

ECO-STRUCTURAL DATA FORMS

CLASSIFICATION OF DATA ANALYSIS USING PERCEIVED DESIGN AFFORDANCES FOR MUSICAL OUTCOMES

Timothy Opie

Queensland University of
Technology, 2 George Street,
Brisbane, QLD, 4000

Box Hill Institute, 1000
Whitehorse Road, Box Hill,
VIC, 3124, Australia

Andrew Brown

Queensland University of
Technology, 2 George
Street, Brisbane, QLD,
4000, Australia

ABSTRACT

This paper explores a method of comparative analysis and classification of data through perceived design affordances. Included is discussion about the musical potential of data forms that are derived through eco-structural analysis of musical features inherent in audio recordings of natural sounds. A system of classification of these forms is proposed based on their structural contours. The classifications include four primitive types; steady, iterative, unstable and impulse. The classification extends previous taxonomies used to describe the gestural morphology of sound. The methods presented are used to provide compositional support for eco-structuralism.

1. INTRODUCTION

"One final and strangely bizarre possibility presents itself. We might imagine a music whose logic was based entirely upon the logic of the evolution of natural events as evidenced by natural morphologies of the sound-objects used." [17]

Eco-structuralism is a compositional technique that uses the structures or natural morphologies inherent in natural sounds events as templates to generate new musical material. The templates are produced through the analysis of audio events. The data collected includes structural information about amplitude, frequency, timbre, and space. This data is then used in a strict serial fashion, abiding with the rules of eco-structuralism to create musical sequences, define musical articulations, to organise the macrostructure of a musical work, to resynthesize the original sound or synthesize new tones [13, 14].

Eco-structuralism has been informed by compositional techniques such as *Musique Concrète*, *Serialism*,

soundscape composition and *eco-composition*. An ongoing debate amongst composers from these traditions relates to the use of sonic signification in musical works. Pierre Boulez stresses that any sound which carries too heavy an anecdotal burden should not be integrated with *Musique Concrète* [1]. However, this sentiment is not shared by R. Murray Schafer or other composers of the *soundscape* initiative. For example, *Damián Keller* describes *eco-composition* as *soundscape composition* in which the contextualisation of sound events and parameters are vital to the perception within particular societies and cultures. Keller has used *eco-composition* as a compositional tool to re-enact history from a sonic perspective; acknowledging that personal experience and stimuli will give each listener a personal understanding of the piece which will differ from others [6, 7]. In a similar spirit, *Luke Windsor* states that audio recordings carry "extra-musical" (or anecdotal) concerns, which insist upon being dealt with as cues for events [16]. These two opinions are sympathetic with views expressed by *Luc Ferrari* that the structural qualities of *Musique Concrète* could be used in conjunction with extra-musical concerns of the sonic events to bring the music and reality together to tell a story [2].

The role of sonic signification is made even more intricate in *Eco-structuralism*, as this compositional technique makes use of perceptual cues, but does so in a more schizophrenic manner than other forms of *soundscape* or *eco-composition*. This technique totally obfuscates the original recording but attempts to maintain structural elements that carry with them design potential. A brief glimpse at the technique might suggest that the origins of the audio recording are being eradicated in processes of deconstructing the sound recording into independent feature data streams. This could be seen to result in wiping away all of what *Trevor Wishart* calls 'anecdotal' information through the data

Opie, T. and Brown, A. R. 2009. Eco-Structure Data Forms: Classification Of Data Analysis Using Perceived Design Affordances For Musical Outcomes. *Improvisation: Australasian Computer Music Conference*, Brisbane, Australia: ACMA, pp.123-129.

analysis and reduction process. On the contrary, however, eco-structuralism attempts to retain the aesthetic and perceptual signatures that were inherent in the original sound event. It is striving to reveal the anecdotes inherent in sound recordings, even to emphasize them, but from behind a thick curtain. The eco-structural composer employs recordings of natural sounds purposefully chosen as desired sonic events. This aesthetic interest in natural sound sources builds on the fact that nature already provides a limitless array of intrinsically interesting sounds, all with natural morphologies that include many states of complexity and simplicity that provide a huge palette of possibilities. One of the problems with this sheer number of possibilities is finding ways of cataloguing and using the morphological data effectively. This paper presents a system for designating musical potential to structures in data generated by eco-structural analysis.

