Strategies for Engagement in Computer-Mediated Musical Performance

James Nesfield
Department of Media
School of Arts, Design & Architecture
Aalto University
james.nesfield@aalto.fi

ABSTRACT

A general strategy for encouraging embodied engagement within musical interface design is introduced. A pair of example implementations of this strategy are described, one tangible and one graphical. As part of a potentially larger set within our general approach, two separate relationships are described termed 'decay and contribution' and 'instability and adjustment', which are heavily dependent on the action requirements and timeliness of the interaction. By suggesting this process occurs on a timescale of less than one second it is hoped attentiveness and engagement can be encouraged to the possible benefit of future developments in digital musical instrument design.

Keywords

engagement, embodiment, flow, decay, instability, design, NIME

1. INTRODUCTION

Effort and engagement exert strong influences on the intimacy of relationships between interface and performer, performer and audience. Accordingly, the embodied view of perception has become an increasingly popular framework for designing and researching interactive activity. The spectrum of discussion and application covers a wide range of perspectives, from philosophical and phenomenologically informed views [6][21] to more practical applications in activities in sound-related projects such as [9][1][8]

Despite differing formulations of what constitutes embodied activities, several common criteria are apparent across the spectrum of discussion. Accordingly, this paper will not set out to define the limits of embodiment or enaction, or indeed their validity philosophical or applied. Instead, focus will be given to one specific element of agreement within the various definitions of enactive activity: that it requires a form of embodied engagement [10][14] on the part of the agent. As a necessary, but by no means sufficient, component of embodied activity, we present 'engagement' broadly to describe the strongly time-dependent amount of attentiveness or concentration required during performance. Its emergence is dependent on the quantity, nature and the timeliness of interactions between performer and interface, as well as the skill of that performer.

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Computer-mediated tangible interfaces for musical performance present unique challenges to the designer or performer where engagement is considered. Here, large portions of the sound creation process can either be automated or created from scratch by the computer. This stands in contrast to acoustic instruments in which the physical construction of the device is the transducer between the musician's excursion and its acoustic output. The shifting of the responsibility for sonic output can reduce the required amount of mental and physical contribution from the performer and in doing so, minimise the sense of embodiment in part by reducing the level of engagement between performer and computer.

In this paper we introduce two design considerations for creating, maintaining or increasing the level of engagement in computer-mediated musical performance, termed 'decay' and 'instability', which are presented from a designer's perspective.

2. ENGAGEMENT

Embodied activity has a long history of discussion within NIME and further afield [5][1][8]. As a component part of embodied experience, engagement has been investigated in a musical context directly [16] as well as approaches more broadly in the context of general HCI [19] which collectively credit engagement with an important role in embodied activity.

The definition of the term 'engagement' varies substantially across these discussions. Our paper begins with a conception of the term which Armstrong [1] defines as occurring when the agent 'is required by the task domain' such that it 'presents challenges to the agent that consume a large portion of her attention'. Adding to this, we believe it is necessary here to immediately place temporal considerations within our definition where this dependency on time is distinct from the timeliness of action and feedback under the larger umbrella of embodied activity. By emphasising the temporal considerations in isolation, we seek to differentiate between Heidegger's 'ready-at-hand' and 'present-at-hand' manifestations of engagement without *necessarily* appealing to higher-level, embodied contexts. In plain terms, this differentiation is used to separate engagement as the term is used in passive settings to denote interest or 'entertainment attention' from its use in performative settings where it denotes a level of attentiveness, active concentration and set of time-dependent action requirements.

The kind of 'embodied engagement' investigated here stands in contrast to its use in settings such as 'last night's captivating or *engaging* performance', in which engagement is used to denote interest and attentiveness without action. 'Embodied engagement' is active, involves repeated bodily actions and is contingent on higher-level intentions of the agent. Additionally, we will suggest that this type of engagement takes place when the action cycle is within a time-scale of below one second.

3. DECAY

The term decay here is used in a quite general sense to mean ‘a loss of energy’ or ‘a declining state’, as opposed to any strict thermodynamic or philosophical formulations. In this broad sense then, we simply assume that energy or work of some kind is required, and that it has temporal constraints.

