Database and mapping design for audiovisual prepared radio set installation

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ABSTRACT
This paper describes both the design strategies behind a database of radio gathered percussive sounds, and also the interaction scheme used to embed this database in an audio-visual installation. In particular we describe the implementation of a complex mapping system that uses a model of heat energy and 'one to many' mappings to encourage a holistic cognitive mode in the user.

Keywords
Mapping, database, audiovisual, radio, installation art.

1. INTRODUCTION
As part of the FIX 07 Festival [12] an audiovisual installation featuring a prepared (hacked) radio set and accompanying visuals was created. The objective of the piece was to engage users in a musical system where they felt they had a degree of control in its output, without having to confront them directly with instructions for its use. Instead the piece relied on the audiovisual feedback and the pre-existing experience people have of browsing for signals on radios. Rather than concentrating too hard on the individual effect of each dial and switch, the objective was to place the user in what has been described as a 'holistic' mode [5] where they concentrate more on overall effect of the installation. Aesthetically the piece hinged on the re-appropriation of an existing technology, the radio set, for re-use in an installation context without altering its appearance. This allowed the interesting possibility of remapping and subverting the existing relationship people have with the object into the parameters for a constructed, database driven, musical engine that appeared to be hidden within it.

2. BACKGROUND
John Cage, in his piece "Imaginary Landscape N° 4", set out with the idea of "erasing all will and the very idea of success" [13] by scoring for twelve radio sets each with two players. The piece composed using Cage's I-Ching method to create tables referring to tempi, duration, sounds and dynamics. In contrast the installation described aimed to encourage the listener to perceive that their will, expressed through interaction with a single radio's dials and buttons, was imposed on to an unfolding sonic landscape, reconfiguring and exploring it. The re-appropriation of existing objects for artistic examination is not itself a new concept and can trace its roots from Duchamp through the movement of appropriation art. More recently in the sonic arts it has seen use in the form of 'hardware hacking' [3]. Good examples are Phil Archer's carefully broken and re-appropriated CD Players and printers [1] and Nicolas Villar's ColorDex DJ system [9] that works with re-appropriated harddrives as interfaces for track selection, cueing and speed control. The key difference between these examples and the outlined work is the subtlety with which the appropriated object is tampered with. The author would argue that simply breaking the radio in a creative fashion and presenting it for use in a 'circuit bending' style is too nihilistic an approach and that Villar's harddrive turntable emulators are far removed from the real media they control and are more a visual comment about where the media is stored. The author's piece represented an attempt to engage the public in a musical style often represented as inaccessible, challenging this assertion by housing it in a comfortable style icon and allowing the public to reconfigure it interactively. This allowed for the investigation of mapping the controls of a functioning, yet altered, radio to the variables of a musical system and the development of a large, expanding, database of sounds that formed the raw input for the audiovisual output.

Parameter mapping and it's importance in defining the experience of an instrument/installation has been the subject of recent investigation [4][5][6] and some of the conclusions that can be drawn are that mappings which are not one-to-one are more engaging for users and the use of metaphor can be a way of building transparency into interfaces. This encouraged the development of the outlined piece's use of a heat energy model as a metaphor for interaction. One of the key aims of the piece was to encourage a holistic cognitive mode, this can be thought of as the opposite to an analytical mode where the user is focused on the logical, sequential details and cause and effect of an interaction; rather a holistic mode places the emphasis on the overall effect of interaction and attempts to refocus the mind on the bigger picture of the experience. This was felt to be important in the context of an art installation where the public were unlikely to be minded to learn a system but rather more interested with playful interaction, seeing and hearing the effects of their explorations with the radio set's knobs and dials.