2. MUSICAL POTENTIAL IN GESTURAL MORPHOLOGY

There is a tradition or history of gestural morphology in composition. In 1964 Stockhausen described 68 unique gestures within the score for *Mikrophonie I*. He included terms such as cracking, grating, groaning, and whimpering. It was claimed that "For the first time a perceptual equivalent to totally organized structure has been discovered, and it is particularly significant that this has been done with very simple means" [8].

Other composers have also made attempts at capturing morphological structure. Morton Subotnick developed the *Ghost Box* in order to capture subtle auditory gesture. The *Ghost Box* converted gestural information into control voltages which were then used to adjust the frequency or control the amplitude envelope. It is referred to as a ghost score because the score for the *Ghost Box* is a mono audio recording which is simply processed and translated, without being heard directly by the audience [9]. Subotnick's first piece utilizing the *Ghost Box* was *Two Life Histories*, written in 1977.

The UPIC (*Unité Polygogique Informatique de CEMaMu*) was a computer system designed by Iannis Xenakis which employed graphical drawn gestures. It allowed the composer to draw various musical elements onto a large electromagnetic drawing board, using an electromagnetic pen. Xenakis completed his first piece for UPIC in 1978, entitled *Mycenae Alpha* [5].

It is instinctual to look for shape, form and structure in music and so it is not surprising that this theme persists. A particular advocate of composing with sound based on ideas presented as shape, form and gesture was Trevor Wishart. He proposed that all sounds can be ascribed a particular shape, form, structure or gesture. Wishart identified categories for different types of gesture. In his

book *On Sonic Art* he suggests methodologies for labelling sound morphology. He suggests three basic states; Continuous, Iterative and Unsteady [17]. He also explains how these three types can be combined with each other to form more complex variations on the type. Another method for classifying data lies in the way we want to be able to use the data. When analysing an eco-structural data stream, a question that comes to mind is, what is the musical potential of this data? One useful perspective on potential is to think of the data as a signifier or a perceived affordance [12]. The term affordance was coined by J. J. Gibson [4] to describe an understanding of the opportunities presented by the world in terms of how we may personally interact with it. The affordance of an object or environment is influenced by our accumulated experience of similar objects and by our current needs and motivations. Affordances are somewhat subjective, based on our perception of the opportunities for action we choose how to interact with the object, usually in an intuitive non-calculated manner. "When affordances are perceptible, they offer a link between perception and action" [3]. In general, affordance resonate with our intuitive knowledge of how to interact successfully with the world around us. As Gibson stated "affordance cuts across the dichotomy of subjective-objective and helps us understand its inadequacy" [4].

The case can be made however that sound does not afford anything, it merely suggests or notifies us of prospective affordances, which may or may not exist. In order to use this idea more conventionally, the works on design signifiers or perceived affordance for design by Donald Norman offer a more nuanced insight. On discussing design for icon-based interaction on a computer, Norman states "Those displays are not affordances; they are visual feedback that advertise the affordances: they are the perceived affordances" [12]. We suggest that it is useful and appropriate to think of musical structures and sonic morphologies as offering perceived affordances. Norman goes on to state that "Symbols and constraints are not affordances. They are examples of the use of a shared and visible conceptual model, appropriate feedback, and shared, cultural conventions" [12]. A designed object can signify something if it was designed to act in a specific routine, and if social and cultural conventions agree that that was the correct routine. Norman suggests "Designers can invent new real and perceived affordances, but they can not so readily change established social conventions" [12]. With this in mind, it becomes important to identify potential from within established social and cultural conventions.

Fortunately music has very long standing conventions of form. By combining notions based on gestural morphology with those of perceived design affordance, a much stronger case can be made for identifying and classifying eco-structural data streams as exhibiting

Opie, T. and Brown, A. R. 2009. Eco-Structure Data Forms: Classification Of Data Analysis Using Perceived Design Affordances For Musical Outcomes. *Improvisation: Australasian Computer Music Conference*, Brisbane, Australia: ACMA, pp.123-129.

particular gestural morphologies and their perceived affordances for use in composition, as a form of culturally contextualised sound design. This provides a theoretical basis upon which to classify and identify musical potential in the data from eco-structural analysis.

3. CLASSIFICATION

After examination of a large number of data sets, a classification of morphological types has been derived similar to the three suggested by Wishart, although we use some different terms to make the meanings more clear. Also a fourth type has been identified. These types will be introduced and discussed in this section.

Each type will be labelled as a form, as this is more suggestive of an encompassing type which holds many variations on similar themes. It must be noted that there is no ideal form in eco-structuralism as change and variation is integral to all forms of music.

