

## CHAPTER FIVE

# CONTINUOUS MOVEMENT, FLUID MUSIC AND EXPRESSIVE IMMERSIVE INTERACTIVE TECHNOLOGY: THE SOUND AND TOUCH OF ETHER'S FLUX

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The synaesthesias of Scriabin, Schoenberg, and Kandinsky still fascinate, despite the intricately coordinated musicality of Balanchine's, Kilian's and Morris's dance choreographies and the startling visuality of the musical dance theatre works of Merce Cunningham and Alwin Nikolais. It's an old but potent dream to interrelate music, dance and visual art. Yet simple mappings between them always pale in the face of the affective complexity experienced within any of them. To succeed, mappings must forge affective complexity that is needed for art to be aesthetically compelling. Our starting point has been to use recent technologies to develop our own interactive system to generate computer music through movement of the body; such movement is channelled through various quantitative mappings that physically, physiologically and psychically suggest imaginary worlds to experience as observer or participant.

What is generated is a non-repeating stream of music that is expressive in that it enables mood shifts by allowing nuanced but audible emergent qualities to be spontaneously steered through motions of the body. We hope to spur a synergy between spontaneous movement, computation and sound, thus initiating a technology-fuelled fusion of dance and music, which in turn will prompt new cross-fertilizations between choreographic and sonic composition and improvisation. Because these interactions steer fluctuating emergent qualities through continuous motion in space, they suggest tantalising syntheses between organisms in motion and the continuous flux of their environment.

## The Fluxations Approach to Embodied Interactive Music Generation

Our Fluxations is one of many interactive systems developed in recent years. Fluxations is distinct in intention and result primarily because of the way it negotiates the discrepancies between music and dance performance. As Schacher explains:

The fundamental issue of combining dance with interaction and music is that the experience, training and perception of the performers in the domains of dance and music do not cover the same emphasis of performing music or gesture.

Fluxations addresses this primarily by circumventing the issue of gesture. This permits the dance to have gestures without demanding that the spectator recognise them as such in order to sense a correlation with the generated music. So bodily gestures relate almost incidentally to the dance-music interaction, which instead derives from spatial positions and orientations of the whole body and its individual parts.

The advantage emerges when distinguishing two potentials of interactive systems. An interactive system is *immersive* to the extent that every noticeable bodily movement produces a change in the generated music. It is *expressive* to the extent that the performer can anticipate the change in the generated music that will be produced by a movement and to the extent that a variety of musical changes are thus accessible at the performer's discretion.

The complexity arising in immersive interactive systems often comes at the expense of expression. Rokeby's *Very Nervous System* presents an immersive environment in which a change of bodily position initiates or perpetuates a complex of musical sounds but, by design, the manner of this generation evolves as the system runs, resulting in a fascinating long range unpredictability, thus "a complex and resonant relationship between the interactor and the system" (Rokeby 1983, Salter 2010). In this sense, *Very Nervous System* (VNS) pushes the instrumentality of expression beyond reach of the dancer-improviser's volition.

While VNS is immersive but not optimally expressive, other systems are expressive but not immersive. These act as instruments of expression—either by generating individual sounds (or a collection of sounds) directly in response to discrete gestures or by using gestures to manipulate

playback of sounds sampled from outside the system.<sup>1</sup> The metaphors of *driving* and *flying* have also been suggested (Wessel and Wright 2002), but have not been actually implemented to any significant extent. On the contrary, often in interactive dance systems, much technical sophistication and nuanced understanding is put to the task of parsing a dancer's movement into discrete expressive gestures (Schacher 2010). Such detected bodily gestures are then "mapped" (one-to-one, one-to-many or many-to-one) to discrete musical gestures as a means of expression. Much literature on interactivity focuses on gesture-to-gesture mapping.

This interpretation of bodily movement is somewhat artificial considering the situation our bodies are normally immersed in: continuous space, in which only a miniscule fraction of bodily motions are recognised as gestural. There is the wave, the handshake, the salute, the bow and certain memorable poses noticed in a dance such as the *plié* and *arabesque*. Though these stand out as symbolic, one is equally aware of the infinity of other motion preceding and following these, especially when movement is one's focus, as when watching dance. To the dance spectator, the continuity of movement often overwhelms any sense that the dance is presenting a series of discrete gestures.

