Control Strategies for Navigation of Complex Sonic Spaces

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ABSTRACT

This paper describes musical experiments aimed at designing control structures for navigating complex and continuous sonic spaces. The focus is on sound processing techniques which contain a high number of control parameters, and which exhibit subtle and interesting micro-variations and textural qualities when controlled properly. The examples all use a simple low-dimensional controller - a standard graphics tablet - and the task of initimate and subtle textural manipulations is left to the design of proper mappings, created using a custom toolbox of mapping functions. This work further acts to contextualize past theoretical results by the given musical presentations, and arrives at some conclusions about the interplay between musical intention, control strategies and the process of their design.

Keywords

Mapping, Control, Sound Texture, Musical Gestures

1. INTRODUCTION

In the context of computer-based music discussion, the word and concept "mapping" has come to refer to many aspects of the gesture-to-sound chain of control – from signal conditioning to perceptual and cognitive issues related to causality and expectation in performance [12]. In the construction of a musical performance system, the issue of mapping manifests in the choice of strategies for transference of physical input gestures to sonic results, which includes both the decision of what parameter associations to make as well as the behavior of this transference itself [9]. This choice is informed by the presentational idiom and such concomitant issues as whether one is creating an instrument with which to develop one's art or a composed system [3] which itself is the art. There are many time-scales on which one can control a musical process - and this is further determined by the aesthetic consideration of performative and sonic issues.

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2. MUSICAL CONTROL CONTEXT

Rather than concern ourselves with the various issues surrounding physical gestures and performance, our focus here is on "musical gestures" in the sense of those traces embedded within a sound which might evoke a sense of the physical process responsible for its production [1]. There are many styles and sub-genres of digital music performance that do not have the communicative aspects of human gestures as their primary concern [2] and yet real-time control and organization of sound materials is often still of paramount importance. Indeed, the ability to organize complex sound materials, to continuously move amongst these and to repeatably and reliably evoke musical gestures is our main concern here. Further, we focus on means of sound processing that have many controllable parameters and that are not immediately suggestive of a particular physical gesture. The aesthetic choice is centered around sounds having rich textural properties, and micro-variations that are not directly controllable, but rather must be affected by virtue of simultaneously affecting many other parameters.

We chose a standard Wacom tablet due to its ubiquity, accuracy [15], cost-effectiveness and suitability for "laptop performance" as well as other more physical styles of computer-based music. Its physical layout and low-dimensionality are also suitable for the desired control context, which might be considered as navigating within a "timbre space"[13] in that we wish to navigate a sound space to morph between known sound qualities[1], with the added goal of wanting our dynamic input to result in subtle gestures within the sound dynamics.

3. DESIGN CHOICES

In previous work we have presented various mapping strategies as functions between geometric spaces of control and sound synthesis parameter sets, respectively [11]. The given overview of analytic properties can help inform one's choice of mapping in designing an interactive musical system. Properties such as local/global definition, editability, continuity, linearity, smoothness, etc. take on more or less importance depending on a given musical control context as discussed above, and can even embed interesting musical gestures in the control system if designed properly [9]. In order to explore these issues from a phenomenological/musical practice perspective as well to explore the perception of other users in regards to mapping structure, we have developed a tool-

[1]Though we should be careful in our use of this concept, given the multiplicity of definitions of "timbre", e.g. [5][8].

box of multi-dimensional functions [10] for interpolation, extrapolation and regression of control/sound data. Included in this collection are several core functions for few-to-many mappings [3] including piecewise linear (relative to a triangulation of parameter space), multilinear and spline-like techniques. Given our aesthetic goals, having the mapping toolbox at our disposal and guided by awareness of its deeper structure led us to design the following sonic control spaces.

4. EXAMPLES

4.1 Transformation of Resonant Models

We originally chose to work with a bank of second order resonant filters [4] in Max/MSP in order to compare with one of the few existing works to explicitly utilize geometric models for designing musical control spaces [6]. We found interesting sonic potential in the given filter implementation and explored several control possibilities. Beginning with a model of a resonant percussive instrument (its modal frequencies, amplitues and decay rates), we drove the filter bank with a noise source, and created several "presets" or known sound states by transforming the model into more abstracted textures. In the process of transformation, several additional modes were created within the sound model around the primary ones, leading to a perceptual "roughness" quality that could be indirectly affected. We then designed mappings from the x-y position of the tablet to the parameters spectral slope, spectral corner, global decay, global gain, as well as location, spread, attenuation and decay of the "clustering" modes.

