Tim Swalling
Electronic Music Unit
Elder Conservatorium of Music
University of Adelaide
North Terrace
Adelaide, 5005
Australia
timothy.swalling@adelaide.edu.au

The Perpetual Commotion Machine: An Exploration of Background Music, Genetic Algorithms and Physical Proportion

Abstract

The Perpetual Commotion Machine (PCM) is a sound installation that combines an evolutionary sonic output within a rigid and angular visual form. Its development is the result of practical research in the areas of background music, genetic algorithms and physical proportion.

The PCM's sound design employs a genetic algorithm realised using Cycling 74's Max/MSP software, while the container has been designed according to the principles Le Corbusier's Modulor. This paper seeks to provide an overview of the PCM, examining some of the major principles and ideas that guided its design.

An Introduction to Background Music

The prevalence of recorded sound in modern western societies has led to a dramatic increase in our passive consumption of music. It is now common for music to be used solely as ambient sound that is not intended for our conscious attention. Such music provides a background of 'sonic wallpaper' to our surroundings.

Although modern attitudes and technology have created this current 'sea' of music, the idea of a 'sonic ambience' or background music is not new. Much of the music of the baroque and classical periods was intended to provide the aristocracy of the day with a pleasant background to their activities. Furthermore, some of the more extravagant baroque gardens featured what may be regarded as simple sound installations, including artificial birdsong and the water-produced harmonies of hydraulic organs (Lanza 1995:9).

Furniture Music

It wasn't until the 20th century that background music was introduced to mass audiences. In 1920 the French composer Erik Satie, not altogether successfully, pioneered the concept, having been inspired by the statement made by the famous painter Henri Matisse (Myers 1977:542):

> What I dream of is an art of balance, of purity and serenity, devoid of troubling or depressing subject matter, an art which could be for every mental worker, for the businessman as well as the man of letters, for example, a soothing, calming influence on the mind, something like a good armchair which provides relaxation from physical fatigue (Matisse 1978:38).

Satie termed this concept *musique d'ameublement*, meaning 'furniture music' and was conceived as being utilitarian, not art or even entertainment. It was intended to "…fill the same role as light, warmth, and comfort in all its forms". Satie described his concept thus:

> …there's a need to create furniture music, that is to say, music that would be a part of the surrounding noises and that would take them into account. I see it as melodious, as masking the clatter of knives and forks without drowning it completely, without imposing itself. It would fill up the awkward silences that occasionally descend on guests. It would spare them the usual banalities. Moreover, it would neutralise the street noises that indiscreetly force themselves into the picture (Gillmor 1988:232).

Musique d'ameublement premiered at the Galérie Barbazanges. The musicians were spread around the theatre, so that the music "might seem to come from all sides at once" (Orledge 1990:143). The music consisted of various ostinato passages, combined with fragments of well-known pieces, such as Camille Saint-Saëns's *Danse Macabre* and Ambroise Thomas's *Mignon*, as continuously repeated patterns (like the designs of wallpaper). The audience were instructed to ignore the musicians and to carry on as if the music did not exist. These instructions were promptly ignored, causing Satie to shout "Go on talking! Walk about! Don't listen!" (Gillmore 1988:233). This was Satie's only public performance of *musique d'ameublement*, but he continued to experiment with the concept.

Military Music

At about the same time as Erik Satie was developing furniture music, US Army Brigadier General George Squier was also experimenting with the idea of background music derived through technological means rather than live performances. During his work with the army he had invented several innovative systems of sending both wired (cabled) and wireless transmissions. With his retirement imminent, he turned his attention to music broadcasting. He developed 'wired radio', a subscription music service delivered by means of electrical wires. Given the ubiquity of 'wireless' radio in private residences, Squier focussed his provision of wired radio on small businesses. However, in order to increase the marketability of his service, he wanted a catchier name than *wired radio*; he combined the word 'music' with the prominent brand name Kodak, and so *Muzak* was born.

Muzak began to take an increasingly scientific approach to the music it broadcast. During the mid-1930s the level of analytical structure present in the music programmes was increased: the tempo, instrumentation, mood and style of the music were carefully matched to specific periods of the day. The Muzak programmers generally used innocuous instrumental arrangements of well-known tunes to create a familiar but unobtrusive sonic background. A former Muzak engineer stated that "Muzak was never meant to be played loudly, just subdued like wind playing between leaves of trees." (Lanza 1995:43).

The US government used it extensively during the Second World War; in addition to increasing the productivity of the war effort, it was also used to broadcast training instructions and news reports. Muzak even developed a special programme to be played in air-raid shelters to soothe the nerves of those huddled within such grim confines.

