Kinetic predictors of spectators' segmentation of a live dance performance

Klaus Förger
ICI project, Labex ARTS H2H,
Université Paris 8
Paris, France
klaus.forger@iki.fi

Coline Joufflineau
ICI project, Labex ARTS H2H,
Université Paris 8
and
UMR 8218, Institut ACTE, Université Paris 1
Paris, France
coline.esterase@gmail.com

Asaf Bachrach
ICI project, Labex ARTS H2H,
Université Paris 8
and
UMR 7023 CNRS
Paris, France
asaf.bachrach@cnrs.fr

ABSTRACT

We present a pilot study that explores the relation between acceleration patterns of dance movements and the temporal segmentation of the dance reported by spectators during a live performance. Our data set consists of recorded accelerations from two 7 minutes long duo dances that were annotated by 12 spectators in real-time. The annotations were indications of perceived starts and endings in the dance. We were able to create an acceleration based predictor that has a significant correlation with the pooled subjective annotations. Our approach can be useful in analysis of improvised dance where the segmentation cannot rely on repetitive patterns of steps. We also present suggestions for future development of acceleration based dance analysis.

KEYWORDS

dance perception, acceleration data, composition, live performance, segmentation

1 INTRODUCTION

A dance performance, not unlike speech or music, is a compositional, temporally extended, event [1]. The temporal structures that an audience perceives in a dance performance effectively segment the performed motions. In related literature, segmentation of motion is often treated as detection of borders between basic actions such as standing and walking [2, 4, 6]. While this view of segmentation is useful for creating animations, for laboratory movement or for certain daily repetitive motion, it is of limited use for (improvised) dance movements or more generally to many cases of naturalistic human behavior. For example, segments perceived from improvised dance might not form distinct categories, and the segmentations could differ greatly between observers. As pointed out by [3] and [5], dance segmentation is also different from segmentation of other human actions [8] (e.g. folding laundry) as events in dance are usually longer from standard goal oriented actions and dance movement is not goal oriented. [7] have correlated movement parameters such as acceleration and speed with subjective event segmentation by observers for everyday actions but previous work on dance [3, 5] has not investigated quantitatively this relationship.

In this paper, we present a pilot study where we do not assume a single ground truth for segmentation, and instead we concentrate on understanding the peaks of agreement between spectators of a live dance performance. Our preliminary result is that relatively simple measures designed to reveal rising and falling edges in accelerations of the dancers seem to predict subjective segmentation by spectators.

Figure 1: Dancers performing a duo.

2 METHODS

In our pilot study, we asked 12 spectators (with mixed dance experience) to indicate, in real time, subjective 'beginnings' and 'ends' while viewing two 7-minute dance duos as seen in Figure 1. The annotations were done by pressing one of two 'buttons' on the screen of a tablet. Spectators were instructed not to look for movement phrases, and matching of beginnings with endings was not required. Instead they were instructed to indicate, via the tablets, moments which they intuitively perceived as a beginning or and end of a 'some' dance event (insisting on the subjective rather than objective validity of these annotations). Five accelerometers per dancer and video were used to capture the dances.

To predict the annotations, we calculated contrast of averaged global acceleration of all accelerometers between two consecutive 2.5-second windows. A rise in the level of acceleration served as predictor for beginnings and a drop, for endings. More precisely, a_1 and a_2 being the total accelerations in first and the second windows, the predictor for starts is:

$$startPredictor = \frac{|a_2|}{|a_1|} \tag{1}$$

Similarly, the predictor for endings is:

$$endPredictor = \frac{|a_1|}{|a_2|} \tag{2}$$

These predictors were correlated with the number of persons making subjective annotations within a 5-second sliding window. A

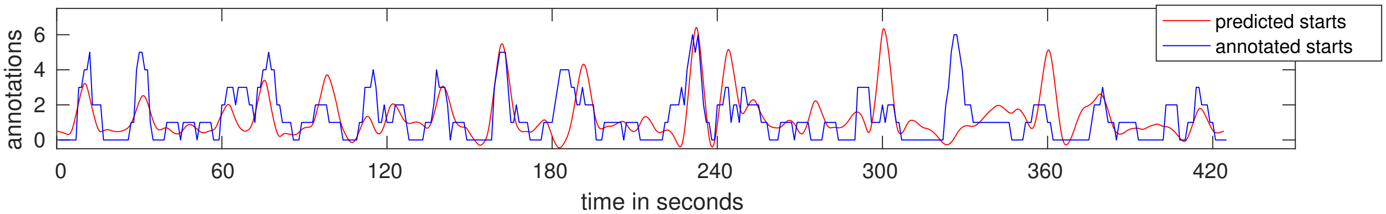

Figure 2: Predicted and actual annotations indicating starts seen in a duo dance. The predictor values have been scaled to same range with the number of annotations.

window of 5 seconds was chosen since with shorter windows inter-annotator agreement was too rare to be useful, and with longer windows all peaks in the data would be flattened. Two consecutive 2.5-second windows were used for the acceleration data to match the annotation window. A visual example of a comparison between predicted starts and the actual annotations is given in Figure 2.