By establishing a non-gestural but spatially driven interaction, Fluxations generates music with the complexity of immersive systems but with the transparency of expressive instruments. This is because the complexity in the music is algorithmically achieved instead of having to be derived from complexity of dance movement. This allows the dance to focus on clarity of expression, which, in a top-down manner, steers the qualities of the generated musical complexity. The complexity emerges from stochastic procedures (controlled randomness) in the music algorithm. The stochastic aspects of the algorithm create detail that is complex but yet neutral (statistically uniform) in relation to the emergent properties whose flux is expressively manipulated by the dancer-improviser. Thus it is observed how the user-improviser wilfully sculpts the characteristics of complexity in real-time, exemplifying a cybernetics of cybernetics (2<sup>nd</sup> order cybernetics).<sup>2</sup> Thus our technology is immersive but also expressive.

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<sup>1</sup> Hunt and Wanderley 2002, Tanaka 2009, Tanaka 2010, Wessel and Wright 2002.

<sup>2</sup> Pask and Foerster describe second-order cybernetics as the cybernetics of observing systems making a distinction between two orders of analysis. One in which the observer enters the system by stipulating the *system's* purpose... and a second order in which... the observer enters the system by stipulating *his own* purpose. (Foerster 1979, 283-86).

Fluxations was initially developed by the first author as a MaxMSP patch and as an iPhone app (Mailman 2012a, 2012b). The app is played by tilting and twisting the iPhone smoothly with the wrist (and by moving sliders on its face), thus enabling only two or three of the music generating algorithm's dozen or so input parameters to be affected simultaneously. In the Fluxations paradigm, the ability to manipulate more input parameters spontaneously translates into greater musical expression.

For this, *The Sound and Touch of Ether's Flux* constitutes the first phase of the Fluxations Human Body Interface.<sup>3</sup> With this we exploit interactive technology to address the relation of complexity to perception. So far it has been demonstrated in New Jersey, London and New York (Mailman and Paraskeva 2012ab, 2012b). A second phase of the human body interface involves spontaneously controlled animated computer graphics and was presented in Montreal and San Diego (Mailman 2012c). It extends the same motivations, systematic principles, and technology of interaction discussed here.

### **Interactive Technology Design for the Dancing-Thinking Body**

The system works by tracking absolute and relative positions of parts of the body as they move through space. Though not all the music generating parameters are continuous (discrete pitches are used), the movement space is treated as continuous, just as we normally experience it. So too, though composed of discrete pitch events, the music is generated as a continuous stream.



Fig. 5-1: Xbox Kinect infrared video camera.

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<sup>3</sup> The authors thank Harvestworks and the Columbia Computer Music Center (CCMC) for use of their space to prototype the motion tracking interface.



Fig. 5-2: Joshua B. Mailman (right) demonstrating right and left hand sensor gloves designed, built and programmed by Sofia Paraskeva (left). Cornell University, May 2012. Photo by Evan Cortens.

Emergent qualities of the stream remain stable when the dancer is still but shift as the dancer moves. Complete technical details of the Fluxations system are beyond the scope of this essay, but here is an overview: An infrared video camera (Kinect), shown in figure 5-1, sends a stream of 3D point data converted to OSCeleton data through OpenNI and PrimeSense's NITE middleware. In this way, absolute positions X (horizontal), Y (vertical), and Z (depth) of parts of the human body (head, hands, feet, shoulders and torso) are continuously fed into a MaxMSP patch running on a MacBook Pro. For some of these (hands, feet and shoulders), additional data points are computed, such as maximums and differences. Additionally, as in figure 5-2, the dancer-improviser wears two sensor gloves which are custom designed, built and programmed by the second author. Using flex (bend) sensors, these gloves detect the extent to which the wrist is bent and continuously send this data (through a Lilypad microcontroller and Xbee wireless transmitter) to a MaxMSP patch. Each glove also has a slider and several buttons whose data is sent with the wrist bend data. Like the other bodily movements detected through the camera, the wrist flexing motions are observed as part of the spectacle. By contrast the use of the sliders and buttons is much less a part of the dance, but is needed for additional remote control of the music (and graphics) algorithm.



Fig. 5-3: Viscous vs. fluid texture controlled by height (head or hands, whichever is higher).

