A STRATEGY FOR COMPOSING MUSIC USING THE SONIFICATION OF "SNAPSHOT"-TYPE DATA COLLECTIONS "SCHNAPPSCHUSS VON DER ERDE"

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ABSTRACT

Transforming the sonification of data into a musical experience that is satisfying on scientific as well as aesthetic grounds requires balancing similar and competing objectives and sensibilities. One possible solution, described here, is used to create the digital music composition *Schnappschuss von der Erde* in response to the call for compositions by the International Community for Auditory Display (ICAD) Conference, 2006.

1. INTRODUCTION

The International Community for Auditory Display 2006 Conference provided the basic data resources and objectives for realizing a musical composition for a concert entitled *Global Music - The World by Ear*.

The mapping strategy and compositional process used to create *Schnappschuss von der Erde* are described in the body of this paper. While the possible approaches to transforming sonifications into music are numerous, this investigation will focus on representing data in as clear a manner as possible, while satisfying the aesthetic demands of musical form.

2. DATA COLLECTION

Data was downloaded from the public database at the World Bank website [1]. Data from the most recent available year between 2000 and 2004 is used. The original data set selected by the composer includes 187 countries and 23 categories

3. STRATEGIES

Transforming data that represents a snapshot in time into an art form that unfolds in time, such as music, requires strategies different than say, mapping time series data which would seem more adapted to musical interpretation. In order to satisfy aesthetic demands, interesting, artistic patterns must be a result of the investigation. Scientific interests tend to be more concerned with the level of objectivity in the representation. In order to satisfy the later, the sonic representations of the data are created algorithmically and are not subsequently edited, distorted, or augmented in any way, except as mentioned in the performance notes. The resulting sonifications are then selected for their musical value and are used as is and in their entirety to assemble the musical composition in a collage-like fashion.

My daughter was beading one night while I was working and I offered her this analogy: Imagine a black shoe box that makes beads. You throw bead making stuff into the box and shake it up until you hear the bead start to rattle in the box. You open the box. If the bead is pretty, you keep it. If it is ugly, you discard it. Do this dozens of times until you have the beads that you want. Then string the beads together one after another in a pattern, and you have a beautiful necklace.

3.1. Perceptual background

The most basic description of the structure of a musical sound is its pitch, loudness, timbre, and temporal placement. Each of these descriptors are in themselves complex structures that are not necessarily discrete. For the purposes of this composition, only pitch, loudness, timbre, and temporal placement are used.

Musical events, such as notes, tend to organize themselves into perceptual streams [2]. The fusion of discrete sound events into streams and the segregation of one stream from another falls to the task of the auditory system. In general, the perceptual system fuses and segregates on the basis of similarity or dissimilarity along some particular characteristic or set of characteristics that may either reinforce or compete against each other. Thus the fusion of discrete notes into some sort of pattern will be effected by similarity or dissimilarity of pitch, loudness, timbre, or temporal placement.

3.2. Plotting data

In order to make data useful (to render patterns observable), we often convert it into a visual representation accessible to our perceptual system. Scatter plots are used to look for a correlation between data, with one variable plotted on the horizontal axis and and second on the vertical axis of a Cartesian coordinate plane. A third variable may be used to color the dots. The advantage of using this type of graph as a metaphor rather than a bar graph or a pie chart, is that the data retain their individual identities. They are scattered across two-dimensional space. As a composer, the job is to get the dots to get up off the page and move through time, the fourth dimension.

In most cases, scientists hope for a thin, squashed, oval shape that slants from one corner of the graph to the opposite. This shows a strong correlation and is usually an indicator for further research. An amorphous blob of dots scattered across the page shows no correlation and the relationship is generally disregarded as not being able to provide any useful information.

If one maps time (order of events) along the horizontal axis and loudness along the vertical axis, a strong positive correlation would create increasing loudness over time, or a crescendo. If the the vertical axis maps pitch, then a rising (melodic) line is created. A falling line or decrescendo is created by a strong negative correlation. A zero correlation produces randomness, or simply noise. Or maybe it is not so simple.

3.3. Mining for useful information

Rising and falling melodic lines, crescendo and decrescendo are useful in music composition, but they are not sufficiently complex to sustain aesthetic interest. However, what has been generally disregarded as being unable to provide useful information, the zero-correlations, are exactly the place to look for aesthetically useful material. These data sets are not uniform in their distribution. However, their distribution is not necessarily random (i.e. white noise). There may be subgroups that show some degree of correlation. These correlations may be so variable that the overall result is a zero-correlation. While the aesthetic purpose here is to find patterns that mix predictability with unpredictability, for the scientist, hearing patterns that are not traditionally strong correlations may inspire investigations from a previously untried perspective. One might ask, "Why do these subsets of data form a pattern and not those sets? Why does this subset of data sound so similar to some other subset of data?"

