HEXADECIMAL COMPOSITIONS – USING HEX DATA TO SONIFY IMAGES OF THE FOUND ENVIRONMENT

Cissi Tsang
Edith Cowan University
WAAPA

ABSTRACT

There have been numerous efforts to explore the relationship between the visual and aural, in particular in relation to converting one medium into another. The interchange between music and images can create powerful, evocative, multi-sensory and immersive narratives for both the audience and the artist. One method of relating the aural and visual is through data composition, where data from the visual is used to create the aural. This paper will discuss the usage of hexadecimal data in relation to the artist's own practice and experiments in sonifying the found environment. This practice combines music created from converting field footage and photographs into hexadecimal data and music visualisation, to offer multiple perspectives of a specific scene. The resultant works from this process are audio-visual pieces where both the aural and visual are intertwined. This paper will conclude with some examples of work.

1. INTRODUCTION

Combining the visual with music, and exploring the interchange between musical and visual inputs have been steady preoccupations in many fields, including composition and the visual arts. The combination of both the visual and aural in a work can create powerful, evocative, multi-sensory and immersive experiences for the audience. For artists, linking the visual and the aural offers powerful tools in conveying the narrative of their works. In more recent years, there has been a move towards a synthesis between digital sound and image, and creating analogous relationships between the two mediums.

There have been numerous excursions into the concept of using images as the source for music in order to create multimedia works. Some methods centre on the use of colour to sonify images. One such method is the sonART software, which is a program that uses images to map pitch, time, spatial coordinates and timbre (Yeo, Berger and Lee, 2004). For instance, sonART allows artists to map tones according to colour (i.e. red is 440Hz, green is 530Hz, blue is 580Hz, yellow is 550Hz), or to map pitch and loudness according to colour intensity and graduation area.

Another method of using colour to sonify images is Wave Terrain Synthesis, where colour can be used to map the direction of the sound i.e. red for the left channel, blue for the right channel (James, 2005). Designed for sonifying geographical maps, Wave Terrain Synthesis works on the interplay between the spectrogram of an image and the colours of a contour map.

Other methods of using images as a source for composition involve analysing the data held within the image itself. This can involve elements of the appearance of the image, or the format in which the image is held. One method involves mapping the contours of an image, and using that as a basis for graphical notation of scores (Vickery, 2015).

Inverse spectrogram mapping is another way by which images can be sonified. This is a fixed method of scanning the data elements within an image where the speed cannot be arbitrarily modified during the sonification process (Yeo and Berger, 2005). Other methods involve probing the data elements of an image, where the pathing of sonification can be modified during the process.

Yet another method involves using hexadecimal data. Hexadecimal (HEX) is a positional numeral system with a base of 16. HEX involves usage of the symbols 0-9 and A-F, with the latter representing numbers 10-15. The most commonly-seen usages of HEX are as a way of holding computer data, and also as a format to render colours on websites (for instance, #FFFFFF is white, #000000 is black, #FF000 is red). Using this method, field footage is converted into HEX, and the HEX then converted into musical notation.

HEX, when combined with field footage (still and moving), field recordings and music visualisation, can be used as a data element to sonify the found environment, by creating multiple perspectives of the environment into the work. It also strengthens the connection between the aural and the visual by creating links between both mediums. In a sense, this form of practice demonstrates a nexus between visual and aural.
2. SONIFICATION VIA HEX

HEX was utilised as a compositional method of creating a dynamic interplay between images and music. This exploration was sparked by an initial desire to combine music and photographs and to discover further ways of connecting these mediums. The intent behind this desire was to create meaningful relationships between the two mediums, in order to create works where both practices were intertwined in the result. Another consideration was the desire to convey multi-sensory responses to the found environment.

On the surface, HEX lends itself well to music composition because base-16 correlates to 16 notes, or two octaves of the musical scale. Therefore, it is a straightforward process to map HEX to notes using the following conversion table:

<table>
<thead>
<tr>
<th>Pause: 0</th>
<th>D 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>C 1</td>
<td>E Hex-A</td>
</tr>
<tr>
<td>D 2</td>
<td>F Hex-B</td>
</tr>
<tr>
<td>E 3</td>
<td>G Hex-C</td>
</tr>
<tr>
<td>F 4</td>
<td>A Hex-D</td>
</tr>
<tr>
<td>G 5</td>
<td>B Hex-E</td>
</tr>
<tr>
<td>A 6</td>
<td>C Hex-F</td>
</tr>
<tr>
<td>B 7</td>
<td></td>
</tr>
<tr>
<td>C 8</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. HEX-to-music conversion table.