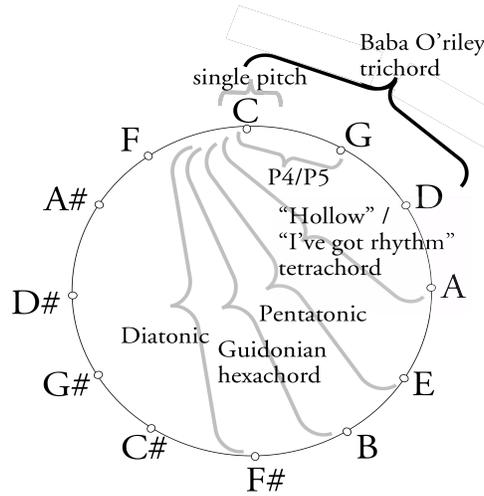


Fig. 5-4: Circle of 5<sup>ths</sup> based harmonic space: population ranging from hollow (one pitch class) to full (all twelve pitch classes) and every increment in between.

Moving forward toward the camera.

Filling the harmonic space from hollow to full.

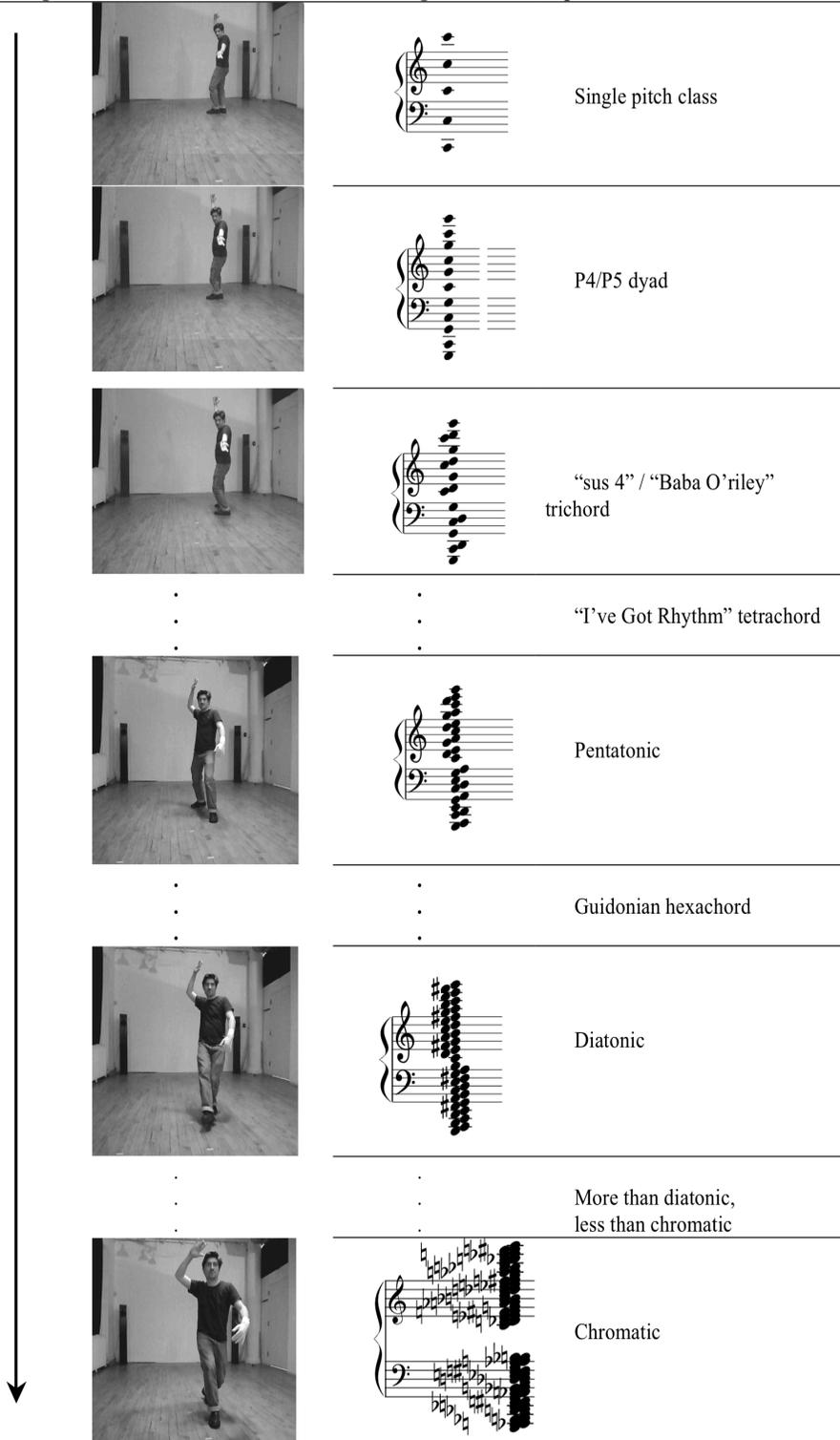


Fig.5-5: Filling in (populating) the circle of 5ths harmonic space by moving forward.

