DOI 10.14393/OUV18-v12n1a2016-4

B - is for Bird -
A game-audio musical work for resynthesized syrinx

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ABSTRACT
Birdsongs have inspired humans and informed musical compositions and other art forms for centuries. This paper discusses preliminary conclusions deriving from the design of an interactive music system for mimicking birds' vocal anatomy. It aims to drive a modular synthesizer, as the basis for a multiplayer game-audio environment. The piece is partially controlled by audience's interaction using mobile devices equipped with an Augmented Reality tool. When the tablet / smartphone detects the markers, it generates singing meta-birds which will become players on a game-engine server platform.
The creative outcome is an evolutionary aural ecosystem entitled *B - is for Bird* - mostly generated with pure analogue synthesis driven by birdsongs and rendered in 3D. Its premiere is aimed at the Sines-Squares(.org) event in November 2016.
B's system flow includes four block components: a Syrinx Recognition Scheme (SRS), a Mapping-to-Modular Tool (MTM), a Compositional Navigation Artefact (CNA) and a Structural Evolutionary Device (SED). The piece aims to build on existing musical repertoire and tradition emerging from composers who, in one way or another, were fascinated by birds and in some cases, became amateur ornithologists. The author's preliminary field-recording work for *B* in Manchester's peak district's natural reservoir strengthened his personal connection with nature. It also raised his self-awareness on the importance of preserving of our sonic environment and it provided ideas for the game-audio chronicle in *B*. The piece's narrative unfolds during the colonisation of a new planet, where humans had to artificially rebuild aspects of our ecosystem, including the construction of a virtual habitat for meta-birds singing and calls.

KEYWORDS
Syrinx, birdsongs, meta-bird, game-audio, Artificial Neural Network, Modular Synthesizer, Augmented Reality, colonisation.

RESUMO
Cantos dos pássaros têm inspirado os seres humanos e fomentado composições musicais e outras formas de arte ao longo dos séculos. Este artigo discute algumas conclusões preliminares derivadas do desenvolvimento de um sistema musical interativo para imitar a anatomia vocal das aves. Destina-se a controlar um sintetizador modular como base para um ambiente de jogo *multiplayer* de áudio. A peça é parcialmente controlada pela interação do público por meio de dispositivos móveis equipados com uma ferramenta de Realidade Aumentada. Quando o *tablet* / *smartphone* detecta os marcadores, gera meta-pássaros cantadores que se tornarão jogadores em uma plataforma de servidor do jogo.
O resultado criativo é um ecossistema aural evolutivo entitulado *B – is for Bird* - gerado principalmente com síntese analógica pura guiada por cantos de pássaros e renderizado em 3D. Sua estréia está prevista para o evento Sines-Squares(.org) em Novembro de 2016.
O fluxo do sistema de *B* inclui quatro blocos de componentes: um Esquema de Reconhecimento de Siringe (SRS), uma Ferramenta de Mapeamento-para-Modular (MTM), um Artefato de Navegação Composicional (CNA) e um Dispositivo de Evolução Estrutural (SED). A peça tem o objetivo de construir-se sobre um repertório e uma tradição musical que emerge de compositores que, de uma forma ou de outra, foram fascinados por aves e, em alguns casos, tornaram-se ornitólogos amadores.
O trabalho preliminar de gravação em campo para a composição de *B*, feito pelo autor no reservatório natural do *Peak District* de Manchester reforçou sua conexão pessoal com a natureza. Além disso, aguçou sua auto-consciência sobre a importância da preservação do nosso ambiente sonoro e forneceu idéias para a crônica do jogo de áudio em *B*. A narrativa da peça se desenrola durante a colonização de um novo planeta, onde os seres humanos tiveram que reconstruir artificialmente aspectos do nosso ecossistema, incluindo a construção de um habitat virtual para cantos e chamadas de meta-pássaros.

■ PALAVRAS-CHAVE

Siringe, Cantos de pássaros, Meta-pássaro, Jogo de áudio, Rede Neural Artificial, Sintetizador Modular, Realidade Aumentada, Colonização.

Introduction

Inspiration and composition:

Can birdsongs spawn and articulate a virtual forest populated with mechanical birds? The author's research journey ineludibly includes Messiaen's 1950's birdsong-inspired works and papers (HOLD, 1971; DEMUTH, 1960; HILL, 1994) as point of departure. Compositions such as, Réveil des Oiseaux, Exotiques and Catalogues, or Jonathan Harvey's Bird Concerto with Pianosong, are supreme choreographies of birdsong spectra immersed in a rich forest-ecosystem represented by instrumental forces.

While writing this piece, the author of this paper became fascinated by the different aesthetic concepts and approaches found when studying the mimicking of birdsongs. These included examples of contemporary singing techniques such as, bird-talking by Berlin-based Ute Wassermann[1], and birds imitating other birds and unusual mechanical artefacts, as in the popular lyre-bird's video introduced by naturalist Sir David Attenborough for the television show BBC wildlife[2].

In fact, the author's main point of inspiration has been the study of birds themselves (HOLDE, 2006)[3]; their sounds, timbres and complex articulation of rhythm and dialogue. Many emerging compositional ideas departed from the analysis of the spectral channels that birdcalls and birdsongs occupy in our sonic echo system.

The physics of the avian vocal tract instrument:

To fully understand how birds sing and call, it is imperative to know, in physics terms, how the syrinx operates and could be modelled. The syrinx is the unique vocal organ of the songbird, which resembles a woodwind-like complex acoustic instrument. Electronic engineer and acoustics specialist Stephan Bilbao suggested to this author to have a look at Tamara Smith's and Julius O. Smith III's papers and models of the avian vocal tract, which she implemented using waveguide synthesis and numerical methods at Stanford University (SMYTH, ABEL and SMITH III, 2003; SMYTH, SMITH III, 2002).