In HEX, each binary digit (aka pairing of HEX symbols) equals one byte. For instance, FF is equal to a whole byte. The above table uses each half-byte, or 'nibble' (aka a singular F) as a basis for conversion into music.

Various software exists for converting images - or any other form of digital media - into HEX. One such program is Notepad++, a free program that has an add-on HEX editor.

As an example, the first four nibbles in Figure 3:

| 2 4 e 3 |

Can be mapped to the following notes:

| D F B E |

3. LIMITATIONS OF HEX-TO-MUSIC

The main limitation of HEX is the comparative lack of ways to control the duration of time. Beyond 0 being used to denote a pause, there is no other way of denoting the duration of notes using HEX. There is also no ready method of denoting the tempo of a data set from the HEX source. It became quickly evident that a level of intervention from the composer on the data was required, or otherwise a HEX composition tended to sound like a pure stream of meaningless notes.

The above illustrates a broader issue with using data as a basis for sonification. The nature of sound itself utilises time as a parameter for other aspects of the composition - such as duration of each tone, and the duration of the sound itself. As data from images are not organised in time sequences, nor do they contain time-relevant information, then finding ways of relating time to such data can be difficult (Yeo and Berger, 2005).

Overcoming time-based limitations involves exploring and expanding the role of the composer in data-based compositions. For instance, there has been research into creating data-based music where the composer manipulates the output or while interacting with the computer. This creates a more interactive and flexible means of creating music from data, and allows some form of time to be interjected.

One such method involves a program that sense the output from a user and creates music from the output, essentially creating a feedback loop between composer and computer (Obrenovic, 2005). Such a program relies on measuring everyday interactions between the user and the environment and using that data as a form of music. This method is passive, but with the option for the composer to take manual control. In this example, the composer introduces the notion of time to the data through the existence of the feedback loop, as all everyday actions involve an element of time. The option of manual control also creates that extra element of time control and introduction.

A similar feedback process between the composer and data occurs in live coding, for instance through Supercollider. This involves active manipulation by the composer with the data, with the composer essentially coding and creating the piece on the fly. In live coding,
a composer has full control over the pitch, sound, length and loudness of each note. Essentially, the composer introduces both improvisational and aesthetic elements into the data, with the data being used as an evocative springboard for aural concepts.

Both these models assume a level of interaction by the composer with the data elements to introduce the element of time. Through exploring these avenues, active manipulation of the data from the composer in order to introduce the mechanics of time in compositions became part of the process of sonifying with HEX. This approach expanded to include intuitive elements as a way to explore further ways of incorporating time.

One way for the composer to interact with the data was to firstly select a random section of HEX from a photograph or field footage to convert into notes. The sections of HEX were then used according to subjective judgment on their aesthetic value, rather than following a strict, sequential interpretation of the data. A further consideration as to what sequences were used, and in which order, was whether the sound produced from the converted data accurately represented the emotive and narrative responses to the found environment. However, while the order of the sequences were changed, the note order of each sequence was preserved.

With this method of using HEX, the composer additionally dictates the pitch and duration of notes, and the tempo of composition. These decisions were also made largely on an aesthetic level, and how they would affect the intended narrative of the piece.

Another decision made to incorporate HEX in compositions was to group the notes in sets of four, rather than six in HEX format. There were two reasons for this - firstly, it helped introduced an element of time to the general data set by grouping them into 4/4 time, and secondly, it divided each line of HEX more evenly in a musical context.

An additional question arose regarding the use of percussion in composition. This method of using HEX did not lend itself to the generation of percussive scores. Adding percussion to pieces required the use of public domain samples.

### 4. HEX AS PART OF AN AUDIO-VISUAL WORK

Converting an image or piece of field footage into HEX produces a sheer mass of data, and to attempt to use all the data in a composition would be overwhelming. Therefore, a selective use of data is required in order to create a workable selection of notes to use. However, focusing on a section of the data comes at the expense of losing the data within the overall context of the work. Therefore, there was a need to convey the connection between the source visual material and the aural element of the piece.

One method of resolving this issue is to situate the composition in the context of an audio-visual work, where the source image and the composition are linked via a music visualisation. Using a music visualisation creates an additional layer of reactivity between the source image and the audio, and acts as a additional visual cue for audiences.

This process – of combining the field footage with the composition and the music visualisation - essentially situates the works on a nexus between the aural and the visual. Without the source footage, the audio cannot exist. Without the audio composition, the music visualisation would not exist.