The music algorithm is encoded as a procedural score script programmed in the RTcmix language; this runs in an `rtcmix~` object in a MaxMSP patch. In the MaxMSP patch, the raw and computed data from the Kinect camera and glove feed as input parameters to `rtcmix~` object which runs in a loop, producing the continuous stream of music, whose qualities shift according to the fluctuating values of the input parameters. As of this writing there are 12 input parameters accessible at a time and three more that are accessible indirectly, by switching the operating mode of some of the glove controls. Additionally, one of the glove buttons initiates a pitched percussion attack on demand—a gestural capability that is an exception to the continuous stream interactivity paradigm of Fluxations. The pitched percussion attack is played by a dedicated `rtcmix~` object which coordinates with the continuous streaming (looping) `rtcmix~` object in terms of its pitch content.

The spatial mappings deserve discussion here, as they define how the dancer-improviser's moves affect the generated musical stream and therefore its expression. We do not map raw sensor data directly to physical properties of sound; rather we employ a *multi-layered mapping* strategy (Hunt and Wanderley 2002), which means we translate the raw sensor data into quantities that are more easily conceptualised.

Texture is affected primarily by the vertical position of the body. In particular, the maximum height of the dancer's head and hands affects the viscosity versus fluidity of the texture (average duration of pitch events regardless of their interonset interval, their pulse speed) as shown in figure 5-3 (Mailman 2010, 2012b).

The Fluxations algorithm chooses its pitches based on: (1) the harmonic space chosen, (2) how sparsely or fully the harmonic space is populated; (3) pitch-class (circular) transposition and (4) minimum and maximum pitch boundaries. In the Fluxations paradigm minimum and maximum pitch boundaries are not often used expressively; they are usually set wide and the octaves of the pitch events are randomly distributed to create a diverse harmonic wash. One of the harmonic spaces is based on the circle of fifths, as in figure 5-4. At its most hollow, it is populated by a single pitch class (pitch regardless of octave). As the dancer moves closer to the camera, the harmonic space incrementally fills in to a P4/P5 dyad, the “sus 4” trichord, the “I’ve Got Rhythm” tetrachord, the pentatonic scale, the Guidonian hexachord, the diatonic scale and eventually the full chromatic, and, at the closest proximity to the camera, the microtonal continuum. This is partly shown in figure 5-5.

