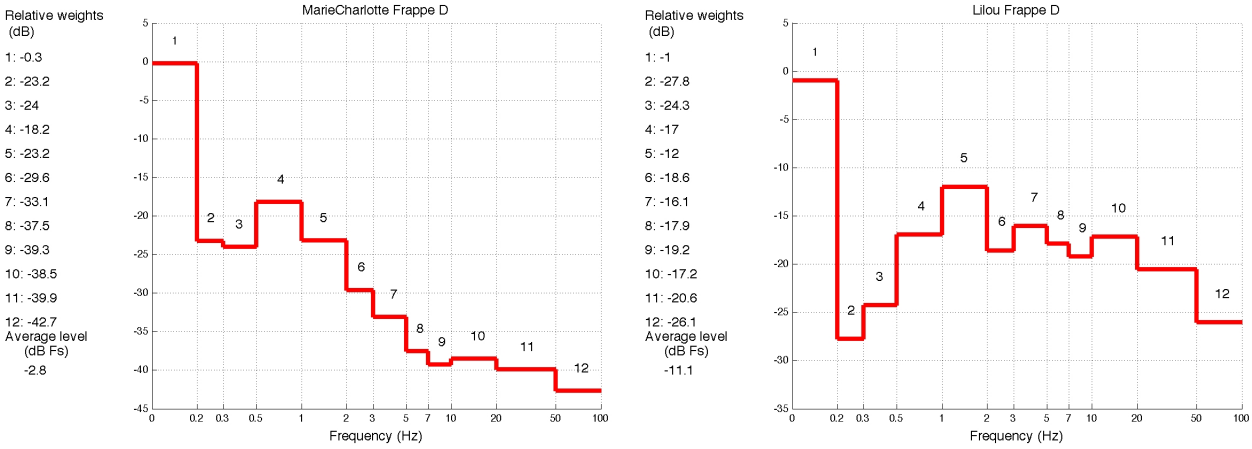

Figure 2: Marie-Charlotte and Lilou thrusting quality

[4]This paper is a development from: Yohan Zeitoun, Danse et Nouvelles Technologies - Inscrire le Corps dans les Dispositifs Interactifs, Master Thesis, ENS Louis Lumière

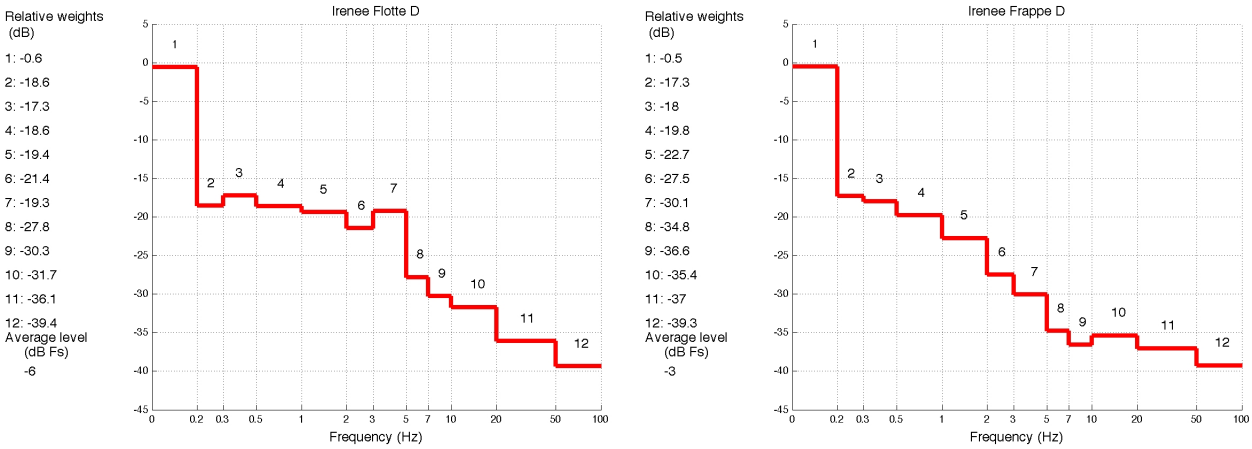

Figure 3: Irénée floating and thrusting quality

Video, Irénée floating quality
Video, Irénée thrusting quality
Video, Marie-Charlotte floating quality
Video, Marie-Charlotte thrusting quality