Eco-structural forms can be classified by generating a graph of the data, and then comparing this to the forms below to find the best match.

1. The Steady Form:

Description: Relatively flat data. Can contain some minor discrepancies.

Graphical Example:

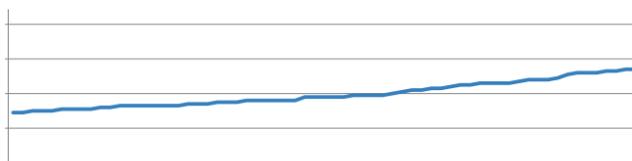


Figure 1: The Steady Form

Compositional Potential: Stasis, Stability, Drone, Basso Ostinato

Notes: The steady form is similar to what Wishart termed continuous, although continuous can be misleading as all sounds can be continuous in any number of forms. Finding stable forms in natural sounds is quite rare. R. Murray Schafer points out that only man made devices will emit an unchanging audio signal [15]. This is of course far from ideal as the musical potential would be quite dull, unless it were combined with something less steady. The term stable is also not used because stability implies a certain accuracy and reliability that steady does not. A signal can be steady without being stable, reliable or accurate, which is more functional in this context.

2. The Iterative Form:

Description: Mostly patterned data.

Graphical Example:

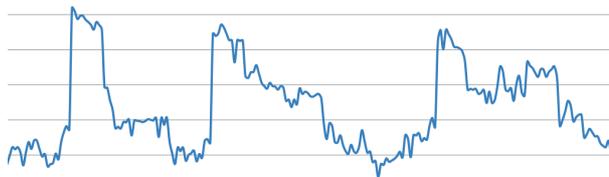


Figure 2: The Iterative Form

Compositional Potential: Motif, Melody, Harmony, Macrostructure, Effects, Curves, Smooth Transitions, Repetition.

Notes: This is the same term used by Wishart. The form is characterized by identifiable symmetry and repetition. The presence of iteration, or repetition, in music is well understood. Indeed the ability of humans to tolerate repetition in music is surprising given our quick boredom with it in other media such as language, visual design, and haptics.

3. The Unstable Form:

Description: Fluctuating data in a mostly rough manner, but still with some linearity.

Graphical Example:

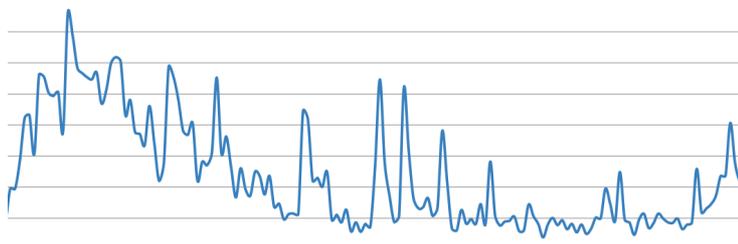


Figure 3: The Unstable Form

Compositional Potential: Fluctuation, Solo, Macrostructure, Effects, Surprise, Variety.

Notes: Wishart refers to this form as unsteady. The term unstable has been used instead of unsteady as it is more familiar. Data with this form can be used to provide interest and variation particularly in moderate amounts and as a modulation source for steady or iterative forms.

4. The Impulse Form:

Description: A short discrete impulse that does not match the surrounding data.

Graphical Example:

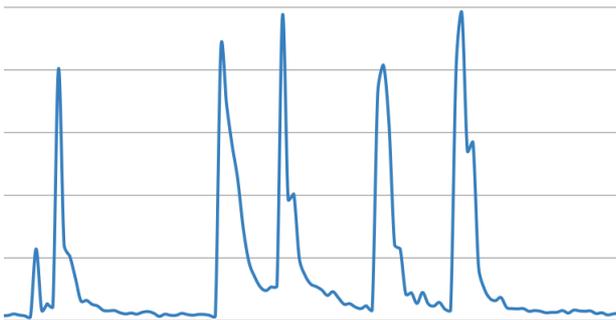


Figure 4: The Impulse Form

Compositional Potential: Switch, Gate, trigger.