3 RESULTS

We found more peaks with more than five spectators agreeing on a beginning/ending than is expected from randomly made annotations. Simulated randomly timed annotations reach the same or greater level of agreement less the once in 10000 simulations. There was also a tendency to indicate more beginnings than endings with 10% difference in amount of total annotations.

For both dances, the pooled annotations positively correlate (Pearson correlation) with both predictors as is shown in Table 1. For comparison, the correlations between annotated ends and predicted starts (or vice versa) were always less than 0.1.

Table 1: Correlations between predictors and annotations

	Correlation	p-value
Beginnings dance 1	0.38	$8.0 \cdot 10^{-16}$
Beginnings dance 2	0.30	$1.6 \cdot 10^{-10}$
Endings dance 1	0.49	$4.4 \cdot 10^{-27}$
Endings dance 2	0.46	$1.1 \cdot 10^{-23}$

4 CONCLUSION

This is the first study to our knowledge to explore dance segmentation during a live dance performance. Our behavioral data demonstrated statistically significant inter-subject agreement on the segmentation of an improvised dance, though (unlike previous work on dance segmentation [3, 5]) spectators watched the dance only a single time. Blasing does not report inter-subject agreement but inter-subject agreement here was higher than the one observed by Noble and collegues. This could be due to a number of factors (here we used a longer time window, the dance was in an occidental rather than Indian style, the spectators were all watching the live performance together and the task instructions were different).

Our preliminary results suggest that accelerations can explain a large part of the subjective segmentation by spectators of an improvised dance performance. Our results are in agreement with the results of [7] that found fine event segmentation to correlate with (among other features) the acceleration profile of the movement. The results extend the results of Zacks and colleagues to a different domain (dance) and to a live in-situ situation with 2 movers. Our approach can be useful in analysis of improvised dance where the segmentation cannot rely on repetitive patterns of gestures. Beginnings/ends annotation could be too high-level for an on-line task. We are now testing the use of a unique 'change' annotation. A different approach would be to distinguish, as in [7] between coarse and fine segmentation.

This study was limited to acceleration data, and considering also spatial information could allow better predictions of the subjective data. However, accelerometers can be more reliable and less intrusive than vision based systems that record spatial data. Accelerometers are particularly advantageous for dance styles that include physical contact between the dancers or dance performances with multiple participants were occlusion is a major obstacle for optical systems. From a technical point of view, our approach is simple to implement, and thus it can be a useful baseline for more advanced methods using, for example, machine learning or a larger set of features.

Another lesson we learned is that synchronization between a large number accelerometers and tablets can be challenging when they are not connected through wires. We are currently designing a new system for wireless synchronization between mobile devices as that is required for experiments needing high temporal accuracy such as reaction time measurements.

REFERENCES

[1] Asaf Bachrach, Corinne Jola, and Christophe Pallier. 2016. Neuronal bases of structural coherence in contemporary dance observation. *NeuroImage* 124, Part A (2016), 464 – 472.
[2] Jernej Barbič, Alla Safonova, Jia-Yu Pan, Christos Faloutsos, Jessica K. Hodgins, and Nancy S. Pollard. 2004. Segmenting Motion Capture Data into Distinct Behaviors. In *Proc. of Graphics Interface 2004 (GI '04)*. Canadian Human-Computer Communications Society, School of Computer Science, University of Waterloo, Waterloo, Ontario, Canada, 185–194.
[3] Bettina E Bläsing. 2015. Segmentation of dance movement: effects of expertise, visual familiarity, motor experience and music. *Psychological perspectives on expertise* (2015), 64.
[4] Fengjun Lv and Ramakant Nevatia. 2006. *Recognition and Segmentation of 3-D Human Action Using HMM and Multi-class AdaBoost*. Springer Berlin Heidelberg, Berlin, Heidelberg, 359–372.
[5] Katie Noble, Donald Glowinski, Helen Murphy, Corinne Jola, Phil McAleer, Nikhil Darshane, Kedzie Penfield, Sandhiya Kalyanasundaram, Antonio Camurri, and Frank E Pollick. 2014. Event segmentation and biological motion perception in watching dance. *Art & Perception* 2, 1-2 (2014), 59–74.
[6] Qinfeng Shi, Li Wang, Li Cheng, and A. Smola. 2008. Discriminative human action segmentation and recognition using semi-Markov model. In *2008 IEEE Conference on Computer Vision and Pattern Recognition*. 1–8.
[7] Jeffrey M Zacks, Shawn Kumar, Richard A Abrams, and Ritesh Mehta. 2009. Using movement and intentions to understand human activity. *Cognition* 112, 2 (2009), 201–216.
[8] Jeffrey M Zacks, Nicole K Speer, Khena M Swallow, Todd S Braver, and Jeremy R Reynolds. 2007. Event perception: a mind-brain perspective. *Psychological bulletin* 133, 2 (2007), 273.