Traces – Body, Motion and Sound

Jan C. Schacher, Angela Stöcklin

Abstract

In this publication the question of motion analysis and mapping is regarded from a very specific angle. When dealing with elements that characterize a dance movement terms such as the motion description fundamentals start to appear: inertia, energy, space and temporal structure but also terms of expressive potential and of anticipation, perception and recognition of specific motion patterns. In an attempt to better understand these fundamentals a scenario for interactive dance that originates from a real-life artistic process is identified and defines a small exploratory study. The movements and the measured data are combined in an audification and sonification process, as well as in different technical visualisations.

Background

In general four types of movement can be distinguished: reflex, locomotive, instrumental, and expressive movement. Musical actions are essentially instrumental, and only a small percentage actually becomes expressive.
In other fields than music, such as communications theory and linguistics, gestures denote a very specific type of motion. It is considered „an expressive movement that is not consciously thought out beforehand" [2] and serves to enhance thought and communication. Gestures also carry a signification: „Gestures are not just movements and can never be fully explained in purely **kinetic** terms. They are not just arms waving in the air but symbols that exhibit meaning in their own right". [6] A term that originates from linguistics and which highlights a difficult challenge for motion analysis and mapping is that of co-articulation. [4]
Contemporary dance attempts to render movement into something abstract and detached from everyday connotations and situations. These abstract dance-movements represent traces of physical but also mental processes concerning the body in space.
The main categories described in [...] dance-languages are energy, placements and motion paths of body parts, placement in space and shape of body motion with regards to physical properties such as momentum and inertia.

Scenario

The scenario devised starts from the idea that a dancer will perform a dance sequence consisting of a chain of gestures that can be chunked into movement elements. In order to gain more precise information the situation is a reduction to a few core aspects and consists of short twenty-second phrases covering a limited space horizontally as well as vertically.

Method

The measurement technologies we use range from simple accelerometer bracelets, to more complex inertial measurement units, from frontal two-dimensional video tracking with classic image analysis to an eight-camera marker-based motion-capture system.

Sensors

The wireless **sensor bracelets** consist of a three-dimensional accelerometer and also provide two dimensions of gyroscopes. The update rate is between 50 and 100 Hz. The wireless **inertial measurement unit** (IMU) provides three orthogonal data streams for each measurement type: acceleration, gyroscope rotation and magnetic orientation. The frontal and vertical **two-dimensional video** camera setup is used for body silhouette and lateral spatial analysis. By using an industrial firewire camera sufficiently high frame rates are obtained to be useful in comparison with the other sensors. The update rate can go from 60 to almost 100 Hz. The **marker-based motion-capture** system we use is a smaller commercial eight-camera system. The three-marker solid bodies work very well in a space of the size of our lab (see Figure 1.). It delivers 100 frames per second and sub-millimetre precision.

Figure 1. The dancer in our lab wearing accelerator bracelets and motion-capture markers on her wrists. The insert shows one of the bracelets in combination with a rigid-body marker used for motion capture.

Software

All the acquisition software was developed specifically for these sensors. The wireless sensors and their serial streams are parsed and transformed to OSC with dedicated proxy servers written in C++. The frontal camera input and analysis is using Jitter and some custom code to calculate the convex hull and cardinal points of the silhouettes. [8] The motion-capture system runs its own software package on a dedicated windows machine and needs a proxy to translate from its native Nat NET protocol to OSC. This is a dedicated command line application written in C++. The data time tagging and storage is implemented with the Jamoma [7] module for GDIF [5] recording, which is based on FTM [1] and writes SDIF files.

Analysis

Only the accelerations from the motion-capture system and the wearable sensor bracelets were analysed. The position data from the motion-capture system is analysed to its first two derivatives. These are purely spatial traces or kinematic calculations, no forces or masses are taken into account. The accelerometer measurements are transformed to their summed absolute values, which only represents energy. This data type differs from the former as it represents masses – actually a real micro-mass within the sensor – and the forces exerted onto them.

