Body as Instrument – Performing with Gestural Interfaces

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ABSTRACT

This paper explores the challenge of achieving nuanced control and physical engagement with gestural interfaces in performance. Performances with a prototype gestural performance system, *Gestate,* provide the basis for insights into the application of gestural systems in live contexts. These reflections stem from a performer's perspective, summarising the experience of prototyping and performing with augmented instruments that extend vocal or instrumental technique through gestural control.

Successful implementation of rapidly evolving gestural technologies in real-time performance calls for new approaches to performing and musicianship, centred on a growing understanding of the body's physical and creative potential. For musicians hoping to incorporate gestural control seamlessly into their performance practice, a balance of technical mastery and kinaesthetic awareness is needed to adapt existing approaches to their own purposes. Within non-tactile systems, visual feedback mechanisms can support this process by providing explicit visual cues that compensate for the absence of haptic feedback. Experience gained through prototyping and performance can yield a deeper understanding of the broader nature of gestural control and the way in which performers inhabit their own bodies.

Keywords

Gestural interaction, non-tactile, augmented instruments, vocal, ancillary gestures, Kinect, audiovisual.

1. INTRODUCTION

The notion of body as instrument, unconstrained by the physical constraints of a tangible interface or screen-based controller, reflects a body-centric approach to examining how performers adopt gestural sensor technology in their own practice. This concept is particularly applicable to vocal performance, where the vocal sound source emanates from the body, bearing the personal and emotional expressive imprint of the performer [11]. This individual body signature is further magnified when the voice intersects with motion in a non-tactile control interface.

Gestural control offers vocalists remote access to the real-time processing capacity of audio software with larger scale gestures and energetic input than available through conventional control modes. The broader range of movement available through spatial control contrasts with the behavioural conformity that accompanies the physical design of a particular instrument or the micro-movements [6] of laptop performance.

The opportunity to directly engage with the audience while maintaining sole responsibility over vocal signal processing, a role usually relegated to a sound engineer, attracts vocalists who prefer independent control over their overall sound. The ever-shifting dynamics of body movement provide a rich source of control information, fuelling exploration by bypassing conscious approaches to creative decision-making and any form of artificiality. This added physical engagement could deliver potentially varied and unpredictable sonic outcomes, transcending the influence of the mind and ego on live music-making. The innate movement styles of individual performers can also colour sound in unexpected ways.

The creative potential of gestural control will be explored through reflections on prototyping and performance experiences that stem from an artistic perspective.

NIME'14, June 30 – July 03, 2014, Goldsmiths, University of London, UK.

2. BACKGROUND

The prototype system described in this paper relates to gestural enhancement of vocal performance [4, 14, 19] and augmented instrument design that embraces the unique gestural nuances of individual performers.

Non-sound-producing performer movements, infused with the idiosyncrasies of an individual musician's playing style, have been identified as significant in communicating expressive intent [21]. Referred to alternately as ancillary, extra-musical or expressive gestures, these intuitive body movements contain expressive and emotive content, conveying musical meaning between the performer and audience [5]. Motion tracking studies have confirmed the communicative impact of ancillary gestures, influencing emotional expression, timing, musical structure and audience perception [7, 8, 9, 20].

Augmented instruments that rely on ancillary movements as a control input include the gesturally controlled improvisation system for piano by Nicholas Gillian [12], Multimodal Music Stand [2], and a guitar enhancement system that provides control of digital audio effects with head and weight shifting movements [16]. In a vocal performance context, the design of Donna Hewitt's eMic [13] integrates common gestures displayed by vocalists.

In addition to ancillary gestures, virtual instruments and looping functions in *Gestate* are controlled by open air gestures, borrowing features from non-tactile gestural controllers, which are defined by Rovan and Hayward as alternative performance interfaces that employ non-contact sensing technologies such as near-field capacitive measurement, infrared, ultrasound and video [18]. Open air gestures are not traditionally associated with music-making, offering the performer an opportunity to transcend habitual movement patterns and explore fresh links between gesture and sound.

3. PROTOTYPING FOR PERFORMANCE

3.1 Mapping

As musicians seek to adapt existing controllers to their unique musical purposes or develop their own gestural instruments for sonic experimentation, knowledge of mapping is paramount in bridging gestural input to sonic parameters.