During the 1960s there was extensive US Army research demonstrating Muzak's positive effect on concentration and reaction time, reinforcing the effectiveness of earlier Stimulus Progression programming. Because of its proven effectiveness, the US Armed Forces classed Muzak as 'Optional Equipment' in the late 1960s (Lanza 1995:149). In fact, Muzak reached right to the top of US politics: Presidents Eisenhower, Kennedy, Nixon and (Lyndon) Johnson are all known to have favoured its use in the White House.

Despite these accolades, Muzak has had many detractors. It is frequently criticised for its shallow artistic content and the very name 'Muzak' has become synonymous with lightweight and trivial 'easy listening' music. But Muzak was never intended to provide musical performances of artistic merit; it is self-declared 'functional music', in much the same way as Satie's *musique d'ameublement*. Both forms were designed to avoid making a conscious impression, yet still create an ambience. As Satie himself stated: "We wish to establish a form of music designed to satisfy 'utility' requirements. Art does not come into these requirements" (Satie 1996:200).

It is important to remember that Muzak's audience is generally a captive one. Following the introduction of Muzak into public transport in Washington, D.C. in the late 1940s, two disgruntled passengers took the Public Utilities Commission to court, claiming the broadcast infringed upon their constitutional rights. The case was eventually dismissed, the court declaring that the freedom of conversation was not impinged, nor were passengers entitled to the same degree of privacy on public transport as they are in their own home. However, the decision was not unanimous, the dissenting judge stating:

> The streetcar audience is a captive audience. It is there as a matter of necessity, not of choice. One who is in a public vehicle may not of course complain of the noise of the crowd and the babble of tongues. One who enters any public place sacrifices some of his privacy. My protest is against the invasion of his privacy over and beyond the risks of travel (U.S. Supreme Court 1952)

Ambient Music

While Muzak was echoing through the Nixon White House, Brian Eno was experimenting with a style of music he called ambient music. Whereas Muzak was functional, using bland arrangements of popular music to create an atmosphere, Eno's ambient music drew heavily on the techniques and aesthetics of the minimalist composers La Monte Young, Steve Reich and Terry Riley, using simple creative processes to create complex evolving textures.

> I want the music to be as much as possible a continuous condition of the environment. Something that you add to your environment… and therefore I want the music to be capable of being entered and left at any point. So this means that I am not going to have a narrative structure; I am going to have something that is… a continuous texture, or an ambience, which is why I use the phrase ambient music (Eno 1986).

Eno was a founding member of Roxy Music, a British Glam Rock group, but he had been losing interest in the band. He finally decided to leave when he caught himself thinking about his laundry in the middle of a gig. He was interested in more thoughtful music, and had been impressed by Steve Reich's tape piece *It's Gonna Rain*, created using two tape recorders containing identical tape loops of a preacher saying "it's gonna rain".

While the performance begins with the two loops in unison, mechanical imperfections cause the loops to drift out of synchronisation. Over a period of approximately 17 minutes one loop 'overtakes' the other, the piece finishing when the loops are again synchronised. This simple process creates complex and dynamic textures. Eno stated that "…this completely intrigued me. Partly because I've always been lazy, I guess" (Eno 2005). He began experimenting with tape loops, and other compositional process that "…once set in motion will create music for you." (Eno 2005)

Eno was particularly interested in processes that created varied and slightly random or 'organic' outputs, a process that could never create the same piece twice. Eno's main objection to Muzak is that it is devoid of uncertainty and provides no motivation for careful listening. Whereas Muzak was designed to be heard but not listened to, Eno's ambient music is gentle enough not to disturb people who do not wish to listen, but provides a strong level of interest to those who do.

The Perpetual Commotion Machine

The PCM draws inspiration from many aforementioned background music techniques. As the name implies, its sonic output has the potential to continue in perpetuity – the result of complex phase relationships and stochastic operations. The physical and musical structure of the PCM is unobtrusive, so as not to irritate a captive audience, yet yields a greater level complexity for those who wish to examine it in greater detail.

The rigid outer shell of the PCM provides a stark contrast to the continually evolving musical structure. It is both a container for the electronics and a simple bench - a literal return to the concept of furniture music, but without the physical presence of musicians that proved so distracting to Satie's audience.

Algorithm Design

A genetic algorithm is a stochastic data processing procedure that mimics the process of biological evolution (Negnevitsky 2002:220). Genetic rearrangement and mutation acts as a process of continual refinement and variation. Using musical relevant data allows the process to be used for algorithmic composition. A genetic algorithm functions through a process of selection and reproduction. It requires a series of data sets, often termed a 'population'. Individual data sets are replaced or created by combining data from two 'parents'. The likelihood of any given data set being selected to reproduce is proportional to the suitability, or 'fitness', of the data sets. The resultant data set will not necessarily have a higher fitness than its parents, but over time the fittest data sets will predominate (Luger and Stubblefield 1993:530).