Instead of using humans-like vocal chords to produce sound, birds have a vocal organ called the syrinx, which behaves as a self-oscillating upside down Y-shape artefact to modulate two columns of airflow. The syrinx is capable of producing extremely complex timbres and rhythms, which have alternative functions, from

[1] Ute Wassermann's bird-talking. Available on: <https://archive.org/details/ar063UteWassermann/>. Last visited: 7 June 2016.
[2] Lyre-bird's video by naturalist Sir David Attenborough, BBC wildlife. Available on: <http://www.bbc.com/travel/story/20140416-an-australian-bird-that-mimics-the-sound-of-a-chainsaw>. Last visited: 5 June 2016.
[3] Also: All About Birds. The Cornell Lab of Ornithology. Available on: <https://www.allaboutbirds.org>. Last visited: 1 April 2016.

calling other birds, to claiming or defending territory birds need for mating, nesting and raising baby birds.

Conclusions from these papers combined with the author's recent investigation on the concept of 'modular metaphor' (CLIMENT, PILKINGTON and MESÁ-ROŠOVÁ, 2016) on synthesizers led to the idea of exploring literal transcriptions of complex modulation of tones from birds' vocal anatomy onto an electronic modular synthesizer. This not only served as a point of compositional departure but also as a benchmark for spectral accuracy and mapping.

<u>FFT flow on the system's design:</u>
To build such an interactive system, it required experimentation and research on frequency analysis using the Fast Fourier Transform (FFT), in different areas, not often found together:
a) FFT was implemented on Artificial Neural Networks using acoustic feature extraction, with Matlab[4];
b) It was used in Cycling 74's Max[5] for mapping real-time extracted data from a computer device to a modular synthesizer, for high-precision communication via the Lightpipe/ CV Interface from Expert Sleepers's ES-3 (and the ES5 expander);
c) It was finally employed in Unreal Engine 4[6] using the game engine's Frequency Analysis and Dynamics plugin in order to map live spectral information onto the size, colours or other properties of 3D assets.

The interactive music system

The structural flow of a resynthesis-like compositional system for *B*, is described below:

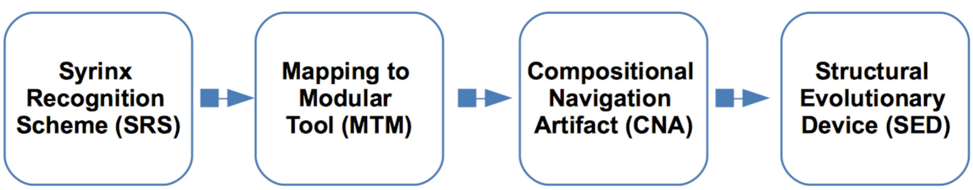

Figure 1. System Flow

Such set of tools is designed not only to identify a number of bird species but also to transcribe birdcalls and songs into musical phrases, as a point of departure for live sound organisation. The musical system maps a wealthy pool of complex data analysis onto a purposely-built modular synthesizer, as the primary audio engine. Its implementation on Unreal Engine 4 game-audio forest-like environment provides navigation through sound in a fictional 3D journey.

[4] Visit: <http://de.mathworks.com/products/matlab/>. Last visited: 10 June 2016.
[5] Visit: <https://cycling74.com/products/max/>. Last visited: 10 June 2016.
[6] Visit: <https://www.unrealengine.com/what-is-unreal-engine-4>. Last visited: 13 June 2016.

Syrinx Recognition Scheme (SRS)

Introduction:

The SRS consists of three elements; a purposely-built database of bird sounds and calls, an Artificial Neural Network on *B*'s server and an Augmented Reality (AR) mobile app including meta-birds for audience interaction.

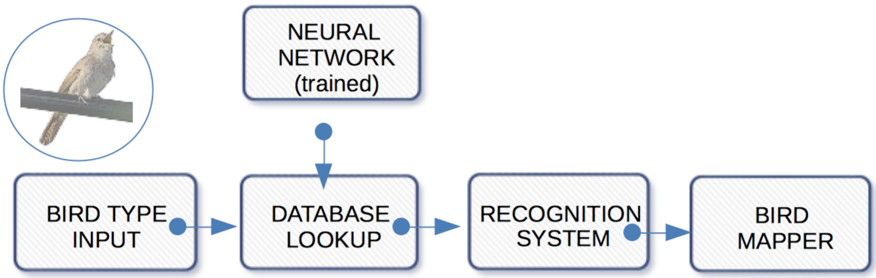

Figure 2. Artificial Neural Network to identify different bird species

System details:

The database of bird-sounds requires significant registers; e.g. 50 samples per species, clean of background noise or other disturbances. The Artificial Neural Network needs to be trained in order to be able to classify birds based on acoustic feature extraction with a required, sufficiently high, degree of accuracy.

How does it work?

When birdsongs or calls input the system, the audio is analysed and compared with the stored database and associated bird typo-morphologies. Once the source of the birdsong is detected (e.g. a magpie), this information is passed onto the Mapping-to-Modular (MTM) system for further processing.

The system's input consists of a number of AR markers distributed across the installation space. When an AR marker is scanned with the mobile's built-in camera, e.g. a smartphone with *B*'s app installed, it pops up a meta-bird on the device. Augmented 3D birds on the mobile device are capable of singing, and their syrinx and movement can be controlled by the user, via the camera's relative position or screen touch.

B's 'server' receives the birdsong information via audio communication, feeding the system in two ways: Firstly, trained Artificial Neural Network use the data to recognise the bird's typology and secondly, Max receives the audio signal and starts a different FFT analysis for mapping purposes. It sends the data from the Optical output of the soundcard to the optical input of the ES3-ES5 from Expert sleepers[7], converting data into voltage to operate the Eurorack synthesizer.

[7] Visit: <http://www.expert-sleepers.co.uk/>. Last visited: 13 June 2016.

Finally, the app also sends OSC to *B*'s server, directly to the OSC module by Rebel Technologies[8] controlling the modular synthesizer and via OSC to Max's Open Sound Control external Object.