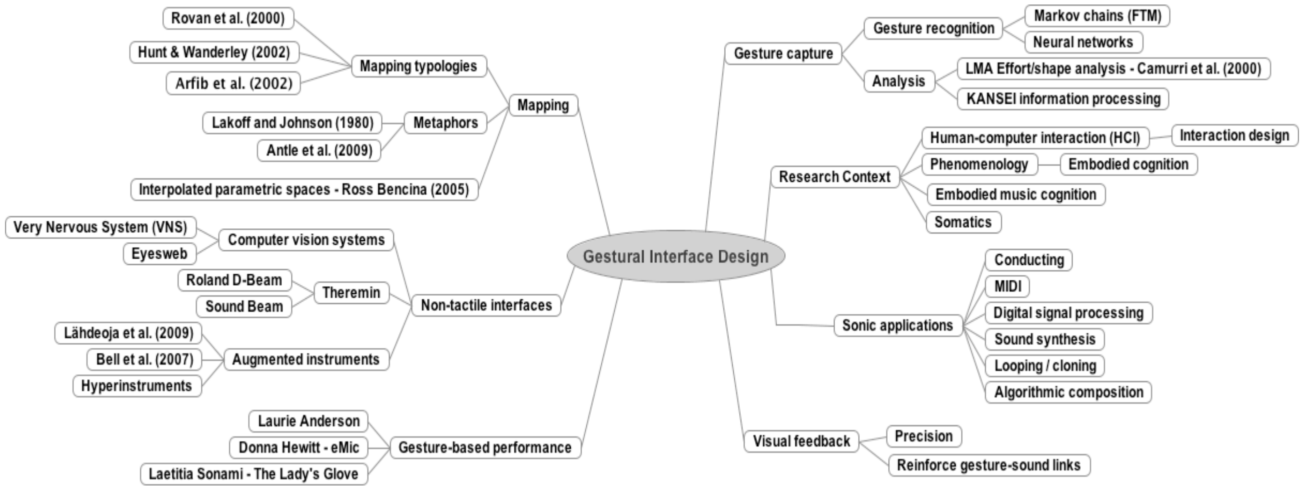

Figure 1. The rich background of gestural interactive interface design shown in this diagram demonstrates the primary influences that this research builds on.

In a field dominated by customised and personalised approaches, the absence of standard gestural libraries can make prototyping a daunting undertaking for performers. Without prior programming knowledge, inventing a mapping scheme that represents meaningful relationships between gesture and sound represents a significant challenge.

A range of toolkits are available through academic institutions including McGill University, Canada.[1] The Centre for New Music and Audio Technologies (CNMAT) at the University of California in Berkley also provide Max/MSP objects that can route movement data from selected sensors and audio processing modules to aid in constructing mapping designs for individual projects. For a more integrated solution, the Metasurface, implemented in AudioMulch,[2] simplifies the process of designing mappings further for musicians [3].

3.2 Kinaesthetic Awareness

The development of mappings require much experimentation and adjustment to feel natural and intuitive for a musician. By reflecting on first-hand physical experiences with gestural systems, performers' skills in translating deliberate and unconscious aspects of their innate body language into sonic form constantly evolve.

Carrie Noland sees kinaesthetic awareness as a force that encourages experimentation and freedom from habitual "socially acquired bodily practices" [17]. Like every instrument, the experience of practice and exploration leads to greater levels of familiarity and proficiency. It is not adequate to rely on the system to deliver all of the expression. The performer's degree of physical engagement and heightened sense of proprioception also play a major role. By shifting the emphasis in non-tactile gestural interface design to prioritise movement awareness, creative practitioner perspectives founded on direct experimentation and experience in live performance scenarios can enrich the development of these technologies.

Well-developed proprioceptive or kinesthetic awareness of individual body state, such as position, velocity and forces exerted by the muscles is essential when using alternative controllers [18]. Dancers are trained to develop this type of awareness and motor control. However musicians often need to acquire these skills through direct engagement with the interface, processing visual and proprioceptive feedback in order to orient and calibrate their performance gestures.

Studies investigating performance movements from a performer's perspective are rare [10]. Focusing attention on the lived body and drawing from musicians' experiences can provide insights into the nature of physical engagement during live performance. To facilitate such understandings, a design diary is used throughout the prototyping process to document first-hand impressions of initial mappings in performance. Video recordings of rehearsals and performances provide an added source of information about the effectiveness of selected mappings and experiences of gestural control. Insights gathered thus far reveal an increasing sense of bodily awareness and kinaesthetic skill, evolving simultaneously with the technical aspects of the system design. Physical engagement with the system during rehearsals and performances has influenced the refinement of mappings, highlighting the equal importance of bodily awareness and understanding of technical mapping concepts for the gestural performer.

3.3 Embodied Metaphors

The *Gestate* system also borrows from embodied metaphor theory to inform interaction and establish meaningful relationships between gesture and sound. Interactive audio systems that incorporate bodily awareness and pre-reflective, automatic knowing [1] incorporate familiar associations and embodied understandings of physical phenomena. By tailoring movement-based systems to pre-existing knowledge, grounded in bodily experience, users are armed with a real-world basis for exploring mapping relationships.