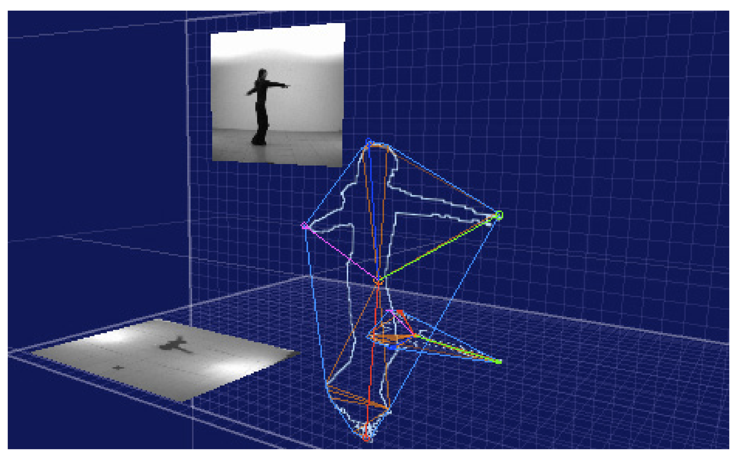

Figure 2. Dual camera silhouette analysis.

Visualisation

The visualisation tries to reintegrate as much information as possible into images and graphs. In an attempt to fuse spatial and temporal dimensions of the collected data, two graphical solutions – the timeline and the 3d representation with trails – are chosen.

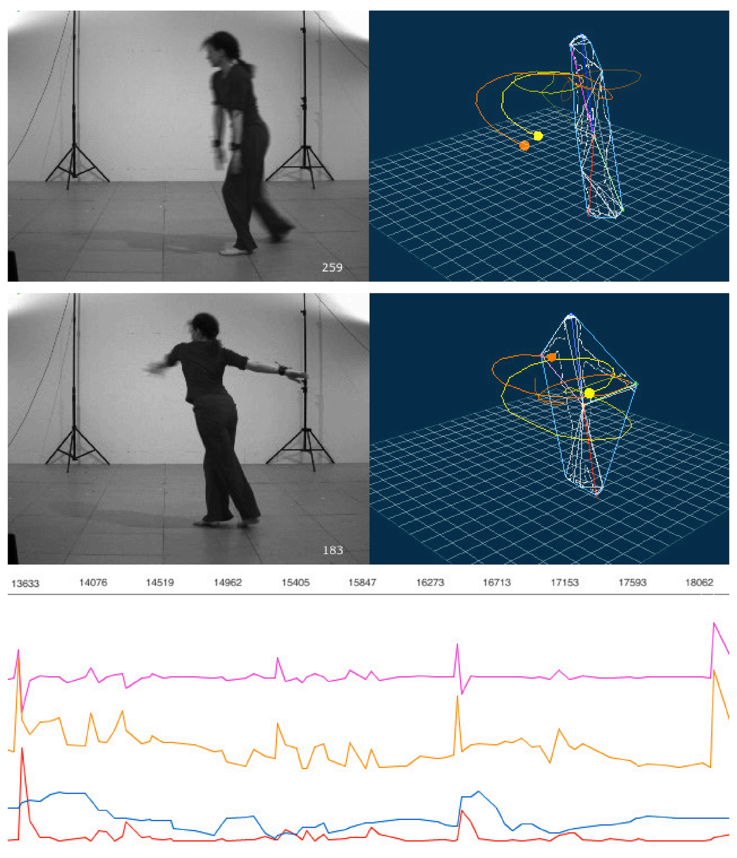

Figure 3. Visualisation of motion traces and wrist accelerations. The red trace shows the absolute kinematic acceleration, the blue trace depicts the dynamic acceleration.

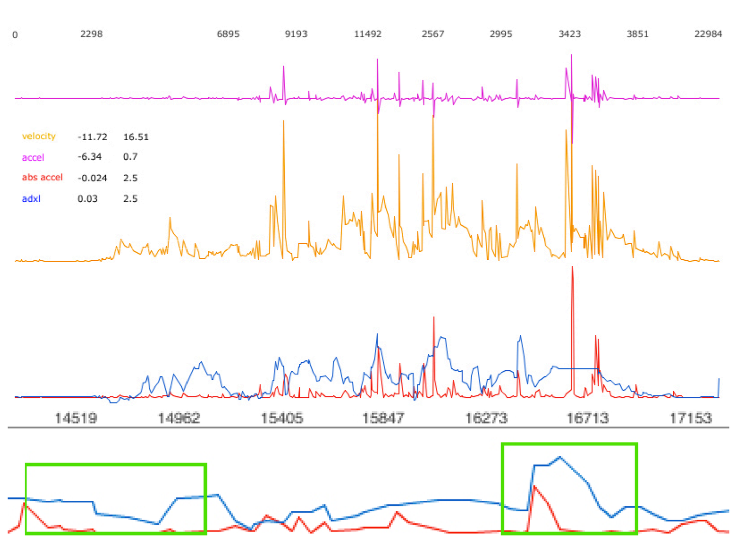

Figure 4. The red line depicts kinematic acceleration extracted from the motion capture; the blue line shows the accelerometer values. Note the overhang in the green boxes, this indicates inertia and co-articulation.