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3. CONSTRUCTION

3.1 Physical Construction

A re-issued TR-82A Bush radio was selected by the author both for its aesthetic beauty, its fifties styling and the large amount of empty space within it. Several key modifications were made to the functioning of the radio. Firstly the set was disassembled and rotary potentiometers were fitted to one side of the volume, tone and frequency dials. These were then fixed in place such that the dial's rotation could be measured as a resistance across the potentiometer. Custom built pressure sensors comprising of quantum tunneling compound squares and springs were placed under the switches allowing the pressure from a user's fingers to be gauged. All of these were wired to a USB Arduino unit that was housed in the battery compartment of the radio. The op-amp feeding the radio's speaker was located and rewired to allow the interruption and diversion of the set's received signal and the supply of a new signal to the speaker. A small section of the back of the radio was neatly cut and filed out to allow the attachment of two RCA phono sockets, a USB socket and a small switch. The phono sockets were connected to the rewired op-amp via the switch such that the radio could either function normally or have its 'normal' output diverted to a phono socket and play a signal supplied by the second. The USB socket was connected to that of the Arduino. The set when installed was connected by USB and audio cables to a laptop hidden a plinth. This was running a Max/MSP patch that received the natural output of the radio, supplied a replacement and interpreted the movements of the controls. It was within Max that a database of sounds from the tuned radio signal was constructed.

Figure 1. TR82A Bush radio set installation.

3.2 Database Construction

The construction of a large, browsable and sortable database of sounds was an important idea behind the piece inspired in part by Lev Manovich's idea of the database as an art form [7]. This idea has seen currency within the sonic arts/technology in Casey et al's research [2], i.e. soundspotter and the semantic hifi project [15]. The approach implemented within the piece was to construct a database of percussive sounds taken from the unaltered radio signal. These were categorized by their spectral information and automatically added to a hsql database [14] inside MaxMSP. The onset of percussive sounds and spectral information was gathered from the analyzer~ [11] object which triggered the recording and subsequent saving of a 250 ms snippet of audio from a delay line suitably delayed to take into account the time required for analyzer~ to detect the attack. The brightness (spectral centroid), noisiness and loudness of the first 50 ms of the recorded audio was averaged and then stored along with a unique filename in the database. Before entry the properties of the sound were compared to those existing in the database, if more than four existing recordings were found with properties closer than a specified amount then the sound was rejected. Each database entry also had a play count to record the number of times it had been played as part of the installation.

3.3 Mapping

The musical output of the installation fell into two modes depending on the radio being tuned or not. Within these two modes the behaviour was determined by a combination of the real time positions of the volume, tone, mode selector dials and buttons and an extra hidden inner variable the author defined as the 'heat' of the system that took into account the recent activity in the installation. As the knobs and dials of the set were twisted 'energy' was added to a portion of the Max/MSP patch that modeled the first order differential equation governing the cooling of heated bodies. The amount of 'energy' added to the system was proportional to rotational velocity of dial. This allowed for the piece to internally measure the degree of interaction that was going on with the radio. As the dials and knobs were twisted and used the 'heat' value stored in the patch rises for as long as it was being played with and in proportion to the degree of interaction, i.e. light stroking movements with the dials produced less of an increase than frenzied twiddles. As soon as the set was left it began to 'cool' and the 'heat' value dropped. Along with this idea of heat an idea of 'biasing' was included in the mapping strategy. Biasing occurs in many acoustic instruments [8] where an effect only occurs or suddenly changes when enough energy is put into a system. Biasing as implemented here means that a heat controlled effect changed when the heat parameter was above a threshold value. The inclusion of this extra heat parameter coupled with biasing allowed for an interesting non-linear mapping of the controls to multiple parameters of system.

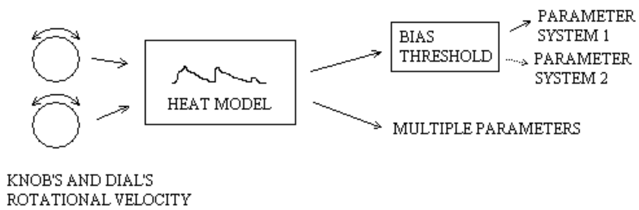

Figure 2. Heat Model and biasing to provide non linear mapping.

