THE NOISE OF MORPHONS AND BIONS

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ABSTRACT
Morphons and Bions is a real-time, computer-generated work that uses white noise as the fundamental synthesis component combined with classical synthesis techniques. Random and stochastic processes control the synthesis parameters. This approach creates sounds evocative of living mechanisms. The sonic mechanisms can metamorphose between noisy, engine-like sounds to pitched, chatter-like sounds. This paper details the concepts behind the sound synthesis, as well as showing the random processes controlling the synthesis. A brief discussion follows of the philosophy of the work.

Key words: Sound synthesis, random and stochastic processes, real-time computer music, post-digital aesthetics, noise music.

1. INTRODUCTION
Morphons and Bions is a real-time浦 composition that explores noise-based synthesis techniques and random processes to create the impression of living mechanisms. These mechanisms live and grow independently until reaching a critical mass, when they become a single organism.

From the slow introduction of mechanical noise to the lively chatter of little being, the organisms begin autonomously and die when they finally work together. The morphologically independent sounds combined with the sounds that behave together as a single organism give rise to the title, Morphons and Bions. Morphons and bions refer to two units of living things in taxontology: morphologically independent units, morphons, and the physiological units of organisms, bions.

As real-time computer music, the details of each realization change from performance to performance. However, the consistent timbres and overall form of the work retain the identity of the piece.

This work also endeavours to expand upon the notion of textural composition [6][7] without relying on recorded sounds as previous works have done [5]. In textural composition, normative and goal-oriented musical features such as gesture and trajectory are rejected in favour of immersive, textual material. Necessarily, this requires unidentifiable sound sources and a non-perceptual approach to spatialisation.

All sounds in the work are synthesized as opposed to recorded. However, synthesized sounds can often seem artificially clean and plastic. Inspired by the micro-fluctuations in amplitude and frequency components of real-world, acoustic sounds, Morphons and Bions uses noise-based synthesis techniques. By using noise to alter the amplitude and frequency of synthesized sounds, richer inner detail of sounds can emerge. So, the techniques seek to synthesise rich sounds while creating musical texture and the impression of sonic immersion. Classical synthesis techniques and random processes then mediate the basic substrate of white noise and digital noise.

Since the work is built on a foundation made entirely of noise, the piece is situated within certain philosophical and aesthetic issues surrounding noise, its use, and its definition. This piece is not, however, ‘noise music.’ Despite the acoustic groundings in noise, the sounds exhibit harmonic and quasi-harmonic behaviours, especially as the sounds develop in the course of the work. Ultimately, the piece crosses back and forth over the thin line of ‘sound’ and ‘noise,’ where both are valid musical materials.

2. SYNTHESIS METHODS
There are two main synthesis building blocks: noise modulated oscillators combined in additive synthesis and frequency-modulated noise where ‘voltage-controlled’ filters are controlled by oscillators. These two methods then combine for a third, hybrid synthesis. Additionally, amplitude envelopes whose values are determined by random processes are accelerated until they act as amplitude modulation on the synthesis methods above.

2.1. Noise-modulated oscillators
The simplest synthesizer modulates a carrier frequency with white noise. When the amplitude of the noise is small, the sound is very pitched in nature. When the amplitude of the noise is very large, the white noise affects the sound strongly, sounding more like coloured noise. An oscillator can produce ‘pitched’ noise, or ‘coloured’ noise. In an exponentially distributed variable, values closer to 0 are more likely.

Where:

- \( f_c \) = center frequency of the bandpass filter;
- \( f_{filter} \) = oscillation speed of the filter;
- \( D \) = depth of the filter oscillation;
- \( f_v = D \sin[(2\pi f_{filter})] \) (4)

The spectrum of this sound changes significantly in time due to the influence of the white noise. In the implementation in the piece, the weight of the sine, expressed in (1) as 1/k, and the frequency ratio of the partial, k, are randomized such that:

- \( w(t) \) = Gaussian random variable with mean \( \frac{1}{k} \);
- \( h(t) \) = Gaussian random variable with mean \( 1 \);
- \( x(t) = \sum_{k=1}^{\infty} \sin(2\pi f_k t) \) (2)

Additionally, \( f_n \) and \( D \) are changed in time using a Gaussian random variable. This results in:

- \( x(t) = \sum_{k=1}^{\infty} \sin(2\pi f_k t + Dn(t)) \) (3)

One interesting thing about this synthesizer is that the noise is not affecting the amplitude of the spectrum directly. Rather, by increasing the amplitude of the noise, the depth of frequency modulation is increased. Therefore, it is actually the random sidebands that are creating the noise profile. Regardless of this, the perception of the noise is ultimately the same due to the nature of white noise.