4. METHOD

Data was downloaded and assembled into a spreadsheet. The spreadsheet was the converted to a text file to be used by a commercial music composition language, Symbolic Composer 5.0.1 [3]. SCOM is a LiSP [4] based language that processes lists of data into a MIDI [5] file. Quicktime [6] was then used to render the MIDI files into .WAV files.

4.1. Sonification algorithm

An algorithm was written that allows the composer to select data categories and assign them to control the order of presentation (controlling temporal placement), pitch, or loudness in the resulting sonification. The data, always bound to its country, was then coordinated in ordered lists. In this process, any missing data in any of the three selected categories caused the deletion of that country and its data from the final result.

The ordering algorithm ranks orders the input data and controls the the ordering of all data in constructed lists.

The pitch mapping algorithm rank orders the data before it is mapped to the set of 128 keyboard symbols provided by the SCOM language.

Data that controls loudness is scaled and rounded to integers between 20 and 127. This data is not rank ordered. The integers 0-127 are standard controller values for MIDI messages.

Rank ordering of pitch data distributes the pitches more evenly across the tessitura of the piece and allows for more "step" sized melodic movements. This is important because of the prevalence of stepwise motion throughout the musics of the world [8]. Scaling the loudness data without rank ordering allows for the creation of more sudden changes of loudness. This creates a model for accents (suddenly louder notes) and ghost notes (suddenly softer notes). The pattern of accents creates the perception of rhythm.

Longitude (of the capital city) data for each country is bound with the selected data categories, and is used as values for the main volume controller. This distributes the amplitude between eight (8) separate .WAV files, each of which is used to drive eight individual speakers arranged in a circle around the perimeter of the performance space. Using one speaker to represent 0 degrees longitude and assuming 45-degree spacing between adjacent speakers, a line is calculated from each longitudinal data point to its surrounding speakers. Using a unit circle and allowing 1 to represent full volume, the inverse ratio between the two lines controls the volume data for the two speakers, each assigned their own instrument in the SCOM language. The longitude data places the musical note at a specific location along the perimeter of the room.

Reference to the data sets that control the musical variables will be referenced in the following manner throughout this paper - order : pitch : loudness.

Flexibility exists to invert values or retrograde the group. Inverting values exchanges low values with high values symmetrically around the center. Retrograding the group simply reverses the order. These manipulations preserve symmetry and do not distort the relationships between data. It simply allows the data to be heard from a new perspective.

4.2. Making beads

The process begins with selecting the data categories, then selecting which ordered combination of three (3) categories should be used as input to the sonification algorithm. There are a huge number of possible comparisons that can be made between three variables when each variable can have multiple values. Time and patience preclude examining every possibility.

The strategy above suggests that categories be selected by the following criteria:

1. Select categories of scientific interest.
2. Select categories that create useful musical constructs.

Creating useful musical constructs would include musical streams that ascend and get louder, descend and get quieter, descend and get louder, ascend and get quieter. These can be useful patterns, but the greater point is; what aesthetically interesting patterns lie within the data that await to be discovered?

To create the basic musical tools (i.e. crescendo and decrescendo), data categories were selected where one might intuit a strong correlation, positive or negative, since inverting the relationship is an option. With one category mapped to the order control list, the other can be mapped to either pitch or loudness to create the desired result: a strong positive correlation between order, pitch and loudness should produce a pattern that, on average, gets louder and higher in pitch over time, an ascending melodic line with a crescendo. Of course intuition and reality do not always agree. Some of the actual results are described in the analysis of the composition.

To create streams that do not conform to the shape of these basic tools, categories had to be intentionally selected that would intuitively seem to lack strong correlation.

Since creating the sonifications with the algorithm essentially meant typing in three names and executing the code, it was like a bead making machine. Different categories were simply entered into the execute file to control the musical variables and the files were run on the computer. The results were examined. Results that were aesthetically pleasing were kept. Those that were not were discarded.

Fifty (50) sonifications were retained in the final pool. These were examined and reexamined to the point that they were becoming learned. Descriptions were notated with each name. With the sonifications at hand, assembling them into a musical composition could begin. A total of eighteen different combinations of data ended up in the final composition.

5. COMPOSITION

The sonifications tended coalesce into groups; the successful basic tools, short groups with internal patterns, longer more complex groups, often with embedded subgroups forming internal patterns.

In order to facilitate the linking of one sonification with the next, care had to be taken to consider the beginning and ending characteristics of each.

5.1. Form and analysis

The composition is created in three (3) continuous movements. The shape of the form may be visualized as a horizontal hour glass, in that the more free, more random, and more complex material is used to surround a more restricted internal movement created by a select group of ostinati. The internal structure mixes binary and ternary elements. There is a significant amount of interleaving of material between and within movements. The total duration is 9' 19".