Decay of some kind is present in all physical systems as a result of friction. For designers of new musical instruments working in the digital domain, the physical coupling between energy input and parameter decay evaporates. By ensuring that constant input is necessary for the maintenance of system state, ongoing effort/attentiveness is demanded of the user. It is posited here that a re-emphasis on the requirement for continued work by the performer could be beneficial to the design of interfaces which seek to take advantage of embodied activities in their use.

Ideas of effort in musical performance are certainly not new, and have been discussed at length [14][3]. In investigating the role of decay with respect to engagement in a collaborative setting, Bryan-Kinns & Healey [4] suggest that ‘decay engender(ed) a more focused musical interaction in experienced participants’. The ‘engendering of focus’ is clearly related to the notions of engagement presented in this text. Several texts have also investigated the contribution of physical effort in expressive musical performances, including [20], but the application of energy here is not necessarily one of purely physical exertion. For the purposes of this paper, with engagement prioritised above gestural, physical expressivity, the work needed to maintain a performance need not be physically strenuous per se. Instead, it may be sufficient for this paper’s design goals that the activity simply requires continuous, successive action, rather than this requirement dictating these actions should provide a certain level of excursion.

The ‘effort’ described here then is not necessarily or predominantly physical: it is the requirement for physical action, but this action may, for the purposes of this argument, be as simple as a button press or open-air hand gesture: the significant factor for this design strategy is simply that the performer must provide continuous movement, or successive discrete actions, which alter some perceivable aspect of the output of the system.

4. INSTABILITY

Instability can provide a second method for engendering engagement, and, though non-musical, has been explored in the context of with technology and embodiment[12]

In this scenario again, the performer must be attentive her activity in order to ensure its adherence to her musical intentions. Here however, instead of constantly adding energy to the system, the user is required to constantly adjust the state of its processes to maintain a steady course. The activity is constructed so as to ensure that actions (if viewed from an analytically serial perspective) are required at a rate faster than 1Hz. These constraints are placed both on the time taken for unstable behaviour to manifest as a deviation from its current trajectory, and on the delay involved in its adjustment or correction.

This frequency or magnitude of the continuous demands of the system on the performer is crucial, as this factor can be primarily responsible for the perception of the system interaction being ‘managerial’ as apposed to engaging at the level of the body. That is, that given sufficiently slow or undemanding requirements from the performer, he or she assumes the role of manager or ‘babysitter’[17] rather than attentive balancer.

Though no distinction need be made from the argument presented here with regard to analytically ‘serial’ (e.g. button presses) and continuous instrumental gestures (i.e. selection/exciter and modification gesture), continuous control provides an immediate starting point for a concept device utilising these notions of instability in the design application described in the following section’s application.

4.1 The EQuilibrium Device

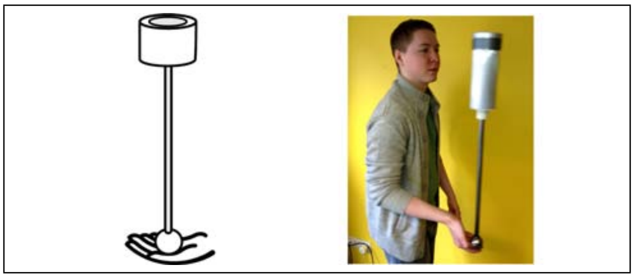

Figure 1: The EQuilibrium Device

The development of a test-of-concept device provided the opportunity for investigating the ideas presented in this paper. The design consisted of a top-heavy ‘inverted pendulum’ design which houses a speaker, accelerometer and sound synthesis/control module which the performer is required to control by adjusting its balance as it rests on the palm of her hand.

The inaccuracy of any compensation when applied to unstable systems[1] maintains the continuous requirement for action without mitigating possibilities for higher-level goals and intentions. This strongly coupled feedback loop of action-reaction has parallels in many other areas of current discourse within embodied cognition, human perception and HCI [10]. For out present purposes however, it is sufficient to observe that this design provides ample opportunity for demanding attentiveness as well as the likelihood of continued exchange by taking advantage of our simple, innately familiar sense of balance.