Audification and Sonification

The audification uses filtered noise. The band pass filter is controlled on the frequency domain by the horizontal spatial x-axis, the output gain by the horizontal spatial y-axis and the steepness by the sum of acceleration on the bracelet. (see Figure 5. upper half) The sonification uses a granular cloud, where all spatial parameters obtained from motion capture are applied to the grain parameters and all accelerometer values influence the sample playback and windowing of the grains. (See Figure 5. lower half)

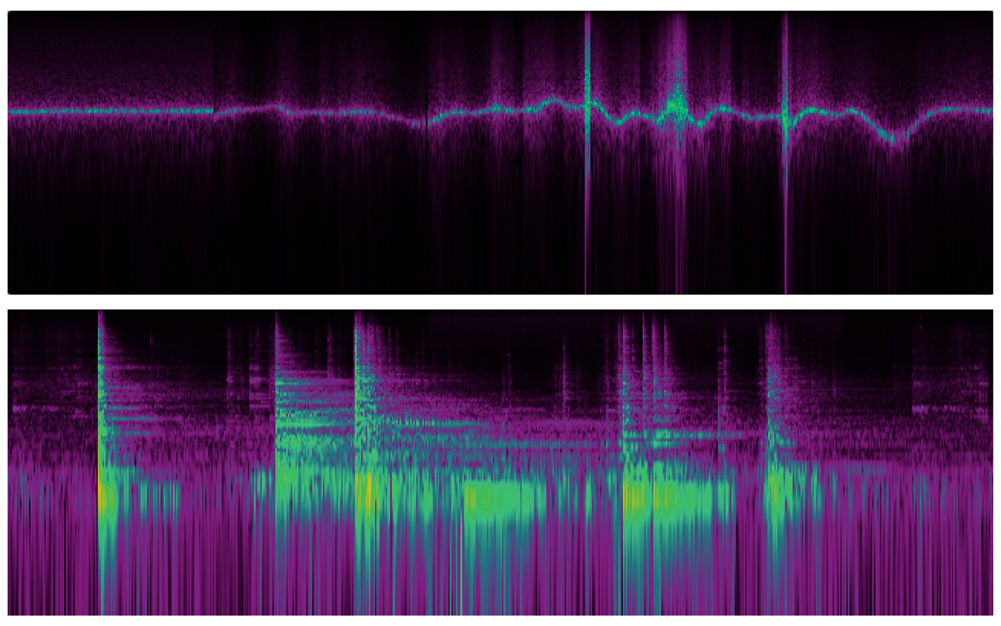

Figure 5. Sonogram of the audification of the motion fragment and of the sonification via granular synthesis.

Both hearing-based methods of data-display afford a perception of the motion sequences that emphasises the gestalt. The difference between the two methods, from the purely parametric mapping to a more subjective interpretation changes the richness of the sonic output.

Results and Discussion

The comparative evaluation begins with the main feature visible in the circular motions of both wrists in space. The spikes in the accelerations correspond to the changes in direction, which is clearly visible in the first frame's yellow line (Figure 3. upper half) and in the very last peak on the first time plot and the spike located at around 17.9 seconds immediately before the highest point in the second plot. (See Figure 3. lower half) By isolating and equalising two streams of values coming from the wrist of the dancer we can confirm a salient feature.
The elements that comprise a gesture rather than a movement seem not to be clearly accessible in the data-streams, even though segmentation or chunking [3] is easily achieved at the rest-points of spatial, kinematic motion. This would indicate that in order to more naturally reflect the dynamic states of the body – which is what our perception principally anticipates and interprets – a physical model of the body should be introduced as a mapping category.
This exploratory investigation also indicates that on-body sensors with their egocentric perspective remain a valid tool even when compared to the allocentric visual motion acquisition systems. When focusing on the perception of motion through other channels than the purely visual mode, the kinematic traces in space do not represent our motion as well as is implied by the technology. The combination of the different types of sensor information with a model-based approach seems to promise the richest translation possibilities for body motion to sound.

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Zürcher Hochschule der Künste
Zurich University of the Arts

Institute for Computer Music and Sound Technology
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