The genetic algorithm used in the PCM has been realised using Max/MSP software. The Max/MSP patch contains 128 data sets, while each set contains a 16 note musical sequence. The population size is constant, with each sequence playing once before being replaced by a new data set. Because different sequences start and finish at different times, each sequence has many chances to 'reproduce' before it is replaced.

A fitness value for each note in a data set is obtained by mapping its pitch to a fitness scale. This value is then divided by the square root of the number of times it appears in the set. The total fitness value for each data set is the square of the sum of all the previous values. Essentially, the fitness scale provides a guideline for the tonality of each musical sequence, but with a weighting to encourage tonal variety.

$$\left(\sum_{i=1}^{16} \frac{f(i)}{\sqrt{n_i}} \right)^2$$

Where $f(i)$ is the pitch fitness value of each note in the sequence, and n_i is the number of times the note occurs.

Figure 1. *The formula for calculating fitness values.*

There are several additional parameters, associated with the amplitude envelope of the sound, that are selected in the same reproductive process:

1. Primary Transition Time
2. Primary Level
3. Secondary Transition Time
4. Secondary Level
5. Decay Time
6. Rest Time

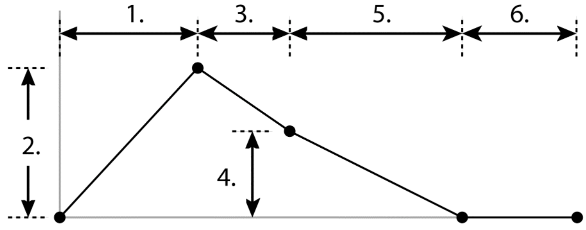

Figure 2. *Amplitude envelope parameters used in the PCM*

Although pitch is the only parameter that directly affects fitness, longer sequences will tend to dominate, as their longer 'life span' gives them more opportunity to reproduce.

Each sequence may be regarded as a 'chromosome' that contains 'genes' for pitch and amplitude parameters. New data sets are created using a process of recombination and mutation. In living organisms, recombination occurs during the formation of sex cells (Tobin and Morel 1997:291). This process is often referred to as 'crossover'

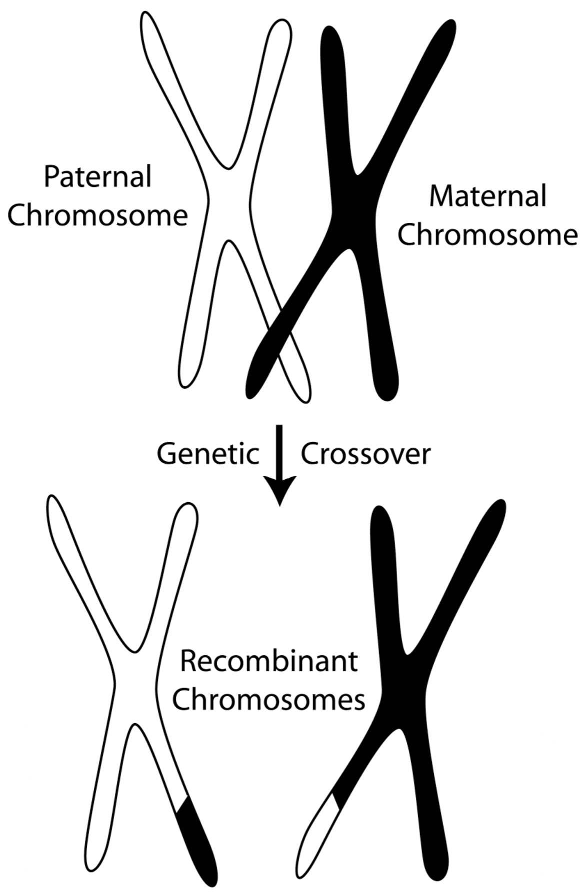

Figure 3. *Genetic recombination*

The maternal and paternal chromosomes swap a small portion of equivalent DNA, ensuring a greater degree of genetic diversity, as any pair of chromosomes in the next generation will have DNA from not two, but four, grandparents. Without this process, it would be possible for two children, who were not identical twins, to have identical DNA. For simplicity, the PCM discards the least fit of the two recombinant 'chromosomes'.