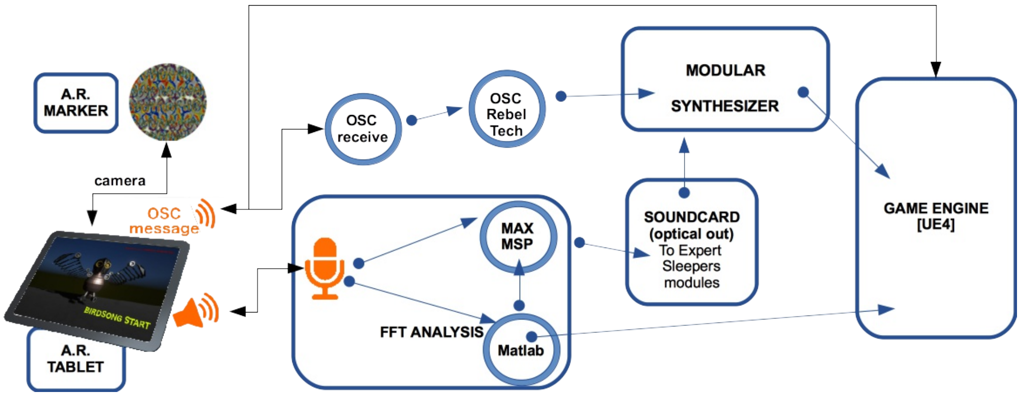

Figure 3. *B*'s System structure in more detail

OSC information is used for ultimate control of the virtual meta-bird clone, spawn from the app onto the 3D game-engine environment and therefore, seen and heard on the main installation projection system. This means that audiences can not only create individual birds on their mobile devices but also clone and place them in a virtual forest with others.

A similar combination of AR and VR technologies was tested alongside analogue synthesisers by Climent, Manusamo&Bzika and Pilkington on a previous project (Putney Ponozky Cislo II).

Artificial Neural Networks, Model:

B's Matlab feature extraction elements and flow are informed by Abewardana and Sonnadara's system (ABEWARDANA, SONNADARA, 2012) and other related research (SELIN, TURUNEN, TANTTU, 2007; DAWSON, CHARRIER and STURDY, 2006). The Sri Lanka researchers made use of forest recordings from 10 different bird species. For the classification of birds they made use of FFT and Artificial Neural Networks, although they had to previously apply a good degree of audio cleaning to remove background noise and unwanted vocalisations from the forest background. Their database consisted of 50 samples per species, 35x10 of which were used for training the Neural Network.

[8] Visit: <http://www.rebeltech.org/>. Last visited: 13 June 2016 // Rebel Technology's Open Sound Module - WiFi OSC to CV/Gate interface.

Figure 4. Climent's 2016 collaborative work Putney Ponozky Cislo II. Audience member using AR marker to send OSC data via Android tablet to the server's game-audio engine and OSC module synth.

Database of birdcalls:

For the purpose of this composition, obtaining a large, noise-free, collection of bird species to train the artificial network was a massive task and out of the question for the needs and artistic decisions made by the composer on *B*'s system design. Instead, for training purposes, 50 variations per bird species were generated using Bill Schottstaedt's CLM's instrument code bird.clm on Common Lisp Music[9], first-time used by this author in the 1997 on SGi and NeXT computers at Queen's University, Belfast.

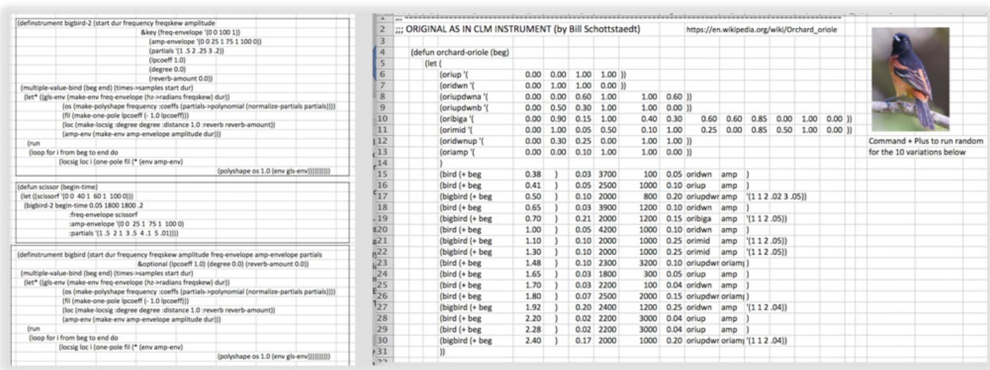

Figure 5. CLM's orchard-oriole bird instrument before parametrical randomness was applied to produce variations (on right)

[9] Visit: <https://ccrma.stanford.edu/software/clm/>. Last visited: 10 June 2016.

Acoustic features extraction:

For a system to listen to birdsongs and being able to identify species using Matlab, it requires to extract a number of acoustic features and their medians. For example, in Abewardana / Sonnadara's study, they use SF-start frequency, EF-end frequency, PF-peak frequency, AD-ascending duration, DD-descending duration and TD-total duration.

Below, a Matlab example used in B for extracting spectral information from audio files using 100 birdcalls from orchard and magpie generated using CLM is presented. The Matlab analysis is stored on a excel spreadsheet, scanning detailed data from the audio waveform.