5.1.1. First Movement

The first movement is subtitled Jazz Licks. It begins with a short introduction using the grand-piano timbre; a ten (10) second pass that plots longitude against longitude to control order and pitch creates an ascending glissando that starts at zero (0) degrees longitude and traverses counterclockwise the circumference of the room. This is to help orient the listener at the beginning of the piece. The notes are accented by military spending data positively correlated with loudness, i.e. higher spending equals louder notes, to create aesthetic and scientific interest. The controller set, computers : fertility : hiv-rate, with the loudness control inverted, creates a strong descending line with an embedded sequence. The descending line indicates a negative correlation between the number of computers in a nation and the fertility rate. The overall low rate of HIV infection throughout the world provides relatively consistently high loudness values when inverted. Longitude : energy : co2-emissions creates a complex line that spins around the room. A strong correlation between CO2 emissions and energy use per capita produce higher notes that are consistently louder that lower notes.

At this point, the timbre changes to acoustic-guitarnylon. Female-literacy : male-literacy : hiv-rate creates a sparse, ascending accented line. The degree of smoothness of the ascent indicates the strength of the positive correlation between male and female literacy rates. The accented notes indicate countries where HIV rates are high. Computers : fertility : hiv-rate create a complementary descending line. Whereas the descending line was strong when the this combination was used in the piano, here it is quieter, but accented by the high HIV rate countries.

The last three sonifications of this movement use a fretless-bass timbre reminiscent of the late Jaco Pastorius. Computers : gdp-per-capita : co2-emissions creates a line that starts low in pitch. There is a bit of a sequence in the beginning, along with some nice jazz-like accents provided by the CO2 emissions data. Again, the rising line shows a positive correlation. The degree of smoothness of the melodic line (the less it bounces pitch-wise) indicates the strength of correlation. Fertility : Female-literacy : co2-emissions creates a complimentary line by maintaining the same accent structure, but now finding a negative correlation between fertility rate and the level of female literacy. The fertility : infant-mortality : gni-percapita sonification creates an extended line with internal structure. Some relatively extreme loudness variations at the end of the sonification helps to create a perceptual cue akin to a musical cadence to close the first movement. This final phrase will return at the end of the third movement as the final phrase of the piece, thus rounding the form. The duration of the first movement is 2' 05".

5.1.2. Second Movement

The middle movement (l'Ostinati) is created from four (4) sonifications, each repeated to become an ostinato. The four controller groups are - military-spending : gdp-per-capita : co2-emissions, military-spending : male-literacy : computers, hiv-rate : male-literacy : female-literacy, and the retrograde of military-spending : male-literacy : computers.

The patterns are repeated and interleaved to attempt to satisfy the aesthetic need for repetition and variation. The movement is bisected by timbre; orchestral-harp for the antecedent and vibraphone for the consequent. The pattern is:

aaaaa bbbb aaa cc bb || bb aa ccc bb cc ddd bd aa cc

The harp timbre returns with the 'a' parts near the end of the consequent section. No alterations to the sonifications were made to create rhythms or pitch collections. Since the sonifications here are not rising and falling lines, one should not be listening for correlation in this movement, but rather the focus should be the data points that group together into patterns. It may be that some unexplored variable or relationship in the real world is responsible for creating the pattern that we hear in the musical world. The duration of the second movement is 3' 12".

5.1.3. Third Movement

The Percussion Finale begins by borrowing the ostinato idea from the second movement. The perceived 4/4 common time is a result of the sonification. The respite from the odd meter is extended by repeating this pattern. The pattern is created by inverting the loudness control of the military-spending : hiv-rate : computers controller set. Xylophone, woodblock, and kalimba timbres are used to explore the same data set with different tone colors. Note that the placement of the few high pitched notes indicate high HIV-rates and that the inversion of the number of computers controls the loudness (fewer computers results in greater loudness).

Throughout the final, freer section of the third movement, one should focus listening more on patterns than on correlation. The listener can draw his or her own conclusions, but the third movement shows that this method of composition can be quite effective for creating a percussion solo. It is similar in sound to some of the music of Iannis Xenakis, known for his exploration of stochastic composition. This section starts with the woodblock. The first of the two sonifications is the retrograde-inversion of fertility : sanitation : child-mortality. To unravel the comparison, the ordering is from high to low fertility. High sanitation rates produce low notes and vice versa. A strong positive correlation between the ordering controller and the pitch controller creates an ascending line. A strong positive correlation between the ordering controller and the loudness controller creates a decrescendo. A strong positive correlation between the pitch controller and the loudness controller means that the lower notes would be louder. The second sonification played be by the woodblock is the retrograde-inversion of co2-emissions : military-spending : gni-per-capita with the loudness controller also inverted. In this case the loudness relationships are inverted compared to the immediately preceding description.