Notes: The impulse form is one not discussed by Wishart, although after analysing various data streams, it is apparent that this phenomena crops up quite regularly. If the impulse occurs multiple times in one stream it may be useful to describe the periodicity of the impulse. The actual sample used here in the example is a graphical representation of a crackling camp fire. The sound will be familiar to everyone. From a distant perspective the sound of the crackling fire seems quite steady. There is a lull to it which seems constant and unchanging. On closer inspection however, there appears to be two layers at work. There is a steady floor, which is the dim humming of the small flames, but interspersed is an unstable impulse which punctuates the sound. Each impulse is quite similar, so it could be stated that there is an iterative unstable impulse. That impulse is the sound of a crackle. Because they occur quite regularly and are similar in impulse, they only appear as an impulse on close inspection. Another example of a similar combined form that occurs naturally is a thunder storm. The rain forms a steady floor, which is punctuated by unstable impulses of thunder.

As the fire sound example illustrates, these archetypal forms will rarely be found in data from natural sounds. Much more likely is the use of this classification language as a way of describing aspects of a data stream and tendencies of the structural morphology. Clearly there will be an vast number of combination forms, including second order descriptions of stable or iterative combinations and so on.

5. Combinations:

Description: Data that seems to switch between two forms or more forms.

Graphical Example:

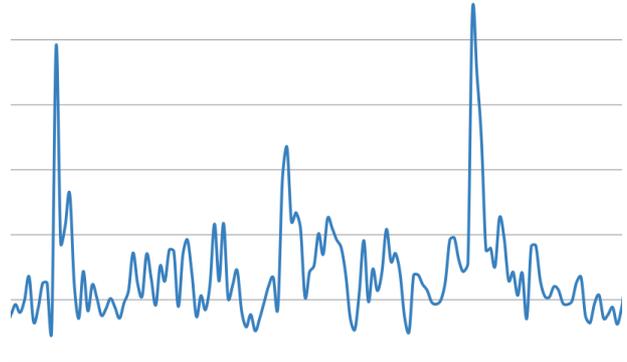


Figure 5: Combinations

Compositional Potential: Solo, Variety, Fluctuation, Macrostructure.

Notes: The use of the combination has already been described in the previous form, whilst explaining the thunder and crackle impulses, there are however multiple combinations that could occur. This example structure could be described as unstable with unstable impulses.

There is a final point to make about the classification of a data stream as exhibiting particular structural characteristics, and therefore particular compositional opportunities. The scale at which the data (or sound) is examined may change our perception of morphological characteristics. Consider again the example of the fire sound. As depicted it appears as an unstable series of impulse forms. However, the time slice under review is very short, that is this is a description of its micro structure. Zooming out to look the sound over a longer time scale, a crackling fire provides a stable, but interesting, background texture. This kind of analysis that is assisted by the language of these form categories highlights the creative utility of this approach for the eco-structuralist composer.

4. APPLICATION

An eco-structuralist data structure is contained within an XML framework with labels identifying many characteristics of the sound and the parameters used to capture the data. Form classification is therefore an intrinsic element of the data structure. The classification system creates a pool of data by which a composer can

Opie, T. and Brown, A. R. 2009. Eco-Structure Data Forms: Classification Of Data Analysis Using Perceived Design Affordances For Musical Outcomes. *Improvisation: Australasian Computer Music Conference*, Brisbane, Australia: ACMA, pp.123-129.

more easily make compositional choices without having to constantly re-evaluate the data. Once a classification is made, the classification can be added directly to the XML data. When data is first extracted it is given the classification form "unknown", so that the composer knows it still needs classifying. The four forms steady, iterative, unstable and impulse can be assigned to any data stream, with a number of permutations.

As we have mentioned, finding data in which these forms appear in a pure form has so far been very elusive. There are definite moments when data is in a pure steady or iterative form, but sometimes that moment is quite fleeting. In one sense this is a good thing, as was noted earlier, change and variation are integral parts of music. When sections of steady or iterative data have been identified that can definitely be used as motifs, sustained pads and chords structures. However, it can make the classification of a data stream in the XML framework approximate.

Going back to the gestural form and categorization of the crackling fire, it was described as having a steady floor, punctuated with an unstable impulse. There are a number of musical potentials that can be explored. Firstly the steady floor offer good sustained pad. If we combine three separate data structures from recordings of crackling fires, we will find the floor is always different. These can be used to create sustained chords on a synth pad. As the floor steadily tends to move in some examples, it will create an evolving synth pad sound which works as an interesting musical foundation. The impulses could then be used for triggering. It could trigger notes based on the height the impulse reaches, or it could trigger another note or chord derived from another structure. Another musical device is that it could trigger an inversion of the pad chord. There are many different musical potentials to consider. Each form stores different potential.

If the same crackling fire structure were to be used in a musical macrostructure, the floor could indicate the key or pitch class for each musical section, with the impulse indicating the start of a new section. For the macrostructure to be more effective, it would need to be scaled over time, which is a simple task for eco-structure [14].