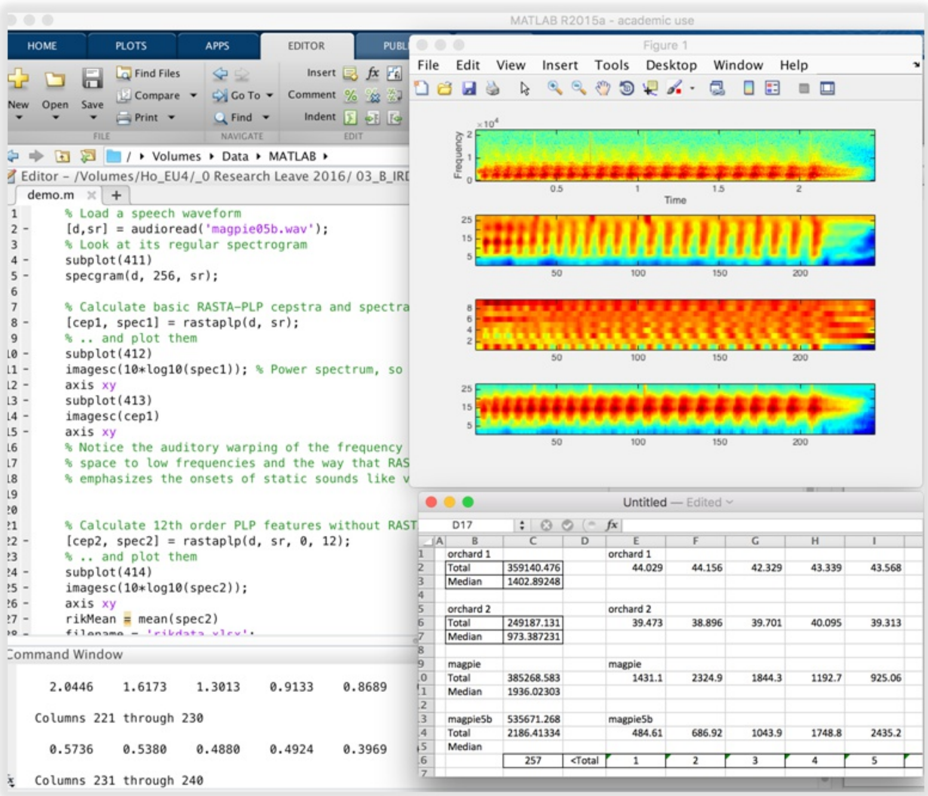

Figure 6. Matlab's extraction for *B* and its storage on an excel file

Artificial Neural Network Training:

200 CLM-produced birdcalls from four species were passed onto the network: they were from an orchard-oriole model, a chipping-sparrow, a grasshop-per-sparrow, and a magpie.

This specific section of the system found in the server computer is currently on-going and has not been fully tested or implemented. Its objective is to listen to the meta-bird audio samples and identify them with a high degree of accuracy. Although the prototype uses variations of five bird species, given enough samples and training, it could include many more.

Audience interaction using AR birds (*B*'s interactive game-audio installation):

One of the main aims of the piece is to provide a window for audience's interaction, for instance, collecting and activating meta-birds songs and calls through the use of mobile devices scanning markers.

B's app[10] consists of a collection of meta-birds, which can be introduced in the 3D game-engine environment directly from the app by the user. Based on Climent's 3Dsketches, meta-bird models and skeletons are yet to be designed by Manusamo&Bzika, the author's long-term 3D modelling collaborators in a number of previous projects such as *s.laag* for bass clarinet and game-audio or *Xi* for Timbila and virtual expression. The AR mechanic-like meta-birds are based on their own popular animals AR series.

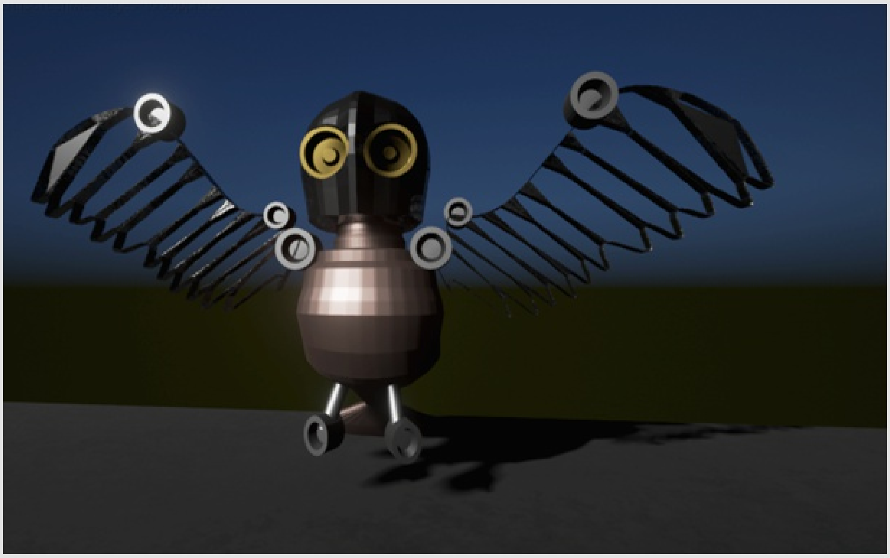

Figure 7. Owl meta-bird prototype in Unreal Engine 4 (sketched by Climent)

Mapping-to-Modular Tool (MTM)

This part of the system combines one piece of software, Max and two pieces of hardware; a multichannel sound card with optical I/O, such as the Fireface 400 and an Expert Sleepers synthesizer module. The software uses three elements: a scalar / pitch-shifter (with an optional filter), an FFT-analysis area which uses the sigmund~ object, (although Alex Harker's eternals are also a choice) and an Expert Sleepers's external object (es5~ encoder).

[10] Tested on iOS and yet to be ported to Android.

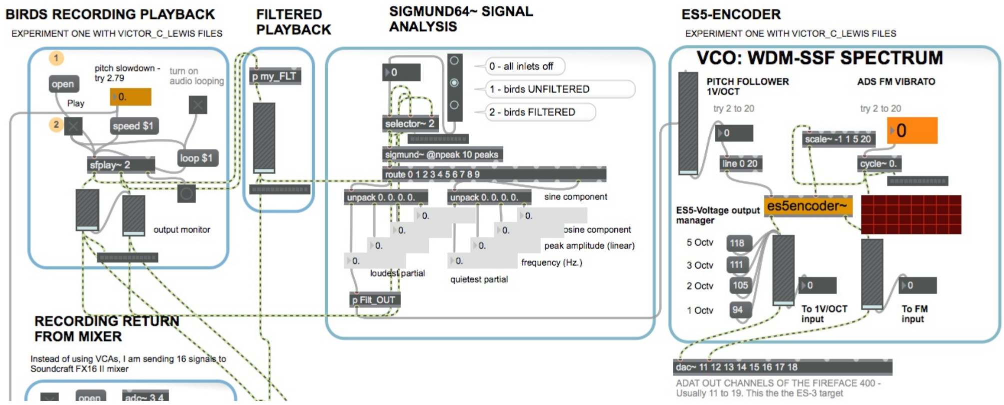

Figure 8. Max encoder patch designed by this author. It listens to the meta-birds, analyses it and talks to the Expert Sleepers module