4.1.1 Sound Design & Construction

As playful equilibristic design was the primary design goal, EQuilibrium’s sonic characteristics were chosen so as to enhance the ludic qualities of the overall design, rather than being taken as a components of a formal instrument. No sound is created by maintaining the controller in a static, upright position. In order to make sound, the user must unbalance the system. Although this provides considerable challenge initially, it does provide scope for continued refinement which, in the right pair of hands, might be considered virtuosic if it were in the context of a more holistically designed, sound-focussed instrument. The interface’s behaviour is governed by its centre of gravity, which is proportional to the length of the vertical section. By changing its geometry in this way, EQuilibrium can vary the amount of challenge presented to each performer.

Audio synthesis is handled by PureData[2] running inside RjDj[3] on iOS 5. iPhone and iPod Touch devices were used

[1]an example here might be the emergence of the ‘fish-tailing’ behaviour of a car when driving down a straight but ice covered road.
[2]http://puredata.info/
[3]http://rjdj.me/

due to their suite of sensors, and their wireless, battery-powered operation. Positioned vertically, the cylindrical design eliminates a 'correct' orientation on the horizontal plane. The two of its horizontal/radial accelerometers responsible for accelerations along these axis are mapped identically, ensuring similar behaviour regardless of its axial rotation. The sound-design goals of this prototype included the creation of playful, complex and slightly chaotic timbres to encourage exploration and to reinforce the sense of imbalance. A combination of AM and FM synthesis was used along with a suite of basic oscillators and noise generators, all of these are connected to a master volume multiplier which is responsible for the interface's fundamental behaviour: silent when still, audible when in motion, with loudness proportional to its degree of unbalance. It was found that a high-order exponential function was a good fit for mapping between balance and volume, affording sensitive minimums with satisfying, achievable maximums and avoiding any issues involved with the introduction of steps or thresholds in the mapping layer.

4.2 Stagger Sequencer

The use of instability as a primary concept for enhancing embodied engagement was also applied to the creation of a simple step sequencer in a graphics-led context.

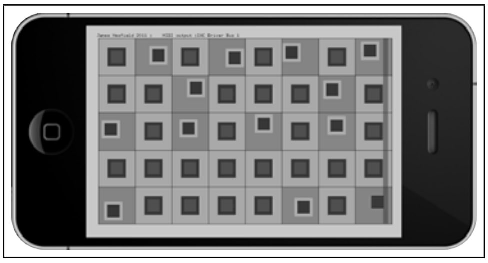

Figure 2: The Stagger Sequencer interface

Here, each step consists of a small box representing one note, each box is confined within an standard step sequencer grid layout, as shown in Figure 2. The sequencer's unstable behaviour emerges from the each step's random movement when active within its grid step. Each step is activated and deactivated with long presses. If an active box then touches the edge of the grid, it activates its neighbouring box on that edge. However, each box can be re-centred by simply tapping within its boundaries. As a sequencer, the application does not create sounds of its own, instead it outputs standard MIDI note messages to be used by any compatible software or hardware synthesiser. The instability of the sequencer's behaviour is modulated by the attentiveness of the performer: the severity of each box's random motion depends on the Actions Per Minute (APM) performed by the user. In our example, a lower APM increases the random jitter of the boxes, higher APM leads to a more stable behaviour. This mapping is intended to behave similarly to EQuilibrium, where sound production/modification is available only when the system is 'off-balance', and ensures that steady-stage behaviour is only possible with a high average APM.

5. DISCUSSION

By requiring continued attention, equilibristic and decaying strategies may provide additional avenues for the creation of more engaging performance systems and activities. A generalisation is presented in Figure 3 as 'modification and compensation' to better reflect their shared characteristics.