4.1.1 Organization of Sonic Space

Because this is a relatively high-level space, it makes sense to associate points in space with steady-state sounds, and to morph between them. This is comparable to the classic conception of a timbre space, wherein one wishes to discover sounds "in-between" the known sound models. To this end, we designed a control structure that was locally defined and locally editable, so that sounds were generated from preset models that were in close proximity in regards to the tablet. Further, new models could be defined at a given location, thereby changing the tablet response in neighboring regions. Thus these regions are defined by the manner in which the stored models are scattered across the plane of the tablet as well as how said regions were connected. In this example, the preset points were triangulated on the tablet surface, which in turn induced a piecewise-linear interpolation of the high-dimensional sound parameters. Again, this is not truly a perceptual space we control in that the degrees of freedom do not correspond to perceived sound qualities, and linear changes in sound parameters do not result in perceived linearity of sound transformations. That said, the high-level nature of the chosen parameters led to a situation in which desired sonic states were able to be found and musical gestures were repeatable. However these musical gestures were not constrained to an absolute path of physical gesture: while the parameter mapping itself was fixed, the perceived mapping varied due to the hysteresis present in the modal synthesis model (due to the inherent memory of the resonant filters employed). Because of this, the process of constructing a particular sound space and a predictable coupling of physical/musical gesture meant varying the speed and ordering of the different pen/tablet trajectories, leading to different sonic gestures at the same tablet location, which in turn prompted the movement or insertion of different sound models in a design feedback loop. Important to note here is is that *the mapping choice as well as the mapping design process itself were determined by the control context (sound model interpolation), the complexity of the sound parameters (relative high vs. low level) and the time-based behavior of the chosen model*.

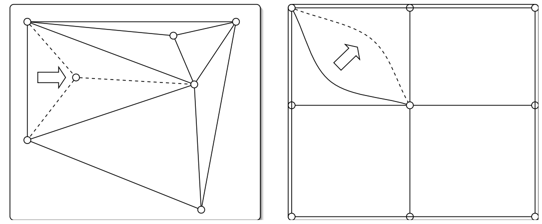

Figure 1: Different spatial layout of sound model presets on tablet surface, and their respective approaches to model interpolation in example 4.1: movement or insertion of new sound models, creating new localized regions (left) vs. weightings of each fixed sound model, creating a different geometry for the model interpolation (right). The former allowed for more defined musical gestures while the latter made it easier to define a global sound quality for a given region.

4.1.2 Tuning of Sonic Space

In a different approach to the same material, we laid out the model states in a grid around the tablet boundary, and utilized a non-linear mapping function to generate our sound space. In this case, rather than move preset points around in control space we tuned the weighting of each model. Given the multilinear quality of the mapping, this amounted to warping the geometric "shape" of the sound space (see fig. 1). While it was more difficult in this case to define a sound to occur at a precise location, it proved to be much easier to define regions that had a certain general character. That is, due to the mapping approach it was easier to construct regions of the tablet having a global feel, but more difficult to construct repeatable musical gestures. The functional properties of the given mapping contributed to this in that the ability to 'tune' this mapping technique compensated for its inability to define model presets at arbitrary locations in control space. Further, the globally smooth nature of the mapping [11] made it easier to create long, smooth musical gestures which worked well within this slow-moving and dense sonic space. These tradeoffs might be seen as beneficial if, for example, one is designing a system for improvisation rather than for composed music.

While the input device and sound synthesis method were the same in this example, as were the underlying sound models, the control structure was different. This structuring was a product of - and suggested the use of - a certain approach to parameter mapping. The design process focused on the tuning of global sound qualities for a given region of the tablet. Thus the focus here was on the "spatial response" (the physical layout of sonic materials), and the perceived smoothness of this across the tablet, in contrast to the temporal dynamics that were of primary importance in the previous example. *This difference arose from a difference in*

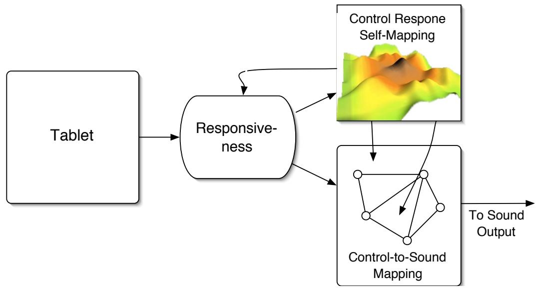

Figure 2: Control structure for example 4.2.1: two concurrent mappings control the possible sound combinations (control-to-sound) as well as the control/sound temporal response (control response self-map). Both determine the resultant musical gestures.

musical control context, which both determined and was informed by the design process as well as the choice of mapping strategy.

4.2 Multi-Layered Approach

The qualities of the resonant models and their high-level nature were suggestive of a certain approach: spatially laying out the known sound models and interpolating between them, in essence a user-defined perceptual space. However, in another scenario we might want to transduce physical gesture into a sonic result in a more immediate fashion. In this example we used a classic granular synthesis approach (sine waves, Gaussian window) with the following relatively low-level parameters: grain size, offset, amplitude min and max, grains/second, frequency min and max, and finally reverberation level and time.