The main purpose of this system-block is to map incoming sound data resulting from the analysis of acoustic features. The patch currently reads from a soundfile (sfplay~) but it can easily read from an external microphone via Max's adc~ to listen to the meta-bird songs. The extracted live audio information is passed onto the modular synthesizer via the Expert Sleepers module, converting dynamic data analysis into variable voltage, which can run and control other modules. A list of modules in *B*'s current system (June 2016) is seen below.

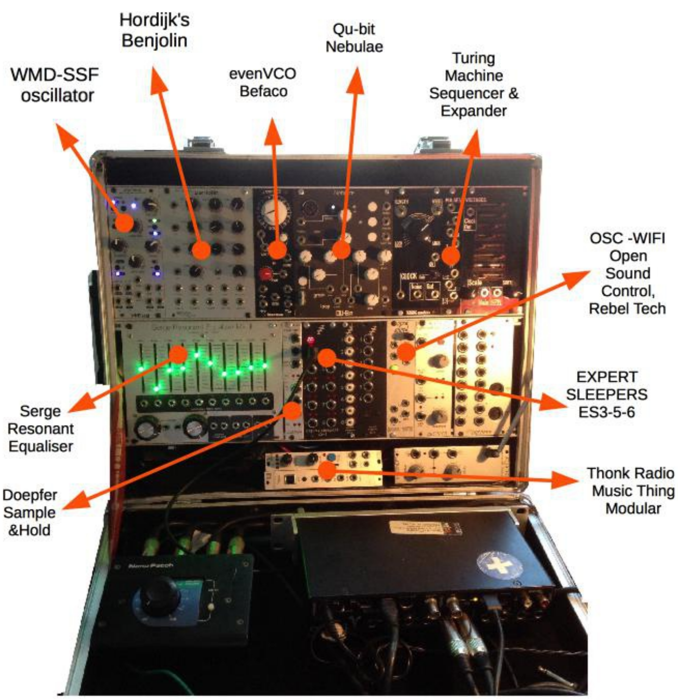

Figure 9. Expert Sleepers ES3 at the heart of *B*'s modular synthesizer.

For exploring the accuracy of this quasi synthesis pitch-follower system, a vinyl with recording of birds from Victor C. Lewis (Golden Guinea, GGL 0483, 1969) was tested.

Matlab was used to benchmark Lewis's recording spectral analysis with its conversion after passing through the ES5. It was used a RASTA-PLP[11], a speech feature representation (standing for Relative Spectral Transform - Perceptual Linear Prediction). Early results were quite promising (as seen below):

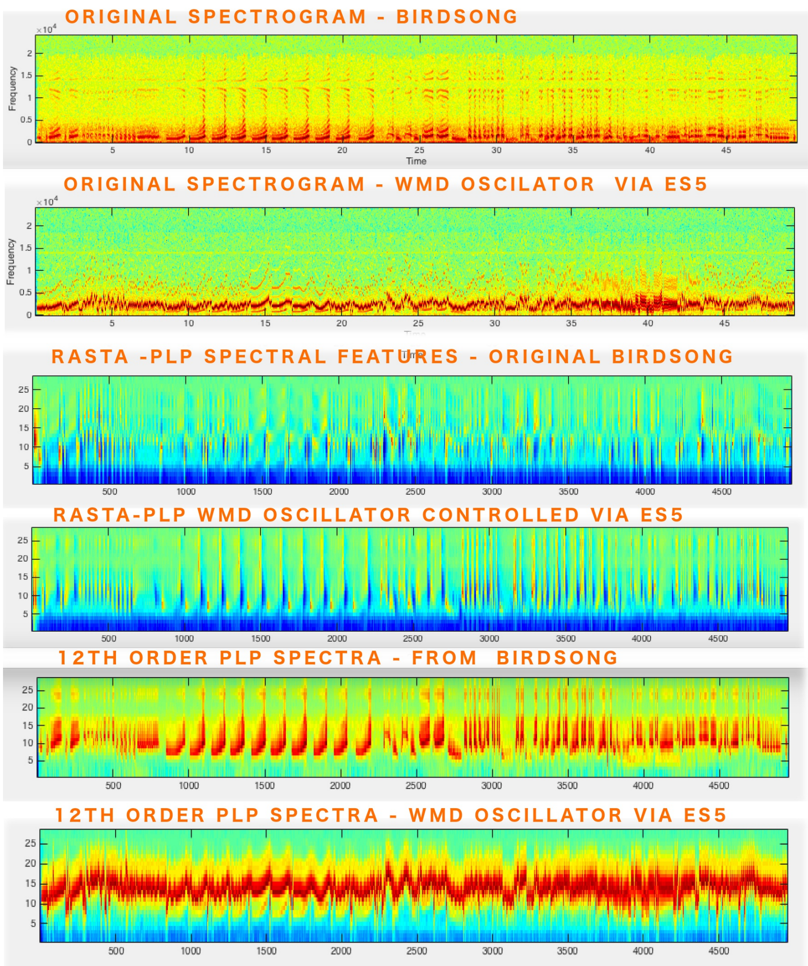

Figure 10. RASTA-PLP plot contrasting the original recording with the synthesizer mapping

[11] PLP and RASTA (and MFCC, and inversion) in Matlab using melfcc.m and invmelfcc.m

Fine-tuning the conversion:

The system has proved to be more accurate when the original recording is pitch-shifted down and the VCO (Voltage Controller Oscillator) employed is the WMD-SFF (from the output of the ES3 module to the 1v/oct input of the VCO). Also, passing a Max high pass filter onto the source helps with the accuracy of the conversion. Finally, adding a fraction of frequency modulation provides extra musical expression to the synthesized sound.