The initial metaphors employed in *Gestate* relate pitch to verticality, panning to horizontal movement and magnitude of movement to processing intensity. These culturally specific metaphors form a starting point for developing intuitive links between open air gestures and sonic outcomes. A user evaluation to test the effectiveness of selected embodied mapping strategies is currently in progress.

4. SYSTEM OVERVIEW

The system's name, *Gestate*, represents an environment for the gradual development of creative ideas, springing from bodily experiences and sensations. This evolution of inspiration does not reside in a completed work, but in the unfolding process of creation. *Gestate* aims to provide a framework to improvise with the temporal and spatial aspects of gestural control in a way that suits the dynamic and experiential aspects of live performance.

The prototype explores the paradigm of a gestural control system that can be used "naturally", in a non-inhibitive or artificial way, to augment instrumental performance with virtual instruments, effects and visualisation. The exemplar refers to performances for voice and piano.

The ideas of mapping gesture and intuitive gesture extend work in the areas of (i) flowing gestural manipulation, e.g. by exploring the continuous control potential of movement to shape the evolving

1 http://idmil.org/projects/mappingtools
2 http://www.audiomulch.com

timbral characteristics of a sound, and (ii) naturalness, intuition, non-tactile gestures for musical control and augmenting expressivity, and (iii) considering the user experience for the performer, especially from the perspective of visualising music, visual monitoring and efficacy of mapping in the predictability, control and expression of gesture-controlled augmentation of sound. The latter draws on questions of correlation, spatial and proprioceptive awareness, responsiveness, latency and accuracy in flowing gestures. Unlike particular cues that are recognised by gesture-recognition systems, this kind of system that analyses continuous flowing gestures does not require an instrumentalist to fundamentally or radically alter their approach to their conventional instrument. This sets it apart from gesture-only interfaces or dancer-actuated systems.

The ancillary motions of the performer are tracked with a Kinect depth camera using freely available motion tracking software, Synapse.[3] Acceleration of upper body motion is mapped to two effects bus levels, a looper and a selection of virtual MIDI instruments within Max/MSP[4] and Ableton Live.[5] Acceleration reveals information about position, speed and magnitude of gesture. When the acceleration stops, the bus levels return to 0, much like a sprung wheel control. Minimal movement or static poses return the user to a dry signal. The distance of either limb from the torso is mapped to increasing volume and processing, thus linking sonic intensity to effort expenditure.

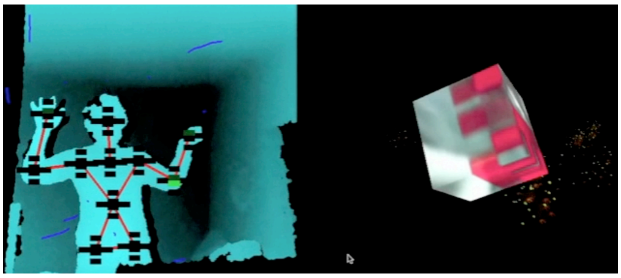

Figure 2. A screenshot depicting skeleton tracking in Synapse and visual feedback in Isadora Core for the audiovisual instrument used in the work, *Alignment*.

4.1 Feedback

The visual feedback component of the *Gestate* system, designed in Isadora Core[6], aims to enhance performability by compensating for the absence of haptic feedback in non-tactile controllers. In seeking to supplement the remaining information channels of aural and proprioceptive feedback for the performer, this system offers insights into the application of visual reinforcement in the context of non-tactile gestural interfaces, building on research findings in the field of multimodal environment design.

Visual feedback offers the potential to expand the communication channel between an instrument and performer [15]. It also strengthens audience engagement by illuminating mapping strategies, helping audiences understand the underlying musical processes behind a performance. The capacity for visual feedback to present 'audio' feedback and movement data in visual form can encourage intuitive understanding and mastery of the interface, allowing simultaneous control of multiple parameters [15]. Visual feedback that reflects varying levels of intensity in the piece establishes multidimensional cues for the performer to support creative exploration.

Another strength of visual feedback is to amplify the subtleties of movement that are sometimes lost in a passing performance. Sensors transform and simplify movement – making it a valuable exercise to depict this data in different ways to advance our understanding of how the machine interprets key movement qualities. This becomes a way to nurture creative engagement, offering a form of representation that highlights previously hidden aspects of gesture and emerging movement patterns.

5. APPLICATIONS

The *Gestate* system has been tested in a range of solo and group performances for both augmented piano and voice.

During a performance at the 2013 Electrofringe Festival in Newcastle, Australia, six pieces with accompanying visual feedback were presented. Each of these studies explored a distinct aspect of gesture manipulation across a range of musical applications, including rhythmic, synthesis, mixing and effects control.