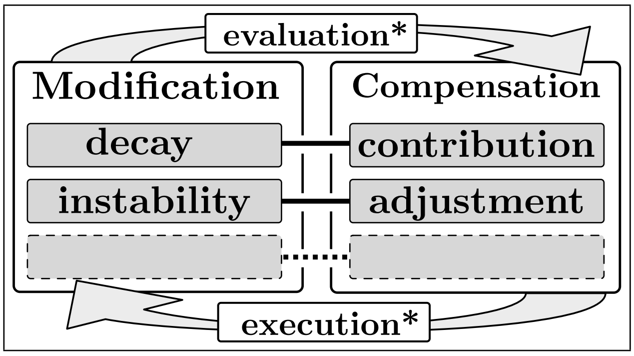

Figure 3: Modification & Compensation. [Integrated from Norman's[15] 'action-cycle']

Without straying the focus of this paper into the phenomenological or enactive roots of these ideas, Norman [15] provides a design-relevant perspective in this area with his Action Cycle model. This model does not include either the significance of timely, concurrent dialog between performer and interface, nor the importance of avoiding interruption during the activity. What is stressed however, is the distinction between design-model and actual, subjective performance. This contrast in perspective is further amplified with the added temporal considerations presented in our model.

Ballard et al provide some evidence for suggesting that timescales of under one second may mark the limits for this interaction cycle in the context of our 'embodied engagement' goal:

> 'Given much less than 0.3 second, computation is decidedly neural because there is not enough time to communicate with the outside world except in the case of primitive reflexes. Given much more than 0.3 second, for example, 10 seconds, there is time to plan behaviour by running internal simulations. Once again, computation becomes predominantly neural, albeit for a different reason.'[2]

The exact speed of this conversation is not crucial, and in fact will depend heavily on the demands of the activity and on the skill and experience of the performer, though [13] discusses similar 'goal sensitive, semi-automatic processes that are permeable to the interests and concerns of the agent' which are 'typically well below half a second'. These temporal windows mark the limits of a spectrum: too fast and the conversation is purely reflexive, too slow and it becomes overly reflective. Csikszentmihalyi's ideas of flow states are readily applicable at this point, and have been discussed at length elsewhere [7][14][11] . Flow is attained, in part, by the continued application of skill in order to meet the requirements of a sufficiently demanding task [7].The relationship between challenge and skill in this scenario is thus results in the exclusion of all other conscious distractions. Engagement then, is a prerequisite for the emergence of flow. Methods of encouraging engagement, especially at the level of the body, may help foster the emergence of more rewarding musical experiences where computer-mediated instruments are concerned. To this end, both strategies presented in this paper aim to support attentive interactions by maintaining the requirement for action while attempting to avoid placing the performer in a 'managerial' role with respect to the maintenance of equilibrium. We believe successful avoidance of supervisory interaction styles can be achieved, in part, through careful monitoring and the adjusting of a system's time-dependent action requirements[4].

For this approach to provide embodied rather than merely entertaining it is important that any measures taken to mitigate the steepness of a learning curve are balanced with the timescale requirements discussed earlier. Digital systems have the capability to monitor a user's performance in parallel with their normal, musical functioning, providing the possibility to adjust the action requirements (both their temporal and functional qualities) dynamically, in sympathy with the user's increasing skill. As these two priorities (action-requirement and user skill) are then interdependent, this has the potential to create a conflict with respect to the creation of situations which encourage optimal flow. Careful consideration and subsequent balancing of these two criteria, especially in the earliest stages of familiarisation, is crucial.

It should also be pointed out that, within this general level, this paper's pair of relationships, by no means represent an exhaustive strategy for encouraging engagement. Though other motives may drive design considerations relating to the action requirements of a particular NIME's interface, the approach outlined within the scope of this paper does not seek to place limits here on this how the specific interaction takes place. In the wider context of general HCI design strategies, [18] offer another relationship pairing which might be termed here as 'ambiguity & interpretation'. This may point the way to additional possibilities for, though real-time implementations of this strategy for musical performance appear initially elusive. The incomplete nature of this strategy is highlighted by Figure 3's empty lower boxes.

6. CONCLUSIONS

A strategy for fostering embodied engagement in computer-mediated musical instruments was presented which contained two elements: 'decay' and 'instability'. The latter element was applied to two different interfaces, one tangible and one graphics-based. Their role as part of a larger design-focussed strategy was discussed with particular attention paid to the temporal dependencies of this approach. The principles of 'decay' and 'instability' were considered as viable components of Norman's 'action cycle', which, it was suggested, could provide fertile ground for the emergence of embodied engagement provided certain time constraints are taken into consideration. With rough time limits of >1Hz placed upon this interaction cycle, the attentive user must constantly act in order to fulfil their overall goals and intention, which in turn may encourage the emergence of flow.