However, pitch-frequency is only one of the many features which can be extracted from sound analysis; e.g. sigmund~ is a sinusoidal analysis and pitch tracking object, but there are other analysis tools such as, Alex Harker's descriptors~ object[12] which can obtain statistical calculations and features (mean / median / standard deviation / max n values).

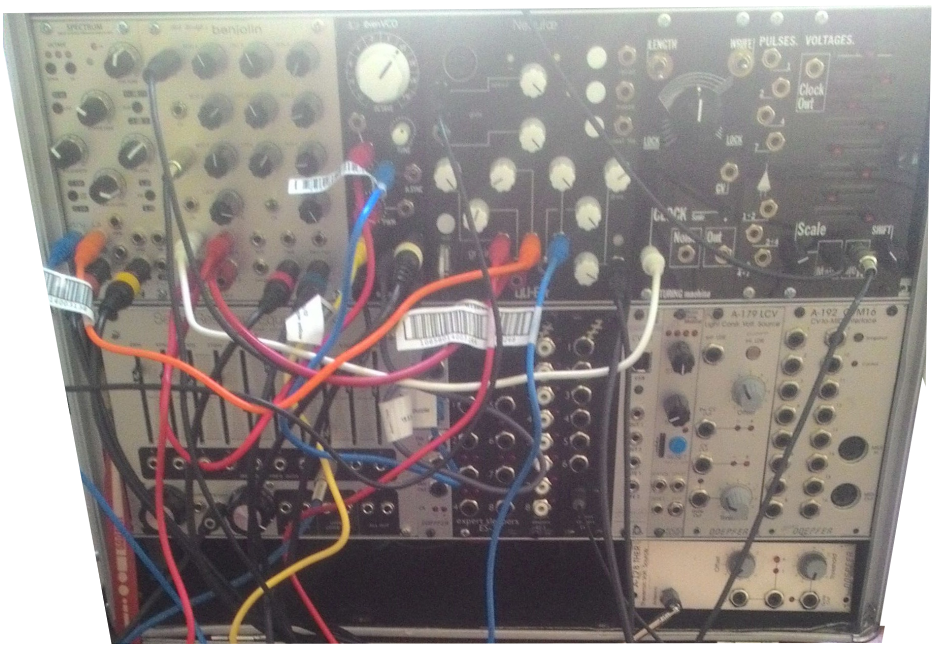

Figure 11. Modular Synth patched for mapping birdcalls after Max's analysis

Compositional Navigation Artefact (CNA)

This system block deals with compositional ideas obtained and deriving from the current system.

Real-time pitch-frequency data or dynamics converted onto voltage (within the ES3 range) range can be sent to other areas of the synthesizer to test what sounds are produced and why. This area is mostly aurally intuitive although it is preceded by the use and construction of the instrument.

As a result of the experimentation, three typologies of aural environment materials were articulated:

[12] Visit: <https://github.com/AlexHarker/AHarker_Externals/>. Last visited: 10 June 2016.

BIRDS LANGUAGE EN GRAMMAR TYPOLOGY — RC — Extracting typology from voc

	Sound Type	When	male / female	made by
6	Silent (generally)	Most times	m/f	Syrinx
7	Loud hiss	When angry	m/f	Syrinx
8	Snorting sound	When angry	m/f	Syrinx
9	Loud throbbing 'waou, waou'	When flying	m/f	Wings
10	High Pitched whistle	When young	m/f	Syrinx
11	Soft, mellow, yelping 'oop, oop' or 'hoo, hoo'	Call	m/f	Syrinx
12	Trumpeting call	Call	m/f	Syrinx
13	Loud whooping	Call	m/f	Syrinx
14	ung-ank', 'ow, ow, ow, ow'	Call	m/f	Syrinx
15	Higher pitched, incesant and rather musical 'wink, wink'	Call	m/f	Syrinx
16	Crackling call with a laughing sound	Call	m/f	Syrinx
17	Crackling and honking calls (like a ship at distance)	Call	m/f	Syrinx
18	Deep, resonant trumpet-like call	Call	m/f	Syrinx
19	Single bark, high-pitched (resemble yapping of dogs at distance)	Call	m/f	Syrinx
20	Single 'waruk' call (dog-like yelping at distance)	flock (mixed)	m/f	Syrinx
21	Clamour grows	flocks takes off	m/f	Syrinx
22	Husky wheezing call	Call	male	Syrinx
23	High pitched 'hur, hur, hur, hur')	Call	female	Syrinx
24	Nasal trumpetting or whooping (female is deeper)	Call	m/f	Syrinx
25	Sweet-sounding whistles	Call	m/f	Syrinx
26	Growling 'ark-ark-ark' (female is lower)	Call	m/f	Syrinx
27	Soft wishtle (variety)	Call	male	Syrinx
28	Soft croak	in flight	female	Syrinx
29	Fast-carrying, musical, two-syllable whistle, 'wee-ooo'	Call	male	Syrinx
30	Harsh growl	Call	female	Syrinx
31	Deep Grasping croak	in flight	male	Syrinx
32	Familiar 'quack'	Call	m/f	Syrinx
33	Quiet, low, rasping 'crrrib'	Call	male	Syrinx
34	Drawn-out 'greee'	Call	male	Syrinx
35	quiet 'took, took'	rivaling males	male	Syrinx
36	Pipping, far-carrying whistle	Call	male	Syrinx
37	Rapid, high-pitched 'quaking'	Call	female	Syrinx
38	Dry rattle and a burping sound	in display	male	Syrinx
39	Hoarse, loud 'bat'	courtship	male	Syrinx
40	Gock' or 'kurr' call	Call	male	Syrinx
41	Soft wheezing 'wiwwierr'	courtship	male	Syrinx
42	Soft 'wuck' and 'we-ooo' call	courtship	male	Syrinx
43	Non vocal sound	display	m/f	Brest beating
44	Rattles, ticking noises and burps	display	m/f	Syrinx
45	Harsh 'karr'	in flight	female	Syrinx

Figure 12. Typology of birdcall, extracted by the author from RSPB Handbook of British Birds

The sonic cells are 'composed' in the form of short studies focused on some aspects of the system. The way to articulate this collection of materials is through Unreal Engine 4's dynamic day-night cycle, briefly explained in the following section.