The music visualisation component of the work can be incorporated into the composition in different forms - as the main visual component of the work overlaid on a static field footage, or as a stand-alone section accompanying a diptych or triptych video of field footage.

The music visualisations are created through a combination of Adobe AfterEffects (a video and visual effects software) and the Trapcode Suite (a set of third-party programs for Adobe AfterEffects, specialising in 3D effects). Two products from the Trapcode Suite that are particularly useful for making music visualisations are Trapcode Sound Key, which creates keyframes from audio, and can be used as a trigger for Trapcode Particular which is a particle effect creator. Another
product, Trapcode Form, can also be used to make visualisations through the audio react option for the visual layers. With Trapcode Form, it is possible to have a visualisation respond to a certain frequency, as well as loudness.

5. DISCUSSION

Through exploration of using HEX in composition, it was found that it was better served as part of a structural process that informed the parameters of a composition. For a practice that is heavily based towards the narrative, the process of how the data is utilised becomes less important than the evocative nature of the overall work.

Rather than use HEX exclusively to generate a composition, HEX became used as a means of gathering and generating compositional materials, with created works being a composed sonification in response to the environment. With this method of practice, the composer/performer is controlling the outcomes of the resultant work.

The active manipulation of data meant that data was being interpreted largely on an aesthetic, rather than numerical level. The data became the basis of a composition, but was not necessarily the whole composition. The selective use of data (in order to make the data set workable for the composer) also meant that not all elements of a data set would be used, which reduced the emphasis of HEX in the overall composition.

A more philosophical consideration that arose from these explorations is the concept of data integrity, particularly in regards to this form of practice. What does 'data' mean in this context, and how much of the compositions are actually derived from 'data'? How much does the concept of data integrity matter?

If data integrity is regarded as preserving aspects of the original data into the work, then some data integrity exists in that the order of notes themselves are not being modified, even if the order of the sequences are altered. It can be argued that data integrity may not matter in the work as whole, since the work is more focused on the narrative and aesthetic elements of the found environment and the images produced by said environment. In this approach, what matters more is the evocative nature of the overall work, rather than how specific elements are used.

This method is perhaps more of a demonstration of how data elements can be used in the creation of structured, composed soundscapes, with the focus on the response of the composer to the found environment, with less emphasis on the data itself. The focus then becomes less about the process of translating data into music, and more about the ways in which a composer uses these elements as part of a narrative statement.

6. EXAMPLE WORK 1: WALYUNGA

Walyunga [2016] is a piece created during a visit to Walyunga National Park, north-east of Perth. The piece incorporates field footage and field recordings into the work, as well as a composition created from HEX converted from the video. In Walyunga, the music visualisation occurs after the field footage, with the former used to set the narrative scene while the visualisation provides the abstraction and visual movement.

Walyunga is a piece that incorporates the environmental and historical elements of the area. The visualisation, as shown in Figure 4., is intended to be an abstraction of the Avon River as it flows through Walyunga, with the steady, pulsating shifts in the visualisation reminiscent of the steady flow of the river.

Walyunga begins with a diptych of field footage from two sections of the Avon River. The diptych is 30 seconds long and is accompanied with a field recording. The field recording is intended to act as an audio cue to orientate the audience.

A diptych video format is visually interesting for two main reasons – firstly, it adds motion and interest to the beginning of the composition. Secondly, it effectively sets the scene of the piece by offering multiple perspectives of the found environment. Having a diptych video can be an effective method of helping the audience relate the piece to the source environment, without being too obtrusive or distracting.

The field footage and recording then fades out into the music visualisation. The rest of the work is more of an evocative response to the found environment using HEX as a compositional base, and is used to set the tempo, pitch and type of instruments used. The music was composed using Ableton 9.

The music visualisation was created using Trapcode Form in Adobe AfterEffects. Multiple audio react levels and a change in camera angle were used to achieve the final effect. The various audio react levels responded to
a certain frequency (i.e. 1000hz) with a change in the shape of the form (i.e. disperse level). An additional aspect regarding Trapcode Form is that the particles do not have a set “time of life” - that is, they will last the duration of a piece. This allows for precise control over the behaviour of the particles – as well as the dispersal level, Trapcode Form allows for modifying their shape (i.e. strength of spherical and fractal fields).

![Figure 4](image4.png)

**Figure 4.** Music visualisation for *Walyunga*, made using Adobe AfterEffects and Trapcode Form.

The audio at the end of the work features a reiteration of the field recording, to act as a bookend.