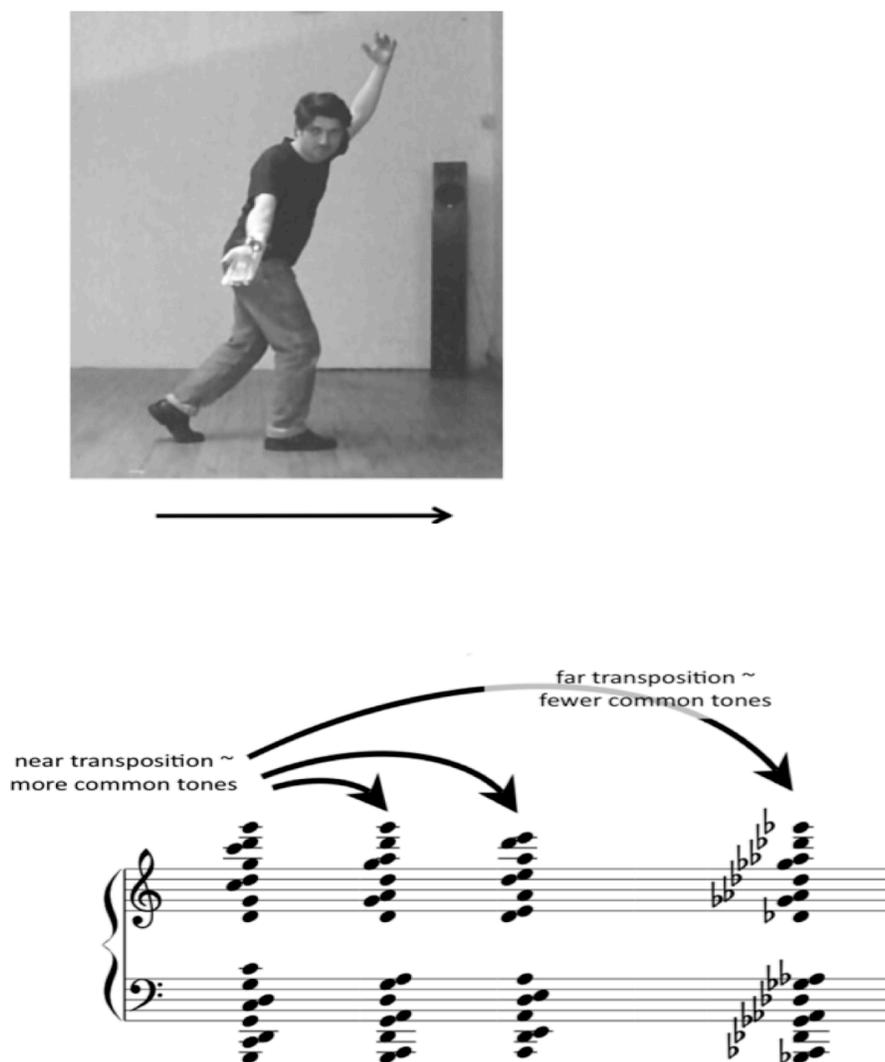


Fig. 5-6: Pitch class transposition effected through lateral movement.

The dancer's gradual movement forward is heard as a gradual change in the generated music because the degrees of harmonic fullness are incremental and the complexity of the texture is sufficient to overwhelm any sense that one is ever crossing over any discrete increments. The change can only be experienced as continuous, because the following parallelism is upheld by Fluxations's action response system: to move to a distant point in physical space one must move through intermediate points; so to move from a harmonically hollow sound (one or few pitch classes) to a fuller one (a full chord or scale etc.) one must move through the intermediate degrees of harmonic fullness. As shown in figure 5-6, the lateral movement in physical space controls pitch-class transposition and

projects the same principle of continuity as just explained: intermediate points in space correspond to intermediate harmonic qualities in the generated music. For whatever pitch-class set is operative based on forward-backward position (harmonic fullness), moving laterally transposes it incrementally on the circle of 5ths. Exactly how continuous this sounds depends a lot on the dancer's forward-vs.-back position, which controls harmonic fullness. This was explained previously by the first author (Mailman 2012a) but is also indicated in figure 5-7. The greater the harmonic fullness (the more forward the dancer is) the more musical continuity there is when moving laterally. At the front-most position, lateral movement causes no change whatsoever.

Rhythm is controlled by the left hand, primarily by flexing the wrist. The flexing works in two modes, toggled by a button on the left hand. In one mode, the algorithm maintains a steady pulse; flexing the wrist increasingly outward causes the aural articulation of the steady pulse stream to become increasingly sparse, by increasing the probability that a pulse point will go unarticulated, as shown in the Mode 1 section of figure 5-8. Unarticulated pulse points are chosen randomly so the wrist flex makes the rhythm increasingly sparse and irregular, thus indirectly making it more syncopated. Additionally, buttons on the left glove multiply or divide the pulse speed, independently of the sparseness. In the second mode, sparseness is disabled and flexing the wrist instead accelerates or decelerates the pulse speed, as in the Mode 2 section of figure 5-8. Other parameters, such as low pass filter (timbral brightness), timbral hardness (marimba loudness), loop length and iterations, textural thickness (number of simultaneous notes), homophony (tendency for multiple notes to coincide), durational diversity, maximum and minimum pitch and which harmonic space (pitch interval basis) is operative are controlled by other dispositions and relative distances of the body, shown in figure 5-9, as well as by glove buttons and sliders.

Though different from conventional instruments, much of the interactivity of Fluxations is clear when observed. This is because it upholds the principle of continuity of space and does so simultaneously in many dimensions of movement (forward-backward, lateral, height, wrist bend and distance between hands) thus infusing a wide variety of trajectories of dance motion with a correspondingly wide variety of trajectories of qualitative change in the generated music.