3. Evolutionary Geophony Ecosystem: The idea of creating an evolutionary geophony[13] ecosystem came from my collaboration with VCS3 performer Mark Pilkington. In our setup for a full concert performance at the Mostra Sonora de Sueca in Valencia, Spain, we tested an alternative way to control the VCS3 synthesizer. It consisted on the following:

- A tablet device for audience interaction to send real-time OSC data via wifi to the Open Sound Control device (by Rebel Technologies), on the modular synthesizer.
- The modular synthesizer distributing the incoming signal from OSC module (both continuous and discrete) as voltage control to a pre-made patch involving two oscillators (WMD-SFF and the Befaco evenVCO, both calibrated), a Benjolin module, the Turing Machine random sequencer with expanders with some feedback loops, Qu-Bit's granulator, (reprogrammed running a PD patch with Andy Farnell's physical models of birds) (FARNELL, 2008), a serge resonant equaliser and Thonk's radio module.

[13] Non-biological such as, water, wind, earth movements, etc

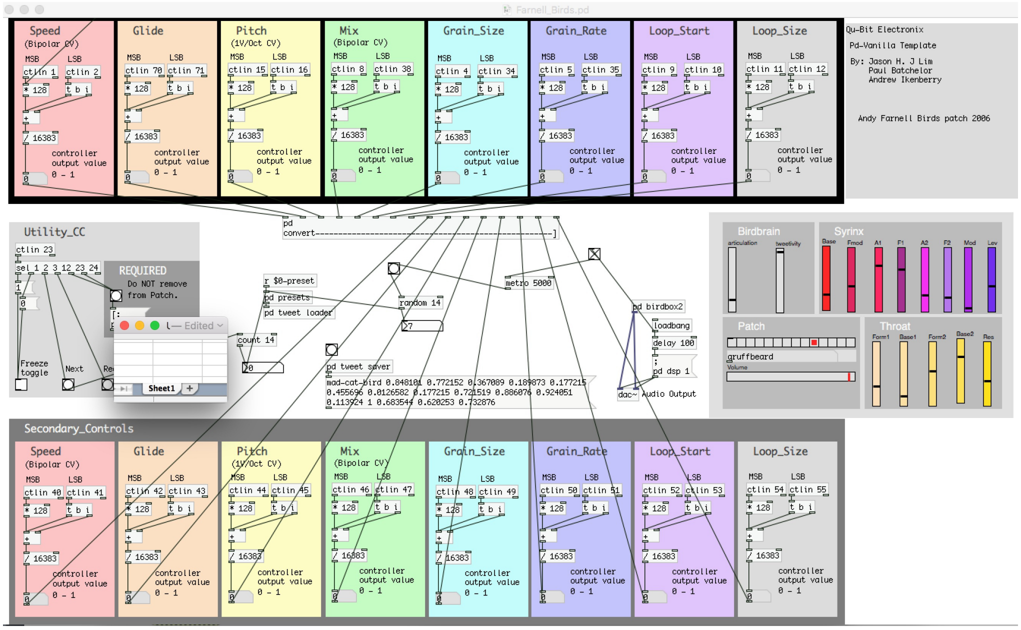

Figure 13. Farnell's physical model of bird patch adapted to QU-Bit by the author

Structural Evolutionary Device (SED)

Since the completion of *s.laag*, I have significantly advanced the use of game-engine environments to unfold compositional narratives. This is a musical work for bass clarinet and game-audio composed for Dutch performer Marij Van Gorkom. The piece's 3D environment navigates the Expo 58 pavilions of Brussels World Expo Fair in 1958 and it is entirely constructed using the game-mechanics and audio engine of Unreal Game Engine 4 (UE4), although the assets and skeletons are created using Blender3D.

Fig 14. s.laag instrument's variations: a meta-human bass clarinet, a fantasia-melody instrument and a mobile windchime-like bass clarinet.

The assets behaviour in *s.laag* is mostly dynamic and procedural, often morphing and expanding using FFT analysis of audio data triggered while navigating the space.

As a result, the different architectural buildings and the environment become an instrument in itself, and it is the same principle I have applied to the forest-like environment in *B -is for Bird-*, where the container becomes the musical instrument and the creatures living in it (meta-birds etc), interact with it using virtual navigation as the dynamic score. SED provides a framework to articulate the three typo-morphologies of sound described in the Compositional Navigation Artefact (CNA), acting as an 'organic score' to navigate the musical structure of the work. How 'Evolutionary' and 'Procedural' (in the algorithmic sense) is the aural live-form and 3D environment in the SED ecosystem is yet to be discovered and fully tested.

<u>Implementing in-game-play audio retrieval:</u>

UE4 is capable of generating procedural levels and therefore, ever-changing visual eco-systems and there are also multiple ways to implement dynamic and procedural audio. A successful UE4 implementation of a dynamic sound system I previously explored in *s.laag* consisted of the use of Audio Data Structures in UE4 to connect to a MS Excel spread-sheet with a huge amount of audiofile data, which is dynamically retrieved using a complex Blueprint. The Blueprint extracts sounds from the spread-sheet database following some rules (implemented as compositional decisions during 3D navigation) and passed then onto the FFT node for analysis of an array of spectral bands, which is mapped in different ways onto 3D assets for alternative types of visual morphing, which can lead to a sense of evolutionary growth when thought carefully.