These applications are just suggested approaches for working with eco-structural data forms, but composers may prefer different approaches to the musical organisation of their works.

5. FUTURE RESEARCH

As an extension to this classification process, it would be beneficial if the classification process could become automated. The XML tag already exists, to be edited manually. The task remaining is to write the algorithm to

identify the forms. As automatic identification of forms is not a critical component for eco-structuralism at this point, it will be explored at a later point. Another extension would be to provide segment form tagging in the XML file so that sections within the data stream could be independently tagged. An advantage of the automated process would be to make the process of selecting musical material much quicker. It could also provide an accurate combination of multiple forms within a single structure. As a drawback however, it may produce a long list of forms that alternate throughout the structure, this however might be solved with fine tuning.

6. CONCLUSION

Eco-structuralism is capable of generating representative structures of natural sounds and sonic events. By creating a cataloguing system based on identification of gestural forms provides a method of filtering and managing the large amounts of data often generated during analysis. It also suggests a descriptive framework for thinking about the features and opportunities of the data. We have provided a theoretical foundation for this classification that suggests there are perceptual affordances in gestural morphologies. Providing a classification links the possibilities for compositional design with the data features arising from in eco-structural analysis. The perceptual affordances, or design opportunities, presented by the data form classification we suggest will both assist the compositional process and continue to reinforce the link between the aesthetic interest of the sound source and the resulting composition. In a practical way the eco-structural data form classification should provide the composer more time to work with sound, rather than sifting through data. When the composer has a musical idea, they can match it against musical potential and use the structures as building devices to create a musical work.

7. REFERENCES

- [1] Boulez, P. (1971) *Boulez on Music Today*. Faber and Faber, London
- [2] Pauli, H. (1971) *Für wen komponieren Sie eigentlich?* Fischer, Frankfurt Am Main, Germany.
- [3] Gaver, W. (1991) Technology Affordances. In *Proceedings of the SIGCHI conference on Human factors in computing systems: Reaching through technology*, p.79-84. New Orleans, Louisiana, United States.
- [4] Gibson, J. J. (1979). *The Ecological Approach to Visual Perception*. Lawrence Erlbaum, New Jersey.
- [5] Harley, J. (2002) The Electroacoustic Music of Iannis Xenakis. In *Computer Music Journal*, Volume 26, Number 1, Spring 2002, pp. 33-57

Opie, T. and Brown, A. R. 2009. Eco-Structure Data Forms: Classification Of Data Analysis Using Perceived Design Affordances For Musical Outcomes. *Improvisation: Australasian Computer Music Conference*, Brisbane, Australia: ACMA, pp.123-129.

- [6] Keller, D. (2004). *Paititi: A multimodal journey to El Dorado*. Doctor in Musical Arts Thesis. Stanford, CA: Department of Music, Stanford University.
- [7] Keller, D. & A. Capasso (2006). New Concepts and Techniques in Eco-composition. In *Organized Sound*. Cambridge University Press, New York, NY, USA.
- [8] Maconie, R. (1972) Stockhausen's Mikrophonie I: Perception in Action. In *Perspectives of New Music* 10, no. 2 (Spring-Summer): 92–101.
- [9] Subotnick, M (2003) Morton Subotnick: Technical Notes. <http://www.mortonsubotnick.com/program.html#technical>. Accessed: 4/5/2009
- [10] Norman, D. A. (1999). Affordance, conventions, and design. In *Interactions* 6(3): 38-43.
- [11] Norman, D. A. (1988). *The Psychology of Everyday Things*. New York: MIT Press.
- [12] Norman, D. A. (2008) Signifiers, not affordances. In *Interactions* 15(6): 18-19.
- [13] Opie, T and A. R. Brown (2006) An Introduction to Eco-structuralism. In *Proceedings of the International Computer Music Conference*. New Orleans, LA, USA.
- [14] Opie, T. (2008) Rendering Soundscapes. In *Proceedings of the Australasian Computer Music Conference 2008*, Sydney, Australia.
- [15] Schafer, R. M. (1993) *The Soundscape: Our Sonic Environment and the Tuning of the World*. Inner Traditions International, Limited
- [16] Windsor, W.L. (1995). *A Perceptual Approach to the Description and Analysis of Acousmatic Music*. Doctoral Thesis, City University.
- [17] Wishart, T. (1985). *On Sonic Art*. New York: Imagineering Press.