The other aspect of the genetic algorithm is mutation. In this context, it is simply a random change in data (within a set range), which also increases diversity. The mutation rate in the PCM is controlled by the microphone signal level - the higher the input level, the greater the rate of mutation.

When the PCM is set running, the random starting parameters have a very low fitness. As the process continues, the fitness rises rapidly, but it is highly unlikely that the entire population will reach maximum fitness. In addition to the continuous introduction of mutations, the small difference in between maximum fitness and other very high levels of fitness provides only a small selective pressure. This process is clearly demonstrated by the presence of the (vermiform) appendix in humans. Although it provided our ancestors with a means of digesting cellulose, it no longer serves any essential purpose and can occasionally become inflamed (a condition known as appendicitis). Although appendicitis can be fatal, its occurrence rarely prevents reproduction (and the propagation of the genetic line) and so natural selection has, as yet, failed to eliminate the appendix.

Audio Design

The Max/MSP software used to realise the genetic algorithms has also been used for sound synthesis. This minimises the amount of hardware required, and removes potential communication problems with external hardware, such as synthesisers. It limits the required hardware to an Apple Power Mac G5, amplifier, microphone and speakers.

As there are 128 separate musical lines, the timbre of the individual notes has been kept quite simple. In addition to the fundamental tone, each note contains only a few very low amplitude harmonics. This simple tone has been loaded into 128 oscillators, with each oscillator assigned to a separate musical sequence. Half of the oscillators have been routed out the left speaker, and the other half out the right in order to create spatial variation, but without complicating the design. The amplitude and pitch of each oscillator is controlled by the data sets generated by the genetic algorithm. When an oscillator reaches the final note in its sequence, it sends a signal to the genetic algorithm to generate a new sequence. This aspect of the PCM has been deliberately designed to be very simple, as the large number of oscillators can create a significant drain of the computer's processing power.

The ranges of values for the PCM have been careful chosen to maintain a balance between short percussive notes, long drones and everything in-between. The average density of the notes has also been selected to ensure there is a reasonable level of activity, but without being too hectic. It provides enough variation to be interesting, but is not too overbearing. The result is a continuously changing, yet at times relatively harmonious, sound. It should be noted that the generative music of Brian Eno was a point of reference when developing these parameters.

Physical Design

Much of the basic physical design is dictated by the specific location of the PCM. In some cases it may be possible for the computer and amplifier to be concealed in a nearby room, but the speakers and microphone will always be in a public location, yet must be secure.

The bench that is the outer shell of the PCM is constructed from various timber panels, while the internal frame is built from 90mm x 45mm construction timber to ensure structural integrity. The prototype is small enough to fit up against a door, yet it can easily hold two medium sized speakers and a microphone. There are two fastening points inside the box so the box can be fastened to the door using two steel cables, although permanent installations could be fastened directly to the wall or floor. A larger scale version could easily be constructed to contain all the necessary hardware, while providing more seating. This would also allow it to be positioned centrally in a space, rather than against a wall.

Figure 4. *The current prototype of the PCM*

Timber was chosen for the box primarily for practical reasons, but the natural variation present in the timber reflects the genetic processes at work in the PCM.

The proportions of the individual panels were calculated using a series of measurements developed by the famous French architect Le Corbusier. Known as the Modulor, the measurements are based on both human proportions and the golden mean.

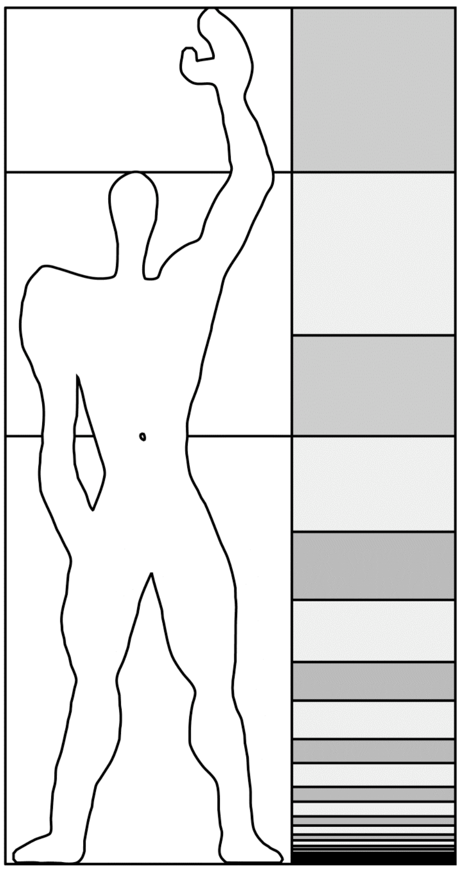

Figure 5. *The proportions of the Modulor.*

There are two closely related series, and they are calculated as follows (Robinett 1989):