The second instrument in the free section is the synthetic-tom. This timbre evokes the impression of some of Frank Zappa's digital music. It begins with fertility : sanitation : mortality, similar to the first sonification of the woodblock in this section, but without the retrograde-inversion. The ostinato from the beginning of the third movement is then repeated twice. Next, new material is added by computers: gdp-per-capita : gdp, with the loudness controller inverted. This is followed by the second woodblock phrase in the new timbre. The synthetic-tom finishes with male-literacy : hiv-rate : computers, which creates a crescendo of low notes at the end to lead into the final section.

The last section of the finale is scored for Taiko-drum. It begins with computers : gdp-per-captia : co2-emissions with the loudness controller inverted. This creates a battery of loud low notes to announce the beginning of the final section. Gdp : gni-per-capita : gdp-per-capita might imply a rising crescendo, but is quite more interesting to listen to than one might expect. Ordering energy use per capita (pitch) and CO2 emissions (loudness) by longitude with the loudness inverted spins around the room, but it is not a rising decrescendo as one might expect.

The closing section of the Taiko-drum solo uses the patterns from the second movement; military-spending : gdp-per-capita : co2-emissions, hiv-rate : male-literacy : female-literacy, and military-spending : male-literacy : computers. The final phrase begins with new material provided by computers : drinking-water : co2-emissions. This creates a short crescendo of high notes near the end, signaling the coming of the finale sonification of the piece. The end of the final phrase of the last movement is the same sonification as the end of the first movement, thus rounding the form. The duration of the third movement is 4' 02".

6. PERFORMANCE NOTES

The pitch collection is an equal tempered 21 note division of the octave. This allows for note combinations that may or may not lie within the chromatic system familiar to most Western listeners. The rate of presentation is 7.5 notes per second. This allows for stream formation to be influenced by all of the musical variables. It is also a comfortable listening tempo that enables the perceptual formations of faster moving passages of adjacent notes and slower moving rhythms created by notes separated in time, but grouped by pitch proximity or loudness similarity.

The following adjustments were made to the final audio files for performance. The last note was trimmed. Echo was added to the new final note to enhance the ending. For some reason, certain iterations of sublists were rendered slightly louder or slightly softer than others resulting is slight changes in loudness for some sonifications. Since this does not distort the relationships rendered by the sonifications and actually creates some aesthetic value, these anomalies were retained, albeit with occasional attenuation of -3 dB or -6 dB. The second movement was equalized on a 10-band equalizer with the 40 Hz and 80 Hz bands boosted 6 dB and the 160 Hz band boosted 3 dB to enhance the melodic stream that creates the apparent bass line. A stereo mix of the eight sound files was also created.

7. CONCLUSIONS

Though there are many possible approaches to the sonification of data, there are likely even more strategies for using sonification to create music. One can imagine controlling such musical parameters as spectral envelope, harmonicity, pitch weight, duration, ADSR envelope, sonorous structures (chord-like structures), scales, tonal systems, repetition patterns, contour, granular synthesis controllers, etc. For the scientist, it may be possible to search for correlations and patterns between multiple sets of data, each set mapped to a domain of musical information. Yet, even a simple rendering of data to the most basic music controllers, with little need of constructing higher order musical architectures, is sufficient to produce aesthetically satisfying material. Such approaches can produce results that present data in a relatively clear manner, retaining its usefulness possibly even to the point of creating a new manner of investigating the real world. A pattern is a pattern is a pattern. There is no reason we should be less inclined to investigate a pattern that we hear than we are to investigate a pattern we see on the page. At the same time, the material can be presented in an aesthetically interesting way that may bring some pattern to the attention of others. Taken a step further in the artistic direction, such investigations may provide the successful basis for purely musical work without regard to scientific rigors. What remains to be seen is how the interaction of art and science will play out as inspiration and in result.

8. REFERENCES

[1] The World Bank, "WDI Data Query," http://devdata.worldbankorg/data-query/, Queried April, 2006.

[2] A. Bregman, Auditory Stream Analysis: The Perceptual Organization of Sound. A Bradford Book: The MIT Press, Cambridge, MA and London, England, First paperback edition 1994, Copyright 1990.

[3] J. Podrazik, P. Tolonen, et. al., Symbolic Composer 5.0.1, MRAC Publishing Ltd., 1998-2003.

[4] G. Byers, S. Hain, A. Hartley, B. St. Clair, Mac Common Lisp, Digitool Inc., 1995-2003.

[5] Complete MIDI 1.0 Detailed Specification v96.1 (second edition), MIDI Manufacturers Association, 2001.

[6] QuicktimeTM 7.0.4, Apple Computer Inc., 1991-2004.

[7] P. von Hippel, "Redefining Pitch Proximity: Tessitura and Mobility as Constraints on Melodic intervals," Music Perception 17(3), 2002, pp. 315-327.