Perceptual fusion of the complex sound is achieved using the same \( n(t) \) for each partial and resetting the phase of each oscillator with each articulation of the sound. A single amplitude envelope controls all the partials, which further creates fusion through like behaviour. The amplitude envelopes are discussed in 2.4.

2.2. Frequency-modulated noise
In order to create frequency-modulated noise, three cascaded bandpass filters modify white noise to create a strongly coloured, almost pitched, noise. An oscillator controls the centre frequency of the filters. The depth (amplitude) of the oscillator and its frequency creates audible sidebands, while retaining some qualities of the noise.

Where:

- \( f_{filter} \) = center frequency of the bandpass filter;
- \( f_{filter} = \) oscillation speed of the filter;
- \( D \) = depth of the filter oscillation;
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the sidebands appear at:

- \( D, D + f_{filter}, D + 2f_{filter}, D + 3f_{filter}, \ldots \)
- \( D - f_{filter}, D - 2f_{filter}, D - 3f_{filter}, \ldots \)

Furthermore, the filter frequency, depth and Q are randomized in each case, the values are a uniform random variable.

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2.3. Hybrid synthesis
For the purpose of creating more complex tones from noise-based synthesis, both noise-modulated oscillators and frequency-modulated noise were combined into one synthesizer.

The frequency-modulated noise with its rich spectrum of sidebands replaces \( n(t) \) in equations (2) and (3). This creates partials with sidebands, forming a rich, quasi-harmonic spectrum.

When partials are added together, especially when the ratios are integer multiples, complex sounds with strong partials and sidebands create complex tones.

2.4. Amplitude envelopes
There are two kinds of amplitude envelopes in Morphons and Bions: the first is an envelope of varying duration determined by an exponential random variable. The second envelope is very similar to the first, but it has a fixed duration.

In the first case, the duration of the envelope is determined by the length of the overall duration, \( t_v \), minus the attack and release times of the envelopes. The silence between envelopes is also \( t_v \).

In the second case, the duration of each amplitude envelope is the same. The space between the envelopes is the time, \( t_v \), minus the fixed duration of the envelope, \( x + \) plus the attack and release.

In an exponentially distributed variable, values closer to 0 are more likely. The mean of the distribution is inversely proportional to \( \lambda \). The method for generating the variable comes from Dodge and Jerse [4].

Where:

- \( x \) = uniformly distributed variable; \( 0 < x < 1 \)
- \( \lambda \) = mean

The duration of each envelope is determined by an exponentially distributed random variable. This means that events tend to happen very quickly. Larger means tend to happen very rarely. Smaller means can slow down changes, but shorter durations are always more common.

2.5. Amplitude-modulated noise
In equation (6), adjusting \( \lambda \) in real time can shape values of \( t \). At stages in the piece, \( \lambda \) is pushed as high as 30.
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As real-time computer music, the details of each realization change from performance to performance. However, the consistent timbres and overall form of the work retain the identity of the piece.

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All sounds in the work are synthesized as opposed to recorded. However, synthesized sounds can often seem artificially clean and plastic. Inspired by the microfluctuations in amplitude and frequency components of real-world, acoustic sounds, Morphons and Bions uses noise-based synthesis techniques. By using noise to alter the amplitude and frequency of synthesized sounds, richer inner detail of sounds can emerge. So, the techniques seek to synthesize rich sounds while creating musical texture and the impression of sonic immersion. Classical synthesis techniques and random processes then mediate the basic substrate of white noise and digital noise.

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The implementation in the piece, the weight of the sine, expressed in (1) as 1/k, and the frequency ratio of the partial, k, are randomized such that:

\[ w(t) = \text{Gaussian random variable with mean } \frac{1}{k}; \]

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\[ x(t) = \sum_{k=1}^{n} \sin(2\pi f_k t + Dn(t)) \quad (2) \]

Additionally, \( f_k \) and \( D \) are changed in time using a Gaussian random variable. This results in:

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One interesting thing about this synthesizer is that the noise is not affecting the amplitude of the spectrum directly. Rather, by increasing the amplitude of the noise, the depth of frequency modulation is increased. Therefore, it is actually the random sidebands that are creating the noise profile. Regardless of this, the perception of the noise is ultimately the same due to the nature of white noise.

Perceptual fusion of the complex sound is achieved using the same \( n(t) \) for each partial and re-synthesizing the phase of each oscillator with each articulation of the sound. A single amplitude envelope controls all the partials, which further creates fusion through like behaviour. The amplitude envelopes are discussed in 2.4.

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The spectrum of this sound changes significantly in time due to the influence of the white noise.