Visual feedback was projected onto a semi-transparent scrim erected in front of the performer. The scrim performed the dual function of providing direct visual feedback to the musician and displaying a visualisation of their motion trajectories to the audience in abstract form.

In the first work, *Alignment*, punching motions in the right arm trigger a selection of MIDI notes from a predefined scale in Isadora Core that are then arpeggiated in Ableton Live. The sound source is an adapted physical mallet model from the Ableton Collision[7] collection. The visual feedback for this process illustrates each punch, or arpeggiated chord trigger, with one spin of a three-dimensional cube, as shown in Figure 2. The left hand controls a range of effects over the sound, visually expressed as a 'spray' of particles emerging from the cube. Each chord transition does not change predictably in pitch, but is subject to a random selection process implemented in Isadora Core, resulting in an almost generative effect. The intention behind controlling a physical model and assigning chords to each cube side was to display a transparent mapping to help orient the audience early in the performance before progressing to more abstract mappings.

This approach illustrates the balance between sonic parameters that are triggered consciously by a collection of discrete gestures, and the control of audio effects by movements naturally occurring during vocal performance.

For the piano application, more subtle effects could be achieved. The 2012 performance of *Concentric Motion: Concerto for Voice, Piano and Gestural Controller*, was composed for a 17-piece orchestra and soloist performing with two forms of gestural control – the first using the ancillary gestures of piano performance and the second driven by the extra-musical motions of the vocalist.

The first movement is introduced with a percussive piano part. Subtle effects manipulations emerge from rhythmic torso rocking and head motions, increasing the resonance and overall sustain of the acoustic piano. The transition to the second movement occurs when the soloist appears to physically grab the tail-end of the last phrase with an upward arm motion, before assuming a standing posture in preparation for a vocal solo.

The subtle effects manipulations that characterise the piano movement contrast with the more pronounced digital signal processing produced by increasingly expansive gestures accompanying the vocal performance. Selected phrases are intensified by granular delay and echo, triggered by sweeping arc-like movements specific to the vocalist's style.

5.1 Performance Challenges

Personal insights that have emerged from these performances confirm well-documented issues related to gestural and augmented instrument

3 http://synapsekinect.tumblr.com

4 http://cycling74.com/products/max

5 https://www.ableton.com/en/live

6 http://troikatronix.com/isadora/about/

7 https://www.ableton.com/en/packs/collision/

performance, including cognitive overload [16]. When performing with effects controllers, the responsibility of maintaining constant audio levels and sonic clarity can distract the performer by adding an additional control layer to existing vocal or instrumental technique. One proposed solution is to introduce non-direct gesture-sound links through a multi-layered mapping strategy that frees the user from full conscious control over effects [16].

Repeated practice can also assist in reducing cognitive overload. When gestural controllers are used extensively as the main instrument throughout a performer's career, a deeper sense of mastery can develop [13]. The temptation to undertake last-minute instrument redesigns is common with interactive systems, leading to possible unresolved technical issues and a steep learning phase for the performer before a performance. The benefit of moving away from the cycles of constant refinement by 'freezing' development allows the performer to explore the system thoroughly, promoting confidence and the multitasking skills that such interfaces require.

Any time the performer uses an augmented instrument it will exercise some influence on their existing technique and movement style, even if this contradicts the intuitive design aims behind such interfaces. The unconscious movements of the performer can be constrained in unnatural ways, causing the performer to adapt their behaviour to the system's output rather than playing in their usual, idiosyncratic style.

With no specific instrument design to conform to or microphone stand to use as a prop, the performer can also feel very exposed before an audience. For vocalists, the freedom of movement offered by non-tactile controllers, paired with wireless microphones, can appear equally liberating and daunting. In these situations, performers need to invent new ways of performing, perhaps even extending or exaggerating their movements to create more dramatic sonic results or impact. For vocalists accustomed to performing with a microphone and stand, this novel way of working with the body may only become comfortable after many rehearsals and performances.

6. REFLECTION

The main contribution of this practice-based research is a mapping design approach guided by experiential factors. This research aims to improve user experience by contributing to performability while also broadening our understanding of gestural interaction. The value of combining physical awareness, a commonplace practice in all vocal and dance training, visual feedback and intuitive mapping are explored as a means to improving the effectiveness and accessibility of gestural performance systems.

The success of gestural technologies relies as much on skillful technical design as the user's openness to exploring their own body's potential. In a mutually beneficial relationship, musicians willing to become more aware of their unconscious movement patterns and bodily sensations during rehearsal and performance are rewarded with richer sonic outcomes that complement technical advances in gestural control of live music.

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