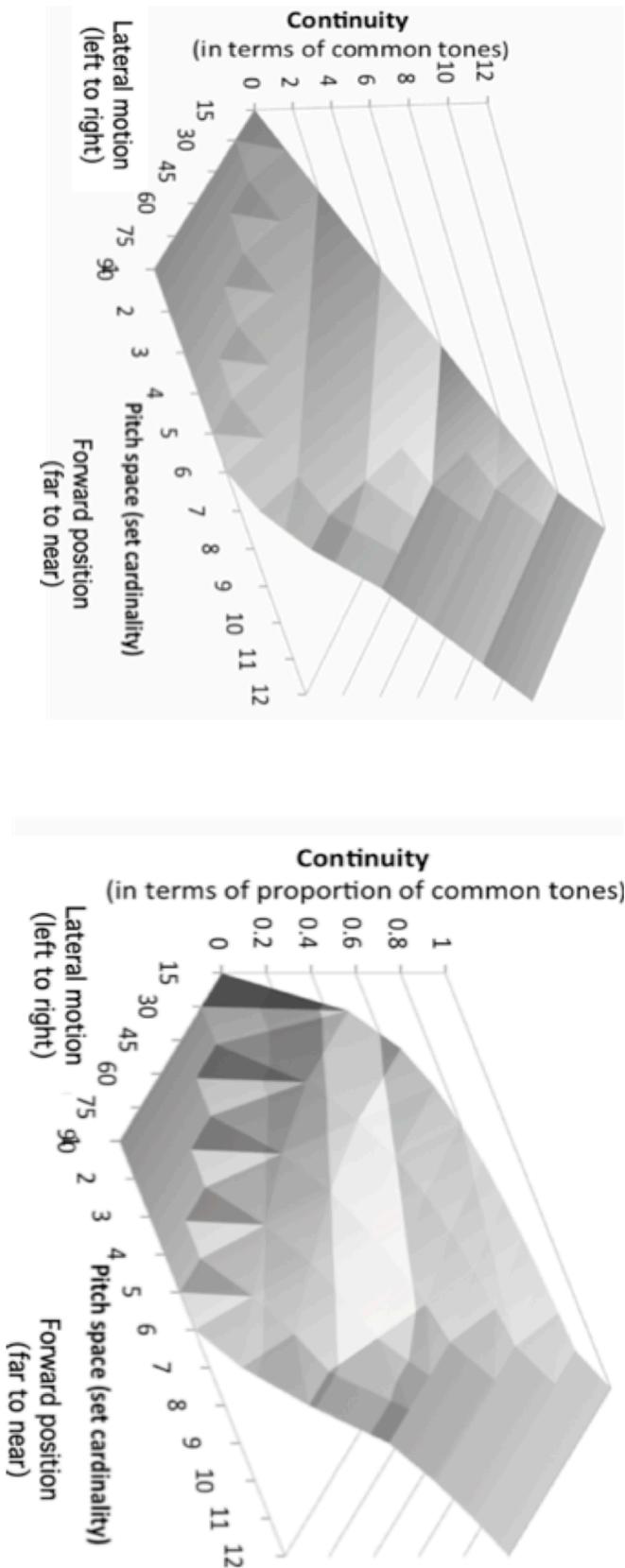


Fig. 5-7: Varying degrees of continuity from lateral motion, as depending on forward vs. back position.