Max/MSP monitored the noisiness of the unmodified radio signal and when it fell below a threshold value the radio was deemed to be tuned, this method was quite effective in differentiating stations from static. This triggered the fading in of the live radio signal that had first been processed through two signal processors, a sample and bit rate reduction unit and a filter and dub delay unit. The signal processing varied with the heat, below a threshold level the sound was passed through the sample and bit rate reduction unit. The heat parameter controlled the amount of sample and bit rate reduction so that if the set was left tuned then slowly over time the sound degraded with a tearing effect. If a gentle motion was applied to any of the dials the sound recovered, a harder motion would supply enough energy to remove the degradation unit from the DSP chain leaving the sound arriving through the filter and dub delay unit. Here the heat parameter controlled the length of the delay line, with higher heat leading to a shorter delay line, to a minimum of 5ms, and the frequency of a low frequency oscillator. This LFO was added to the position of the volume dial to control the frequency of a peak equalizer filter that sat in the feedback path of the delay unit giving it the dub sound. The heat similarly controlled the frequency of another low frequency oscillator that controlled the smooth interpolation between numbers of different filters, the cut off frequency of which was controlled by the tone dial.

When the set was detuned the altered signal was faded and replaced by the output of a phase vocoder that was a loop of the last ten seconds of recorded radio station input. The speed of this output would slowly drop to give the effect of the real signal shifting out of place. This provided a sound bed for the key feature of the untuned set, the sonified, sorted and browsable contents of the database of detected radio sounds. This was achieved through the play back of the 250 ms samples, looped, filtered and enveloped by amplitude and low-pass filter envelopes. The shape of these envelopes was set to track with the heat of the system with higher temperatures corresponding to shorter, sharper envelopes and a brighter filter sound. Similar to the installation's tuned mode the behaviour changed when the heat was above a threshold value. At this point the tone dial would control the length of the loops such that at either extremity of the dial the end point of the loop and the sample would match but as it was rotated towards the centre it shrank towards a 10 ms minimum giving a glitching effect. The selection of samples to voice were taken from the database by sorting the samples in order of loudness, brightness or noisiness depending on which of the FM, MW or LW buttons was depressed and mapping the location of the frequency dial to a distance down the sorted list. Up to eight consecutively ordered samples (thus timbrally similar in some fashion) were voiced at a time. The number and rhythmic timing of the samples was controlled by a collection of first order markov chains, where each entry in a thirty-two step sequence table corresponded to the probability of a sound being triggered at that point. The probabilities changed and interpolated to create more frenetic probability based beats, with more samples voiced, as the heat of the system increased.

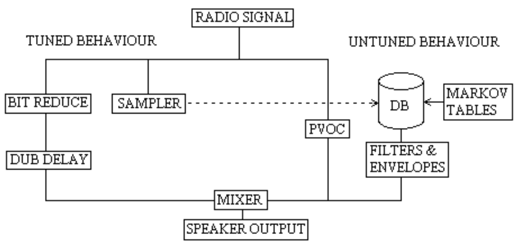

Figure 3. Signal flow diagram.

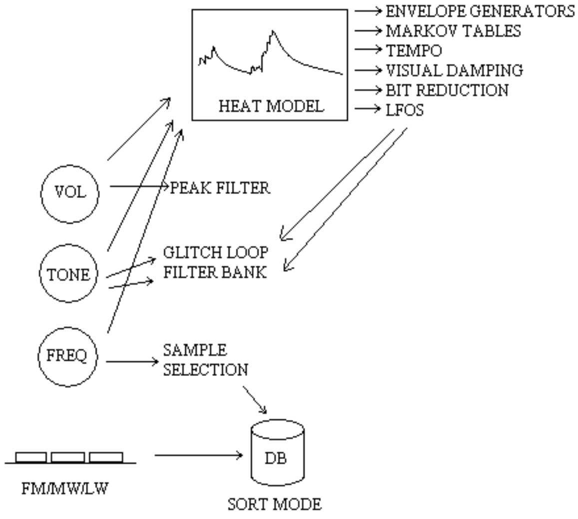

Figure 4. Mapping strategy.