7. EXAMPLE WORK 2: THE ALL-ENCOMPASSING

*The All-Encompassing [2015]* was a work created during a Supported Residency at the Bogong Centre For Sound Culture in Victoria. The work involves a series of photographs and video of the area, along with field recordings and two guitars playing separate parts of sections of HEX that was converted into music. This is an example of data elements being played and recorded using live instruments.

The video was initially assembled using a series of photographs and field footage, and the completed video was converted into HEX. The HEX was then converted into music and played on guitar.

The first half of the work features still images of the forest in the Bogong region with three excerpts from field recordings of a lyrebird that were taken in the area. There is no instrumentation during this half; the focus is on the evocative pairing of the field recordings with the images.

![Figure 5](image5.png)

**Figure 5.** Screenshot from the first half of *The All-Encompassing*, showing a photograph from the forest around the Bogong region.

The second half features a diptych of moving clouds with two accompanying guitars playing the composition. There is no music visualisation, with visual movement instead being portrayed by the diptych of the moving clouds.

![Figure 6](image6.png)

**Figure 6.** A screenshot from the second half of *The All-Encompassing*, featuring shifting clouds.

8. EXAMPLE WORK 3: THE SHADOWS

*The Shadows [2015]* is a work featuring a music visualisation laid over a static field image, with no field recording present. The work was created from a photograph taken at Angkor Wat, Cambodia in April 2015. The work is based on the concept that spirits and memories remain alive in areas, with echoes of events lingering in the background. The visualisation represents these echoes that remains within the walls of Angkor Wat. The visualisation was created using Adobe AfterEffects and Trapcode Particular.

When overlaying a music visualisation over a still image, a line or point in the photograph is used to anchor the visualisation. This also helps incorporate the visualisation into the photograph, by using a point of the photograph as the start and end points. In *The Shadows*, the anchor point is roughly at mid-point between the two central pillars.

![Figure 7](image7.png)

**Figure 7.** Screenshot from *The Shadows*, with a music visualisation overlaid on top of photograph of Angkor Wat.
Unlike Trapcode Form, the particle effects in Trapcode Particular have a set “life span” - that is, the particles are only visible for a certain length of time. This allows for the creation of constantly-shifting effects, with the visualisation changing shape every few seconds. Trapcode Particular allows artists to set parameters regarding colour and opacity over life, creating the addition of shifting colours and visibility, as well as movement.

The Shadows also features a mix between HEX-based composition and improvised instrumentation. The guitar in this piece is a response to the composition. When performed live, this piece highlights how live performers can interact with the underlying HEX-based composition.

9. FUTURE POSSIBILITIES

There is still much to explore with regards to HEX-based compositions and where these compositions are situated in relation to other forms of composed sonification. There are also possibilities with creating interactive installations, as well as improving on live performances of these works. HEX-based compositions offer an interesting avenue to explore the relationship between the aural and the visual, and the aesthetic relationship between composer and data.

There is currently a heavy visual element to this work and there is potential to take the visual elements further. One future possibility is creating HEX-based works that actively engage with viewers and the performer, such as creating responsive installations and projections. For instance, through using OpenFrameworks – an open-source software for creating reactive applications – and Arduino, an open-source prototyping platform, there is the possibility of creating projections and objects that respond to a user's movement and/or sound, or for movement to trigger different lines of a composition.

Currently in live performance, improvised guitar lines are played over the composition, with the projection in the background. There is the potential for all the lines to be played by live musicians, in combination with improvisation, to create more organic interpretations of the data.

The current mapping system can be modified and expanded to introduce accidentals into the composition. By expanding the mapping system, this will introduce greater complexity in sonic possibilities. At present, there are no accidentals in the compositions. One way of introducing greater complexity to the compositions is mapping the the HEX letters (HEX A, HEX B, etc.) to represent accidentals rather than the continuation of the octave scale. Another area to explore is mapping HEX to specific scales, such as pentatonic major and minor scales.

Another possibility is to combine HEX with other forms of data-based composition methods, such as converting DNA from organisms from the found environment into music, or using the contours of the landscape as the basis for a percussive score. With these methods, more facets of the found environment can be incorporated into the composition.

Regarding the issue of incorporating time into compositions, an alternative method is to use the tempo of the field recording as the main method of denoting time. That way, the tempo of the composition would more accurately reflect the rhythm of the found environment. Changing the groupings of the sequences is another way of introducing different elements of time into a work – for instance, grouping sequences in groups of six to approximate 6/8 time, or in groups of three to approximate 3/4 time.

10. REFERENCES