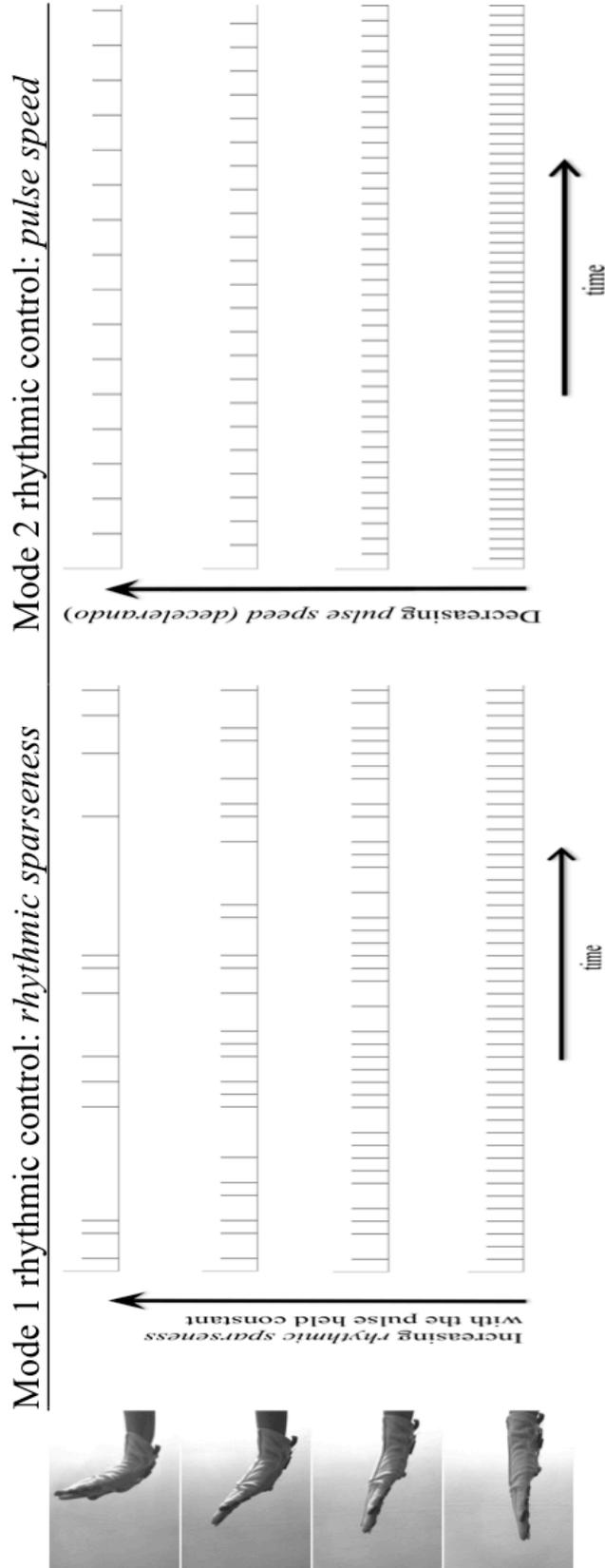


Fig. 5-8: Rhythmic control based on left hand wrist flexing.