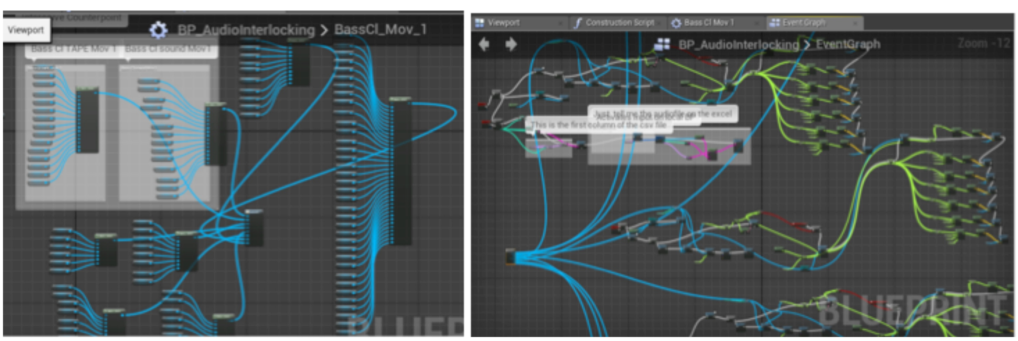

Figure 15. Macro and Audio Blueprint in UE4 retrieving data from a MS Excel database of soundfile names

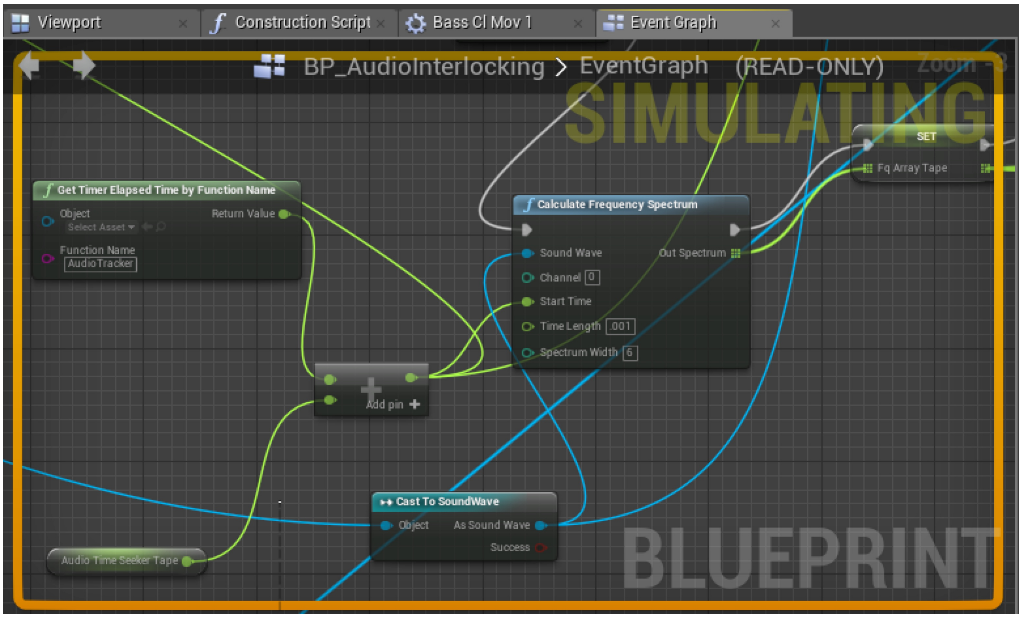

Figure 16. A more detail Blueprint of the FFT analysis node in UE4

Conclusion

It is rather unusual for me as a composer to describe and apply critical thinking to a musical work before it has been fully completed. I often find redundant any effort to verbalise compositional ideas because there is no better form of expression than the language and grammar of the work itself, while it is performed and experienced by listeners. Having said that, to discuss the complex labyrinths of a musical system like the one described here can become a healthy form of musical exorcism, and can help the composer to move on (creatively), when the needs for elongated technical research slows down the flow and imagination of the compositional mind. When problems (technical or compositional) become clearly isolated, it is arguably easier to find a creative solution for them. I often think that composition is nothing more than solving a giant puzzle of sounds from inside a labyrinth, located on unknown coordinates.

B -is for Bird- has benefitted from my compositional work on Interactive Music systems for the last 20 years (if not more) but in particularly, from the last 8 years since I decided to focus on the exploration of game-engines as a compositional and performative tool, around the concept of game-audio and musical interfaces. Navigating visual environments through sound is not only fascinating but also the most efficient tool I found to facilitate the complex language of electroacoustic and contemporary music to non-expert ears, and more importantly, without the need to surrender the complexity of the language and its grammar. However, by doing so, the piece and its performative narratives become something else than what we experience in its abstract form. I am not sure whether this is a good thing or not and probably, I do not care.

In my exploration of game-audio as the compositional vehicle for sonic-centric journeys, I have focused on three strategies, which may be called strands:

Figure 17. Game-audio Strands

The Role-playing of musical instruments normally consists of journeys where the performer collects parts from musical instruments, re-invents musical tradition and tries to earn compositional esteem. Examples of these are pieces for these instruments:

Figure 18. Role-playing pieces of Musical Instruments as a above (*s.laag*, *Xi* and *Putney* respectively)

My sonically-driven expeditions aim to challenge the undisputed dominion of sight and to investigate a number of situations where humans used sound-centric techniques for path-finding and orientation[14].

[14] The bio-simulator strand focuses on mimicing biological forms to unfold aural creativity and to find new routes to organise sound. These were indeed the ultimate goals of the research endeavours described above when composing B.

Figure 19. Pieces using path-finding techniques

Finally, *B -is for Bird-* is my second bio-simulator compositional work following under the umbrella of this strand of game-audio, however, it is strongly informed by the other two strands too. It combines meta-birds (birds with identifiable aural meta-taxonomies) with 3D models of mechanical (meca) birds and it makes use of an identification system to orchestrate the visual and aural canvas.

Figure 20. Two composed bio-simulator

The bio-simulator strand focuses on mimicing biological forms to unfold aural creativity and to find new routes to organise sound. These were indeed the ultimate goals of the research endeavours described above when composing *B*.

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