2. SYNTHESES METHODS

There are two main synthesis building blocks: noise-modulated oscillators combined in additive synthesis and frequency-modulated noise. Where ‘voltage-controlled’ filters are controlled by oscillators. These two methods then combine for a third, hybrid synthesis. Additionally, amplitude envelopes whose values are determined by random processes are accelerated until they act as amplitude modulation on the synthesis methods above.

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The spectrum of this sound changes significantly in time due to the influence of the white noise.

\[ f(t) = 0(\sin(2\pi f_{\text{random}}(t))) \quad (5) \]

Depending on the values of the centre frequency, depth and Q, the difference after the first filter compared to the third can sound very distinct. However, for some values, the difference between the filter outputs can be barely perceptible.

2.3. Hybrid synthesis
For the purpose of creating more complex tones from noise-based synthesis, both noise-modulated oscillators and frequency-modulated noise were combined into one synthesizer.

The frequency-modulated noise with its rich spectrum of sidebands replaces \( n(t) \) in equations (2) and (3). This creates partials with sidebands, forming a rich, quasi-harmonic spectrum.

When partials are added together, especially when the ratios are integer multiples, complex sounds with strong partials and sidebands create complex tones.

2.4. Amplitude envelopes
There are two kinds of amplitude envelopes in Morphons and Bions: the first is an envelope of varying duration determined by an exponential random variable. The second envelope is very similar to the first, but it has a fixed duration.

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In an exponentially distributed variable, values closer to 0 are more likely. The mean of the distribution is inversely proportional to \( \lambda \). The method for generating the variable comes from Dodge and Jerse [4].

Where:

\[ x = \text{uniformly distributed variable}; 0 < x < 1 \]

\[ \lambda = 0.69315 \]

\[ t = \frac{\log(x)}{\lambda} \quad (6) \]

Durations in Morphons and Bions are all determined by exponentially distributed random variables. This means that events tend to happen very quickly. Larger means can slow down changes, but shorter durations are always more common.

2.5. Amplitude-modulated noise
In equation (6), adjusting \( \lambda \) in real time can shape values of \( t \). At stages in the piece, \( \lambda \) is pushed as high as 30.
There are three distributions of random variables in use in Morphons and Bions. The first is the simple uniform random variable. It is used for the frequency and depth of the oscillators controlling the bandwidth filters, as seen in section 2.2. Uniform variables are also responsible for generating the other distributions.

Gaussian variables are used for frequency and depth values in the noise modulation synthetiser in section 2.1. They are also used for the partial frequency ratios in the additive synthesis. In this way, fundamental frequencies and partials move around an integer mean, creating cohesive complex sound that warble or chatter, in some instances, and growl or rumble in others. By centring on harmonic values for frequency ratios, the sounds seem to be tuned. The variability imbues the sounds with a living quality. The method for generating the Gaussian variables is to average five uniformly distributed variables, as given by Dodge and Jerse [4].

Exponential variables are used for all timed events: the amplitude envelopes’ onset times, in some cases the durations and, also, the speed at which the other variables change. This ensures that events happen quickly enough without being predictable, pulsed or consistent. By changing λ, events can become noticeably faster or slower, while maintaining an organic, malleable rhythm.

In addition to the rhythms created by the exponential variable and amplitude envelopes, exponentially distributed random variables control the rate of change in frequency, depth, Q of filters and other random events.

3. SPATIALISATION

In textural composition, the aim is to create a perceptual sound monolith that surrounds the listener. This requires full immersion in the sound without prospective space [11]. That is, the subjective space engendered by the spatialisation of sounds provides no favoured front-view or distinguishes between ‘forward’ and ‘backward.’

The aesthetic decisions regarding spatialisation and textural composition are provided in [6] and [7], as is the technical implementation. Morphons and Bions uses the same algorithm as real-time tape music III for spatialisation.

Cosine curves determine a signal’s weight in a cosine curve's weight in a particular speaker based on the virtual angle of the listener. This requires noticing fast or slow, while maintaining an organic, malleable rhythm.

In addition to the rhythms created by the exponential variable and amplitude envelopes, exponentially distributed random variables control the rate of change in frequency, depth, Q of filters and other random events.

4. PHILOSOPHY OF NOISE IN MORPHONS AND BIONS

A more detailed discussion on the aesthetic implication of noise in Morphons and Bions can be found in [8]. This section summarises the points made. I always worked with recorded sound for my electroacoustic compositions. The richness and variety of acoustic sounds provided enough sonic data for processing and manipulation. Synthesised sounds seemed flat, mundane and plain by comparison. I decided that working with synthesis would be my next challenge.