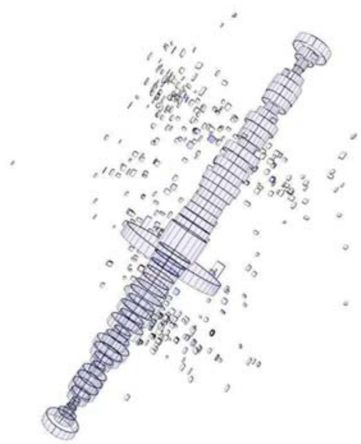

Figure 5. Example of database visualization.

3.4 Database visualization

Tandem to the sonic output of the radio set, the installation included a projected visualization of the sound database, showing the currently selected sounds and a representation of the unfolding audio output. This was achieved through a custom programmed Processing sketch running on a separate laptop wirelessly networked to that running Max/MSP and communicating via OSC. The radius of fifty-one rings was symmetrically mapped to the energy in twenty-five frequency bands with the radius of thicker central ring controlled by the loudest band at any time. The length of the whole graphic equalizer bar extended and contracted with the volume of the output. The degree of damping applied both to this motion and the changing ring radius was controlled by the heat of the system, such that at higher temperatures low damping afforded rapid, jerky movement closely following the output while lower temperatures gave a slow glacial movement. The database of samples was visualized around this central equalizer bar with each sample represented by a rectangle, parallel to the bar and rotated to face outwards. The position of each sample was mapped in cylindrical polar co-ordinates, with the mapping dependent on the current sort mode. In each sample sort mode, chosen with the band selector buttons, the samples arranged themselves in the same order they were sorted by the database, i.e. in order of loudness, brightness or noisiness, along the length of the graphic equalizer bar. In each case the two remaining unused parameters were used to order the radial distance from the central bar and the angle they made with it. As the frequency dial was rotated and different samples selected for use from the database their visual representations shot out and as they were played each sample square expanded and returned to its original shape. The opacity of each square was controlled by the play count of each sample with more frequently played samples producing more opaque, bluer, rectangles.

Again as in the two audio modes of interaction an idea of biasing was included such that when the heat passed above a threshold the visualization would begin to warp and shimmer in a chaotic fashion.

The role of the visualization was partly to augment the idea of the hidden heat variable and provide an idea how the sounds were sorted but also to encourage the 'holistic' mode of cognition through distracting the user from focusing too strongly on the effect of each dial on the audio output.

4. REFLECTION

The radio set had its inaugural installation in Belfast's Catalyst Arts centre between 21st and 30th November 2007. In conversation and correspondence with some of the visitors the author noted in response to the experience that they felt their movements were translated into musical outcomes but not in a manner they felt they wholly controlled or could be exactly repeated. Should we treat repeatability as positive? The author would argue not and as complete repeatability would defer all choice to the listener and require them to engage more deeply and in a more prolonged fashion with the piece to provide pleasing, varied output and defeat the purpose of the activity; namely encouraging the feeling in the listener that they were engaging and customizing a preexisting sound ecology rather than composing their own. Users also stipulated that installation provided a clear distinction between when no one was using it and when it was in use which could be attributed to the use of the heat model as a metaphor for interaction in the piece. The ease of accessibility to the piece without prior understanding was also mentioned and could be mooted as a success for encouraging playful 'holistic' cognition.

The indirect mapping of user interaction with dials through an extra middle layer of mapping has been pointed to in the past [10] and the author would argue that the installation allowed the opportunity to successfully demonstrate the novel metaphor of heat energy as a metaphor for interaction. The use of biasing which occurs in acoustic instruments were a certain effect only comes into play after an amount of energy has been expended was identified as a key way of building depth into the mapping strategy and thus the user's experience. The combination of the hidden mapping layer with direct mapping was a successful strategy for encouraging visitors to engage in a more playful 'holistic' cognitive mode rather than approaching it as a learnable instrument.

5. CONCLUSION

This paper outlined the design and implementation of a sonic database with novel data visualization and the mapping of a re-appropriated object's controls for its use. Some issues of mapping were discussed in particular the idea of using a model of heat as metaphor for the amount of interaction with an installation and the use of biasing to give depth to a mapping strategy.

6. ACKNOWLEDGMENTS

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