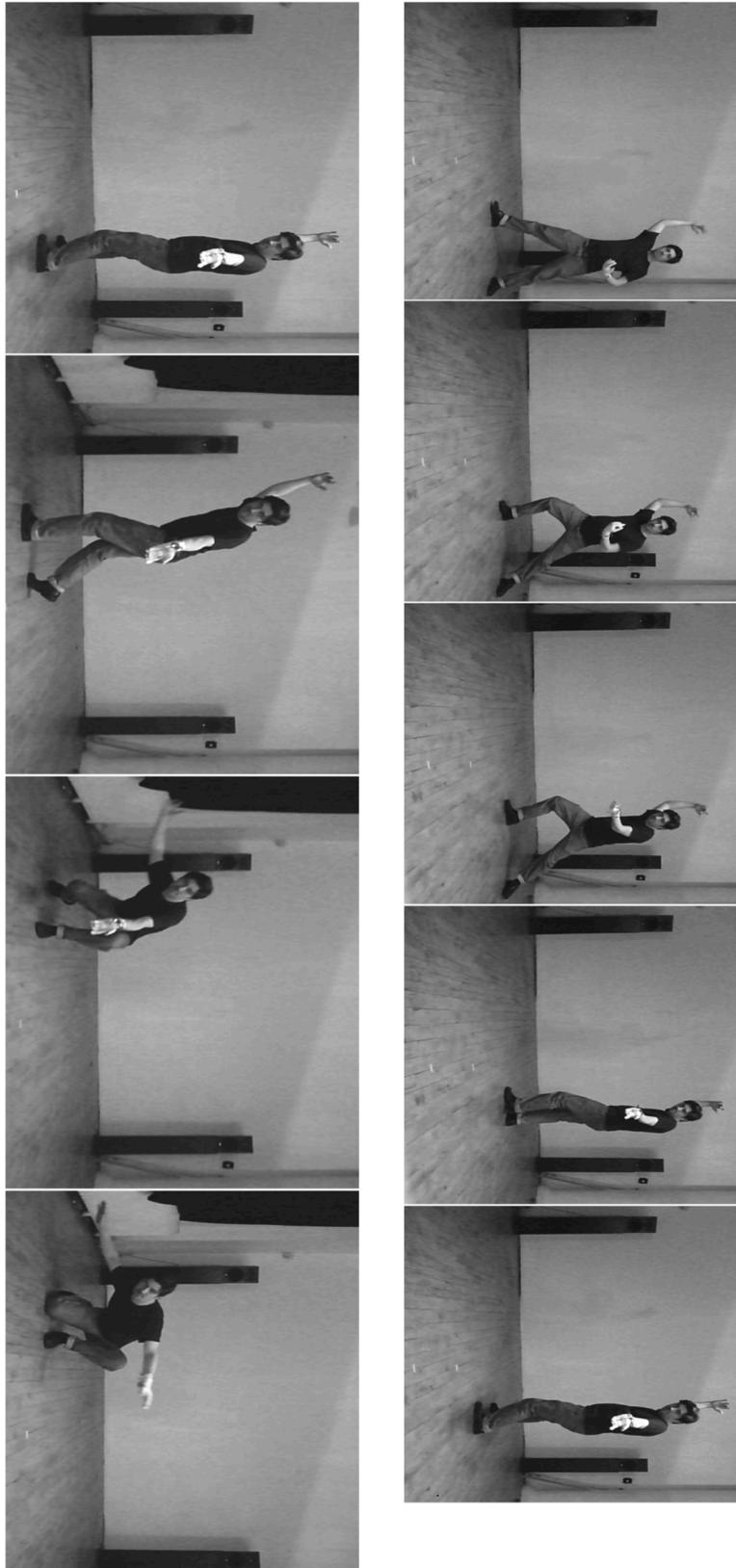


Fig. 5-9: Various interface control moves.

## Artistic and Philosophical Context

The appeal of interactive technology relates back to the avant-garde performance art phenomenon that surged in the 1960s and the more self-conscious theorising of media coinciding with this. Following Cage's 1940s experimental performances at Black Mountain College, Kaprow described "happenings" as event-based performances shaped by participation of the audience that occurred in abandoned factories, lofts, parks, buses and so on (Packer 2001, 280). These, along with the multimedia and cross-media works of Cage, Cunningham, Oldenberg, and Fluxus artists, challenged the fixed work concept in favour of an aesthetics of flux. They traded the *being* of art for the *becoming* of it. The indeterminate, spontaneous and ephemeral aspects were as crucial as their collaborative, participatory and interactive nature. For Kaprow:

The line between art and life should be kept as fluid ... as possible, [which] led to a performance style that pioneered deliberate, aesthetically conceived group interactivity in a composed environment: ...art [as] a continual work-in-progress, with an unfolding narrative that is realised through the active participation of the audience (Packer 2001, xix, 280).

Not all of these tendencies promote expression per se. Yet some contemporaneous theories do just that: Marshall McLuhan famously asserted "the medium is the message" and Buckminster Fuller prompted artists to seek spiritual transcendence, by examining the capabilities and physiology of their medium. Since the 1960s, new and resurgent philosophical developments enable a reframing of the artistic relation of spontaneity to the body, to technology and to media. The *Fluxations* paradigm enables the flexibility to spontaneously create sudden attention-getting changes as well as nuanced atmospheric changes to the audible properties of the stream of musical sound. In the artistic domain, such nuanced fluctuations may serve as "vectors of transmission for feeling" as described in the metaphysics of Whitehead, and recently applied to the aesthetics of media (Whitehead 1929, Shaviro 2009). Through systems such as ours, technologically enriched expression may be embodied in physical motion. Thus an artistic philosophy can now be synthesized with theories of embodied mind developed by Lakoff and Johnson (1980, 1999)<sup>4</sup> and the philosophies of flux and process articulated by Heraclitus,

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<sup>4</sup> See also Lakoff and Nunez 2000.

James, Bergson and Whitehead.<sup>5</sup> Considered in this light, the capabilities and physiology of the medium now suggest active physicality as a path to spiritual transcendence through artistic expression.<sup>6</sup>

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<sup>5</sup> Recent compositions inspired by Heraclitean themes include *Music Literature: Heraclitus* 1–6 (2007), by the Fluxus composer Philip Corner (Frog Peak Music), and Joshua B. Mailman's computer music piece *Heraclitean Dreams* (2008) ([www.joshuabanksmailman.com](http://www.joshuabanksmailman.com)).

<sup>6</sup> To see videos of Fluxations visit <http://vimeo.com/album/1872304> and [http://joshuabanksmailman.com/interactive/interactive\\_gallery.html](http://joshuabanksmailman.com/interactive/interactive_gallery.html). To learn more about the authors' work visit <http://www.joshuabanksmailman.com>, [www.copperbluemediacom.com](http://www.copperbluemediacom.com), and [www.sofiart.com](http://www.sofiart.com).

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