After some consideration, I decided that it was the noise of the acoustic sounds that made them richer: slight noises in articulation, or inconsistencies and unpredictable characteristics in the spectra. So, I approached synthesis from the basis of noise, using noise as the foundation of every synthesis method.

My initial thoughts on noise in the signal were not unique. Cowell [3] noted that noise exists in everything, including musical instruments. The result of working with noise in synthesis was, at first, engine-like sounds. This resonated with Russolo’s real-world noise, sounds that “simulate worldliness” [12].

On a higher level, a work consisting entirely of noises, in this case actual white noise sources, raised more philosophical and musical questions. It bore out Cage’s prediction that “by taking sources and dissonances of music would be the distinction of noise and musical (pitched) sounds” [1]. Because the synthesis methods in Morphons and Bions can metamorphose between pitched and noise sources, it does, in fact, create tensions between materials as consonance and dissonance does in tonality.

Noise, more complicated a concept than its simple acoustic definition. It also refers to the non-significant components of a message, as in information theory. It can also be simpler. “message,” but in Morphons and Bions, the message is, at the least, conveyed by the noise itself. This creates an interesting paradox, well identified by Cascone’s post-digital aesthetics as an option to tradition and example of cultural hybridity. Morphons and Bions cannot exist as dual “others” to two traditions. This allows the work to exist outside any one narrative, providing a historicised perspective of acousmatic music in general.

So, from its acoustico-based synthesis to its overarching role on the edge of acousmatic music, Morphons and Bions explores the notion of noise in music. It only raises questions, however. It does not necessarily answer them.

5. CONCLUSION

This paper detailed the synthesis methods in Morphons and Bions. These methods include noise-modulated oscillators, frequency-modulated noise, and amplitude-modulated noise. This paper also summarised the random processes used to control the work. Some random processes trigger frequency ratios of partials and the weights of harmonics. Others trigger rhythms and amplitude envelopes, which can be accelerated to create amplitude-modulated noise. In this way, random processes determine the micro-composition of sounds. A larger, fixed score controls the form of the piece by triggering parameter changes in the random processes themselves. The formal fixedness on the macro-structure enables the work to maintain its identity despite the micro-differences between realizations.

As Morphons and Bions is another textural composition, the spatialisation technique for the multi-channel work is the same used in the real-time tape music series by the author. The aesthetic issues remain the same: maximize the perception of motility without providing coherent trajectory-based theory. Music is too complicated to have a simple “message,” but in Morphons and Bions, the message is, at the least, conveyed by the noise itself. This creates an interesting paradox, well identified by Cascone’s post-digital aesthetics as an option to tradition and example of cultural hybridity. Morphons and Bions cannot exist as dual “others” to two traditions. This allows the work to exist outside any one narrative, providing a historicised perspective of acousmatic music in general.

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6. REFERENCES


2.6. Summary of random processes

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Cosine curves determine a signal’s weight in a particular speaker based on the virtual angle of the signal and the angle of the speaker in the circle. The algorithm for spatialisation is scalable, allowing for different configurations. However, it is designed to work best in a circular configuration. Elevation has yet to be implemented in the algorithm. The algorithm sends sound in space at random speeds and directions. The output of each synthesis module is spatialized independently. Sounds are highly motile without perceptual cohesion of trajectory or mimetic spatialisation.

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Kahn extends the notion of non-message to the realm of cultural artefact [10]. To this degree, “message” is “meaning.” Any sound, musical or otherwise, that does not serve meaning becomes noise. In other words, the nonsensical or incongruent in any example is noise. Again, the paradox of significance arises: when the noise is the carrier of meaning, it is no longer noise.

Morphons and Bions uses noise not just for musical message, but it also insists on a larger cultural meaning. Presented as it was conceived, as acousmatic music, it does, in fact, create amplitude-modulated noise. In this way, random processes used to control the work. Some random processes determine frequency ratios of partials and the weights of harmonics. Others trigger rhythms and amplitude envelopes, which can be accelerated to create amplitude-modulated noise. In this way, random processes determine the micro-composition of sounds. A larger, fixed score controls the form of the piece by triggering parameter changes in the random processes themselves. The formal fixedness on the macro-structure enables the work to maintain its identity despite the micro-differences between realisations.

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The use of noise complicates the aesthetics of the piece by situating the work in a practice of noise-based and failure-system music systems. At the same time, the piece arose from acousmatic concerns regarding source sounds and their reception. Morphons and Bions uses questions about noise because it lives on the vague boundaries between noise/sound, noise/message, noise/meaning and noise music/acousmatic music.

6. REFERENCES