4.2.1 Concurrent, Parallel Mappings

Granular synthesis is capable of generating vastly different sounds [7], making it rich with possibility yet very difficult to create coherent musical gestures in real-time. One approach would be to find particular and interesting trajectories in sound parameter space, and to constrain a mapping to only produce these sounds. However this might limit one's exploration and expansion possiblities, and would seemingly not make for an interaction design with a very high ceiling on virtuosic use [14]. Our approach here was to use concurrent mappings which "occupy" the same controller domain (i.e. they are both defined on the two-dimensional tablet surface), wherein one acts to map from control to sound parameters while the other acts on the behavior of the control data itself in a feedback control loop (fig. 2). Specifically, we use the aforementioned triangulation-based method to control the mixture of sound parameters, and overlay another mapping - a spline technique with tunable tension and smoothness [11] - which controls the responsiveness of the tablet pen position as determined by a low-pass filter. The filtering of control data serves two purposes: to adjust the "speed" of musical gestures through the sonic parameter space, and to smooth the transition between triangulated regions of control space, which may be necessary as this mapping scheme is not globally smooth.

Once again we are thinking spatially with this example, in that we are laying out preset sound points across a tablet.

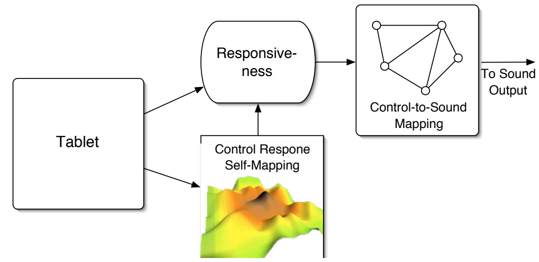

Figure 3: Control structure for example 4.2.2: the control response self-mapping acts as meta-control, affecting the responsiveness in parallel with the mapping from control to high-dimensional sound parameter space.

Another layer of spatial thinking is added in this case, as the second mapping is concerned with adjusting the responsiveness of the control at given points. However, this approach adds a temporal element as well, in that we consider the musical gesture-dynamics that result from a physical input motion. After some adjustments to both mappings, interesting dynamics were possible from the tablet. However another level of mode change or similar modification seemed necessary, as the control-side mapping layer in this example played the role of a simple adaptive filter of control data having little variance in its response.

4.2.2 Meta-Control of Mapping Layer

Towards the end of creating an interface with more hidden surprises and control possibilties, we added a layer of complexity to the above mapping scheme. Rather than define the controller responsiveness at given points in space, we defined a mapping to affect this parameter, taking as input the tilt values of the tablet pen. From a geometric standpoint, the space of control parameters in this example is four-dimensional (two separable two-dimensional planes of control) rather than a single two dimensional surface as in the above example. With this approach to control structuring, we may choose to lay out a mapping "surface" over the tablet as in the above example (i.e. to think spatially about the control of temporal response), or we may define the control based on the phenomenal experience of how we most like to move. In the latter case, we are free to examine ancillary gestures [1] and design a meta-layer that best adapts to one's motion. Not surprisingly this control structure was most difficult in regards to repeating or maintaining a given sound, but it afforded the most diversity of response to different gestures.

While the first multi-layered example was a bit too constrained (in spite of perceptible changes in control response), the second added a potential cognitive overhead that was not trivial to manage in regards to changing the control response in real-time. Ancillary gesture analysis is one possible approach, but without a repertoire of common gestures this might not be the most effective strategy. One thing that is certain is that these two examples underscore *the complex role that mapping plays in the structuring of subtle and articulatory control, including issues such as the potential importance of time-variant mappings through meta-control and/or feedback control.*

5. CONCLUSIONS AND FUTURE WORK

We have presented some examples for navigating sonic spaces using a ubiquitous and low-dimensional controller. The complex and high-dimensional nature of the sound algorithms were managed by designing a proper control/mapping structure, and the richness of sound output depends on this construction in tandem with close attention to appropriate gestures - both physical and musical. In a sense the goal is to see how much sonic control information that we can extract from this limited performance context - though these techniques are general and can work with systems having different sensing modalities and degrees of freedom. However it was the simplicity of the tablet controller that further highlighted the interaction between mapping, musical context, the time-based nature of the sound synthesis model (hysteresis/memory, etc.) and the design process itself, as well as the challenges present in designing a time-variant control structure to achieve a perceptually repeatable and invariant response. In the future we intend to further explore simple controllers and complex mappings, towards the end of designing a satisfying and portable improvisational system.

6. ACKNOWLEDGMENTS

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