Red Series: $S_n = 113 \times ((1 + \sqrt{5}) \div 2)^{(n-1)}$
Blue Series: $S_n = (113 \times ((1 + \sqrt{5}) \div 2)^{(n-1)}) \times 2$

Where $((1 + \sqrt{5}) \div 2)$ is an approximation of Φ, the golden number. These equations yield the following approximations:

n	*Red Series*	*Blue Series*
-10	6mm	11mm
-9	9mm	18mm
-8	15mm	30mm
-7	24mm	48mm
-6	39mm	78mm
-5	63mm	126mm
-4	102mm	204mm
-3	165mm	330mm
-2	267mm	534mm
-1	432mm	863mm
0	698mm	1397mm
1	1130mm	2260mm
2	1828mm	3657mm

The final proportions of the panels on the box deviate only slightly from these values, due largely to a deliberate 1mm gap between panels. The result is a box of 'natural' proportions, comprised of unnatural shapes, ergonomically positioned, emitting biologically inspired sounds.

Conclusions / Future Work

The concept and realisation of the PCM has addressed a wide range of design considerations. It clearly demonstrates the potential for a perpetual and inconspicuous musical performance that is afforded by electronic means. It also demonstrates the suitability of a genetic algorithm to compose music in real-time, as the process of fitness-based selection generates a moderately tonal musical outcome, while the process of recombination and mutation to provides continued variation.

The PCM exhibits simple, functional appearance that is aesthetically pleasing and suitable for a variety of locations. It should be noted that the design was limited by the author's carpentry skills, so future versions of the work may benefit from collaboration with experienced artisans.

Although this paper deals primarily with real-time composition of background music, there is no reason why the principles presented may not be applied to a variety of other forms. The current character of the sound is largely due to the simple synthesis techniques range of parameters chosen. Future versions of the work may expand upon the existing structure to include a wider range of parameters, allowing for greater tonal variety. This could be further enhanced by the use of external hardware. The basic algorithm in the PCM already uses values within the range of 0 and 127, so the genetic information it produces could easily be used as MIDI data. This provides the potential for integration with a range of existing musical hardware, with the PCM algorithm controlling any parameter that can be accessed by MIDI.

Finally, any future work will explore new methods for calculating 'fitness'. The current selection criteria ignore many musical parameters, such as rhythm and timbre, and only deal superficially with the concepts of tonality and variation. A careful expansion of the 'fitness' parameters and the manner in which they are calculated is likely to increase the variety and complexity of the musical output.

References

Eno, Brian. 1986. "Brian Eno talks about his definition of ambient music" *Music / Profiles*. http://www.bbc.co.uk/music/profiles/enobrian.shtml (10th June 2005).

Eno, Brian. 1996. "Generative Music" *In Motion Magazine*. http://www.inmotionmagazine.com/eno1.html (10th June 2005).

Gillmor, Allan M. 1998. *Erik Satie*. Basingstoke: Macmillan Press.

Lanza, Joseph. 1995. *Elevator Music: a surreal history of Muzak, easy-listening and other moodsong*. London: Quartet Books.

Luger, George F. and Stubblefield, William A. 1993. *Artificial Intelligence: Structures and Strategies for*

Complex Problem Solving. 2nd ed. Redwood City, California: Benjamin/Cummings Pub. Company Inc.

Matisse, Henri. 1978. *Matisse on Art*. ed, Jack D. Flam. New York: E.P. Dutton.

Myers, Rollo. 1977. "A Music Critic in Paris in the Nineteen-Twenties: Some Personal Recollections" *The Musical Quarterly*. 63, 4.

Negnevitsky, Michael. 2002. *Artificial Intelligence: A Guide to Intelligent Systems*. Harlow: Addison-Wesley.

Orledge, Robert. 1990. *Satie the Composer*. Cambridge: Cambridge University Press.

Robinett, Michael. 1989. "The Modulor" *michael-robinett.com*. http://www.michael-robinett.com/isis/mod-1.htm (2nd October 2005).

Satie, Erik. 1996. *A Mammal's Notebook: Collected Writings of Erik Satie*. ed, Volta, Ornella. Trans. Anthony Melville. London: Atlas Press.

Tobin, Allan J. and Morel, Richard E. 1997. *Asking About Cells*. Fort Worth, Philadelphia: Saunders College Publishing.

U.S. Supreme Court. 1952. "Public Utilities Commission v. Pollak" *FindLaw for Legal Professionals*. http://laws.findlaw.com/us/343/451.htm (15th June 2005).