As mentioned, the two strategies here do not constitute an exhaustive list with regard to the larger sets of 'modification' and 'compensation'. Further work will attempt to test the ideas presented here from analytical and subjective perspectives in order to provide both qualitative and quantative feedback on their conclusions. Additionally, the two implementations put forward in this paper were directly focussed on demonstrating the concepts described. As such, they did not prioritise aspects of musical instrument design which are equally important to the performance experience as a whole. The development of future interfaces will be integrated into a more holistic approach which, it is hoped, will lead to engaging instruments that balance more delicately other components of musical, performative experience.

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8. REFERENCES

[1] N. Armstrong. *An enactive approach to digital musical instrument design*. PhD thesis, Princeton University, 2006.

[2] D. H. Ballard, M. M. Hayhoe, P. K. Pook, and R. P. Rao. Deictic codes for the embodiment of cognition. *Behavioral and Brain Sciences*, 20:723–67, 1997.

[3] P. Bennett, N. Ward, S. O. Modhrain, and P. Rebelo. DAMPER : A Platform for Effortful Interface Development. *Proceedings of the conference on New Interfaces for Musical Expression*, 2007.

[4] N. Bryan-Kinns and P. Healey. Decay in collaborative music making. In *Proceedings of the conference on New Interfaces for Musical Expression*, 2006.

[5] P. R. Cook. Remutualizing the Musical Instrument: Co-Design of Synthesis Algorithms and Controllers. *Journal of New Music Research*, 33(3):315–320, 2004.

[6] G. Corness. Through the Lens of Embodiment. *Leonardo Music Journal*, 18:21–24, 2008.

[7] M. Csikszentmihalyi. *Creativity: Flow and the Psychology of Discovery and Invention*. Harper Perennial, 1997.

[8] T. Davis. *The Ear of the Beholder: Ecology, Embodiment and Complexity in Sound Installation*. PhD thesis, Queen's University Belfast, 2011.

[9] G. Essl and S. O'Modhrain. An enactive approach to the design of new tangible musical instruments. *Organised Sound*, 11(3):285–296, 2006.

[10] R. B. Gillespie and S. O'Modhrain. Embodied Cognition as a Motivating Perspective for Haptic Interaction Design : A Position Paper. *IEEE World Haptics Conference*, pages 481–486, 2011.

[11] S. Godlovitch. *Musical Performance : A Philosophical Study*. Routledge, 1998.

[12] C. A. Jones. *Sensorium: Embodied Experience, Technology, and Contemporary Art*. MIT Press, 2006.

[13] D. Kirsh. Metacognition, distributed cognition and visual design. In P. Gardinfors and L. E. Johansson, editors, *Cognition, Education, and Communication Technology*. 2004.

[14] T. Magnusson. *Epistemic Tools The Phenomenology of Digital Musical Instruments*. PhD thesis, University of Sussex, 2009.

[15] D. Norman. *The Design of Everyday Things*. Doubleday Business, 1990.

[16] D. Paine. Gesture and musical interaction: interactive engagement through dynamic morphology. In *Proceedings conference on New Interfaces for Musical Expression*, 2004.

[17] W. A. Schloss. Using Contemporary Technology in Live Performance: The Dilemma of the Performer. *Journal of New Music Research*, 32(3):239–242, 2003.

[18] P. Sengers. Staying open to interpretation: engaging multiple meanings in design and evaluation. In *Proceedings of the 6th conference on Designing*, 2006.

[19] C. L. Sidner, C. Lee, C. D. Kidd, N. Lesh, and C. Rich. Explorations in engagement for humans and robots. *Artificial Intelligence*, 166:140–164, 2005.

[20] A. Tanaka. Musical Performance Practice on Sensor-based Instruments. In M. M. Wanderley and M. Battier, editors, *Trends in Gestural Control of Music*, pages 389–406. IRCAM, 2000.

[21] E. Thompson and M. Stapleton. Making Sense of Sense-Making: Reflections on Enactive and Extended Mind Theories. *Topoi*, 28:23–30, 2009.